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1934

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NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society", by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors should submit their papers in typescript and in a condition ready for printing. All physico-chemical symbols and mathematical formulæ should be so clearly written that the compositor should find no difficulty in reading the manuscript. Sectional headings and tabular matter should not be underlined. Pen-illustrations accompanying papers should be made with black Indian ink upon smooth white Bristol board. Lettering and numbers should be such that, when the illustration or graph is reduced to 3½ inches in width, the lettering will be quite legible. On graphs and text figures any lettering may be lightly inserted in pencil. Photomicrographs should be rectangular rather than circular, to obviate too great a reduction. The size of a full page plate in the Journal is 4 × 6½ inches, and the general reduction of illustrations to this limit should be considered by authors. When drawings, etc., are submitted in a state unsuitable for reproduction, the cost of the preparation of such drawings for the process-block maker must be borne by the author. The cost of colouring plates or maps must also be borne by the author.

FORM OF BEQUEST.

I bequeath the sum of £ to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's Rooms, Science House, Gloucester and Essex Streets, Sydney.

Transactions of the Philosophical Society, N.S.W., 1862–5, pp. 374, out of print.

Vols.	I–XI	Transactions of the Royal Society, N.S.W.,					1867–1877	,,	
,,	XII	Journal and Proceedings	,,	,,			1878, pp.	324,	price 10s. 6d.
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Royal Society of New South Wales

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* Died 28th August, 1934; succeeded by C. A. SUSSMILCH, F.G.S.

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† Died 25th May, 1934; succeeded by A. R. PENFOLD, F.A.C.I., F.C.S.

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LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales

P Members who have contributed papers which have been published in the Society's Journal. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch.M., 185 Macquarie-street, Sydney; p.r. "Cooringa," 252 Liverpool-road, Summer Hill.
1904		Adams, William John, M.I.Mech.E., 175 Clarence-street, Sydney.
1898		Alexander, Frank Lee, Surveyor, 21 George-street, Parramatta; p.r. 154 William-street, Granville.
1905	P 3	Anderson, Charles, M.A., D.Sc. (*Edin.*), C.M.Z.S., Director of the Australian Museum, College-street, Sydney; p.r. 17 Towns-road, Vaucluse. (President, 1924.)
1909	P 10	Andrews, Ernest C., B.A., Hon. Mem. Washington Academy of Sciences and of Royal Society of New Zealand, 32 Benelong Crescent, Bellevue Hill. (President, 1921.)
1933		Andrews, John, B.A., Demonstrator in Geography in the University of Sydney; p.r. "Avalon," Neret-street, Hunter's Hill.
1930		Aston, Ronald Leslie, B.Sc., B.E. *Syd.*, M.Sc., Ph.D., *Cantab.*, A.M.I.E.Aust., Lecturer in Civil Engineering and Surveying in the University of Sydney; p.r. 24 Redmyre-road, Strathfield.
1919		Aurousseau, Marcel, B.Sc., 65A Market-lane, Manly.
1923		Baccarini, Antonio, Doctor in Chemistry, *Florence*, c/o Dante Alighieri Society, Box 1168, G.P.O., Sydney.
1878		Backhouse, His Honour Judge A.P., M.A., "Melita," Elizabeth Bay.
1924	P 1	Bailey, Victor Albert, M.A., D.Phil., F.Inst.P., Assoc.-Professor of Physics in the University of Sydney; p.r. 12 Cranbrook-avenue, Cremorne.
1919		Baker, Henry Herbert, F.S.M.C., c/o W. Watson & Son Ltd. Watson House, Bligh-street, Sydney; p.r. 18 Bradley's Head-road, Mosman.
1894	P 28	Baker, Richard Thomas, The Crescent, Cheltenham.

Elected.		
1934	P 1	Baker, Stanley Charles, M.Sc., Science Teacher, St. Paul's College, Newtown.
1919		Bardsley, John Ralph, 76 Wright's-road, Drummoyne.
1895	P 9	Barraclough, Sir Henry, K.B.E., B.E., M.M.E., M.Inst.C.E., M.I.Mech.E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials: Professor of Mechanical Engineering in the University of Sydney.
1933		Bedwell, Arthur Johnson, Eucalyptus Oil Merchant, "Kama," 10 Darling Point-road, Edgecliff.
1909	P 2	Benson, William Noel, D.Sc. *Syd.*, B.A. *Cantab.*, F.G.S. Professor of Geology and Mineralogy in the University of Otago, Dunedin, N.Z.; p.r. 14 Maheno-street, Dunedin.
1926		Bentivoglio, Sydney Ernest, B.Sc.Agr., c/o Tooth & Co. Limited, Sydney; p.r. 14 Gordon-avenue, Coogee.
1923		Birks, George Frederick, Wholesale Druggist, c/o Potter & Birks Ltd., 15 Grosvenor-street, Sydney; p.r. 42 Powell-street, Killara.
1916		Birrell, Septimus, Appian Way, Burwood.
1920		Bishop, Eldred George, Manufacturing and General Engineer, 7 Knox-street, Sydney; p.r. 8 Belmont-road, Mosman.
1923	P 4	Blakely, William Faris, "Myola," Florence-street, Hornsby.
1905		Blakemore, George Henry, "Wawoona," 10 Cooper-street, Strathfield.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, "Inglewood," Florida-road, Palm Beach, N.S.W.
1933		Boan, Robert Farquharson, A.A.C.I., Analyst and Consulting Chemist, 185 Elizabeth-street, Sydney.
1933	P 4	Bolliger, Adolph, Ph.D., Director of Research, Gordon Craig Urological Research Laboratory, Department of Surgery, University of Sydney.
1926	P 5	Booker, Frederick William, B.Sc., "Dunkeld," Nicholson-street, Chatswood.
1932		Boon, Herbert Eril, 10 Murdoch-street, Cremorne.
1920	P 5	Booth, Edgar Harold, M.C., B.Sc., F.Inst.P., Lecturer and Demonstrator in Physics in the University of Sydney. (Hon. Secretary.)
1922		Bradfield, John Job Crew, C.M.G., D.Sc. *Eng.*, M.E., M.Inst.C.E., M.Inst.E.Aust., Barrack House, 16 Barrack-street, Sydney; p.r. 23 Park-avenue, Gordon.
1917		Breakwell, Ernest, B.A., B.Sc., Dept. of Education, Box 33A, G.P.O., Sydney.
1891		Brennand, Henry J. W., B.A., M.D., Ch.M. *Syd.*, V.D., Surgeon Commander R.A.N. Ret., 223 Macquarie-street, Sydney; p.r. 73 Milson-road, Cremorne.
1919	P 1	Briggs, George Henry, B.Sc., Ph.D., F.Inst.P., Assistant-Professor of Physics, University of Sydney; p.r. 13 Findlay-avenue, Roseville.
1906		Brown, James B., No. 1 Maitland-avenue, East Kew, E.4, Victoria.
1913	P 20	Browne, William Rowan, D.Sc., Assistant-Professor of Geology in the University of Sydney. (Hon. Secretary.) (President, 1932.)

Elected.		
1898		‡Burfitt, W. Fitzmaurice, B.A., M.B., Ch.H., B.Sc. *Syd.*, F.R.A.C.S., "Wyoming," 175 Macquarie-street, Sydney; p.r. "Radstoke," Elizabeth Bay.
1926		Burkitt, Arthur Neville St. George, M.B., B.Sc., Professor of Anatomy in the University of Sydney.
1919	P 12	Burrows, George Joseph, B.Sc., Lecturer and Demonstrator in Chemistry in the University of Sydney.
1929		Caley, Gilbert Fatkin, Manager, Matthews & Wilson (1931) Ltd., Manufacturing Chemists, 6 and 8 Cole-street, Borough, London, S.E.1, England.
1909		Calvert, Thomas Copley, Assoc.M.Inst.C.E., c/o Messrs. T. Michell & Gee, 92 Pitt-street, Sydney, Box 560 FF, G.P.O.
1923		Cameron, Lindsay Duncan, Associate of the Ballarat School of Mines (Metallurgy), Manufacturing Chemist, Hilly-street, Mortlake.
1934		Carruthers, H. L., M.B., B.S., Sydney Hospital, Sydney.
1903	P 3	Carslaw, Horatio Scott, Sc.D., LL.D., F.R.S.E., Emeritus Professor of Mathematics, University of Sydney, Fellow of Emmanuel College, Cambridge; Burradoo, N.S.W.
1913	P 4	Challinor, Richard Westman, F.I.C., A.A.C.I., A.S.T.C., F.C.S., Lecturer in Organic Chemistry, Sydney Technical College; p.r. 54 Drumalbyn-road, Bellevue Hill. (Vice-President.) (President, 1933.)
1933		Chalmers, Robert Oliver, A.S.T.C., Assistant (Professional) in Mineralogy, Australian Museum, College-street, Sydney.
1913	P 19	Cheel, Edwin, Botanist and Curator, National Herbarium, Botanic Gardens, Sydney. (Vice-President.) (President, 1931.)
1925	P 1	Clark, William E., 24 Cambridge-street, Epping.
1920		Cooke, Frederick, c/o Meggitt's Limited, Asbestos House, York and Barrack-streets, Sydney.
1913	P 5	Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. Bannerman-crescent, Rosebery.
1928		Coppleson, Victor Marcus, M.B., Ch.M., F.R.C.S., F.R.A.C.S., Surgeon, 225 Macquarie-street, Sydney; p.r. "Cravenna," 8 Macleay-street, Potts Point.
1933		Corbett, Robert Lorimer, Managing Director of Robert Corbett & Co. Ltd., Manufacturing Chemists, Head Office, 379 Kent-street, Sydney.
1882		Cornwell, Samuel, J.P., "Capanesk," Tyagarah, N.S.W.
1919		Cotton, Frank Stanley, D.Sc., Chief Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 7	Cotton, Leo Arthur, M.A., D.Sc., Professor of Geology in the University of Sydney. (President, 1929.)
1892	P 1	Cowdery, George R., Assoc.M.Inst.C.E., Strathfield-avenue, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, c/o Mrs. H. L. Tress, 19 Findlay-avenue, Roseville.

Elected.		
1921	P 1	‡Cresswick, John Arthur, A.A.C.I., F.C.S., Production Superintendent and Chief Chemist, c/o The Metropolitan Meat Industry Commissioner, State Abattoir and Meat Works, Homebush Bay; p.r. 101 Villiers-street, Rockdale.
1925		Curry, Harris Eric Marshall, 89 Ridge-street, North Sydney.
1912		Curtis, Louis Albert, L.S., F.I.S., V.D., Major, Surveyor, 66 Pitt-street, Sydney; p.r. 59 Albyn-road, Strathfield.
1890		Dare, Henry Harvey, M.E., M.Inst.C.E., M.I.E.Aust., 14 Victoria-street, Roseville.
1930		Davies, Harold Whitridge, M.B., B.S. *Adel.*, Professor of Physiology in the University of Sydney.
1928		Davison, Walter Charles, General Manager, Clyde Engineering Co. Ltd., Granville; p.r. 17 Hurlstone-avenue, Summer Hill.
1919	P 2	de Beuzeville, Wilfrid Alex. Watt, J.P., "Mélamere," Welham-street, Beecroft.
1921		Delprat, Guillaume Daniel, C.B.E., "Keynsham," Mandeville-crescent, Toorak, Victoria.
1894		Dick, James Adam, C.M.G., B.A. *Syd.*, M.D., C.M. *Edin.*, F.R.C.S. *Edin.*, Col. A.A.M.C., Comr. Ord. St. John, Medical Practitioner, "Catfoss," 59 Belmore-road, Randwick.
1906		‡Dixson, William, "Merridong," Gordon-road, Killara.
1913	P 3	Doherty, William M., F.I.C., F.A.C.I., "Jesmond," 36 George-street, Marrickville.
1928		Donegan, Henry Arthur James, A.S.T.C., Chemical Laboratory, Department of Mines, Sydney.
1924		Dupain, George Zephirin, A.A.C.I., F.C.S., Director Dupain Institute of Physical Education and Medical Gymnastics, Manning Building, 449 Pitt-street, Sydney; p.r. "Rose Bank," 158 Parramatta-road, Ashfield.
1924		Durham, Joseph, Judge-street, Randwick.
1934	P 6	Dwyer, Francis P. J., M.Sc., Lecturer in Chemistry, Technical College, Sydney.
1923	P 16	Earl, John Campbell, D.Sc., Ph.D., Professor of Organic Chemistry in the University of Sydney.
1924		Eastaugh, Frederick Alldis, A.R.S.M., F.I.C., Associate Professor in Chemistry, Assaying and Metallurgy in the University of Sydney.
1934		Elkin, Adolphus Peter, M.A., Ph.D., Professor of Anthropology in the University of Sydney.
1916	P 2	Enright, Walter John, B.A., Solicitor, High-street, West Maitland; p.r. Regent-street, West Maitland.
1908		Esdaile, Edward William, 42 Hunter-street, Sydney.
1921		Farnsworth, Henry Gordon, Government Stores, Harrington-street, Sydney; p.r. "Rothsay," 90 Alt-street, Ashfield.

Elected.		
1910		Farrell, John, A.S.T.C., Riverina Flats, 265 Palmer-street, Sydney.
1909	P 7	Fawsitt, Charles Edward, D.Sc., Ph.D., Professor of Chemistry in the University of Sydney. (President, 1919.)
1927	P 3	Finnemore, Horace, B.Sc., F.I.C., Lecturer in Pharmacy in the University of Sydney.
1923		Fiaschi, Piero, O.B.E., V.D., M.D. *Columbia Univ.*, D.D.S. *New York*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 178 Phillip-street, Sydney.
1920		Fisk, Ernest Thomas, F.Inst.R.E., A.M.I.E. (*Aust.*), Chairman of Directors, Amalgamated Wireless (Australasia) Ltd., Wireless House, 47 York-street, Sydney; p.r. 16 Beaconsfield-parade, Lindfield.
1888		Fitzhardinge, His Honour Judge G. H., M.A., "Red Hill," Pennant Hills.
1933		Fletcher, Harold Oswald, Assistant Palæontologist, Australian Museum, College-street, Sydney.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R.C.P. *Edin.*, "The Astor," Macquarie-street, Sydney.
1932		Forman, Kenn. P., M.I.Refr.E., 13 Market-street, Sydney; p.r. "Wyreema," Alison-road, Randwick.
1920		Fortescue, Albert John, "Benambra," Loftus-street, Arncliffe.
1905		Foy, Mark, Liverpool and Elizabeth-streets, Sydney.
1933	P 1	Frost, Herbert John, M.Sc. *Syd.*, 20 Aboud-avenue, South Kensington.
1926		Gibson, Alexander James, M.E., M.Inst.C.E., M.I.E.Aust., Consulting Engineer, 906 Culwulla Chambers, Castlereagh-street, Sydney; p.r. "Wirruna," Belmore-avenue, Wollstonecraft.
1921		Godfrey, Gordon Hay, M.A., B.Sc., Lecturer in Physics in the Technical College, Sydney.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., "Eynesbury," Edgecliff-road, Edgecliff.
1932		Goulder, Francis, A.S.T.C., A.A.C.I., Manager, Ever-Ready Works, Marshall-street, Surry Hills.
1934		Hall, Norman Frederick Blake, M.Sc., Chemist, Council for Scientific and Industrial Research (Tobacco Section), Dept. of Organic Chemistry, University of Sydney; p.r. 4 Whatmore-street, North Sydney.
1880	P 5	Halligan, Gerald Harnett, L.S., F.G.S., Retired Civil Engineer and Hydrographer, "Rivenhall," Hastings-road, Turramurra.
1912		Hallman, Edward Francis, B.Sc., Assistant Mathematical Master, Fort Street Boys' High School, Petersham; p.r. 15 Harrington-street, Marrickville.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street, Sydney.
1919		Hambridge, Frank, Adelaide Steamship Co. Chambers, 22 Bridge-street, Sydney; p.r. "The Chalet," Lucinda-avenue, Wahroonga.

Elected.		
1912		Hamilton, Alexander G., "Tanandra," 16 Hercules-street, Chatswood.
1909		Hammond, Walter L., B.Sc., High School, Wollongong.
1933		Hancock, Francis Charles, B.Sc. (Hons.), Dip.Ed. (*University of Bristol*), St. John's C. of E. Grammar School, Forbes-street, Darlinghurst.
1905	P 6	Harker, George, D.Sc., F.A.C.I., Cancer Research Department, University of Sydney; p.r. 75 Prospect-road, Summer Hill.
1913	P 1	Harper, Leslie F., F.G.S., Government Geologist, Department of Mines, Sydney; p.r. 8 Alviston-street, Strathfield.
1934		Harrington, Herbert Richard, Teacher of Physics and Electrical Engineering, 4 Epping-avenue, Eastwood.
1923	P 3	Harrison, Travis Henry John, D.Sc.Agr., D.I.C. (*London*), Lecturer in Botany and Entomology, Hawkesbury Agricultural College, Richmond.
1929		Hawley, J. William, J.P., Financial Agent, 46 Martin-place, Sydney; p.r. 12 King's-road, Vaucluse.
1934		Hayes, William Lyall, A.S.T.C., A.A.C.I., Works Chemist, c/o Messrs. Wm. Cooper & Nephews (Aust.) Ltd., Phillip-street, Concord; p.r. 21 Wandella-avenue, Roseville.
1914		Hector, Alex. Burnet, "Druminard," Greenwich-road, Greenwich.
1919		Henriques, Frederick Lester, 208 Clarence-street, Sydney.
1918		Hindmarsh, Percival, M.A., B.Sc.Agr., Principal, Agricultural High School, Yanco.
1928		Hirst, George Walter Cansdell, B.Sc., A.S.T.C. (Sc.), A.M.I.E. (*Aust.*), A.M.Inst.T., c/o Chief Mechanical Engineer's Office, N.S.W. Railways, Wilson-street, Redfern; p.r. "St. Cloud," Beaconsfield-road, Chatswood.
1930		Hodson, John S., Assoc.I.E.E., Electrical Engineer, H.M. Naval Establishments, Garden Island, Sydney.
1916		Hoggan, Henry James, A.M.I.M.E. (*Lond.*), A.M.I.E. (*Aust.*), Consulting and Designing Engineer, "Lincluden," 81 Frederick-street, Rockdale.
1930		Holmes, James Macdonald, Ph.D., F.R.G.S., F.R.S.G.S., Associate Professor of Geography in the University of Sydney.
1919		Hoskins, Arthur Sidney, Engineer, Steel Works, Port Kembla; postal address, P.O. Box 36, Wollongong.
1919		Hoskins, Cecil Harold, Engineer, c/o Australian Iron & Steel Ltd., Kembla Building, 58 Margaret-street, Sydney, Box 3375 R, G.P.O.
1913		Hudson, G. Inglis, J.P., F.C.S., 55 Wunulla-road, Woollahra Point.
1923	P 2	‡Hynes, Harold John, M.Sc., B.Sc.Agr., Senior Asst. Biologist, Department of Agriculture, Box 36A, G.P.O., Sydney; p.r. "Belbooree," 10 Wandella-avenue, Roseville.
1922		Jacobs, Ernest Godfried, "Cambria," 106 Bland-street, Ashfield.

Elected.		
1929		Jeffrey, Robert Ewen, A.A.C.I., Managing Director, Bardsley's Ltd.; p.r. 9 Greycliffe-avenue, Vaucluse.
1925		Jenkins, Charles Adrian, B.E., B.Sc., 2 Ramsgate-avenue, Bondi Beach.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., C.M.Z.S., Professor of Zoology in the University of Adelaide. (Cor. Mem., 1912.)
1924		Jones, Leo Joseph, Geological Surveyor, Department of Mines, Sydney.
1930		Judd, William Percy, 49 Hirst-street, Arncliffe.
1911		Julius, Sir George A., Kt., B.Sc., B.E., M.I.Mech.E., M.I.E.Aust., Culwulla Chambers, Castlereagh-street, Sydney.
1932		Keeble, Arthur Thomas, B.Sc., Science Master, Sydney Grammar School; p.r. 55 Carlotta-street, Greenwich.
1934		Kelly, Francis de Vere, Pharmacist, The Sydney Drug Stores, 264 Elizabeth-street, Sydney; p.r. c/o Masonic Club, 169 Castlereagh-street, Sydney.
1924		Kenny, Edward Joseph, Geological Surveyor, Department of Mines, Sydney; p.r. 17 Alma-street, Ashfield.
1887		Kent, Harry C., M.A., F.R.I.B.A., 491 New South Head-road, Double Bay.
1934		Kerslake, Richmond, A.S.T.C., A.A.C.I., Industrial Chemist, c/o Australian Paper Mfrs. Ltd., Macauley-street, Matraville; p.r. 55 Harold-street, Matraville.
1896		King, Sir Kelso, K.B., Underwriter, 117 Pitt-street, Sydney; p.r. "Quambi," Albert-street, Edgecliff.
1920		Kirchner, William John, B.Sc., A.A.C.I., Manufacturing Chemist, c/o Messrs. Burroughs, Wellcome & Co. (Australia) Ltd., Victoria-street, Waterloo; p.r. "Wanawong," 27 Thornleigh-road, Beecroft.
1919		Kirk, Robert Newby, Company Manager, 25 O'Connell-street, Sydney; p.r. 8 Lauderdale-avenue, Manly.
1924		Leech, Thomas David James, B.Sc., B.E. *Syd.*, P. N. Russell School of Engineering, University of Sydney; p.r. 57 Clanalpine-street, Mosman.
1934		Leech, William Dale, Director of Research, Australasian Food Research Laboratories, Cooranbong, N.S.W.
1920		Le Souef, Albert Sherbourne, Curator, Taronga Park, Mosman; p.r. 3 Silex-road, Mosman.
1916		L'Estrange, Walter William, 7 Church-street, Ashfield.
1909		Leverrier, Frank, B.A., B.Sc., K.C., c/o Austral Malay Tin Ltd., Challis House, Martin-place, Sydney; p.r. Wentworth-road, Vaucluse.
1929	P 10	Lions, Francis, B.Sc., Ph.D., A.I.C., Lecturer in Organic Chemistry in the University of Sydney; p.r. 31 Chesterfield-road, Epping.
1906		Loney, Charles Augustus Luxton, M.Am.Soc.Refr.E., National Mutual Building, 350 George-street, Sydney.

Elected.		
1924		Love, David Horace.
1927	P 1	Love, William Henry, B.Sc., Ph.D., Cancer Research Department, University of Sydney.
1921		McDonald, Alexander Hugh Earle, H.D.A., Director of Agriculture, Department of Agriculture, Sydney.
1919		McGeachie, Duncan, M.I.M.E., M.I.E. *Aust.*, M.I.M.M. *Aust.*, "Craig Royston," Toronto, Lake Macquarie.
1906	P 2	McIntosh, Arthur Marshall, "Moy Lodge," Hill-street, Roseville.
1891		McKay, R. T., L.S., M.Inst.C.E., Commissioner, Sydney Harbour Trust, Circular Quay, Sydney.
1930		Mackenzie, William Donald, F.I.C., M.I.Chem.E., F.A.C.I., Chairman and Managing Director, Messrs. Lever Brothers Ltd., Balmain; p.r. 5 Tivoli-avenue, Rose Bay.
1932		McKie, Rev. Ernest Norman, B.A. *Syd.*, St. Columba's Manse, Guyra, N.S.W.
1927		McMaster, Sir Frederick Duncan, Kt., "Dalkeith," Cassilis.
1916		McQuiggin, Harold G., M.B., Ch.M., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney.
1909		Madsen, John Percival Vissing, D.Sc., B.E., Professor of Electrical Engineering in the University of Sydney.
1924		Mance, Frederick Stapleton, Under Secretary for Mines, Mines Department, Sydney; p.r. "Binbah," Lucretia-avenue, Longueville.
1880	P 1	Manfred, Edmund Cooper, Architect, Belmore-square, Goulburn.
1920	P 1	Mann, Cecil William, M.A., Lecturer, Teachers' College, University Grounds, Newtown; p.r. 68 Middle Harbour-road, Lindfield.
1914		Martin, Alexander Hutton, F.R.A.I.A., Architect and Lecturer in Charge, School of Architecture, Sydney Technical College: p.r. "Silverdene," 23 Victoria-street, Roseville.
1933	P 2	Martin, Lyster Waverley Ormsby, B.Sc., Chemical Engineer, Dept. Public Works, N.S.W.; p.r. 13 Carlos-road, Artarmon.
1929	P 1	Matheson, Alexander James, Teacher, the High School, Dubbo.
1926		Mathews, Hamilton Bartlett, B.A., F.I.S., F.C.I.V., Surveyor-General of N.S.W., Department of Lands, Sydney.
1933		Mears, Arthur Cyril Weeks, A.S.A.S.M. (Electrical and Mechanical Engineering), Engineer Commander, Royal Australian Navy, Navy Office, St. Kilda-road, Melbourne, S.C.1, Victoria.
1912		Meldrum, Henry John, B.A., B.Sc., Lecturer, The Teachers' College, University Grounds, Newtown; p.r. 98 Sydney-road, Manly.
1929	P 6	Mellor, David Paver, M.Sc., Lecturer and Demonstrator, Chemistry Department, University of Sydney; p.r. 35 Oliver-road, Roseville.

Elected.		
1928		Micheli, Louis Ivan Allan, M.Sc., Ph.D., Research Chemist, c/o Colonial Sugar Refining Co., Pyrmont.
1926		Mitchell, Ernest Marklow, A.M.I.E. *Aust.*, Civil Engineer, Metropolitan Water, Sewerage and Drainage Board, 341 Pitt-street, Sydney; p.r. 106 Harrow-road, Bexley.
1931	P 1	Moppett, Warnford, M.D., Ch.M., Cancer Research Department, University of Sydney.
1922	P 20	Morrison, Frank Richard, A.A.C.I., F.C.S., Assistant Chemist, Technological Museum, Sydney.
1924		Morrison, Malcolm, Curator, Mining Museum, Sydney; p.r. "Tayan," Herbert-street, Rockdale.
1934		Mort, Francis George Arnot, Chemist, c/o Lewis Berger & Sons Ltd., Rhodes; p.r. 16 Grafton-street, Woollahra.
1879		Mullins, John Lane, M.L.C., M.A. *Syd.*, Barrister, 7 Greenknowe-avenue, Potts Point.
1932		Munch-Petersen, Erik, M.Sc., Ph.B., Analytical Chemist, McMaster Laboratory, University of Sydney; p.r. 31 Lytton-street, North Sydney.
1915		Murphy, Robert Kenneth, Dr.Ing., Chem.Eng., A.S.T.C., M.I.Chem.E., A.A.C.I., Lecturer in Charge of Chemistry and Head of Science Department, Sydney Technical College.
1923	P 2	Murray, Jack Keith, B.A., B.Sc.Agr., Principal, Queensland Agricultural College, Gatton, Queensland, and Professor of Agriculture in the University of Queensland.
1893	P 4	Nangle, James, O.B.E., F.R.A.S., F.R.A.I.A., Government Astronomer, The Observatory, Sydney; Room 706, Australia House, Carrington-street, Sydney. (President, 1920.)
1930	P 1	Naylor, George Francis King, c/o Australian Institute of Industrial Psychology, 26 O'Connell-street, Sydney; p.r. "Kingsleigh," Ingleburn, N.S.W.
1932		Newman, Ivor Vickery, M.Sc., Ph.D., F.R.M.S., F.L.S., Linnean Macleay Fellow in Botany of the Linnean Society of N.S.W., Botany Department, University of Sydney; p.r. "Whitehaven," 5 Llandilo-avenue, Strathfield.
1924		Nickoll, Harvey, L.R.C.P., L.R.C.S., Barham, *via* Mudgee, N.S.W.
1891		‡Noble, Edward George, L.S., Local Government Engineer, 8 Louisa-road, Balmain.
1920	P 2	Noble, Robert Jackson, M.Sc., B.Sc.Agr., Ph.D., Biologist, Department of Agriculture, Box 36A, G.P.O., Sydney; p.r. "Warrah," 51 Boundary-street, Roseville. (President.)
1903		‡Old, Richard, "Waverton," Bay-road, North Sydney.
1930		O'Leary, Rev. William J., S.J., Seismologist, St. Ignatius' College, Riverview, Sydney.
1913		Ollé, A. D., F.C.S., A.A.C.I., "Kareema," Charlotte-street, Ashfield.

Elected.		
1932		O'Neill, John Patrick, F.I.I.A., F.C.I. (*Eng.*), Chief Timber Inspector, Department of Railways, Bridge-street, Sydney; p.r. 38 Wilberforce-avenue, Rose Bay.
1921	P 3	Osborne, George Davenport, D.Sc., Lecturer and Demonstrator in Geology in the University of Sydney.
1928		Parsons, Stanley William Enos, Analyst and Inspector, N.S.W. Explosive Department; p.r. Shepherd-road, Artarmon.
1920	P 65	Penfold, Arthur Ramon, F.A.C.I., F.C.S., Curator and Economic Chemist, Technological Museum, Harris-street, Ultimo; p.r. 25 Ramsay-road, Pennant Hills. (Hon. Treasurer.)
1933		Penman, Arthur Percy, B.E. *Syd.*, Mining Engineer, 10 Water-street, Wahroonga.
1881		Poate, Frederick, F.R.A.S., L.S., "Clanfield," 50 Penkivil-street, Bondi.
1919		Poate, Hugh Raymond Guy, M.B., Ch.M. *Syd.*, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, F.R.A.C.S., Surgeon, 225 Mac-quarie-street, Sydney; p.r. 38 Victoria-road, Bellevue Hill.
1896		Pope, Roland James, B.A. *Syd.*, M.D., Ch.M., F.R.C.S. *Edin.*, 185 Macquarie-street, Sydney.
1921	P 2	Powell, Charles Wilfrid Roberts, F.I.C., A.A.C.I., Company Executive, c/o Colonial Sugar Refining Co., O'Connell-street, Sydney; p.r. "Wansfell," Kirkoswald-avenue, Mosman.
1918		Powell, John, Managing Director, Foster Clark (Aust.) Ltd., 17 Thurlow-street, Redfern; p.r. "Elgarth," Ranger's-road, Cremorne.
1927		Price, William Lindsay, B.E., B.Sc., Teacher of Physics, Sydney Technical College; p.r. 60 McIntosh-street, Gordon.
1918		Priestley, Henry, M.D., Ch.M., B.Sc., Associate Professor of Physiology in the University of Sydney.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, Physician, 185 Macquarie-street, Sydney; p.r. "The Astor," Macquarie-street, Sydney.
1929		Pyke, Henry George, A.S.T.C., Assistant Works Chemist, Australian Gas Light Company, Mortlake; p.r. 29 Maple-avenue, Pennant Hills.
1922	P 5	Raggatt, Harold George, M.Sc., Geologist, c/o Mines Department, Sydney; p.r. 83 Epping-avenue, Epping.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1931	P 1	Rayner, Jack Maxwell, B.Sc., A.Inst.P., Physicist to the Department of Mines, Sydney; p.r. 125 William-street, Granville.
1928		Reidy, Eugene Nicholas, A.S.T.C., Analyst, Department of Mines, Sydney.

Elected.		
1932		Richardson, Henry Elmar, Chemist, Chase-road, Turramurra.
1933		Roberts, Richard George Crafter, Electrical Engineer, "Redcliffe," Liverpool-road, Ashfield.
1928		Ross, Allan Clunies, B.Sc., F.C.A. (*Aust.*), Chartered Accountant (*Aust.*), 7 Bent-street, Sydney; p.r. The Grove, Woollahra. (Member from 1915 to 1924.)
1895		Ross, Herbert E., Govt. Savings Bank Building, 14 Castlereagh-street, Sydney.
1925		Roughley, Theodore Cleveland, B.Sc., F.R.Z.S., Economic Zoologist, Technological Museum, Sydney; p.r. Coolong Flats, Coolong-road, Vaucluse.
1929		Royle, Norman Dawson, M.D., Ch.M., 185 Macquarie-street, Sydney.
1907		Ryder, Charles Dudley, D.Eng. *Vienna*, Assoc.I.R.S.M. *Lond.*, Assoc.A.C.I., F.C.S. *Lond.*, Public Analyst (by appointment), Box 2263 G.P.O., Sydney; p.r. 38 Copeland-street, Beecroft.
1934		Salter, Keith Eric Wellesley, B.Sc., Entomologist, Curator Macleay Museum, The University of Sydney; p.r. "Hawthorn," 48 Abbotsford-road, Homebush.
1922		Sandy, Harold Arthur Montague, 268 George-street, Sydney.
1920		Sawyer, Basil, B.E., "Birri Birra," The Crescent, Vaucluse.
1920		Scammell, Rupert Boswood, B.Sc. (*Syd.*), A.A.C.I., F.C.S., c/o F. H. Faulding & Co. Ltd., 98 Castlereagh-street, Redfern; p.r. 10 Buena Vista-avenue, Clifton Gardens.
1933		Selby, Esmond Jacob, Dip.Com., Sales Manager, "Marley," Werona-avenue, Gordon.
1918		Sevier, Harry Brown, Chairman of Directors, c/o Lewis Berger & Sons (Australia) Limited, Box 23, P.O., Burwood; p.r. 7 Albyn-road, Strathfield.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		‡Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1933		Slade, George Hermon, B.Sc., Director, W. Hermon Slade & Co. Ltd., Manufacturing Chemists, 23 Rosebery-avenue, Rosebery; p.r. "Raiatea," Oyama-avenue, Manly.
1922	P 1	Smith, Thomas Hodge, Australian Museum, College-street, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc., B.Sc.Agr., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, "Araboonoo," Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, M.C.I.P.A., F.I.A.P.A., c/o Spruson & Ferguson, Patent Attorneys and Consulting Engineers, 66 Pitt-street, Sydney; p.r. "Bengalala," Neutral Bay.

Elected.		
1916		Stephen, Alfred Ernest, F.C.S., c/o Box 1158 HH, G.P.O., Sydney.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 135 Macquarie-street, Sydney; p.r. Captain Piper's-road and New South Head-road, Vaucluse.
1920	P 1	Stephens, John Gower, M.B., 135 Macquarie-street, Sydney.
1913		Stewart, Alex. Hay, B.E., "Yunah," 22 Murray-street, Croydon.
1900	P 1	Stewart, J. Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; p.r. "Berelle," Homebush-road, Strathfield. (President, 1927.)
1909		Stokes, Edward Sutherland, M.B., Ch.M. *Syd.*, D.P.H. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street, Sydney; p.r. 15 Highfield-road, Lindfield.
1916	P 1	Stone, Walter George, F.S.T.C., A.A.C.I., Senior Analyst, Department of Mines, Sydney; p.r. 14 Rivers-street, Bellevue Hill.
1918		Sullivan, Herbert Jay, Director in Charge of Research and Technical Department, c/o Lewis Berger & Sons (Australia) Ltd., Rhodes; Box 23, P.O., Burwood; p.r. "Stonycroft," 10 Redmyre-road, Strathfield.
1918		Sundstrom, Carl Gustaf, Managing Director, Federal Match Co. Ltd., Park-road, Alexandria; p.r. 74 Alt-street, Ashfield.
1901	P 15	‡Sussmilch, C. A., F.G.S., F.S.T.C., A.M.I.E. *Aust.*, Acting Superintendent, Sydney Technical College; p.r. 11 Appian Way, Burwood. (Vice-President.) (President, 1922.)
1919		‡Sutherland, George Fife, A.R.C.Sc. *Lond.*, Assistant Professor of Mechanical Engineering in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M.D., D.P.H. *Melb.*, B.Sc. *Oxon.*, Professor of Preventive Medicine and Director, School of Public Health and Tropical Medicine, University of Sydney; p.r. "Lynton," 27 Kent-road, Rose Bay.
1926		Tannahill, Robert William, B.Sc. *Syd.*, M.Sc., Romford Isolation Hospital, Rush Green, Romford, England.
1915	P 3	Taylor, Harold B., M.C., D.Sc., F.I.C., F.A.C.I., Second Government Analyst, Department of Public Health, 93 Macquarie-street, Sydney; p.r. 44 Kenneth-street, Longueville.
1919		Thorne, Harold Henry, M.A. *Cantab.*, B.Sc. *Syd.*, F.R.A.S., Lecturer in Mathematics in the University of Sydney; p.r. 55 Railway-crescent, Beecroft.
1934		Tibbett, John G., A.S.T.C. (Chem.), A.A.C.I., Works Manager, Soul Pattinson (Labs.) Ltd., 49 Wentworth-avenue, Sydney; p.r. "Kalua," Hay-street, Vaucluse.

Elected.		
1923		Tindale, Harold, General Manager, The Australian Gas Light Company, Haymarket, Sydney.
1923		Toppin, Richmond Douglas, A.I.C., 22 Miller-street, Hurstville.
1879		Trebeck, P. C., Church-street, Bowral, N.S.W.
1932	P 7	Trikojus, Victor Martin, B.Sc., D.Phil., Lecturer in Medical Organic Chemistry, University of Sydney; p.r. "Buxton," Tusculum-street, Potts Point.
1925		Tye, Cyrus Willmott Oberon, Director of Development and Executive Officer of the Unemployment Relief Council, Treasury Building, Bridge-street, Sydney; p.r. 19 Muston-street, Mosman.
1890		Vicars, James, M.E., M.Inst.C.E., M.Inst.E. *Aust.*, F.R.A.I.A., Architect and Consulting Engineer, Challis House, Martin Place, Sydney; p.r. "Narrango," 4 Burns-road, Wahroonga.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George R., 9th Floor, Barrack House, Barrack-street, Sydney; p.r. "Inveresk," Coventry-road, Homebush.
1933	P 1	Voisey, Alan Heywood, B.Sc., Geologist, St. George's Hostel, West Kempsey, N.S.W.
1903	P 7	Vonwiller, Oscar U., B.Sc., F.Inst.P., Professor of Physics in the University of Sydney; p.r. "Appenzell," Castle Hill, N.S.W. (Vice-President.) (President, 1930.)
1910		Walker, Charles, F.C.S., A.A.C.I., 802 Culwulla Chambers, 67 Castlereagh-street, Sydney; p.r. "Lynwood," Terry-road, Ryde.
1910		Walker, Major Harold Hutchison, Vickery's Chambers, 82 Pitt-street, Box 1723 JJ, G.P.O., Sydney.
1919	P 1	Walkom, Arthur Bache, D.Sc., Science House, Gloucester-street, Sydney; p.r. 45 Nelson-road, Lindfield.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, Lond.; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Barrack House, 16 Barrack-street, Sydney; p.r. "Walsholme," Centennial Park.
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, F.A.C.I., Lecturer and Demonstrator in Physiology in the University of Sydney.
1921		‡Waterhouse, Gustavus Athol, D.Sc., B.E., F.R.E.S., F.R.Z.S., Science House, Sydney; p.r. 39 Stanhope-road, Killara.
1924		Waterhouse, Leslie Vickery, B.E. *Syd.*, Mining Engineer, Wingello House, Angel Place, Sydney; p.r. 4 Bertha-road, Neutral Bay.
1919		Waterhouse, Lionel Lawry, B.E. *Syd.*, Lecturer and Demonstrator in Geology in the University of Sydney.

Elected.		
1919	P 3	Waterhouse, Walter L., M.C., D.Sc.Agr., D.I.C., Faculty of Agriculture, University of Sydney; p.r. "Hazelmere," Chelmsford-avenue, Lindfield.
1910		Watson, James Frederick, M.B., Ch.M., Canberra, F.C.T.
1911	P 1	Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney; p.r. 64 Wentworth-road, Vaucluse. (President, 1925.)
1920	P 37	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum, Sydney.
1920	P 1	Wellish, Edward Montague, M.A., Associate-Professor of Applied Mathematics in the University of Sydney; p.r. 15 Belgium-avenue, Roseville.
1933		Welsh, Arthur Muir, Medical Practitioner and Demonstrator in Pathology in the University of Sydney; p.r. "Sherwood," Warwilla-avenue, Wahroonga.
1921		Wenholz, Harold, B.Sc.Agr., Director of Plant Breeding, Department of Agriculture, Sydney.
1881		‡Wesley, W. H., London.
1931		Wheatley, Frederick William, C.B.E., B.Sc. *Oxon.*, D.Sc., B.A. *Adel.*, A.S.A.S.M., 4 "Rhodesia," Macleay-street, Potts Point.
1922		Whibley, Harry Clement, c/o Box 1860 W, G.P.O., Brisbane, Queensland.
1909	P 3	‡White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teachers' College, University Grounds, Newtown.
1928		Wiesener, Frederick Abbey, M.B., Ch.M., D.O.M.S., Ophthalmic Surgeon, 143 Macquarie-street, Sydney; p.r. Jersey-road, Strathfield.
1921		Willan, Thomas Lindsay, B.Sc., Ipoh, Berak, Federated Malay States.
1920		Williams, Harry, A.I.C., A.A.C.I., Chief Chemist, c/o The Lanoleen Co., Arlington Mills, Lord-street, Botany; p.r. "Southerndale," Burke-street, Oatley.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, "Redcliffe," Liverpool-road, Ashfield.
1906	P 11	Woolnough, Walter George, D.Sc., F.G.S., Department of the Interior, Canberra, F.C.T.; p.r. "Callabonna," Park-avenue, Gordon. (President, 1926.)
1916		Wright, George, Company Director, c/o Farmer & Company Limited, Sydney; p.r. "Wanawong," Castle Hill, N.S.W.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, Seedsman, c/o Arthur Yates & Co. Ltd., 184 Sussex-street, Sydney; p.r. Boomerang-street, Turramurra.

Honorary Members.

Limited to Twenty.

Elected.	
1914	Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, Gower-street, London, W.C.1, England.
1934	Howchin, Walter, F.G.S., Erskine-street, Goodwood, S.A.
1931	Lyle, Sir Thomas Ranken, K.B., C.B.E., M.A., D.Sc., F.R.S., "Lisbuoy," Irving-road, Toorak, Melbourne, Victoria.
1915	Maitland, Andrew Gibb, F.G.S., "Bon Accord," 28 Melville-terrace, South Perth, W.A.
1912	Martin, Sir Charles J., C.M.G., D.Sc., F.R.S., Roebuck House, Old Chesterton, Cambridge, England.
1930	Masson, Sir David Orme, K.B.E., M.A., D.Sc., LL.D., 14 William-street, South Yarra, Victoria.
1928	Smith, Grafton Elliot, M.A., M.D., F.R.S., F.R.C.P., Professor of Anatomy, Institute of Anatomy, University College, Gower-street, London, W.C.1, England.
1915	Thomson, Sir Joseph J., O.M., M.A., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.
1922	Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Cambridge; p.r. 31 Grange-road, Cambridge, England.

Obituary 1934-35.

Ordinary Members.

1919 Bettley-Cooke, Hubert Vernon.
1891 Carment, David.
1909 Chapman, Henry George.
1886 David, Sir Edgeworth.
1908 Dun, William Sutherland.
1918 Gallagher, James Laurence.
1917 Jenkins, Richard Ford.
1879 Moore, Frederick Henry.
1884 Ross, Chisholm.
1921 Stephen, Henry Montagu.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.

Vice-President from 1866 to 1878.

To be awarded from time to time for meritorious contributions to the Geology or Mineralogy of Australia. The prefix * indicates the decease of the recipient.

Awarded.

1878 *Professor Sir Richard Owen, K.C.B., F.R.S.
1879 *George Bentham, C.M.G., F.R.S.
1880 *Professor Thos. Huxley, F.R.S.
1881 *Professor F. M'Coy, F.R.S., F.G.S.
1882 *Professor James Dwight Dana, LL.D.
1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.
1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1886 *Professor L. G. De Koninck, M.D.
1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.
1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892 *Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc.D., F.R.S., F.L.S.
1893 *Professor Ralph Tate, F.L.S., F.G.S.
1895 *Robert Logan Jack, LL.D., F.G.S.. F.R.G.S.
1895 *Robert Etheridge, Jnr.
1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.
1900 *Sir John Murray, K.C.B., LL.D., Sc.D., F.R.S.
1901 *Edward John Eyre.
1902 *F. Manson Bailey, C.M.G., F.L.S.
1903 *Alfred William Howitt, D.Sc., F.G.S.
1907 Professor Walter Howchin, F.G.S., University of Adelaide.
1909 *Dr. Walter E. Roth, B.A.
1912 *W. H. Twelvetrees, F.G.S.
1914 Sir A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History), London.
1915 *Professor W. A. Haswell, M.A., D.Sc., F.R.S.
1917 *Professor Sir Edgeworth David, K.B.E., C.M.G., D.S.O., M.A., Sc.D., D.Sc., F.R.S., F.G.S.
1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.
1920 *Joseph Edmund Carne, F.G.S.
1921 *Joseph James Fletcher, M.A., B.Sc.
1922 Richard Thomas Baker, The Crescent, Cheltenham.
1923 *Sir W. Baldwin Spencer, K.C.M.G., M.A., D.Sc., F.R.S.
1924 *Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., J.P.
1925 *Charles Hedley, F.L.S.
1927 Andrew Gibb Maitland, F.G.S., "Bon Accord," 28 Melville Terrace, South Perth, W.A.
1928 Ernest C. Andrews, B.A., F.G.S., 32 Benelong Crescent, Bellevue Hill.

Awarded.

1929 Professor Ernest Willington Skeats, D.Sc., A.R.C.S., F.G.S., University of Melbourne, Carlton, Victoria.

1930 L. Keith Ward, B.A., B.E., D.Sc., Government Geologist, Geological Survey Office, Adelaide.

1931 Robin John Tillyard, M.A., D.Sc., Sc.D., F.R.S., F.L.S., F.E.S., Canberra, F.C.T.

1932 Frederick Chapman, A.L.S., F.G.S., Melbourne.

1933 Walter George Woolnough, D.Sc., F.G.S., Department of the Interior, Canberra, F.C.T.

1934 Edward Sydney Simpson, D.Sc., B.E., F.A.C.I., Carlingford, Mill Point, South Perth, W.A.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled "The Aborigines of New South Wales."

1882 Andrew Ross, M.D., Molong, for paper entitled "Influence of the Australian climate and pastures upon the growth of wool."

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled "Water supply in the Interior of New South Wales."

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled "The Tin deposits of New South Wales."

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled "Origin and mode of occurrence of gold-bearing veins and of the associated Minerals."

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled "The Anatomy and Life-history of Mollusca peculiar to Australia."

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled "List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood."

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled "The Australian Aborigines."

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled "The Microscopic Structure of Australian Rocks."

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled "The effect which settlement in Australia has produced upon Indigenous Vegetation."

1894 J. V. De Coque, Sydney, for paper entitled the "Timbers of New South Wales."

1894 R. H. Mathews, L.S., Parramatta, for paper entitled "The Aboriginal Rock Carvings and Paintings in New South Wales."

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled "The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*)."

1896 Rev. J. Milne Curran, Sydney, for paper entitled "The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found."

AWARDS OF THE WALTER BURFITT PRIZE.

Bronze Medal and Money Prize of £50.

Established as the result of a generous gift to the Society by Dr. W. F. BURFITT, B.A., M.B., Ch.M., B.Sc., of Sydney. Awarded at intervals of three years to the worker in pure and applied science, resident in Australia or New Zealand, whose papers and other contributions published during the past three years are deemed of the highest scientific merit, account being taken only of investigations described for the first time, and carried out by the author mainly in these Dominions.

Awarded.

1929 Norman Dawson Royle, M.D., Ch.M., 185 Macquarie Street, Sydney.

1932 Charles Halliby Kellaway, M.C., M.D., M.S., F.R.C.P., The Walter and Eliza Hall Institute of Research in Pathology and Medicine, Melbourne.

AWARDS OF LIVERSIDGE RESEARCH LECTURESHIP.

This Lectureship was established in accordance with the terms of a bequest to the Society by the late Professor Archibald Liversidge. Awarded at intervals of two years, for the purpose of encouragement of research in Chemistry. (This JOURNAL, Vol. LXII, pp. x-xiii, 1928.)

Awarded.

1931 Harry Hey, c/o The Electrolytic Zinc Company of Australasia, Ltd., Collins Street, Melbourne.

1933 W. J. Young, D.Sc., M.Sc., University of Melbourne.

PRESIDENTIAL ADDRESS

By R. W. CHALLINOR, F.I.C., A.A.C.I., A.S.T.C., F.C.S.

(Delivered to the Royal Society of New South Wales, May 2, 1934.)

PART I.

We complete tonight the 78th Annual Meeting as the Royal Society of N.S.W. and in pursuance of the time-honoured custom it is my privilege to address you at the conclusion of my term of office.

I wish to thank fellow-councillors and members generally for the loyal support and assistance accorded me upon all occasions. Thanks are especially due to the Honorary Secretaries, Mr. C. A. Sussmilch, Dr. R. J. Noble and Major E. H. Booth, and the Hon. Treasurer, Dr. H. G. Chapman, for the success of the session just completed.

We are also much indebted to Professor J. C. Earl, the Honorary Librarian, for his special services in placing the Society's library upon a more satisfactory footing.

The Sections of Geology, Industry and Physics have held meetings frequently and regularly during the year. The thanks of Council and members are extended to the Hon. Secretaries, Mr. H. G. Raggatt, Dr. G. D. Osborne, Mr. H. V. Bettley-Cooke, Dr. W. H. Love and other officers who have given so much time and attention to the activities of these important sections.

Eight general monthly meetings have been held, at which 21 papers of the usual high standard of quality have been read and discussed. As the average number of papers contributed annually during the preceding 10 years was 23, it is evident that the Society's activities in this respect are being well maintained.

The Society is also indebted to Dr. R. J. Noble and Messrs. F. R. Morrison and A. S. Le Souef for lecturettes given at the August, September and November meetings respectively.

At the invitation of Council, Associate Professor W. J. Young, D.Sc., M.Sc., of the Department of Biochemistry of the University of Melbourne, delivered the second Liversidge Research Lecture on the 8th November, 1933, the title being "The Function of Phosphates in the Fermentations of Sugar". The lecture was well attended by members as well as by representatives of the various local chemical bodies.

Four Popular Science Lectures were delivered during the year, as follows:

20th July.—"Aborigines of the Australian Desert", by Rev. A. P. Elkin, M.A., Ph.D.

17th August.—"Useful Products of the Australian Bush", by A. R. Penfold, F.A.C.I., F.C.S.

21st September.—"The Age of the Earth", by G. D. Osborne, D.Sc.

19th October.—"The Effects of Radium Upon Cancers", by H. G. Chapman, M.D., B.S.

The Society's thanks are tendered to the lecturers.

The Society's membership roll now stands at 288; 17 new members have been elected, 14 have been lost by resignation or default, and the following four members by death—Edward William Knox, John Taylor Lingen, David John Thomas and David Carment.

Edward William Knox was elected in 1877, and prior to his death was the oldest surviving member of the Society. He died at his residence, "Rona", Bellevue Hill, on the 26th June, 1933, at the advanced age of 86 years. Born in Sydney and educated at the Sydney Grammar School, he entered the office of the Colonial Sugar Refining Co. when 17 years of age, at a period when the output of the refinery was small in comparison with its present magnitude. He became General Manager in 1881, and from 1920 up to the time of his retirement in February, 1933, was General Manager and Chairman of the Company. Being a sound business man and a born fighter, he successfully guided the Company's destinies through some very difficult periods. By introducing science into the sugar industry and establishing the policy of strict chemical control in the factories he succeeded in placing one of the greatest commercial activities of Australia upon a sound and economic basis.

Mr. Knox was a member of the Senate of the University of Sydney from 1894 until 1919, a former trustee of the Sydney Art Gallery and of the Sydney Grammar School, a member of the Royal Sydney Yacht Squadron for a number of years, and one of the oldest members of the Australian Jockey Club. He succeeded his father, the late Sir Edward Knox, as president of the Union Club, a position which he retained until he resigned it a few years ago.

JOHN TAYLOR LINGEN died at the residence of his daughter, Mrs. E. A. Lamb, Woollahra, on the 6th of September, 1933, in his 85th year. He was born at Hereford, England, the son of Dr. C. Leslie Lingen, and grandson of the Rev. Dr. Charles Taylor. His earlier education was received at Hereford Cathedral Grammar School, after which he entered Pembroke College, Cambridge, graduating as Bachelor of Arts with distinction in 1870, and later on as M.A. He was called to the Bar of the Middle Temple in 1872.

Mr. Lingen came to Australia in 1880, where he continued the practice of his profession at the Equity Bar in Sydney until 1922. Notwithstanding invitations to "take silk" as far back as 1894, he refrained from seeking the honour of K.C. until 1918 owing to a slight deafness. He was Chancellor for the Diocese of Sydney in 1894 and for the Diocese of Bathurst from 1907 till 1923. For many years he was a member of the Sydney Synod, and was elected Lay Canon of St. Andrew's Cathedral in 1911. He had been a member of this Society for 50 years.

DAVID JOHN THOMAS died suddenly on 7th February, 1934, at the age of 53 years. He became a member of this Society in 1919. Born at Goulburn, he was educated at the Sydney Grammar School and the University of Sydney. After graduating in Engineering (Mining and Metallurgy) in 1902, he spent a year in the laboratory of Sir William Ramsay at the London University and afterwards studied electrolysis under Professor Borchers at the University of Aix-la-Chapelle. He was Lecturer in Chemistry for 6 years at the North China Engineering College at Tong-Shan, after which he returned to England and from there proceeded to the Nigerian Tin-Fields. He spent some time with the Naraquata Tin

Fields Co. and subsequently became manager of the Anglo-Continental Mines Ltd., in whose interest he was able to secure one of the largest hydro-electric power-sites available at Sha Falls. Leaving Nigeria in 1921 he became a partner in the firm of Thomas and Cameron, manufacturing chemists, at Mortlake (Sydney). At their chemical factory the discoveries of the late H. G. Smith and of A. R. Penfold relative to the conversion of piperitone into thymol, menthol and menthone were developed commercially and the products placed upon the world's market in a very pure form. Mr. Thomas was a Fellow of the Geological Society of London and also of the Institute of Mining and Metallurgy.

David Carment was born at Comrie, Perthshire, Scotland, where his father, the Rev. James Carment, was a Free Church minister. He died at his residence, North Sydney, on 29th April, 1934.

He obtained his early education in the Free Church School at Comrie, from which he went later to the Edinburgh Institution and then in 1859 to the Edinburgh University. Continuing his studies he successfully passed the final examinations of the Faculty of Actuaries in Scotland, and was elected a Fellow of the Institute of Actuaries of Great Britain and Ireland. In 1872 he was persuaded to take up service with the Australian Mutual Provident Society, in Sydney, and after filling the position of actuary to this society for several years, he remained in their service until his retirement 20 years ago.

He was a Fellow of the American Institute of Actuaries and of the Actuarial Society of N.S.W., and served a term as President of the latter body.

He was a member of the treasurership committee of the Presbyterian Church, an active officer of St. Peter's Church for the past 50 years, and also a member of the Highland Society.

He had always taken a great interest in the affairs of the Royal Society, having been a member for 42 years, and had been a vice-president and honorary treasurer.

So recently as 1933 he had regularly attended the visits arranged by the Industrial Section, and although prevented at the last from attending had arranged to be present at the Society's Annual Dinner a few days

ago. Up till the time of his death he retained the hon. treasurership of the A.N.Z.A.A.S.

His principal relaxations were sailing and music. He was a life-member and rear-commodore of the Royal Prince Alfred Yacht Club in 1919, vice-commodore from 1920 to 1923, a member of the Royal Sydney Yacht Squadron and the Sydney Amateur Sailing Club. He was also a member of the Philharmonic Society.

Reference must also be made to two scientific workers of note, not members of this Society, who have died during the year.

Clive Errol Lord died on 15th July, 1933, after four days' illness, at the age of 44 years. Though an architect by profession and a Fellow of the Royal Australian Institute of Architects he was Director of the Tasmanian Museum and Art Gallery, President of the Royal Australian Ornithologists' Union from 1931 to 1932, a Fellow of the Linnean Society of London, an associate member of the A.N.R.C., Local Secretary of A.N.Z.A.A.S., a member of the National Park Board, Commissioner of Fisheries under the Tasmanian Sea Fisheries Act, and also Hon. Secretary of the Royal Society of Tasmania for 15 years. The latter society awarded him its medal in 1930.

He wrote several handbooks on Tasmanian subjects, contributed numerous papers to different scientific societies and was joint author with H. H. Scott of "The Vertebrate Animals of Tasmania".

At the July meeting of this Society members present paid their tribute of respect to the memory of their late fellow-scientist and colleague.

Bertram Dillon Steele died in Queensland on the 12th March, 1934. A native of Plymouth, England, he graduated B.Sc. in 1899 and D.Sc. in 1902, at the University of Melbourne, and was successively acting-professor at the Adelaide University, lecturer at McGill University, Montreal, assistant-professor at Heriot-Watt College, Edinburgh, and lecturer at Melbourne University. From 1910 to 1930 he occupied the chair of Chemistry at the University of Queensland, after which he was made Emeritus Professor of Chemistry at that University.

He served during the Great War under the Ministry of Munitions, London, in charge of one of H.M. factories for the manufacture of synthetic phenol during 1916-1918. For his distinguished services to chemical science he was made a Fellow of the Royal Society of London in 1919.

Council is concerned regarding the serious falling-off of membership since 1924, which was the peak period for the past 20 years, when 376 members were on the roll. A steady and continuous decline has set in since then, until this year we have only 288 members.

Fifty-four years ago the membership was 460. The Society at this period appeared to be concerned that the membership would become too great, for it was resolved in 1880 to limit it to 500.

The average annual loss of membership by death and resignation in the past 11 years has been 20, whilst the average addition of new members for the same period has only been 12. Each year, therefore, we have been slipping back by an average of 8 members, and the membership now is 88 less than it was in 1924.

Various known causes have operated to reduce the number of members. Scientific sections hitherto catered for by this Society have launched out as independent scientific societies. The period of financial stringency has been responsible for the resignation of a number who find that they are unable to continue their membership. Names have had to be removed from the roll through default.

Despite the falling-off from these causes it should be possible to counteract them, as there are undoubtedly a considerable number of citizens in this State who have sufficient interest in scientific progress or who have directly benefited from the research work published by this and other scientific bodies, and who would no doubt readily assist the Society by becoming members if invited to do so.

The finances which enable the Society to pay its way, print and distribute the papers of its research workers, bind its volumes, periodicals and donations to the library and otherwise increase the usefulness of the Society to members, are furnished largely from the annual subscrip-

tions. For some time now income from this source has become depleted.

If we assume that the subscriptions of all our present members were paid for the current year, income from this source would be £185 less than it was in 1924, but as the Government Subsidy has also been reduced from £400 to £200, the actual loss of income for the year becomes £385.

Allowing for the average loss of 20 members per annum we should require to elect 108 new members during the coming session to bring our income from subscriptions up to the 1924 level.

Realising the seriousness of the position, Council on the 30th June last appealed to members so to interest their friends and colleagues in the work of the Royal Society that they might be induced to fill in the nomination-forms supplied with the circular. This appeal, so far, has not borne the fruit which might reasonably have been expected.

We should each feel conscious that an obligation rests upon us individually to increase the number of annual subscriptions as far as we are able, by introducing new members as early as possible.

We owe our thanks to the Hon. Treasurer for the capable way in which he has fostered the financial interests of the Society in the past, but, as the figures quoted indicate, he is finding it very difficult to pay our way from income just now, and has especially drawn the attention of the President and Council to this fact.

One experiences some reluctance in making these statements in a Presidential Address, but such diffidence is outweighed by the importance of making every endeavour possible to stem the present drift by appealing to members for their earnest co-operation in bringing about better conditions.

In December last a special meeting of Council was called to consider in what way membership might be made more attractive. Various suggestions were made, including the restoration of the annual conversazione, a social function which would be appreciated more particularly by those members whose interests were not especially scientific in character. These suggestions

will most probably be given effect to during the new session.

The Rules of the Society have not been revised for many years, but during the past session Council has given them a careful and critical scrutiny. The alterations suggested by Council were submitted to a committee of members elected at the October general meeting for the purpose of criticism or further modification if thought desirable. This committee has reported to Council, and in the near future the recommended revisions will be submitted to a general meeting of members for approval.

This year the Clarke Memorial Medal has been awarded to Edward Sydney Simpson, D.Sc., B.E., F.A.C.I., Government Mineralogist and Analyst, W.A., as a recognition of his valuable contributions to Australian Mineralogy.

An informal reception was extended to Dr. Hishashi Kimura, Director of the Mizusawa Observatory, Japan, and President of the International Latitude Commission of the International Astronomical Union, on the 14th July, 1933, by representatives of the Royal Society, the Australian National Research Council and the British Astronomical Association. Dr. Kimura was visiting Australia in connection with the work on latitude variation being carried out in Adelaide. On his return to Japan he forwarded a letter of thanks for the kind welcome given to him in Sydney.

Your President attended a meeting of the Board of Visitors at the Sydney Observatory on the 13th May, 1933, when the Government Astronomer, Mr. James Nangle, laid upon the table the 10th Volume of the Astrographic Catalogue. Progress with this work is hampered by deficient finances, but it is gratifying to know that despite this observations and measurements in the zone allotted to New South Wales are being continued, and that we are endeavouring to honour our undertaking to the other civilised nations that we will do this portion of the work.

During the year the Society was represented upon a deputation to the Minister for Education in regard to instituting enquiries as to the desirability of granting

degrees to diploma-holders of the Sydney Technical College.

Congratulations are extended to two members who have been honoured during the year. Sir Frederick Duncan McMaster has had conferred upon him by the King the title of Knight Bachelor. To the succession of honours which have been bestowed upon Sir Edgeworth David, the University of Sydney has added by conferring upon him the honorary degree of Doctor of Science. It has been the lot of few scientists to awaken such world-wide recognition and appreciation of their endeavours as has been accorded our esteemed and worthy past-President. May we not add to our congratulation the fervent wish that he will continue to be blessed with robust health, so that he may enjoy these fruits of his labours?

Two important schools within the University of Sydney celebrated their Jubilees during the year, the Peter Nicol Russell School of Engineering on the 10th August and the Medical School on the 28th September. On the latter occasion the new Medical Building was officially opened by His Excellency Sir Philip Game. The previous generous benefaction to medicine from Mr. G. H. Bosch stimulated the Rockefeller Foundation to provide a further fund for the erection of this building. Fifty years ago the infant medical school was accommodated in a cottage. A splendid record of achievement has been accomplished since then, but this record should pale into insignificance in comparison with what may be expected from the school during the next 50 years, starting as it does with such ultra-modern accommodation for medical education and research.

At the October meeting of the Society addresses on the past activities of the Medical Section of the Royal Society were given by Dr. Cecil Purser and Dr. W. F. Burfitt, supplemented by remarks from Drs. G. H. Abbott and J. A. Dick. This Section of the Society was established 57 years ago and continued for 23 years.

The first David lecture, the inaugural lecture of the David and Masson Lectureships founded by the A.N.R.C. in honour of its first Presidents, was delivered at Science House on the 17th November on "Some Founders of Australian Geology" by Professor Ernest W. Skeats,

D.Sc., A.R.C.S., F.G.S. The lecture concluded with a fine tribute to Sir Edgeworth David's services to Australian geology.

A Royal Charter of Incorporation was granted by His Majesty the King to the Australian Chemical Institute on the 26th January, 1932.

The fifth Pacific Congress met in British Columbia in June, 1933. Messrs. E. C. Andrews and E. Cheel and Dr. R. J. Tillyard were the official delegates from N.S.W., together with Dr. Ida Brown and Mrs. E. C. Andrews as accredited delegates. Papers upon the various scientific problems of economic importance and common interest to the peoples of the Pacific were read and discussed in the English language. This congress provided further opportunity for mutual understanding and harmony between the many countries represented.

We regret to learn that Dr. R. J. Tillyard suffered a nervous breakdown during his absence abroad, and that this has caused him to resign his position as Chief of the Division of Economic Entomology at Canberra, F.C.T. We wish him a speedy recovery and return to his normal activity.

At the end of 1933 Mr. Jas. Nangle, a past-president of the Society, retired from the position of Superintendent of Technical Education in accordance with the statutory enactments regarding the age-limit of public servants. It is fitting that we should express our appreciation of Mr. Nangle's services to education, the great amount of re-organisation which he has brought about in Technical Education during the last twenty years and particularly the successful organisation of the system of vocational training for returned soldiers, an account of which he gave in his Presidential Address to the Society in 1921.

We offer our congratulations to another of our past-Presidents, Mr. C. A. Sussmilch, on being appointed Acting-Superintendent of Technical Education, but at the same time regret that his extra duties have obliged him to resign his position as Honorary Secretary and member of the Council. The Society's thanks are tendered to him for the loyal and effective service he has rendered, particularly during that period preceding the occupation of Science House, which was a very strenuous one for the executive officers of the Society.

An event of outstanding importance during the new session of this Society will be the visit of His Royal Highness Prince Henry, Duke of Gloucester, to Australia.

Part II.

THE INFLUENCE OF CHEMICAL CONSTITUTION UPON THE CHEMICAL, PHYSICAL AND PHYSIOLOGICAL ACTIVITIES OF ORGANIC COMPOUNDS.

Out of the great number of remarkable developments that have been taking place in chemistry during recent years, particularly in the field of organic chemistry, it has proved difficult to select one which might prove of general interest and which might, moreover, be placed before members in the space of time available for a presidential address. The scope of the subject chosen is very wide and embraces many important and fundamental principles, the application of which has been responsible for the progress of theoretical and applied organic chemistry and all that this means to humanity to-day. Though it will not be possible to deal with the matter adequately it is hoped that some of the recent developments will prove of interest to others besides those who practise chemistry in one or other of its branches.

The writer of an editorial (*Chem. and Ind.*, 1934, *53*, 90) on the growth of chemical theories, interestingly compares this growth with the steps taken in the solving of a crossword puzzle. He points out that while the facts of inorganic chemistry are fewer, and on the whole simpler in character and easier to explain, than those of organic chemistry, it has been a slow and laborious business to understand the structure of organic compounds. The first of those who worked out a small item in the puzzle could not see how important this item was to prove when it was fitted into the scheme with the items worked out by others. By putting these items into the right positions in the puzzle small portions of chaos became reduced to small portions of order.

The independent conception by Kolbe and Frankland, Kekulé and Couper in 1857 of the tetravalency of the

element carbon and the power of one carbon atom to link up with another carbon atom so that the new two-carbon arrangement could still combine with hydrogen, oxygen and other elements, provided so many more letters in the puzzle that the filling-in of empty spaces became easier.

The three-dimensional space-arrangement of the four carbon valencies, suggested by Pasteur, Kekulé, Van't Hoff and Le Bel, brought the solution still nearer to completion. Step by step a pictorial way of representing the atomic arrangements in organic molecules has developed, each molecular structure taking into account the valency of the component atoms and the chemical activities of the compound. The structure assigned to any organic molecule is therefore based upon valency and the physical and chemical characteristics of the compound. The correct constitution of a compound being known, it is possible by chemical methods, which have become perfected by the experience of years, correctly to build up this compound artificially from a selected number of suitable groups or fragments, the new compound being identical in every way with the original.

Many thousands of organic compounds have been synthesised in this way, and indeed the rapid progress of organic chemistry since the latter half of the last century is due very largely to the soundness of this system.

As the molecules become more complex in character, the naming of them becomes more difficult; each name used must be a specification in words of the constitution of the particular compound. Some of these names are very long, but unavoidably so, and to those who have not studied them they must sound exceedingly boring. They are, however, a necessary part of the jargon of organic chemistry.

One of the simplest examples of the effect of a difference in the structural arrangement of the atoms in a chemical molecule is to be found in the two possible isomeric arrangements for a molecular formula C_2H_6O. One of these depicts a structure in which two methyl groups symmetrically share the valencies of the oxygen atom, thus: $CH_3\text{-}O\text{-}CH_3$. This substance is a gas, fairly

resistant to chemical action, and behaves physiologically as an anæsthetic; it is called di-methyl ether. The other possible arrangement represents the 2-carbon group, ethyl sharing the oxygen valencies with hydrogen, thus: C_2H_5-O-H. This substance is a liquid which chemically is very reactive and physiologically behaves as a stimulant; it is called ethyl alcohol.

The influence of chemical structure upon such physical and chemical properties as the melting-point, boiling-point, optical properties, odour, taste, colour, physiological activity, etc., are well known for a large number of compounds, but additions to the known facts are constantly being made, and it is proposed to draw attention to some of these.

Acetic acid has the structure $CH_3 . COOH$, and has a pungent, penetrating odour. B. Rothstein (*Bull. Soc. Chim.*, 1932 [IV], *51*, 834) finds that by replacing one of the hydrogen atoms successively with such groups as methoxy, ethoxy, isopropoxy and isobutoxy, the odour of the acid diminishes rapidly in intensity and persistence as the molecular weight of the substituting group increases.

Urea, or Carbamide, $CO\begin{matrix}\diagup NH_2\\ \diagdown NH_2\end{matrix}$, has a saline taste, but the replacement of one of the hydrogen atoms by the group phenetole produces the compound *p*-ethoxyphenyl carbamide $CO\begin{matrix}\diagup NH \cdot C_6H_4 \cdot O \cdot C_2H_5\\ \diagdown NH_2\end{matrix}$, which possesses a sweet taste, 200 times as intense as that of cane-sugar, and to which the proprietary name "Dulcin" has been given.

Recently E. Wertheim (*J. Amer. Chem. Soc., 53*, 200) has investigated the effect of various changes in constitution upon the sweetness of "Dulcin". By replacing an amino-hydrogen atom with the group $CONH_2$ *p*-ethoxyphenyl biuret,

$$CO\begin{matrix}\diagup NH \cdot C_6H_4 \cdot O \cdot C_2H_5,\\ \diagdown NH \cdot CONH_2\end{matrix}$$

was obtained, which was tasteless. Substitution of a sulphur atom for O in the ethoxy group produced *p*-ethyl-thiol-phenyl carbamide,

$$CO\begin{matrix}\diagup NH \cdot C_6H_4 \cdot S \cdot C_2H_5,\\ \diagdown NH_2\end{matrix}$$

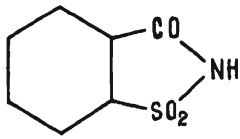
also a tasteless compound.

By replacing both oxygen atoms of "Dulcin" with sulphur *p*-ethyl-thiol-phenyl thiocarbamide

$$CS\begin{matrix}\diagup NH \cdot C_6H_4 \cdot S \cdot C_2H_5 \\ \diagdown NH_2\end{matrix}$$

was obtained; this substance possesses a bitter taste.

It has also been found by B. Oddo and Q. Mingoia (*Gazzetta,* 1931, *61,* 435) that when certain structural alterations are made to the molecule of "Saccharin",



this intensely sweet substance becomes tasteless in the compounds of altered structure.

A further investigation of the taste-intensity of organic compounds by S. Michael (*Bio-chem. Zeit.,* 1932, *255,* 351) shows that this property varies considerably with their structures. With saturated dicarboxylic acids it increases the nearer the carboxyl groups are to each other in the molecular arrangement, and is greater for those acids having an odd number of carbon atoms than for those with an even number. Of the isomeric unsaturated dibasic acids it is found to be greater for the *cis* than the *trans* forms. For organic compounds with substituting groups containing oxygen and nitrogen the taste-intensity is dependent upon the number of and the positions occupied by these groups. With compounds containing the same number of substituting groups it is found to decrease with the increasing number of carbon atoms in the molecule, and to increase the more closely these groups are situated to each other. Taste-intensity is found to be more pronounced with the *meta* disubstituted benzene compounds than with the *ortho* and *para* compounds.

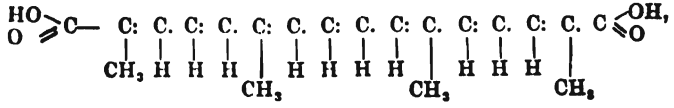
The relative position of the double linkings in diene or triene types has an effect upon the properties of the compound in which they occur, apart from those due to their unsaturated characters. If these double links are situated symmetrically between alternate carbon atoms they are said to be conjugated, and this structural arrangement existing in a chemical molecule confers,

among other properties, that of greater stability. By increasing the number of these conjugated linkings R. Kuhn and M. Hoffer (*Ber.*, 1930, *63*, 2164) found that when a sufficient number of them are present in a molecule the group assumes a chromophorous character and the compounds containing such groups become coloured. They prepared a number of unsaturated fatty acids and found that $\alpha\gamma\epsilon$-octa-trienoic acid, $CH_3.CH:CH.CH:CH.CH:CH.COOH$, with three conjugated double linkings, was colourless, but that $\alpha\gamma\epsilon\eta$-deca-tetraenoic acid,

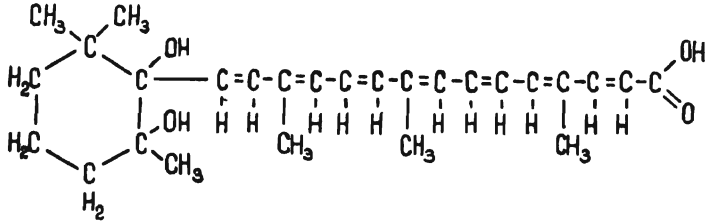
$$CH_3.CH:CH.CH:CH.CH:CH.CH:CH.COOH,$$

with four such linkings, was intensely yellow.

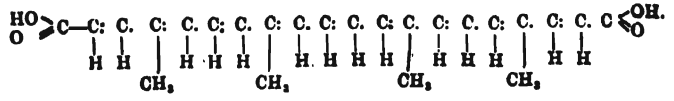
In a lecture to Section B., Brit. Ass. Adv. Sc. (Leicester, 7/9/33) on "Natural Colouring Matters Related to Vitamins" Prof. Kuhn summarises the researches of himself in collaboration with some of his associates. They had isolated a number of intensely coloured carotenoid acids. Of these crocetin, the pigment derived from *Crocus sativus* (saffron), contained seven conjugated double links:



Azafrin, from *Escobedia* roots, also had seven conjugated double linkings:

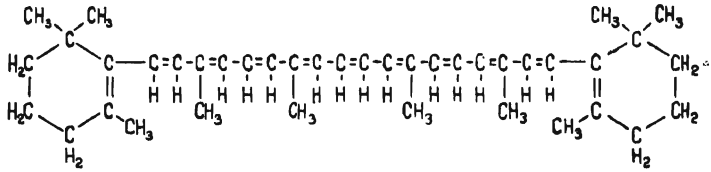


and bixin, a dicarboxylic acid from the seeds of Annato (*Bixa orellana*) had nine double linkings:

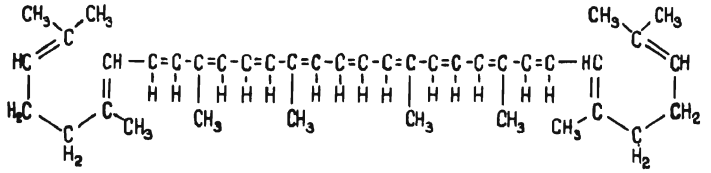


Willstätter has shown that carotene, the colouring

matter of carrots, palm oil, stinging nettle, etc., and lycopene, the colouring matter of tomatoes and the berries of a number of plants, are isomeric hydrocarbons of molecular formula $C_{40}H_{56}$. In the formulæ assigned to these compounds there are thirteen double bonds, eleven of which are conjugated double linkings, and each compound is intensely red. Carotene is known in three isomeric forms: α-carotene, β-carotene and γ-carotene. To β-carotene, the symmetrical isomer, is assigned the structure:

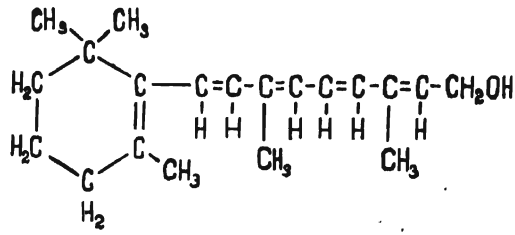


and to lycopene,



The hydroxyl-containing xanthophylls—lutein of egg-yolk and the yellow petals of various plants, fucoxanthine of brown algæ, xeaxanthine from yellow maize, flavoxanthine from *Ranunculus acer*, violxanthine from yellow pansies and horse chestnut leaves, taraxanthine from dandelions and rhodoxanthine from the seeds of yew—are also 40-carbon carotene pigments structurally related to the carotenes.

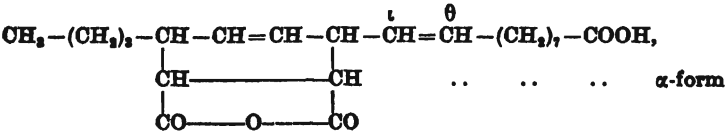
Karrer established the formula of vitamin-A, $C_{20}H_{30}O$, as

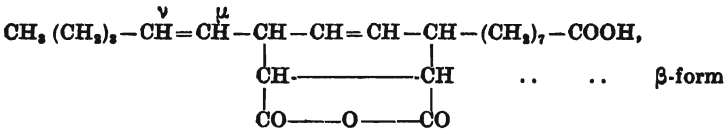


It is a pale yellow, viscous oil, and its biological activity is found to be associated with a molecular structure having a ring of the β-ionone type attached to an aliphatic chain with at least four conjugated double bonds. Prof. H. V. Euler proved that carotene promotes growth in rats receiving a diet deficient in vitamin-A, and T. Moore has shown also that carotene is converted into vitamin-A in the animal's body. The experimental results indicate that two molecules of vitamin-A are formed from one molecule of the symmetrical carotene, *viz.*, $C_{40}H_{56} + 2H_2O \rightarrow 2C_{20}H_{30}O$, the transformation apparently taking place in the liver (S. H. Tucker, *Chem. Ind.*, 1933, 967).

When carotene becomes oxidised in the atmosphere the sweet-scented violet odour of the β-ionone fragment of the molecule is apparent.

The first example of a thermo-hardening property closely connected with the structure of a chemical molecule is provided by S. Marks, R. S. Morrell and Samuels (*J. Soc. Chem. Ind., 52,* 1933, T. 130-132) who, during their research on the constitution and properties of elæostearin, the glyceride present in tung oil, found that this compound exists in two isomeric forms, *alpha* and *beta*, the α being the *cis* form and the β the *trans* form; the principal constituent is α-elæostearin, which constitutes 80 to 85% of the oil. The addition of 0·01% iodine dissolved in 2 c.c. benzene catalyses the transformation of the α completely into the β form, which is a white solid of m.p. 58°C. On splitting off the fatty acid from the glyceride the elæostearic acid was found to have a structure in which three conjugated double linkings were present in a long-chain aliphatic molecule: $CH_3\text{-}(CH_2)_3\text{-}CH = CH\text{-}CH = CH\text{-}CH = CH\text{-}(CH_2)_7\text{-}COOH$. The α and β isomers of this acid were completely separated and each converted into its maleic anhydride addition-product, the reaction being found to take place at a different position in each of the two isomers, as shown by the structures:





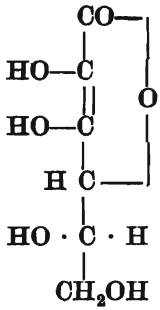
β-form

In a similar manner the maleic anhydride derivatives of the individual α and β glycerides were prepared. They consisted of syrupy masses in each case, but were found to respond differently to the action of heat. Fifty per cent. solutions in benzene of each of the products were spread on glass plates and stoved in contact with air at 100°C. for 90 mts. The β-compound produced a film which was hard, bright, colourless and resistant to the action of cold benzene, xylene, and alcohol. The α-compound did not exhibit any thermo-hardening property even after a longer period of heating.

The authors attribute this thermo-hardening characteristic to the structural arrangement present in the β-molecule, which on heating underwent both oxidation and association—a change they consider to be due to the $\mu\nu$ double bond present in the β but absent in the α structure.

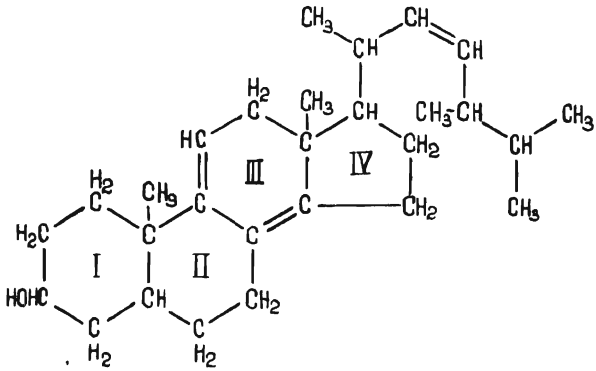
Chemical constitution appears to be very definitely related to the trypanocidal activity of aryl arsenoxides. The effectiveness of these aromatic arsenic compounds prepared and used as specifics for sleeping sickness and syphilis is shown to be due to the direct action of the trivalent arsenic in the molecule. Quinquevalent arsenic in the compounds is relatively inactive, but in contact with the parasites (trypanosomes and spirochetes) it becomes reduced to the trivalent arsenoxide structure and then exerts a positive lethal action upon them.

That the physiological activity of the vitamins is very definitely related to their chemical structures has already been indicated in the case of vitamin-A. We have another example in vitamin-C or *lævo*-ascorbic acid, which was isolated in a crystalline form from the Red Hungarian Capsicum by Szent-Györgyi. The constitution of this molecule, $C_6H_8O_6$, was first determined by Haworth, Hirst, Percival, Reynolds and Smith (*J. Chem. Soc.*, 1933, 1278) as the enolic form of 3-keto-1-gulo-furanolactone,



It was synthesised by Haworth and Hirst, and is the first vitamin to be built up by the methods of the organic chemist. It gives detectable physiological effects at a dilution of 1 in $1{\cdot}4\times10^6$.

Vitamin-D or calciferol, of molecular formula $C_{28}H_{43}OH$, is an isomer of ergosterol, a sterol that always accompanies cholesterol in the body-tissues. Ergosterol structurally is a polycyclic hydroxy-compound with a substituted aliphatic side-chain containing one double bond and with two more double bonds in one of the six carbon rings, thus:



When acted upon by ultra-violet rays ergosterol isomerises to vitamin-D, the constitution changing in regard to the position occupied by one of these double bonds. This slight constitutional change has an astounding effect upon its biological activity as the anti-rachitic vitamin which can be detected physiologically in a dilution of 1 part in 2240×10^6.

The hormone insulin is a complex protein-like compound of high molecular weight. Its chemical molecule is built up within the body presumably from the amino-acids derived from the digestion of proteins in the food.

Up to the present time 88% of the total amino-acid radicles in the insulin molecule have been recognised and their relative proportions determined. In times of normal health it is secreted by the pancreas into the blood circulation proportionately to the concentration of the blood-sugar, which it maintains at about 0·1% of glucose. Certain disorders of the pancreas result in an insufficient amount of insulin being discharged into the blood, the consequence being that the blood-sugar concentration increases and the person so affected suffers from *diabetes mellitus.*

Insulin artificially extracted, by the fine-chemical manufacturer, from the pancreas of animals slaughtered for food, and administered to affected persons in amounts sufficient to make up the deficiency, keeps countless men and women alive today. One part of insulin will account for the removal from the blood of 40,000 parts of glucose. Quantities in excess of the required amount are dangerous to life. Its physiological effects are detectable at a dilution of 1 part in 192×10^6.

Although the structure of the insulin molecule is not yet known, it is found that comparatively minor alterations in this structure produced by methylating or acetylating the molecule give derivatives which are physiologically inactive (F. H. Carr, *Chem. and Ind.*, 1934, *53*, 113).

Probably the most universally interesting examples of the influence of molecular constitution upon the physiological properties of compounds have been brought to light by those engaged in the campaign against cancer.

The magnificent work which is being carried on by the combined efforts of medical, physical, chemical and biological scientists in all parts of the civilised world to-day is undoubtedly the greatest example of scientific team-work the world has ever known. The problems to be solved are of the greatest complexity.

Reports of the central body for the British peoples, the British Empire Cancer Campaign, are eagerly read for information regarding the advances being made towards the successful control of this mysterious disease, and humanity patiently looks on waiting for the final results of the long-continued effort to crystallize out.

Australia is effectively taking her part in this co-operative research, and from the published accounts of the workers of the Cancer Research Committee of the University of Sydney we must realise how arduously new fields are being explored by them, in an endeavour to find new methods for the control and cure of the disease. An appeal to the community for finances with which to carry on the local work met with a generous response, and one feels that, should it ever be necessary to make a further appeal, so that the efficiency of our effort might be promoted thereby, public assistance of a practical character would readily be forthcoming.

The literature does not appear to find a final answer as to what cancer is. It is stated that the cells of the body, acting under some unknown influence, appear to become overactive and grow at an abnormally rapid rate until ultimately a tumor is produced. Prolonged irritation at one spot was thought to be one of the influences responsible for cancer-production, but the results of the experimental application of various kinds of chemical products of an irritating character to the skin of thousands of animals, with negative reactions so far as cancer production is concerned, indicate that some additional factor or factors must be looked for. There are many known examples of industrial skin-diseases, caused by chemical irritation, which have not led to the production of malignant tumors. Mustard gas is very irritating to the skin, so also is acridine from coal-tar, but they have not produced cancer when applied experimentally to animals. Workmen who come into contact with chromium compounds develop ulcers, but there is no evidence of cancer production from this cause. Continued application of a solution of potassium bichromate to mice is irritant, but no tumor formation has followed upon this experimental treatment.

On the other hand we now have evidence that no apparent irritating action occurs when the most potent of the recently-discovered cancer-producing compounds is applied to the skin.

The road leading to the isolation of the responsible chemical compounds in many of the known carcinogenic mixtures took many years to traverse. It had been known for a long time that many workmen in various industries

who came into contact with certain lubricating oils and coal-tar products ultimately developed cancer, but the systematic investigation of experimental cancer-production in animals did not begin until after the two Japanese investigators, Yamagiwa and Ichikawa, found, in 1915, that cancer could be produced in rabbits by periodically painting their ears with tar. Since then a great number of natural and artificially-prepared crude mixtures have been tested. Positive results were obtained with crude petroleum, paraffin oils, shale lubricating oils, hydrocarbon mixtures produced by heating acetylene or isoprene in hydrogen, and by the action of aluminium chloride upon acetylene, xylene, naphthalene and tetralin; commercial tetralin, coal-tar, pitch, and artificial tars produced from yeast, human skin, muscle and hair.

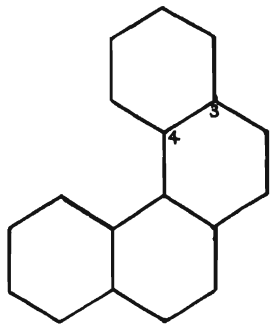
E. L. Kennaway found that these cancer-producing substances, which could only be hydrocarbons, gave a strong fluorescence which suggested that they were of a polycyclic aromatic type (*J. Path. Bact.*, 1924, *27*, 234; *Brit. Med. Jur.*, 1925, *2*, 1; *Biochem. J.*, 1930, *24*, 497).

Mayneord in 1927 was the first to apply the fluorescence spectrum in the search for carcinogenic substances, and subsequently I. Hieger found that tars and mineral oils which produced cancer also gave a specific fluorescence spectrum with bands at 4000, 4180 and 4400 Å. (*Biochem. J.*, 1930, *24*, 505).

At the Cancer Hospital Research Institute, London, J. W. Cook started in 1930 to search for an active cancer-producing hydrocarbon of known structure. With indications pointing to a polycyclic aromatic hydrocarbon of high boiling-point, Cook synthesised some 50 or more pure polycyclic hydrocarbons containing four, five, six and eight benzene rings condensed in the systems, as well as many derivatives of each, to prove the chemical structures assigned to them. This splendid chemical work occupied about four years.

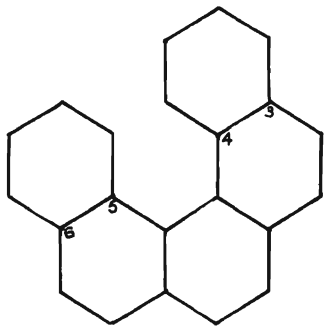
All of the pure compounds were tested experimentally upon animals by E. L. Kennaway for carcinogenic activity, whilst I. Hieger compared their fluorescence spectra with the characteristic banded spectrum of tars and other known cancer-producing mixtures. Their results are published in the Journals of the Chemical

Society and the Biochemical Journals. Of these pure hydrocarbons the compound of the simplest chemical structure that proved to be carcinogenic was that of 3:4-benz-phenanthrene,

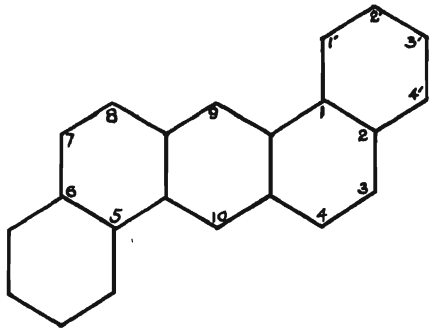


a colourless crystalline compound of m.p. 68° C., which is isomeric with chrysene of m.p. 254° C. It possesses pronounced cancer-producing activity.

The hydrocarbon phenanthrene is not carcinogenic, and the only other benzene derivative of phenanthrene that had even a feeble cancer-producing activity was the five-ring compound 3:4:5:6-dibenz-phenanthrene, crystallizing in colourless needles with a m.p. of 177-178°.

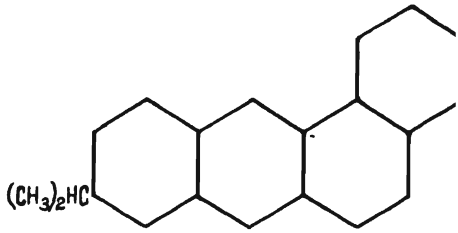


Anthracene and 1:2-benzanthracene were found to be non-carcinogenic, but by the addition of another benzene ring to the 5:6 position the colourless crystalline

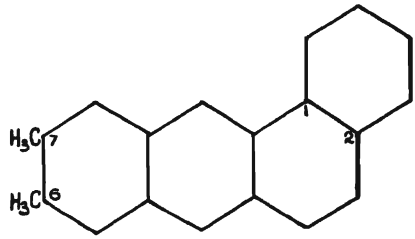


1:2:5:6-dibenzanthracene obtained proved to be the most active cancer-producing compound of all those synthesised.

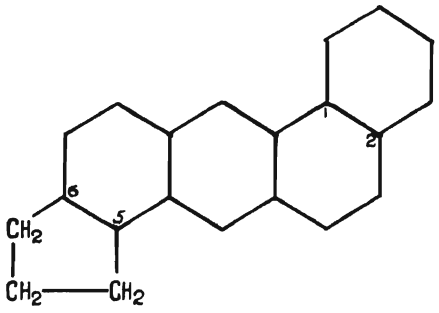
Other derivatives of 1:2-benzanthracene with proved cancer-producing activity are:



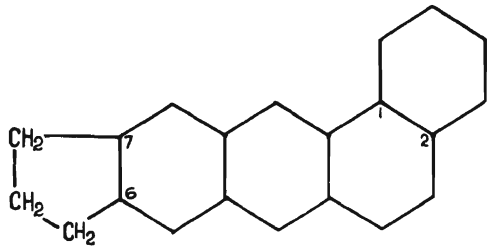
6-*iso*propyl–1:2-benzanthracene,



6:7-dimethyl–1:2-benzanthracene,



5 : 6-*cyclo*penteno–1 : 2-benzanthracene, and

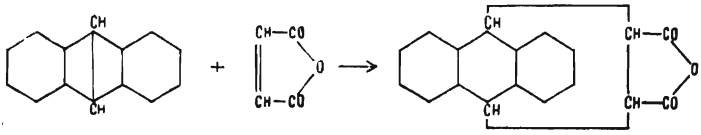


6 : 7-*cyclo*penteno–1 : 2-benzanthracene.

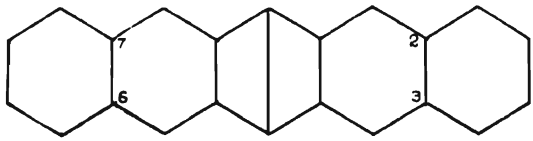
The effect of certain alterations in the constitution of 1 : 2 : 5 : 6-dibenzanthracene upon its cancer-producing properties showed that by replacing hydrogen atoms at positions 2′ or 3′ by methyl groups, at position 9 by amino or methoxy groups and at positions 9 and 10 by two benzyl groups, the carcinogenic activity of the molecule was diminished but not destroyed. Catalytic hydrogenation produced a 9 : 10 dihydro-derivative with very much reduced activity, and an octahydro-derivative, obtained by the reducing action of sodium in amyl alcohol, possessed no carcinogenic action at all.

Seeking an explanation of this carcinogenic activity, J. W. Cook (*Journ. Chem. Soc.*, 1931, 3273) examined the chemical reactivity of 1 : 2 : 5 : 6-dibenzanthracene in comparison with that of the parent substance anthracene. One sensitive test which serves to distinguish qualitatively between the different degrees of reactivity of the *meso* ring in the anthracene molecule is the readiness

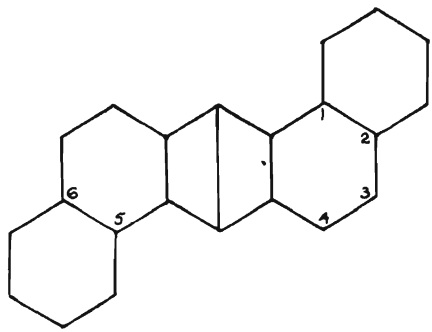
with which maleic anhydride forms an addition compound, thus:



With anthracene this reaction takes place readily, but with its benzene derivatives the position occupied by the added rings influences its reactivity considerably; for example, with two benzene rings condensed on to anthracene at the 2:3 and 6:7 positions respectively, *i.e.*, in a "linear" manner, as is the case with 2:3:6:7-dibenzanthracene,



a compound is produced which reacts instantly with maleic anhydride. On the other hand, if the added rings form an "angular" structure like that found in 1:2:5:6-dibenzanthracene,

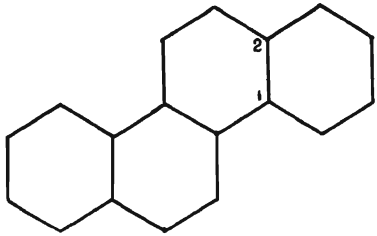


the aromatic character of the *meso* ring is strengthened and its *meso*-reactivity suppressed. 1:2:5:6 dibenzanthracene and maleic anhydride only react with great reluctance. Further experimental evidence led Cook to the conclusion that the cancer-producing property of 1:2:5:6-dibenzanthacene is not primarily due to any enhanced chemical activity of the anthracene ring-

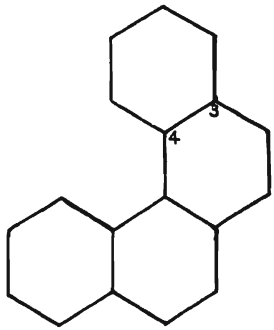
system present in the molecule, although it is still possible that the *meso*-activity is a contributory factor.

Whatever may be the ultimate explanation of the activity of these biologically-tested pure hydrocarbons, it is certainly striking that those which have been proved to be cancer-producing have their benzene rings situated structurally in "angular" attachment to the parent hydrocarbon, a condition which favours the aromatic state, diminished reactivity and increased stability. A tricyclic phenanthrene ring-system is also common to them all.

Phenanthrene does not react with maleic anhydride, and possesses very little *meso*-reactivity. Chrysene, which is a 1:2-benz-phenanthrene,



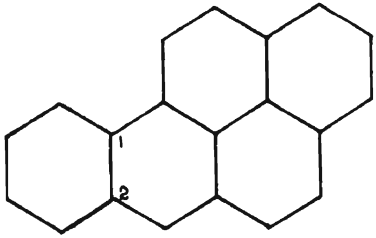
is similarly constituted; and so also is 3:4-benz-phenanthrene.



Both of these phenanthrene derivatives, however, possess pronounced cancer-producing activity.

Subsequently to the discovery of these synthetic carcinogenic compounds J. W. Cook, C. L. Hewett and I. Hieger (*Journ. Chem. Soc.*, 1933, 395) isolated the most active of the cancer-producing hydrocarbons yet

known from a medium soft pitch which had been found to be carcinogenic and which gave the characteristic fluorescence spectrum. About 7 grains of crystalline 1:2-benz-pyrene was isolated from 2 tons of this pitch. After allowing for loss in the various extractions it was estimated that the pitch contained not less than 0·003% of this substance.



A synthetic pure 1:2-benz-pyrene, like the pitch isolate, was a pale yellow crystalline substance of m.p. 175·5° to 176·5°, strongly carcinogenic and giving an enhanced fluorescence spectrum.

The discovery of the hormones which regulate the sexual functions has provided another link in the lengthening chain of evidence that may at no very distant date lead to a clearing up of the mysteries associated with cancer. Several of these hormones have been isolated and purified, and their chemical constitutions determined. As a result we now possess a knowledge of the chemical structure of molecules that can produce a condition of œstrus in the animal.

Compounds have also been isolated from a variety of natural sources such as apples, the pistils and stamens of the begonia, the female flowers of the willow, palm-kernels, germinating grain, etc., which, too, have molecular structures similar to that of the human sex-hormone œstrin, and are capable of exciting the same kind of biological activity when applied to animals.

Extracts from brown coal, bituminous coal, asphalt, petroleum, etc., are also found to produce a sex-response in animals similar to that of the follicular hormone œstrin. The presence of these substances in coal and petroleum, the metamorphosed organic material which many ages ago made up the living and growing matter of the animal and vegetable kingdom, leads one, by the

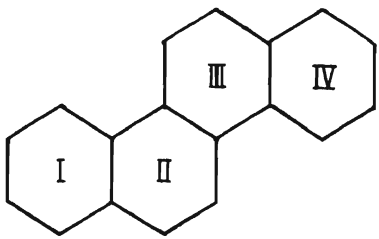
way, to suggest the possibility that the chemical structures of the active compounds present in the original organic material have survived the ravages of time and change, since after the lapse of millions of years they can, when extracted, excite in animals biological responses similar to those of the active substances which have recently been isolated from living matter.

That there is a close chemical relationship between sex-hormones, certain cancer-producing compounds, the sterols and bile acids, is indicated by a consideration of the following experimentally established facts:

(*a*) Bituminous extracts applied to animals can produce cancer and an effect similar to that of the sex-hormone.

(*b*) Three of the synthetic cancer-producing compounds—9:10 dihydroxy-9:10 di-n-butyl-9:10 dihydro-1:2:5:6 dibenzanthracene, 5:6 cyclopenteno 1:2:5:6-benz-anthracene, and 1:2-benz-pyrene—also possess œstrogenic activity (J. W. Cook and E. C. Dodds in *Nature*, 1933, *131*, 205).

(*c*) The removal of hydrogen from the molecules of cholesterol, ergosterol and cholic acid by a catalytic process produces, among other products, the carcinogenic hydrocarbon chrysene (J. W. Cook and C. L. Hewett, in *Journ. Chem. Soc.*, 1933, 1098).



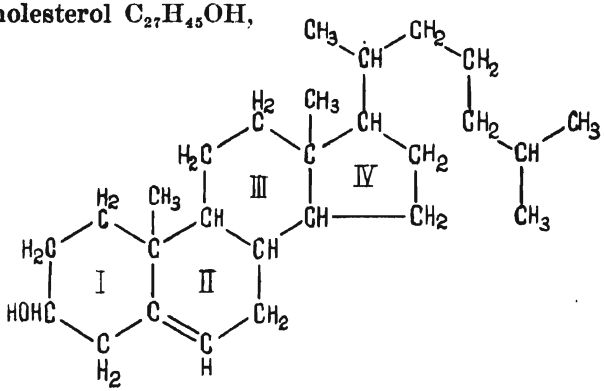
(*d*) The addition of hydrogen, catalytically, to progynon, a crystalline female sex-hormone, causes it to lose its specific biological activity (A. Butenandt: *Naturwiss.*, 1929, *17*, 879).

(*e*) The addition of eight atoms of hydrogen to 1:2:5:6-dibenzanthracene destroys its cancer-producing activity.

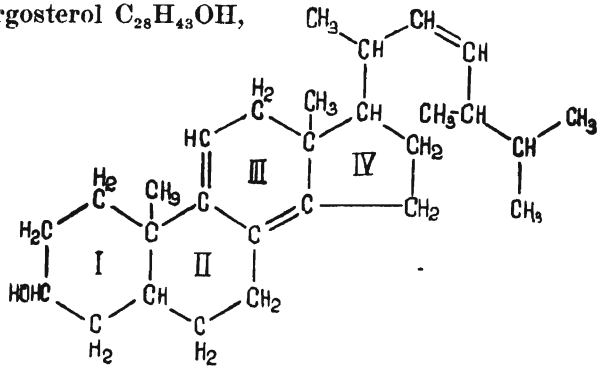
According to O. Rosenheim and H. King (*Chem. and Ind.*, 1932, 955; 1934, 91), recent investigations show the

molecules of the sterols, bile acids and œstriol to possess the following similar chemical structures:

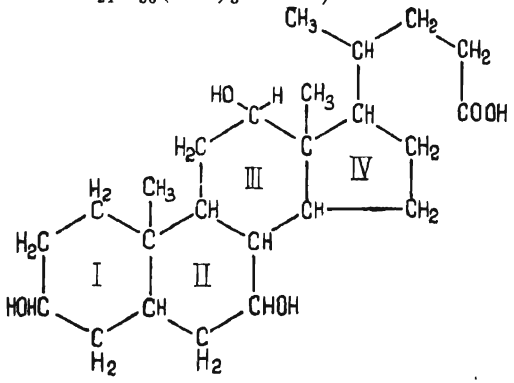
Cholesterol $C_{27}H_{45}OH$,



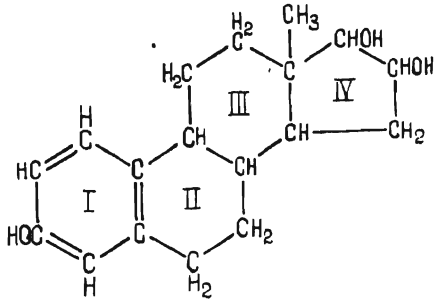
Ergosterol $C_{28}H_{43}OH$,



Cholic Acid $C_{24}H_{36}(OH)_3COOH$,



Trihydroxy œstrin œstriol (follicular hormone hydrate), $C_{18}H_{21}(OH)_3$,



Each of these structural arrangements includes a three-ring system of the phenanthrene type, which is common to the cancer-producing hydrocarbons, and also a four-ring system structurally related to the carcinogenic hydrocarbon chrysene. Transformation to chrysene, however, involves removal of oxygen, modification of the hydrogen content and conversion of ring IV into a six-membered ring, a change which is considerable, but one which has been accomplished in the laboratory. The possibility of a change of this kind taking place in the body is probably a remote one under normal conditions, but it is a possibility to be considered if conditions are present which may favour it.

There is no evidence at present that carcinogenic substances are formed from œstrin or its derivatives in the animal body.

For the performance of the multitude of biological functions which operate to carry on the life-processes water is an essential medium. Approximately 65 per cent. of the body-weight is water. Under favourable conditions water will give up its oxygen or hydrogen to bring about oxidation or reduction.

A normal constituent of living tissues, the sulphur-containing tripeptide glutathione, isolated by Sir Frederick Hopkins in 1921, undergoes reversible oxidation and reduction in the cells, and acts as a purveyor of hydrogen and oxygen where these elements are required.

It may be surmised that an active substance such as glutathione, suitably catalysed or activated in some way,

may, in the presence of water, cause the hydrogenation of substances possessing appropriate chemical structures, like those assigned to the sterols and bile acid, and change them into structural arrangements which possess cancer-producing activity. Changes of this kind have already been carried out artificially with these substances in the laboratory.

It is noteworthy in this connection to mention that Carl Voegtlin and Dr. Thompson reported at the Second Annual Cancer Conference at Canberra (26/3/31) that they had found considerable amounts of glutathione in malignant tumors. Changes of the nature indicated cannot be normal ones, as the precursors of the potentially dangerous substances are ordinary constituents of the tissues, but, if it be supposed that under some extraordinary circumstances suitable activators become available, then the necessary sequence of reactions may occur and produce, from these normal constituents, compounds which have proved carcinogenic activity. In the research papers published from time to time by Dr. G. Harker one gathers that he and Dr. H. G. Chapman are searching for some such activating substance.

Though not a parallel example one may quote the cyanogenic glucoside, which is apparently quite harmless until it makes contact with an activator such as a suitable enzyme, in the presence of water; the molecule then becomes broken up into its constituent parts, and lethal effects follow upon such a chemical change, as one of the constituents set free is the powerful poison, prussic acid.

We have become accustomed to regard water as a very simple compound of molecular weight 18, built up of two hydrogen atoms of atomic weight 1, united to the atom of oxygen. The recent discovery by Urey, Brickwedde and Murphy of an isotope of hydrogen, of atomic weight 2, for which they suggested the name *deuterium* (provisionally named *diplogen* by Lord Rutherford), and which is found to be present in ordinary hydrogen to the extent of about 1 part in 4,000, opens up new and vast problems with regard to all the hydrogen-containing compounds, inclusive of water and the other compounds mentioned in this address.

Several new compounds containing this heavy hydrogen atom have been found to occur side by side with the normal hydrogen compounds. A new form of water of molecular weight 20 has been found to exist in ordinary water.

G. N. Lewis and R. T. MacDonald provisionally estimate the concentration of the heavy hydrogen isotope in ordinary water to be about 1 in 6,500. They isolated a small quantity of this heavy water, H_2^2O or D_2O, which contained not more than 0·01% of ordinary hydrogen, and found that it had a freezing-point of + 3·8°, a boiling-point of 101·42° and a density of 1·1056, and differed in other physical properties from ordinary water.

Biologically the effect of this heavy water is different from that of ordinary water. G. N. Lewis (*J. Amer. Chem. Soc.*, 1933, *55*, 3503), found that tobacco-seeds will not germinate in it. It is also stated that tadpoles cannot live in it.

The probable presence of heavy water in the body-fluids thus adds an unexpected factor which undoubtedly must be taken into consideration, with other factors, in regard to the causation of cancer. Its significance, together with that of diplogen, the hydrogen isotope, must be investigated, particularly as to a possible share in influencing change in chemical structure of the molecules of some of the normal body constituents, with the possible production of compounds structurally similar to those which have been found to produce abnormal physiological effects, and also in view of the remarkable fact that, so far, the only known pure carcinogenic compounds are hydrocarbons.

With a knowledge of the chemical structures responsible for cancer-production it should now be possible to build up a chemical structure which will prove equally potent as an anti-carcinogenic agent. Many substances have been tested with more or less promising results. Some of these have been prepared from natural sources, whilst others are chemical compounds of known constitution. The compound dichloroethyl sulphide or mustard gas $Cl{-}CH_2{-}CH_2\diagdown S\diagup CH_2{-}CH_2{-}Cl$ has given the best results, so far, in retarding the growth of tumours experimentally produced by tar or by the cancer-producing hydrocarbon 1 : 2 : 5 : 6 - dibenzanthracene.

Mustard gas is a reactive compound, but unfortunately it is also very irritating to the skin.

The possibility that the inhibiting effect of mustard gas might be due to a chemical reaction taking place between it and the carcinogenic substance, whereby this substance was rendered ineffective through a change in composition, has been anticipated by the workers engaged in this research, who carried out a number of the experiments in such a manner that this possibility was precluded. Its action appears to be a more direct one, for in the 9th Annual Report of the British Empire Cancer Campaign it is suggested that mustard gas exerts a biological effect upon the body cells in some curious or unknown manner so that the effects of the cancer-producing substance are counteracted.

With the known chemical structure of mustard gas as a clue the synthesis of a number of compounds of like constitution might be anticipated. To find that one or more of such compounds possessed increased anti-carcinogenic characters, and at the same time had decreased or totally eliminated irritant effects, would provide another step forward in this campaign of mercy.

The universal interest of cancer research and the contributions being made by chemistry call for a further concluding remark with regard to the necessity which apparently exists for a reliable blood-test for the condition of malignancy. According to the 10th Annual Report of the British Empire Cancer Campaign there is at present no reliable test available. As a preliminary step it would be of great value to discover a reliable and very sensitive physical or chemical test which is definitely characteristic for the chemical structures which are at present known to be cancer-producing. The fluorescent spectrum of these compounds is of great value in respect to their detection, but, as the researches of Kennaway and Hieger show, this method has limitations. They find that commercial tetralin will produce experimental cancers in mice, but it is non-fluorescent, and on the other hand that tars produced from oleic acid and benzyl oleate give the characteristic fluorescence spectrum but do not produce cancer.

At the conclusion of this incomplete review of some of the recently-announced evidence of the importance and

significance of chemical structure, I should like briefly to emphasize the part played by chemistry, the eldest among the sciences, in the solution of the problems that confront the world from day to day. Many of these problems require the close co-operation of most branches of science, but they also depend largely upon the continued advances which are being made in chemistry for their satisfactory solution. One example may be mentioned, namely, the partnership between chemistry and medical science, which has been responsible for so many of the recent advances made in medicine. Newly-discovered substances, in great variety, possessing valuable medicinal and physiological properties, are handed over to the organic chemist for isolation, purification, analysis and identification of the active constituents. By skilful labour the chemical constitutions of these active substances are worked out and methods for their synthesis are perfected in the laboratory. The problems, so far solved, are then passed on to the chemical staff of the fine-chemical manufacturer, who in turn adapts the laboratory processes to production on the commercial scale; after purification and standardisation the pure finished article is placed at the disposal of the medical practitioner to take up his phase of the work.

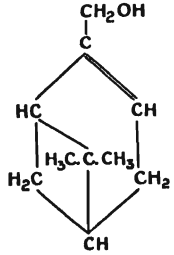
Finally it appears that the contributions of organic chemistry, in co-operation with the other branches of science, towards the solution of the cancer problem are likely to prove of the greatest importance. These contributions also provide further evidence of the intimate relationship which exists between a particular molecular constitution and its specific physiological effect.

THE IDENTITY OF DARWINOL WITH *d*-MYRTENOL.

By A. R. PENFOLD, F.A.C.I.,
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G. R. RAMAGE, M.Sc., Ph.D.,
Assistant Lecturer in Chemistry, University College of North Wales, Bangor,
and J. L. SIMONSEN, D.Sc., F.I.C., F.R.S.,
Professor of Chemistry, University College of North Wales, Bangor.

(*Read before the Royal Society of New South Wales, June 6, 1934.*)

Some years ago one of us (Penfold, *This Journal*, 1923, *57*, 237) separated from the essential oil present in the shrub *Darwinia grandiflora* an alcohol, $C_{10}H_{18}O$, for which the name *darwinol* was tentatively suggested, and which was characterised by the preparation of a crystalline acid phthalate and α-naphthylurethane. Later the same alcohol was shown to occur in the oils from the "Green Leaf" of *Leptospermum lanigerum* (*ibid.*, 1926, *60*, 8), and the shrub *Eriostemon coxii* (*ibid.*, 331). A consideration of the physical constants of this alcohol, together with the melting-point of the acid phthalate, suggested that it was probably identical with the dicyclic



alcohol *d*-myrtenol (I), $C_{10}H_{16}O$, isolated by Semmler (*Ber.*, 1907, *40*, 1363) from myrtle oil. The reactions of this alcohol were studied later by Rupe and his collaborators (*Annalen*, 1915, *409*, 344; 1927, *459*, 171).

Through the kindness of Professor H. Rupe, who generously presented us with a quantity of myrtle oil, we have now been able to prove conclusively that

darwinol is actually identical with *d*-myrtenol, as will be seen from the data recorded in the table. The name *darwinol* can therefore be removed from the literature.

Comparison of Properties of d-*Myrtenol and "Darwinol."*

	d-Myrtenol.	"Darwinol."
b.p.	218°/771 mm.; 103–104°/11 mm.	218–219°/771 mm.; 104–105°/11 mm.
$d^{20°}$	0·9763*	$d^{15°}_{15°}$ 0·981
$n_D^{20°}$	1·49668*	1·4951
α_D	+45·45°*	+45°
Acid phthalate, m.p. ..	114–115°*; 111–112°	111–113°
Phenylurethane, m.p. ..	58–59°	58–59°
α-Naphthylurethane, m.p.	92–93°	92–93°

*Semmler, *Ber.*, 1907, *40*, 1363.

By the oxidation of both *d*-myrtenol and "darwinol" with chromic acid *d*-myrtenal was obtained in poor yield and was characterised by the preparation of the *semicarbazone*, decomp. 220-221°, and the *phenylsemicarbazone*, decomp. 180°. Semmler recorded a melting-point *ca.* 230° for myrtenal semicarbazone, but he did not recrystallise his product, and this value is undoubtedly too high unless he obtained a stereoisomeric form.

Experimental.

The *d*-myrtenol and "darwinol" used in these experiments were prepared by the hydrolysis of the carefully recrystallised acid phthalates. Titration with camphoric acid peracid (Miles and McAlevy, *Journ. Amer. Chem. Soc.*, 1933, *55*, 349) in chloroform solution showed, as was to be anticipated, the presence of only one ethylenic linkage. In agreement with Semmler, the acid, probably *d*-pinic acid, obtained by oxidation of the alcohol with potassium permanganate in acetone solution, could not be obtained crystalline.

The derivatives described below were in all cases prepared from both *d*-myrtenol and "darwinol", the melting-points and mixed melting-points being identical.

The *acid phthalate* after three crystallisations from ligroin (100–120°) was obtained in prisms, m.p. 111–113°.

3·38 mg. gave 8·89 mg. CO_2 and 2·12 mg. H_2O. C = 71·7, H = 7·0.

$C_{18}H_{20}O_4$ requires C =72·0, H = 6·7 per cent.

d-*Myrtenol phenylurethane.*—A mixture of equal volumes of myrtenol and phenyl*iso*cyanate was allowed to stand at room temperature for three days, the viscid oil was dissolved in ligroin (40–60°) and filtered from diphenylurea, and after removal of the solvent the liquid phenylurethane was kept in the ice-box for two months, when it crystallised. A crystal nucleus being available, other preparations of the urethane crystallised immediately on inoculation. The phenylurethane separated from ligroin (40–60°) in large prisms, m.p. 58–59°.

5·27 mg. gave 0·2548 cc. N_2 at 24° and 761 mm. N = 5·5.

$C_{17}H_{21}O_2N$ requires N = 5·2 per cent.

The *α-naphthylurethane* prepared in a similar manner solidified at once on scratching. It was somewhat sparingly soluble in ligroin (60–80°) and crystallised from methyl alcohol in well-formed needles, m.p. 92–93°.

3·89 mg. gave 11·25 mg. CO_2 and 2·67 mg. H_2O. C = 78·9, H = 7·6.

$C_{21}H_{23}O_2N$ requires C = 78·5, H = 7·2 per cent.

d-*Myrtenol.*—*d*-myrtenol and "darwinol" were oxidised to the aldehyde under the conditions used by Semmler (*Ber.*, 1907, *40*, 1363), the yield in each case being poor. The semicarbazone crystallised from methyl alcohol in fine needles, decomp. 220–221°.

3·72 mg. gave 0·6487 cc. N_2 at 20° and 769 mm. N = 20·6.

$C_{11}H_{17}ON_3$ requires N = 20·3 per cent.

The *phenylsemicarbazone* crystallised from methyl alcohol in prismatic needles, decomp. 180°.

3·785 mg. gave 0·4919 cc. N_2 at 21° and 769 mm. N = 15·2.

$C_{17}H_{21}ON_3$ requires N = 14·8 per cent.

The authors are indebted to the Government Grants Committee of the Royal Society of London and to Imperial Chemical Industries Limited for grants which have in part defrayed the cost of this investigation.

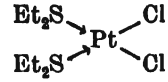
SOME TETRA-COVALENT COMPOUNDS OF PLATINUM WITH TERTIARY ARSINES.

By G. J. Burrows, B.Sc.,
and R. H. Parker, M.Sc.

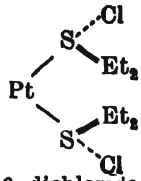
(Read before the Royal Society of New South Wales, August 1, 1934.)

Introduction.

Tetra-covalent platinous compounds have attracted considerable attention during recent years on account of the isomerism almost invariably observed in this type of derivative. The explanation originally advanced by Werner, that the occurrence of isomers in the case of diammine platinous chloride is due to the planar nature of the molecule permitting *cis* and *trans* arrangements of the chlorine atoms and ammonia groups around the platinum, was later challenged by Reihlen and Nestle (*Ann.*, 1926, *447*, 211, and *448*, 1312). From molecular weight determinations (in liquid ammonia) these authors were led to conclude that one "isomer" was in reality a polymer of the other. Werner's original view was still later supported by Hantzsch (*Ber.*, 1926, *59*, [B] 2761), who found that the molecular weights of the two bis-pyridine platinous chlorides in molten phenol were practically identical. More recently Angell, Drew and Wardlaw (*Journ. Chem. Soc.*, 1930, 349), in discussing the isomeric bis-diethyl sulphide platinous halides, advanced the view that the differences observed in the properties of the two forms were capable of a quite different interpretation. They assigned to the chlorides, for example, the formulæ

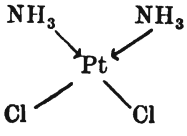


α dichloride.

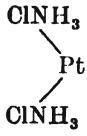


β dichloride.

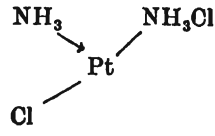
In a subsequent paper (*Journ. Chem. Soc.*, 1932, 988) Drew, Pinkard, Wardlaw and Cox recorded the isolation of a third isomer of diammine platinous chloride, and assigned the following formulæ to the three isomers:



α



β



γ

Further evidence of the coplanar arrangement was supplied by Cox (*Journ. Chem. Soc.*, 1931, 1089) from X-ray analysis of tetrammine platinous chloride. On the other hand, the resolution into optical enantiomers by Reihlen and Huhn (*Ann.*, 1932, *499*, 144) of bis-isobutylene diammine platinous chloride and of bis-2-amino-methyl-3-methyl-4-ethyl quinoline platinous chloride cannot be reconciled with a planar arrangement, and we are forced to believe that, in these compounds at least, the arrangement is tetrahedral.

Still more recently (*Journ. Chem. Soc.*, 1934, 219) Drew and Head repeated the preparation of isobutylene diammine platinous chloride, and stated that their product was a mixture of two isomers with distinctly different solubilities in alcohol, a result to be expected for a coplanar arrangement of the two isobutylene diammine groups co-ordinated with the platinum. It is quite obvious that our knowledge of the stereochemistry of these compounds is still very obscure.

In view of the remarkable stability of the complex ions formed by silver with tertiary arsines (Burrows and Parker, *Journ. Amer. Chem. Soc.*, 1933, *55*, 4133), it was decided to prepare and examine the corresponding platinous compounds. Cahours and Gal (*Journ. Prakt. Chem.*, 1870, *110*, 460; *Compt. Rend.*, 1870, *70*, 897, 1380, and *71*, 208) described compounds formed by trimethyl arsine and triethyl arsine with salts of platinum, palladium and gold. In particular they recorded the occurrence of isomeric bis-trimethyl platinous chlorides and bis-triethyl platinous chlorides having different solubilities in ether. Mann and Pope (*Journ. Chem. Soc.*, 1922, *121*, 1758) described platinum bis-chlorovinyl bis-

$\beta\beta'\beta''$-trichloro trivinyl arsine, which they apparently obtained in one form only.

Phenyl dimethyl arsine and diphenyl methyl arsine were selected for this investigation in view of their comparative stability and the ease of obtaining them in a pure condition. They were found to react readily with chloroplatinic acid* or with chloroplatinous acid, yielding fine crystalline compounds having characteristic melting-points. They are very soluble in cold chloroform, are appreciably soluble in acetone, and can be recrystallised from hot toluene. They are insoluble in methyl alcohol or ethyl alcohol and are regarded by us as being non-polar compounds of the type R_2PtX_2, in which X is a molecule of the arsine. Quite early in the investigation we were led to believe that our products were mixtures of two forms—slight variations in colour were observed after crystallising from different solvents —but it was not found possible to effect a separation by employing different solvents. In this respect our experience was quite different from that of Cahours and Gal, who found that one form only of bis-triethyl arsine platinous chloride was soluble in ether or alcohol. Furthermore, only slight differences in melting-points were observed after recrystallising the various compounds from different solvents. It was observed, however, that where two different crops of crystals of any one product were obtained, one being paler than the other, the paler substance on heating appeared to change into the darker just before melting. Also, the final products appeared to be the same when prepared from the arsine by treatment with either chloroplatinic acid, potassium chloroplatinite or chloroplatinous acid. More definite evidence of the existence of isomers was obtained by examining the compounds many months after their preparation. A specimen of bis-diphenyl methyl arsine platinous dichloride, for example, melted at 214°C., appeared to be homogeneous when first prepared, and had a very pale yellow colour. The same specimen after eleven months appeared to be a mixture of two substances, one of which was bright yellow and the other almost colour-

* Portion of the arsine first reduces the chloroplatinic acid to the platinous condition; unchanged arsine then combines with the platinous chloride.

less. This product had originally been crystallised from hot toluene, in which solvent it was quite soluble. On heating the compound in toluene, eleven months after preparation, portion only was found to be soluble, and it was found possible to effect a separation with this solvent. Repeated extraction with toluene yielded:

(*a*) a solution from which a yellow crystalline form was obtained melting at 214°; and

(*b*) a residue which crystallised from hot chloroform in pale-yellow needles, melting at 218°C.

Another specimen of bis-diphenyl methyl arsine platinous dichloride was recrystallised from toluene, melting at 214°C. It was then carefully heated just to its melting-point in a tube immersed in sulphuric acid. It resolidified on cooling to a yellow mass which was almost insoluble in toluene, but readily soluble in chloroform; the pale yellow product from this solvent melted at 218°C. After crystallisation from chloroform the compound was insoluble in toluene. No significance is attached to the difference in melting-points, but the behaviour towards toluene is considered to indicate that these compounds are capable of existence in isomeric forms. When first prepared the compounds are soluble in toluene, but they appear to change, slowly at the ordinary temperature and rapidly at the melting-point, into a form which is practically insoluble in that solvent. This behaviour has been observed in the case of the three compounds we have prepared, namely, bis-phenyl dimethyl arsine platinous chloride, bis-diphenyl methyl arsine platinous chloride, and bis-phenyl dimethyl arsine platinous bromide.

Unfortunately we have been unable to obtain accurate results for molecular weight determinations owing to the comparatively low solubilities of these large molecules in suitable solvents. The behaviour towards heat is not incompatible with Reihlen's results for bis-pyridine platinous chloride. It is quite possible that one form may be a polymer of the other and may depolymerise on long standing or on heating. Further work is at present in progress with other arsines, and it is hoped that by isolating more soluble compounds it will be possible to make accurate determinations of the molecular weights.

Experimental.

Bis-diphenyl Methyl Arsine Platinous Chloride $(Ph_2MeAs)_2PtCl_2$.

This compound was prepared from chloroplatinic acid, from chloroplatinous acid and from potassium chloroplatinite.

(*a*) Platinum (1 atom) was converted to chloroplatinic acid in the usual way, and to a concentrated aqueous solution an equal volume of alcohol was added. Diphenyl methyl arsine (3 molecules), dissolved in alcohol, was then added dropwise to this solution with vigorous stirring. The brown solution was then heated on the water-bath until the colour had almost disappeared. On standing a yellowish hard mass separated, and this was extracted with hot toluene, whereby the compound was obtained in short, thick, pale-yellow prisms melting at 207°C. A further extraction yielded a second crop of crystals of the same colour melting at 215°C., the total yield being 70 per cent. The extra molecule of arsine is used in reducing the chloroplatinic acid to platinous chloride. Bis-diphenyl methyl arsine platinous chloride is insoluble in water, ethyl and methyl alcohols, ether ligroin and ethyl acetate. It is only slightly soluble in hot benzene. It may be recrystallised from acetone, acetic acid, toluene or chloroform, being extremely soluble in the last. The melting-points after recrystallisation from acetone, chloroform, toluene and acetic acid were found to be 212°, 213°, 214° and 211°C. respectively.

Found Pt 25·8, Cl 9·2, As 19·6 per cent.

$C_{26}H_{26}As_2Cl_2Pt$ requires Pt 25·9, Cl 9·4, As 19·9 per cent.

(*b*) Platinous chloride (1 atom), prepared according to the method of Nilson (*Journ. Prakt. Chem.*, 1877, 123), was treated in aqueous alcohol with diphenyl methyl arsine (2 molecules). The platinum chloride, however, did not dissolve, and was recovered and converted into chloroplatinous acid with warm hydrochloric acid. An alcoholic solution of the arsine (2 molecules) was then added with stirring, and on warming a clear solution was obtained from which the compound separated in almost colourless needles on cooling, the yield being 80 per cent. This compound melted at 213°C. and resembled

that described under (*a*) as regards its solubility in different liquids.

(*c*) Potassium chloroplatinite (1 molecule), prepared from chloroplatinate and potassium oxalate and dissolved in 5 times its weight of hot water, was added to an alcoholic solution of diphenyl methyl arsine with continuous stirring. After some minutes a white precipitate began to separate. The stirring was continued for about two hours, when the precipitate was separated, washed with alcohol and ether and recrystallised from hot toluene. The product, pale-yellow needles, melted at 214°C. and was found to contain 25·6 per cent. of platinum. It was identical with the product obtained by the other methods.

As Angell, Drew and Wardlaw (*Journ. Chem. Soc.*, 1930, 349) had found that only one form of bis-diethyl sulphide platinous chloride reacted readily with moist silver oxide, it was decided to apply the same treatment to the arsine derivative. For this purpose an excess of freshly-prepared moist silver oxide was rubbed with the arsine in a glass mortar for about twenty minutes, after which hot water was added and the resulting suspension filtered. The filtrate on treatment with hydrochloric acid remained clear, but on evaporation yielded a very small amount of yellowish solid which on recrystallisation from chloroform melted at 214°C. The residue from the above filtration was repeatedly extracted with small quantities of absolute alcohol, and the extract on evaporation *in vacuo* over phosphorus pentoxide yielded a product melting at 200°C. This was not analysed, but was considered to be bis-diphenyl methyl arsine platinous hydroxide $(Ph_2MeAs)_2Pt(OH)_2$. It was converted to the chloride by treatment with hydrochloric acid, and this product after drying and recrystallising from chloroform melted at 214°C.

Reference has already been made in the introduction to the change which takes place in the compound after a long period at the ordinary temperature or on melting. Heating to the melting-point converts the compound into a form which, although no longer soluble in toluene, is readily soluble in chloroform and can be recrystallised from this solvent in the form of pale-yellow needles melting at 218°C. and containing 25·7 per cent. of

platinum. A specimen, originally crystallised from toluene, after eleven months was found to have changed into a mixture, portion of which was soluble in toluene from which it crystallised in yellow needles (m.p. 214°C., Pt 25·6 per cent., As 19·5 per cent). The remaining portion, insoluble in toluene, was crystallised from chloroform, also in yellow needles (m.p. 218°C., Pt 25·6 per cent., As 19·5 per cent.).

Bis-phenyl Dimethyl Arsine Platinous Chloride $(PhMe_2As)_2PtCl_2$.

This compound was prepared from phenyl dimethyl arsine and either chloroplatinic acid or chloroplatinous acid in the same manner as the previously-mentioned compound. In the preparation from chloroplatinic acid the alcoholic solution obtained from the arsine and the acid was treated with ether to precipitate the phenyl dimethyl arsine hydroxy chloride formed in accordance with the equation:

$$PhMe_2As + H_2PtCl_6 + H_2O = PtCl_2 + 3HCl + PhMeAs{<}^{OH}_{Cl}$$

This separated in white needles (m.p. 167°C.). It is a coincidence that this compound has the same melting-point as the platinum derivative of the arsine. The latter was obtained by concentrating the filtrate from the above, and separated in beautiful yellowish-green plates melting at 167°C. It is soluble in toluene, chloroform or acetone, yielding products from these solvents having the same melting-point and the same colour.

Found Pt 31·0, Cl 11·2, As 23·5 per cent.

$C_{16}H_{22}As_2Cl_2Pt$ requires Pt 31·0, Cl 11·3, As 23·8 per cent.

The compound obtained from chloroplatinous acid was identical with the above. Treatment with moist silver oxide yields a hydroxide which on extracting with hot water dissolves only to a very slight extent, yielding with hydrochloric acid a chloride melting at 166°C. The residue on treatment with alcohol gives a solution from which the chloride (m.p. 167°C.) is precipitated by the addition of hydrochloric acid. Bis-phenyl dimethyl arsine platinous chloride changes after some months, yielding a mixture of two forms, one soluble in toluene

(m.p. 166°C.; Pt = 30·9 per cent.), the other insoluble in toluene but soluble in chloroform (m.p. 165°C.; Pt = 30·9 per cent.). Also on heating to the melting-point the form originaly soluble in toluene becomes insoluble, but is readily soluble in chloroform (m.p. 166°C.; Pt = 30·9 per cent.).

Bis-diphenyl Methyl Arsine Platinous Bromide $(Ph_2AsMe)_2PtBr_2$.

This was prepared from bromoplatinic acid and excess of the arsine in alcoholic solution. The solution was heated on the water-bath for several hours, the colour becoming considerably brighter, and a yellow crystalline precipitate separated. This was removed by filtration, washed with alcohol and ether and air-dried. The compound resembled the corresponding chloride in solubilities. Portion was recrystallised from chloroform in yellow needles melting at 196°C.

Found Pt 23·0, Br 18·8 per cent.*

$C_{26}H_{26}As_2Br_2Pt$ requires Pt 23·1, Br 19·0 per cent.

A sample of this product from chloroform was found to change on prolonged exposure to light to a reddish product melting at 144°C. and containing 22·1 per cent. of platinum. This has not been investigated further. Another portion was recrystallised from toluene in yellow plates melting at 193°C. Found Pt 23·3, Br. 18·7 per cent. On heating to the melting-point this compound was rendered insoluble in toluene, although it could be recrystallised from chloroform, yielding a compound containing 23·1 per cent. platinum and melting at 196°C.

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* In the analysis platinum was estimated by ignition. For the estimation of bromine, 0·1 gramme of the compound was heated with a few c.c. of concentrated nitric acid in the presence of silver nitrate, giving silver bromide and platinum, the latter being removed by filtration. The filtrate was treated with zinc dust and then with a little nitric acid to dissolve any silver precipitated. The resulting platinum was added to the first residue and, after weighing, the amount of platinum was subtracted, giving the silver bromide.

AN X-RAY STUDY OF OPALS.

By F. P. Dwyer, M.Sc.
and D. P. Mellor, M.Sc.

(*Read before the Royal Society of New South Wales, August 1, 1934.*)

The presence of crystalline material in opals has been noted by Levin and Ott (*J. Am. Chem. Soc.*, 1932, *54*, 828), (*Z. Kris.*, 1933, *85*, 305), and ourselves (*This Journal*, 1932, *66*, 378). Collected data from all three sources indicate that opals may contain crystallites of either β- (high) cristobalite, α- (low) cristobalite, or α- (low) quartz.

The presence in opals of β-cristobalite, which has presumably existed through geological ages, is so interesting as to warrant a study of the manner of its origin. In this connexion the Australian opals afford excellent material, since it is possible to obtain specimens which have been formed under the most diverse geological conditions.* Of particular interest are those opals formed in association with groundwaters, as at Lightning Ridge, Coober Pedy and White Cliffs. This type of occurrence is probably unique.

Experimental Results.

Employing the usual Debye-Scherrer technique, the authors obtained powder photographs of two types:

(1) Those showing the lines of β-cristobalite or α-quartz, and

(2) Those showing a broad band in the position of the most intense line of either α- or β-cristobalite.

The demarcation between the two types of pattern was not sharp. There occurred a gradual variation from lines of excellent sharpness to the broad lines characteristic of colloidal crystal dimensions, and finally to a broad diffuse band.

* The authors wish to thank Professor W. R. Browne for geological data, and also Dr. Ida A. Brown and the Curator of the Mining Museum, Mr. M. Morrison, for specimens of opal.

TABLE I.

	No.	Locality.	Pattern.	Matrix.	Probable Mode of Formation.
(*a*)	1	Querétaro, Mexico	β-Cristobalite	Rhyolite (?)	Hot magmatic waters
	2	Tintenbar, N.S.W.	,,	Basalt	,,
	3	Bergalia, N.S.W.	,,	,,	,,
	4	Tooraweenah, N.S.W.	α-Quartz	Trachyte	,,
	5	Rocky Bridge, N.S.W.	β-Cristobalite	Basalt	,,
(*b*)	6	Lismore, N.S.W.	,,	Rocks under basalt	,,
	7	Ballina, N.S.W.	,,	,,	,,
(*c*)	8	Coober Pedy, S.A.	Broad Band	Sedimentary, shales and sandstones	Groundwaters
	9	Lightning Ridge, N.S.W.	,,		,,
	10	White Cliffs, N.S.W.	,,		,,

The results on all opals examined are summarized in Table I, the specimens being placed in descending order of crystal grain-size. Within very approximate limits, specimens 1 to 5 contain crystallites of average dimensions 10^{-4} to 10^{-5} cm. on edge, numbers 6 and 7 about 10^{-6} cm., while in numbers 8 to 10 the grain-size is below 10^{-6} cm.

Further, it is obvious that those opals which have been intimately associated with lava-flows all show sharp diffraction lines of either β-cristobalite or α-quartz. The non-crystallised opals have all been characterised by absence of exposure to heat during their geological history. Different specimens taken from the same field gave the same pattern irrespective of the outward characteristics of the specimen, indicating that a particular pattern is characteristic of a particular field, and hence of its geological history.

As indicated previously (*This Journal*, 1933, *67*, 420), attempts made in the laboratory to imitate this natural process of crystallisation of β-cristobalite were entirely successful. Opals of class (*c*) of Table I readily crystallised at all temperatures between 710°C. and 1000°C. on treatment with fluxes to give sharp patterns characteristic of (*a*).

Discussion.

On the basis of the above studies it seems fairly well established that the presence of crystals of β-cristobalite or α-quartz in opals of such a size as to give well-defined X-ray diffraction patterns depends on their thermal history. It is considered that silica in the gel from which opals are formed possesses a pseudo-crystalline structure —most probably that of α-cristobalite. In the presence of, or by the agency of, hot magmatic waters, an inversion of the α-cristobalite to the β-form, followed by simple crystal growth, has occurred. Factors such as time of contact with the magmatic waters and variations in their temperature would account for the wide range of variation in grain-size.

The persistence of β-cristobalite in opals seems to be intimately connected, as we have suggested in a previous paper, with its low temperature of crystallisation, and

not, as claimed by Levin and Ott,* a result of simple physical strains. This is borne out by the persistence of laboratory specimens of β-cristobalite. β-cristobalite prepared from opals by fluxing at 800°C. persisted up to six months, while specimens prepared from the same opals at 1500°C. inverted promptly on cooling. In all cases the persistence became more marked as the temperature of fluxing was lowered. It is considered therefore quite feasible that the cristobalite produced at the relatively low temperatures of magmatic waters, often as low as 200°C., should show great stability.

The occurrence of quartz in opals can be accounted for on two explanations: (1) greater length of contact with the magmatic waters, in which case the unstable cristobalite phase would pass to the stable quartz phase, or (2) slight alkalinity of the waters. In this latter regard G. Spezia (*Journ. Chem. Soc.*, *76* (2), 300), has observed that when opal is heated with alkaline silicates, it becomes a mass of quartz crystals.

Summary.

(1) The presence of cristobalite in opals has been correlated with their geological history.

(2) The growth of β-cristobalite in non-crystalline opals can be induced by heating with appropriate fluxes at all temperatures between 710°C. and 1000°C.

(3) The persistence of cristobalite in the "high" form is dependent on its temperature of formation.

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* See also Greig: *Journ. Amer. Chem. Soc.*, 1932, *54*, 2846.

THE VOLUMETRIC MICRO-DETERMINATION OF ORTHO-NITROPHENOLS WITH METHYLENE BLUE.

By ADOLPH BOLLIGER, Ph.D.*

(Read before the Royal Society of New South Wales, Sept. 5, 1934.)

Some time ago it was found that picric acid (Bolliger, A., THIS JOURNAL, 1933, *67*, 240) and 2-4 dinitrophenol (Bolliger, A., *Med. Journ. Austr.*, Mar. 17, 1934, 367) could be titrated with methylene blue and possibly other thiazine dyes by removing with chloroform the sparingly water-soluble reaction-product. Broadly speaking, this method can be applied to phenols and other aromatic acids in general, provided that the reaction-product with methylene blue or other thiazine dyes is sparingly soluble in cold water, but considerably more soluble in chloroform. The present communication is limited to ortho-nitrophenols.

In general the procedure is as follows: An alkaline or alkaline earth salt of the ortho-nitrophenol in aqueous solution is transferred to a cylindrical separatory funnel containing chloroform. If dealing with an extract in an organic solvent or with a watery solution of a free nitrophenol, one adds a small excess of calcium carbonate, although, as will be shown later, in some instances the free nitrophenol in aqueous or chloroform solution can be used as such. The amount of chloroform required depends roughly on the amount of the nitrophenol present and on the solubility of the thiazine phenolate formed, and may vary from 10 to 100 c.c. The standard thiazine dye solution, usually methylene blue, is practically insoluble in chloroform in the dilution used. It is added from a burette and the thiazine phenolate formed is then extracted with the chloroform present.

* Acknowledgments are due to Prof. J. C. Earl and Dr. V. M. Trikojus, who very kindly supplied some of the chemicals used in this investigation; also to Miss Dorothy Dark for valuable technical assistance.

With the most suitable nitrophenols, such as picric acid, the colour of the phenol solution, after extraction with chloroform, diminishes to an extent which is proportionate to the amount of the thiazine dye added, while the chloroform—after extraction of the thiazine phenolate formed—becomes correspondingly more deeply coloured. On the other hand, under less favourable conditions the reaction-product will also stain the aqueous layer. If some of the precipitated thiazine phenolate remains undissolved in the chloroform, more chloroform must be added. If the chloroform becomes very dark in colour it has to be separated and replaced with fresh chloroform.

Theoretically, the end-point is reached when the aqueous layer becomes colourless. This, of course, only occurs when the reaction-product is very sparingly soluble in water and considerably more soluble in chloroform, as, for example, in the case with the picrate of methylene blue. It is preferable in all cases to consider as the end-point the first appearance of an unextractable colour of the standard dye solution. In many instances the chloroform solution of the thiazine phenolate is of a colour distinctly different from that of the thiazine dye used, which facilitates the observation of the end-point.

In most cases methylene blue was found to be distinctly superior to other commonly used thiazine dyes, such as methylene green, toluidine blue and thionine, which will only require occasional mention.

The following o-nitrophenols have been examined:

A. *o-Nitrophenol and o-Nitro-p-Cresol.*—o-Nitrophenol reacts at room-temperature with thiazine dyes only in the form of its salts. With methylene blue a compound is formed which is considerably soluble in water with a blue colour. This compound dissolves in chloroform with a purplish-blue colour.

On account of the water solubility of the compound formed, as well as its instability in an aqueous medium, titration with thiazine dyes is not suitable as a method for estimating o-nitrophenol.

The salt formed by o-nitrophenol and toluidine blue dissolves in chloroform with a scarlet-red colour.

o-Nitro-p-cresol behaves in a similar way to o-nitrophenol in its reaction towards methylene blue.

B. *2-4 Dinitrophenol.*—In connection with some work on the detection of 2-4 dinitrophenol in urine (Bolliger, A., *Med. Journ. Austr.*, Mar. 17, 1934, p. 367), it was observed that 2-4 dinitrophenol forms with methylene blue a salt which is almost as sparingly soluble in cold water as the corresponding picrate. Its solubility in chloroform, however, is only 0·04%. Therefore, with amounts over 1 mgr. of dinitrophenol, it is advisable to precipitate with a known amount of methylene blue the greater part of the nitrophenol present. Then one removes the precipitate by filtration or centrifugation and completes the analysis on the filtrate, which is transferred either *in toto* or in an aliquot part to the separatory funnel containing chloroform. On titrating a 0·01N solution of sodium or calcium dinitrophenolate with 0·001N methylene blue a sharp end-point can be obtained, and the error does not exceed 1·5%. An excess of methylene blue has to be avoided, because part of it is absorbed by the precipitated methylene blue dinitrophenolate.

2-4 Dinitrophenol forms a more chloroform-soluble compound with methylene green, but on account of the water-solubility of this salt and the similarity between the colour of the reagent and the product of reaction the observation of the end-point is difficult.

C. *2-6 Dinitrophenol.*—In contrast to 2-4 dinitrophenol, 2-6 dinitrophenol forms with methylene blue a compound which dissolves in water considerably with a green colour. However, this salt is somewhat more soluble in chloroform than the 2-4 dinitrophenolate, and therefore a quantitative estimation, although less satisfactory, is still possible. The volumetric results with 10 c.c. of a 0·002N solution of the calcium salt 2-6 dinitrophenol against a 0·001N methylene blue solution vary amongst themselves not more than 1%, if near the end point the aqueous layer is carefully extracted several times with chloroform. However, the end-point, although indicated by a fairly sharp change from green to blue, is delayed, and with the amount mentioned the results are 5% too high. Of course by the use of larger amounts

in higher concentration, this error will be made correspondingly smaller.

D. *2-5 Dinitrophenol.*—The salt formed between methylene blue and 2-5 dinitrophenol dissolves sparingly in chloroform with a blue colour, but is more soluble in water. Consequently titration with methylene blue is not suitable for 2-5 dinitrophenol. With 0·001N solutions errors up to 10% were encountered.

E. *2-6 Dinitro-p-Cresol.*—This phenol forms with methylene blue a dark green salt which dissolves in chloroform with a royal blue colour. The solubility of this salt in water is somewhat higher than that of the corresponding picrate, but the solubility in chloroform is sufficiently great to make a titration possible.

For testing the accuracy of the titration a 0·005N solution of 2-6 dinitro-p-cresol calcium was prepared. Quantities of this solution varying from 1 to 10 c.c. were titrated with 0·001N methylene blue. They could be recovered with an error not exceeding 2%, but near the end-point intensive extraction with chloroform was necessary. The end-point is a change from yellowish green to bluish green.

F. *2-4 Dinitroresorcinol.*—2-4 Dinitroresorcinol can only be titrated with thiazine dyes in its free form. In this case it is almost as well suited for titration with methylene blue as picric acid. It forms a purple monomethylene blue resorcinolate which is sparingly soluble in cold water, but more soluble in chloroform. The chloroform solution is green. In titrating a 0·001N solution of dinitroresorcinol with 0·001N methylene blue the error did not exceed 1%. As in the case with picric acid a colourless stage of the aqueous layer can be observed.

The mineral salts of dinitroresorcinol form a bluish compound with methylene blue, probably a di-methylene blue resorcinolate, which is only sparingly soluble in chloroform but more soluble in water.

G. *Picric Acid.*—In addition to the previous communication (Bolliger, A., This Journal, 1933, *67*, 240), it may be mentioned that the alkaline and alkaline earth salts of picric acid are equally or even more suitable for titration with methylene blue than the free acid. In this

case with 0·001N solutions the error was found not to exceed 0·3%.

The solubility of the methylene blue picrate in chloroform was found to be 0·08% at room temperature. The solubility in water is below 0·001%.

The methylene green picrate if precipitated in the absence of chloroform is, however, as soluble in chloroform as the methylene blue picrate. If precipitated in the presence of chloroform the precipitate tends to form an emulsion, and is then considerably less soluble in chloroform.

Thionine picrate is practically insoluble in water, but also very little soluble in chloroform.

H. *2-4 Dinitro-α-Naphthol.*—2-4 Dinitro-α-naphthol, if added to a solution of methylene blue, forms a dark green salt which is almost insoluble in cold water, but considerably soluble in chloroform. The colour of the chloroform solution is green. However, 2-4 dinitro-α-naphthol can only be titrated successfuly with methylene blue in a comparatively neutral medium. For this reason it is recommended to add always some calcium carbonate to the solution to be titrated, even if 2-4 dinitro-α-naphthol is already present in the form of an alkaline or alkaline earth salt.

Under these conditions a very satisfactory end-point is obtained, as in the case of picric acid. Varying amounts of 0·001N 2-4 dinitro-α-naphthol calcium titrated with 0·001N methylene blue could be recovered with an error not exceeding 0·5%.

I. *7-Sulpho-2-4 Dinitro-α-Naphthol (Naphthol Yellow S).*—Apparently the entrance of a sulpho-group into the naphthalene ring has deprived to a large extent the methylene blue compound of the chloroform solubility of the 2-4 dinitronaphthol, and the titration of the 7-sulpho-2-4 dinitronaphthalene with methylene blue combined with chloroform extraction of the reaction-product is impracticable. The methylene blue salt of 7-sulpho-2-4 dinitronaphthol, however, is very sparingly water-soluble, and it is possible to estimate, within an error below 5%, the amount of naphthol yellow S present in a dilute solution, simply by adding 0·001N methylene blue. Near the end point the solution becomes quite

colourless, and after filtering off the precipitate one is able to complete the titration.

Discussion.

Seguin and Seguin, in a paper on the gravimetric determination of methylene blue with picric acid (*Journal de Pharmacie et de Chimie,* 1929, Série 8, *10,* 5), assumed the reaction to be a simple addition of picric acid on to methylene blue chloride, as, for example, the formation of naphthalene picrate. They gave the methylene blue picrate a molecular weight of 548·5. This, however, is not the case, and the reaction which takes place is as follows:

$$C_{16}H_{18}N_3S\ Cl + HO.C_6H_2(NO_2)_3 = C_{16}H_{18}N_3S\ OC_6H_2(NO_2)_2 + HCl$$

and the molecular weight is 512. The hydrochloric acid liberated can be demonstrated in the filtrate. This reaction does not take place in the absence of water, and the acidity of the nitrophenol in question plays an important part. Only very acid compounds such as picric acid ($K_{18°} = 1{\cdot}6 \times 10^{-1}$) give readily and quantitatively compounds with methylene blue in their free form. Nitrophenols of less acidity, such as ortho-nitrophenol ($K_{25°} = 2{\cdot}7 \times 10^{-8}$), react with thiazine dyes only in the form of their neutral salts. Otherwise the hydrochloric acid liberated prevents the formation of the salt. In some cases, such as 2-4 dinitronaphthol, the quantitative determination is only possible in a strictly neutral medium.

The methods as described are essentially micro-methods suitable for a few milligrams or less, and with larger amounts one precipitates most of the nitrophenol to be determined with methylene blue, the determination being terminated on the filtrate as described in the case of the 2-4 dinitrophenol.

As already mentioned in a previous communication, certain precautions are necessary with the chloroform extraction of the reaction-product in order to get satisfactory results. If possible the chloroform should not be renewed till near the end-point.

Summary.

The following o-nitrophenols have been examined with regard to their suitability for titration with methylene blue:

o-nitrophenol, o-nitro-p-cresol, 2-4 dinitrophenol, 2-6 dinitrophenol, 2-5 dinitrophenol, 2-6 dinitro-p-cresol, 2-4 dinitroresorcinol, picric acid, 2-4 dinitro-*a*-naphthol, and 7-sulpho-w-4 dinitro-*a*-naphthol.

The following were found to be suitable to a varying degree: 2-4 dinitrophenol, 2-6 dinitrophenol, 2-6 dinitro-p-cresol, 2-4 dinitro-resorcinol, picric acid, and 2-4 dinitro-*a*-naphthol.

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THE ACTION OF NITROUS ACID ON DIMETHYLANILINE.

PART III.

By JOHN CAMPBELL EARL, D.Sc., Ph.D.,
and ALAN WILLIAM MACKNEY, B.Sc.

(Read before the Royal Society of New South Wales, Sept. 5, 1934.)

During a study on the action of nitrous acid on dimethylaniline, p-nitrosodimethylaniline nitrate was obtained as one of the products (THIS JOURNAL, 1933, *67*, 419). Many years previously the same product had been obtained by Cohen and Calvert (*J. Chem. Soc.*, 1898, *73*, 163), but was not identified by them. They observed also that when the substance was warmed with glacial acetic acid p-nitrodimethylaniline was formed.

In the earlier stages of this investigation (THIS JOURNAL, 1933, *67*, 233) another substance was isolated from the decomposition of p-nitrosodimethylaniline nitrate in glacial acetic acid, by carrying out the reaction under conditions more carefully controlled than those used by Cohen and Calvert. This new product melted at 86°C., gave a strong Liebermann nitroso-reaction, and on analysis was found to contain 21·5% of nitrogen. A closer study of the decomposition has now been made, and by operating under controlled conditions described in the experimental part of this paper, the principal product formed has been identified as 2.4.dinitrodimethylaniline (m.p. 86°C.), accompanied by smaller quantities of p-nitrodimethylaniline (m.p. 160-160·5°C.) and p-nitrophenyl methyl nitrosamine (m.p. 99·5°C.). It was the presence of small quantities of the last-named material in the original product which accounted for the positive nitroso-test. It is of interest to note that in the determinations of nitrogen in p-nitrophenyl methyl nitrosamine, whatever method was used for its preparation, it was difficult to obtain consistent results; but there can be no doubt of the identity of the substance.

The production of nitro- and dinitrodimethylaniline is easily accounted for by such nitration and oxidation processes as one might expect to occur under the conditions employed, but the mechanism of the formation of p-nitrophenyl methyl nitrosamine is by no means clear. The yield of the substance, however, was never great, whatever the experimental conditions, so that it is probably to be regarded as a secondary product.

Experimental.

The Decomposition of p-Nitrosodimethylaniline Nitrate in Glacial Acetic Acid.

p-Nitrosodimethylaniline nitrate (10 grams) and glacial acetic acid (200 c.c.) were mixed and stirred vigorously at 33°C. for ninety minutes, when the nitrate had passed almost completely into solution. The solution was then filtered, and the filtrate poured into excess of water (1,000 c.c.). A yellow solid was precipitated and the mixture allowed to stand overnight. After filtration the precipitate was washed with water and allowed to dry in air. Yield, 7·2 grams, melting at 40-50°C. and giving a strong Liebermann nitroso-test.

The crude product was subjected to an exhaustive fractional crystallisation from rectified spirit, when there were obtained:

(A) 2·2 grams of a substance, melting at 86°C., which did not give a nitroso-reaction. Nitrogen found, 19·6 per cent.; calculated for $C_6H_3(NO_2)_2.N(CH_3)_2$, 19·9 per cent. A mixed melting-point of the product with an authentic sample of 2.4.dinitrodimethylaniline prepared by treating dimethylaniline with nitric acid at a low temperature (Mertens, *Ber.*, 1886, *19*, 2123), showed no depression.

(B) 0·06 gram of a substance melting at 160-160·5°C. and identified as p-nitrodimethylaniline. A mixed melting-point with an authentic sample showed no depression.

(C) 0·03 gram of a substance melting at 99·5°C. and giving a strong nitroso-test. Analyses by the micro-method gave varying results (Found N, 31·9, 24·8, 27·5, 23·6, 23·9, 30·7, 29·0, 32·2, 26·7

per cent.; calculated for $C_7H_7N_3O_3$, 23·2 per cent.). p-Nitrophenylmethylnitrosamine was prepared by two different methods (Stoermer, Hoffmann, *Ber.*, 1898, *31*, 2528; Bamberger, *Ber.*, 1894, *27*, 370), the product in each case melting at 99·5°C. and showing no depression of melting-point when mixed with the sample under examination. Analysis of these products also gave varying results for nitrogen (Found N, 24·3, 28·1, 39·0 per cent.).

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A THEORY OF ASSOCIATION.

By L. W. O. MARTIN, B.Sc.

(Read before the Royal Society of New South Wales, October 3, 1934.)

Two principal theories are at present advanced to explain the association of the molecules of fluids to form polymerised complexes. The difficulties are great. Compounds which are known to be associated show that the energy of association is small, that the association is not accompanied by any apparent characteristic chemical properties, and that the association is very sensitive to its environment. On the other hand association seems to be definitely related to the occurrence of hydroxyl groups within the molecule. This has led to the formulation of two theories, namely :

(1) The physical theory of dipole attraction, and
(2) The chemical theory of association.

The dipole theory of molecular association postulates that the forces of attraction due to the dipole moment of the molecules tend to hold the molecules together, and thus give rise to loosely bound molecular complexes.[1] [2] Though data are incomplete, this seems to occur in many cases and, indeed, the above forces must induce a tendency towards association.

The association of benzoic acid varies from solvent to solvent, when the degree of association is deduced from distribution coefficients. Some results are shown in Table I below, in which C_1, in all cases, is water.

If the dipole moment was the cause of association, one would expect to find that as the dipole moment (μ) of the solvent increased the association of the solute would decrease. This is not so. Moreover, the association of many molecules is completely stopped by a small change in the dipole moment caused by some change in the chemical structure of the molecule. Results for acetic acid and esters are shown in Table II.

TABLE I.—*Association of Benzoic Acid in Solvents.*

Solvent.	Concentration Range in Solvent.	Dipole Moment of Solvent $\times 10^{-18}$ e.s.u.	Degree of Association.
C_6H_6[3]	0·1449 to 5·4851	0·0	Double molecules
C_7H_8[4]	6·58 to 69·70	0·4	Double molecules
$C_6H_5OCH_3$[4]	9·42 to 111·50	1·2	$\frac{C_1}{C_2^{0·63}}=K=0·15$
$C_6H_5OC_2H_5$[4]	17·7 to 93·9	1·0	$\frac{C_1}{C_2^{0·63}}=K\doteq 0·18$
$C_2H_5OC_2H_5$[4]	53·8 to 354·0	1·12	$\frac{C_1}{C_2}=74\pm 4$

It seems difficult to cover these facts by the physical theory of association, so that attention is focussed on the chemical theory. Sidgwick[5] noted that most definitely associating substances contain a hydroxyl group within the molecule, and put forward his theory of association through a co-ordinate link, the hydrogen of one hydroxyl group being bonded to its "own" oxygen atom by a covalent bond, and accepting an electron pair from an oxygen atom of another molecule. This theory explains, so far as it goes, the cessation of association of carboxylic acids, alcohols, *etc.*, when the hydroxyl hydrogen is removed, but it gives no reason why this should be so, nor why any hydrogen atom will not act as the acceptor to form the co-ordinate bond postulated. Sidgwick does not attempt to explain the association of hydrogen fluoride on the

TABLE II.—*Association and Dipole Moment.*

Substance.	Moment; $\mu \times 10^{-18}$ e.s.u.	State.
CH_3COOH	1·73	Double molecules
	1·4	
CH_3COOCH_3	1·67	Single molecules
	1·75	
$CH_3COOC_2H_5$	1·80	,, ,,

above theory. In a more recent book[6] he considers the associating powers of the various hydrogen bonds, giving the observed fact, and suggesting a connection between the magnitude of the moment and the associating powers of the bond.

In this paper some of the most striking and interesting facts will be considered, and a theory deduced. A few examples will then be given to illustrate the application and accuracy of the theory.

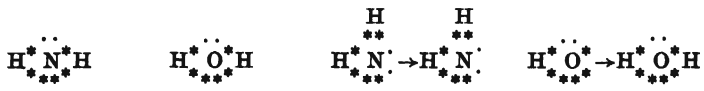
Water vapour is associated,[5] and Wrewsky[7] has shown that the vapours of acetic and formic acids are associated (at 80° C. the molecular weights are 99·7 and 76·1 respectively). Alcohols are generally regarded as associated, but esters, ethers, *etc.*, are normal. Table III gives for comparison the relevant results.

TABLE III.—*Association, Physical and Chemical Properties.*

Substance.	Formula.	Mol. Wt.	Moment $\times 10^{-18}$ e.s.u.	B.P. in ° C.	State.
Water	H—O—H	18	1·85	100	Associated
Formic Acid ..	$H-C\begin{matrix}\nearrow O\\ \searrow OH\end{matrix}$	46	(1·2)	101	,,
Hydrogen Fluoride	H—F	20	—	19·4	,,
Methyl Acetate	$CH_3-C\begin{matrix}\nearrow O\\ \searrow O-CH_3\end{matrix}$	60	1·7	51·9	Normal
Ether	CH_3-O-CH_3	46	1·32	−23·6	,,
Methyl Alcohol	CH_3-O-H	32	1·68	64·7	Associated
Acetone	$CH_3\!>\!C=O$ CH_3	58	2·80	56·5	Normal

It is indeed noteworthy that association ceases with destruction of the hydroxyl group, but, on the other hand, Sidgwick's theory is not satisfactory. It gives no reason why a paraffin or aromatic hydrogen atom is not sufficient. It assumes that the hydrogen concerned in the association has two electron pairs, *i.e.* four electrons and an atomic number one. Sidgwick[6] considers that in the normal covalent hydrogen bond the electron pair is in the first, and that the co-ordinate pair is in the second quantum group. The author[8] has advanced reasons why it seems most probable that, except in hydrogen-hydrogen bond, the hydrogen atom has no electron in the first quantum group.

Consider the structure of water and ammonia. The formulæ may be written as shown in I and II.



I II III IV

where $\cdot$ = an s electron pair,

$\overset{*}{*}$ = a p electron pair.

It is assumed in these formulæ that the electron pair bonds are 2p ones. The 2s electrons are paired in the atom itself, and there are no reasons why this pair should be broken up on combination of the atom with other atoms. Thus in ammonia the only unshared pair of electrons left to form a co-ordinate bond is a nitrogen (N) 2s pair; whereas in the water molecule there are two pairs, an O 2s pair and 2p pair. Ammonia at ordinary temperatures and pressures is a gas, whilst water is a liquid. The physical properties are shown in Table IV, and these are so close that one would not, at present, expect this difference in state.

TABLE IV.—*Properties of Ammonia and Water.*

Substance.	Formula Wt.	$\mu \times 10^{-18}$.	M.P.	B.P.
Ammonia ..	17	1·49	−75·5° C.	−33·5° C.
Water ..	18	1·85	0° C.	100° C.

If we write the formulæ of the double molecules as in III and IV, one of the hydrogen atoms of an ammonia molecule has associated with it one N 2s and one N 2p pair of electrons, whilst the hydrogen in the water molecule has associated with it two pairs of electrons, but both pairs are O 2p pairs, *i.e.* similar and corresponding electron pairs, so that once the double molecule is formed it is impossible to distinguish between the original covalent electron pair and the co-ordinate electron pair, except by

reference to the position of the remaining hydrogen atoms in the molecule.

Since these electron pairs, in the case of the double molecule of water, are the same, every condition for *quantum mechanical resonance*[9] [10] would seem to be fulfilled, so that the bond (co-ordinate) would be stabilised and an attractive force exerted, despite the fact that the hydrogen nucleus has four electrons associated, in quantum relations, with it.

In the case of ammonia there is an energy difference between the two electron pairs associated with the same hydrogen nucleus (since the energy of a 2s pair $\neq$ that of a 2p pair), so that quantum mechanical resonance would not stabilise this association; or, more probably, the binding force due to the resonance, if any, must be less than in the case of the water molecules, so that the bond must be weaker, only stabilising the double molecule of ammonia at much lower temperatures than in the case of water. This appears to be so, as liquid ammonia is believed to be associated.[11]

The faculty of ammonia to form co-ordinate compounds with salts, which are similar and, indeed, in no way different from salt hydrates, might perhaps be considered to bear some relation to the associating power of ammonia. This seems to be the case, as ammines of salts (ammates) are much more readily decomposed, *i.e.* less stable, than the corresponding salt hydrates, *e.g.* $CuSO_4.5NH_3$ decomposes at 91·5°,[12] whilst $CuSO_4.5H_2O$ decomposes at much higher temperatures under the same pressure of water vapour as of the ammonia over the ammine. In addition the central atom of the complex is a charged ion, and this introduces a new and important factor.[6] The author hopes to consider this in a later paper.

The temperature effect on the stability of the bond in association may be briefly considered. The bond holding the associated molecules together is based on resonance between similar electron pairs associated in quantum relations with a single nucleus. The energy levels of electrons only change discontinuously, and these changes require very large amounts of energy. Consequently, for the usual changes of temperature the energy of the electron pairs will not be altered. Therefore we may say that the binding forces of the double molecule do not change (within wide limits of temperatures). But the rotational and vibrational energies do change much more easily than

electron energies, and in fact these may change (increase) with small increases of temperature above ordinary.

The observed binding strength of a bond is equal to the sum of the binding forces minus the sum of the disrupting forces, *i.e.*

$$\beta = \Sigma\psi - \Sigma\triangle$$

where β = effective (observed) binding force
ψ = binding forces
$\triangle$ = disrupting forces.

For increases of temperatures, within wide limits above ordinary, electron energies do not change, so that

$$\Sigma\psi = K$$

where K = a constant.

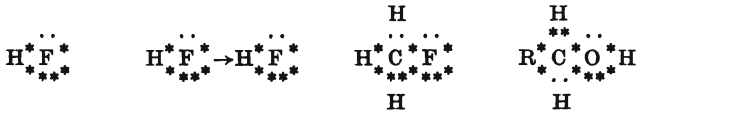
But $\Sigma\triangle$ increases with increases of temperature,

$$\therefore \Sigma\triangle = f(T) \qquad (T = \text{temperature}).$$

Hence $\beta = K - f(T)$,

that is, the binding force decreases with increasing temperature. Therefore a weak bond will be able to hold the double molecule together at lower, but not at higher temperatures.

The theory of association, therefore, which is advanced in this paper, is that definite chemical association takes place, at ordinary temperatures, only when one atom (A), which is bonded to another atom (B) by a covalent bond, can be the acceptor of a pair of electrons donored by an atom (B) of another molecule, and when the donored (co-ordinate) electron pair is similar (n and 1 the same) to the electron pair forming the covalent bond between A and B.



V VI VII VIII

The application of the theory is satisfactory. Consider hydrogen fluoride (V), in which the hydrogen-fluorine bond is a F 2p electron pair. The fluorine atom has two pairs of unshared 2p electrons left, so that a double molecule (VI) can be formed in which the co-ordinating hydrogen nucleus has two similar electron pairs associated with it. If we take methyl fluoride, the formula VII shows that the only hydrogen atoms with which the fluorine atom can form a co-ordinate bond are already bonded to carbon

atoms by C 2p electron pairs. The energies of C 2p and F 2p electron pairs are very different, hence there is no association. Table V gives a summary of the properties.

TABLE V.—*Physical Properties of Methyl and Hydrogen Fluorides.*

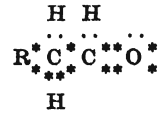
Substance.	Formula Wt.	$\mu \times 10^{-18}$ e.s.u.	B.P.	Complexity.
HF	20	1·5 ?	19° C.	Associated
CH_3F	34	1·8 ?	−78° C.	Simple

(μ has been estimated in these cases.)

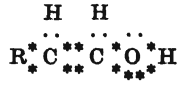
It is to be noted that hydrogen fluoride can form very complex molecules as each fluorine atom can form two co-ordinate bonds.

Similarly, alcohols (VIII) have an oxygen-hydrogen link formed of O 2p electron pair, and the oxygen has an unshared 2p pair. Resonance can occur, so that complex molecules can be formed. Ethers, however, have only O 2p or 2s electron pairs unshared, and the hydrogens have covalent C 2p or 2s electron pair bond. Resonance cannot occur, so the ethers are simple liquids. The reasoning leads one to the conclusion that, provided no intramolecular re-arrangement takes place, esters, acid chlorides and anhydrides should be normal. This is found to be the case.[13]

Aldehydes and ketones are interesting. They are sometimes considered as abnormal liquids, but the weight of evidence does not support this contention. Their formula may be written as in IX, in which there is no possibility of chemical association. Taking acetone as a typical example: $\mu = 2{\cdot}80 \times 10^{-18}$ e.s.u., but viscosity,[14] distribution coefficients and V. Meyer molecular weight determinations indicate that acetone is a normal, unassociated liquid and vapour. The distribution coefficients of acetone between water and various solvents are given in Table VI.[15]



IX



X

TABLE VI.—*Distribution Coefficients of Acetone.*

C_1	C_2	$\frac{C_2}{C_1}$	$\frac{\sqrt{C_2}}{C_1}$	
(in water)	(in benzene)			
0·10	0·08	0·80	2·830	at 20° C. C_1 and C_2 in gms./1,000 cc.
0·20	0·12	0·60	1·733	
0·30	0·28	0·833	1·665	
0·40	0·34	0·850	1·458	
10	12·0	1·20	0·347	
50	41·7	0·834	0·127	
100	101·5	1·015	0·101	at 25° C.
150	155·9	1·039	0·083	
200	225·0	1·125	0·075	
(in water)	(in carbon tetrachloride)			
0·186	0·0833	0·448	1·55	C_1, C_2 in mols/litre
0·322	0·146	0·453	1·19	
1·01	0·514	0·509	0·710	
1·66	0·997	0·601	0·602	
2·87	2·10	0·732	0·505	
(in water)	(in chloroform)			
0·032	0·168	5·26	12·96	C_1, C_2 in mols/litre
0·0781	0·399	5·11	8·09	
0·145	0·676	4·66	5·67	
0·263	1·17	4·45	4·10	
0·493	1·98	4·02	2·79	
1·01	3·06	3·03	1·73	
(in water)	(in pentachlorethane)			
0·144	0·251	1·74	3·48	C_1, C_2 in mols/litre
0·541	0·859	1·59	1·72	
0·806	1·275	1·58	1·40	
1·149	1·763	1·53	1·17	

It will be seen on comparing columns 3 and 4 that the acetone is definitely non-associated in the organic solvents.

It is interesting to note that ketones can form hydroxy compounds (X) by internal re-arrangement, *i.e.* the well-known keto-enol tautomerism. The occurrence of this tautomerism is dependent, in the cases hitherto studied, on the presence of certain groups within the molecule.[16] There is, however, no reason to suppose that the external environment of the ketone is unable to affect, in all cases, this activation, giving an enol form, which would most certainly

associate. The isolation of the enol aceto-acetic ester at low temperatures, and its reversal to the keto form above the low temperatures,[17] indicate that the above effect should be looked for at low temperatures. It is interesting to note that the enol form of aceto-acetic ester is stable at low temperatures. The ester has a high molecular weight, and thus association increases as the temperature decreases, and the association of the enol form should tend to stabilise it. The author has found indications of an enol and associating form of acetophenone at its melting point.

Both ketoximes and aldoximes possess the necessary conditions for chemical association. If, however, the hydroxyl hydrogen was replaced by an alkyl group, the association would cease, as resonance would not then be possible. Oximes are associated,[6] but the methyl ether of acetoxime (B.P. 72° C.) would, compared to the acetoxime (M.P. 59–60° ; B.P. 135° C.), appear to be normal.

The nitroparaffins as nitro-paraffins would not associate, but the form of the tautomeric acid would associate. On the above reasoning, low temperatures where the tendency to associate increases should increase the concentration of the acid form.

The carboxylic acids associate.[7] It is noteworthy that formic and acetic acid vapours are much more strongly associated than water vapour at corresponding temperatures. Each associated acid molecule has two co-ordinate bonds, as suggested by Sidgwick[18] and Pennycuick.[19]

The hydrides of sulphur and chlorine families do not associate at ordinary temperatures. There are unshared S and Cl electron pairs similar to the S and Cl covalent electron pair bonds in the hydrides. But the principal quantum numbers of these bonds are 3p, and this is a large promotion for the hydrogen. The author has previously pointed out how this promotion may be used to explain the weakening of the bonds in the series.[12] The energy of association is then so weak that at ordinary temperatures the bond is broken. Liquid hydrogen chloride and sulphide should be associated. Even in the case of the hydrides at ordinary temperature there is evidence[1] that the hydrogen nucleus is buried within the kernel of the heavier atom.

It is, perhaps, not out of place to reiterate[8] briefly the author's reasons for assigning the above quantum numbers to the electron pair bond between the atoms. The basis is the London[20] theory of the covalent bond,

which postulates that the covalent bond is a sharing of a corresponding pair of electrons between the two atoms, formed from the unpaired and unshared single electrons belonging to the separate and free atoms. A corresponding pair of electrons has the quantum numbers n, 1, and m the same, but the electron spins opposite. It is necessary that, if a corresponding pair of electrons is to be formed, the principal quantum numbers must be the same for both atoms *once the bond is formed.* If in the single uncombined atoms the principal quantum numbers are different, since they *must be the same in the bond*, then either the free electron belonging to the atom of lower atomic number must be promoted to pair off with the free electron of the atom of higher atomic number, or the free electron belonging to the atom of higher atomic number must be taken to a lower level than its normal one. This latter alternative is impossible, as the levels below the valence one are complete, so that the electron of the lighter atom must be promoted.

The methods for determining association have lacked significance, because workers have really not known what to look for. Perhaps the most conclusive methods are:

(1) Determination of the molecular complexity in the vapour state,
(2) distribution determinations under ideal conditions,
(3) molecular weight determinations in solution,
(4) Raman spectra, and
(5) fine structure of X-ray terms.[21]

It is hoped to consider most of the above methods in a subsequent paper.

Summary.

(1) Two forms of association can occur, physical and chemical. In all cases of association considered in this paper chemical association seems to occur.

(2) In chemical association it is suggested that the bond is formed by an atom of a molecule donoring a similar pair of electrons to an atom which is already bonded to an atom of the same kind as the donoring atom by a similar electron pair.

(3) This bond is stabilised by quantum mechanical resonance.

(4) When the electron pairs are such that they are promoted by more than $n = 1$ for the atom of lower atomic number the bond is too weak to bind the molecules

at ordinary temperatures, although it may do so at lower temperatures.

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SOME HYDROXY SALTS OF SECONDARY AND TERTIARY ARSINES.

By G. J. BURROWS, B.Sc.

(Read before the Royal Society of New South Wales, October 3, 1934.)

INTRODUCTION.

A specimen of phenyl dimethyl arsine which had been prepared from phenyl di-chlorarsine and methyl magnesium iodide was observed after several years to contain a white crystalline deposit. This was soluble in water, methyl alcohol and ethyl alcohol, but sparingly soluble in ether, chloroform and acetone. The compound was purified by dissolving in hot methyl alcohol, adding a few drops of ether, and allowing the solution to cool. Colourless needles were obtained, melting at 180° C., giving an aqueous solution which was acid to litmus and having an equivalent weight of 196. The substance was naturally thought to be an oxidation product of phenyl dimethyl arsine. It was found to combine with acids, such as hydrochloric and nitric, yielding crystalline derivatives. The product obtained by the action of hydrochloric acid, however, was found to have a melting point of 105° C., whereas the melting point of phenyl dimethyl hydroxy arsonium chloride is 164° C. This led to a systematic examination of the compound which had separated from the arsine, and this was ultimately identified as phenyl methyl arsinic acid. Meanwhile various related arsine derivatives were prepared, and these are described in this communication.

The oxidation of phenyl dimethyl arsine to phenyl methyl arsinic acid is a most unexpected reaction, and involves oxidation by atmospheric oxygen in the presence of moisture with the elimination of methyl alcohol in accordance with the equation :

$$PhMe_2As + O_2 + H_2O \rightarrow PhMeAs{:}O \cdot OH + MeOH.$$

It has since been observed that the rate of formation of the arsinic acid is greatly accelerated by free access of air and moisture, and quite appreciable amounts of the arsinic acid have been prepared in this way.

The usual product of oxidation of a tertiary arsine is an arsine oxide. Thus diphenyl methyl arsine in ethyl alcohol reacts vigorously with 30% hydrogen peroxide to give a product which on heating on an oil bath at 170° C. is finally converted to diphenyl methyl arsine oxide. The mechanism of this reaction is obviously represented by the following:

$$Ph_2MeAs + H_2O_2 \rightarrow Ph_2MeAs(OH)_2 \rightarrow Ph_2MeAs{:}O + H_2O.$$

In the case of phenyl dimethyl arsine it is difficult to isolate the arsine oxide, but if the oxidation be carried out in the presence of hydrochloric acid or nitric acid the hydroxy chloride or nitrate is obtained; *e.g.*,

$$PhMe_2As + H_2O_2 + HCl \rightarrow PhMe_2As\overset{OH}{\underset{Cl}{}} + H_2O.$$

Oxidation of a tertiary arsine with bromine results in the formation of a dibromide which may be converted to oxide by treatment with silver oxide. Furthermore, a tertiary arsine may be readily oxidised to an arsine oxide or dihydroxide by treatment with potassium permanganate.

There would therefore seem to be a fundamental difference between the mechanism of oxidation of a tertiary arsine by moist oxygen and its oxidation by reagents such as hydrogen peroxide and permanganate. In no case has it been found possible to identify phenyl dimethyl arsine oxide (or a derivative) in the products of atmospheric oxidation.

Steinkopf and Schwer (*Ber.*, 1921, *54* [B], 2802) studied the decomposition of phenyl dimethyl hydroxy arsonium bromide on heating *in vacuo*. They found that the compound could decompose in various ways, but one of the products was phenyl methyl arsenious acid obtained in accordance with the reaction:

$$PhMe_2As\overset{OH}{\underset{Br}{}} \rightarrow PhMeAsOH + MeBr.$$

The phenyl methyl arsenious acid could then be oxidised to the corresponding arsinic acid. It is not likely that such a reaction would proceed to any extent at the ordinary temperature. Nevertheless the possibility of some such decomposition from a corresponding iodo-compound was considered by the author in the present work, and considerable care was taken to prepare phenyl dimethyl arsine free from all traces of iodo-compounds. But there was no noticeable effect on its oxidation to phenyl methyl arsinic acid.

The amphoteric nature of phenyl methyl arsinic acid was recorded by Bertheim (*Ber.*, 1915, *48*, 350). There is a progressive variation of acidic properties accompanying the alkylation or arylation of arsenic acid:

Arsenic acid, $O{:}As(OH)_3$, is a fairly strong acid with no basic properties.

Phenyl arsonic acid, $O{:}As\overset{(OH)_2}{Ph}$, is a weak acid without basic properties.

Phenyl methyl arsinic acid, $O{:}As\overset{OH}{\underset{Ph}{Me}}$, is a still weaker acid with weak basic properties, neutralising acids to form derivatives such as the hydrochloride.

Phenyl dimethyl arsine oxide, $O{:}As\overset{Me_2}{Ph}$, is not acidic, but weakly basic, combining with acids to form derivatives such as the hydrochloride.

As will be seen in the experimental portion of this paper, not only will phenyl methyl arsinic acid and *p*-tolyl methyl arsinic acid combine with hydrochloric acid to form hydrochlorides, but the derivatives so formed will react with silver nitrate or silver sulphate to yield crystalline nitrates or sulphates. In addition, they are readily converted to brom-camphor sulphonates.

The constitution of the compounds formed by arsinic acids and tertiary arsine oxides with acids is by no means clear. This basic property is apparently associated with the oxygen atom present in these compounds. Since the arsenic atom already has an octet of electrons, the constitution of these compounds may possibly be represented by the formulæ:

$$\overset{HO}{\underset{Ph}{Me}}\ As{:}O\cdot HCl$$

in the case of the hydrochloride of phenyl methyl arsinic acid dissociating as

$$\begin{bmatrix} Me & OH \\ & As \\ Ph & OH \end{bmatrix} Cl \quad \ldots\ldots\ldots\ldots \quad A,$$

and

$$\overset{Me_2}{Ph}As{:}O\cdot HCl$$

in the case of the hydrochloride of phenyl dimethyl arsine oxide dissociating as

$$\left[\begin{matrix} Me & & OH \\ & As & \\ Me & & Ph \end{matrix}\right] Cl^{*} \quad \ldots\ldots\ldots\ldots \quad B.$$

The hydroxyl groups in both A and B are acidic and can be titrated by alkalies, but this property can be ascribed to secondary dissociation.

Experimental.

Phenyl Methyl Arsinic Acid, PhMeAs:O·OH.—As mentioned in the introduction, this compound was obtained by the spontaneous oxidation of phenyl dimethyl arsine in moist air. This acid was described by Bertheim (*Ber.*, 1915, *48*, 350), who prepared it by methylating sodium phenyl arsenite and purifying it through its silver salt. Gibson and Johnson (*J.C.S.*, 1928, 92) converted phenyl methyl chlor arsine to the oxide, and oxidised with chloramine-T. For the purpose of the present investigation it was conveniently prepared and purified as follows :— Phenyl dichlor arsine (1 mol.) was treated in aqueous alcohol with sodium hydroxide (4 mols.) and methyl iodide (1 mol.) and allowed to stand overnight. The alcohol was removed by boiling, and the methylated product reduced in hydrochloric acid solution with sulphur dioxide in the usual way. The phenyl methyl iodo-arsine was then converted to phenyl methyl arsine oxide by treatment with sodium carbonate (concentrated solution); the arsine oxide was separated, dried with sodium sulphate, and distilled under diminished pressure. It was found to boil at 199° C. at 13 mm. Steinkopf and Schwer (*Ber.*, 1921, *54* [B], 1447) gave the boiling point as 94° C. at 11 mm. The arsine oxide was then dissolved in acetic acid, and heated with excess of 10% hydrogen peroxide solution. The solution was concentrated on the water bath, and the acetic acid removed with steam. It was then evaporated till solid and recrystallised by dissolving in hot methyl alcohol, adding a small quantity of ether and allowing to cool. In this way colourless needles were obtained, melting at 179° C. and giving the

*This formula is consistent with Meisenheimer's successful attempts at the resolution of amine and phosphine oxides (*Ann.*, *449*, 188 and 213).

same melting point when mixed with the product obtained by the atmospheric oxidation of phenyl dimethyl arsine.

Phenyl Methyl Dihydroxy Arsonium Chloride, $[PhMeAs(OH)_2]Cl$.—This was prepared by the action of hydrochloric acid on an aqueous solution of phenyl methyl arsinic acid. The compound separates from a concentrated solution in colourless needles melting at 111° C. It was rapidly prepared in quantity by oxidising phenyl methyl arsine oxide with chlorine. In carrying out the oxidation the arsine oxide was covered with water in a flask and a stream of chlorine passed into the water. (If the chlorine comes in contact with the arsine oxide itself, the reaction is accompanied by a flash of light.) On completion of the reaction the solution was concentrated till it crystallised on cooling, and the product purified by recrystallising from acetone containing a little ether. The compound functions as a dibasic acid, and in addition it reacts immediately with silver nitrate. Found: Cl, 15·1%. Equivalent weight by titration with barium hydroxide solution using phenolphthalein as indicator, 117. $C_6H_5CH_3As(OH)_2Cl$ has a molecular weight of 236·5, and requires Cl, 15·0%.

Phenyl Methyl Dihydroxy Arsonium Nitrate, $[PhMeAs(OH)_2]NO_3$.—This was prepared from phenyl methyl arsinic acid by treatment with dilute nitric acid and concentration. The product recrystallised from ethyl alcohol was found to melt at 151° C. Found: As, 27·6; NO_3, 24·1%; equivalent weight, 132. $C_6H_5CH_3As(OH)_2NO_3$ requires As, 28·5; NO_3, 23·6%; mol. wt., 263.

Phenyl Methyl Dihydroxy Arsonium Sulphate, $[PhMeAs(OH)_2]_2SO_4$.—This was prepared by treating the dihydroxy chloride with the calculated quantity of silver sulphate, removing the silver chloride by filtration, and concentrating. Recrystallised from acetone the compound was obtained in colourless hygroscopic needles melting at 70° C. Found: As, 30·0%; equivalent weight, 124. $(C_6H_5CH_3As{:}O\cdot OH)_2H_2SO_4$ requires As, 30·1%; mol. wt., 498.

Phenyl Dimethyl Hydroxy Arsonium Chloride, $[PhMe_2As\cdot OH]Cl$.—This was prepared by Steinkopf and Schwer (*Ber.*, 1921, *54* [B], 2791) by the action of concentrated hydrochloric acid on phenyl dimethyl arsine dihydroxide in alcohol. It is readily prepared by oxidising phenyl dimethyl arsine with perhydrol in the presence of

hydrochloric acid and concentrating the solution. On recrystallisation from alcohol it separates in colourless needles melting at 174° C. Found: Cl, 15·2; equivalent weight, 232. $C_6H_5(CH_3)_2AsOHCl$ requires Cl, 15·1; mol. wt., 234·5.

Phenyl Dimethyl Hydroxy Arsonium Nitrate, $[PhMe_2AsOH]NO_3$.—This was obtained by oxidising the arsine in alcohol with hydrogen peroxide in the presence of nitric acid. It crystallises from alcohol in colourless needles melting at 152° C. It dissolves readily in water to give an acid solution. Found: As, 28·4; equivalent weight, 260. $C_6H_5(CH_3)_2AsOHNO_3$ requires As, 28·7; mol. wt., 261.

Diphenyl Methyl Arsine Oxide, $Ph_2MeAs{:}O$.—This was prepared by adding 30% hydrogen peroxide to an alcoholic solution of diphenyl methyl arsine. After the vigorous reaction had moderated it was heated on an oil bath at 170° C. till there was no further action. On cooling it solidified to a very hygroscopic white solid melting at 142° C. It dissolves in water to give a solution which is not acid to phenolphthalein. Found: As, 29·0%. $(C_6H_5)_2CH_3AsO$ requires As, 28·9%.

Diphenyl Methyl Hydroxy Arsonium Nitrate, $[Ph_2MeAsOH]NO_3$.—This was prepared from the preceding compound by treatment in alcohol with dilute nitric acid and concentration on the water bath. It was recrystallised from hot water in needles melting at 128° C.. Found: As, 22·9; NO_3, 19·0%; equivalent weight, 324. $(C_6H_5)_2CH_3AsOHNO_3$ requires As, 23·2; NO_3, 19·2%; mol. wt., 323.

p-*Tolyl Dichlor Arsine*, $C_7H_7AsCl_2$.—This was prepared in the usual way by the Bart reaction from *p*-tolyl diazonium chloride and sodium arsenite followed by reduction of the arsonic acid, in hydrochloric acid solution containing a little iodine, by sulphur dioxide. The oil was separated, dried over calcium chloride, and distilled. It is an almost colourless crystalline solid melting at 42° C. The melting point given in the literature is 31° C. (Michaelis, *Ann.*, 1902, *320*, 301). Found: As, 31·1%. $C_7H_7AsCl_2$ requires As, 31·6%.

p-*Tolyl Arsine Oxide*, C_7H_7AsO.—This was prepared from the preceding compound by treatment with sodium carbonate and recrystallisation from acetone, and was obtained in almost colourless needles having the properties

ascribed to it by Blicke and Smith (*J.A.C.S.*, 1929, 3481). Found: As, 40·8%. C_7H_7AsO requires As, 41·2%.

p-*Tolyl Methyl Arsine Oxide*, $(C_7H_7CH_3As)_2O$.—This was obtained in excellent yield by methylating sodium tolyl arsenite. For this purpose tolyl arsine oxide (1 mol.) was dissolved in sodium hydroxide (2 mols.) in aqueous alcohol (2 litres) and to the cold solution methyl iodide (1 mol.+10%) was added. After standing overnight the alcohol was removed by distillation, hydrochloric acid (1 litre) added, and the solution reduced with sulphur dioxide. The crude iodo-compound which separated as an oil was removed and treated with concentrated sodium carbonate solution on the water bath. The oil was separated, dried over sodium sulphate, and distilled under diminished pressure. *p*-Tolyl methyl arsine oxide is a colourless, highly-refracting oil boiling at 220° C. at 12 mm. Like secondary arsine oxides in general, it is insoluble in alkalies, but is converted by hydrochloric acid into the chlor arsine. Found: As, 39·4%. $(C_7H_7CH_3As)_2O$ requires As, 39·7%.

p-*Tolyl Methyl Chlor Arsine*, $C_7H_7CH_3AsCl$.—This was prepared by treating the arsine oxide with concentrated hydrochloric acid, drying over calcium chloride, and distilling under diminished pressure. It is a colourless oil with a characteristic odour, boiling at 147° C. at 24 mm. pressure or 138° at 14 mm. Found: As, 33·8; Cl, 16·5%. $C_7H_7CH_3AsCl$ requires As, 34·6; Cl, 16·4%.

p-*Tolyl Methyl Arsinic Acid*, $C_7H_7MeAs{:}O{\cdot}OH$.—This was prepared by oxidising *p*-tolyl methyl arsine oxide in acetic acid with hydrogen peroxide (20%). The product after oxidation was evaporated to a wax and recrystallised from toluene, then from acetone, and finally from water. It was obtained in colourless needles melting at 151° C. Found: C, 44·6; H, 5·3; As, 34·8%; equivalent weight, 215. $C_7H_7CH_3As{\cdot}O{\cdot}OH$ requires C, 44·9; H, 5·1; As, 35·0%; mol. wt., 214.

p-*Tolyl Methyl Dihydroxy Arsonium Chloride*, $[C_7H_7MeAs(OH)_2]Cl$.—This was prepared from the arsinic acid by treatment with hydrochloric acid and evaporating to crystallisation. The same compound was obtained in quantity by placing tolyl methyl arsine oxide in a flask, covering with water, and passing in chlorine till the substance had all dissolved. It was concentrated on the water bath under diminished pressure till it solidified on cooling and was recrystallised from acetone in needles

melting at 133° C. It was extremely soluble in water, and reacted immediately with silver nitrate. Found: As, 28·9; Cl, 14·1%; equivalent weight, 125. $C_7H_7CH_3As(OH)_2Cl$ requires As, 29·3; Cl, 14·2%; mol. wt., 250.

p-*Tolyl Methyl Dihydroxy Arsonium Nitrate*, $[C_7H_7MeAs(OH)_2]NO_3$.—This may be prepared either from the arsinic acid and nitric acid or by treating the dihydroxy arsonium chloride with the calculated amount of silver nitrate, removing the silver chloride, and concentrating. It crystallises from acetone in needles melting at 157° C. Found: As, 27·0%; equivalent weight, 139. $C_7H_7MeAs(OH)_2NO_3$ requires As, 27·0%; mol. wt., 277.

p-*Tolyl Methyl Dihydroxy Arsonium Sulphate*, $[C_7H_7MeAs(OH)_2]_2SO_4$.—This was prepared in the same manner as the preceding compound, silver sulphate being used. It crystallises from acetone in beautiful prisms melting at 85° C. Found: As, 28·3; SO_4, 18·5%; equivalent weight, 131. $[C_7H_7CH_3As(OH)_2]_2SO_4$ requires As, 28·5; SO_4, 18·3%; mol. wt., 526.

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THE ESSENTIAL OILS OF THE GENUS *CALYTHRIX*.

PART II.—*CALYTHRIX TETRAGONA* (LABILLARDIÈRE), VARIETY "A".

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The myrtaceous shrub *Calythrix tetragona*, var. "A" was collected first in 1924 by the official collector to the Technological Museum, Sydney, at Denman, New South Wales. Its botanical characters have been under investigation by Mr. E. Cheel, Botanist, National Herbarium, Botanic Gardens, Sydney, for some considerable time. Owing, however, to the confused state of the nomenclature of the genus *Calythrix*, no definite decision has yet been reached, although the study of the essential oil points to the particular plant from Denman being a new species. Mr. Cheel is making an exhaustive study of the genus, but his results will not be available for some time. Under the circumstances it has been deemed advisable to postpone no longer the results of the chemistry of the essential oil. The plant has, therefore, been tentatively named *Calythrix tetragona*, variety "A", until such time as Mr. Cheel's revision of the genus is published.

Calythrix tetragona, var. "A", grows to a height of about three to five feet; it has very small dark leaves, and is characterised by a profusion of very beautiful flowers, either pink or white, and by the calyx lobes, which are lengthened into fine hair-like awns. Although its occurrence has been recorded in several localities, it has only been found abundantly at Denman, and the whole of the material used in this investigation was obtained from there.

The oil, which was obtained in a yield varying from 0·7% to 1%, was pale yellow in colour and had a fragrant odour of citronellol and its esters, modified by the characteristic odour of citronellic acid. The principal constituents of the oil which have been identified are *d*-α-pinene, *d*-citronellol, *d*-citronellyl formate and the methyl esters of geranic and probably citronellic acids, the ester fraction comprising from 60 to 70%. So far as we are aware this is the first natural occurrence of geranic acid which has been reported. This is due possibly to the great difficulty experienced in identifying the acid, for which no crystalline derivatives are described in the literature. (See pp. 86-87.)

The liquid acids (see p. 85) were separated by distillation into three fractions which, although they differed slightly in their physical constants, were shown by analysis to have approximately the same composition and to be mixtures of acids of the formulæ $C_{10}H_{18}O_2$ and $C_{10}H_{16}O_2$, the latter predominating. This was confirmed by catalytic hydrogenation, when the hydrogen absorption showed the mixture to consist of approximately 80% of an acid, $C_{10}H_{16}O_2$, the fully reduced acid being identified as *dl*-tetrahydrogeranic acid by the preparation of a number of crystalline derivatives. These results indicated that the liquid acids consisted of a mixture of citronellic and geranic acids, and the presence of the latter was confirmed by the preparation of the two crystalline esters described below. Rigid proof of the presence of citronellic acid was not obtained, but we regard this as almost certain in view of the facts that the mixture of acids (*a*) showed slight optical activity, (*b*) gave only tetrahydrogeranic acid on catalytic hydrogenation, and (*c*) gave citronellic acid on electrolytic reduction.

Preliminary experiments with geranic acid, prepared from both citral and geraniol (Tiemann and Semmler, *Ber.*, 1899, *26*, 2716) showed the amide, *p*-toluidide and *p*-bromotoluidide to be oils due possibly to the geranic acid employed being a mixture of *cis-trans*-isomerides, but p-*phenylphenacyl geranate* and p-*bromophenacyl geranate* were obtained crystalline, the former having m.p. 79-80° and the latter m.p. 67°. The yield of crystalline material was in each case poor, and it is probable that they were derivatives of the higher melting *trans*- form of the acid. Both these derivatives were prepared from the natural acid, in a somewhat enhanced yield, and no depression in

TABLE I.

The Essential Oil of Calythrix tetragona, *var.* "*A*."

Date.	Locality.	Weight of Leaves in Pounds.	Percentage Yield of Oil.	$d_{15}^{15°}$	$a_D^{20°}$	$n_D^{20°}$	Solubility in 70% Alcohol.	Ester No. 1½ hours Hot Sap.	Ester No. After Acetylation.
							Vols.		
6/11/24	Denman, N.S.W.	116	0·96	0·9016	+5·75°	1·4633	1·7	203·6	254·2
18/1/28	,, ,,	37	0·8	0·8984	+5°	1·4622	1·6	183·3	252·1
18/1/28	,, ,,	78½	1·1	0·9032	+4·4°	1·4640	2·0	198·5	251·3
2/4/29	,, ,,	81½	0·66	0·9073	+4·85°	1·4651	1·6	210·2	260·3
13/11/31	,, ,,	163	0·85	0·9065	+4·4°	1·4655	1·6	211·4	259·1

melting point was observed on admixture. p-*Phenylphenacyl citronellate*, m.p. 37°, was also prepared, but this low-melting derivative could not be obtained from any of the acid fractions from the essential oil.

Experimental.

The leaves and terminal branches of *Calythrix tetragona*, var. " A ", totalling 476 lbs., cut as for commercial purposes, gave on distillation with steam essential oils possessing the properties given in Table I.

The oil from each batch was examined separately, but the results recorded below refer to a mixture of the distillates obtained during 1928, 1929 and 1931.

The oil (300 cc.), after being washed with aqueous (8%) sodium hydroxide solution (*A*), was hydrolysed by digestion for twenty-four hours with aqueous potassium hydroxide solution, the neutral oil (*B*) separated (61 cc.), and the potassium hydroxide solution diluted with water, when a further quantity (33 cc.) of a neutral oil (*C*) separated.

The alkaline solution *A* gave on acidification a very small amount (0·4 gm.) of a mixture of phenols and acids which was not further examined.

Fractions B and C.

The oil (49 cc.) obtained from *B* by distillation in steam, which removed resinous impurities, was distilled under diminished pressure with the results recorded in Table II.

Table II.

No.	B.P. (at 10 mm.).	$d_{15}^{15°}$	$n_D^{20°}$	$a_D^{20°}$	Yield.
					cc.
1	45–65°	0·8643	1·4691	+20·85°	14
2	65–99°	0·8717	1·4701	+9·4°	5
3	99–120°	0·8829	1·4716	+4·3°	22

From *C* two fractions having very similar constants were obtained:

Table III.

No.	B.P. (at 10 mm.).	$d_{15}^{15°}$	$n_D^{20°}$	$a_D^{20°}$	Yield.
					cc.
1	−90°	0·8696	1·4666	+16·6°	6
2	90–112°	0·8730	1·4624	+3·5°	22

d-α-*Pinene.*

Fraction 1 (Table II) was repeatedly distilled over sodium, when an oil (8·5 cc.), b.p. 155·5–157° (776 mm.), $d_{15}^{15°}$ 0·863, $n_D^{20°}$ 1·4681, $a_D^{20°}$ +24·2°, was obtained, which was identified as *d*-α-pinene by oxidation to pinonic acid, the semicarbazone of which melted at 207°.

d-*Citronellol.*

Fractions 3 (Table II) and 2 (Table III) were digested separately with equal weights of phthalic anhydride and benzene on the water bath for two hours and the alcohol regenerated from the sodium salt of the hydrogen phthalate in the usual manner. The alcohol (19 cc.) had b.p. 109–110° (10 mm.), $d_{15}^{15°}$ 0·8613, $n_D^{20°}$ 1·4550, $a_D^{20°}$ +4·5°, and it was identified as *d*-citronellol by the preparation of the silver salt of the hydrogen phthalate, which melted at 126°. *d*-Citronellol was isolated also in a yield of 10% by treatment of the crude oil with phthalic anhydride, the alcohol regenerated from the hydrogen phthalate having the constants b.p. 110–112° (10 mm.), $d_{15}^{15°}$ 0·8622, $n_D^{20°}$ 1·4554, $a_D^{20°}$ +4·3°.

Isolation of Methyl Alcohol.

The potassium hydroxide solution from which the neutral oil *C* had been separated was distilled with a column, the distillation being repeated until the most volatile fraction had been reduced to 50 cc. Addition of anhydrous potassium carbonate separated an oil (32 cc.), which on distillation was obtained in two fractions: (i) b.p. 66–69° (766 mm.), $d_{15}^{15°}$ 0·8125, $n_D^{20°}$ 1·3329, $a_D^{20°}$ ±0° (16 cc.), and (ii) 69–84° (766 mm.), $d_{15}^{15°}$ 0·8388, $n_D^{20°}$ 1·3377, $a_D^{20°}$ +0·4° (9 cc.). A higher boiling residue consisted of *d*-citronellol. These two fractions were methyl alcohol containing a trace of *d*-citronellol, the identity of the former alcohol being established by the preparation of the *a*-naphthylurethane, m.p. 120° both alone and in admixture with an authentic specimen.

Acid Fraction–Geranic Acid.

The alkaline liquid remaining after the removal of the methyl alcohol was acidified, when a liquid acid separated (yield 50–60 cc. from 100 cc. of oil). The acid was isolated, washed with water to remove soluble acids, dried, and

distilled. The results obtained with the oils prepared in 1929 and 1931 are given in Table IV.

TABLE IV.

Date.	B.P. (5 mm.).	$d_{15}^{15°}$	$n_D^{20°}$	$a_D^{20°}$	Yield.
					cc.
2/4/29	132–132·5°	0·9508	1·4742	+2·75°	45
13/11/31	132–133°	0·9541	1·4782	+2°	58

The acids were combined and refractionated, when the fractions given in Table V were obtained.

TABLE V.

No.	B.P. (6 mm.).	$d_{15}^{15°}$	$n_D^{20°}$	$a_D^{20°}$	Yield.
					cc.
1	138–140°	0·9477	1·4737	+3°	10
2	140–143°	0·9498	1·4754	+3°	32
3	143·5–145°	0·9541	1·4794	+2·4°	39
4	Residue	0·9603	1·4852	+1·25°	5

Analysis of fractions 1, 2 and 3 showed them to have approximately the same composition:

Fraction 1.—0·1068 gave 0·2746 CO_2 and 0·0927 H_2O (C, 70·1; H, 9·7).

Fraction 2.—0·1203 gave 0·3129 CO_2 and 0·1064 H_2O (C, 70·8; H, 9·8).

Fraction 3.—0·1046 gave 0·2718 CO_2 and 0·0919 H_2O (C, 71·4; H, 9·5).

$C_{10}H_{16}O_2$ requires C, 71·4; H, 9·5%. $C_{10}H_{18}O_2$ requires C, 70·6; H, 10·5%.

Each fraction (1 gm.) was reduced separately with hydrogen in methyl alcohol solution in the presence of palladium-norite (1 gm., 10%); absorption of hydrogen was complete in thirty minutes, the following results being obtained:

Fraction 1: 225 cc.
Fraction 2: 233 cc.
Fraction 3: 251 cc.

(Calculated for 1 gm. of an acid $C_{10}H_{16}O_2$ with two ethylenic linkages: 267 cc.)

The reduced acid was converted through the acid chloride into the amide, m.p. 105° (after crystallisation from ligroin), and the *p*-toluidide, m.p. 81°, and these melting points were unaltered after admixture with the corresponding derivatives prepared from *dl*-tetrahydrogeranic acid. The yields of the amide and of the *p*-toluidide were quantitative.

Electrolytic Reduction of the Liquid Acids.

43 cc. of the mixed liquid acids having the following characters:

B.P. 130–142° (4 mm.) $d_{15}^{15°}$ 0·9549, $a_D^{20°}$ +2°, $n_D^{20°}$ 1·4795

were reduced electrolytically, the anode being a platinum spiral and the cathode freshly-etched nickel (2 sq. dcm.). The liquid in the outer (cathodic) cell consisted of a mixture of the acid (43 cc.), alcohol (95%, 350 cc.), sulphuric acid (10%, 50 cc.) and nickel sulphate (1·5 gm.), and the inner (anodic) cell contained sulphuric acid (10%).

During the reduction, which lasted six hours, a further quantity of acid (50 cc.) was added, the bath being maintained at 23° C.; C.D. 3–4 amps., E.M.F. 13 volts.

After reduction was completed the contents of the cathodic cell were poured into a large volume of water and the acid separated purified by distillation first in steam, and finally by reduction under reduced pressure. The reduced acid was found to possess the following characters:

B.P. 129–130° (3 mm.), $d_{15}^{15°}$ 0·9361, $a_D^{20°}$ +2°, $n_D^{20°}$ 1·4541.

The amide was obtained in good yield of m.p. 82°. The electrolytic reduction of the acids, therefore, gave only *d*-citronellic acid.

The presence of geranic acid in fraction 3 (Table V) was established by the preparation of the two crystalline derivatives described below.

p-*Phenylphenacyl Geranate.*

A mixture of geranic acid (0·3 gm.), *p*-phenylphenacyl bromide (0·5 gm.) and aqueous sodium hydroxide (N; 1·9 cc.) in alcohol (10 cc.) was heated on the water bath for twenty minutes, the alcohol removed, and the insoluble oil dissolved in ether; the ethereal extract was dried and the ether evaporated. The residue partially crystallised on keeping and was purified by recrystallisation from methyl alcohol (95%), from which it separated in glistening plates, m.p. 77°, raised by two further crystallisations to 79–80°. A specimen prepared in a similar manner from

fraction 3 melted alone and in admixture at this temperature.

3·80 mgm. gave 11·1 mgm. CO_2 and 2·35 mgm. H_2O (C, 79·7; H, 6·9). $C_{24}H_{26}O_3$ requires C, 79·6; H, 7·2%.

p-*Bromophenacyl Geranate.*

By treatment of geranic acid with *p*-bromophenacyl bromide under conditions similar to those described above and recrystallisation of the solid so obtained from methyl alcohol, the bromo-ester was obtained in glistening rectangular plates, m.p. 67°, both alone and after admixture with a specimen prepared from fraction 3.

3·91 mgm. gave 8·58 mgm. CO_2 and 1·99 mgm. H_2O (C, 59·8; H, 5·6). $C_{18}H_{21}O_3Br$ requires C, 59·2; H, 5·7%.

p-*Phenylphenacyl Citronellate.*

d-Citronellic acid gave with *p*-phenacyl bromide an oil which solidified when cooled in a freezing mixture. After two crystallisations from methyl alcohol the ester was obtained in needles, m.p. 37°. It was very readily soluble both in methyl alcohol and in ligroin. 4·025 mgm. gave 11·68 mgm. CO_2 and 2·71 mgm. H_2O (C, 79·2; H, 7·5). $C_{24}H_{28}O_3$ requires C, 79·1; H, 7·7%.

The aqueous solution remaining after the removal of the liquid acids referred to above was distilled in steam, when formic acid was found to be the principal volatile acid.

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THE PHYSIOGRAPHY OF THE MIDDLE NORTH COAST DISTRICT OF NEW SOUTH WALES.

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(With three text-figures.)

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INTRODUCTION.

General geological investigations have been carried out in the Middle North Coast District of New South Wales since 1928, and it is thought that the physiographic observations made during that time merit some record.

The quantitative side of this work was limited to the measurement of the most significant heights with the aid of an aneroid barometer and an Abney level. The bases of gravel- and shell-deposits were determined, as well as the heights of river-terraces, and gravel and alluvial areas were mapped in connection with the geological structures. The boundary between the recent plain deposits and the older rock practically coincides with the 20 feet contour-line on account of the abrupt change in slope. This level has been mapped, otherwise no detailed contouring has been attempted. The accompanying relief-map (Fig. 1) shows the chief topographical points, and will be useful for reference.

The essential physiographic features to be noted are :—

(1) The deeply dissected New England Tableland to the west ;
(2) an intermediate area with broad valleys, in which the rivers have been entrenched ;
(3) horizontal coastal plains of accumulation with inliers of older rock ; and
(4) a coast-line consisting of long, curving beaches between rocky headlands.

There are two definite breaks in slope. The first is from the main plateau level at about 2,000 feet on to the broad valley-floor level between 50 and 300 feet, and the second from this on to the low-lying sandy coastal plains.

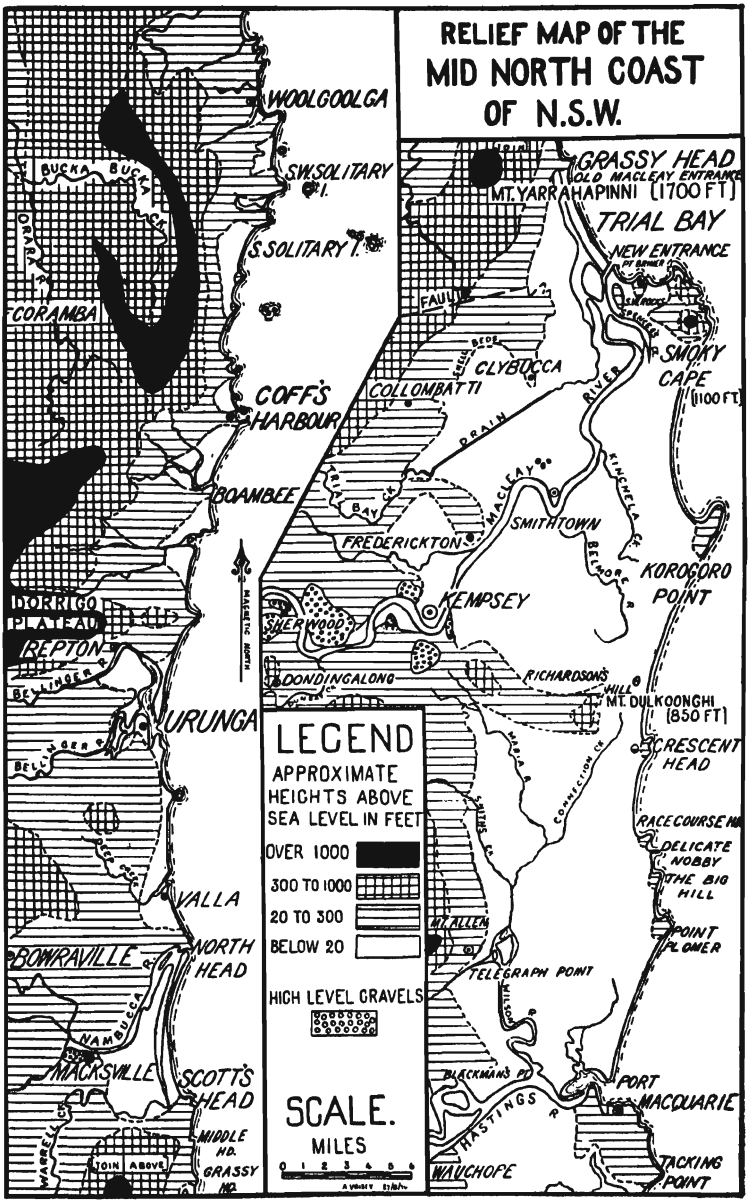


Fig. 1.—Relief Map of the Mid-North Coast of N.S.W.

Both of the higher levels slope to the east. They are to be attributed to successive uplifts of the land, followed by periods of stillstand and erosion.

The coastal plain is wide in the Macleay district, where soft sandstones and tuffs have been rapidly eroded. The short Nambucca and Bellinger Rivers flow through slates and phyllites strengthened by granitic intrusions, while north of Urunga much harder quartzites and cherts have been instrumental in restricting the extent of the plain.

The islands, drowned valleys, shell-beds and estuarine deposits indicate a submergence of at least 70 feet, while rock-platforms, fossil cliffs, high-level sea-worn caves, raised beaches, sandy plains, land-tied islands, lagoons and sand-ridges betoken a more recent small movement of emergence.

Previous Literature.

Only slight references have been made to any portion of the Middle North Coast in literature. Halligan[6] discussed the formations about the Macleay River entrance and described the zeta-curves of the beaches, and Woolnough[7] made some general remarks about the coast-line. The most important papers relating to the coastal formations are those written by Andrews.[1] [2] [3] His work in New England, and later that of Craft,[4] bear upon the history of the area. Other minor references are mentioned in the text.

General Physiography.

From the coastal plains on the North Coast, the western horizon is seen to be bounded by the blue peaks and flat-topped residuals of the New England Highlands, some of which, about the headwaters of the Macleay River, reach 5,000 feet. Conspicuous among the higher points are Kemp's Pinnacle, Mt. Banda Banda and Anderson's Sugarloaf. Basalt-capped projections from the plateau at somewhat more than 2,000 feet form the Dorrigo and Hastings ridges separating the Clarence, Macleay and Hastings basins.

A divide between the north-flowing Orara River and the short coastal creeks extends from the eastern end of the Dorrigo Plateau, rising to over 1,000 feet. The North Coast Railway takes advantage of a col in this ridge to cross from the coast at Coff's Harbour to Coramba in the Orara Valley. The high land descends suddenly on the

east to an undulating area several miles wide, extending to the coast, and keeping between 150 and 300 feet above sea-level; from this cliffs drop steeply to rock-platforms and fringing beaches. Between Woolgoolga and Coff's Harbour small sandy flats break into the line of cliffs, becoming more extensive to the south.

Part of the ridge close to the coast is formed of Mesozoic sandstones dipping gently towards the Clarence Basin to the north-west. These overlie hard quartzites and cherts interbedded with slates and tuffs and striking at right angles to the coast. The resistance to erosion of this metamorphic series is responsible for the presence of high land.

In the vicinity of Coff's Harbour vertical bands of hard, siliceous rock give rise to projecting headlands with islands east of them. The softer tuffs and slates have been worn away, and beaches link the headlands together. Between Coff's Harbour and Boambee, both on hard rock, there is a plain four miles long and two miles wide.

The Dorrigo Plateau presents a steep southern escarpment to the Bellinger River, and breaks away towards the coast in a series of hills. The two arms of the Bellinger meet at Urunga, where river alluvium covers the coastal flats.

As far south as Nambucca Heads phyllite hills rise to several hundred feet and approach the coast, forming cliffs similar to those just south of Woolgoolga. Fringing rock-platforms abound a little above high-tide mark and protect the cliffs from marine erosion. Flats with small lagoons are also conspicuous.

The phyllite series strikes parallel to the coast south of Urunga, and shows little variation in rock-type. The intrusive granite at Mt. Yarrahapinni has hardened the contact-rock, and spurs from the mountain run down to the coast at Middle Head and Grassy Head.

The great change in topography south of Yarrahapinni has been caused by the Kempsey Fault, running from Grassy Head to a point west of Bellbrook; it has brought a series of soft tuffs, sandstones and shales into contact with the phyllite.

The plain about the Lower Macleay extends inland as far as Kempsey, and covers 250 square miles. It is broken by older rocks at Smoky Cape, Rudder's Hill near South-West Rocks, Richardson's Hill, Korogoro Point, and Smithtown. Otherwise it is horizontal, at a height of about 10 feet above sea-level, over the whole area, save

for the levées of the Macleay and the sand-ridges near the coast. The landward limit of the plain is marked by a very definite break of slope, and low cliffs, generally about 50 feet high, may be traced from Grassy Head in a rough semicircle to Crescent Head.

In the north the land of the intermediate area is gently undulating, but it gives way to hills near Mt. Yarrahapinni, while masses of hard rock stand well above it in the south. Mt. Dulkoonghi (850 feet) is the most prominent of these, and forms the eastern extremity of the divide between the Macleay and Hastings Rivers. At Kempsey the Macleay emerges from a broad valley in which it has become entrenched, and flows across a low plain. The level represented by the floor of the older valley forms the crest-plane of the 50-feet scarp. On either side of the valley hills run up towards the plateau. Those to the south are composed of hard conglomerate, sandstone, and tuff. Secomb's Mount at Yessabah is 1,300 feet high, and many such residuals exceeding 1,500 feet occur in the much-dissected country on both sides of Dungay Creek.

A soft sandstone series forming part of a northward-plunging anticlinal structure has an arcuate outcrop between Bellbrook and Kempsey; this accounts for the course of the Macleay and for its broad valley.

The watershed between the Macleay and Hastings Rivers is very low to the south of Kempsey, and the railway-line runs through the gap. The Cooperabung Mountains and Mount Allen near Telegraph Point scarcely reach 1,000 feet, but represent the highest points in this district. The Wilson River has cut quite a broad valley to the west. This rather broken country gives way towards the sea to another large sandy plain comparable in size to that about the Macleay, and stretching from Crescent Head to the Hastings River.

The Lower Macleay Plain.

To an observer looking east from Gowing's Mountain at Dondingalong the Lower Macleay plain seems to be quite flat. The prominent hills, Smoky Cape and Korogoro Point, stand up from it like islands in a calm sea. A thin golden line between them marks a fourteen-mile beach, beyond which lie the blue waters of the Pacific. The low chain of hills to the south-east ends in Mt. Dulkoonghi, while on the north-east Mt. Yarrahapinni, rising to 1,700 feet, marks the northern boundary of the plain. In the foreground

Dungay Creek winds towards the Macleay, both streams entrenched in the wide valley, which can be seen to better advantage if one looks north-west. Through a gap in the hills near Anderson's Sugarloaf the flat-topped Dorrigo Plateau stands out to the north.

The Macleay leaves the rocky country at Kempsey and meanders through the level plain, collecting Christmas Creek, Belmore River and Kinchela Creek. Lines of farmhouses mark the levées on either side of the streams. During floods most of the plain is inundated, an indication of its uniformity of level. For a mile or more on either side of the river there is a veneer of alluvium, which thins out away from the river and passes into swamp-deposits of fine clay and black mud. Peaty material from reeds and grasses is slowly accumulating and aiding in the building up of the swamps into dry land. Much of the plain might be described as the lagoon marsh-meadow of Andrews.[1] The once extensive swampy areas have been drained and are now covered only after heavy rains. The swamp and lagoon water is fresh, but coloured brown by oils from the tea-trees which characterise the marshy country.

A special type of swamp is the crescentic lagoon occurring behind curving sand-dunes which follow the beach and prevent the water, which is generally a few feet above high tide, from draining seawards. During storms and specially high tides waves break through the sandhills and allow some of the water to escape, while salt water may mingle with the fresh. At Crescent Head the lagoon connects up with the sea only during exceptionally high tide periods. In January, 1934, seaweed was washed a mile from the entrance into the lagoon. The water here is generally quite salt or brackish, owing to the influx of sea-water, though after heavy rains it is fresh and flows into the sea.

Some of the plain is covered by wind-blown sand, which is freely mixed with the black swamp-muds. The sandhills have been formed through the combined action of wind and tide, and are held in place by abundant vegetation. They curve sympathetically with the beaches, and rise behind them to a height of more than 30 feet, but are piled up to hundreds of feet against the headlands. The dunes in the vicinity of Smoky Cape are particularly large. Between Smoky Cape and Korogoro Point there is a second line of sandhills at a distance, in places, of as much as

half-a-mile behind the present-day beach. This shows that the beach has advanced eastwards during comparatively recent times.

It is clear that the Lower Macleay plain marks the site of a former shallow bay.

Shell Deposits.

(a) *Oyster Beds.*

A heavy deposit of shells follows the somewhat irregular line of the old coast almost continuously from Grassy Head to Collombatti, keeping at about the same general height of 10 feet above high-tide level. *Ostrea cucullata* and *Arca trapezia* are the most common shells. An occasional gastropod is found, while human bones and pieces of flint have been reported from Collombatti. Most of the *Arca* shells have been broken at the posterior margin, a circumstance indicating that the deposit represents not a raised beach, but an aboriginal kitchen-midden. Anderson has noted that shell-deposits, probably middens, follow the margins of bays in the South Coast district of New South Wales, and it appears probable for the Kempsey area that the water in which the molluscs lived lapped the old cliffs during the human period, or, in other words, that the emergence which drove the sea eastwards occurred after the advent of the aborigines.

(b) *Estuarine Shell-Beds.*

Another deposit, quite different from the middens just described, is exposed by the Clybucca Drains, which cut through a bed of shells from one to two feet in thickness. This underlies at least 25 square miles of the plain, and almost certainly a much greater extent. The chief types represented are *Spistula trigonella* and *Arca trapezia*, typically estuarine forms. Similar shell-beds were met in a bore at Smithtown, one at 30 feet, and another at 50 feet below H.W.M. Sand-drift and clay, again indicating estuarine conditions, were found interbedded with the shell-beds to a depth of 70 feet, where bed-rock was struck.

There is thus evidence of a submergence of at least 70 feet, as the beds could not have been laid down under estuarine conditions at such depths with the sea at its present level. Without the sedimentary deposit which now fills the old bay the Macleay River would enter the

sea at Kempsey, and Smoky Cape, Korogoro Point, *etc.*, would be islands.

The shells, where exposed by the drain, are at about the level of high tide, but they are several feet above this near Mr. Plummer's house at Clybucca. Their presence above sea-level seems to demand an emergence of small magnitude following the deposition of the estuarine sediments.

The Old Macleay Gravels.

The gravels at Willawarrin and Sherwood were first noted by W. G. Woolnough,[8] who thought that they

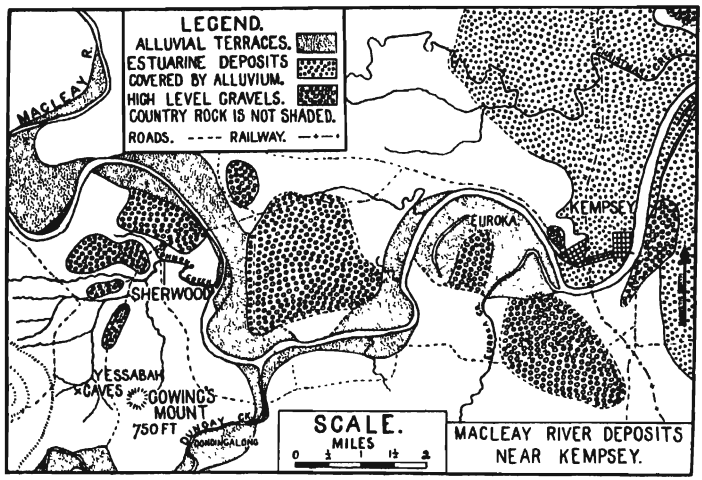


Fig. 2.—Macleay River Deposits near Kempsey.

were of Permo-Carboniferous age, probably because they have been cemented into a hard conglomerate and are associated with a Permo-Carboniferous limestone at the latter locality. These deposits, locally known as "ridge gravels," are very extensive around Sherwood, and they cap most of the hills between it and Bellbrook (Fig. 2). They consist generally of rounded pebbles of quartz, jasper, chert, slate and quartzite set in a sandy matrix. The level of the base of the gravel varies from 140 to 180 feet at Yessabah, but is only 80 feet near the Sherwood Bridge, where the Macleay River is 30 feet above sea-level. At Temagog boulders up to two feet across cover the hills at heights of over 100 feet above river-level, and at

Willawarrin they are about 200 feet above. Fine quartz-gravel is common about Kempsey, and is mixed with river-silts containing much iron oxide. The height of the base of the gravel varies greatly here, from about 30 feet in some localities to 100 feet in others.

These gravels are close to the present coast, but the coast-line was certainly further east when they were laid down, though exactly how much further we cannot say. The gravels are spread out over the floor of a broad valley in which the river has become entrenched. They have been cut into by Commong Creek.

The elevated position of these river-deposits is attributed to an uplift which was insignificant at the coast, but increased in magnitude to the west, so that the land-surface received a decided easterly tilt. This uplift took place at an interval after the main uplift represented by the time it took the Macleay to cut a broad valley in the plateau. Even though the river worked in soft rocks this period must have been considerable. Since then the river has only eroded a comparatively narrow valley. This valley has rocky banks which are faced with terraces at various levels. About Sherwood Bridge these are at heights of 5, 10, 25, and 50 feet above the river. The stream in places is eroding earlier-formed terraces. It would appear that the time that has elapsed since the entrenchment of the river has been small compared with that taken to cut the earlier broad valley.

Quartz-gravels many feet thick constitute most of the School Hill at Macksville on the Nambucca River. The base is 15 feet above river-level.

The Coast-Line.

(i) *Fossil Cliffs and Rock-Platforms.*

Where cliffs border the coast south of Woolgoolga they are fringed by rock-platforms just above high-tide mark. These have been worn away in places by the waves, and sand has covered the remnants, which are thus still influential in protecting the cliffs behind from attack. The shape of the cliffs indicates that they were formerly more exposed to the attack of the sea than they are at present. Old caves at the base are sand-filled, and the face of the slope is covered by vegetation.

The broad rock-platform at Nambucca Heads is cut out of strongly-folded phyllites, and the surface is almost

independent of the structures, showing that the explanation offered for the formation of some platforms in horizontal rocks is not applicable here. Furrows are at present being cut into the platform, indicating that the sea is at a lower level than it was when the platform was formed.

(ii) *Pulpit-Rocks.*

Masses of rock are found standing up from the rock-platforms or beaches along the shore. Wellington Rock at Nambucca Heads is one of these. It owes its fantastic shape to interlacing quartz-veins in phyllite. These pulpit-rocks do not seem to be undergoing much erosion at present. They are remnants of former cliffs which have been cut off by waves and left standing on the platforms. This could only have been done when the sea stood at a slightly higher level.

(iii) *Islands.*

The Solitary Islands off the coast were once residuals of hard rock on a coastal plain of denudation; they have been converted into islands by submergence.

(iv) *Land-Tied Islands.*

Like the Solitaries, Smoky Cape, Korogoro Point, Crescent Head, Point Plomer and all the coastal headlands between Grassy Head and Port Macquarie were formerly residuals standing on the plains of denudation around the Macleay and Hastings Rivers, and as a result of drowning became coastal islands. The area between them and the old coast, however, was never far below sea-level. In fact, during the drowning of the land, the accumulation of silts kept pace with the submergence, and sand-spits forming from the islands kept them in intermittent connection with the coast. It may also be that recent emergence helped to complete the work of currents and to tie the islands definitely on to the mainland.

(v) *Beaches.*

The land-tied islands are linked to each other by beaches which take on a characteristic zeta-curve, as described by Halligan.[6] He considers that the fourteen-mile beach between Smoky Cape and Korogoro Point is perhaps as good an example of the zeta-curve beach as there is on the coast. Halligan also states that the current impinging

upon the headland of Laggers' Point has scooped out sufficient land to form Trial Bay. Although the shapes of beaches are dependent on the currents, Trial Bay is accounted for by the fortuitous position of the former islands, Smoky Cape and Point Briner. These were linked together by sand-bars, thus giving rise to the projection of the coast which enfolds the bay.

The Lower Courses of the Rivers.

All the North Coast rivers flow through the flats representing their silted estuaries for some distance before entering the sea. As they have reached base-level and the modern estuaries are tidal, their entrances are dominated by ocean-currents and winds. All of them pass through salt-water lagoons before they reach the sea. These lagoons owe their existence in the first place to the formation of sand-banks isolating bodies of salt water, and their maintenance is due to their incorporation into the courses of rivers. The extra flow of water accomplishes what the lagoons could not do alone, and keeps a permanent connection with the ocean.

However, the scour of the river, already reduced through following a winding course across the plain, is not strong enough to keep a deep channel through the beach, and a wide, shallow entrance results, with some of the water flooding back into the lagoon. The Hastings River at Port Macquarie furnishes a good example. Its entrance has extended in recent years to about a mile across, with consequent shallowing, and salt-water lagoons stretch out to the north.

The Macleay River once had such an entrance near Grassy Head, after flowing behind the sandhills through an old lagoon area for several miles. During 1895 flood-waters broke through the southern end of the lagoon, and the main river cut across one of its own tributaries, Spencer's Creek, and formed a new mouth. The construction of two breakwaters to restrict the opening has been a successful project. The flow of the river and the tidal scour keep the channel deep enough for coastal steamers to enter.

Halligan's conclusions with regard to currents and the formation of sand-bars are very relevant when applied to the North Coast, but it does not seem that currents are directly responsible for all the curves of the rivers near the coast. He supposes that the Macleay, for instance, first entered the sea near South West Rocks, but was

forced to move northward by coastal currents, its mouth taking up successive positions until Grassy Head was reached. It may be suggested, however, that the Macleay first entered a lagoon, this being formed through the building of a sand-bank by coastal currents. The river happened to choose the site of the northern end of the lagoon for its entrance. The Hastings in a somewhat similar position chose the southern, influenced no doubt by the currents and the headland of Port Macquarie.

Warrell Creek should enter the sea near Scott's Head, but turns north, probably through a lagoon tract, to meet the Nambucca near its mouth. The main river is certainly being forced north. It cut into the phyllite headland as its southern bank advanced until the advance was checked by a breakwater. Now the entrance has become so shallow with the accumulation of sand that ships of any size cannot pass.

The Macleay and Nambucca have north-east trends as they flow through the plains. This is in all probability due to the operation of currents during the time when the strand-line was rising and the bay was silting up. The river entrances were continually being pushed towards the north. The present courses are probably very much the same as they were before the recent small uplift entrenched the rivers in the older silts.

Physiographic History.

The Pliocene period found Eastern Australia, and in particular the Middle North Coast District of New South Wales, at a lower altitude than at present. There was a Main Divide in somewhat the same position as today. This rose in places to a little over 3,000 feet, the main ridges and hills being composed of the most resistant rocks and solid structures. The hard rocks were mainly the New England granite massif and Lower Palæozoic schists and slates. South of the Nambucca River and east of Bellbrook on the Macleay highly folded Upper Palæozoic sediments of variable hardness had been worn down to an undulating plain. Volcanic activity ensued, thick basalt sheets covering the plains, filling in the river valleys and causing some re-organisation of the drainage. Then came the Kosciusko epoch, marking the close of the Tertiary Era and involving the slow elevation of the Main Divide some 2,000 feet with a tilt towards the coast, which was much further east than at present. The coastal

rivers rapidly cut downwards in an attempt to keep pace with the rising land, thus forming deep V-shaped gorges like that of the Apsley River. Nearer the sea the Macleay River followed a series of soft sandstones and tuffs from the site of Bellbrook to the coast, widening its valley until it reached harder units in the Lower Palæozoic phyllites to the north and the Carboniferous conglomerates and tuffs to the south. In the soft rocks also it formed a broad coastal plain of denudation with residuals of the harder tuffs and intrusive rocks. Brought from the hills,

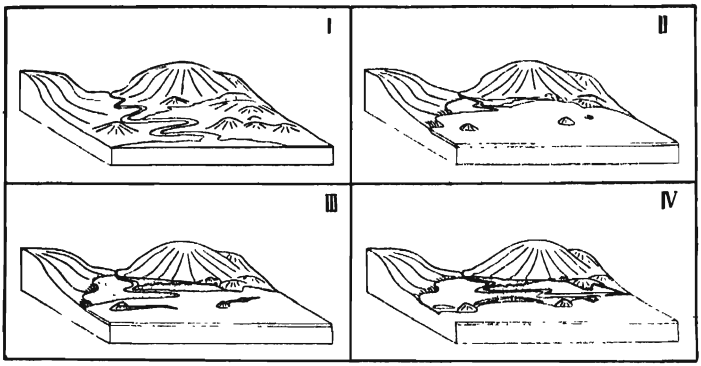


Fig. 3.—Stages in the Evolution of the Lower Macleay Plain.
I. A coastal plain of denudation with residuals.
II. Flooding of the plain by the rising sea.
III. The development of an internal delta and sandspits.
IV. Final stage, deposition being supplemented by small uplift.

boulders of jasper, quartzite, slate and sandstone were strewn out over the valley floor as the river slowed up and meandered through the broader valley. Nearer the present site of Kempsey the finer quartz-gravel and silt were deposited (See Fig. 3).

Later came a further uplift of the land, with a seaward tilt, which caused the Macleay above Kempsey to be entrenched in its older broad valley. Streams commenced to cut down into the older gravels, leaving them capping low hills, residuals of the valley floor. Much later still a submergence inundated the coastal plain and turned the residual hills upon it into islands. However, the sediment from the river, which now flowed into a shallow protected bay, built up the floor of the bay, giving rise to an internal

delta. As in the case of Narrabeen Lagoon,[5] accumulation balanced subsidence. Thus the estuarine shells *Spistula trigonella* and *Arca trapezia* became buried in sand-drift and river-silts. Sand-spits extended from island to island because of the shallowing of the sea-floor, and thus bodies of salt water were isolated from the sea.

The limit of sea-transgression was in the vicinity of Kempsey, and after the cessation of the transgression, since the forces of deposition were still dominant, alluvium spread over the swampy mangrove-flats. Aborigines by this time were living on the land behind the lagoons and swamps, and obtained their food largely from the abundant shell-fish living therein. Innumerable shells accumulated round the shores where the coast was not protected by sand-bars, and the waves cut rock-platforms and caves into the cliffs. The entrance of the Macleay was now in a broad lagoon separated from the sea by low sand-banks joining Grassy Head to Point Briner and Lagger's Point. A slight uplift of the land caused further narrowing of the lagoons and draining of much of the swampy land, while the rock-platforms were brought to a higher level and accepted the attack of the waves, which had previously been expended upon the cliffs behind.

Having incorporated the lagoon into its course, the Macleay sought an outlet to the sea to the north, influenced by winds and currents, and this was maintained until the more southerly entrance was formed in 1895. The northern entrance has since become completely closed.

A somewhat similar sequence of events has taken place in the case of the Hastings, Nambucca and Bellinger Rivers. The Hastings still enters the lagoons, which have not silted up so much as those of the Macleay.

Comparisons with other Coastal Areas.

It is interesting to note the differences in effect that the two most recent movements of the sea have had upon various portions of the Eastern Australian coast.

In the Sydney district the sea flowed into V-shaped gorges, giving rise to the typical drowned valley shore-line with the deep harbours of Port Jackson and Broken Bay. The subsequent small withdrawal did not cause much change in the form, merely exposing rock-platforms and aiding in the building up of small flats.

South of Sydney the drowning of less dissected country gave rise to a less indented shore-line, but owing to the

lack of large rivers, the slope of the sea-floor and the action of currents there was little deposition close to the shore. Hence, again, the effect of the emergence was to give elevated rock-platforms and small reclaimed areas and, in addition, some land-tied islands such as Red Head near Gerringong.

Next the Queensland coast between the New South Wales border and Brisbane may be considered. The drowning here is masked very successfully by the land which has been reclaimed from the sea. The inner shore-line may be considered to pass through Brisbane, but between it and the coast much low land is seen, through which project hills of older rock. Obviously the sea covered an undulating coastal plain, giving rise to a shallow island-studded bay.

Shallow Moreton Bay is little more than a great lagoon fenced off from the sea by the huge sandhills of Moreton Island. The rocky extremities of both Moreton and Stradbroke Islands have provided nuclei from which crescentic sand-bars project southwards, almost connecting with the mainland at Southport. If the emergence had been a little greater it would have caused the complete infilling of Moreton Bay, moving the outer shore-line from Sandgate to the eastern sides of Moreton and Stradbroke Islands.

The coast between the Nambucca and Hastings Rivers represents the most complete obscuring of the effects of the drowning owing to the removal of the shore-line to the outer islands produced through the drowning.

Ultimately the main factor in the evolution of the present coast-line has been the nature of the rock-material and its structures. Acting upon these the eroding agencies, notably running water, determined the degree of denudation before the drowning took place. Where soft Upper Palæozoic rocks form the coastal lands, the Nambucca–Hastings coast-type is formed, but where phyllites and schists are present the features which prevail between Woolgoolga and Nambucca Heads are met. Narooma and Tathra on the South Coast of New South Wales have much in common with North Head on the North Coast, especially in regard to cliffs, rock-platforms and stacks.

Acknowledgments.

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A NOTE ON THE OCCURRENCE IN NEW SOUTH WALES OF BLACK CHAFF OF WHEAT CAUSED BY *BACTERIUM TRANSLUCENS* VAR. *UNDULOSUM* S. J. AND R.

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Communicated by DR. W. L. WATERHOUSE.

(Read before the Royal Society of New South Wales, Nov. 7, 1934.)

INTRODUCTION.

Black chaff of wheat, caused by *Bacterium translucens* var. *undulosum*, was first described in 1917 by Smith[1] in U.S.A. Its occurrence has since been recorded in Canada, South Africa, France, Denmark, Russia and China. Under certain conditions it is capable of causing economic loss.[2]

This paper records the incidence, for the first time, of the disease in New South Wales, and describes experiments dealing with its identification.

THE DISEASE.

When the plant is half grown the disease becomes apparent, mainly attacking the more succulent parts. Water-soaked areas and yellowish stripes first appear, which may develop later into pale brown necrotic areas, but the constant and distinctive characteristic of the lesions is their translucency. Water-soaked areas occur also on the stems and ears, later developing into more or

*It is desired to acknowledge the excellent work of D. R. L. Steindl, student in Advanced Plant Pathology, in confirming all the experimental results, and the generosity of Dr. W. L. Waterhouse in allowing the publication of his personal experiences with this disease and in correcting the manuscript. The work was carried out with financial aid from the Endowment Fund of the Commonwealth Council for Scientific and Industrial Research.

[1] Smith, E. F.: A New Disease of Wheat, *Jour. Agr. Res.*, 1917, *10*, 51-54.

[2] Jones, L. R., A. G. Johnson and C. S. Reddy: Bacterial Blight of Barley, *Jour. Agr. Res.*, 1917, *11*, 625-644.

less sunken dark stripes. Under favourable conditions slimy drops of bacterial ooze may be seen on the lesions, sometimes coalescing to form a greyish film on drying. The bacteria may be carried in pockets in the grain, resulting in honeycombed and shrivelled kernels which, with a shortening of the spikes of infected plants, result in a diminished yield. As the plant matures the disease makes rapid progress.

For several years Dr. W. L. Waterhouse, of the University of Sydney, has noted these symptoms in commercial fields of wheat at Cowra, and in experimental plots at Bathurst, Cowra, Richmond and the Sydney University. Platings of similar specimens sent from other wheat areas of New South Wales have consistently given shining yellow bacterial colonies. The disease was noted as bacterial blight, but no attempt was made to identify the causal organism by the usual tests. It seems reasonably certain, however, that the yellow colonies were those of *Bacterium translucens* var. *undulosum*. If this assumption is true, then black chaff of wheat has been present for some time in New South Wales.

Early in 1934 heads of Hope wheat, which showed typical black chaff symptoms, were received from Glen Innes. In this year other varieties at the Hawkesbury Agricultural College, Richmond, showed an abundant infection of the flag. Further, seedling leaves of Hope and other varieties of wheat grown in the greenhouse from seed raised at Cowra, N.S.W., developed disease lesions. The central part of the leaf, at first water-soaked, died and collapsed, giving the leaf a scalded appearance, apparently identical with the " physiological breakdown " of leaf-tissues recorded by Johnston.[3]

In addition, pinched grains of Hope (Cowra, 1933) were surface-sterilised with 1/1000 mercuric chloride for seven minutes, cut in half, and planted on potato dextrose agar. Over 60% of these gave positive results. Platings of the material obtained from all these three sources produced yellow bacterial colonies, which were positively identified as *Bacterium translucens* var. *undulosum*. Stained microtome sections through grains of wheat suspected of containing the organism failed to reveal the presence of any bacteria.

[3] Johnston, C. O.: Studies on Physiological Specialisation in *Puccinia triticina*, *U.S. Dept. Agr. Tech. Bull.* 313, 1932.

Isolation, Infection and Control.

Morphologically and physiologically the organism fits the description given by Jones, Johnson and Reddy (*loc. cit.*) for *Bacterium translucens*. Cross inoculation experiments show that it is able to infect wheat and rye and is, therefore, *Bacterium translucens* var. *undulosum*. Cultures of the bacterium are being maintained and the studies continued.

Cultures were used to inoculate certain varieties of wheat, *viz.*: Canberra, Dundee, Emmer, Federation, Florence, Hope and Nabawa. Twenty seedlings, raised from sterilised grain, were grown in sterilised soil in each pot, half being inoculated and the remainder retained as controls.

Four methods of inoculation were used:

(i) Spraying a bacterial suspension on to grain before sowing;
(ii) Spraying a bacterial suspension on to leaves which previously had been lightly rubbed;
(iii) Prick inoculation;
(iv) Hypodermic inoculation.

The plants were grown in cages covered with coarse muslin, a temperature of approximately 25° C., together with high humidity, being maintained. The best results were obtained from the third and fourth methods of inoculation, typical black chaff symptoms being produced in all inoculated plants. The organism was re-isolated from such infected areas and identified.

Little is known concerning the relative resistance of wheat varieties to black chaff. Hope, a variety valuable for certain plant-breeding purposes, is highly susceptible. In the experience of the writer Federation, grown under greenhouse conditions, is less susceptible than Hope. The organism has been isolated from plants of the following varieties of wheat growing in the field: Baringa, Bobin, Canberra, Ceres, Dundee, Federation, Florence, Hope, Nabawa and a number of Hope hybrids.

Some form of seed treatment, such as steeping in mercuric chloride or formalin, has been shown by workers abroad to reduce the amount of black chaff. Preliminary tests by the writer in the greenhouse at the Sydney University indicate that the hot water treatment for the prevention of loose smut in wheat also reduces infection by black chaff.

COMPOUNDS OF PALLADIUM WITH BENZILDIOXIME.

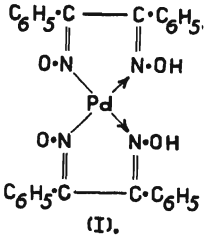
By F. P. DWYER, M.Sc.,
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(*Read before the Royal Society of New South Wales, Nov. 7, 1934.*)

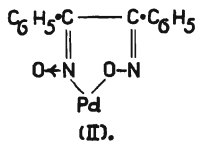
In marked contrast to the extensive work carried out on the co-ordination compounds of dioximes with iron, nickel, cobalt and copper (Thilo: Die Valenz der Metalle Fe, Co, Ni, Cu, und ihre Verbindungen mit Dioximen, *Sammlung chemischer-technischer Vortrage*, begrundet von F. B. Ahrens, Neue Folge, Heft 13) the published work relating to palladium is confined to compounds formed with dimethylglyoxime and benzoylmethylglyoxime. In connection with experiments dealing with the isomerism of the palladium bisbenzylmethylglyoximes, it was considered advisable to investigate the compounds of palladium with benzildioxime, a dioxime which has been separated into the three isomers predicted on the basis of of the Hantzsch-Werner hypothesis. This course became necessary since there was definite evidence that benzylmethylglyoxime was not simple, as suggested by Sugden (*J. Chem. Soc.*, 1932, 246), but a complex mixture of some, or all, of its four possible isomers. The object of the following experiments, therefore, was to ascertain which form, or forms, of benzildioxime were capable of producing four-covalent inner complexes with palladium. As regards the type of compounds produced with the different forms of benzildioxime, palladium shows some resemblances to, as well as some differences from, nickel. Thus, it was found that palladium, like nickel (Atack, *J. Chem. Soc.*, 1913, *103*, 1317) forms a compound (I), in which two molecules of the dioxime are co-ordinated with the metal, only in the case of the α-(anti) benzildioxime.* Also, in analogy with nickel, the γ-(amphi) dioxime forms an orange-yellow compound (II), in which one molecule only of the dioxime is combined with palladium. No other compound of palladium with γ-benzildioxime, could be

* The dioxime configurations of Meisenheimer, *Ber.*, 1921, *54*, 3206, are used throughout.

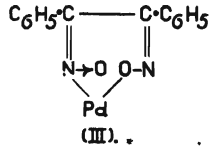
prepared. However, unlike all other metals, palladium, in neutral and acid solutions, co-ordinates with the β-(syn) form of the dioxime to form a compound (III).



(I).



(II).



(III).

On account of its high specificity, β-benzildioxime may be used as an analytical reagent for the detection of palladium.

Experimental.

α-Benzildioxime.

This was prepared by the modified method of Brady and Perry (*J. Chem. Soc.*, 1925, *127*, 2874), and melted at 235° C. Owing to the insolubility of the dioxime in organic solvents, the palladium compound was made with difficulty by the addition of a boiling alcoholic solution to a boiling neutral solution of sodium chloropalladite. A certain amount of reduction by the alcohol took place, and this palladium could not be removed from the orange-yellow α-benzildioxime complex.

An alternative method of preparing this compound was to boil palladium γ-benzildioxime with excess of α-benzildioxime, in acetone solution. Excess of α-benzildioxime and the displaced γ-benzildioxime could be removed by treating with cold dilute caustic soda solution.* The substance, which was analysed by a micro-method (Pregl, "Quantitative Organic Microanalysis", p. 135), was heated with two drops of concentrated sulphuric acid, then strongly heated in a current of hot air in a micro-muffle until decomposition to palladium was complete. All analyses for palladium were made by this method, using five to six milligrammes of the substance.

$Pd(C_{14}H_{11}N_2O_2)_2$ requires Pd 18·2%; Pd found, 18·5%.

* Evidence was obtained of the existence of an intermediate compound of palladium containing both α and γ-benzildioxime. However, this type of compound will form the subject of a later paper by one of us (F.P.D.).

β-Benzildioxime.

This substance was prepared by the method of Brady and Perry (*J. Chem. Soc.*, 1925, *127*, 2874), and was freed from traces of the α-form by the addition of a boiling acetone solution to a hot, slightly ammoniacal solution of nickel sulphate, and melted, after recrystallisation, at 212° C. When added, in acetone or alcoholic solution, to a solution of sodium chloropalladite and sodium acetate, it gave the palladium complex as a pale yellow precipitate.

$Pd(C_{14}H_{10}N_2O_2)$ requires Pd 30·95%; Pd found, 30·9%.

Freshly precipitated palladium β-benzildioxime is quite soluble in benzene. If, however, after being dissolved in benzene it is reprecipitated by adding petroleum ether, and allowed to stand for some time, its colour changes to a dark brown. The dark brown substance is insoluble in benzene. The nature of the change is not clear, and it is intended to investigate this compound further. β-benzildioxime precipitates palladium quantitatively from dilute hydrochloric acid solution to which sodium acetate has been added. Under similar conditions platinum, rhodium, ruthenium, gold, nickel and all the other common metals tried, failed to form any insoluble compound with β-benzildioxime. Thus β-benzildioxime appears to be quite specific for palladium, under the above conditions. The reagent can be used to detect a minimum concentration of 3γ/ml. of palladium. This test is not so sensitive, therefore, as that employing dimethylglyoxime, which is also specific for palladium in acid solution (Gilchrist, Bureau of Standards, Journ. of Research, 1934, *12*, 283).

Repeated attempts were made to estimate palladium quantitatively with β-benzildioxime by a Gooch crucible method. Owing to the nature of the precipitate filtration was extremely slow, and for this reason this reagent is quite unsatisfactory for quantitative estimations.

γ-Benzildioxime.

This was prepared by the method of Auwers and Meyer (*Ber.*, 1899, *22*, 705), and melted at 170° C. The addition of a cold alcoholic solution to a solution of sodium chloropalladite and sodium acetate gave the palladium compound as a bright yellow precipitate, soluble in acetone and benzene to an orange-yellow solution.

$Pd(C_{14}H_{10}N_2O_2)$ requires Pd 30·95%; Pd found, 30·5%.

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THE FASTNESS OF CERTAIN AMINO-AZO DYES TO WASHING.

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(*Read before the Royal Society of New South Wales, November 7, 1934.*)

In the course of an investigation on the formation of amino-azo from diazo-amino compounds, it was observed that N-benzyl-amino-azo-benzene, when dyed on wool from a dilute hydrochloric acid bath, yielded a dyeing which was faster to washing that that of some other amino-azo compounds. A study of this phenomenon on a roughly quantitative basis was therefore undertaken.

The series amino-azo-benzene, methyl-amino-azo-benzene, di-methyl-amino-azo-benzene, benzyl-amino-azo-benzene and benzyl-methyl-amino-azo-benzene was first selected for examination. One gram of amino-azo-benzene, or the molecular equivalent of this in the case of the other compounds, was dissolved in alcohol (70 ccs.), conc. HCl (7 ccs.) and 200 ccs. of water. The solution was brought to the boil in a beaker covered with a clock glass and 1 gm. of wool immersed in the solution for eight minutes. The wool was squeezed out, washed for five minutes in a 100 ccs. cold sodium acetate solution, rinsed in 100 ccs. of cold water, and allowed to dry.

An equivalent small fraction of the wool was removed in each case, and the remainder boiled for 30 minutes in 100 ccs. of water. When cold the wash was made up to a definite volume, 100 ccs. in most cases, but 250 ccs. in the case of the methyl compound and 500 ccs. in that of the di-methyl compound. The two last-named washes were pink in colour before dilution, indicating a certain degree of acidity.

Standard solutions were prepared by dissolving 0·1 gm. of each substance in 20 ccs. of alcohol and diluting 1 cc. of this solution to 250 ccs. with water. The standard and wash solutions were then compared in a colorimeter, 1 cc. of a saturated sodium acetate solution being added to

each 10 ccs. of every solution to guarantee approximately equivalent acidity conditions.

From the comparisons the following results were arrived at:

Substance.	Mgms. Washed Out. (Mean of two determinations.)	Mgms. Washed Out × 1,000 ÷M. Wt.
Amino	0·255	1·29
Methyl-amino	0·455	2·16
Di-methyl-amino	0·605	2·69
Benzyl-amino	0·560	1·94
Benzyl-methyl-amino	0·083	0·36

A similar series of comparisons was made with the *p*-sulphonic acids of the last four of the above compounds with parallel results. Equimolecular quantities of the sodium salts (corresponding to 0·0250 gm. of the amino compound) were dissolved in water (150 ccs.), 5 ccs. of a solution of sodium bisulphate (20 gms. in 200 ccs.) added, and the solution brought to the boil; 1 gm. of wool was added, the bath being kept at the boil for 45 minutes; the wool was squeezed out, rinsed for five minutes in 100 ccs. of cold water, and dried. Small samples of each were kept, and the remainder boiled for thirty minutes in 100 ccs. of water. The wash solutions were made up to 100 ccs. and compared with standards containing 0·001 gm. per 100 ccs.; sodium acetate was used as before.

Substance.	Mgms. Washed Out.	Mgms. Washed Out × 1,000 ÷M.Wt.
Methyl-amino	2·30	7·35
Di-methyl-amino	2·34	7·15
Benzyl-amino	1·67	4·29
Benzyl-methyl-amino	0·97	2·40

It is apparent from these results that the substitution of one of the hydrogens of the amino group by benzyl tends to give a dye which is faster to washing than the corresponding methyl substituted compound, while the substitution of the second hydrogen by methyl results in a very much greater improvement in fastness to washing.

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THE MOISTURE EQUILIBRIUM OF TIMBER IN DIFFERENT PARTS OF NEW SOUTH WALES.

PART II.—MURWILLUMBAH.*

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(*Read before the Royal Society of New South Wales, November 7, 1934.*)

During the latter part of 1930 and in 1931 and 1932 a timber moisture equilibrium survey was carried out in various parts of New South Wales, and the results obtained from a number of centres were published in this Journal, 1933, *67*, 364–75. Unfortunately the returns from Murwillumbah were not forwarded in time for inclusion, but since the North Coast of New South Wales is an important timber-producing area it is desirable that the results of the investigation should be published, since they may give some indication of the moisture conditions in air-seasoned timber at different periods of the year. This station was chosen because it was thought that it would possibly give the highest humidity conditions experienced on the North Coast, but no figures are available to enable a comparison to be made with the Dorrigo plateau.

The general conditions of the experiment have already been described in the earlier paper, but they can be briefly summarised as follows: Ten woods were used, each measuring $6'' \times 3'' \times \frac{1}{2}''$, dressed, but without end-coatings; all samples were placed in well-ventilated rooms, Nos. 1, 3, 5, 7, 9 with a southerly, and Nos. 2, 4, 6, 8, 10 with a northerly aspect, and were weighed each Tuesday, except during school vacations. At the completion of the experiment the timbers were returned to Sydney, oven-dried to constant weight, and the moisture contents calculated. The results of the investigation are given in Table I.

* Grateful acknowledgment is made to the Headmaster of Murwillumbah High School, who obtained the necessary data for this paper, and to the Director of Education, who authorized the investigation at the school.

TABLE I.—*Mean Monthly Percentage of Moisture for each Timber.*

	1	2	3	4	5	6	7	8	9	10	Mean
1930—											
October ..	13·8	12·4	13·2	14·7	14·0	13·2	14·4	13·3	12·6	12·9	13·5
November ..	13·0	11·9	12·8	14·3	13·7	13·0	13·4	12·9	12·2	12·6	13·0
December ..	12·5	11·6	12·7	14·0	13·5	12·8	13·0	12·6	11·9	12·3	12·7
1931—											
March ..	16·3	13·6	15·8	15·7	16·2	14·5	17·1	14·5	14·1	14·0	15·2
April	14·6	12·5	14·3	14·5	14·7	13·5	15·0	13·2	13·7	12·9	13·9
May	15·9	13·9	15·3	15·2	15·7	14·1	16·6	14·7	15·4	13·8	15·1
June ..	14·7	12·4	14·6	14·5	14·9	13·3	15·2	13·3	13·9	12·9	14·0
July	13·4	11·1	13·6	13·8	14·1	12·8	13·7	12·0	12·6	12·0	12·9
August ..	13·0	10·3	13·4	13·3	13·8	12·5	13·0	11·3	12·1	11·4	12·4
September ..	13·0	10·0	13·3	13·3	13·6	12·4	12·6	11·8	12·2	11·7	12·4
October ..	12·2	10·6	12·5	12·8	12·6	11·9	12·6	11·1	11·6	11·1	12·0
November ..	14·3	12·6	14·2	14·2	14·6	13·4	14·9	13·3	13·8	12·9	13·8
1932—											
February ..	13·1	11·7	13·0	13·7	13·4	12·8	13·4	12·4	12·3	12·2	12·8
March ..	12·9	11·5	13·0	13·5	13·4	12·6	13·4	12·3	13·4	11·9	12·8
April	13·2	11·3	13·3	13·5	13·7	12·7	13·6	12·3	12·4	12·0	12·8
May	13·7	11·6	13·6	13·6	13·9	12·7	14·0	12·3	12·9	12·1	13·0
June ..	13·6	11·7	13·6	13·8	13·9	13·1	14·1	12·4	13·1	12·2	13·2
July	13·1	11·9	13·2	13·2	13·5	12·4	13·5	11·6	12·2	11·5	12·6
August ..	13·6	11·4	13·4	13·1	13·7	12·2	14·2	11·9	12·9	11·7	12·8
September ..	13·8	12·0	13·7	13·7	14·0	12·8	14·4	12·1	13·1	12·3	13·2
Mean ..	13·7	11·8	13·6	13·9	14·0	12·9	14·1	12·6	12·9	12·3	13·2

1 = Queensland kauri (*Agathis Palmerstoni*).
2 = Hoop pine (*Araucaria Cunninghamii*).
3 = White cypress pine (*Callitris glauca*).
4 = Tallow-wood (*Eucalyptus microcorys*).
5 = Blackbutt (*Eucalyptus pilularis*).
6 = Spotted gum (*Eucalyptus maculata*).
7 = Queensland maple (*Flindersia Brayleyana*).
8 = Coachwood (*Ceratopetalum apetalum*).
9 = Silky oak (*Cardwellia sublimis*).
10 = Pacific maple (*Shorea* sp.).

With respect to individual timbers the results are similar to those previously obtained, *e.g.* Hoop Pine showed the lowest mean of 11·8%, and Queensland Maple the highest mean of 14·1%. The average equilibrium figures for Hoop Pine and Pacific Maple appear to be in the vicinity of 12%, Coachwood, Silky Oak and Spotted Gum about 13%, and Queensland Kauri, Cypress Pine, Tallow-wood, Blackbutt, and Queensland Maple about 14%.

At several periods during 1931 the average monthly percentage of moisture for a number of timbers, including Blackbutt and Tallow-wood, was above 15%, and since it is to be expected that even higher figures would have been obtained if the timber had been outside, it seems obvious that during periods of high atmospheric humidity it is not possible to air-season certain hardwoods to the

maximum content permitted by the Standards Association of Australia in seasoned flooring.*

The actual maximum and minimum weekly moisture percentages are given in Table II.

TABLE II.—*Maximum and Minimum Weekly Moisture Percentages for each Timber.*

	1	2	3	4	5	6	7	8	9	10
Maximum	16·3	14·2	15·8	15·7	16·2	14·5	17·1	15·2	15·9	14·0
Minimum	11·2	8·8	12·0	12·3	12·5	11·6	11·3	9·7	10·4	10·3
Variation	5·1	5·4	3·8	3·4	3·7	2·9	5·8	5·5	5·5	3·7

As in the previously published results for other centres, Spotted Gum showed the minimum variation with 2·9%, whilst Queensland Maple gave the maximum variation of 5·8%. Tallow-wood was next to Spotted Gum with 3·4%, followed by Blackbutt and Pacific Maple 3·7%, Cypress Pine 3·8%, Queensland Kauri 5·1%, Hoop Pine 5·4%, and Coachwood and Silky Oak 5·5%. A minimum of 8·8% was found in Hoop Pine in July, 1931, and a maximum of 17·1% in Queensland Maple in March, 1931.

The mean moisture content of all timbers over the whole period was 13·2%, whereas similar timbers under the same conditions in Sydney gave a mean of 12·0%.

The combined mean monthly relative humidity percentages and mean monthly moisture percentages are given in Table III.

From an examination of the figures given in Table III there does not appear to be any pronounced seasonal variation in moisture content. For example, the maximum figure for 1931 was 15·2% in March, yet in 1932 this month, with 12·8%, was the second lowest; again in 1931 the maximum was in March and the minimum in October; in 1932 the maximum was in June and September and the minimum was in July. It seems, therefore, that periods of high moisture content are liable to occur at almost any period throughout the year.

The relative humidity figures for Murwillumbah were compiled from data supplied by the High School, whilst the Lismore figures were supplied by the Commonwealth

* Technical Standard No. O.3, 1934, "Australian Standard Grading Rules for Milled Flooring," Standards Association of Australia, Sydney.

TABLE III.—*Mean Monthly Moisture Percentages and Mean Relative Humidities at Murwillumbah and Lismore.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1930—												
M% ..	—	—	—	—	—	—	—	—	—	13·5	13·0	12·7
r.h.M.	—	—	—	—	—	—	—	—	—	—	—	—
r.h.L. ..	—	—	—	—	—	—	—	—	—	68	56	58
1931—												
M% ..	—	—	15·2	13·9	15·1	14·0	12·9	12·4	12·4	12·0	13·8	—
r.h.M.	72	79	88	81	88	85	81	82	74	70	77	71
r.h.L. ..	60	77	81	72	81	78	71	75	67	59	68	69
1932—												
M% ..	—	12·8	12·8	12·8	13·0	13·2	12·6	12·8	13·2	—	—	—
r.h.M.	68	69	72	81	86	85	84	78	77	72	71	65
r.h.L. ..	65	70	76	77	83	75	72	71	70	64	59	59
Mean M%	—	12·8	14·0	13·4	14·1	13·6	12·8	12·6	12·8	12·8	13·4	12·7
Mean r.h.M.	70	74	80	81	87	85	83	80	75	71	74	68
Mean r.h.L.	63	74	79	75	82	77	72	73	69	64	61	62

M% = Mean monthly moisture percentage for all timbers.
r.h.M. = Monthly average of daily relative humidities at 9 a.m. at Murwillumbah.
r.h.L. = Monthly average of daily relative humidities at 9 a.m. at Lismore.

Meteorological Bureau, that being the nearest station to Murwillumbah for which records were available.

A comparison with the figures given in the previous paper for Sydney shows that the relative humidity was considerably higher at Murwillumbah, although at Lismore the increase was less appreciable. The variation between summer and winter conditions was considerably less than that experienced at many inland centres, and is more comparable with the variation found at Sydney. An examination of the individual monthly records for both Murwillumbah and Lismore shows that even during the winter months mean humidities occur which are even lower than those found to occur during the summer. In general, October to January appears to be the driest period, if the figures given can be accepted as being typical of conditions experienced during other years.

SUMMARY.

During the period October, 1930, to October, 1932, a moisture equilibrium investigation was conducted at Murwillumbah, New South Wales. It has been found that in general the atmospheric humidity conditions are higher than at Sydney, and the mean moisture content of ten different timbers kept indoors over the period was 13·2%,

whereas similar timbers under the same conditions at Sydney showed a mean of 12·0%. Periods of very high humidity were found to occur, during which the mean monthly moisture content for timbers such as Tallow-wood and Blackbutt was in the vicinity of 16% and that for Queensland Maple exceeded 17%. During such periods satisfactory air seasoning of timber for the Sydney market does not appear to be practicable.

STONE SCRAPERS: AN INQUIRY CONCERNING A CERTAIN CONVENTIONALIZED TYPE FOUND ALONG THE COAST OF NEW SOUTH WALES.

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Communicated by ASSISTANT PROFESSOR W. R. BROWNE.

(With Plates I-VI and seven text-figures.)

(*Read before the Royal Society of New South Wales, Nov. 7, 1934.*)

DESCRIPTIVE.

Flaked Types from the Coast.

The flaked stone implements found along the coast of New South Wales may be placed in the following divisions:

(1) Conventionalized scrapers, to which the name "Elouera"[26] has been given [Plate I (*b*)];
(2) unconventionalized flakes showing retouch;
(3) chipped "points"—a conventionalized type [Plate I (*a*)];
(4) flaked knives.

The implements mentioned in division (1) form the subject of this paper. They have been described by certain writers as chipped-back knives.[25] [9] I shall show that they really belong to a whole series of scrapers, and that they are comparable to the conventionalized scrapers found along the Darling and Paroo Rivers.

For convenience in the following pages I shall refer to "coastal" types, flakes, *etc.*, and to "Darling and Paroo" types, flakes, *etc.* "Coastal" refers only to that part of the coast of New South Wales between Port Macquarie and Bateman's Bay; and "Darling and Paroo" refers to the areas along those rivers from Wilcannia northwards towards the Queensland border. The accompanying

* I desire to offer my sincere thanks to Professor A. P. Elkin for kind assistance, also to Mr. S. Moriarty for making the drawings for the text-figures, and to Mr. G. C. Clutton for the photographs from which the plates were made.

sketch-map (Fig. I) indicates the positions of the various areas mentioned.

The unconventionalized flakes showing retouch, which I have mentioned in division (2), belong to the scraper family. Similar flakes are found almost everywhere in Australia. Of the chipped implements they form the largest class. They exhibit all varieties of shape, and have been retouched to suit the requirements of the job in hand—for scraping, planing, graving, and so on.

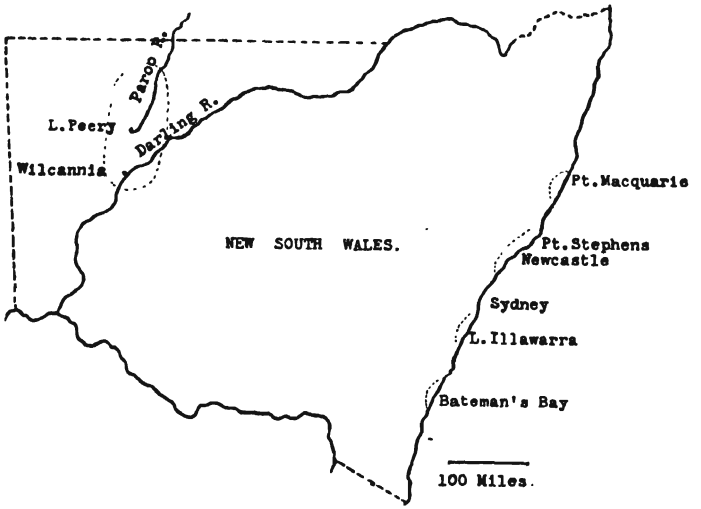


Fig. 1.—Map of New South Wales, showing the districts referred to in the text.

The separating of the conventionalized scrapers in division (1) from very many of the unconventionalized scrapers placed in division (2) is arbitrary. With large numbers of the implements there is always some doubt whether they should be placed in the one division or the other, but for the purposes of classification a separation is desirable. It is based on the form of the implements rather than on the method in which they were used. Those implements which possess in common certain formal characteristics have been placed in division (1), and treated as a conventionalized type. They are generally well developed, and in this paper I shall consider them in detail. Without any doubt they possess the characteristics which are common to implements of the scraper family.

They are not (as some writers have conjectured) chipped-back knives.

The chipped " points " mentioned in division (3) are a well-developed type. They differ from the elouera in two ways : they are very slender flakes, their length being their greatest dimension, and they are usually pointed at the distal end. They resemble the elouera in general form (they are asymmetrical), and in marginal retouch.* Some of the explanations given of the use of the " point " are quite inadequate. They have been called chipped-back knives, chipped-back surgical knives, chipped-back cicatrizing knives, chipped-back scarifying knives. It would not be difficult to show that none of these descriptions takes into account the form and the distribution of the implement. Much further investigation will have to be made before a satisfactory description can be attempted.

There seems to be no doubt that the " points " were generally made of the best available material, which would respond to the finest retouch. There are reasons for stating that certain materials were used in greater proportions for the " points " than for the eloueras.

The flaked knives mentioned in division (4) are of importance.[10] They are unchipped flakes, and for that reason are not usually taken into account as implements. According, however, to the evidence of observers in many parts of Australia, the aborigines used unchipped flakes freely as cutting implements.[21] It is not usually possible to discriminate between the unchipped flakes, as such, and those which have actually been used as knives, but the widespread distribution in Australia of implements of this simple kind must not be disregarded.[2] Roth[17] states that a knife is " always sharper " with an untrimmed edge. Wherever flake-work has been carried out, the unchipped flakes greatly exceed the chipped flakes in numbers.

In addition to the implements already mentioned, certain conventionalized types (such as the crescent) which occur plentifully in some other areas are occasionally

* See Pulleine, R. H. : " The Tasmanians and their Stone Culture " (A.A.A.S. Report, Hobart, 1928, p. 304) for the different kinds of retouch. In this paper I am concerned only with marginal (or scraper) retouch. I regard this term as being synonymous with marginal or secondary chipping, or with any other terms used to mean that the margin of the flake has been " touched up ", for the purpose either of sharpening or of improving its working edge.

found along the coast. Because of their scarcity they should not be regarded as separate coastal types. They are really variant forms. On a later page I shall deal with these variations from the type.

Perhaps another division should be added [Plate I (*c*)]. Pieces of material—usually not more than one inch across, and somewhat rectangular or square in form—are found on all the camping-grounds. They are usually stone scraps—not whole flakes—which have been chipped to a working edge from *both* sides. These are the so-called "button" flakes or scrapers. Many of them would have been suitable for gouging or graving purposes.

Material Used Along the Coast.

Along the coast the material used for the flaked implements varied greatly. The aborigines used a hard felspathic sandstone and a chert of the poorest quality in the north near Port Macquarie, a coarse-grained porphyry and a fine-grained chert near Port Stephens, a fine-grained chert near Newcastle, silicified wood, jasper and chalcedony in the Illawarra district, and porphyry and quartzite on the South Coast near Bateman's Bay. This great variety of material* produced several interesting variations in the flakework; but throughout the area, the implements were essentially asymmetrical in form. On the whole, the material was refractory, some of it very refractory. We shall ignore the several local differences which may be observed in the flakework from these coastal areas, as they do not affect the present discussion. However, it may be well to note that the coastal implements vary greatly in size. In the Newcastle and Port Stephens districts, for instance, we find implements ranging from seven inches—a large and massive form—to very small specimens of not more than one inch in length [Plate I (*d*)]. In the Illawarra district we do not usually find implements greater than two inches in length [Plate I (*b*)]. On the South Coast, near Bateman's Bay, we find implements slightly larger in size than those from the Illawarra district. At Port Macquarie, in the north, the stone flaked so poorly that the implements of the hard felspathic sandstone are usually large and unconventionalized. The chert flakes found in the same locality are of inferior material and few, if any, of them conform to the conventionalized types.

* I have mentioned only the principal materials used in the different localities.

Material Used Along the Darling and Paroo Rivers.

On the Darling and Paroo Rivers the material used for flaking does not vary so greatly as that found along the coast. Nearly all the flakes are of quartzite which, however, varies greatly in quality from a coarse-grained to a very fine-grained, porcelain-like material. Some of the coarser-grained varieties appear in some respects to be rather refractory for flaking purposes, but the finer-grained material flakes well. Near Wilcannia, and for some distance to the northwards, a coarse-grained material was used almost universally, and the conventionalized type-implements are very few in number in comparison with the great quantities of chipped flakes which may be readily collected. Further north, along the Paroo River, as at Lake Peery, some of the material used by the aborigines was very fine-grained and of good flaking quality. In such areas the conventionalized type-implements are found much more plentifully. We must, however, keep in mind that even at Lake Peery a large proportion of the material used for flaking was coarse-grained.

The flaked implements found in this area show clearly how greatly form depends on material. There is no doubt that the fine-grained and more homogeneous materials produced by far the greater number of implements belonging to the conventionalized types.

Flaked Types from the Darling and Paroo Rivers.

The flaked implements from the Darling and Paroo Rivers may be placed in the following divisions :

(1) Conventionalized scrapers, to which I shall compare the coastal conventionalized scrapers [Plates IV (*g*) ; V ; VI (*a*), (*b*)] ;
(2) unconventionalized chipped flakes ;
(3) symmetrical " points "—a conventionalized type [Plate IV (*e*)] ;
(4) crescents—a conventionalized type [Plate IV (*f*)] ;
(5) adzes—a conventionalized type [Plate VI (*c*)] ;
(6) knife flakes, comparable to those mentioned in division (4) of the coastal implements.

As with the coastal implements, it is difficult to decide whether some of the scrapers should be placed in division (1) or (2). The implements in divisions (3) and (4) are rarely found along the coast. The adzes, mentioned in division (5), were hafted for use. They do not occur along the coast.

Marginal Retouch and its Significance.

Before dealing with the main subject, it is necessary to mention one important matter. Aiston[1] has pointed out that nearly all the chipped stone tools found on camping-grounds have been used and discarded. Those who have done extensive collecting must endorse this statement. As an instance, on the Darling and Paroo Rivers I have collected hundreds of worn-out adzes (those which have been used in a haft) and relatively few unused or slightly used specimens [Plate VI (*c*), (*d*)]. Describing the scrapers used by the aborigines near Lake Eyre, Aiston[1] has shown how they were sharpened with a hammer-stone as they became blunt, and finally, after they had become too blunt for further use, they were thrown away. Such are the flaked implements which we usually collect on camping-grounds, whether they be in Central Australia, in the far west of New South Wales, along the coast, or elsewhere.

It is important, therefore, to keep in mind that marginal retouch was done in the process of sharpening the cutting edge of the implements as they became blunt in use; and, in this paper, I shall classify the conventionalized scraper types in accordance with the position of the marginal retouch on the flakes.

Material and Its Influence on Type.

In order to understand any of the flaked stone implements of the aborigines, I believe that it is necessary to commence with a study of the flakes themselves. In general, the form of the flake, more than any other factor, controls the form of the implement: and the retouch, being marginal, does not usually modify very greatly the original form of the flake. For this reason it is possible to follow the process by which the aborigines developed their implements from the flakes. Spencer and Gillen[22] have remarked that the implements of the Arunta were " of a very simple nature ", and this statement applies to all the stone implements found in Australia.

Symmetrical and Asymmetrical Conventionalized Types.

For the purposes of this paper, it is necessary to deal with the flakes in two ways:

(1) According to their cross-sectional form, and

(2) according to their longitudinal shape.

We have to try to discover the reasons for the occurrence of asymmetrical implements along the coast (Plates I,

II, III). Why do they not also occur as normal types along the Darling and Paroo Rivers? The asymmetrical form of the coastal flake is further emphasized because the retouch is usually along the side [Plate II (*a*), (*b*), (*c*) ; Fig. 6 (*a*)]. What are the reasons for this?

In contrast to the asymmetrical flakes from the coast, we find that along the Darling and Paroo Rivers the flakes are generally much more symmetrical in form, and that the retouch is most frequently at the distal end [Plates V, VI (*a*), (*b*)]. For the purposes of comparison, we may consider the flakes from this area as representing the symmetrical type. Perhaps the best examples of symmetrical implements are the long flaked knives from Central Australia, as described by Spencer and Gillen[22] [Fig. 2 (*d*)]. The implements from the Darling and Paroo

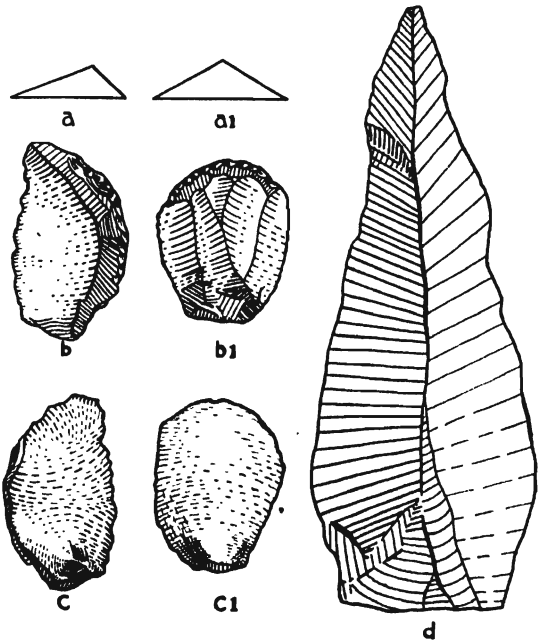


Fig. 2.—*a*, *b*, *c*, asymmetrical implement, coastal conventionalized type; and *a1*, *b1*, *c1*, symmetrical implement, Darling and Paroo rivers, showing the idealized cross-sections, the lower (the faceted) surfaces, the upper (the plane) surfaces; *d*, symmetrical knife flake from Central Australia. Compare with figures *b* and *b1*. Size, approximately half actual.

Rivers possess the characteristics of symmetry, but frequently the facets on the lower surface have removed all traces of the median ridge.

In this paper, the term *asymmetrical* means that the longitudinal ridge on the lower* surface of the flake, considered as an ideal form, is not a median ridge [Fig. 2 (*b*); Plate I (*b*); II (*a*)], and that the bulb of percussion on the upper* surface is usually not quite medially situated at the butt end of the flake [Fig. 2 (*c*); Plate II (*b*)]. On the other hand a *symmetrical* implement, considered as an ideal form, is one on which the median ridge on the lower surface divides the flake into two equal parts longitudinally [Fig. 2 (*d*)], and the bulb of percussion on the upper surface is medially situated at the butt end of the flake [Fig. 2 (*c*1)].

In these descriptions I am merely attempting to summarize the essential differences revealed in the ideal type implements from the two areas. In dealing, however, with the implements generally, the terms must not be interpreted too rigidly. Frequently the variations in form are considerable. Strict adherence to form must not be expected in the flaked stone implements of the aborigines; but, *by contrasting* the flakes which have been used for the type implements in the one area with those which have been used for the type implements in the other area, the one series is seen to be essentially symmetrical, the other essentially asymmetrical.

The Differences between the Implements from the Coast and those from the Darling and Paroo Rivers.

The problem to be dealt with, therefore, may be stated in the following terms. We have to try to discover why the flakes along the coast are generally asymmetrical and why the conventionalized scrapers are principally side scrapers. We have to consider why they differ from the flakes from the Darling and Paroo Rivers where the flakes are more symmetrical in form and the conventionalized scrapers are principally end scrapers.

It seems to me that the two principal reasons for the differences between the coastal and the Darling and Paroo implements are:

(1) The kind of material available,[21] and

(2) the desire of the aborigines to obtain satisfactory flakes for use.[12]

* For the use of the terms, see Roth, W. E.: Bulletin 7, Nth. Queensland Ethnography, 1904, pp. 16-17. Briefly, the "lower" surface is the faceted surface of the flake; the "upper" (the plane surface) is the one on which the bulb of percussion is present.

We are dealing with a practical problem. The aborigines used stone implements as their daily working tools. They well understood the flaking qualities of the different kinds of stone, and we may be sure that, in so far as they could control their material, they would flake it in the way which gave them the most suitable flakes for their requirements.

The Different Kinds of Material Available.

In Australia there does not appear to have been any extensive system of bartering siliceous stone for flaking purposes. Each local group or horde appears to have used the stone available within or easily accessible to its own territory, although, in some parts, certain flaked implements (such as the long flaked knives from Central Australia) were regular objects of barter. In those areas where they were not able to obtain sufficient quantities of siliceous stone suitable for flaking, the aborigines brought other implements into use to serve the same purposes as the flakes. Spencer[20] states that "stone implements are rare amongst the Kakadu and allied tribes, and they and the Melville Islanders seem to use shells for cutting". Knut Dahl[5] states that the North Australians are "curiously independent" of many of their possessions. "Thus any sharp object will serve as a knife to cut up an animal for food, or the native will simply bite it open." Since there were many objects, such as "pebble choppers",[12] ground-edge knives and scrapers of basic material,[14] shells,[19] bone,[8] teeth,[19] and so on, which could be used as implements in place of stone flakes, the aborigines did not usually go very far afield for supplies of siliceous material. In any locality, however, where stone was available in sufficient quantities for flaking purposes, the aborigines made extensive use of it; and, in the different parts of the continent, they used materials which varied greatly in both kind and quality. In some parts several kinds of material of varying quality were used; in other parts where only one kind of material was available, it usually varied greatly in quality. Such differences in the material were of the greatest importance, because they determined the general form of the flakes found in any locality.[13] [11] [16] Some materials were tractable: they were fine-grained and homogeneous, and fractured freely in any direction. Some were very refractory: they were difficult to flake satisfactorily, they fractured badly, or

were uniformly poor in quality, were coarse-grained or very tough. Some of the material was so refractory[17] that it would not even flake; it was shattered by a blow from the hammer-stone. Roth[17] states that "The Camooweal blacks maintain that pebbles from the neighbouring Nowranie Creek provide the best gouge heads, while the stones lying along the bed of the Georgina River . . . are too short and too full of flaws to manufacture good knife blades from."

Not only are the differences in the flaking qualities of the materials reflected in the flakes themselves, but each kind of material flaked in a characteristic manner. Some materials readily produced a proportion of large flakes, some only small flakes; some produced long tapering flakes, and so on. Certain implements found in one area may not occur in another area because the material is such that it will not readily produce the requisite form of flake. For instance, on the coastal areas of New South Wales, seldom, if ever, is it possible to find a flake similar in shape and size to the long tapering knives of Central Australia; the material is of such a kind that it would not flake satisfactorily in that manner. Spencer and Gillen[22] have made it clear that the Central Australian knives occur in those areas where suitable quartzite was obtainable. The Central Australians did not possess a superior knowledge of the technique of flaking. Try as they would, they could not have produced such knives in the Illawarra district of New South Wales, where silicified wood, jasper, and similar kinds of material were used. On the whole, these are very refractory materials, and do not usually produce flakes more than two inches in length. The Central Australians would have had no better success on other parts of the coast. Further south, near Bateman's Bay, a porphyritic material shows similar flaking characteristics to the material in the Illawarra district. In the Newcastle district the fine-grained chert was not nearly so satisfactory for flaking as its appearance would suggest. It would not normally produce large, thin, tapering flakes. Its principal defect for flaking purposes is that it possesses a typical chert fracture along definite planes. Even on the Darling and Paroo Rivers it is seldom that a knife flake is found similar to the knives from Central Australia. Small flakes of this form are found, but the material generally tends to flake in symmetrical curves. These examples should be sufficient

to show that the aborigines contented themselves with the kinds of flakes which they were able to obtain readily from the material at hand. For this reason the formal differences in the flakework from one locality to another may be noteworthy.

The Desire of the Aborigines to Obtain Satisfactory Flakes for Use.

The characteristics of the implements, therefore, found in any locality depend primarily on the kind and quality of the stone available for flaking. The aborigines did not attempt the impossible task of trying to secure flakes which the material would not satisfactorily produce; but, in so far as they could do so, they undoubtedly endeavoured to control the flaking of their material. This was possible only to a limited extent. Spencer and Gillen[22] have described the method employed by the aborigines of Central Australia to obtain long flaked knives; and I shall show that along the coast, because of the refractory material, a definite method of flaking was also adopted. The aborigines knew the method required to produce certain kinds of flakes, although, apparently, they were not able to control their material sufficiently to be sure that the kind of flake they required would necessarily come off at each blow of the hammer-stone. Roth[17] has stated that the aborigines could not account for the occurrence of long and short flakes from the same core, and he added that if they required a certain kind of flake (*e.g.* a long knife blade), they continued to strike off flakes until they had obtained one suitable for their requirements. Although, therefore, the aborigines could not exercise full control over the flake which came off at each blow of the hammer-stone, they could control the manner and the direction in which the blow was given. In other words, by adopting appropriate methods of flaking, the aborigines had sufficient control of their material to produce either symmetrical or asymmetrical flakes (Fig. 3). Each of the diagrams shown in Fig. 3 (*a*) and (*a*1) represents the striking platform of a core, the one prepared to produce a symmetrical, the other an asymmetrical flake. It may readily be seen that in order to produce the one or the other kind of flake the method of treatment slightly differs. In each diagram the part below the broken line represents the butt end of the flake as it would appear if it were detached from the core. In order to produce a

symmetrical flake, a part of the core had to be suitably prepared. The direction of the blow from the hammer-stone was at right angles to the line of fracture (represented by the broken line in the diagram) and inclined towards

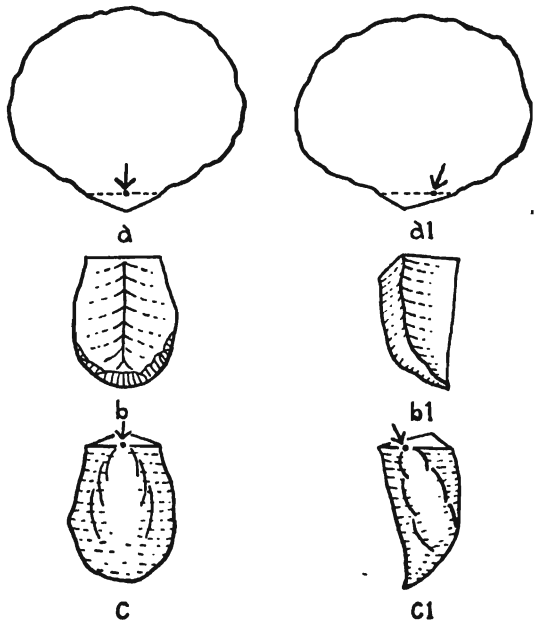


Fig. 3.—*a*, *b*, *c*, diagram, symmetrical type; *a1*, *b1*, *c1*, diagram, asymmetrical type; *a* and *a1*, striking platform of core, showing the angle prepared for flaking, and the point of percussion with the hammer stone; *b* and *b1*, lower surface of flake produced by the method described in the text; *c* and *c1*, upper surface of same flake. Notice the different positions of the bulb of percussion.

Note: These diagrams are not intended to cover all the details of technique. They are drawn merely to illustrate certain general differences in the methods of flaking. In actual practice, the aborigines did not always adhere strictly to either method.

the longitudinal ridge, the point of percussion being directly behind the ridge [Fig. 3 (*c*); Plates V, VI]. This is the method described by Spencer and Gillen.[22] As the diagram indicates, it was slightly modified to produce an

asymmetrical flake. A different angle was prepared on the core, and usually the direction of the blow from the hammer-stone was inclined diagonally towards the longitudinal ridge [Fig. 3 (*c*1)]. Normally the point of percussion was not directly behind the ridge; it was nearer the middle of the line of fracture, although usually it was not quite medially situated [Fig. 3 (*c*1); Plate II (*b*)].

The Flaking Methods Adapted to the Material.

The aborigines, therefore, could produce either symmetrical or asymmetrical flakes according to the manner in which they prepared the core and in which they struck it with the hammer-stone. But why did they alter their method of flaking from the core? Why, in other words, are flakes in one area predominantly asymmetrical, in another area predominantly symmetrical? The reason seems to be clear. In order to obtain satisfactory implements, the aborigines adapted their flaking methods to their material. They could flake tractable material freely, but they had to overcome various difficulties in flaking very refractory material. There is no doubt, for instance, that the aborigines of the Darling and Paroo Rivers flaked their material much more freely than the aborigines of the coast were able to flake the material at their disposal. In other words, the material available for use along the coast was of such a refractory kind that by treating it in one way rather than in any other way the aborigines were able to obtain flakes—usually asymmetrical—suitable for their requirements.

Differences in Longitudinal Form.

Now, if the flakes along the coast are compared with those from the Darling and Paroo Rivers, we shall understand one of the important reasons which caused the aborigines to adapt their flaking methods to their material. For this purpose, let us consider briefly the two kinds of flakes in longitudinal section. On the Darling and Paroo Rivers the material is such that the distal end of the flake usually forms a satisfactory working edge. The flakes do not tend to taper too rapidly or to curl towards the distal end, and the conventionalized scrapers are predominantly end scrapers [Fig. 4 (*b*); Plate IV (*d*)]. In comparison, the flakes from the coast do not generally possess a good working edge at the distal end; frequently they curl or fracture badly at that end, or they taper too much [Fig. 4 (*a*);

Plate IV (*c*)]. Such flakes cannot be used satisfactorily as end scrapers. They are, however, suitable for use as side scrapers. The aborigines appreciated this fact, because by flaking their material in the manner I have described they could be reasonably sure of obtaining at least one good scraping edge along the thick side of the flake [Fig. 6 (*a*)].

The method, therefore, adopted by the aborigines to obtain flakes was based on knowledge of the manner in which their material would behave. Their aim was not to invent new types, but to secure the best implements that the material would produce. Because the implements of the one area are symmetrical in form, and of the other area asymmetrical, their nature and purpose are not altered,

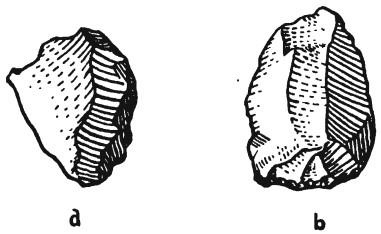


Fig. 4.—*a*, implement from the coast; *b*, implement from the Paroo River. To show characteristic differences in longitudinal form. Size, approximately half actual.

and I shall show that the one may be readily correlated with the other. The difference in form made little, if any, difference in the flake as a working tool. If the symmetrical implements from the Darling and Paroo Rivers are scrapers, it is impossible to assert that the asymmetrical implements from the coast are not scrapers. I may add that the marginal retouch is the same on both forms [Plate IV (*a*) and (*b*)].

In New South Wales asymmetrical flakes predominate in several areas where very refractory materials were used for flaking. In other parts, where the material was more tractable and could be more freely flaked, the asymmetrical flakes dwindle rapidly in numbers and importance. Sometimes they persist in certain types of implements side by side with symmetrical types.

Before developing the subject further, I think that brief explanations are necessary concerning certain of the matters already discussed.

Local Variations in Form.

Flakes in cross-section tend to vary more or less from the ideal forms such as I have shown in Fig. 2 (*a*) and (*a*1). Frequently the lower surface has several facets. Fig. 5, for instance, shows forms with three facets. The broken lines indicate the parts which had already been removed from the core before the flakes were struck off. Further, the variation from the ideal forms may be great enough for the asymmetrical and the symmetrical implements to merge into each other. For instance, on the Darling and Paroo Rivers we find occasionally that asymmetrical flakes have been used as side scrapers in the same way as the coastal implements. On the other hand, some of the few symmetrical flakes which are found along the coast have been used as end scrapers. Such extreme variations from the predominant types are important, since they indicate how closely the one type is related to the other.

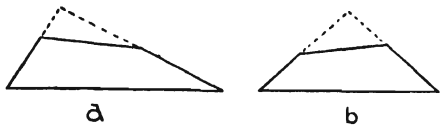


Fig. 5.—Idealized cross-sections:

Similar statements may be made concerning the implements somewhat crescentic in form, which are occasionally found along the coast. Although they resemble some of the crescents which are so well developed in Victoria, they are too scarce along the coast to be regarded as separate coastal types. It is clear that they have been developed from flakes which happened to be more or less crescentic in form. They should, in the circumstances, be dealt with as variant forms of the conventionalized scrapers. Similar variations are found amongst the "points". Those which are more or less crescentic in form are too few in numbers to constitute a separate coastal type.

Correlation of Scraper Types.

Having obtained a supply of flakes, the aborigines, of either area, would then put them to use. I shall now show how completely the asymmetrical scrapers from the coast may be correlated with the symmetrical scrapers from the Darling and Paroo Rivers.

The following are some of the principal ways in which a flake may be used as a scraper:

(1) Along one side—side scraper;
(2) along both sides—side scraper;
(3) at the distal end—end scraper;
(4) along one side and at the distal end—end and side scraper;
(5) along both sides and at the distal end—end and side scraper;
(6) all round—circular or oval scraper.*

Varieties of Symmetrical Scrapers, Darling and Paroo Rivers.

If this formula be applied to the scrapers found on the Darling and Paroo Rivers, each variety is represented. As they are all well recognized scrapers, it does not appear to be necessary to deal with them in detail. Having a good material for flaking, the aborigines produced a great variety of implements. The end scraper easily predominated as a type, but frequently one variety merges into another. Thus we find implements which are both end and side scrapers, and so on [Plates V, VI (*a*), (*b*)]. The presence of the circular scraper indicates the use of a superior class of material which could be readily retouched in that manner [Plate VI (*e*)].

On the coast the same variety of forms is found amongst the asymmetrical implements. With the exception of the circular scraper, each variety given in the formula is represented, the side scraper predominating. The shifting of the longitudinal ridge on the lower surface of the flake from the middle to the side has altered the appearance of the flake, but the following classification will show that the implements are essentially the same as the scrapers from the Darling and Paroo Rivers. As I have already stated, it is most important to keep in mind that the retouch on the scrapers in both areas is identical in every respect [Plate IV (*a*) and (*b*)]. The difference is in the form of the flake.

Varieties of Coastal Asymmetrical Types.

(1) *Side Scrapers* [Fig. 6 (*a*); Plate II (*a*), (*b*), (*c*)].

* I am not now taking into consideration those forms (such as the crescent) on which the bulb or butt end of the flake has been given marginal retouch.

On this form the retouch has been carried along one edge, invariably on the stronger side of the flake. Those flakes which are poorly developed at the distal end are frequently of this form. This is a normal type, the reasons for the occurrence of which I have already given.

On many of the flakes the opposite side also shows evidence of use, but it seldom shows very much retouch.

(2) *Semi-end Scrapers* [Fig. 6 (*b*) ; Plate II (*e*)].

The term semi-end scraper has been adopted to distinguish between this form and the end scraper proper,

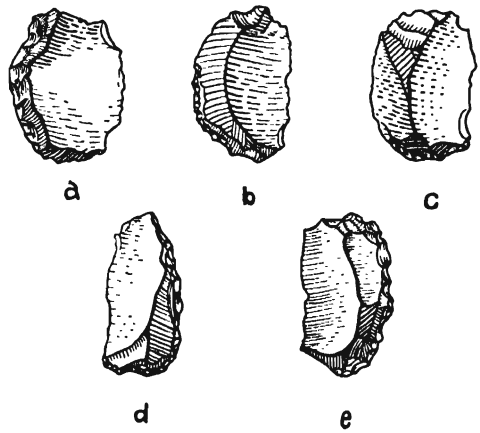


Fig. 6.—Some varieties of the coastal conventionalized type. *a*, side scaper; *b*, semi-end scraper; *c*, end scraper; *d*, side and end scraper; *e*, side and semi-end scraper. Size, approximately half actual.

which is dealt with in the next section. It is probable that both forms were used in much the same manner, and they frequently merge into each other. Probably the difference is of no practical importance, but it is necessary in this analysis to make the distinction.

The term *semi-end* means that the scraping edge was on the curved part of the implement between the side proper and the extreme distal end. Asymmetrical flakes do not usually produce satisfactory end scrapers, but large numbers of them may produce satisfactory semi-end scrapers. Because of the form of the flake the curved part

of the implement is generally much more useful as a scraper than the distal end proper. On some implements the retouch is confined entirely to this curve. These implements are accordingly classified as semi-end scrapers.

The curved working edge was a favourite form for scrapers, and was almost universal where flakework was carried out by the aborigines. Undoubtedly this is the reason why so many of the coastal implements show such definite retouch along this curve.

(3) *End Scrapers* [Fig. 6 (*c*) ; Plate II (*d*)].

Some flakes have a suitable scraping edge at the distal end and, although they are asymmetrical in form, they are true end scrapers.

The end and the semi-end types are of the utmost importance, because they both reveal clearly the reason for the retouch, and because they correlate completely the asymmetrical with the symmetrical types. Asymmetrical end scrapers do not occur in great numbers, but we must not under-estimate their significance. As implements there is clearly no difference between them and the symmetrical end scrapers from the Darling and Paroo Rivers. If the one kind is a scraper, the other is also a scraper.

(4) *Side and End Scrapers* [Fig. 6 (*d*) ; Plate III (*b*)].

This form is quite as important as the end scraper, because it further emphasizes the completeness of the correlation. These implements show continuous retouch along one side, round the distal end, and sometimes well down the opposite side of the flake. In this form we have an asymmetrical flake which is a true side and end scraper. We have seen that there cannot be any question as to the correlation of the end scrapers from the two areas, and the continuous retouch on this form must lead to a similar conclusion. The significance, too, of carrying the retouch well down the second side of the flake should be noted. It shows clearly that the scraper retouch was the important consideration, and not the knife edge. If this side—as some have asserted—was the cutting edge of a knife, why has the retouch destroyed the keen edge and reduced it in length ?

(5) *Side and Semi-end Scrapers* [Fig. 6 (*e*) ; Plate III (*a*)].

The side and end scraper proper is not found in very great numbers, but the side and semi-end scraper is very

plentiful. On this form the retouch is carried along one side and round the curve towards the distal end of the flake. It is important to note that on very large numbers of the implements of this form the retouch is not carried to the extreme distal end. It ceases where the flake has become too thin for scraping. This indicates clearly that the aborigines did not bother to retouch that part of the flake which they did not require for use.

(6) *Two Sides and End Scrapers.*

Some flakes are found which show continuous retouch along both sides and round the distal end. On these forms there cannot be any doubt as to the purpose of the retouch. They are quite as definitely scraping implements as the end and side scrapers already discussed.

(7) *Scrapers Retouched along Adjacent Edges.*

Owing to the asymmetrical form of the flakes, a further variety of scraper has been developed along the coast. Normally, the marginal retouch on the flakes is confined to the edge or edges where the lower surface meets the upper surface. Some of the coastal flakes, however, have two equal plane surfaces, and the aborigines—as we should expect—have taken advantage of this feature; it gave them an additional scraping edge. They have retouched the flake along the two adjacent edges, as shown in Fig. 7. [See also Plate III (*c*).] This method of treatment has given the flake a well-chipped appearance *between* the two working edges, but it has no other significance. It is an entire misinterpretation of the marginal retouch to assert

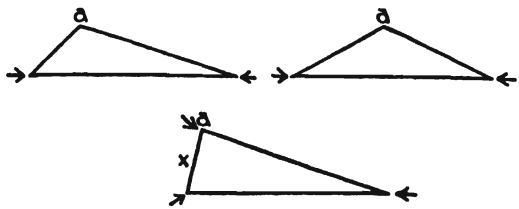


Fig. 7.—Idealized cross-sections. The arrows show the edges along which marginal retouch may be carried out. The longitudinal ridge (*a*) on the lower surface, as shown in the two upper diagrams, has become one of the working edges, as shown in the lower diagram, the side *X*, in consequence, being well chipped.

that this chipped surface is the " back " of a knife. The form of the flake, and the choice of the two adjacent working edges, indicate clearly the manner in which the implement has been developed in use. The marginal retouch on the flake is similar in every respect to that found on the flakework generally.

The Working Edge Modified for Special Purposes.

I have now shown that the coastal implements consist of a series of forms belonging to the scraper family. In order to simplify the matter I have assumed in my classification that the retouch on the flakes is always evenly carried out, but we find that large numbers of the flakes have apparently been retouched for special purposes, and that their form has been modified in such a manner that projections, serrations, *etc.*, have been produced along their working edges. Such modifications are common to implements of the scraper family ; they are significant and useful, but there could not be any reason for their presence on chipped-back knives [Plate III (*d*)].

In my analysis I have shown that on some coastal implements one side only has been retouched, or the distal end only, the remaining edges being quite sharp and apparently unused. But this has no unusual significance, because the same feature is found on the flakes from the Darling and Paroo Rivers and elsewhere. Many end scrapers do not show signs of use along the sides. This evidence does not support the idea that the unchipped side was left on the coastal flake to be used as a knife. On any implement of this kind which generally has one edge with little, if any, retouch we may conclude that that edge was of less value to the aborigines as a working part.

To this stage our inquiry shows that the aborigines were not so much concerned with the kind of flakes which they had at hand ; they were more concerned with their effectiveness in use. They wanted flakes which would cut or scrape satisfactorily. Having obtained a suitable supply, they put to use the parts of each flake which would serve their purpose.

Some General Remarks Concerning the Coastal Scrapers.

The Significance of Flaked Implements.

Why is it that the coastal flakes have been called chipped-back knives? It seems to me that the name is a mis-

conception of the purposes for which the aborigines used flaked implements. A flake is not significant in itself, but it is significant as a tool which, in the hands of the aborigines, had to produce results. Immediately it failed to function satisfactorily it was thrown aside and another flake was brought into use. Why were flakes used? Were they not used in the process of making things of permanent value to the aborigines, such as wooden weapons and utensils, for preparing skins, and so on? These were the significant things to the aborigines, and the flake was only a means to an end. Flakes were so easily obtained that an expert operator could produce hundreds of them in a very few hours. Only in those parts where material was scarce would flakes be kept until they had been used to the smallest scraps. Where material was plentiful, it is evident to all who have been on the camping-grounds that the aborigines were prodigal with them.

Further, a flake showing fine and even retouch is too frequently given attention out of all proportion to its real significance. It is not always properly understood that fine-grained and homogeneous material will produce some ideal type-specimens.[16] As specimens they may doubtless show admirable symmetry of form and retouch. But why should this feature be emphasized? Is it not of much greater importance to deal with implements in relation to the environment in which they were produced and used? Specimens of fine-grained, homogeneous material were not necessarily of greater value as working tools than those of coarser material. In the hands of the aborigines they had to produce the same results as any other flake. Unless implements, therefore, are dealt with in relation to their environment misconceptions may arise, and the idea of a chipped-back knife is one of them.

The chipped-back knife theory, as applied to the coastal implements, raises many difficulties. I discussed some of them in a previous publication, and shall not repeat them.[26] In the following paragraphs I shall discuss briefly some of the objections to the theory.

Stone and Shell Knives Used Along the Coast.

There is plenty of evidence that the aborigines along the coast had a superabundance of knives. They had:

(i) Innumerable sharp flakes;

(ii) unlimited supplies of shells with sharp cutting edges. Shells were used very extensively.[15]

If not more important, they were at least as important as the sharp flakes ;[24]

(iii) the wommera, in one end of which a piece of shell was fastened, and this implement, in Collins's[4] words, " they use for the same purposes that we employ a knife ". Similar implements were used in Central Australia, except that a piece of stone was used instead of a piece of shell, and Spencer and Gillen[22] have stated that they were the most important cutting implements of the aborigines.*

Is it likely, in such circumstances, that the aborigines would need to develop a type of chipped-back knife? It would have been in every way a much less efficient implement than the shell in the end of a wommera. On every coastal camping-ground the aborigines had more knives—*in esse* or *in posse*—than they could possibly have used.

It seems to me that the term *knife* does not mean quite the same to the white man as it did to the aborigines, who were also concerned with scrapers. With his steel knife with its keen edge, the white man thinks in terms of cutting, not of scraping; but with the material at his disposal the native thought in terms of scraping as well as cutting. Roth[17] has written an interesting sentence on this difference in the point of view. " Amongst aborigines out of reach of European settlement, even sometimes amongst civilized ones, an ordinary pocket-knife or table-knife is employed rather as a scraper than as a cutting instrument." For the aborigines the scraper had as wide a range of uses as the knife.[3]

Method of Using Coastal Flakes.

Because we can place our forefinger round the chipped side (miscalled the " back ") of some of the coastal flakes, we are not entitled to infer that we are following the

* In his Historical Journal of the Transactions at Port Jackson and Norfolk Island, 1793, John Hunter has written an interesting sentence : " The throwing stick (of an inland native) had a piece of hard stone fixed in gum instead of the shell which is commonly used by the natives who live on the sea coast " (p. 519). There seems to be no doubt that shell implements were used so frequently by the coastal tribes near Sydney that the use of stone for the same purpose by an inland native was a circumstance worthy of record. David Collins (" An Account of the English Colony in N.S.W. ", 1798, p. 586) makes a similar observation respecting spears which had stone flakes fixed in a groove near the point instead of pieces of shell.

practice of the aborigines, or that the implements are necessarily knives. "The human hand is such an adaptable appendage that it 'fits' anything not too angular or too large."[16] Interpretations, therefore, based on such methods are of no value; they do not explain the implements as the working tools of the aborigines. Further, we have no reason for assuming that the coastal aborigines handled flakes so clumsily that they needed to blunt one edge before using them. Relying on the testimony of observers in all parts of Australia, I have no doubt that the few minor cuts which the aborigines may occasionally have received, would go almost unnoticed. The indifference of the natives to such mishaps is well illustrated in the following observation made by Basedow. In making his spear-head, the native of North-West Australia "often cuts his fingers on the flake or razor-sharp splinters; the blood which follows he removes by passing his fingers through his hair".[2] On the other hand, there is no reason to deny that, for a special purpose, the aborigines may have occasionally blunted a part of one edge of an implement. Roth,[17] for instance, conjectured that the chipping near the handle of a small knife from North Queensland had been done to blunt that part of the edge. He, however, was not able to give an entirely satisfactory explanation of similar chipping on a larger implement of the same kind.

It has sometimes been asserted that in his "Ancient Stone Implements of Great Britain", Evans[7] figured an Australian chipped-back knife, and that the coastal implements are related to it. The implement figured by Evans is a variant form of the long flaked knives (usually hafted) found in Central Australia and Queensland. On the other hand, the small asymmetrical implements from the Illawarra district [Plate I (*b*)] belong to the same series as the large asymmetrical implements [Plate I (*d*)] from the Newcastle and Port Stephens districts. This should be sufficient to indicate how greatly the implement figured by Evans differs from the coastal implements. They belong to two distinct series which must not be confused. It happens that the implement figured by Evans somewhat resembles *in form* the coastal types.

The Spear-Head of North-West Australia.

Undoubtedly, the serrated spear-head of North-West Australia is highly specialized. Some have asserted that

since the aborigines of that part were capable of producing such a type, there is no reason why the aborigines of the coast of New South Wales should not produce a chipped-back knife. This does not quite represent the facts. It does not follow that a spear-head—a part of a weapon—should be compared with a working tool, be it chipped-back knife or scraper. Consider for a moment the long flaked knives of Central Australia and Queensland. The reason that the aborigines were so careful of them was not that they were merely domestic implements. Roth[17] has pointed out that they were primarily fighting weapons, and secondarily implements.[18] [23] [10] In few words, they possessed a much wider significance than a mere tool. They took their place amongst the articles of more permanent value to the aborigines, such as spears, boomerangs, wommeras, and so on. In the same way, the stone spear-head from North-West Australia had much more value and significance than a flake. Attached to a shaft, it helped to provide the native with his food supply. Articles of permanent value to the natives often had much time and care spent on their making. On the other hand, I have yet to learn from the writings of any authority who has worked amongst the aborigines that they spent any time in the preparation of stone tools, except the time necessary to make the tools suit their immediate or actual requirements.

With respect to the stone spear-head from North-West Australia, I may add that the method of making it may have been borrowed by the aborigines from an alien people. A similar suggestion has also been made with respect to the art of that area.[6] In the circumstances it is not advisable to set up the spear-head as a standard by which certain implements found on the opposite side of the continent may be judged.

Summary and Conclusion.

Over a great part of the continent stone flakes were used as tools. In one locality certain types predominated, in other localities other types. Because of this diversity, there is no reason to assume that the aborigines of one part possessed a knowledge of stone-working not known to the aborigines of other parts. The different forms cannot be regarded as separate cultures known only to the aborigines in whose local areas they are found. The

explanation is that the stone available was generally more suitable for one form than another. I have already shown this with respect to two areas. The aborigines were not so much inventors of stone types, as they were adapters of flakes to their needs. They did not usually chip flakes to such an extent that the original form entirely disappeared. Seldom, if ever, is the original flake, although well retouched, difficult to reconstruct.

In this paper I have endeavoured to deal with certain coastal flakes as the working tools of the aborigines, and I have, I believe, shown that they belong to the scraper family of stone implements. The great variety of forms in which these implements are found, not only over the whole area, but also in any one locality, indicates very clearly that the retouch was not done for the purpose of reproducing an ideal form such as a chipped-back knife. The diversity of closely inter-related forms is a sufficient refutation of the chipped-back knife theory. A chipped-back knife would be an ideal type. We should expect all such implements to conform more or less closely to the ideal which the aborigines would strive to reproduce in each separate implement. To do this they would have had to modify considerably the flakes at their disposal, a proceeding which was not attempted by them. As I have already shown, marginal or scraper retouch was all they ever attempted along the coast of New South Wales.

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Explanation of Plates.

NOTE: All the implements shown in the plates are approximately one-half their actual size.

Plate I. Implements from Coastal Areas.

Illawarra District:
(*a*) Ten chipped "points".
(*b*) Four conventionalized scrapers.
(*c*) Five "button" flakes (so-called).

Newcastle District:
(*d*) (On left) Larger sized implement showing the working edge along the side.

Port Stephens District:
(*d*) (On right) Larger sized implement showing the working edge at the distal end.

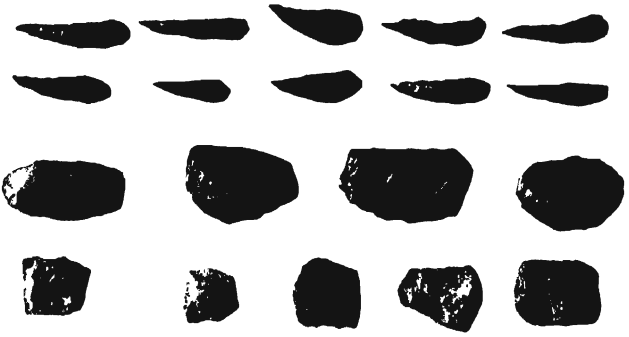
Plate II. Implements from Coastal Areas.

Illawarra District:
(*a*) Four side scrapers, showing the lower (the faceted) surface.
(*b*) The same implements, showing the upper (the plane) surface.
(*c*) Eight side scrapers, showing the working edge.
(*d*) Four end scrapers.
(*e*) Four semi-end scrapers.

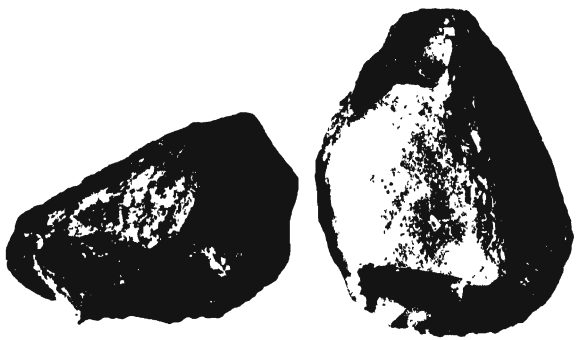
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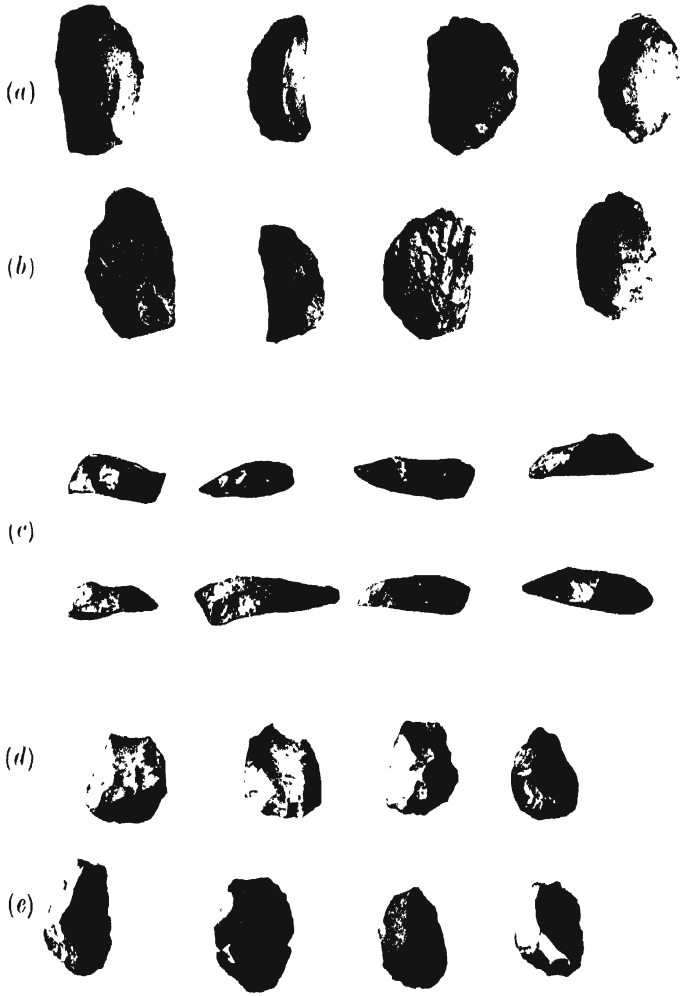
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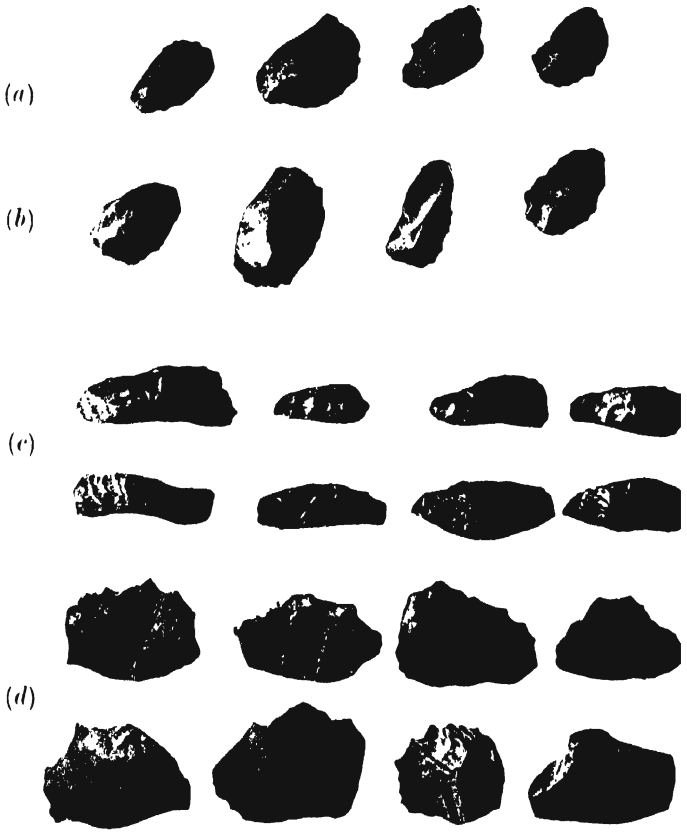
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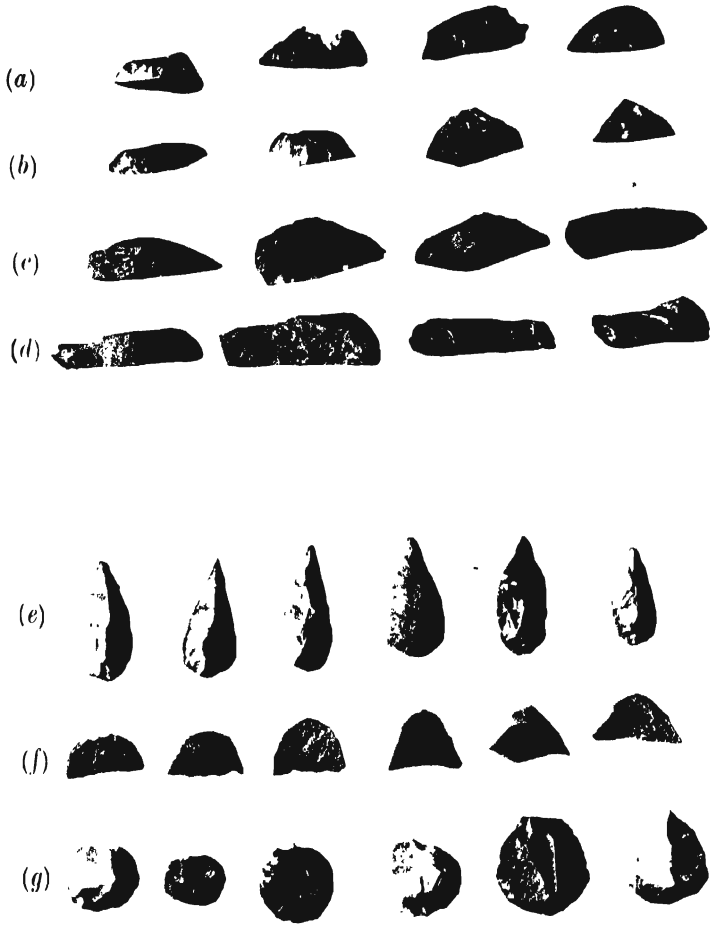


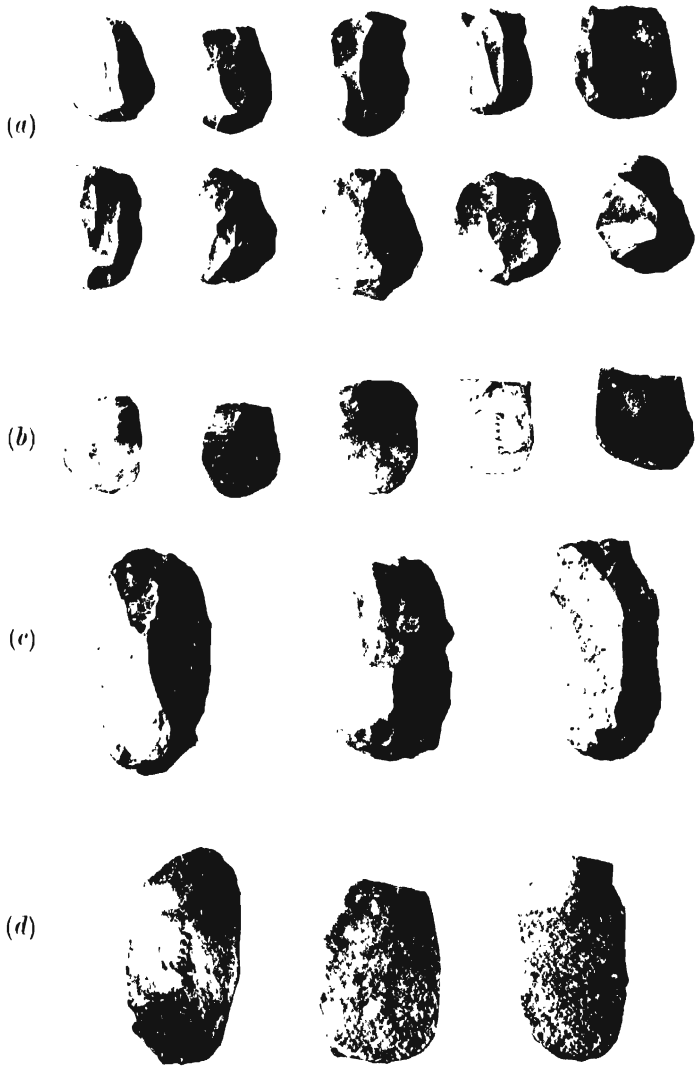
(*d*)




(a)
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(a)
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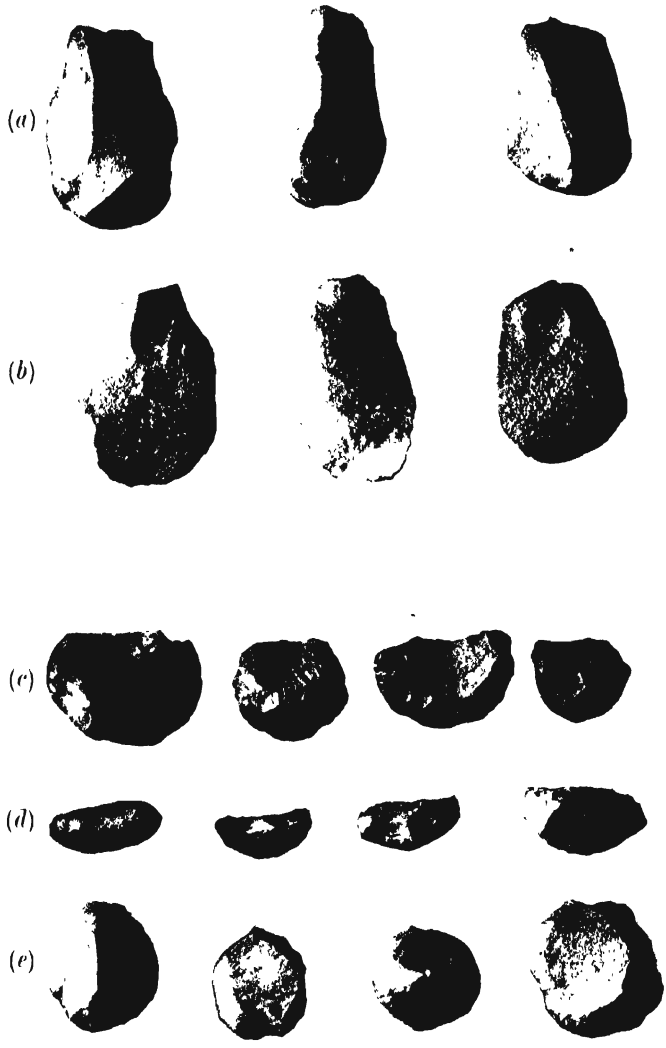

(a)
(b)
(c)
(d)
(e)

PLATE III. IMPLEMENTS FROM COASTAL AREAS.

Illawarra District:

(*a*) Four side and semi-end scrapers.
(*b*) Four side and end scrapers.
(*c*) Eight side scrapers, showing retouch along the two adjacent working edges.
(*d*) Eight scrapers. showing the working edge modified for different uses.

PLATE IV. (*a-d*). IMPLEMENTS FROM COASTAL AREAS COMPARED WITH IMPLEMENTS FROM THE PAROO RIVER.

Illawarra District:

(*a*) Four *side* scrapers, compared with

Paroo River:

(*b*) Four *end* scrapers, in order to show the identity of retouch along the working edges.

Illawarra District:

(*c*) Four *side* scrapers, compared with

Paroo River:

(*d*) Four *end* scrapers, in order to show the characteristic differences in the form of the flakes. Both sets are shown longitudinally, the bulb or butt end being on the left.

(*e-g*). IMPLEMENTS FROM THE DARLING AND PAROO RIVERS.

(*e*) Six symmetrical " points ".
(*f*) Six crescents.
(*g*) Six small scrapers.

PLATE V. IMPLEMENTS FROM THE DARLING AND PAROO RIVERS.

(*a*) Ten scrapers, showing the lower (the faceted) surface.
(*b*) Five of the same scrapers, showing the upper (the plane) surface. Predominantly end scrapers.
(*c*) Three scrapers, showing the lower surface.
(*d*) The same implements, showing the upper surface.

PLATE VI. IMPLEMENTS FROM THE DARLING AND PAROO RIVERS.

(*a*) Three scrapers, showing the lower surface.
(*b*) The same scrapers, showing the upper surface.
(*c*) Four adzes (always hafted).
(*d*) Four adzes (worn down through use).
(*e*) Four circular scrapers.

MYOPORUM DESERTI.

A Preliminary Investigation.

By Adrien Albert, B.Sc.*
Communicated by Mr. H. Finnemore.

(Read before the Royal Society of New South Wales, Dec. 5, 1934.)

Myoporum deserti is a shrub, from three to twelve feet in height, occurring, according to published statements, in all the States of the Commonwealth, Tasmania excepted. In New South Wales it is confined to the western plains and slopes. It is known variously as Dogwood Poison Bush, Ellangowan Poison Bush, a Turkey-bush and Sweet-fruited Myoporum. It is a somewhat variable species; for instance the leaves vary in length. It had long been suspected of being toxic, and came for reconsideration on account of a request of the C.S.I.R. to the Poison Plants Committee to investigate fatalities to cattle occurring in Queensland.

The small fruits, which have been reported as less toxic than the leaves, were found to be free from alkaloids and cyanogenetic glucosides. They contain an enzyme which hydrolyses prunasin and sambunigrin but not amygdalin, and which can therefore be used for distinguishing between these mono- and di-glucosides. The fruits examined came from Broken Hill, Temora and Queensland.

The leaves are from one to three inches in length, with more or less conspicuous oil-glands. The seven specimens forwarded were from Broken Hill, Cobar, Grenfell, Temora, Currabubula, Clover Creek (Darling River) and Queensland. They contained no cyanogenetic glycosides, cyanhydrolytic enzyme or alkaloids.

* This investigation was made under the Poison Plants Committee of the Council of Scientific and Industrial Research. Thanks are due to the University of Sydney for the provision of laboratory facilities, to Mr. H. Finnemore, B.Sc. (Lond.), F.I.C., for assistance and guidance, and to Dr. H. R. Seddon, Chief of the Veterinary Research Station, Glenfield, for forwarding supplies of the plant and for arranging to have the extracts tested.

Tests undertaken at Glenfield Veterinary Research Station by Mr. R. O. C. King, B.V.Sc., have shown both air-dried leaves and fruits to be toxic for sheep. The leaves tested on a calf were also attended with lethal results, and there is no doubt as to the harmfulness of this shrub to stock. Actually Mr. King also included in his tests material from the same source as that with which I have worked. With this material it was found that 1 lb. of berries and 1 lb. of air-dried leaves were each lethal for sheep.

The work now to be described was done on a 40-lb. lot of the leaves, collected in Queensland while the plant was fruiting (reputedly the most poisonous season).

Acetone Extraction.

Dried leaves in powder (9,000 g.) were refluxed with boiling acetone (16 litres) for six hours. The liquid was decanted whilst hot, and on cooling deposited crystals (3·8 g. from 2,000 g. leaves). These were washed free from colouring matter with ethyl acetate, and after recrystallisation were identified as mannitol (2·8 g.), m.p. 165° C. (Hexacetate m.p. 120° C.).

The filtrate was mixed with calcium carbonate, and the acetone distilled off on the water-bath. The thick paste remaining was shown to be non-toxic to sheep. No crystalline substance could be isolated from it, although concentrates giving glycosidal reactions were obtained.

The marc, which was still toxic, was extracted again with boiling acetone (16 litres). The solution was decanted after cooling, and on evaporation as before gave a non-toxic extract. The marc, however, was still toxic to sheep in doses of 200 g.

Alcohol Extraction.

The marc (6,000 g.) was exhausted by percolation with cold alcohol (28 litres industrial spirit). The percolate was mixed with calcium carbonate, and the alcohol distilled off from the water-bath. During the process of concentration sodium chloride (3·5 g.) and a little more mannitol were deposited. After evaporation on a water-bath a thin greenish-brown paste remained which was shown to be non-toxic, and the marc remaining was also non-toxic. It would appear, therefore, either that the toxic principle had been destroyed or that the toxic action is due to a

synergistic effect, the constituent agents having become separated.

Nature of Alcohol Extract.

About half the alcoholic extract, obtained as described above, was steam-distilled until no more volatile oil passed over (28 hours). Diacetyl was not present in the faintly acid distillate. To the oil obtained in this way (11 cc.) was added a further quantity (3 cc.) obtained by exhausting the brine-saturated aqueous portion with petroleum ether (b.p. 40° to 60° C.).

This quantity of oil represented 0·46% of the dried leaves, whilst the quantity obtained in a like manner from the acetone extract represented only 0·002%. As the oil was miscible with acetone, it is noteworthy that it was not extracted by the acetone, but appeared instead in the subsequent alcoholic extract from the marc. It is possible that a certain amount of terpenes, *etc.*, is common to the oils from both extracts, but that the large quantity in the case of the oil from the alcoholic extract is derived from a glycoside hydrolysed during the extraction.

The Volatile Oil.

The oil was thoroughly dried over anhydrous sodium sulphate. It was golden yellow in colour, with a cooling, mint-like taste, and an odour that was mentholaceous and sweetish, as well as having a slightly unpleasant quality not unlike that of carrot-water. When freshly distilled it was, in addition, pungent. It was slightly soluble in water, and the solution reacted neutral. Neither the aqueous nor the alcoholic solutions gave any pronounced reaction with solution of ferric chloride, sodium hydroxide or Schiff's reagent. The oil did not reduce Fehling's solution even in the presence of alcohol. Ammoniacal silver nitrate yielded a black precipitate, but no mirror. One part of the oil dissolved in 30 parts of 70% alcohol.

The specific gravity at 20° C./20° C. was 1·0048, which indicates the presence of oxygenated bodies. Refractive index=1·4767 at 24° C., and $\alpha_D^{25°C.} = -14·9°$.

The oil was oximated according to the method for carvone (*B.P.*, 1932); 1·298 grams of the oil required 4·13 cc. N/1 alcoholic potash. This is equivalent to 51% of a (terpene) ketone (menthone) or 80% of a (sesquiterpene) ketone of the formula of ngaione, the ketone isolated from *M. lætum* (McDowall, *Jour. Chem. Soc.*,

1925, *127*, 1200). The odour of the residual oil was like that of fresh pine needles.

The oil was examined for phenols in a specially made cassia flask of capacity 15 cc. with neck graduated in one-hundredths of a cc. It was found that 1·34 cc. of oil contracted by 0·02 cc., equivalent at the most to 1·4% phenols v/v. The residual oil smelt more truly menthol-like, whilst the alkaline solution on neutralisation deposited an oil soluble in alkali. This oil gave a brown coloration with very dilute solution of ferric chloride. It has an odour reminiscent of eugenol, but also of tea. It gives a purple colour with vanillin in sulphuric acid.

The ester value of the oil, determined by the B.P. 1932 process, is 1·43 (equivalent to 0·5% bornyl acetate).

In the small cassia flask described 0·98 cc. was treated with 20% sodium bisulphite solution. The flask was heated at 98° C. for one hour, and the contraction after cooling observed. This was 0·04 cc., equivalent to 4·1% aldehydes. The odour of the residual oil was less pungent and more truly menthol-like. The aqueous layer was rendered alkaline and extracted with ether. A yellow oil was obtained with a foul odour similar to that of burnt fat.

The oil (1·58 cc.) was also examined with normal sodium sulphite. (Details as cinnamon oil analysis, *B.P.* 1914.) A contraction of 0·04 cc. occurred, equivalent to 2·5% v/v aldehydes.

The results obtained on oximation and with sodium bisulphite and sulphite indicate that a ketone such as menthone or ngaione is present rather than one of the carvone-piperitone type. An attempt was made to prepare a quantity of the oxime of the ketone. The oil (1·5 cc.) was treated with 6 cc. of N/1 hydroxylamine hydrochloride, in 90% alcohol, and the same quantity of N/1 alcoholic potash added. The product was heated at 70° C. for eight hours, and cooled. Alcoholic potash (1 cc. of N/1) was added, and the KCl filtered off. The alcohol was partly distilled off under reduced pressure, water was added and the mixture shaken out with petroleum ether to free the solution from terpenes. The aqueous portion was then made neutral and shaken out with ether. After evaporation of the ether a thick uncrystallisable lemon-yellow oil was left. Attempts to prepare the *p*-nitro phenylhydrazone led to a similar result.

The following table compares the oil of *Myoporum deserti* with that of *M. lætum* examined by McDowall.

	Myoporum deserti.	*Myoporum lætum.*
Colour	Golden.	Reddish-brown.
Odour	Mentholaceous, sweetish and somewhat foul when first distilled.	
Sp. Gr.	1·0048.	1·0203.
Specific Rotation	−14·93.	−26·54.
Refractive Index	1·4767.	1·4823.
Yield	0·46%.	0·12% to 0·30%.
Schiff's Reagent	No action.	No action.
Fehling's Solution	No action.	Slowly reduces.
Ammon. $AgNO_3$	Considerable blackening.	No action.
Ester Value	1·43.	17·9 (saponification value)
"Aldehydes"	2–4%.	"No trace."
Phenols	1·4%.	0·41%.
Ketones (calculated as Ngaione)	80%.	86%.

Summary.

The isolation from *Myoporum deserti* of a volatile oil containing a large percentage of an unidentified ketone is described.

The toxic effect of this plant has been confirmed, but no substance to which its poisonous nature may be ascribed could be isolated. There is evidence of the presence of a glycoside.

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A CHEMICAL EXAMINATION OF BLACKFELLOW'S BREAD, THE SCLEROTIUM OF THE FUNGUS *POLYPORUS MYLITTÆ* CKE. AND MASS.

By J. C. EARL, D.Sc., Ph.D.,
and G. H. MCGREGOR, B.Sc.*

(*Read before the Royal Society of New South Wales, Dec. 5, 1934.*)

A sample of the sclerotium of the fungus *Polyporus mylittæ* Cke. and Mass, commonly known as " blackfellow's bread ", was obtained through the kindness of Dr. R. J. Noble. As received it was a roughly spherical mass weighing 1,772 gms. Most of the chemical work was carried out on the material after it had been cut into slices, dried in a vacuum oven at 50° C. and ground to a powder which passed completely through a 90-mesh sieve. A preliminary examination was made, however, of the moist material.

EXAMINATION OF THE MOIST MATERIAL.

Reducing Substances.—An extract made by boiling the material with water showed only a faint reducing action of Fehling's solution.

Alkali-soluble Substances.—When 30 gms. were heated with 30 cc. of five per cent. sodium hydroxide solution a slightly coloured extract was obtained, which yielded no precipitate after neutralisation and addition of alcohol.

Hydrolysis with Sulphuric Acid.—To 32 gms. of the moist material 40 gms. of concentrated sulphuric acid were added in small quantities. After standing for three days the material had dissolved completely. The mixture was then diluted to 400 cc. and boiled under a reflux condenser for ten hours. The solution was filtered, neutralised with barium carbonate, again filtered, and made up to 500 cc. The optical rotation of this solution

* One of the authors (G.H.McG.) is indebted to the University of Sydney for the grant of a Science Research Scholarship, during the tenure of which this work was carried out.

was observed, and the amount of material in solution determined by evaporating an aliquot part to dryness. From these data the specific rotation of the dissolved material was calculated: $[\alpha]_D = +38{\cdot}8°$.

From the solution by treatment with phenyl hydrazine and acetic acid phenylglucosazone was obtained (m.p. 204° C.; no depression when mixed with an authentic sample). Pentoses were absent (phloroglucinol test), but ketoses were definitely present (diphenylamine test).

Percentage of Moisture.—On drying at 105° C. the fresh material lost 75·4% of its weight.

Examination of the Dried, Powdered Material.

Preliminary Analysis.—Nitrogen: 0·37%, estimated by the Kjeldahl method. *Fats:* 19·443 gms. of the material, extracted with ether in a Soxhlet apparatus, gave 0·437 gm. of ether-soluble material, equivalent to 0·23%. *Ash:* 0·38%.

Solubility in Alkali.—40 gms. were heated in a boiling water bath with 200 cc. of a 5% solution of sodium hydroxide. The insoluble material, which was in the form of gelatinous granules, was filtered off and washed with 50 cc. of boiling water. The combined filtrate and washings, which were dark brown in colour, were neutralised with hydrochloric acid, and an equal volume of alcohol was added. The white precipitate was filtered off, washed with alcohol, and dried at 80° C. The weight obtained was 4·14 gms., or 10·3% of the original dry material. This alkali-soluble substance was free from pentosans (phloroglucinol test) and galactosans (no mucic acid being produced on oxidation with nitric acid), but gave the characteristic ketose test after hydrolysis.

Acetylation.—A sample was acetylated by Irvine's variation (*J. Chem. Soc.*, 1922, *121*, 1587) of Barnett's method. 5 gms. of material were allowed to stand with 25 cc. of glacial acetic acid through which chlorine had been bubbled in a rapid stream for thirty seconds. At the end of half an hour 30 cc. of acetic anhydride were added, and sulphur dioxide passed rapidly into the mixture for one minute. After a further hour's standing the mixture was heated at 65° C. for six hours. At this stage the undissolved solid was removed by centrifuging, and washed with glacial acetic acid, the washings being added to the main bulk of the liquid. Chloroform (30 cc.) was

then added, and the recovery of the acetate proceeded with according to the directions given by Irvine. For purification it was redissolved in a mixture of chloroform and alcohol, the solution being shaken with animal charcoal, filtered and treated in the usual way for the recovery of the acetate.

The yields of ester and residue in the three experiments and the specific rotation of the ester in chloroform solution are given in the following table:

Experiment.	Wt. of Material Taken.	Wt. of Triacetate.	Wt. of Residue.	$[\alpha]_D$.
	gms.	gms.	gms.	
A	5	3·5	2·25	−36·5
B	5	4·9	1·1	−24·9
C	20	21·5	5·0	−24·1

In experiments B and C the chlorine was bubbled into the acetic acid for one minute instead of thirty seconds.

The percentage of acetyl in preparation B was determined by the method of Knoevenagel and König (Hess, *Chemie der Zellulose*, 1928 ed., p. 417). Found CH_3CO: 44·8, 45·1%; calculated for cellulose triacetate: 44·8%.

Breakdown of Acetate.—The triacetate (3·2 gms. of preparation B) was heated at 125° C. in a sealed tube with methyl alcohol (45 cc.) containing 0·75% by weight of hydrogen chloride, for 68 hours. The resulting pale yellow solution was neutralised with silver carbonate, filtered and evaporated to dryness under reduced pressure. The weight of glycosides was 2·025 gms., corresponding to 94·1% of the quantity of methyl glucoside which could be obtained from a polyglucosan triacetate. The specific rotation of the glycosides in methanol was +85·5°.

On standing in concentrated methanol solution portion of the glycosides crystallised. After one recrystallisation the solid material (0·479 gm.) was identified as α-methyl glucoside by the melting-point (164-5° C.) and the rotation $[\alpha]_D = +156·8°$ in water.

The syrup remaining, together with that obtained by evaporating the mother liquors from the recrystallisation, was equilibrated by heating for three hours at 100° C. with 20 cc. of 0·75% methyl alcoholic hydrochloric acid. The solution, without neutralisation, was made up to 100 cc. and the rotation observed. Then it was neutralised and

evaporated to dryness, when 1·128 gms. of syrup were obtained. The specific rotation of the glycosides in the acid solution, calculated from these data, was $[\alpha]_D = +86°$, a value considerably lower than that observed when α-methyl glucoside is equilibrated under similar conditions, namely $[\alpha]_D = +98·6°$.

Insoluble Material Recovered from the Acetylation.— The part undissolved during acetylation (Experiment B) was examined. It contained 0·30% of nitrogen and 8·7% of acetyl. On further acetylation of 1 gm. by the usual method, 0·84 gm. of acetyl compound and 0·43 gm. of residue were obtained. The acetylated part, isolated in the usual way, showed a specific rotation in chloroform of $[\alpha]_D = -11·9°$, and contained 53·14% of acetyl. The rotation and the high acetyl content indicate that considerable degradation of the original molecular structure had taken place.

Conclusions.

It would appear that the material is largely composed of a substance closely allied to ordinary fibre cellulose. Associated with the main polyglucosan constituent is probably a polyfructosan, since the presence of ketosans is indicated. Such an admixture would probably account for the divergence of the specific rotation of the triacetate from the normal value for cellulose triacetate, namely $[\alpha]_D = -22°$. Fats and proteins are almost entirely absent.

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A NOTE ON THE DECOMPOSITION OF COBALT AMALGAM.

By J. W. HOGARTH.
Communicated by MR. F. P. J. DWYER.

(Read before the Royal Society of New South Wales, Dec. 5, 1934.)

During some experiments with cobalt amalgam, prepared by the electrolysis of cobalt sulphate solution with a mercury cathode at a C.D. of 5·8 amps./sq. dcm., it was observed that the solid phase remaining after the removal of the liquid mercury by chamois leather underwent an unexpected change when exposed to the atmosphere. Black spots at first appeared on the surface of the bright silvery amalgam, and later droplets of liquid mercury. Eventually, in a few hours, nothing remained but an intensely black, finely-divided powder and liquid mercury, the latter containing only a minute trace of cobalt. The rate of reaction increased with the concentration of cobalt in the amalgam. With the cobalt concentration at a maximum ten to fifteen grams of amalgam changed completely in about two hours.

The black powder was insoluble in water, and was found to contain cobalt and minute traces of mechanically enclosed mercury. On treatment with dilute (5E) hydrochloric or sulphuric acid, hydrogen was evolved and the usual pink cobalt solution obtained. No chlorine was evolved with hydrochloric acid. Pure, dry hydrogen passed over the heated powder (dried over calcium chloride) gave neutral water, leaving grey metallic cobalt. It thus appears that the decomposition product of the amalgam is a suboxide of cobalt.

The amalgam, freed as much as possible from adhering mercury by pressure, is a brittle, somewhat silvery solid, apparently insoluble in mercury, and of somewhat lower specific gravity. It is stable in hydrogen, specimens sealed in hydrogen for more than thirteen months showing no evidence of decomposition. The decomposition is also inhibited considerably by dilute sulphuric acid solution. A search of the literature has not revealed any information regarding these observations. Further investigation of the amalgam and the black substance is intended.

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BROWN ROT OF FRUITS AND ASSOCIATED DISEASES OF DECIDUOUS FRUIT TREES.

II. The Apothecia of the Causal Organisms.*

By T. H. Harrison, D.Sc.Agr.

(With Plate VII and one text-figure.)

(Read before the Royal Society of New South Wales, Dec. 5, 1934.)

Introduction.

In Part I of this series[62] the conclusion was reached that the various strains of " Brown Rot " fungi, occurring on deciduous fruit trees throughout the world, were referable to three species, named as follows :—

(1) *Sclerotinia fructigena* Ader. & Ruh., for the fungus characterised by large, domed, buff pustules on infected fruits in Europe and Asia ;

(2) *S. laxa* Ader. & Ruh., for the fungus producing small grey pustules on fruits, twigs, and flowers in Europe, in Asia and on the Pacific coast of North America ;

(3) *S. fructicola* (Wint.) Rehm, for the fungus producing fawn pustules on infected parts of fruit trees in North America, New Zealand and Australia.

For many years it has been recognised that the apothecial stage of these fungi is very important taxonomically, and that under certain conditions it may be of the greatest practical importance, serving to spread the organisms. For these reasons the author has endeavoured to study all available type material, to examine critically all records, and to induce experimentally the production of apothecia of all species.

Attention has been called to the rarity of apothecia of *S. fructigena* Ader. & Ruh. and *S. laxa* Ader. & Ruh.,

* The laboratory work was carried out in the Plant Pathology laboratories of the Imperial College of Science, London, while the author, on leave from the New South Wales Department of Agriculture, held the Ben Fuller Travelling Scholarship. For the facilities provided the author expresses his gratitude to the authorities concerned.

and to the abundance of this stage of *S. fructicola* (Wint.) Rehm wherever these fungi occur.

Through the generous co-operation of mycologists in England, Europe, and North America, here gratefully acknowledged, it has been possible to assemble a collection of all extant type, or co-type, material. The author also has obtained apothecia, not hitherto reported, of *S. fructigena* and of *S. laxa*, and during the past ten years in Australia large numbers of apothecia of *S. fructicola* have been collected. Consequently, for critical comparison there is at present available a collection of apothecia of the various species of Brown Rot fungi more extensive and representative than in the possession of any previous investigator. It is hoped, therefore, in this paper to present a more complete picture of the important perfect stage of each of these fungi than has hitherto been possible.

The Apothecia of *Sclerotinia fructigena* Ader. & Ruh.

(1) The Original Record, Germany, 1905.

Until Solkina[42] in 1931 described apothecia of this fungus, the only authentic record of *Sclerotinia fructigena* was that of Aderhold and Ruhland[2] in 1905. Woronin[67] in 1888 had shown that a *Monilia* occurring on *Vaccinium Vitis-Idæa* was the imperfect stage of a *Sclerotinia*, which he named *S. Vaccinii*. Following this discovery mycologists in Europe searched in vain for the perfect stage of the species of *Monilia* which caused Brown Rot of fruits, realising clearly that this was essential to a solution of both the taxonomic and the pathological problems involved.

When Norton[25] in North America, in 1902, found apothecia of the American brown rot fungus he named it *S. fructigena*. These apothecia were obtained from " sclerotia " which appeared to be more than a year old.

In the autumn of 1902, shortly after the publication of Norton's work, Aderhold and Ruhland placed out of doors, in flower-pots, a large number of apples, peaches, apricots, greengages, plums and cherries mummified by *Monilia*, each species of fruit being kept separate. The pots were embedded in the ground between bushes on the experimental field at Dahlem, Germany, were protected by wire-netting, and had weeds removed from them twice during the year.

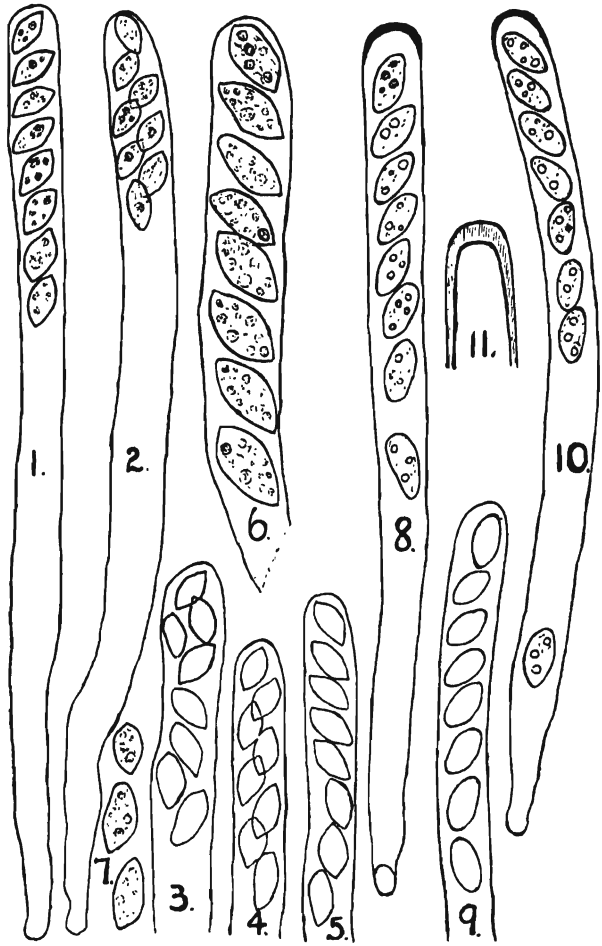
No apothecia developed in the first spring, but on April 20, 1904, on two apple mummies Aderhold and Ruhland found some immature *Sclerotinia* ascocarps (three and seven respectively). These apple mummies were taken indoors, replaced on earth, and covered with a bell-jar. Six days later they had produced four and thirteen mature apothecia respectively, and other small primordia. Cultures obtained from an ascospore cloud gave a *Monilia* stage, identical with the common buff-pustuled fungus on apples.

Aderhold and Ruhland were thus able to publish the only complete description of *S. fructigena*. With minor modifications it is repeated by Saccardo.[37] Aderhold and Ruhland's description is well supported by adequate illustrations.

Through the courtesy of Mr. J. Ramsbottom, Keeper of Botany, British Museum (Natural History), London, and Dr. O. Appel, Director der Biologischen Reichsanstalt für Land-und-Forstwirtschaft at Dahlem, the author obtained four apothecia from the limited supply of type-material. Illustrations of these are shown in Plate VII, Fig. D. They were very small, the largest having a diameter of 3 mm., and a stipe, which appeared incomplete, measuring 4·5 mm. Aderhold and Ruhland gave the diameter of the fresh apothecia as from 3 to 5 mm.

The asci were of the shape illustrated in the text-figure, Nos. 1 and 2. The ascospores were arranged in either one or two rows, the latter being less common. As described by Aderhold and Ruhland, paraphyses were only slightly swollen at the apex, pluri-cellular, branched or single, filiform and slightly longer than the asci. The shape of the ascospore is quoted by Aderhold and Ruhland as a cardinal point of difference between *S. fructigena* and *S. laxa*. The ascospores of *S. fructigena* are described as "oval, occasionally somewhat irregular, but always provided at both ends with distinctly expressed tapering points" (translation). In the Latin diagnosis occurs the phrase "*Sporidiis . . . ovato-fusoideis, utrinque acutis*". Aderhold and Ruhland's illustration is in support of this as a diagnostic feature.

After examining a number of preparations of the type-material the author considers that the ascospores are not always pointed, a few having rounded ends. The majority, however, are much more pointed than is usual for either *S. laxa* or *S. fructicola*. Several mycologists, including



Nos. 1-7.—Camera lucida drawings of Aderhold and Ruhland's type material of *S. fructigena*. Magnification 1,000, except Fig. 6, which is ×1,650. Note that the ascospores are pointed at one or both ends and that both mono- and distichous arrangements occur. The inclusions present in the spores did not react for oil when tested by the usual chemical and physical methods.

Nos. 8 and 9.—Camera lucida drawings of asci and spores of Wormald's material of *S. laxa*. The rounded bodies in this case are oil drops. ×1,000.

No. 10.—Ascus and spores from *S. fructicola* treated similarly to the *S. laxa* material. ×1,000.

No. 11.—Thickened end of ascus common to both *S. laxa* and *S. fructicola*. ×1,650.

Dr. H. Wormald, who saw some of the author's preparations, agreed with the above contention. It is therefore considered that, although exaggerated somewhat by Aderhold and Ruhland, the pointed nature of the ascospore of *S. fructigena* is a valuable diagnostic character. Asci and spores of this fungus are illustrated in the text-figure, Nos. 1–7. With the exception noted, the author considers that Aderhold and Ruhland's description of the apothecia of *S. fructigena* is verified by an examination of portion of the type-material.

(2) Occurrence in U.S.S.R.

In 1931 Solkina[42] published the second description of the apothecia of *S. fructigena*. A translation of the Russian original, supplied by the Imperial Mycological Institute, contains the following pertinent facts:

"On 5th June, 1931, apothecia were found on the surface of a mummified apple, lying on forked earth under an apple tree in the orchard of the Soviet Farm, Krasnaya, Slavyanka, near the town Slutzk. The concave face of the sclerotium, turned towards the earth, bore four immature apothecia, which were champagne-glass in shape. When placed under a bell-jar in a moist atmosphere the apothecia developed completely within 23 days, and on the 27th June they were examined in the systematic section of General Phytopathology of the A. A. Lebedeva Pan-Soviet Institute of Plant Protection . . .

The size of the apothecial cups varied from 0·6 to 1 cm. in diameter, and their colour was dark greyish-brown. The asci are cylindrical, from 112 to 150 by 9 or 10 to 12 μ in diameter. The paraphyses are threadlike, hyaline, from 130 to 180 μ in length by 3 to 4 μ in width, and protrude over the asci. The ascospores are ovoid, elliptical, tapering at one or both ends, occasionally almost acuminate at the tips, one-celled, hyaline, 9 or 10 to 12 μ in length and 5 to 6 μ in width . . .

In comparing these measurements with those indicated in the comparative table given in H. Wormald's paper,[51] in which are presented the measurements found by different authors of the asci and ascospores of *Sclerotinia*, it will be seen that the specimens found by us stand closest to the data given by Aderhold and Ruhland for *S. fructigena*. The description given above of the apothecia also agrees with Schröter's description of *S. fructigena*.[40]

Thus the fungus found by us may be correctly identified with *Sclerotinia fructigena* Schr. Our specimen is preserved at the General Pathology Section of the Pan-Soviet Institute of Plant Protection."

A photograph of the apothecia received from the above Institute is reproduced in Plate VII, Fig. C. In addition, the author received a micro-slide, bearing a crushing of an old apothecium, in which most of the asci were empty. In a few cases germination of the ascospores within the ascus had taken place. The germ tube was straight, and

usually emerged from one end of the ascospore. Most of the ascospores available for inspection had pointed ends, and agreed in general conformation with spores from other *S. fructigena* material. Solkina's description of the ascospores is supported by the limited studies made of her material.

The measurements of asci and ascospores, upon which Solkina appears to have relied for determination of her fungus, are of limited value in determining the species of Brown Rot fungi. In any case, the table cited does not support her claim that her specimens stand closest to data given by Aderhold and Ruhland for *S. fructigena*. In the table mentioned the asci of *S. fructigena* are given as measuring 120–180 × 9–12 μ, while those of *S. laxa* are quoted as 121·5–149·9 × 8·5–11·8 μ. Solkina's figures for her fungus are 112–150 × 9 or 10–12 μ, and hence are closer to those of *S. laxa* than to those of *S. fructigena* of Aderhold and Ruhland. The size of the ascospores given by Aderhold and Ruhland are: *S. fructigena* 11·0–12·5 × 5·6–6·8 μ; *S. laxa* 11·5–13·5 × 5·2–6·9 μ. Solkina's figures are 9 or 10–12 × 5–6 μ. It can be seen that, apart from the length of the ascospore, the figures given by Solkina do not agree "most closely with those given for *S. fructigena*".

The reference to Schröter's description of *S. fructigena* is misleading, because Schröter did not describe the apothecia of *S. fructigena*, merely recording of this stage "Schlauchfrucht unbekannt". Solkina makes no mention of the fungus having been obtained in culture. However, *S. fructigena* is the only species of "brown rot" fungus recorded as rotting apples in Europe. This supports the conclusion that Solkina's apothecia were those of *S. fructigena* Ader. & Ruh.

(3) Occurrence in Denmark.

Another interesting record dealing with the apothecia of *Sclerotinia fructigena* is that of Weber,[60] who in 1926 stated: "The apothecial stage has been found on one and a half-year-old apples" (translation). Weber was asked for some of this material, but she replied that the apothecia referred to were those mentioned in J. Lind's "Danish Fungi as represented in the Herbarium of E. Rostrup", 1913, p. 112. The following statement is the only reference there to *S. fructigena*: "Ascomata have been produced by the mummified apples which had

been kept for one and a half years in moist sand ". Dr. Christensen, Curator of the Botanical Museum at the University of Copenhagen, stated that no specimens had been preserved in Rostrup's herbarium. Dr. Phil. C. Ferdinandsen, Professor of Botany at Copenhagen, wrote on January 5, 1932, that " Lind's statement is derived from a source which cannot be traced out. Nothing seems to be published about the matter, and the late Prof. E. Rostrup's correspondence here in this department is mute upon the subject."

The author is of the opinion, therefore, that because this record of *S. fructigena* from Denmark cannot be substantiated it should be discarded.

(4) Occurrence in Italy in 1919.

In August, 1931, the author visited the " Institutio Superiore Agrario " at Bologna, Italy, where amongst the teaching collections of the Plant Pathology Department was one specimen labelled " *Sclerotinia fructigena* Su Mele, April, 1919 ". This consisted of about one-half of a mummied apple, upon which there were approximately twenty-five apothecia in various stages of development. This specimen was collected in the grounds surrounding the Institute. An irregular piece of the mummied apple, approximately 22×17 mm., and from 0·5–2 mm. thick, bearing six mature and four immature apothecia, was given to the author by Dr. Mario Sacchetti ; it is illustrated in Plate VII, Fig. E. These apothecia were dull flesh pink in colour, crateriform, with glabrous uniform margins, and measured from 3·5 to 10 mm. in diameter. They were on stipes which varied in colour from light brown to black, in length from 3 to 8 mm., and in thickness from 0·75 to 2 mm. The stipes in most cases were without rhizoids, but in one case rhizoidal tufts were present.

A detailed study of three of the apothecia was made. They were found to coincide in all important particulars with Aderhold's type-material of *S. fructigena*.

Of 100 monostichous asci the mean length was 152·34μ, and the range 130–184 μ. The mean diameter was 8·2μ, and the range 7·0–9·75 μ. Each ascus contained eight spores, arranged diagonally in either one or two rows (see text-figure No. 5 and Plate VII, Fig. F). The spores were mostly pointed at one or both ends. The impression received upon examination of a slide of this material is the same as that given by Aderhold's material. This has

been confirmed by several mycologists, including Dr. H. Wormald.

Dr. Sacchetti expressed the opinion that, if attempts to prove the connection of the apothecia with the *Monilia* stage were made, no record was kept. However, on apples in Italy the only Brown Rot fungus recorded is *S. fructigena*. This may be regarded as evidence that the apothecia were those of this fungus. Detailed examination supports this, and hence the author considers that the apothecia found at Bologna in 1919 are those of *S. fructigena* Ader. & Ruh.

(5) Occurrence in Holland.

The author has previously stated[62] that, in 1912, Westerdijk[46] reported the occurrence in Holland of a *Sclerotinia* arising from mummied sour cherries. No specific name was given to this fungus, although Westerdijk thought it different from both *S. fructigena* and *S. laxa* of Aderhold and Ruhland. The author, however, has examined some of Westerdijk's material, and presents evidence to support the conclusion that this fungus must also be referred to *S. fructigena*.

Westerdijk's description of the apothecia is reproduced hereunder :

"Die Länge der Apothecien ist von 4–6 mm. ; der Stiel geht allmählich in den Becker über. Ein Drittel des ganzen Apotheciums, und zwar der untere Stielteil, ist dunkelviolett gefärbt ; darauf folgt eine Hellbraune Zone, während das obere Drittel eine dazwischen stehende Farbe, namentlich hellbraun-violett, aufweist.

"Die Asci sind 158·4–171·6 lang und 7·9–8·5 breit. Die sporen messen 13·2–16·8 × 4·3–5·2. Sie sind also länglich und meistens zugespitzt. Oeltröpfchen kommen vor. Die Paraphysen sind meistens etwas länger als die Asci und am Ende schwach angeschwollen."

Westerdijk presents a table in which Aderhold and Ruhland's measurements of asci and ascospores of *S. fructigena*, *S. laxa* and *S. cinerea* are compared with the above dimensions.

Westerdijk apparently considered that the only Brown Rot fungus occurring on cherry fruits in Holland was the grey pustuled one, at that time named *S. cinerea*. Without connecting her fungus with a *Monilia* stage she assumed that, because it arose from mummied cherries, it could not be *S. fructigena*. The author has, however, frequently noticed the large buff pustules of *S. fructigena* on rotting cherries in Europe, including Holland. Further, this fungus has been noted from its earliest records, occurring

on stone fruits. Westerdijk was also mistaken in regard to the size of the apothecia of *S. fructigena*. She stated that because her apothecia measured only 5 mm. in diameter, it was unlikely that they were identical with Aderhold and Ruhland's apothecia, which measured 10–15 mm. in diameter. Actually the latter apothecia are quoted by Aderhold and Ruhland as being 3–5 mm. in diameter.

Westerdijk's reasons for deciding that her fungus could not be *S. fructigena*, despite her conviction that " sie kommt der *Sclerotinia fructigena* am nächsten ", are therefore open to question. Westerdijk also concluded that her fungus could not be *S. laxa*, as she believed that this fungus was restricted to apricots. This reasoning is also now known to be unsound.

Could her fungus then be *S. cinerea*? The measurements given by Aderhold and Ruhland under this heading were obtained from a study of American material, received from Norton. They are not only of a different fungus, but also very low for the fungus actually studied by Aderhold and Ruhland, who gave the following figures: Asci 89·3–107·6 × 5·9–6·8 μ, ascospores 6·2–9·3 × 3·1–4·6. Other workers have found figures at least 50% greater than these for the same fungus. The pointed nature of the spores, as well as the sizes given for asci and ascospores of her fungus, convinced Westerdijk that her fungus could not fit in with Aderhold and Ruhland's description of *S. cinerea*. She thus concluded:

" Neben den 3 beschriebenen Obstsclerotinien is dann also eine spezielle Kerschensclerotinie aufzustellen."

In Westerdijk's description the number of asci and spores measured is not stated, nor is an average given. An analysis of the figures reveals the following: The asci reproduced were found to measure 68–74 mm., which at the magnification quoted (550) represents an actual size of 123·6–134·5 μ. The size quoted by Westerdijk, however, is 158·4–171·6 μ, hence in reproduction the plate has been reduced by approximately 22%. The spores in ascus No. 1 were found to be 6·5–8 mm. long, representing a length of 11·8–14·54 μ, or with 22% added, 14·4–17·74 μ. In breadth the spores in the same ascus measured 2·8–3·5 mm., representing a size of 5·1–6·36 μ before adding 22%, which increases it to 6·36–7·76 μ. On applying the same principles to the isolated ascospores it was found that the length varied from

17·5 to 20 mm. At a magnification of 750 this represents an actual size of 23·3–26·7 μ, a length far in excess of that quoted by Westerdijk, even without the addition of 22%, which would make the figures 28·31–32·53 μ. In diameter the size is from 5 to 6 mm., representing an actual size of 6·66–8 μ, or, with 22% added, 8·0–9·76 μ. Both these sets of figures make a striking contrast with those quoted by Westerdijk, *i.e.*, 13·2–16·8×4·3–5·2 μ.

The author considers that such serious discrepancies cast doubt on the reliability of the measurements of asci and ascospores given by Westerdijk.

An examination of portion of Westerdijk's material showed that the few ascospores present were pointed at one or both ends, and of a size comparable with the type material of *S. fructigena*.

Westerdijk's short reference, *viz.*, " Oeltröpfchen kommen vor ", is insufficient evidence to prove the nature of the inclusions noticed in the spores. In the illustrations one of the five isolated ascospores is shown without any inclusions, as also are the ascospores included in the asci. Moreover, Westerdijk did not make any further reference to them in a discussion of the distinguishing features of the various species of *Sclerotinia*. The author was not able to demonstrate the presence of oil drops, although certain inclusions were present in the spores examined.

The above facts have led to the conclusion that Westerdijk's record, while imperfect, must be considered as one of *S. fructigena* Ader. & Ruh.

The Apothecia of *S. laxa* Ader. & Ruh.

Apothecia of this fungus have been recorded twice, *viz.*, by Aderhold and Ruhland in Germany in 1905 and by Wormald in England in 1921. After discussing these two records the author will report the occurrence of apothecia of this fungus in England in 1932.

(1) Occurrence in Germany.

Aderhold and Ruhland[2] exposed mummied apricots to the same conditions which were responsible for the development of apothecia of *S. fructigena*, and on May 1, 1904 found two mummied apricots bearing apothecia. They wrote :

" Von den beiden am 1 Mai Fruchtkörper zeigenden Aprikosen-Mumien trug die eine wohlentwickeltes und ein kleineres Apothecium, die andere 3 unvollkommen ausgebildete Apothecien."

Cultures obtained from ascospores of this material yielded a *Monilia* with grey conidial pustules. Believing that they had the perfect stage of the fungus Ehrenberg had described as *Oideum laxum*, Aderhold and Ruhland published a complete Latin description of their fungus under the name *Sclerotinia laxa* (Ehrenb.) Ader. & Ruh. It is repeated in Saccardo.[37]

Particular emphasis was placed by Aderhold and Ruhland upon the details of the ascospore. In the Latin description the spores are described as " utrinque obtusissimus, saepe 2–3 guttulatis, 11·5–13·5 μ longis, 5·2–6·9 μ latis ". In the text,[2] p. 433, they wrote :

" Im Gegensatz zu denen von *Sclerotinia fructigena* waren sie aber beidendig stets abgerundet, nicht mit einem Spitzchen versehen und wiesen vielfach noch 2-3 kleine Öltröpfchen im Innern auf, welche bei *Sclerotinia fructigena* fehlten."

The description of the apothecial stage of both *S. laxa* and *S. fructigena* shows that, apart from insignificant differences in measurements of asci and ascospores, the details of the apothecial stage of one would apply to the other, except for the two features mentioned. Aderhold and Ruhland regarded the pointed ascospores, devoid of oil-drops, as characteristic of *S. fructigena*, and the rounded ascospore, with two to three oil-drops, as equally characteristic of *S. laxa*. They separated their fungi very definitely, however, by securing the *Monilia* stage of each. The small grey pustules produced by *S. laxa* were very distinct from the large buff pustules of *S. fructigena*.

An endeavour was made to obtain some of the type-material of *S. laxa*, but Dr. Appel, who was approached, stated that Aderhold and Ruhland had preserved no specimens ; they had used the whole of their limited material in their experiments. It is therefore impossible to check Aderhold and Ruhland's description.

(2) Occurrence in England.

In March, 1920, Wormald found apothecia arising from plums collected during the winter of 1918–19, and exposed from January, 1919, to normal conditions at Wye, Kent, England. These apothecia were thoroughly described and illustrated in January, 1921.[51] A critical study of Wormald's material, generously made available to the author, confirmed in detail the published description.

There are several points in the paper of special interest. First, Wormald proved that single ascospores of his fungus

gave rise to the grey-pustuled *Monilia*, identical with *M. cinerea* f. *pruni* (= *S. laxa*).

Secondly, Wormald stated in regard to the ascospores: " The ends are generally rounded but often narrowed and almost pointed, occasionally one end mucronate ". Illustrations of ascospores, both in and free from the ascus, support the above statement. The impression received when one examines a slide containing asci and ascospores of Wormald's material is that the spores are rounded at the ends (see also text-figure, Nos. 8 and 9). The opposite impression is received when one examines Aderhold and Ruhland's material of *S. fructigena*; the ascospores in this case are generally pointed.

Wormald does not state the nature of the rounded bodies shown in the ascospores in his illustration, but the author is convinced that oil-drops are present. One to three bright, highly refractive bodies show up clearly in each spore in preparations stained lightly in cotton blue.

Thirdly, Wormald found that " the asci, when treated with iodine, showed a bluish ' pore ' at the apex ", whereas Aderhold and Ruhland stated that in *S. laxa* the thickened apex did not stain blue with iodine. It is possible that differences of technique may explain this discrepancy. It is significant to note, in this connection, that Aderhold and Ruhland stated that the pore of the ascus of *S. fructicola* (Wint.) Rehm did not stain blue with iodine, whereas, in the fresh condition at least, the opposite holds.

Wormald considered that the differences between his fungus and Aderhold and Ruhland's *S. laxa* were insufficient to separate them. He considered that both should be included within the species *S. cinerea* (Bon.) Schröt. The author has recently discussed this conclusion.[62]

(3) An Additional Record in England.

During the autumn of 1930 the author assembled at the Biological Field Station of the Imperial College of Science, situated at Slough, Bucks, England, large quantities of naturally mummied plums and other fruits, collected from various fruit-growing districts of England. These mummied fruits were placed in shallow wooden trays containing soil so arranged that some of the mummied fruits were buried to a depth of 25 to 30 mm., others were half-buried, while others were on the soil surface. Some of the trays were then exposed to normal winter conditions in three separate situations. Others were subjected to

rapid changes in environmental temperature by being placed for alternating intervals in the refrigerator and in warm places at the Field Station.

No apothecia were obtained during the following spring and summer, despite frequent searches for them. The majority of the mummied fruits had disintegrated by the winter of 1931–32, when the residue of the material was left exposed to normal climatic conditions at Slough.

On March 13, 1932, Professor Brown, who had the material under observation, found some fifteen to twenty apothecia in various stages of development. One mature apothecium was forwarded to Dr. H. Wormald who, after studying asci and ascospores, stated that he thought the apothecia were those of *S. cinerea* (= *S. laxa*). The remaining material, together with cultures obtained from an ascospore cloud, was forwarded to the author at Richmond, New South Wales.

Morphological Studies.

A total of fifteen apothecia was available for examination. They arose from three irregularly shaped remnants of mummied plums. These remnants were black, tough, corrugated pieces of pseudo-sclerotium. They consisted of an external layer of thick, dark hyphæ, within which were some relatively hyaline hyphæ, and incorporated cells of fruit tissue. The thickness of this pseudosclerotium was variable. In some cases two layers had become fused during shrivelling of the fruit, but a single layer was approximately 0·25 to 0·4 mm. thick (see Plate VII, Fig. G).

The *apothecia* were stipitate, mostly light brown to brown in colour, and from 2·5 to 8 mm. in diameter. The average of fourteen mature apothecia was approximately 5·5 mm.

The *shape* varied considerably, but most were concave, a few were flattened, while a few others were recurved. The margin was glabrous and uniform except for splits which apparently developed as the apothecia flattened out. The hymenial surface of the apothecia was consistently puckered or foliated, a feature absent from the majority of the apothecia of *S. fructicola* found in America and Australia (see Plate VII, Figs. A and B).

The *stipe* measured 1 to 10 mm. in length, and was normally thin, measuring from 0·75 to 2·5 mm. in diameter.

In all cases it tapered from the base of the apothecium to reach its minimum thickness at about 0·5 mm. from the pseudosclerotium. In colour it ranged from the black of the pseudosclerotium to the light brown at the base of the apothecium.

The *asci* were cylindrical, clavate, with rounded ends. The pore was centrally placed, and was indicated clearly in some asci from which spores had been ejected. It also stained blue with iodine. Of 100 monostichous asci the mean length was 148·2μ, with a range from 140–160 μ. In diameter the mean size was 10·32μ, and the range 9·2–12·3 μ. The material was probably shrunken by preservation in spirit.

The *paraphyses* were hyaline, septate, filiform, approximately as long as the asci, and usually slightly swollen at the tips. Both branched and unbranched types were present, the latter predominating.

The *ascospores* varied considerably in shape. Some were ovoid, some pyriform, others elliptical, but all had rounded ends, in contrast to those of *S. fructigena*. Both the monostichous and distichous arrangements of the spores were present.

Oil-drops were present in the majority of the spores. Usually two or three spots of a highly refractive nature could be seen in the preserved material which the author examined. In some cases these spots did not occur, suggesting that perhaps the oil-drops are differentiated only at certain periods in development of the spores.

A culture, obtained by Professor Brown, agrees with the stock cultures of *S. laxa* at the Imperial College of Science, London. It also agrees in cultural characteristics with many other isolations of *S. laxa*, made from plum fruits and twigs in England. The two apothecia, which together gave the cloud from which the subculture was obtained, are the same in all features, and have the rounded ascospores found reliable in separating *S. laxa* from *S. fructigena*.

In culture and on fruits it has behaved as the typical form of *S. laxa*, hence the author considers that this record represents the third one of the apothecial stage of the fungus *S. laxa* Ader. & Ruh.

Apothecia of a Brown Rot Fungus in the Caucasus.

During 1930 Dr. J. G. Dickson, of the University of Wisconsin, visited the Caucasian region of U.S.S.R. in

search of hardy cereals. In the mountain region inland from Batum wild plum trees are abundant. The humid conditions prevailing there during the summer favour the development of the Brown Rot fungus to such an extent that each year most of the fruit is destroyed by it. In May, 1930, under clumps of plum trees growing on the foothills, Dr. Dickson collected hundreds of apothecia for use in the Plant Pathology classes at Madison. He did not then realise the special significance of his discovery, because apothecia of the Brown Rot fungus in America are abundant each year. With other material, the apothecia were despatched to Madison, Wisconsin, U.S.A., but unfortunately the whole consignment was lost in transit.

It would appear that the apothecia were of either *S. laxa* or *S. fructigena* or both. There is no record of *S. fructicola* having been found in Europe or in Asia. Balakhanoff[3] has recorded the effects of both *S. fructigena* and *S. laxa* on fruit trees on the Black Sea littoral, and it is reasonable to suppose that these fungi are responsible for the rotting of plums in the foothills east from Batum. If this be so, apothecia of one or both of the European Brown Rot fungi appear to have been as abundant in the Caucasian region in May, 1930, as those of *S. fructicola* are in favourable seasons in North America and Australia.

The Apothecia of *S. fructicola* (Wint.) Rehm.

It has been shown by Wormald,[52] Roberts and Dunegan,[36] and the author[15] that this species is the Brown Rot fungus widespread throughout North America, and is the only one present in New Zealand and Australia. In each country the apothecia are abundant.

The apothecia of this fungus were first found on mummied peaches, in May, 1883, by Rau at Bethlehem, Pennsylvania, U.S.A.[36] [62] The next occasion was in 1902, when Norton found them in large numbers on mummied peaches in Maryland. It is fitting that Norton, who taught pathologists where to look for the apothecia, should assist in the preparation of a bulletin entitled "Apothecia of the Brown Rot Fungus,[26] which appeared in 1923. This incorporated Norton's experience during twenty years at College Park, Maryland, and the detailed studies of Ezekiel and Jehle. By means of sketches and photographs the development of the apothecia is traced from the first appearance of the primordia to maturity.

Morphological Studies.

Reade,[32] Matheny,[23] Pollock,[30] Jehle,[64] Bartram,[56] Barss,[55] Honey,[16] Roberts and Dunegan,[36] have all made contributions to our knowledge of the appearance and morphological details of the apothecia in America. One of the best photographs of the apothecia is that of Honey,[16] which is reproduced by Heald.[63] The apothecia have been recorded arising from mummied apples, apricots, cherries, peaches, pears and plums.

Shape.—The author collected apothecia in several places in U.S.A. in 1932, and studied large numbers of preserved specimens in various herbaria and teaching collections. He was impressed by the fact that, in the vast majority of cases, the apothecia were concave at maturity with a uniform, thin, smooth margin and a relatively smooth hymenium. They are fairly represented in Plate VII, Fig. A. McCubbin[65] has published a photograph illustrating the occurrence of this same feature in Canada. Cunningham's[58] illustrations and description of the apothecia, as they occur in New Zealand, photographs by Davies,[59] and an examination of specimens from New Zealand, all support the view that the typical apothecium in that country is the same as described above. An examination of large numbers of fresh apothecia collected in Australia shows that the shape varies considerably. The majority are crateriform at maturity although, later, apothecia may become flattened and even reflexed. Typical specimens are illustrated in Plate VII, Fig. B.

The author feels that, while exceptions occur, the crateriform apothecium, with fairly even or smooth hymenium, is a usual feature of *S. fructicola*. This type of apothecium was not present in the limited material of *S. laxa* so far studied. Examination of more material of the latter fungus, however, may show that these features are not of taxonomic significance.

Monospore isolates obtained from apothecia of *S. fructicola* exhibiting in one case a much wrinkled and in the other a smooth hymenium, collected in September, 1932, in New South Wales, showed no differences in culture. Such differences in external morphology may, however, be heritable. Efforts are being made to obtain the necessary evidence.

Size.—Size of the apothecia of *S. fructicola* is most variable. Norton[25] stated: "The expanded disc is

from 2 to 15 mm. wide, usually about 5–8 mm." Reade[32] gave the diameter of the apothecia as 5–30 mm. Most of those inspected by the author in U.S.A. were 5–10 mm. in diameter. Cunningham recorded the size as 1/12th to 3/4ths of an inch in diameter. In Australia, also, the diameter of the cup of this fungus varies enormously.

In 1932 of twenty-three apothecia collected within a few square yards under one plum tree at Sackville Reach, New South Wales, the mean diameter was 6·9 mm. and the range 1·5–25 mm. In 1934, a favourable season for development of apothecia, 165 collected in the Kurrajong district, New South Wales, gave a mean diameter of 8·24 mm., with a range of 2·5–30 mm. So many variables govern the size of apothecia that further statistical examination of the figures is undesirable. The variables include the nature, size, productivity and position of the pseudosclerotium, apart from the influence of atmospheric conditions and strain variation. It is clear, therefore, that size alone of the apothecia can be of little taxonomic significance.

Colour.—The colour of the apothecia is also variable. Specimens found in Australia have varied from a whitish fawn through light and mid-brown to dark brown, depending on age and on moisture present. Usually a light brown on the edge of the cup will gradually give place to a dark brown in the centre. When dry the hymenium is reddish-brown, while the underside of the cup may be whitish.

Stipe.—The length and thickness of the stipe show considerable variation, depending on the conditions of production. The author has recorded a maximum stipe length of 37 mm., but one of 48 mm. was found in 1932. Norton stated: "The sinuous stipe is 5–30 mm. long and from 0·3 to 1·5 mm. thick." Roberts[36] records a stipe 60 mm. long. The diameter of the stipe varies from the minimum, usually at a point about midway between the apothecium and pseudosclerotium, to the maximum as it enters each of these structures. The thickened base is particularly noticeable in developing apothecia. The stipe is usually circular in outline and from 0·5 to 2 mm. in diameter. The colour varies from the black of the substratum to the light brown of the apothecium.

Hymenium.—The hymenium consists of asci and paraphyses packed tightly together. This is well illustrated

by Matheny,[23] by Roberts and Dunegan,[36] and by Norton *et al.*[26]

Asci.—The above workers have described and figured the asci, which are cylindrical, clavate, tapering below, rounded at the ends, somewhat thickened and possessed of a central pore which usually stains blue with iodine. They contain eight spores arranged in either one or two rows, depending on stage of development.

The size of the asci varies considerably, as is shown in the complete table given by Roberts and Dunegan.[36] The figures given by the various authors, however, may not be strictly comparable, because Wormald[51] has shown that the asci enlarge prior to the discharge of ascospores. The author is convinced that normally the monostichous asci are less mature than the distichous ones, and hence the arrangement of spores should be stated. Matheny,[23] who measured 490 asci from peach apothecia, found the size 135–190 × 6·9–10·5 μ, mostly 163 × 8·9 μ, but he did not state the nature of the asci measured. Ezekiel[11] found that fresh monostichous asci had a mean size of 146·2 × 8·7 μ, while Dunegan[34] found the size of similar asci to be 130–186 × 5·7–13·3 μ. Reade, after studying large quantities of fresh apothecia from plums, peaches and cherries, wrote in an unpublished thesis as follows:

"In size the asci vary somewhat in different lots of material. The smallest measured were 125–130 × 7–9 microns; the largest were 190–215 × 8·5–10. A common size for medium asci would, perhaps, be 170 or 180 × 8–10 microns."

From his statement that the spores were "obliquely uniseriate or subseriate", it is inferred that the asci were measured in the monostichous condition.

Ascospores.—The ascospores have been figured and described by Matheny,[23] Roberts and Dunegan,[36] by Norton *et al.*,[26] and by the author.[15] All are agreed that the great majority of the spores have rounded ends. The judgment of Roberts and Dunegan may be taken as one reached after consideration of all relevant facts. They wrote:

"The eight monostichous hyaline ascospores found in each ascus are ellipsoid to ovoid in shape with rounded ends. The monostichous arrangement becomes irregular just before the spores are discharged. The spores contain oil droplets, and are non-septate while in the ascus, but many become two-celled prior to germination."

The author has paid special attention to the ends of the ascospores because of the use of this feature to separate *S. fructigena* from *S. laxa*. Preparations from apothecia

obtained from peaches, plums and apples in Australia, from peaches in New Zealand, from cherries, plums and peaches in America, and from the co-type material of *S. fructicola*, have been examined. His considered opinion is that the normal ascospores have rounded ends and are fairly illustrated in the above-mentioned publications. Oil-drops are present in most spores, being readily demonstrated with osmic acid. To the above description, therefore, he would merely add that the ascospores sometimes assume the distichous arrangement in the ascus. This, occurring just prior to the expulsion of the spores, is considered to be an arrangement for distending the ascus, and to have no taxonomic significance.

Paraphyses.—The paraphyses are hyaline, septate, filiform, with rounded, slightly swollen ends. They are mostly unbranched, usually slightly longer than the asci, and 2–4 μ in diameter.

Spore Dispersal.—The ascospores are ejected in clouds from the apothecia when the atmosphere surrounding these bodies is disturbed, or has its pressure quickly reduced. The attention of the author has often been directed to a clump of apothecia by a cloud of spores caused by disturbance of the surrounding rubbish. Roberts and Dunegan[36] have shown that the spores may be discharged to a height of 4·3 cm. by forces within the asci. The author has observed clouds of ascospores being wafted, like thin smoke, through the air for a height of from 2 to 3 metres. The spores are so light that the initial forces of expulsion start an upward movement sufficient to enable them to reach the flowers of stone fruit trees, where infection may result. A definite correlation between apothecial production and the occurrence of blossom blight and twig wilt was established in several districts of New South Wales in 1932 and 1934.

Germination.—The method of germination of the ascospore has been discussed and illustrated by Roberts and Dunegan,[36] and by the author.[15] Normally a single germ tube, which usually remains straight and unbranched for a considerable distance, is produced from the ascospore.

Subhymenium.—The subhymenial layer consists of loosely interwoven hyphæ similar in essentials to those present in the stipe. The length and diameter of these cells are most variable. Most are indented at the septa. The details are fairly represented by Norton *et al.*[26] and by Roberts and Dunegan.[36]

Discussion.

A careful review of the above descriptions of the apothecial stage of the three brown rot fungi will show that, when normally accepted morphological criteria are used, it is difficult, if not impossible, to separate the two last species by a study of the apothecial stage. This led the author to compare critically some of Wormald's material of *S. laxa* with material of *S. fructicola*, preserved similarly and for the same period. Careful studies of every feature to which attention has been given in the above descriptions showed that these two species could not be separated by this means alone (see text-figure, Nos. 4 and 5).

This result is not surprising if, as Honey[16] suggests, the work of Durand[60] tended to show that the apothecia of the genera *Ciboria*, *Sclerotinia* and *Stromatinia* were identical in both external and internal morphology.

The author therefore tested the value of detailed studies of the stipes of *S. laxa* and of *S. fructicola* as a means of separating the apothecia of these two species. It was considered that if there were significant differences in the size of the vegetative cells of the two species, as stated by Ezekiel,[11] the cells of the stipes might show similar differences.

Portions of the stipes of one apothecium of each fungus, preserved in 90% alcohol for about ten years, were treated as follows: By easy stages the material was transferred through grades of alcohol to water, where it remained for three days; it was then fixed in Farmer's reagent, and eventually transferred to wax, and both transverse and longitudinal sections were prepared and stained.

Microscopic examination showed that in *S. fructicola* the cell arrangement was clearly defined in the interior of the stipe, but in *S. laxa* the cells were discontinuous except for the first few layers. Whether or not this was general for the two species could not be determined because of the author's limited material of *S. laxa*. Experiments with the object of producing, under identical conditions, apothecia of both these fungi have not yet been successful.

Moreover, detailed studies of stipes of other apothecia of *S. fructicola*, collected recently in Australia, show that the internal structure of the stipe is variable. It is therefore necessary to await adequate supplies of apothecia of both fungi grown under identical conditions, before this matter can be further investigated.

From the studies made, however, it is clear that the range in diameter of the hyphæ is so great in both species as to make this feature of doubtful taxonomic significance.

The author considers, however, that because of the very striking differences between *S. laxa* Ader. & Ruh. and *S. fructicola* (Wint.) Rehm in the imperfect stage, it is necessary to retain these two species distinct. In subsequent papers the author will present evidence of field and laboratory studies made in Europe, America and Australia in support of this conclusion.

Summary.

1. A comprehensive account is presented of the apothecia of the three common brown rot fungi: (a) *Sclerotinia fructigena* Ader. & Ruh., (b) *S. laxa* Ader. & Ruh. and (c) *S. fructicola* (Wint.) Rehm.

2. Aderhold and Ruhland's record of *S. fructigena* is still the most complete available, but apothecia described by Westerdijk in 1912 and by Solkina in 1931 are referred to that species.

3. An additional record of this fungus found at Bologna in 1919 is presented.

4. The record of *S. fructigena* from Denmark is discarded.

5. The occurrence of apothecia of a brown rot fungus in the Caucasus is discussed.

6. The records of Aderhold and Ruhland (1905) of *S. laxa* and of Wormald (1921) of *S. cinerea* are reviewed as two excellent descriptions of the same fungus for which the name *S. laxa* Ader. & Ruh. is preferred.

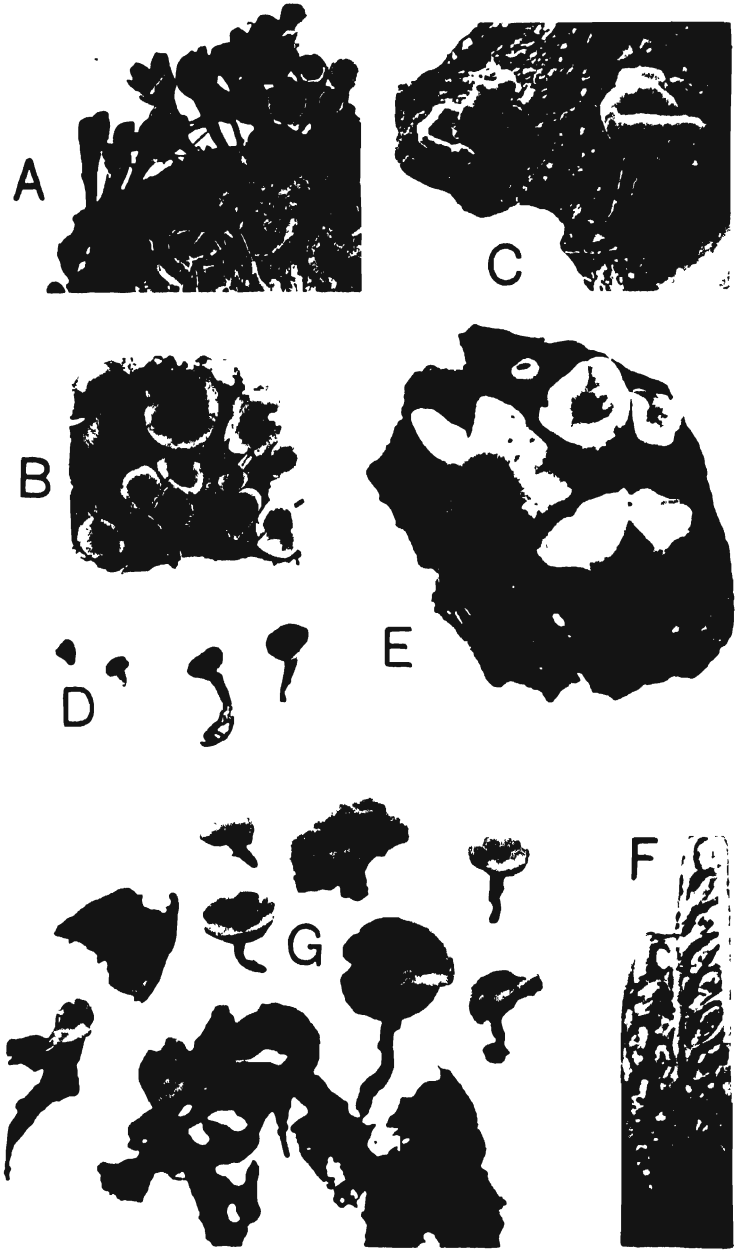
7. The occurrence of apothecia of this fungus in England in 1932 is recorded.

8. Existing records of *S. fructicola* (Wint.) Rehm are briefly reviewed, and supplemented by critical observations made of this fungus in Australia.

9. Apothecia of *S. laxa* and *S. fructicola* appear to be morphologically inseparable, but the material of the former is too limited for adequate study. Attempts to separate the apothecia by stipe studies are reported.

10. The striking differences between the two species in the imperfect stage justify their separation. Evidence in this connection will be presented in subsequent papers.

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A
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Many of the references in this paper are the same as those in Part I of this series,[62] hence it is considered unnecessary to repeat the details.

The same reference numbers are used in the two papers. Additional references are detailed below.

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EXPLANATION OF PLATE VII.

Fig. A.—Apothecia of *S. fructicola* from a mummied plum, showing uniform margin and smooth hymenium. Natural size. Photograph supplied by H. P. Barss, Corvallis, Oregon, U.S.A.

Fig. B.—Apothecia of *S. fructicola* from mummied peach, Colo, N.S.W., Sept., 1934. Natural size.

Fig. C.—Reproduction of print of apothecia of *S. fructigena* recorded by Solkina.[42] Three apothecia arise from portion of a mummified apple. ×3.

Fig. D.—Four of the type apothecia of *S. fructigena*. Note the relatively small size of these, especially of those on the left. Photographed in alcohol, in London, 1931. ×2·4.

Fig. E.—Apothecia of *S. fructigena* obtained by the author from Bologna, Italy, in 1931. Apothecia found on mummied apple, May, 1919. Photographed in alcohol, Richmond, N.S.W., 1934. ×2·5.

Fig. F.—Photomicrograph of asci and spores of *S. fructigena* from Bologna. Note that one ascus shows the monostichous, the other the distichous arrangement. The pointed nature of the spores is evident. ×900.

Fig. G.—Apothecia of *S. laxa* Ader. & Ruh. found at Slough, England, May, 1932. Note puckered hymenial surface of apothecia and tendency for apothecia to recurve and crack at edges. Portions of thin pseudosclerotium also shown. Photographed in alcohol, Richmond, N.S.W., 1933. ×2.

THE CHEMISTRY OF THE CONSTITUENTS OF THE WOOD-OIL OF THE "CALLITRIS" PINES.

PART II.—GUAIOL.

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and D. E. WHITE, M.Sc.

(Read before the Royal Society of New South Wales, Dec. 5, 1934.)

Guaiol, the characteristic crystalline sesquiterpene alcohol from the wood-oil of the *Callitris* pines, was first isolated from this source in 1910 by Baker and Smith ("A Research on the Pines of Australia", Sydney, 1910, pp. 63, 118). It had previously been obtained from Guaiacum wood-oil (Schimmel's Report, 1892, ii, 42), which has served as the chief source for constitutional studies by Semmler, and more recently by Ruzicka and their co-workers.

Guaiol appears to be a bicyclic tertiary alcohol, $C_{15}H_{26}O$, with one ethylenic linkage or a labile third ring. Since it yields on dehydrogenation a member of the blue hydrocarbon series, the azulenes, rather than the naphthalene derivatives cadalene or eudalene, progress upon its constitution has been slow, and very little insight has been obtained into its elusive structure.

The present investigation was undertaken in connection with the study of the constituents of the wood-oil of the anti-termitic *Callitris* genus, as outlined in Part I (THIS JOURNAL, 1932, *66*, 284) and is chiefly concerned with attempts to degrade the molecule to identifiable fragments by oxidation.

Semmler and Mayer (*Ber.*, 1912, *45*, 1391) obtained a substance $C_{15}H_{28}O_3$ by permanganate oxidation of guaiol, and this was later shown to be a dihydroxy ether, m.p. 218°, $C_{15}H_{26}O_3$, by Ruzicka and Haagen-Smit (*Helv. Chim. Acta*, 1931, *14*, 1131), who were able to isolate it also

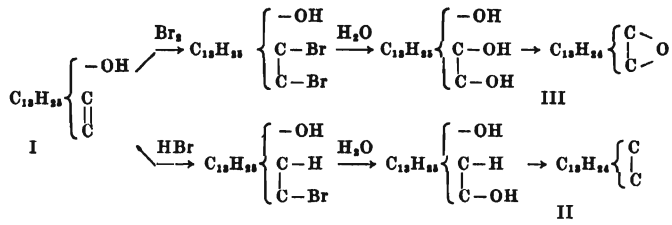
from the products of ozonolysis of guaiol. By exhaustive extraction of the manganese dioxide sludge with alcohol we have almost doubled the yield of this substance (4 g. from 10 g.) and have isolated from the residual oil (about 1 g. from 10 g. guaiol) a product, m.p. 95–97°, for which analyses and molecular weight determinations suggest a formula $C_{13}H_{24}O_3$. This substance distils unchanged at 0·5 mm., and is stable, like the dihydroxy ether $C_{15}H_{26}O_3$, towards excess permanganate in acetone; it does not appear, therefore, to be a secondary oxidation product *via* the latter substance. The nature of the oxygen atoms is as yet undetermined. A small quantity of a sodium carbonate-soluble product (about 0·8 g. from 30 g. guaiol) was also obtained in the above oxidation and its acid character proved by esterification with ethyl alcohol–sulphuric acid to a fragrant ester, which distilled at about 160° C. at 0·7 mm., but in insufficient quantity for fractionation. Such an acid by-product was obtained in only one oxidation, corresponding experiments yielding only neutral substances.

Criegee's elegant method of oxidation of glycols with lead tetracetate (*Ber.*, 1931, *64*, 260), was employed upon the dihydroxy ether, but we were unable to isolate ketonic products, which are characteristic of the oxidation (by this method) of substances containing vicinal hydroxyl groups.

The presence of an ethylenic linkage or labile third ring is further shown by the ease of oxidation of guaiol with percamphoric acid, when a quantitative yield of a substance, $C_{15}H_{26}O_2$, is obtained. This compound appears to be capable of partial oxidative degradation and is being further studied. Dehydration with anhydrous potassium bisulphate or formic acid gave only small yields of volatile material.

In studying the action of bromine (1 mol.) on guaiol dissolved in ice-cold cyclohexane or chloroform, the purple solution, which already contained much hydrogen bromide, was decomposed with ice, and a volatile oil, of narrow boiling range, was isolated in about 40% yield. Analytical values indicate the presence of an unsaturated hydrocarbon, probably $C_{15}H_{24}$ (II), contaminated by a proportion of an ether, $C_{15}H_{24}O$ (III). Repeated fractionation in high vacuum, distillation over sodium and treatment with zinc dust failed to remove oxygen com-

pletely. The decomposition may be conceived to have occurred in the following manner (I represents guaiol):



Reduction of the product with platinum oxide–hydrogen yielded a colourless volatile oil which again could not be separated, and appeared to consist of substances of formulæ $C_{15}H_{26}$ and $C_{15}H_{26}O$.

Guaiene, the product of dehydration of guaiol (Wallach, *Annalen*, 1894, *279*, 395; Gadamer and Amenomiya, *Arch. Pharm.*, 1903, *241*, 22; Gandurin, *Ber.*, 1908, *41*, 4359; Ruzicka, Pontalti and Balas, *Helv. Chim. Acta*, 1923, *6*, 862), was prepared and submitted to oxidation in benzene–acetic acid solution, by Kuhn's method with deci-normal chromic acid. Guaiene is, however, stable even on boiling under these conditions. Oxidation of dihydroguaiene (Gandurin, *loc. cit.*), with permanganate in acetone, also failed to yield characterisable material. The investigation is being continued.

Experimental.

Guaiol.

Isolation of Guaiol.—Callitris species, such as those from North Australia, are rich in guaiol showing a relative diminution in the content of the more volatile "callitrol" (*l*-citronellic acid; see Part I), whereas in the more temperate zones the ratio is reversed. Accordingly *C. intratropica*, from the neighbourhood of Darwin, was used in this work. Shavings of the wood were steam-distilled for about twenty hours, as in the following example:

Shavings	24·4 kg.
Yield of oil after 9½ hours	330 g.
Yield of oil after 17 hours	490 g.
Alkali-soluble	28 g.
Crude guaiol (filtered from oil)	130 g.
Guaiol, m.p. 92-93°	78·5 g.
$[\alpha]_D^{21°}$: −29·4°; −29·1°.	

By distillation of the residual oil in high vacuum, and recovery from the mother liquors, the yield of pure material was increased to about 100 g., corresponding to 0·41%.

Oxidation with Permanganate in Acetone (*Cf.* Semmler and Mayer; Ruzicka and Haagen-Smit, *loc. cit.*).—Guaiol (10 g.), dissolved in acetone (50 ml.) and water (10 ml.) was gradually treated with powdered potassium permanganate (15 g.), the temperature being controlled with a stream of water. Crude dihydroxyether (4·5 g.) was obtained by exhaustive extraction of the manganese dioxide sludge with absolute ethyl alcohol, and yielded 4 g. of pure material of m.p. 218°. The residual oil from three such experiments was distilled at 0·5 mm.,

Fraction 1. B.p. 100–105°—1·5 g.
Fraction 2. B.p. 155–165°—7 g.
Fraction 3. Residual.

On the addition of dry ether to fraction 2 the mass solidified, and 4·7 g. of crystals, m.p. 82–83°, were obtained. On recrystallisation several times from benzene, and finally from ether, this substance was obtained as colourless hair-like needles, m.p. 95–97°, being soluble in acetone and alcohol, and sparingly soluble in ether, benzene and petroleum ether. The m.p. is depressed somewhat on keeping, probably owing to slight decomposition, but the substance is easily repurified from benzene. (Found: C, 68·3, 68·4; H, 10·8, 10·8. Mol. wt. (benzene): 225, 225. $C_{13}H_{24}O_3$ requires: C, 68·4, H, 10·5%. M.w., 228.) It may be recovered unchanged from a solution in acetone containing potassium permanganate.

In another experiment the residual oil (from 5 g. guaiol) was separated, without distillation, to give about 0·5 g. unchanged guaiol and 0·5 g. of a product (m.p. 90–92°) which, on repeated crystallisation, proved to be identical with the substance $C_{13}H_{24}O_3$ isolated above.

In one experiment the residual oil (from 30 g. guaiol), after removal of the dihydroxy ether, was dissolved in ether and extracted with dilute aqueous sodium hydroxide. Of 1·3 g., obtained after acidification, 0·8 g. was soluble in aqueous sodium carbonate, and was esterified by heating with ethyl alcohol–sulphuric acid and distilled. B.p. *c.* 160°/0·7 mm.; 0·3 g.

Oxidation of Dihydroxy Ether.—Lead tetracetate was prepared, according to the method of Dimroth (*Ber.*, 1920, *53*, 484). Dihydroxy ether (7·2 g.) was suspended in a solution of lead tetracetate (12·4 g.) in acetic acid

(500 ml.), and shaken until solution was complete (about twenty-four hours). Water and ether were then added, and the extract washed free from acetic acid, dried, and evaporated. Some dihydroxy ether was recovered and about 50% of the residue distilled at 108–180° (0·5–2 mm.), but no single product could be isolated.

Oxidation with Percamphoric Acid.—A solution of guaiol (12·4 g.), in the minimum amount of dry ether was added to a solution of percamphoric acid (11·56 g.; Milas and McAlevy, *J.A.C.S.*, 1933, *55*, 349), in dry ether (340 ml.) and allowed to stand for seven days at room temperature. After washing with aqueous sodium carbonate the solution was evaporated, and the residue distilled at 2·1 mm. B.p., 135–136°; 11 g. Found: C, 75·2, H, 10·9. $C_{15}H_{26}O_2$ requires: C, 75·5; H, 10·9%. $[\alpha]_D^{21°}$ (in ethyl alcohol), −33·3°. The product is an extremely viscous oil which could not be induced to crystallise. Attempted dehydration with potassium bisulphate or anhydrous formic acid led mostly to resinous products. It darkens and appears to decompose on standing, since after a few weeks at room temperature it boils over a range of about 20°.

Bromination.—The addition of bromine gave better results in cyclohexane solution than in chloroform. Dry bromine (10·9 g., 1 mol.) in cyclohexane (100 ml.) was added gradually to guaiol (purified from cyclohexane, 15 g.) in cyclohexane (500 ml.), cooled in ar. ice-and-salt mixture and in an atmosphere of dry hydrogen. The solution first turned red, and after standing about two hours became purple. It was then decomposed with ice, the cyclohexane layer neutralised by shaking with dilute aqueous potassium hydroxide and steam-distilled, the cyclohexane being evaporated from the separated and dried distillate. Yield: 7 g. of a mobile oil, b.p. 84–94°/0·3 mm. and 113–120°/2·3 mm. After being treated, in petroleum ether solution, with phosphoric acid (sp. gr. 1·5) it distilled almost entirely at 92–93°/0·3 mm. as a colourless mobile oil (green to blue if rubber stoppers used), and was free from halogen. It was redistilled at 13·5 mm., and divided into two fractions: (1) b.p. 135–137°; (2) b.p. 137–138°. Fraction (1) was distilled twice over sodium (b.p. 133–135°/14 mm.) and analysed. (Found: C, 86·2; H, 11·6%.) Heating with zinc dust at 20 mm., with a bath temperature of 180°, made little difference to the analytical figures. (Found: C, 86·3, 86·2; H,

11·5, 11·3%.) Fraction (2) was twice distilled in high vacuum and analysed. (Found: C, 87·0; H, 11·6. $C_{15}H_{24}$ requires: C, 88·2; H, 11·7. $C_{15}H_{24}O$ requires: C, 82·0; H, 10·9%.) Reduction of a purified product (6·2 g.), obtained from a bromination in chloroform solution with platinum oxide–hydrogen, until absorption was complete, yielded a product, b.p. 97–98°/0·8 mm., and containing C, 83·5, 83·2; H, 12·0, 12·0%. After distillation over sodium the following values were obtained: C, 83·0; H, 12·1. $C_{15}H_{26}$ requires: C, 87·4; H, 12·6. $C_{15}H_{26}O$ requires: C, 81·2; H, 11·7%.

Guaiene.

The dehydration method of Ruzicka, Pontalti and Balas (*loc. cit.*) was found to give the best yield of guaiene, which had b.p. 100–102°/1·2 mm. and $n_{25°}$ 1·4965.

Oxidation of Guaiene with Chromic Acid.—Guaiene (5 g.), dissolved in benzene (50 ml.) and acetic acid (50 ml.), was treated with deci-normal chromic acid (417 ml., equivalent to 5 atoms of oxygen), over a period of two hours, with vigorous stirring. The mixture was then refluxed for eight hours and separated with the aid of ether, washed free from acid, and distilled.

Fraction 1. B.p. 104–105°/1·9 mm.
Fraction 2. B.p. 128–138°/1·4 mm.; 0·3 g.

Practically the whole material was in fraction 1, and consisted of unchanged guaiene, as indicated by its refractive index. Fraction 2 failed to give characterisable derivatives.

Reduction of Guaiene.—Guaiene (5 g.) was dissolved in ethyl acetate and reduced with platinum oxide–hydrogen until two atoms had been taken up, and then distilled. B.p. 102·2°/1 mm.; $n_{23°}$, 1·4836.

Oxidation of Dihydroguaiene.—The purified product from the previous experiment (3 g.), dissolved in acetone (15 ml.) and water (3 ml.), was gradually treated with powdered potassium permanganate (4·5 g.) at room temperature with vigorous agitation. After filtration, and washing of the precipitated manganese dioxide with ethyl alcohol, the combined extracts were distilled in steam and the residue extracted with ether. The latter extract yielded a small quantity of crystals, m.p. 135–140°, together with 1·5 g. of an uncharacterisable oil. The steam distillate gave an ether extract, which contained only a very small quantity of residue.

ACKNOWLEDGMENTS.

We are indebted to the Executive of the Division of Forest Products of the Council for Scientific and Industrial Research for facilitating the supply of *C. intratropica*, and to Mr. A. J. C. Hall, B.Sc., for some assistance in this work. One of us (D.E.W.) held a Science Research Scholarship whilst engaged in portion of the investigation, and desires to express his gratitude to the Senate of the University.

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A SUMMARY OF CHANGES NOTED IN THE ALLANTOIC MEMBRANE OF THE CHICK IN 500 EXPERIMENTS.*

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Communicated by PROFESSOR O. U. VONWILLER.

(*Read before the Royal Society of New South Wales, Dec. 5, 1934.*)

INTRODUCTION.

This work was commenced in order to extend Miss Goulston's work dealing with the action of radium on the allantoic membrane of the chick.[1] Miss Goulston had worked chiefly with exposures of a few hours' duration, and it was decided to include an investigation of the effect of much longer exposures, for example one, two, three or four days, in the hope that something of importance might be found bearing on the embedding of radium needles or radon seeds in the cancers of human patients for similar periods.

RADIUM EXPERIMENTS.

Technique.

It was decided on Dr. Moppett's advice to expose the prepared egg face downwards on the radium needle whilst provision was made for exposing a control egg in the same manner with the aid of a blank platinum case. Specimens were prepared, with slight variations according to the technique originated by Moppett,[2] and followed by Goulston. A fertile egg was selected at the eighth or ninth day of incubation, and a "window" 1 cm. square was marked out accurately, a position a little to one side of the embryo as seen by transillumination being chosen.

* This work was carried out under the control of the Cancer Research Committee of the University of Sydney and with the aid of the Cancer Research and Treatment Fund.

[1] Goulston, D. L.: *Med. Journ. Aust.*, 1931, Mar. 21, 335, and July 18, 74.

[2] Moppett, W.: *Proc. Roy. Soc.*, 1929, B *105*, 402.

After sterilisation of the region with 70% alcohol, the "window" was raised with a knife which had been dipped in alcohol and flamed. This operation exposed the intact shell membrane which overlies the living allantoic membrane. Irradiation was carried out in a lead box with walls 5 cms. thick in all directions, which was built up inside an incubator. Four shallow recesses were provided, which were covered with a thin layer of cotton wool and held two 3-milligramme radium needles (with 0·5 mm. platinum screenage) and two blank platinum cases respectively.

The prepared eggs were then placed with the window in contact with the needle (or case) and were left untouched for periods up to four days. The window was then sealed and the egg incubated a further three days, after which the specimen was opened for inspection, which was followed in most cases by a confirmatory microscope examination.

Radiation Results.

Satisfactory reactions occurred on the irradiated membrane, hypertrophy to atrophy depending on the length of exposure. The size and shape of the reactions showed considerable variation, and hypertrophic changes were observed either in a central position or, more commonly, near the periphery of the window, whilst atrophy was always central. The results are tabulated below.

TABLE I.—*Radiation Results.*
(Window downwards on radium needle in lead box.)

Exposure.	Number of Eggs.	Number Surviving.	Normal.	Hypertrophic Reaction.	Atrophic Reaction.
2 hours	2	1	1	—	—
3 „	6	1	—	1	—
4 „	2	2	—	2	—
6 „	2	0	—	—	—
Total	12	4	1	3	—
1 day	2	2	—	1	1
2 days	2	1	—	—	1
3 „	9	6	—	3	3
4 „	4	2	—	—	2
6 „	2	0	—	—	—
Total	19	11	—	4	7

Control Results.

Unfortunately from the start the controls also reacted, though to a smaller degree, many of the specimens showing only a slight peripheral hyperplasia. See Table II.

TABLE II.—*Control Results.*
(Window downwards on blank case in lead box.)

Exposure.	Number of Eggs.	Number Surviving.	Normal.	Hypertrophic Reaction.	Atrophic Reaction.
2 hours	2	2	2	—	—
3 „	7	3	3	—	—
4 „	2	0	—	—	—
5 „	4	1	—	1	—
6 „	1	1	—	1	—
Total	16	7	5	2	—
1 day	4	3	2	1	—
2 days	4	2	—	2	—
3 „	9	3	1	2	—
4 „	2	2	—	2	—
6 „	2	1	—	1	—
Total	21	11	3	8	—

Discussion.

A pronounced difference will be observed between the results in Tables I and II. In the case of the short exposures the controls are mainly normal and the irradiated specimens mainly hypertrophic, but numbers are unfortunately scarcely adequate, partly owing to the accidental loss of some records. In the case of the long exposures the control reactions are only hypertrophic, and 27% of the specimens are normal, whilst in the irradiated series all specimens show reactions, and these are mainly of the more intense atrophic type. I therefore consider there is definite evidence that the radium may produce effects in the case of long exposures. As some of the controls react I consider that the reaction is not entirely due to radium, but that some unknown factors associated with exposure contribute to the production of a reaction.

Further Investigation of Controls.

It was considered advisable to attempt to obtain radium results under conditions in which controls do not react,

and to this end the next part of this paper is concerned with controls.

In this work eggs were exposed in different positions and under different conditions in the stock incubator, and, to commence with, specimens were placed face up with the window fully exposed to the air, as in Miss Goulston's work. In the first instance long exposures were given, with the following results:

TABLE III.—*Results with Long Exposures.*

(Window upwards in stock incubator.)

Exposure.	Number of Eggs.	Number Surviving.	Normal.	Hypertrophic Reaction.	Atrophic Reaction.
1 day	18	7	—	1	6
2 days	15	3	—	—	3
3 „	12	1	—	1	—
4 „	8	0	—	—	—
Total	53	11	—	2	9

As may be seen from the above table, there was a very heavy mortality, and all the survivors showed reactions which were mainly of the atrophic type. Accordingly a thorough investigation of the effect of short exposures was commenced, continuing with the face up position. The results are shown in Table IV.

TABLE IV.—*Results with Short Exposures.*

Exposure.	Number of Eggs.	Number Surviving.	Normal.	Hypertrophic Reaction.	Atrophic Reaction.
0 hour	48	18	18	—	—
1 „	40	16	14	2	—
2 hours	71	26	14	12	—
3 „	107	50	8	42	—
4 „	33	8	2	5	1
Total	299	118	56	61	1

No reactions were obtained when the window was cut in the egg and closed immediately, indicating that mechanical injury of the operation had little part in

causing the reactions. The proportions reacting were 12%, 46%, 84% and 75% for one, two, three and four hours respectively, and only one atrophic reaction was observed.

Aseptic Technique.

Compared with Table II, Tables III and IV show a large number of deaths and a high proportion of reactions among the survivors, and this suggested that an infective process might be facilitated by the free exposure to the air of the stock incubator. An aseptic technique was therefore tried, following a method used by Goulston and Mottram.[3] The incubated egg was "sterilised" by scrubbing with warm water and soap and swabbing with warm 70% alcohol. The window was then cut in a sterile enclosure, and exposure was carried out under a sterile jar with adequate provision for respiration. Since short exposures may show a high percentage of blanks, it was decided to test the aseptic technique in a rigorous manner by exposing for four days. In order to avoid any further manipulation the specimens were opened and examined at the end of this period. In the course of this work slight modifications were made in an attempt to secure improved results, but without success. The data obtained are grouped together in Table V below.

TABLE V.—*Results of Exposure under "Aseptic" Conditions.*

Exposure.	Number of Eggs.	Number Surviving.	Normal.	Hypertrophic Reaction.	Atrophic Reaction.
4 days	32	17	—	8	9

On comparing Table V with Table III it will be seen that results are of the same order, all specimens reacting. This is in accord with a recent observation by Duthie[4] to the effect that an aseptic technique makes no difference. Even if it is difficult or impossible to secure complete asepsis in the presence of living hen eggs, the precautions described should have caused an appreciable diminution in the number of reactions, particularly if one assumes that the causal agent is an organism present in the air of the

[3] Goulston, D. L. and Mottram, J. C.: *Brit. Journ. Exp. Path.*, 1932, *13*, 175.

[4] Duthie, E. S.: *Brit. Journ. Radiol.*, 1934, *7*, 238.

incubator and presumably falling downwards after the disturbance caused by closing a door.

My suggestion that an infective agent is not involved is supported by negative attempts to culture bacteria from pieces of reacting membrane. As Goulston and Mottram mentioned moulds, I attempted in collaboration with Dr. Moppett to obtain cultures, but without success. We also failed to find any microscope evidence of moulds in the specimens examined, although special staining methods were employed.

Effect of Sheltering the Windows.

Since the controls in Table II showed much less abnormality than those exposed freely to the air of the incubator, it was decided to carry out further experiments with the window face down on cotton wool; the results are shown in Table VI.

TABLE VI.—*Results of Exposure with Window Face Down on Cotton Wool.*

Exposure.	Number of Eggs.	Number Surviving.	Normal.	Hypertrophic Reaction.	Atrophic Reaction.
1 day	4	1	1	—	—
2 days	12	3	1	2	—
3 „	14	6	1	5	—
4 „	8	0	—	—	—
Total	38	10	3	7	—

The mortality was high, but a sufficient number survived to confirm the suggestion that partial sheltering of the window caused a decrease in reaction incidence, whilst the abnormal specimens were recorded only as slight hypertrophies.

In the absence of any positive evidence for infection it was thought that the above procedure must inhibit abnormal loss of fluid or absorption of irritating substances at the window, and these factors were postulated as the cause of reactions in controls.

X-RAY EXPERIMENTS.

The reactions from short exposures recorded in Table IV have a bearing on Moppett's (*loc. cit.*) X-ray work,

particularly as adequate numbers were treated to secure a reliable estimate.

At this stage 490 experiments had been completed and, on Dr. Moppett's invitation, ten exposures were made to homogeneous X-radiation of wave-length 0·5 Å. Two windows were cut side by side, one to serve as a control, and the specimen was placed sideways in a small accessory incubator on the X-ray spectrometer. An exposure of one hour was employed, so that there would be little chance of reaction in the control window. Unfortunately, all specimens died, possibly because this work was carried out in the middle of winter, when vitality appears to be low. In one, however, the structures were sufficiently recognisable to show a difference between the control and irradiated windows.

The sideways position employed by Moppett should be intermediate between the face-down and face-up positions with regard to control reaction, so that results should be more favourable than those in Table IV. Even in these experiments the two hours' exposure showed 54% unchanged, and the remainder hypertrophic, whilst Moppett claimed 58 out of 60 atrophic reactions for a two hours' exposure to the radiation employed in the above attempt. I do not think that the present experiments justify any conclusion with regard to Moppett's work, except to indicate that factors associated with exposure to the air may aid in producing the reaction, but not nearly to the same extent as in the case of the radium exposures lasting for one or more days.

Conclusions.

Reaction to Irradiation.

(1) It has been shown that rays from a 3-milligramme radium needle produce a definite effect in the chorio-allantoic membrane when exposure is made through a window for one or more days.

(2) The result is considered to be partly due to injury associated with exposure which activates the tissues to the feeble γ-rays.

(3) Although indications of effect were obtained with short exposures, Miss Goulston's work cannot be supported, since she used the unfavourable face-up position, and the peripheral reaction she attributed to scattered radiation has been observed frequently in controls.

Reaction in Controls.

(1) The abnormalities observed appear to be due to abnormal drying or some other factor associated with free exposure to the air, since reactions increased rapidly in frequency and intensity with exposure period.

(2) There is no evidence of an infective origin, and the mechanical injury of removing the shell appears to have no direct association.

(3) When exposure is made face down on cotton wool the reaction-free time is increased about tenfold, and this should form the basis of a satisfactory irradiation technique.

I wish to thank Dr. W. Moppett for help in the arrangement of this paper.

NOTE ON THE DETERMINATION OF TRACES OF PRUSSIC ACID IN TISSUES.*

By G. HARKER, D.Sc.

(With one text-figure.)

(*Read before the Royal Society of New South Wales, Dec. 5, 1934.*)

During the progress of some work being carried out under the direction of the Cancer Research Committee of the University of Sydney it became necessary to find a method for the estimation of very small quantities of prussic acid in animal tissues. Through the kindness of Mr. H. Finnemore, Lecturer in Pharmacy, a reference was obtained to the work of L. Chelle[1] on this subject. The method devised by this author appears highly suitable for the estimation of minute quantities of prussic acid, and was used by him for determining this substance in the blood and organs of animals poisoned by administration of cyanide. Chelle also showed that after death the cyanide is gradually converted to thiocyanate. This latter can be readily oxidised in presence of acid to prussic acid and estimated by an extension of his method.

The usual means of estimating prussic acid in tissues is to macerate with water, render faintly acid and distil. Chelle points out that for minute quantities the method is unsuitable, because the prussic acid does not all come over in the first portion of the distillate, and the consequent dilution is unfavourable in the succeeding estimation. His method is first to distil and then afterwards concentrate the prussic acid in the distillate by removing it with a sufficiently large current of air, absorbing in a small volume of N/10 caustic potash solution. The procedure adopted by him was as follows:

The organ to be examined was shredded with scissors, 40 grammes placed in a flask with 75 ml. of water and 5 ml.

* This work was carried out under the control of the Cancer Research Committee of the University of Sydney and with the aid of the Cancer Research and Treatment Fund.

[1] L. Chelle: *Comptes rendus*, 1919, *169*, 726, 852 and 973.

of phosphoric acid and distilled, 50 ml. of distillate being collected. The distillate was placed in a flask and a rapid current of air (20–25 litres per hour) drawn through it for three hours. The prussic acid carried over was absorbed in 1 ml. of N/10 caustic potash placed in a special bubbling apparatus and determined either by the formation of prussian blue or by the ammoniacal silver iodide reagent. The prussian blue test was stated to be capable of determining 0·01 mg. prussic acid in the solution tested, and the ammoniacal silver iodide 0·001 mg. For the latter test the reagent is prepared by taking 10 ml. N/1,000 silver nitrate solution, adding 2 ml. concentrated ammonia solution and five drops of 10% potassium iodide and diluting to 100 ml. with distilled water. The test sample is placed in a test tube and the reagent added until a permanent turbidity is obtained. Comparisons are made with known quantities of cyanide in solution treated similarly. 1 ml. of the reagent corresponds to 0·0054 mg. prussic acid.

Before the work referred to at the beginning of this communication was entered on, Chelle's method was subjected to rigorous examination. This revealed that the method underestimates the prussic acid and that in using it certain safeguards must be taken and allowances made. A modified and more direct method is also suggested whereby higher yields can be obtained.

In testing Chelle's method cyanide solutions of known strength were first estimated by the prussian blue and ammoniacal silver iodide tests described in the papers quoted above, and found to give the results claimed. The ammoniacal silver iodide is a particularly delicate means of estimating small quantities of prussic acid. Minute quantities of cyanide in solution were then taken, the solutions slightly acidified, the prussic acid removed in a current of air and absorbed in 1 ml. of N/10 caustic potash. Here at first the results were low and irregular, but it was found that, if the air is first freed from carbonic acid before passing for two hours through the test solution, over 90% of the prussic acid present in the test solution (0·064 mg.) was absorbed and could be estimated in the 1 ml. of liquid in the absorption vessel. With 0·0016 mg. the yields were over 80%. That the presence of carbonic acid has a detrimental effect was shown by bubbling ordinary air for two hours through 1 ml. N/10 caustic potash containing cyanide, when a distinct loss of cyanide

was noticed. This loss does not take place if the air is first freed from carbonic acid, and is doubtless due to the displacement of prussic acid in the absorption vessel by carbonic acid. Small known quantities of cyanide (0·01 mg. to 0·1 mg.) were next added to animal tissues which had been ground with sand and water, and the mixture acidified and distilled, an oil bath being used to avoid local heating. Here considerable losses were noted of which Chelle seems to have been unaware. Cyanide solutions without animal tissue were treated similarly, but the results were practically identical. Slightly higher yields were obtained by reducing the proportion of phosphoric acid used by Chelle to one-tenth, and this reduced quantity was employed in all succeeding work. Very weak aqueous solutions of prussic acid on distillation showed similar losses. In these distillation tests approximately 9 ml. of liquid with or without tissues were contained in a 50 ml. flask and distilled at an oil bath temperature of 113–115° C., and 6 ml. of distillate were collected. If the distillation was carried further so as to give 7 ml., the last ml. was found to be nearly free from prussic acid, so that the loss was not due to the substance being left in the flask. Under the conditions described and for the quantities of cyanide mentioned, the yields of prussic acid found were all between 50% and 60%. By taking 55% as the average figure, an allowance could safely be made which would leave but a small margin of error. The loss is doubtless due to hydrolysis of the prussic acid, and this explains why the yields were approximately the same with varying quantities of cyanide. It follows from these results that Chelle's analytical figures for the animal tissues examined by him are all definitely low.

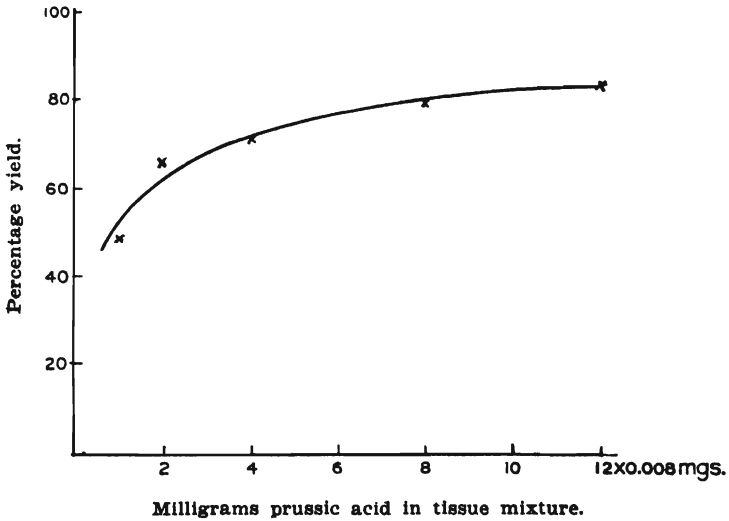
Since there is considerable loss of prussic acid on distillation, it seemed worth while to carry out a few tests to determine whether this substance could be estimated directly from the tissue by means of an air current. The tissue was ground with sand and water as before, known quantities of cyanide were added, and slightly acidified, and air was drawn through for three hours at the rate above stated, the prussic acid being absorbed in 1 ml. N/10 caustic potash. The organic material frothed badly, but this was overcome, on the suggestion of Prof. Priestley, by the addition of a drop of capryl alcohol. To minimise the risk of any liquid carrying over, a vessel was constructed

like a large test-tube with a bulb blown in the middle. The following are the results actually obtained:

Mgrms. Prussic Acid Present.	Percentage Yield.
0·008	49·4
0·016	66·4
0·032	71·4
0·064	79·4
0·096	84·1

These results are shown graphically below. As might have been expected, the prussic acid was not removed by the air current so easily from the organic material as from acidified cyanide solutions. The only objection to the method is that the caustic potash in the absorption vessel tends occasionally to become a little turbid, which renders the estimation with the ammoniacal silver iodide less definite. Otherwise it has the advantage for minute quantities that the prussic acid is concentrated in a small volume at one operation, and for the quantities taken, except the lowest, the yields were higher than by Chelle's

Graph showing percentage yield of prussic acid obtained direct by the air current method from a tissue mixture with known amounts of added cyanide.



original method involving distillation. It is quite likely that the yields would be improved by drawing the air through for a longer period.

Summary.

Chelle's method for the determination of minute amounts of prussic acid in tissues has been tested by adding known quantities of cyanide to different lots of tumour tissue of about three grams each. The method involves the distillation of the prussic acid and its subsequent concentration in a small volume of potash solution, by removing it from the distillate with a current of air. Owing to destruction of nearly half the prussic acid in the preliminary distillation process—a destruction which takes place also in the absence of tissue—the results were distinctly low. The percentage loss, however, is fairly constant, and an allowance can be made for it, leaving but a small margin of error. The direct removal of the prussic acid from the tissue by a current of air was tested and found to give higher yields except when less than 0·01 mg. prussic acid was present.

THE VOLUMETRIC MICRODETERMINATION OF PICROLONIC ACID IN ORGANIC PICROLONATES WITH METHYLENE BLUE.

By ADOLPH BOLLIGER, Ph.D.

(*Read before the Royal Society of New South Wales, Dec. 5, 1934.*)

Recently picrolonic acid has been used extensively for the purposes of isolation and identification of organic bases, particularly in the field of biochemistry. Analytically, however, these picrolonates have so far been of little value, more particularly in view of the fact that the elementary composition of picrolonic acid is similar to that of many biologically important bases. For this reason Zimmermann and Cuthbertson (*Ztschr. f. physiol. Chem.*, 1932, *205*, 38) prepared a bromopicrolonic acid in the salts of which the bromine content could be determined. This acid, however, is not easily available, and in any case a microchemical bromine determination is necessary. Schiedewitz (*Ztschr. f. physiol. Chem.*, 1933, *214*, 177), therefore, proposed the determination of picrolonic acid and organic pircolonates by means of acridin. In this process picrolonic acid is precipitated with acridin, and the compound formed, an acridin picrolonate, is determined gravimetrically.

In continuing my work on thiazine compounds of *o*-nitrophenols, however, I observed that picrolonic acid formed with methylene blue a compound which was very sparingly soluble in water, but fairly soluble in chloroform. The solubility of methylene blue picrolonate in chloroform was 0·16%, the solubility in water less than 0·001%. These findings show that picrolonic acid is so far the most suitable *o*-nitrophenol for titration with methylene blue. Its solubility in chloroform is almost twice that of picric acid.

The technique of the titration is the same as that described for picric acid or other *o*-nitrophenols (Bolliger, A., THIS JOURNAL, 1933, *67*, 240; 1934, *68*, 51). The picrolonic acid solution is transferred to a cylindrical

separatory funnel containing chloroform and some calcium carbonate. The standard methylene blue solution, usually 0·001N, is added from a burette. The methylene blue picrolonate formed dissolves in the chloroform to form a green solution. Near the end-point, after extraction with fresh chloroform, the aqueous layer becomes colourless and the end-point is reached with the first appearance of an unextractable bluish tinge in this layer. The end-point is very sharp. Varying amounts of 0·01N picrolonic acid could be recovered with an error not exceeding 0·2%.

Organic picrolonates are best dissolved beforehand in hot water, or if necessary in about 0·1N hot hydrochloric acid. After cooling, and neutralisation of the excess hydrochloric acid with calcium carbonate, the solution is transferred to the separatory funnel containing chloroform.

The picrolonates of α-naphthylamin, piperidin and *p*-toluidin were prepared and examined for their picrolonic acid content by the method described, with the following results :

Picrolonate of	Amount Titrated. (Mgm.)	Picrolonic Acid. Per Cent.	
		Found.	Calculated.
α-naphthylamin	7·06	64·0	64·86
	11·4	64·5	
p-toluidin	12·21	70·3	71·16
	18·2	70·6	
Piperidin	10·03	74·28	75·63
	15·9	74·9	

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THE GEOLOGY OF THE CUDGEGONG DISTRICT.

By P. M. Game, B.Sc.,
Deas-Thomson Scholar in Geology, University of Sydney.
Communicated by Dr. W. R. Browne.

(With Plate VIII and two text-figures.)

(*Read before the Royal Society of New South Wales, Dec. 5, 1934.*)

Introduction.

The village of Cudgegong is situated on the Sydney-Mudgee main road, at a distance of 146 miles from Sydney. It is, approximately, in the centre of the district examined and mapped by the author. This district extends from Mudgee south-eastwards for about 40 miles and is 10 to 15 miles wide. Little detailed work has previously been done in this region, although C. A. Sussmilch[1] has described and given sections of the Devonian strata to the east of the area. His work, however, covers only a small portion of the area in question, and does not deal with the Silurian rocks, nor does it discuss the boundary between Silurian and Devonian strata. It is considered that these features are of sufficient interest to warrant further descriptions.

Carne and Jones[2] have described many of the limestone and dolomite deposits in this district, and much use has been made of their report by the author.

[1] "The Devonian Strata of the Kandos District, New South Wales", This Journal, 1933, 67, 206.

[2] "The Limestone Deposits of New South Wales", Dept. of Mines, N.S.W., Min. Res. No. 25, 1919.

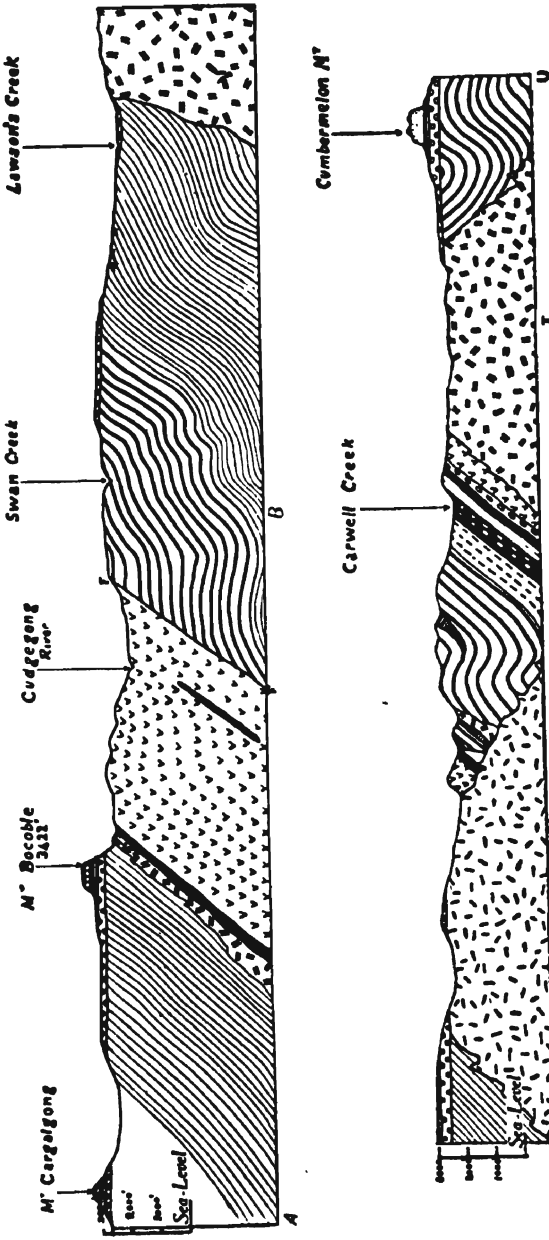


Fig. 1.—Sections across the Cudgegong district. Geological units indicated as on map, Plate VIII.

The following geological formations are represented in the district:

Pleistocene and Recent,
Tertiary,
Triassic (Hawkesbury and Narrabeen Series),
Kamilaroi (Upper Marine Series and Upper Coal Measures),
Devonian (Upper and Middle),
Upper Silurian.

The Silurian and Devonian sediments are contorted and faulted, and have been abundantly intruded by plutonic and hypabyssal igneous types, which accompanied the Kanimbla orogeny. Upon the upturned edges of the older Palæozoic rocks and upon the igneous intrusive masses rest the undisturbed and almost horizontal Kamilaroi and Triassic strata. These, in turn, are overlain in places by Early Tertiary basalts and dolerites, remnants of former widespread flows and sills, now largely removed by denudation.

The alluvium of the fertile flats of the chief river valleys, especially well developed around the town of Mudgee, is the most recent member in the geological sequence.

The general relations of the various units are shown in the maps and sections (Plate VIII and Figs. 1 and 2).

Stratigraphy.

The Silurian System.

Silurian strata are the oldest rocks in the district, no Ordovician sediments having been discovered. The base of the system is not exposed in the region dealt with in this report. The palæontological evidence furnished by the limestones in the sequence definitely proves them to be of Upper Silurian age.

The lowest exposed Silurian beds are tuffs and breccias with associated altered lavas, and these grade upwards through felspathic tuffs and tuffaceous slates into clay-slates and limestones. A good section across the Silurian sequence may be examined in the Parish of Wells. Most of the members are exposed on the Cudgegong-Rylstone road, beyond the Carwell Creek bridge, from the 7 to the 8 mile peg. However, the best exposures occur about half

a mile or one mile to the north of the road, where several small creeks have cut across the strike of the beds. The general dip of the Silurian beds in this locality is to the south-west. The average is S. 30° W. at 38°.

The nature and approximate thicknesses of the separate members in descending order are as follows:

	Feet.
(?) Fissile and siliceous clay-slates	2,000
Limestone	100
Conglomerates	740
Felspathic tuffs	1,150
Limestones and silicified slates	75
Felspathic tuffs and breccias	550+
Total	4,615+

The basal tuffs and breccias of this sequence have been intruded by huge masses of late Devonian quartz-felsite, so that the true base of the series is not seen, and it may, indeed, be much thicker than is indicated by the above figure.

The youngest member of this sequence, *viz.*, the fissile clay-slate, has not been proved definitely to be of Silurian age, and is queried accordingly. It may belong to the Middle Devonian series, although the author considers that it may be correlated with the Silurian clay-slates of the Green Gully Valley.

The tuffs and breccias at the base of the sequence are well exposed on the south side of the Cudgegong-Rylstone road, in Portions 59, 72 and 74, Parish of Wells. A thin horizon of strongly developed breccias occurs at the side of this road in Por. 59. This breccia has a hard, pale-grey matrix, in which are set numerous angular and torn fragments of other rocks and minerals. The fragments vary from microscopic dimensions to half an inch or so in length. Angular quartz and felspar grains are common, the latter having been largely kaolinized. The remaining fragments are considerably larger and consist of soft, dark, slaty rock and of hard, yellowish-white felsite. The igneous fragments are more abundant than the slaty ones, which probably represent portions of underlying Silurian strata torn from their position by the violence of the eruptions, and incorporated in the showers of volcanic dust.

The tuffs, which are more abundant than the breccias, have a greenish-grey body colour and a fine grainsize.

This rock is not completely massive, but appears to be roughly banded on several faces, with elongated streaks of certain constituents. It is a finely crystalline felspathic type, with some cherty inclusions. In thin section this tuff is seen to consist of plagioclase (andesine), calcite, chlorite, sericite, magnetite and a little orthoclase. The plagioclase forms the main constituent. It is mostly considerably altered to sericite and calcite. It is usually in the form of subidiomorphic prisms, about ½ to ¾ mm. in length, with terminal faces undeveloped. The chlorite impregnates the other minerals, and also forms small allotriomorphic crystals, which may be pseudomorphs after an original ferromagnesian mineral.

The silicified slates which, together with a few limestone lenses, divide this thick horizon of tuffs, have a pure white colour and are somewhat hardened. These altered slates are exposed from the N.W. to the S.E. of Por. 46, Parish of Wells. Above this very thin horizon of slates a further considerable thickness of tuffs is encountered, of character similar to those already described, but often silicified and cherty.

The next highest member of the sequence is a rather thick horizon of conglomerate. This type outcrops strongly on the banks of the Cudgegong River in the middle of the northern boundary of Por. 149. The bed is in contact with the underlying tuffs at the extreme N.E. corner of this portion. The horizon can be traced almost to the main road, but is cut off by a fault running parallel to and just to the north of this road, on Pors. 73 and 111. This rock type shows the effects of the tectonic forces which operated after its deposition. The pebbles are considerably flattened and elongated. No recrystallization has occurred, however. The pebbles are usually less than one inch in length and extremely hard; they consist of a black chert. A thin section through one of them showed it to be composed chiefly of quartz and sericite, with a little interstitial felspar. The matrix of these conglomerates is dull grey, closely laminated and rather friable.

Overlying the conglomerates is a limestone horizon. This does not actually form a continuous outcrop (as indicated on the general map, in order to clarify it), but occurs as a number of small lenses, which can be traced

along the line of strike for about 1½ miles. The belt is displaced about 400 yards by a dip-fault, which runs along the northern boundary of Por. 111, cuts across Por. 154, and is lost under the alluvium of Carwell Creek, about 300 yards due north of the bridge on the main road. The limestone on the south side of this fault shows the effect of the drag to the west, which has drawn it out in an east-west direction, so that it tapers out to the east, as shown on the map.

The limestone, in most outcrops, is recrystallized and has a medium to coarse grainsize. The outcrops on the Rylstone road show large, pink hæmatite patches. Shaly partings are rather common. It is fossiliferous, but the fossils are more plentiful in the weathered shales which are interbedded with the limestone. The following forms were identified by the late Mr. W. S. Dun:

Actinozoa—
- *Favosites*
- *Tryplasma*
- *Heliolites*
- *Arachnophyllum*
- *Cyathophyllum*
- *Murchisonia.*

Brachiopoda—
- *Rhynchonella*
- *Pentamerus knighti.*

Crinoidea—
- Crinoid stems.

The youngest member of the Silurian sequence in this district is the fissile slate bed to which reference has already been made. This clay-slate has undergone some regional metamorphism, and is siliceous in most places. It is exceedingly fissile. Usually it is quite soft, but locally it has been hardened by intrusions of quartz-porphyry. It has a pale purplish to pale bluish-grey body colour and weathers to a rusty-brown shade. At the side of the Cudgegong road, in Por. 40, Parish of Wells, the slate is interbedded with a pure white, fine-grained, strongly jointed quartzite. This rock shows numerous small ridges and furrows, approximately parallel to each other, and only seen on the bedding-planes. These are thought to be ripple-marks, indicative of shallow water conditions during the deposition of this

horizon. The ripples are symmetrical and appear to have been formed by wave action, which must, however, have been very slight to produce such delicate markings.

At the top of this slate horizon a conformable junction is thought to occur between the Silurian and the Middle Devonian strata. The nature of this junction will be discussed in more detail later.

Before passing on to a description of the Silurian formation in other parts of this district, it may be well to compare the results obtained by the author with those given by C. A. Sussmilch. The latter includes all the beds just described in the Middle Devonian sequence, whereas the author considers them to be of Silurian age. The thickness obtained by Sussmilch for each of the horizons to which reference has been made is considerably less, in most instances, than that given above. The greatest discrepancy occurs in the thickness of the fissile slate horizon, for which Sussmilch gives a thickness of 650 feet, whereas, in the author's opinion, it is 2,000 feet thick. This is based upon several traverses made across the strike, both to the north and to the south of the Rylstone road. One traverse along a creek which flows through Pors. 65, M.L. 6, 69, 105 and 106, Parish of Wells, showed the thickness of slate to be actually greater than that given, and no noticeable change of dip occurs.

In the Limestone Creek region, and along Green Gully, in the south-west of the area, the lowest member of the Silurian sequence is a limestone bed, which, however, is not persistent and only outcrops locally near Cudgegong, extending north-west from the village for about 1½ miles. This is followed by tuffs and associated flows, which are succeeded by a thick, persistent limestone horizon. The youngest member is a thick slate bed. The whole sequence has been intruded by felsites, porphyries, etc., of the Kanimbla epoch. The lavas and tuffs form a continuous, wide tract, which extends almost from Mudgee to the Aaron's Pass granite, a distance of more than 20 miles. The Cudgegong-Mudgee road follows the strike of this band, and the Silurian strata outcrop chiefly to the south of this road between the two localities.

The lower limestone is about 300 feet thick, and forms several disconnected lenses near Cudgegong, which were formerly thought to be of Middle Devonian age until

Pentamerus knighti was recently obtained from this band. The following forms have been collected from these older limestones:

Actinozoa—
Favosites, massive sp.
Favosites, dendroid form (2 species)
Cystiphyllum
Heliolites
Cyathophyllum shearsbyi
Cyathophyllum, small sp.
Hydrozoa—
Stromatopora.
Crinoidea—
Crinoid stems.
Brachiopoda—
Small species (indet.)
Chonetes (cf. *Ch. hardrensis*)
Pentamerus knighti.
Trilobita—
Encrinurus.

These species were obtained from the limestone lenses in Pors. 7, 8 and 92, Parish Arthur; Por. 123, Parish Dungeree; and Por. 39, Parish Tannabutta. The trilobite was found in the clay-slates on Por. 7, Parish Tannabutta.

The lavas and tuffs overlie this limestone bed at Cudgegong. A well-marked flow makes a bold outcrop immediately below the Cudgegong bridge, and has been traced about a quarter of a mile along its strike. The rock is a dark, greenish-grey, massive hornblende-augite-andesite. It contains hornblende, augite, both felspars, olivine and a little chalcedony and calcite. The hornblende crystals are rudely columnar, up to 4 mms. long, and often simply twinned. Hornblende also forms a large part of the groundmass of this rock. The phenocrysts contain inclusions of idiomorphic felspar and occasional augite. Many of the hornblende phenocrysts have suffered some resorption by the groundmass. The augite is less abundant, and the phenocrysts are generally almost idiomorphic. One individual shows a perfect cruciform twin, the composition plane being (101). The average size of the pyroxene phenocrysts is only about $\frac{1}{4}$-mm. The plagioclase (probably andesine) is more abundant than the orthoclase; the idiomorphic

prisms average ¼-mm. in length. No flow-structure occurs in the groundmass, which consists of a mixture of cryptocrystalline material and tiny grains of felspar and ferro-magnesian minerals.

A similar type—probably a continuation of the same flow—is again seen on the bend of the Cudgegong River in Por. 72, Parish of Tannabutta. The phenocrysts consist of hornblende and felspar. There is no augite or olivine, but some epidote and apatite are present. The hornblende prisms are somewhat bleached, and average ¼-mm. to 1 mm. in length, though some reach a length of 4 mms. The felspar has been completely altered to kaolin.

To the S.W. of these flows are other altered Silurian lavas and tuffs. Near Mullamuddy the main types seem to be lavas, but between Cudgegong and Mt. Bocoble an extensive band of tuffs outcrops, with but few interbedded flows. The lavas to the west have been altered and albitized almost completely, but the texture furnishes evidence as to their original characters. The flows were probably originally of an andesitic or trachytic type, but have now been converted to keratophyres. One micro-slide from a type outcropping on the northern boundary of Por. 234, Parish Tannabutta, shows subidiomorphic and idiomorphic albite phenocrysts about 1 to 2 mm. long, around which "swirls" the groundmass, composed mainly of minute idiomorphic needles of felspar, giving a pilotaxitic texture. Another specimen collected near the S.W. corner of Por. 227 is an original orthophyric trachyte, with phenocrysts of plagioclase up to 5 mms. in length. There is also some orthoclase, but the felspars have been albitized, converting the rock into a keratophyre.

One more strongly developed lava outcrops in the Limestone Creek district; this type forms the northern boundary of a tributary of Limestone Creek, and can be traced from Por. 202, Parish Tannabutta, westwards for about a mile. It is a grey coloured, crystalline type, and a micro-slide showed orthoclase, oligoclase, calcite, apatite, magnetite and chlorite. Orthoclase occurs as large, irregular, altered phenocrysts, and also in small, fresh, sharply idiomorphic square sections and elongated prism sections. The oligoclase also forms idiomorphic phenocrysts, one of which is 4·5 mm. long. The average

length is 1 to 2 mm. Calcite is very abundant, the felspars being extensively carbonated. This rock-type appears to be an oligoclase trachyte. The absence of any ferro-magnesian mineral is unusual.

Above these lavas is a wide belt of felspathic tuffs. These outcrop in the south-east part of the Parish of Bocoble, and as they are traced along their strike towards Mudgee they become interbedded with the lavas previously described, until the volcanic types almost displace the pyroclastic. The tuffs are exposed at numerous localities in the neighbourhood of the village of Cudgegong and on Cudgegong, Bocoble and Four Mile Creeks. The tuffs make bold, angular outcrops over a belt of country three miles wide, stretching from the Cudgegong road to the Silurian limestone belt under Mt. Bocoble. It seems probable that the great width of outcrop of these tuffs is due to local folding of the beds and consequent varying dips. Unfortunately the tuffs are highly jointed and do not show any bedding-planes, so this speculation cannot be verified. These Cudgegong tuffs vary but little in mineralogical constitution. Megascopically the rock is not unlike the andesites previously described, but has a paler grey body colour. No visible ferro-magnesian phenocrysts occur. It is hard, tough and massive. In thin sections the following minerals can be distinguished: orthoclase, plagioclase (andesine), calcite, magnetite, hornblende, quartz and apatite. The felspars form by far the greater part of the rock. Both felspars are rather extensively altered to sericite and kaolin. The average grainsize is about ¾ to 1 mm. The calcite and quartz are interstitial and probably secondary. Magnetite and hornblende are sparse, and form small irregular grains. There are also dark patches, consisting of small angular fragments of quartz and felspar set in a dark, fine-grained base; these are probably portions of other included rocks. This tuff is, therefore, an intermediate felspathic type, which has probably undergone some resorting after formation.

The belt of country occupied by these tuffs has been cleared and makes good pasture land. The hills are frequently rather steep, however, where silicified, cherty types outcrop. The creeks draining this area have a typical dendritic pattern.

Overlying the Cudgegong tuffs and the lavas to the north-west is a thick belt of limestone. This occurs in lenses, which can be traced from near the G.S.B. quarry, 2½ miles S.E. of Cudgegong, to the Cudgegong River near Mt. Frome, a distance of about 20 miles. Most of the limestones are fossiliferous, although the variety of forms obtained is not very great.

The small lenses of limestone and shale which outcrop on Pors. 30, 68, 46, 101 and 69, Parish Bocoble (*i.e.*, just to the west of the road to the G.S.B. quarry), are crowded in certain horizons with the brachiopod *Pentamerus knighti*. This is proof of the Upper Silurian age of this belt. The two large lenses of limestone which outcrop on the N.E. flank of Mt. Bocoble also contain *Pentamerus*, which is again found in the Limestone Creek belts, although here it is very sparse. Again, the long limestone belt which outcrops along the Windeyer road ("Queen's Pinch Belt" of Carne and Jones) is fossiliferous, and *Pentamerus knighti* occurs also in this band.

A complete list of the Silurian forms obtained from these limestone horizons is given below:

Actinozoa—
- *Favosites* (massive and dendroid forms)
- *Zaphrentis*
- *Rhizophyllum*
- *Tryplasma* (*liliiformis* type)
- *Cyathophyllum shearsbyi.*

Brachiopoda—
- *Leptæna rhomboidalis*
- *Atrypa reticularis*
- *Orthotetes,* nov. sp.
- *Rhynchonella*
- *Pentamerus knighti.*

Gastropoda—
- A Euomphaloid type.

Cephalopoda—
- *Orthoceras.*

Crinoidea—
- Crinoid stems.

(*N.B.*—Many of these genera were obtained not from the limestone itself, but from zones of impure, calcareous sandstones and shales which are associated with the limestone. Two productive localities occur in the Limestone

Creek district. One is from a belt of sandstones, near the source of Limestone Creek, just west of the point where it crosses the parish boundary fence of Portion 237, Parish Tannabutta. The other is near the centre of the northern boundary of Portion 182, where a fossiliferous tuffaceous horizon occurs.)

Above the limestone is a thick horizon of clay-slates and quartzites, which is prominent towards the south-west of the district. These strata outcrop along Green Gully and continue towards Mudgee to the west of and almost parallel to the Windeyer road. They are again encountered on Cudgegong and Bocoble Creeks, where, however, they are altered by the Aaron's Pass granite. No recognizable fossils have as yet been obtained from this horizon. The slates are soft and vary considerably in fissility and closeness of bedding. They dip S.W. in conformity with the overlying limestone belt.

It will be seen, therefore, that the general sequence of the Silurian strata in the centre, south and south-western areas of the district corresponds with that obtaining in the Parish of Wells, to the east. The strongly developed conglomerate bed of the latter area is absent from the former region. This is not unexpected, since the conglomerates were probably deposited over a relatively narrow zone of sea-floor, under shallow-water conditions obtaining near the shore-line.

The Silurian strata in the north of the district remain to be described. Such description must necessarily be brief, because less detailed work has been done in this region.

The Silurian formation here consists of a thick horizon of tuffs and tuffaceous slates, underlying a thin limestone horizon. These strata dip to the south-west under the broad belt of Upper Devonian quartzites, which form a high and rugged ridge, the Silurian rocks occupying the broad, mature valley of Lawson's Creek. The lowest horizons here consist of clay-slates. The argillaceous types become tuffaceous as they are traced upwards, and pass into bedded tuffs. There are also thin horizons of conglomeratic breccias, which make bold outcrops in the clay-slate series. These types have all been more or less altered and are usually schistose in appearance. In addition to this regional metamorphism they

have, locally, been metamorphosed by the Havilah granite and the adjacent porphyries of the Kanimbla epoch. Good exposures of clay-slates and tuffaceous slates may be seen along the Bayly and Wollar roads and also on the Havilah-Lue road. The bedding is prominently shown in most places. No fossils have been found in the slates or in the tuffs, but the limestones at the top of the sequence show a variety of forms. The most productive belt is that which outcrops along the Buckaroo road. This limestone horizon can be traced for about 1½ miles. It passes upwards, *conformably,* into Upper Devonian slates and quarzites. Also it appears to overlie Upper Devonian beds, the apparent anomaly being due to a strike-fault, which follows the road and causes the sequence to be repeated. There are probably two or three parallel strike-faults in this area, as the sequence Upper Devonian sandstones overlying Upper Silurian limestones is repeated three times in one locality. Both the Upper Devonian and the Upper Silurian beds furnish direct palæontological evidence of age, and may be seen in direct contact just west of the Buckaroo road. They appear to be completely conformable. If there be any unconformity it must be very slight. There must be, however, a considerable disconformity between the two formations.

The Silurian fossils obtained from this Buckaroo limestone belt include the following forms:

Actinozoa—
Acervularia
Syringopora
Favosites (massive and dendroid forms).
Brachiopoda—
Atrypa
Pentamerus knighti.
Cephalopoda—
Orthoceras.
Crinoidea—
Crinoid stems.

Boundary Between Silurian and Devonian Systems.

Before describing the succeeding Devonian strata it may be well to discuss the nature of the boundary between the two formations. By reference to the map

it will be seen that there are two broad tracts of Silurian country, between which is the high ridge of Devonian rocks. To the north of this ridge the Silurian system dips under the Upper Devonian strata, and there is nothing to suggest an unconformity between the two series. It has already been stated (p. 211) that in the neighbourhood of Havilah, along the Buckaroo road, the Upper Silurian and Upper Devonian rocks are in direct, conformable contact. Now the Upper Devonian strata dip to the south-west, and are followed to the south by Silurian rocks, which also dip in this direction. This apparent anomaly can only be explained by a large strike-fault, running along the Cudgegong valley and separating the two formations.

Evidence of the presence of this large fault is clearest near the G.S.B. quarry, Parish Bocoble. A zone of Silurian limestone, crowded with *Pentamerus knighti*, runs parallel to and just to the west of the Quarry road. Just to the east of the same road, and immediately opposite the Silurian belt, is a thin horizon of Upper Devonian limestone, which also runs approximately parallel to the Silurian horizon and to the road. The two formations are separated by a strip about 100 to 300 yards wide, which is occupied by highly silicified rock-types, such as cherts, etc., and in part by alluvium. Further to the east the beds of Upper Devonian age, stratigraphically below the limestone, outcrop. This thin limestone belt is, therefore, the highest exposed member of the Upper Devonian Series, and the wider Silurian limestone across the road is the lowest exposed member of that system. The fault almost follows the road itself, and must have a very considerable throw. By reference to the detailed map (Fig. 2) these points will be made more clear.

A well-marked belt of silicified types follows the road; this silicification is no doubt due to the ascent of siliceous solutions along the fault-zone.

There is little evidence to show whether the fault is overthrust or normal; however, it is certainly not a true plane, but gently curved, and the author is inclined to think that it is overthrust. It can be traced along the Cudgegong valley past Mullamuddy and Mt. Frome, being lost under the Mudgee alluvium.

There are probably some subsidiary parallel faults, and the main Cudgegong Fault (as it will be termed) is thought to branch about 1 mile south-east of Cudgegong

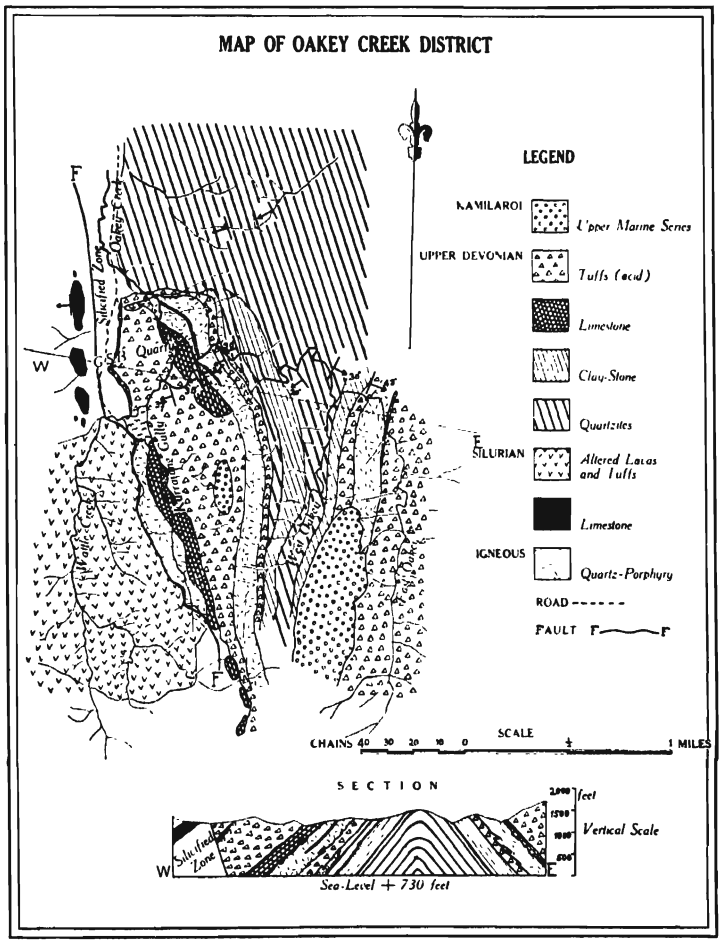


Fig. 2.

into two parallel faults, with a strip of Middle Devonian sediments between them.

The fault must be post-Devonian (since it has displaced beds of this age) and pre-Upper Marine (since the residual outliers of Upper Marine basal conglomerate are

at the same elevation on each side of the fault). The fault was probably connected with the great orogenic movements of the Kanimbla epoch.

The boundary between the Silurian and Devonian strata is seen also on the Cudgegong-Rylstone road, on the Rylstone side of Carwell Creek, Parish of Wells. The relationships here are somewhat analogous to those obtaining near Havilah, as might be expected, since the Silurian belt is on the same side of the Devonian ridge in both districts. However, there is one important difference. In the Havilah area the Silurian strata pass upwards conformably into Upper Devonian beds, whereas, in the Carwell Creek region, Middle Devonian sediments overlie the Silurian rocks, also conformably. Although, as has already been stated (p. 202), it is not certain whether the boundary between sediments of the two periods should be drawn above or below the thick horizon of fissile slates, there is no doubt that the Silurian tuffs, conglomerates, limestones and possibly slates are conformable with the overlying Middle Devonian limestones, acid tuffs and clay-slates.

The Devonian System.

The Devonian strata comprise both Middle and Upper Devonian beds.

Middle Devonian Series.

The best series of Middle Devonian age occurs in the Parish of Wells. Good exposures are seen on the Cudgegong-Rylstone road, on Carwell Creek and on the Cudgegong River. Sussmilch has described these Middle Devonian strata in this area. The nature and approximate thicknesses of the horizons in the sequence are:

	Feet.
Clay-slates with interbedded quartzite lenses	2,050
Acid tuffs	60
Clay-slates	15–20
Limestones	520
Basal limestone-breccia and brecciated conglomerate	345
Total	2,995

The series is, therefore, over half a mile thick. The limestone-breccia or brecciated conglomerate at the base of the series forms a persistent horizon, which can be traced from the road just east of the Carwell Creek bridge to the Charbon limestone quarry, a distance of about 2¾ miles. Near the quarry this rock has the appearance of a breccia, but further north it merges into a conglomerate with elongated pebbles. The breccia has a rusty-brown colour, and contains angular pebbles of a siliceous, pale-grey, hard rock in a porous, sandy-coloured matrix. The pebbles are very numerous. The largest are about 1½ inches across; some, however, are very small. They appear to have the character of a felsite or related type. Many are considerably flattened. In the lower horizons of this bed the pebbles are not usually highly angular, and have probably undergone some transportation before being cemented. In the upper horizons the fragments are nearly all of limestone or claystone and much more angular.

The limestone which overlies the breccias is thick and persistent. It has been traced for over 5 miles—from the Charbon quarry almost to the Cudgegong river. The outcrop is concealed for a distance of one mile beneath the Carwell Creek alluvium, but is otherwise unbroken, except for a small gap on Por. 69, Parish of Wells. This limestone is being quarried on a large scale for the Charbon and Kandos cement works. Two large quarries have been opened at the southern end of the belt, where it is cut off by a large intrusion of quartz-porphyry. At this southern end the limestone band is folded. The Charbon and Kandos quarries lie, respectively, on the western and eastern limbs of an anticline, whose axis strikes about N. 25° W. and which pitches to the south. Several smaller folds are superimposed on this anticline. This folding causes a very wide outcrop at the Kandos quarry, where the width of the outcrop does not indicate the true thickness of the bed.

The limestone has a strike of about N. 33° W., and dips S.W. at about 53°. It is a dense, blue-black, finely crystalline variety, and is generally very pure. However, in its upper horizons it is interbedded with claystones and hardened sandstones. A thin horizon of clay-slates immediately overlies it. The middle and lower horizons

are crowded with organic remains, many of which are, unfortunately, not well preserved. Sussmilch (*loc. cit.*, p. 214) has collected a representative fossil fauna, identified by the late W. S. Dun as being of Middle Devonian age.

The eastern limb of the anticline, already referred to, does not make a continuous outcrop as does the western limb just described. The limestone band appears to have several small folds, and lenses of limestone occur in the neighbourhood of the Kandos quarry, on Pors. M.L. 6, 100 and 66, Parish of Wells. There may be small, oblique faults, and the precise way in which this bed is folded and faulted in this eastern limb of the Carwell anticline is not quite clear. Intrusive quartz-porphyry types cut off the wide outcrop at the Kandos quarry both to the north and to the south. A thin zone of clay-slate overlies the limestone, and is exposed on Carwell Creek where it crosses Por. 108.

Overlying this slate band is a thin but interesting horizon of acid tuffs, the occurrence of which indicates volcanic activity during the Middle Devonian epoch. This tuff has been described by Sussmilch (*loc. cit.*, p. 210). Usually it is fine in grainsize, but locally becomes much coarser. The fragments are highly angular and consist of abundant quartz and felspar grains, the latter being much weathered to kaolin. Secondary calcite is abundant as a result of this decomposition of the felspar. The matrix of this tuff is black in colour and has a pitchy lustre.

This horizon is well exposed on Carwell Creek, near the Charbon quarry, in Portion 32, and can be traced southwards for almost 1½ miles, but is not seen again to the north.

The tuffs are overlain by a thick horizon of clay-slates, and these occur to the west of the limestone belt. They are soft, have a medium grey colour and are thinly bedded. They are interstratified with numerous narrow quartzite bands. They merge upwards, without a definite boundary, into the Upper Devonian quartzites. Two small brachiopods are the only fossils obtained from this horizon; they are both probably species of *Chonetes*.

This clay-slate belt is cut off to the north by a dip-fault which runs along a tributary of Carwell Creek, flowing

W.S.W. across Pors. 84 and 85, Parish of Wells. The horizon has not been found north of this creek, and it is difficult to see how it has been displaced by the fault.

In the neighbourhood of the village of Cudgegong is a thick series of clay-slates, which furnish palæontological evidence of being of Middle Devonian age. These are first seen immediately west of the G.S.B. quarry road. They continue in a north-westerly direction across the Cudgegong River, through the southern part of the Parishes of Dungeree and Arthur, and have been traced as far as Por. 44, Parish of Arthur. They appear to underlie the Cudgegong Silurian limestone belt, but there is probably overturning of the strata in this area; an overturned fold is responsible for the apparent anomalous relationship. This clay-slate bed may be correlated with that above the Carwell quarry limestone. It is about 2,060 feet thick.

Sandstone horizons are interstratified with the clay-stones. On the western bank of the Cudgegong River, on the boundary of Pors. 22 and 133, Parish Dungeree, is a narrow horizon of sandstone crowded with brachiopods. Two species of *Chonetes* are the only forms represented, but they are in extraordinary abundance and confined to this narrow horizon, two or three feet thick. Sussmilch (*loc. cit.*) has also collected from these clay-slates, and records several forms also from the bank of the river in Portion 132. In each instance the commonest form is closely related to *Chonetes hardrensis*. The brachiopods are somewhat flattened, but otherwise excellently preserved.

These Middle Devonian sediments have not been found in the vicinity of Mullamuddy or Mudgee, but in those districts the Cudgegong fault separates Upper Devonian and Upper Silurian beds. Also, in the north of the district, in the Havilah-Lue areas, the Silurian slates and tuffs pass directly upwards into the Upper Devonian sandstones and quartzites without the intervention of the Middle Devonian series. What actually happens to this series in the north-west of the district is something of a mystery. It is possible that they are in some way faulted under the Upper Devonian strata, as they appear to be in the Carwell region, where they terminate abruptly against the small tributary of Carwell

Creek, which flows W.S.W. across Pors. 84 and 85, Parish of Wells. In the neighbourhood of Cudgegong the Middle Devonian series appears to occupy a zone between two faults, the great Cudgegong fault and a smaller fault which branches from the main one half a mile north of the G.S.B. quarry. Both these faults are probably overthrust.

Upper Devonian Series.

Upper Devonian strata are strongly represented in this district, and the rock-types, being hard and resistant, have formed a well-defined ridge, trending about N. 40° W., and curving gently to the north near Mudgee. The Upper Devonian strata consist mainly of quartzites, but also include horizons of limestones, claystone, tuffs and grits. Fossils are abundant almost throughout the series, and are excellently preserved, although the variety of genera is not great.

The best section of Upper Devonian strata occurs in the Parish of Bocoble, along Oakey Creek, upstream from the Marble quarry. A detailed geographical map of this area has been prepared from aerial mosaics made by the R.A.A.F. This has been used for the preparation of the geological map (Fig. 2). The character and thickness of the various horizons of this sequence are as follows:

	Feet.
Limestone and marble	40–60
Acid tuffs and grits	770
Limestone	250
Grits	185
Quartzites	150
Claystones and sandstones	300
Quartzites (base)	7,000+
Total	8,700+

The quartzites at the base of this series are fairly pure and fine-grained, being completely recrystallized. The bed is very thick, but so extensively folded and faulted that no very accurate determination of its thickness is possible. It is well bedded and jointed, and tends to disintegrate into cubical blocks. It forms rough rugged country, useless for agricultural purposes.

Stream gullies in the quartzite are usually dry, owing, probably, to the abundant joint-systems of this rock-

type. The streams flow below the surface and reappear beyond the quartzite. Two features of especial interest are shown by these Upper Devonian quartzites:

1. Many horizons show wonderfully developed, symmetrical ripple-marks. The ripples appear to have been developed in the original sands by oscillatory currents, due to wave-action in a shallow sea. The amplitude of the ripples is commonly about 2 to 3 inches, and the troughs are about half an inch deep. The ripple-marks occur throughout a great thickness of quartzites in various parts of the district, and are by no means attributable to local causes. It would seem that deposition of the sands kept pace with subsidence of the sea-floor during this period, with the maintenance of shallow water conditions.

Two other indications of the extremely shallow water conditions under which the sandy beds were originally laid down are worm-tracks and imprints of rain-drops. Both these features may be observed on the north bank of the Cudgegong River near the boundary of Pors. 22 and 133, Parish Dungeree. At certain times, therefore, during their deposition the sediments were actually raised above sea-level and became sand-flats.

2. The quartzite, in many horizons, is crowded with Crinoid stems, whose axes are always arranged perpendicularly to the bedding-planes of the strata. The extraordinary abundance of these stems in certain horizons produces a remarkable appearance. The accumulation of sediment must have been sufficiently rapid to engulf the stems in their natural upright position of growth. There was not time for them to be broken and drifted into other positions.

In hand-specimens the pure quartzite has an almost white colour and a subvitreous lustre, and is exceedingly hard. A micro-slide of this type showed it to consist of fine quartz grains, with a little altered felspar, biotite and iron-ore. The quartz grains average 0·2 mm. across. The grains interlock, but the edges are not sutured, and there is no evidence of addition of secondary quartz. Many grains show undulose extinction, and the larger ones are often granulated. This indicates the strain to

which these sediments were subjected in the orogenic epoch which followed their deposition.

In this Oakey Creek area these basal quartzites form the core of a plunging anticline; a section across this anticline is shown with the map of this region. The quartzites are exposed at the junction of the left and right hand branches of Oakey Creek on Pors. 81 and 97, Parish Bocoble. Fossils are scarce, but the occurrence of *Spirifer disjunctus* and *Rhynchonella pleurodon* is proof of the Upper Devonian age of this horizon.

Overlying these quartzites is a horizon of claystones and fine-grained sandstones, which are exposed on Oakey Creek in Por. 81 (western limb of anticline) and in Por. 97 (eastern limb). The claystones are very fine and even-grained, and extremely soft, and the joints are very closely spaced. Harder sandstone horizons occur with the claystones, the rock consisting of fine, sub-angular quartz grains, averaging 0·03 mm. in diameter, set in a finer-grained base, composed of shreds of sericite and kaolin. Many hæmatite flakes are present, elongated in the same direction as the mica shreds; they probably represent an original ferro-magnesian mineral such as biotite. This rock is an extremely fine-grained type, in which the component material has probably been broken down by mechanical agencies in an arid climate. Little transportation can have occurred.

Overlying these clay-slates and sandstones, on the western limb of the Oakey Creek anticline, is a thin horizon of quartzites. They are fairly pure and well-bedded, and possess no features of especial interest. This horizon is not represented on the eastern limb, having, apparently, thinned out rather rapidly to the east.

The next overlying bed is a tuffaceous grit. A narrow sill of quartz-porphyry has been injected between the quartzite and grit horizons. This grit has a mottled, pale whitish-grey colour and a medium grainsize. Sub-angular fragments of quartz are cemented by decomposed, whitish felspar grains. It is hard, tough and well-bedded.

A rather thick sill of quartz-porphyry separates this horizon from the overlying marble band. This thick horizon of marble is of especial interest, since the Commonwealth Savings Bank building in Sydney has been

partly constructed from it. The horizon is best seen on the western limb of the anticline, where it crosses Oakey Creek in Por. M.L. 4, Parish Bocoble. On the eastern limb the band is much thinner and more impure, but it crosses the creek in Por. 97. The marble is a fine-grained type, and is completely recrystallized. For commercial purposes two varieties are recognized, the Cudgegong Golden and the Cudgegong Ivory. Both varieties are handsome ornamental stones and take a high polish. The marble owes its commercial value to the presence of impurities, chiefly iron oxides and silica. Limonite veins are regularly spaced in the 'Golden' variety, and patches of deep red, recrystallized hæmatite also occur. Quartz grains are sometimes seen. In the 'Ivory' variety quartz grains are the chief impurity. Although it has been thoroughly recrystallized the marble is well bedded; it strikes N. 30° W. and dips S.W. at 35°. In the eastern limb the strike is about N. 12° E. The marble forms a thick convex lens tapering rather rapidly to the north-west and south-east. It is completely devoid of fossils.

This marble is overlain by a thick horizon of grits, grading upwards into acid tuffs. This horizon is similar to the one beneath the marble belt. The acid tuffs differ remarkably in appearance from the grits, but are composed of essentially the same minerals. The tuff is almost black in colour and has a vitreous lustre. It is rather fine-grained and extremely hard but brittle. A micro-slide of this rock showed it to be composed of highly angular quartz grains and decomposed felspar (both orthoclase and plagioclase) set in a cement of minute biotite granules, which are closely crowded in the interstices.

These tuffs cannot have undergone any transportation before deposition, but must have settled on the sea-floor immediately after the explosive eruptions which produced them. They are well-bedded and have the appearance of a typical sedimentary rock. Oakey Creek is juvenile in character where it cuts through this tuff band.

The tuffs are overlain by a rather thin horizon of marble, which is the youngest member of the Upper Devonian sequence in this region. This belt has a narrow outcrop near its northern end, but the outcrop widens considerably to the south, where the marble follows the

course of Kurrajong Gully. In the gully the marble is a pale grey, fine-grained, completely recrystallized variety. Further north, at the point where the belt meets the quarry road, a few poorly preserved fossil corals were found. The species were not identifiable. The belt pinches out just as it meets the road.

This concludes the account of the detailed section of Upper Devonian strata in the Oakey Creek area. Elsewhere the details of the Upper Devonian System have not been mapped, but the same lithological characters have been observed throughout. The strata are mainly quartzites with thinner horizons of acid tuffs, grits, limestones and clay-slates. It has already been stated (p. 212) that Upper Devonian strata have been traced north-westwards from Cudgegong, parallel with the Cudgegong River, through the Parishes of Arthur and Derale, and north of Mt. Frome. In the Parish of Derale a series of very rugged hills is formed by the Upper Devonian quartzites. Their summits rise 1,600 feet above the river and separate the Cudgegong Valley from Lawson's Creek valley to the north. These hills were monadnocks in the Carboniferous Period, and stood above the surrounding plain of erosion. They were never covered by the Upper Marine Sea.

Fossils are very abundant and well preserved in a great many localities where the Upper Devonian series outcrops. The best localities are the following:

1. Por. 78, Parish Bocoble, on the Cudgegong road, 2½ miles from the village.
2. Southern bank of the Cudgegong River, in Por. 5, Parish of Wells.
3. In the Parish of Derale, throughout the entire thickness of quartzites.
4. In the neighbourhood of Mt. Frome.
5. Along the Havilah-Buckaroo road.

A great many more localities are known, but they are too numerous to mention. The five given are the best, and representative specimens may be collected from them. A complete list of the forms obtained is given below:

Actinozoa—

Zaphrentis
Cyathophyllum.

Crinoidea—
Crinoid stems.
Brachiopoda—
Rhynchonella pleurodon
Spirifer disjunctus
Spirifer sp. (not *disjunctus*)
Orthis (*striatula* group).
Orthotetes
Chonetes
Strophomenoid, nov. sp.
Atrypa (not *A. reticularis*)
Pterinea, nov. sp.
Terebratuloid shell.
Spirifer, sp. indet.
Gastropoda—
Loxonema.

Spirifer disjunctus and *Rhynchonella pleurodon* are the commonest forms.

The Upper Devonian series in this region can be correlated, on lithological and palæontological grounds, with the Mt. Lambie series, which occurs near Rydal, some 40 miles to the south. The Upper Devonian formation can be traced southwards to the Kanimbla Valley, south of which it is covered by the Triassic and Permian strata of the Blue Mountain tableland.

The Kamilaroi System.

The Kamilaroi strata consist of the Upper Coal Measures and the Upper Marine Series, the Lower Marine Series being overlapped. The Upper Coal Measures and the overlying Triassic beds have been removed over most of the region, but the basal Upper Marine conglomerates still survive over a considerable part of the district.

The Upper Marine Series, about 350 feet thick, was laid down close to the Permian coast-line, which was mainly composed of Upper Devonian quartzites. Hence the lowest horizon of the series is a strongly developed conglomerate, about 100 feet thick. The pebbles consist dominantly of quartzite, and a few pebbles were found to contain an Upper Devonian fossil fauna. Some of the boulders are as much as 4 or 5 feet across, but their average size is about 3 or 4 inches. Nearly all the pebbles are well rounded and have obviously been waterworn

before cementation took place. Sussmilch considers that these Kamilaroi conglomerates furnish evidence of the existence of glacial conditions in this region during their deposition. He postulates transport of large Devonian boulders by floating ice, and subsequent deposition some miles from the shore-line when the ice melted. No glacial striæ were found on a fair number of boulders examined; also nearly all the boulders are waterworn. However, the hypothesis of an Upper Marine ice-sheet or glaciers reaching the coast cannot be discarded, although the author contends that it is by no means proved.

This horizon may, tentatively, be correlated with the Muree glacial horizon of the Upper Marine Series in the Hunter Valley. Above the basal conglomerates the series consists of shales and sandstones. Few fossils have been obtained from the strata. However, several fragments of *Edmondia* were found by L. L. Waterhouse and the author in an arkosic breccia near the top of Aaron's Pass. This breccia has a rather remarkable appearance. It consists of a hard, dark grey matrix, in which are set numerous fragments of quartz and orthoclase; the quartz grains are up to one-third of an inch across, and irregular in shape, while the orthoclase crystals are up to three-quarters of an inch in length, some of them being idiomorphic. The rock has probably been formed by the disintegration and subsequent cementation of the underlying granite. It is thought not to be of pyroclastic origin.

The Upper Coal Measures consist chiefly of soft, pale-grey shales with a *Glossopteris-Gangamopteris* flora. Sandstones are frequently interstratified with the shales, and a few thin coal-seams are interbedded.

The Upper Coal Measures are found under the dolerite sills of Mts. Bocoble, Tongbong, Cargalgong and Boiga, and under the Triassic outliers which form the eastern boundary of the district. The series is about 140 feet thick.

The Upper Coal Measures and the Upper Marine Series are not absolutely horizontal, but dip very gently to the north-east. Towards the west of the district the dip was found to be about ½° in a direction N. 58° E. In the eastern areas the values obtained were 0° 50′ in

a direction N. 63° E. The overlying Triassic sandstones also conform to this gentle dip.

The Triassic System.

The Triassic sediments are limited to the eastern part of the area, where they outcrop under the basalt caps of Cumbermelon Mountain, Mt. Fitzgerald and the "High Basaltic Mountain". The series is thickest on Cumbermelon Mountain, where a thickness of 520 feet was measured. Both the Narrabeen and Hawkesbury Series are present, the former being only about 80 feet thick, while the latter is 440 feet. The Chocolate Shale horizon is well marked on Cumbermelon Mountain. The Hawkesbury Series has numerous horizons of conglomerates with pebbles of milk-white quartz; these conglomerates may possibly represent beach deposits on the shores of a large freshwater lake. The Narrabeen Series is finer-grained and somewhat massive in its upper horizons. It forms a smooth, vertical cliff about 30 feet high, which extends along the western side of Cumbermelon Mountain.

The Triassic sediments thin rather rapidly to the south. On Mt. Fitzgerald they are 290 feet thick and on Cherry Tree Hill only 195 feet. This matter will be dealt with in connection with the overlying basalts.

It is difficult to say precisely where the western margin of the Triassic sandstones originally lay. It is probable that they covered the coal-measures of Mts. Bocoble, Cargalgong, Boiga and Tongbong, and that the dolerite sills which now cap these mountains were injected between the Upper Coal Measures and the Triassic sandstones.

The Tertiary Group.

There are no Tertiary sediments within the district, but evidence of the extensive volcanic activity of this era occurs in several localities. It is thought that both sill- and flow-remnants are present; post-Tertiary erosion has removed the greater portions of the once widespread intrusions and extrusions, and the hills which are now capped by dolerite and basalt are monadnocks above the general level of the plateau.

Mts. Boiga, Cargalgong, Bocoble and Tongbong are capped by dolerite, while Cumbermelon Mountain, High

Basaltic Mountain, Mt. Fitzgerald, Bradley's Head and Cherry Tree Hill have resistant basalt caps. The four first-named mountains differ from the others in that the dolerite covers Upper Coal Measures, whereas the basalt caps Triassic sandstone.

It will be seen, therefore, that the dolerite occupies a horizon stratigraphically below the basalt, as might be expected if both sill and flow were produced at the same period. However, owing to the gentle N.E. dip of the Coal Measures and the overlying Triassic strata, the height above sea-level of the bases of the sills and flows is, approximately, the same.

It will now be well to set forth the evidence for assigning an intrusive nature to some of these occurrences and an extrusive origin to others.

It was originally thought that all the monadnocks were capped by basalt flows. Quite recently, however, the author found Upper Marine sandstones and grits *above* the igneous rock on Tongbong Mt. This rock, therefore, must be intrusive, and the internal evidence obtained by megascopic and microscopic examination tends to support this contention. Now the igneous sheets of Mts. Bocoble, Cargalgong and Boiga occupy the same stratigraphical horizon as that of Tongbong Mountain, and are petrologically identical with the dolerite of this hill. Since no evidence in opposition to an intrusive origin for these remnants has been found, they too will be classified as sills. Turning now to the remaining monadnocks, we find stratigraphical evidence to suggest that they are capped by flows and not sills. The igneous sheets are found to transgress the bedding-planes of the underlying Triassic sandstones. Thus the thickness of Triassic strata on Cumbermelon Mountain is 520 feet, on Mt. Fitzgerald 295 feet, and on Cherry Tree Hill only 195 feet. It is unlikely that the Triassic measures are thinning in a south-east direction (as might at first be inferred from the figures given above); it is much more probable that the Triassic beds were gently tilted before the Tertiary era, and that a true peneplain was then cut out of the gently dipping sediments during the Tertiary Era, but before the Oligocene Period. Thus the almost horizontal surface of this Early Tertiary peneplain would not be quite accordant with the bedding-

planes of the sandstones. The outpouring of Oligocene basalts over the peneplain, and subsequent uplift, would produce precisely the relationship observed to-day.

Both flows and sills are thought to be of Early Tertiary age (probably Oligocene). Erosive agencies have removed the greater portion of the igneous sheets, and have also cut down more than 1,700 feet into the underlying strata. Broad, mature valleys now exist at this level below the summits of the sills and flows. It is demanding rather much of erosion to presume that it could accomplish this amount of denudation since the Pliocene Period. Furthermore, basalts are found at Gulgong, in the Cudgegong Valley, 2,000 feet below those which cap Cumbermelon Mt., etc. This indicates that a considerable time elapsed after the Early Tertiary outbreak, during which erosion exposed the old Carboniferous peneplain and carved the U-shaped valley of the Cudgegong River in the Palæozoic rocks. This mature valley then became filled with the Late Tertiary (Pliocene) basalts.

This argument requires a considerable uplift after the outpouring of the Oligocene basalts and before the close of the Tertiary Era, *i.e.*, before the Kosciusko uplift. Several periods of uplift and peneplanation are known to have occurred during the Tertiary Era, although the amount of each uplift and the period in which it occurred are still unknown.

The thickness of the respective igneous cappings and the height of their bases above sea-level are given below (all figures only approximate):

	Height of Base Above S.L.	Thickness.
Sills—		
Mt. Bocoble	3,080 ft. ..	340 ft.
Mt. Cargalgong	3,100 ft. ..	335 ft.
Tongbong Mt.		
Flows—		
Cumbermelon Mt.	3,250 ft. ..	155 ft.
High Basaltic Mt.	3,275 ft. ..	120 ft.
Cherry Tree Hill	3,300 ft. ..	200 ft.

There has been no magmatic differentiation in any of the flows or sills examined; the types are simple dolerites and basalts. They vary in grainsize and in fabric, but there appears to be no method of distinguishing, by purely petrological means, between the intrusive and extrusive types. The dolerite from Mt. Bocoble is typical

of the sills. It contains plagioclase (about $Ab_{40}An_{60}$), augite, olivine and magnetite. There is a well-developed ophitic fabric, and the order of crystallization appears to be: olivine, labradorite, magnetite, augite. The Tongbong Mt. dolerite contains a little interstitial analcite, and this mineral is probably present in the other dolerites also.

The basalt from Cumbermelon Mt. is somewhat similar in appearance; it contains the same four minerals, but there is no typical ophitic fabric. This basalt is quite strongly magnetic and polar, due to the abundance of magnetite. There is no flow-structure. The plagioclase is close to $Ab_{47}An_{53}$. A little biotite occurs in this rock, and the occurrence of this mica is admittedly unusual in flows. However, in the centre of a thick flow conditions may approximate to those obtaining in sills.

Pleistocene and Recent.

Deposits of alluvium occur along the valley of the Cudgegong River and its tributaries; also fertile alluvial flats are found along Lawson's Creek valley and its tributaries. Both streams have reached the stage of maturity along the greater portions of their courses. In their lower reaches, towards Mudgee, both valleys become senile in character, and very extensive fertile alluvial flats have been developed around this town. Since the streams have cut their channels through a great variety of rock-types, the alluvial soil deposited is rich in plant foods. The alluvium of both valleys contains traces of gold and other precious minerals. Diamonds were first recorded from this State in the Cudgegong valley. Other non-metallic minerals include topaz and barytes, while, of the ore minerals, cinnabar, cassiterite and magnetite are the most important. The depth of the alluvium is considerable in many places. Prospecting shafts have been sunk 45 feet through unconsolidated sediment without reaching bedrock.

Igneous Intrusives.

The intrusions are all of the Kanimbla epoch; no synchronous bathyliths occur in the district. Two bosses of granite have been mapped, and a great many intrusions of quartz-porphyry and allied types occur. These are

of various shapes and dimensions. Many of them are irregular in plan, although some are typical sills and dykes. They are intruded into the folded Silurian and Devonian strata and underwent peneplanation during the Carboniferous and the early part of the Permian periods.

The larger of the two granite intrusions is the boss which outcrops to the south of Cudgegong. The Ilford-Cudgegong road crosses the granite, which is seen from the 24- to the 30-mile peg. Outcrops are not very numerous except near the margin of the granite. The granite itself is a rather acid type, and is generally somewhat weathered, due to its long exposure to atmospheric weathering agencies. It is medium-grained, with a general light grey body-colour. At the margins it is locally porphyritic with phenocrysts of pink orthoclase, some of which are 2 inches long and 1 inch broad. In thin sections the following minerals can be distinguished: quartz, orthoclase, plagioclase (acid andesine), biotite, apatite, magnetite, muscovite, zircon, chlorite and cassiterite.

The muscovite and chlorite have been formed from the alteration of the felspars and of biotite. Magnetite is very scarce. Apatite is mostly present as idiomorphic inclusions in the biotite. Cassiterite is an interesting accessory mineral; it is present as small, idiomorphic prisms with a pale yellowish-brown colour.

The Havilah granite boss is smaller, but exposures are more numerous and the rock is fresher. It is a porphyritic variety with phenocrysts of pink orthoclase. Biotite is abundant; and zircon and apatite are accessory minerals. The plagioclase is found to be albite. This granite is therefore a porphyritic biotite type.

These two granite bosses have well-marked contact-metamorphic aureoles. That surrounding the Cudgegong intrusion is wider than might be expected from a comparatively small intrusive mass, being a mile wide in places. It is probable that the granite dips gently away from the ground surface, and would be found at no great distance below the surface over much of the surrounding country.

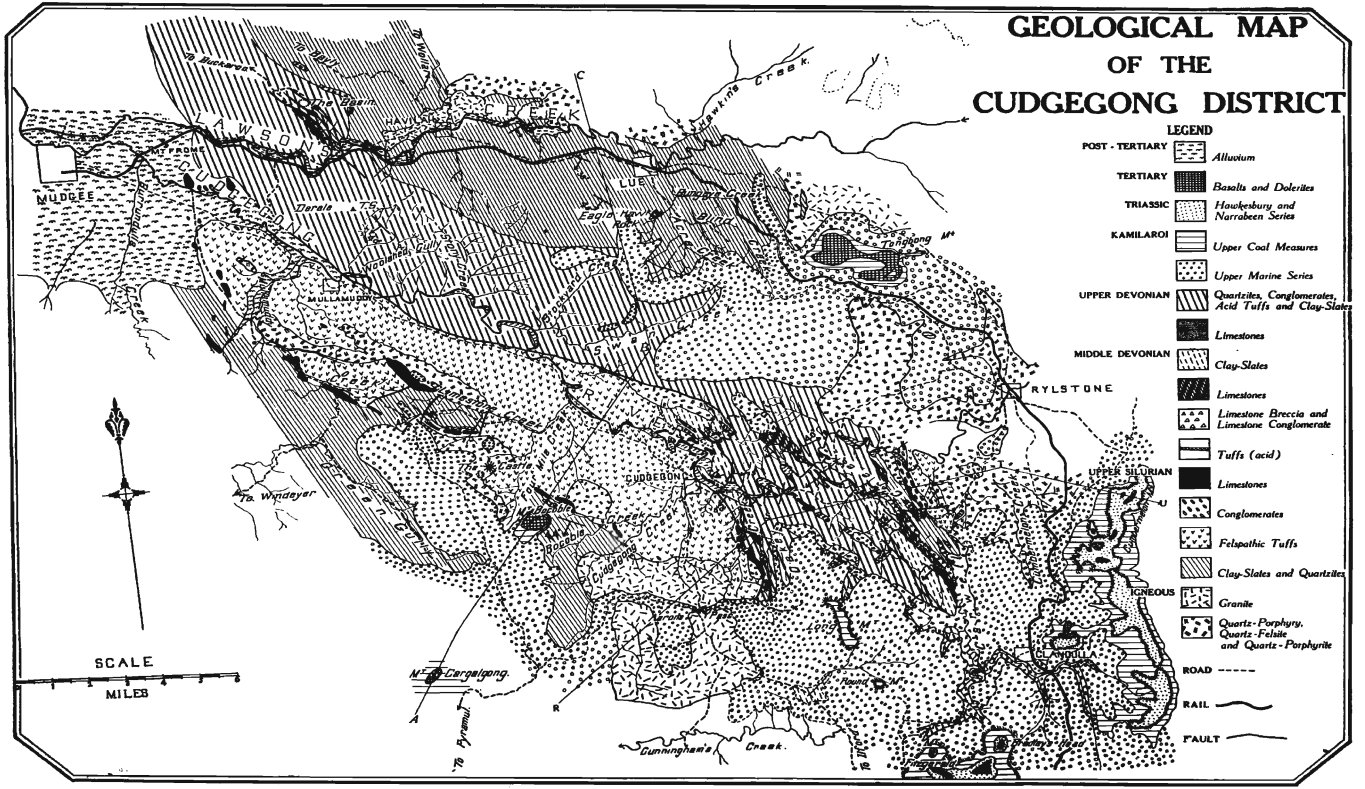
The intrusions of porphyry types are exceedingly numerous throughout the district. They are of varied shapes and of all dimensions. One of the commonest

petrological types is a quartz-porphyry, with a deep purplish-black body colour and numerous phenocrysts of quartz and orthoclase. It is hard, but extremely brittle. It is regularly jointed, the joints giving the appearance of bedding-planes when seen at some little distance. This rock forms the sills which intrude the Upper Devonian series in the Oakey Creek area. Some of the types show a well-developed flow-structure locally. One such type occurs to the north-east of Limestone Creek, in the Parish of Tannabutta, and forms a high ridge between the creek and the Cudgegong-Mudgee road. In several places this rock might be mistaken for a typical rhyolite, but it is a quartz-porphyrite grading into a quartz-felsite. It sometimes has a rather curious greenish-grey body-colour with a somewhat greasy lustre, but most specimens are light coloured and highly siliceous in appearance.

The porphyry which has been dissected by Carwell Creek above the limestone quarries is also a somewhat uncommon type. It has a light green colour, and is not completely massive, but contains some elongated streaks of a dark green cherty type. Phenocrysts of quartz, but no felspar phenocrysts, can be seen. The groundmass is dull green and stony in appearance. In thin section small, corroded phenocrysts of quartz and numerous elongated patches of a fibrous mineral, which may be an amphibole or bleached biotite, are seen. The original felspars have been completely altered, and are not recognizable in the slide. The groundmass is extremely fine-grained and rich in sericite, which forms parallel bands, giving the impression of a flow-structure.

One more igneous type may be mentioned, since it occupies very large areas in parts of the district. It is a quartz-felsite, which intrudes the Silurian formation on the Cudgegong-Rylstone road. Good outcrops occur along the road where it crosses Pors. 13, 12, 51, 52, 55 and 58, Parish of Wells. The small tributary of the Cudgegong River, which flows across Por. 3 in a north-west direction, has carved a vertical bluff about 150 feet high through this resistant rock-type.

This felsite has a dull white body-colour and numerous small, angular inclusions of hæmatite, which forms pseudomorphs after pyrites. Also negative crystals of pyrites are common. The green patches seen in most


GEOLOGICAL MAP
OF THE
CUDGEGONG DISTRICT
LEGEND
POST - TERTIARY
Alluvium
TERTIARY
Basalts and Dolerites
TRIASSIC
Hawkesbury and Narrabeen Series
KAMILAROI
Upper Coal Measures
Upper Marine Series
UPPER DEVONIAN
Quartzites, Conglomerates, Acid Tuffs and Clay-Slates
Limestones
MIDDLE DEVONIAN
Clay-Slates
Limestones
Limestone Breccia and Limestone Conglomerate
Tuffs (acid)
UPPER SILURIAN
Limestones
Conglomerates
Felspathic Tuffs
Clay-Slates and Quartzites
IGNEOUS
Granite
Quartz-Porphyry, Quartz-Felsite and Quartz-Porphyrite
ROAD
RAIL
FAULT
SCALE
MILES
MUDGEE
RYLSTONE
CUDGEGONG
Mt. Cargelgong.
Gunningham's Creek.
Hawkins Creek
Eagle Hawk Creek
Castle Hill Creek
Wiagdon Creek
Cudgegong River
Mullamuddy Creek
To Windeyer
To Pyramul
To Mudgee
To Rylstone
Mt. Tonalong
Mt. Frome
Mt. Buckaroon
Mt. Dangar
Darala
Mullamuddy
Lue
Havilah
Lawson
Cudgegong
Ilford
Clandulla
Round Mt.

specimens are thought to be chloritized pyroxene. The groundmass appears to consist chiefly of fine-grained quartz and some secondary sericitic fibres.

Space does not permit of further descriptions of other Kanimbla intrusive rocks. All the types are acid and hypabyssal in character. The area occupied by these rocks is very considerable, as may be seen by reference to the general map of the district.

This epoch of igneous activity has been responsible for the introduction of several metallic ore-minerals, such as gold, molybdenite and chalcopyrite. The deposits have been worked in various parts of the district, but an account of their occurrence cannot be given here.

Geological History.

In the Silurian Period the sea covered this district. Vigorous volcanic activity produced fragmental material and lava flows; both products accumulated on the sea-floor together with re-sorted volcanic products, which were washed down by streams from the land-surface. The sea-floor underwent slow subsidence, allowing the accumulation of a great thickness of tuffs and lavas. All traces of the Silurian volcanic vents have now been obliterated. Later in Silurian time deposition temporarily ceased, and limestone-making conditions occurred. The Upper Silurian sea was shallow, clear and warm, and small coral reefs existed in it. Some lime was also precipitated by chemical reactions. Towards the end of the Silurian Period the old land surface had been largely worn down, until it had little relief. The old streams could only transport the finest material to the sea, and this deposition of silt continued uninterruptedly for a long time.

No orogenesis took place at the close of this period, but the land-surface may have been uplifted, rejuvenating the streams, which once more transported coarse material to the oceans, fragmentary volcanic material and gravel intermixed.

The waters again became clear, and extensive coral reefs grew upwards from the shallow, subsiding sea-floor. A brief period of vulcanism followed; this gave place to another long interval of quiescence, during which the mature streams deposited mud and finer material not far from the shore-line.

At the close of Middle Devonian time either:

1. Erosion became more vigorous, due to some climatic change or to an uplift of the land surface, or
2. A general uplift of the sea-floor occurred, with an advance of the Devonian shore-line.

As a result much coarser material was deposited conformably on the finer sediments beneath. Deposition of this coarse material, mixed with some volcanic fragmental material, kept pace with subsidence of the sea-floor. The water was often extremely shallow, and the sands were even exposed at intervals. The water was warm and brachiopods dominated the life of these Devonian seas.

The widespread orogenesis of the Kanimbla epoch closed the Devonian Period, and this earth-movement was followed by a very long period of quiescence, in which erosive agents formed an extensive peneplain from the uplifted land-surface. In Upper Marine time the sea encroached upon this peneplain and covered it except for some isolated resistant hills, which had not been reduced to base-level, and remained as islands. Shingle followed by sands and muds was deposited in the Upper Marine sea, which was cold and inhospitable to organic life in this district. Glacial conditions may have prevailed at the beginning of the epoch. At the close of Upper Marine time the sea became excluded from the area by a rise of the sea-floor, and the region was occupied by a shallow, marshy lake, in which decaying vegetation accumulated, the climate being warm and humid. A time of stillstand then occurred, followed by a deepening of the lake. In Triassic time vigorous deposition of coarse sandy material took place in this lake. The region then underwent elevation and very slight tilting.

A long period of erosion followed, and, at the beginning of the Tertiary Era, a peneplain once again existed. In Oligocene time extensive igneous activity occurred, and basalts were outpoured upon this peneplain, and sills of dolerite were injected below the surface. Several periods of uplift and peneplanation followed; finally, at the close of the Tertiary Era, the great epeirogenic Kosciusko uplift took place and the region was raised some 3,000 feet. Since this uplift, denudation has proceeded

uninterruptedly, and has exposed the surface of the old uplifted Carboniferous peneplain.

Summary.

The oldest strata in the district are of Upper Silurian age, but the base of this system has not been found. The Silurian sequence comprises a thick horizon of tuffs and lavas, passing upwards through conglomerates and limestones into slates.

There is no unconformity between the Silurian and the overlying Devonian strata. At Havilah Upper Devonian beds rest conformably on Upper Silurian. At Cudgegong and Carwell Creek a Middle Devonian sequence intervenes.

The Silurian and Devonian strata are intruded by acid plutonic and hypabyssal types of the Kanimbla epoch, and these older Palæozoic rocks are contorted and faulted. A well-developed peneplain was cut out of the older series during the Carboniferous and the early part of the Permian periods. The Upper Marine Series, Upper Coal Measures and Triassic sandstones are almost horizontally bedded, and rest, with a high angular unconformity, on the bevelled, upturned edges of the older, tilted strata. The Triassic rocks are covered by thick basalt flows; thick sills of dolerite have intruded the Kamilaroi strata. Both basalts and dolerites are believed to be of Early Tertiary age. The hills capped by these basic igneous sheets are all of the monadnock type.

Fertile alluvial plains occur along the main river valleys, which are now at a mature stage of their development.

Acknowledgments.

The author is deeply indebted to the officers of the R.A.A.F., who prepared the aerial photographs from which the large-scale map of part of the district has been prepared. He also wishes to record appreciation of the help given by the late W. S. Dun, whose determinations of the fossil fauna were of the greatest value. His sincere thanks are due to Mr. L. L. Waterhouse and Dr. W. R. Browne for their invaluable help and advice, and to all those residents of Cudgegong who helped to make his visits so pleasant. Finally, he is extremely grateful to Mr. and Mrs. White, of Havilah, whose warm hospitality he deeply appreciates.

TESTING A LUMMER-GEHRCKE INTERFEROMETER.

Its Use in a Search for Abnormality in the Relative Abundance of the Isotopes of a Special Sample of Mercury.

By S. C. Baker, M.Sc.

(With Plate IX and one Text-figure.)

(Read before the Royal Society of New South Wales, Dec. 5, 1934.)

The Interferometer.

In the investigation a Hilger Constant Deviation Spectrograph, type D, was used; in this type one arm is extended in order that the Lummer-Gehrcke plate[3] or other interference apparatus may be mounted between the collimator and the prism. The parallel faces of the L.G. plate are horizontal, so that the spectral lines are broken into a system of horizontal lines—the interference pattern.

The ordinary spectrum is viewed through a horizontal slot 2 cm. wide, but only a few fringes of the interference pattern of each line can be seen through it. If the camera be rotated until this slot is vertical then the whole of the vertical interference pattern of one line or two close lines can be seen through it. The prism is rotated to bring the desired line into view. With this arrangement, however, the magnified image of the slit is curved (Plate IX, Fig. 1) because the angle of incidence of the light issuing from the L.G. plate on to the prism varies.[10] Because of this the collimator and camera were interchanged. The light was now dispersed before entering the L.G. plate, that is to say, the light passed from the prism into the L.G. plate and thence to the camera lens, by which it was focussed on the photographic plate ; the fringes were now in a vertical line. This arrangement of the apparatus is illustrated by the diagram. A collimator slit which could be opened to a width of 2·5 mm. was used, giving a wide interference pattern which was easier to photometer.

An interference pattern could be seen with almost any adjustment of the plate, but it was found necessary, if the fringe system was to be measured, to have the central plane of the camera lens perpendicular to the L.G. plate and its principal axis directed along the central plane of the latter, otherwise the relation (7) below did not hold. This arrangement rendered the fringes from the top and bottom of the L.G. plate symmetrical about a centre which was now easily found, there being no central ray from an L.G. plate.

Before using this instrument for new work it was desirable to test it and find out to what extent the actual performance

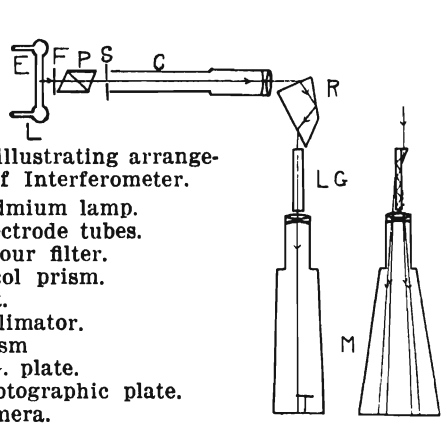


Diagram illustrating arrangement of Interferometer.

L = Cadmium lamp.
E = Electrode tubes.
F = Colour filter.
P = Nicol prism.
S = Slit.
C = Collimator.
R = Prism
LG = L.G. plate.
T = Photographic plate.
M = Camera.

of the plate coincided with what it was theoretically capable of doing. Much depends on the plane-parallelism of the faces, the slightest trace of dust affecting the sharpness of the fringes to an extent easily seen with the eye. Again, the plate had to be placed in position some time before taking a photograph, because the warmth and moisture from the hand distorted the fringes. Many early workers found hyperfine lines in their photographs which were really "ghost" lines due to irregularities in the plate. The cadmium red line was used to test the plate.

The Cadmium Lamp.

The type of lamp used by Michelson[6] was troublesome. Lummer and Gehrcke have described a quartz-cadmium

amalgam lamp[4] in which the amalgam has to be heated with a blow-lamp to melt it, being then run like an ordinary mercury vapour lamp. A similar lamp was made from Pyrex glass, tungsten wire being used as electrode. (The special glass made for sealing tungsten wire into Pyrex[2] was unprocurable.) When the wire was cleaned, by repeatedly warming and then plunging it in a sodium nitrite solution, and finally polishing with the thumbnail (to avoid bubbles in the seal), the Pyrex did not adhere to the glass very well, and a slightly leaky joint resulted; but it was found that if, after cleaning, the wire was held in a broad oxygen-coal gas flame until it became biscuit-coloured or purple, a good seal could be obtained if the wire was sealed in quickly.

The lamp was of the H type in shape; the diameter of the legs was 1·7 cm., and their length 10 cm.; the diameter of the cross-piece was 0·8 cm., and its length 10 cm. The large size of the legs compared with the cross-piece allowed the latter to carry an intense discharge without melting. Connection to the amalgam within the lamp was made through two tungsten-to-Pyrex joints which were put in two short arms at the bottom of each leg of the lamp so that they would not get very hot; it was also convenient to make the tungsten seals separately in these tubes before joining to the lamp. Outer connection was made through mercury caps over the ends of the tungsten joints. These side-tubes were placed at right angles to the plane of the H, so that when the tube was tilted to strike the lamp, the amalgam remained in contact with the tungsten electrodes.

The amalgam contained 10 gm. of cadmium to 100 gm. of mercury, and was liquid at the room-temperature, so that no preliminary heating was necessary. When evacuated and sealed off, this lamp carried 5 amperes D.C. when 100 volts were applied. It was struck by tilting, like a Cooper-Hewitt mercury vapour lamp. When first lighted only the mercury lines appeared, but after it had been running a minute or more the cadmium lines appeared. To the eye the cadmium red line appeared quite as strong as the mercury green line, though the photographic plate is far more sensitive to the latter. A small inductance placed in the circuit had the effect of steadying the current. The strongest lines in the visible spectrum of this lamp were:

The cadmium lines: 644, 509, 480, 468 mμ.
The mercury lines: 599, 577, 546, 436 mμ.

The Relative Intensity of the Interference Fringes.

The cadmium-amalgam lamp was placed so that the cross-piece of H was in the line of sight of the spectrograph collimator. A nicol prism, placed before the collimator slit, with its long axis vertical, polarised the light and made the fringes very much sharper. A red colour-filter was placed before the slit to eliminate a continuous background of the pattern. There were no lenses between the lamp and collimator slit. Ilford Special Rapid Panchromatic Plates were used. The arrangement of the apparatus is illustrated by the sketch, and a photograph of the cadmium red line fringes for a two-minute exposure is shown in Plate IX, Fig. 2.

The relative intensities of the fringes were measured by taking on the same plate as the fringes a set of photographs of a continuous spectrum, each for a different collimator slit width but same time of exposure. (An incandescent lamp was placed one metre from the slit, all interference attachments of the spectrograph having been removed.) From the measurements of the Moll recording microphotometer records of these spectra at the wavelength of the cadmium red line, a curve of relative blackness against slit-width was constructed (on logarithmic paper, for convenience). The relative blackness of each fringe having been worked out from its photometer curve, the slit-width corresponding to this blackness was read off the relative blackness slit-width curve. The ratio of these slit-widths gives the relative intensity of the fringes. This is the method worked out by Ornstein.[8] In Table II, columns 6 and 7, are the slit-widths found in the above manner for the first five fringes of the cadmium red line from two different plates. In the next two columns these intensities are given as a percentage of the fifth fringe. Thus the values given in columns 8 and 9 are the relative intensities of the fringes in the interference pattern (based on the fifth fringe 100, for convenience), and are to be compared with the theoretical values in column 5, the derivation of which is given below.

The Theoretical Intensity Distribution.

The intensity of a ray transmitted through a medium, after multiple reflection, is given by Airy's formula:

$$I=\frac{(1-\alpha^2)^2}{(1-\alpha^2)^2+4\alpha^2\sin^2\frac{\delta}{2}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where α is the coefficient of reflection and $\frac{\delta}{2}$ the phase-difference between an emergent and a reflected ray, the intensity of the emergent ray being taken as unity. In practice the number of reflections is not infinite, as equation (1) assumes; if the number of reflections be N, then that equation becomes:

$$I=\left\{(1-\alpha^{2N})^2+4\alpha^{2N}\sin^2\left(N\frac{\delta}{2}\right)\right\}\frac{(1-\alpha^2)^2}{(1-\alpha^2)^2+4\alpha^2\sin^2\frac{\delta}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This correction makes the curve for I as a function of $\frac{\delta}{2}$ less sharp, both diminishing the maximum intensity and broadening the curve and introducing small secondary maxima.

The coefficient of reflection α is given by the Fresnel formula:

$$\alpha=\frac{\sin(r-i)}{\sin(r+i)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

the polariser being so oriented that this was the appropriate one; i is the angle of emergence from and r the angle of incidence within the plate; i is calculated by measuring the distance between the same order fringe on either side of the interference pattern with a travelling microscope. Half this length is the distance of that fringe from the centre of the pattern. In Table I the values x_1, x_2, *etc.*, are the distances of the fringes p, p−1, *etc.*, from the centre. The ratio of these distances to the focal length of the camera lens (53·5 cm.) is the tangent of the grazing angle (φ) of emergence from the plate (the values of φ are given in Table II), i is the complement of φ, and r is found from the relation

$$\sin i=\mu \sin r \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where μ is the refractive index of the glass. The values of α can now be calculated from equation (3), and are given in Table II. φ and the length of the plate (13 cm.) being known, the number of reflections (N) within the plate is 17 for all fringes of the red line.

The maximum value of I is at $\frac{\delta}{2}=0$, hence

$$I_{(max.)}=(1-\alpha^{2N})^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The values of $I_{(max.)}$ for the first five fringes are given in the fourth column of Table II. In the next column they

are expressed as a percentage of the fifth, taken as 100, and are to be compared with the observed values in columns 8 and 9. The agreement is within the experimental error of 5%.

TABLE I.

Distances of Fringes from Centre.		Difference $(x_n^2 - x_{n-1}^2)$
$x_1 = 0{\cdot}678$ cm.	$x_1^2 = 0{\cdot}461$ cm.	
$x_2 = 0{\cdot}945$,,	$x_2^2 = 0{\cdot}911$,,	0·450
$x_3 = 1{\cdot}165$,,	$x_3^2 = 1{\cdot}360$,,	0·449
$x_4 = 1{\cdot}347$,,	$x_4^2 = 1{\cdot}811$,,	0·451
$x_5 = 1{\cdot}501$,,	$x_5^2 = 2{\cdot}260$,,	0·449
$x_6 = 1{\cdot}645$,,	$x_6^2 = 2{\cdot}710$,,	0·450

TABLE II.—*Observed and Calculated Intensities.*

Order of Fringe.	φ	α	Calculated Intensity.		Observed Intensity.		% of 5th.	
			I(max.)	% of 5th.	(i)	(ii)	(i)	(ii)
p	0° 40′	0·974	0·348	53	0·120	0·175	50·7	50·0
p–1	1° 1′	0·969	0·430	65	0·157	0·232	66·3	66·3
p–2	1° 15′	0·964	0·510	77	0·179	0·271	75·5	77·5
p–3	1° 16′	0·959	0·586	89	0·202	0·316	85·2	90·3
p–4	1° 36′	0·952	0·660	100	0·237	0·350	100	100
1	2	3	4	5	6	7	8	9

A further check on the reliability of the L.G. plate is obtained from a consideration of the values of x in Table I. The retardation q between two successive transmitted rays from the plate of thickness t and refractive index μ is given by

$$q = 2t\sqrt{(\mu^2 - \sin^2 i)} = p_n \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where p_n is the order. If $2x_1$, $2x_2 \cdots 2x_n$ be the distances between the centres of the fringes taken in pairs, one being on either side of the centre of the photograph, and b the focal length of the camera lens, we have:

$$\lambda = \frac{t}{b^2} \cdot \frac{x_n^2 - x_{w1}^2}{\sqrt{\mu^2 - 1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

so that the quantity $(x_n^2 - x_{n-1}^2)$ should be constant over the whole fringe pattern, since φ was actually a small angle,

as was assumed in deducing this formula. The values of x_1^2, x_2^2 . . . x_n^2 are given in Table I; it will be seen that they are in arithmetical progression, and that the quantities $(x_n^2 - x_{n-1}^2)$ are constant over the range measured; this was not the case if the L.G. plate was not carefully adjusted as previously described.

The Half-Value Width.

The width of the photometer-curve at half the maximum intensity is the experimental half-value width. The height of the curve corresponding to half intensity must be read off the relative blackness slit-width curve. The half-value widths of the fringes p, p−1, *etc.*, are given in Table III, together with the distances between the adjacent fringes. In order to compare with theory the half-value width of p−1 is expressed as a ratio to the distance between the centres of p and p−2, that of p−2 to the distance between p−1 and p−3, and so on. The first fringe has only one adjacent fringe, and so it is not given in the table. The measurements for three different plates are given; the third was obtained immediately after the cadmium lamp had been lighted and when it was carrying a larger current than for the other two, but with a stream of cold water playing on it. In this case the ratios are consistently less than the others, which shows that the width of the lines was influenced by the treatment of the lamp.

The theoretical half-value width ratios were obtained by a graphical method from the curve: I against $\frac{\delta}{2}$ [equation (2)]. They are given in Table III, and in the fourth column are expressed as a ratio to 2π, the distance between the two adjacent maxima, for comparison with the

Table III.—*Calculated and Observed Half-Value Widths.*

Order of Fringe.	α	$\frac{\delta}{2}$	$\frac{\delta/2}{2\pi}$	Half-value Widths in Cm.			Distance between Adjacent Maxima in Cm.			Ratio.		
				(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
p–1 ..	0·969	10° 9′	0·0303	0·18	0·18	0·16	3·29	3·32	3·31	0·055	0·054	0·048
p–2 ..	0·964	11° 1′	0·0308	0·17	0·17	0·15	2·91	2·89	2·88	0·058	0·059	0·052
p–3 ..	0·959	11° 3′	0·0314	0·14	0·15	0·13	2·53	2·55	2·54	0·056	0·059	0·051
p–4 ..	0·952	11° 5′	0·0319	0·12	0·12	0·11	2·00	2·02	2·02	0·060	0·060	0·055

experimental ratios. Although the experimental maxima are not evenly spaced, it can be shown that the comparison is a fair one by plotting the curve ordinal number of fringe against its distance from a fixed zero.

When it is remembered that the sharpness of the photometer curves is limited by the width of the photometer thermopile slit,[13] that the cadmium lamp was a very hot one, on which cooling produced a measurable effect, and that there may be spreading of the lines in the photography, it must be considered satisfactory that the experimental half-value width ratios are less than double the theoretical values.

The Mercury Green Line.

An approximate expression for the resolving power of an L.G. plate is given[11] by

$$\text{R.p.} = \frac{l}{\lambda}\left(\mu^2 - 1 - \lambda\mu\frac{\delta\mu}{\delta\lambda}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

where l is the length of the plate, and μ its refractive index at the wavelength λ. $\frac{\delta\mu}{\delta\lambda}$ was found to be -520 from a dispersion curve, l being 13 cm. and μ 1·5107 at λ 5461, the resolving power is 334×10^3, according to which the smallest change in wavelength which could be observed at this wavelength is 0·016 Å.

The mercury green line came out strongly in the cadmium amalgam lamp. Its interference pattern consisted of a set of wide mainline fringes, between each consecutive pair of which were four fainter satellites (Plate IX, Fig. 3). The wavelengths of the latter were measured by a method due to McLennan,[5] which identified them as the

positive satellite No. 1 (0·079 Å)
positive satellite No. 2 (0·120 Å)
negative satellite No. 4 (−0·107 Å)
negative satellite No. 3 (−0·075 Å)

moving outwards from the centre. These wavelengths differ from those of many modern workers, but are almost identical with those given by McLennan.[5] It is known, of course, that there are other satellites of this line, and that the mainline consists of four close lines[7]; in all the green line has been resolved into twelve hyperfine lines. There may have been some overlapping with this particular L.G. plate.

Isotopes and Hyperfine Structure.

There have been many attempts to explain the hyperfine structure of spectral lines in terms of the isotopes of the emitting element. Schüler and Keyston[9] have found it possible so to control the temperature and pressure of a mercury arc lamp that the relative intensities of the hyperfine lines are proportional to the relative abundance of the isotopes as given by Aston.[1] They assume the mainline to be the sum of the effects of the even isotopes, the satellites being assigned to the odd isotope 199 or 201. Thus positive satellite No. 1 of the green line would be due to isotope 199, positive No. 2 and negative Nos. 3 and 4 to isotope 201. In the case of the green line some of the satellites due to the odd isotopes coincide with the mainline, which makes its analysis more difficult.

A few grammes of mercury of Australian origin were available for investigation; owing to the nature of the origin of this mercury it is possible that the proportions of the isotopes differ from those of ordinary mercury. If such is the case it might be possible to detect a difference in the relative intensity of the hyperfine lines and hence discover an irregularity in the isotopes of this mercury. Even if the lamps were not adjusted to give Schüler's "theoretical intensity distribution" it might be possible to detect a difference. A search for such a different intensity distribution was made.

There was not sufficient Australian mercury available to make an arc lamp. The final method of excitation used was the high frequency external electrode discharge obtained from a Hartley oscillator operating at a wavelength of 50 metres. The oscillator was coupled to a coil which was in parallel with a large condenser and the discharge tube. External electrodes of tin-foil were used. The tube was 40 cm. long and 4 cm. in diameter. (In a long tube the weaker satellites are relatively strengthened[12] and it does not become so hot.) The pressure was maintained at 0·1 mm. during an exposure. The same tube was used for both types of mercury. Three-hour exposures were necessary to obtain the fainter satellites.

The relative intensities of the satellites were measured in the same way as described above for the cadmium red line fringes. A collimator slit width-relative blackness curve was constructed for each plate. From this a slit-width corresponding to its relative blackness was read off for each satellite. The slit-widths thus obtained from

three different plates are given in Table IV under the heading " Intensity ". They are expressed as a percentage of the first positive satellite in the last three columns for comparison. Similar measurements are given from two plates of the Australian mercury. It will be seen that there is no consistent difference between the relative intensities for the two types of mercury, the difference between the mean percentage for any satellite being less than 2%; hence there is no difference between the two samples of mercury within 2%, so far as these satellites are concerned.

TABLE IV.

Order.	Satellite.	Intensity.			Percentage.		
Ordinary Mercury.							
p	+1	0·375	0·250	0·310	100	100	100
	+2	0·197	0·132	0·165	52·6	52·8	53·1
	−4	0·202	0·135	0·169	53·9	54·0	54·6
	−3	0·324	0·215	0·260	86·4	86·0	84·0
p–1	+1	0·480	0·350	0·411	100	100	100
	+2	0·270	0·179	0·216	56·3	51·2	52·5
	−4	0·278	0·186	0·222	57·9	53·2	54·0
	−3	0·407	0·290	0·342	84·7	82·8	83·2
Australian Mercury.							
p	+1	0·238	0·347		100	100	
	+2	0·130	0·195		54·7	56·2	
	−4	0·133	0·200		55·8	57·6	
	−3	0·207	0·290		87·0	83·6	
p–1	+1	0·350	0·460		100	100	
	+2	0·183	0·248		52·3	54·0	
	−4	0·185	0·253		52·8	55·0	
	−3	0·286	0·370		81·8	80·5	

The first positive satellite and mainline were next compared; since the intensity of the latter was much greater than that of the former, an intensity reducer was placed before the wide collimator slit. This reducer was a photographic plate having several panels, each of different blackness, on it. The appropriate panel was placed half across the slit so as to divide it vertically into a lighter and darker half, so that now each fringe of the interference pattern was also divided into a lighter and a darker half. In the lighter half the blackness of the mainline was comparable with the blackness of the satellite in the lighter half (see Plate IX, Fig. 4).

In Table V the slit-widths for this satellite (unreduced) and the mainline (reduced) read off a slit width-relative blackness curve, are given under the heading " Intensity "

without regard to the reduction factor of the reducer; it was unnecessary to make this correction, as a difference only between the two types of mercury was sought in the first instance. The intensity of the satellite is expressed as a percentage of the mainline under the heading "Percentage". The first two sets of readings are for ordinary, the third for Australian mercury; again there is not a consistent difference.

TABLE V.

Order.	Satellite.	Intensity.			Percentage.		
p	Mainline.	0·144	0·185	0·177	100	100	100
	+1	0·110	0·137	0·132	76·5	74·1	74·5
p-1	Mainline.	0·163	0·199	0·188	100	100	100
	+1	0·124	0·146	0·143	76·3	73·5	76·1

On the spectroscopic evidence obtained by this study of the green line it is concluded that there is no difference to within 2% between the two types of mercury. In Schüler's theory this would indicate that the relative abundance of the isotopes of the Australian mercury is normal to within the same limit.

SUMMARY.

An account is given of the use of the cadmium red line to test the Lummer-Gehrcke plate. No ghost lines were found. The cadmium lamp is described. The relative intensities and half-value widths of the interference fringes, measured by a photographic method, are compared with the theoretical values calculated from data of the apparatus. In the former case the agreement is within the experimental error (5%), in the latter the actual half-value widths are nearly twice the theoretical; this discrepancy is accounted for by the experimental limitations. The resolving power of the L.G. plate is found to be 334×10^3, the mercury green line being resolved into five components.

A comparison of the relative intensities of the satellites of the green line emitted by the two samples of mercury—one Australian, the other foreign—when excited by a high-frequency discharge, is made. There is no difference to within 2%. This is taken as an indication that there is no difference in the relative abundance of the isotopes of the two samples.

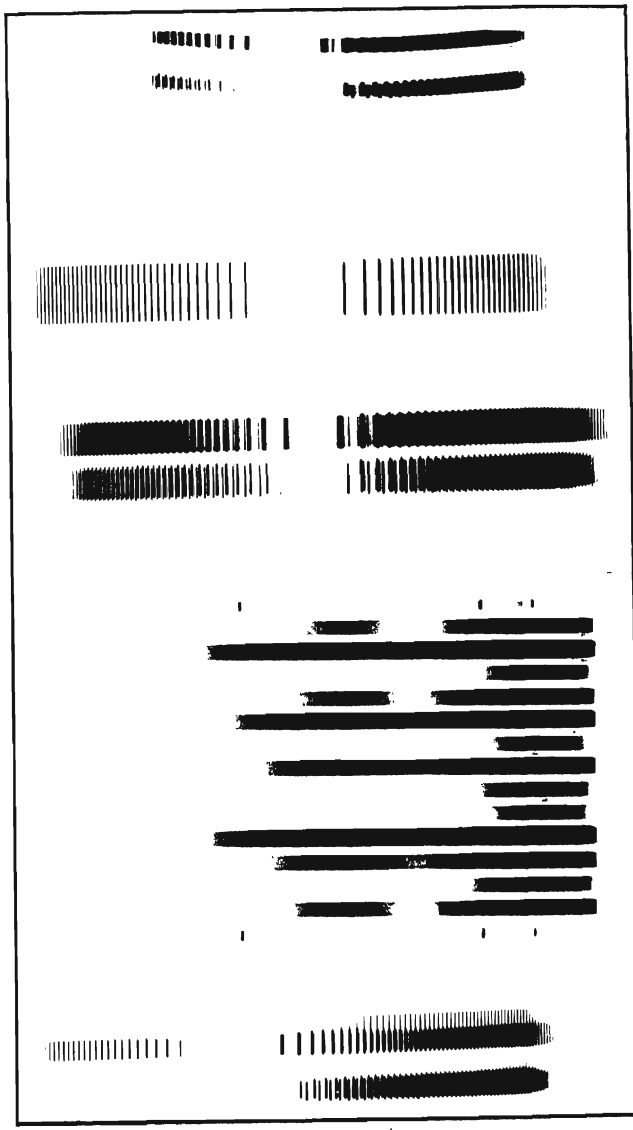


Fig. 1

Fig. 2

Fig. 3

Fig. 4

In conclusion the author wishes to express to Professor O. U. Vonwiller his sincere appreciation of ever-ready advice and constant encouragement throughout this investigation, and to acknowledge his indebtedness to the Cancer Research Committee of the University of Sydney for the use of their microphotometer.

This work was carried out in the Physics Laboratory of the University of Sydney.

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Explanation of Plate.

Fig. 1.—The mercury green (upper) and yellow (lower) interference patterns showing curving.

Fig. 2.—The cadmium red line pattern.

Fig. 3.—The mercury green and yellow lines showing satellites. (In the original the satellites were stronger relative to the mainline than reproduced here.)

Fig. 4.—A full plate with density marks and the mercury green and yellow with reducer across.

NOTES ON WATTLE BARKS.

PART IV.—THE TANNIN CONTENT OF A VARIETY OF *ACACIA MOLLISSIMA* WILLD.

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(With Plate X.)

(*Read before the Royal Society of New South Wales, Dec. 5, 1934.*)

INTRODUCTION.

About twelve years ago an investigation was commenced to determine the tannin content of various wattle barks by modern analytical methods, attention being directed particularly to the pinnate-leaved species of the *Acacia decurrens* group.

It has generally been accepted, both in Australia and abroad, that the Black Wattle, *A. mollissima* Willd., yields one of the most valuable tan-barks, and a number of samples were collected and analysed.[1]

It was soon found that certain trees occurring in the Bargo district, about sixty miles south of Sydney, were not typical *A. mollissima* and could readily be separated on taxonomic grounds from that species. As the investigation progressed other localities were found, many being widely separated, in which this form occurs. In the Bargo district the variety is associated with *A. decurrens* and *A. mollissima*; in the Goulburn district with *A. decurrens* only; at Cockwhy Creek, a few miles north of Bateman's Bay, with *A. mollissima* and *A. irrorata* (*pauciglandulosa*), and in certain other areas with *A. irrorata* only. In its flowering period it is similar to *A. mollissima*, and the pods

[1] Welch, Coombs and McGlynn: Notes on Wattle Barks, Part III. THIS JOURNAL, 1931, *65*, 207-231.

also take some twelve months to mature. The trees are similar in general appearance, but the leaves of the variety are typically shorter, more glabrous, and paler in colour, and the pinnules are considerably coarser than those of the species. The variety has been found growing on sandstone, shale and limestone soils (though it appears to reach its maximum distribution on the last formation), and from sea-level to an elevation of a little over 2,000 feet. Whilst the distribution has been found to be chiefly in areas south of Sydney, this is possibly because these have been examined more thoroughly, and the range will no doubt be found to be more extensive.

Since the tannin content is reasonably high and there are undoubted affinities between this form and *A. mollissima* it is considered that no useful purpose would be served by increasing the multiplicity of species, and it is therefore proposed to call it *Acacia mollissima* var. *A.*

ACACIA MOLLISSIMA VAR. *A.*

Description.

A medium-sized tree up to 15 m. in height and 45 cm. diameter. Bark usually smooth, brown in colour, rossed in old or diseased trees.

Leaves, branchlets and pods tomentose when young, becoming glabrous, or almost so; young shoots golden yellow; branchlets occasionally slightly glaucous. Leaves up to 150 mm. in length. Pinnæ usually opposite, broad linear, usually 5 to 10 mm. in width, but in luxuriant growth up to 15 mm. in width; 3 to 11 pairs; length usually not exceeding 60 mm. Glands 1 to 4 between each pair of pinnæ, variable in size and shape; secondary glands rarely present at the base of the pinnæ.

Pinnules usually crowded, rarely overlapping, and often spaced, the gap as much as twice the width of the pinnule, length 4–10 mm.; 0·5–1·2 mm. in width; larger pinnules frequently strongly curved, a character not found in *A. mollissima.*

Flowers 5-merous, 20 to 40 in head; calyx shortly lobed, ciliate; petals glabrous, usually in racemes or occasionally in small panicles. Pods usually under 5 mm. in width and 120 mm. in length, sometimes constricted between seeds. Flowering period December and January, pods taking twelve months to ripen.

Distribution.

Narrabeen, Whale Beach, Kingswood, Bass Hill, Burragorang, Bargo, Belanglo, Windellama, Gurrundah, Towrang, Bungonia, Marulan, Cockwhy Creek.

Tannin Analyses.

Moisture 11·5%.

Bark Thickness.	Tannin.	Non-Tannin.	Height.	Girth.	Locality.
(mm.)			(m.)	(cm.)	
4·6–4·8	51·5	9·5	7	46	Bargo.
5·0–5·3	45·4	9·9	8	65	Bargo.
5·5–5·8	45·1	8·6	7	50	Bargo.
4·7–5·3	43·7	10·4	7	58	Gurrundah.
5·2–5·4	40·7	7·2	6	135	Gurrundah.
4·5	40·4	9·5	7	52	Marulan.
4·2–5·0	39·8	9·2	8	45	Bargo.
4·5–5·0	39·6	7·3	7	58	Gurrundah.
3·8–4·2	38·8	10·0	7	41	Bargo.
3·6–5·5	37·5	7·5	7	47	Bungonia.
3·2–3·9	34·0	12·1	8	40	Belanglo.
3·4–3·5	32·5	6·8	8	107	Windellama.
4·8–5·2	32·1	8·3	6	47	Windellama.
4·7–6·6	28·0	6·9	7	47	Bungonia.
3·4–5·5	26·5	7·5	6	40	Towrang.
3·7–6·0	23·6	8·2	4	35	Windellama.
4·0	22·9	6·9	5	37	Towrang.

The ratio of tannin to non-tannins is 4·8 in the case of *A. mollissima*,[2] whereas in variety *A* the ratio is 4·4. Whilst some of the lowest tannin values are lower than any yet recorded by us for *A. mollissima*, it will be noted that they are from rather small trees, although the bark is not abnormally thin. The results show that the variety may yield a very useful bark, similar in colour and general properties to that of *A. mollissima*, but the wide variation in the results indicates that caution should be exercised in stripping this form until the tannin value of average samples from the locality has been proved.

Explanation of Plate.

Acacia mollissima var. *A*. For comparison a typical leaf of *A. mollissima* is included. Each square is 25 × 25 mm.

[2] Welch, Coombs and McGlynn, *loc. cit.*



Acacia mollissima var. A.

THE LONGITUDINAL VARIATION OF TIMBER DURING SEASONING.

PART II.

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(*Read before the Royal Society of New South Wales, Dec. 5, 1934.*)

In 1932 the results of a number of measurements of the longitudinal variation of timber during seasoning were published and it was noted that whilst most timbers showed a normal shrinkage, others actually increased in length.[1] It was found that in the same species both shrinkage and swelling could occur.

Since the date of that publication further measurements have been made, and it is of interest to compare the density of the woods with the length-variation during seasoning. Koehler[2] has recorded that Redwood (*Sequoia sempervirens*) of low density, which consisted almost entirely of early wood, shrank appreciably, whereas wood of the same species with a high density and consisting of late wood shrank very little and even elongated.

A comparison is made between the movement from the green condition to the fibre-saturation point (approximately 30% moisture), from fibre-saturation point to the air-dry condition (13%), and from the green to the air-dry condition. The discrepancies between the total number of test pieces in each case is due to the fact that in some test pieces the original moisture content of the "green" wood was too close to the fibre-saturation point, and these were not included in the "green" class. Again, in a number of the

* Acknowledgment is made to Messrs. F. B. Shambler and J. Hodges of the Museum staff, who assisted very materially during the investigation, and to the Forestry Commissioners of N.S.W., who kindly arranged for their field-staff to obtain the necessary wood samples.

[1] M. B. Welch: The Longitudinal Variation of Timber During Seasoning. THIS JOURNAL, 1932, *66*, 492-7. Experimental details are given, and need not be repeated.

[2] A. Koehler: Longitudinal Shrinkage of Wood. *Trans. Amer. Soc. Mech. Eng.*, 1931, *53*, WO1, 53, 2.

earlier measurements insufficient records were made to enable the length to be determined accurately at the fibre-saturation point; these are included, however, in the "green to air-dry" class.

The comparison of density and movement is given in Table I.

TABLE I.—*Comparison of density of wood and percentage of samples for each density range which showed shrinkage or swelling, or was stationary during seasoning.*

Wt. per Cub. Ft. in Lbs.	Green to f.s.p.				f.s.p. to air-dry.				Green to air-dry.			
	Sh.	Sw.	S.	No.	Sh.	Sw.	S.	No.	Sh.	Sw.	S.	No.
	%	%	%		%	%	%		%	%	%	
20–30	25	75	0	4	100	0	0	4	67	33	0	6
30–40	31	50	19	26	94	0	6	32	78	12	10	51
40–50	44	25	31	61	66	22	12	64	61	32	7	66
50–60	34	39	27	130	73	15	12	131	66	25	9	142
60–70	26	33	41	39	44	36	20	39	47	40	3	47
70–80	12	25	63	8	0	100	0	11	0	87	13	8
Total ..	34	36	30	268	67	21	12	281	63	28	9	320

f.s.p. = fibre saturation-point.
Sh. = Shrinkage.
Sw. = Swelling.
S. = Stationary.
No. = Number of samples.

NOTE.—All densities are based on air-dry volume and weight (approximately 13% moisture.

For the sake of convenience the densities have been grouped in classes of 10 lbs., although unfortunately only a few timbers were available in the lowest and highest classes, and the results may not be representative.

An examination of the movement from a green condition to the fibre-saturation point indicates that for all woods approximately one-third shrank, one-third swelled and one-third remained stationary. Woods with a density of 20 to 40 lbs. showed least tendency to remain stationary and the greatest tendency to swelling, whereas from 60 to 80 lbs. there was the greatest tendency to remain stationary. With one exception, namely the 40-50 lbs. class, the number of samples which swelled was greater than the number which shrank.

From the fibre saturation-point to an air-dry condition 67% of all samples shrank, 21% swelled, and only 12% remained stationary. In the 20-40 lbs. classes none of the samples swelled, whereas in the 70-80 lbs. class all swelled.

With the exception of the 50-60 lbs. class there is a progressive decrease in the number of samples which shrank and an increase in the number which swelled, as the density increases.

During seasoning from a green to an air-dry condition, swelling increased, in general, with density, with the exception of the 20-30 lbs. and the 50-60 lbs. classes. In the former only six samples were measured, and two of these, of the same species, swelled ; it is obvious that many more woods of this density should be examined. Although only eight samples were measured in the 70-80 lbs. class, none showed shrinkage.

The results suggest that from the green condition to the fibre saturation-point the tendency is for the wood to swell or remain stationary (66%), whilst from the fibre saturation-point to the air-dry condition the tendency is for shrinkage to occur (67%). It should be understood that the swelling from green to f.s.p. was in many instances minute, amounting to only 0·01%, the mean for all timbers being 0·023%. The maximum swelling was 0·10% in a species of *Sterculia* with a density bringing it into the lowest class. Whilst lack of space obviously forbids any attempt to give the individual behaviour of each timber, it is of interest to follow the movement of one piece of *Sterculia* with an initial moisture content of 109% ; at 50% moisture the swelling amounted to 0·12%, at the f.s.p. it was reduced to 0·10%, and in the remaining stages of drying the swelling was successively 0·06%, 0·08% and, at the air-dry state, 0·07%. Several woods with densities varying from 30 to 60 lbs. per cu. ft. showed a swelling of about 0·04%, but in the densest group the mean swelling was only 0·015% from green to f.s.p.

Irregular movement was also observed in a number of other woods. Thus in cases where shrinkage occurred from green to f.s.p. greater shrinkage or actually swelling took place at an intermediate point ; again, timber which swelled from green to f.s.p. occasionally showed a greater swelling or even shrinkage before the f.s.p. was attained. Similar variations were noted during seasoning from the f.s.p. to the air-dry condition. Out of a total of 192 samples, 22% showed a tendency to swell and 6% shrank at an intermediate point between green and f.s.p., and 6% swelled and 33% shrank at some point between the f.s.p. and the air-dry condition. In other words, longitudinal

movement during seasoning is not always a function of the moisture content of the wood.

It has already been mentioned that 34% of the timber samples shrank from green to the f.s.p., and, as with swelling, many of the readings were minute (0·01%), the actual mean for all timbers being 0·042%. Certain of the eucalypt hardwoods which collapsed showed shrinkage movements of as much as 0·22%, although in every case collapse was not associated with excessive shrinkage. The actual maximum, minimum and mean percentages of longitudinal movement for the different density classes during seasoning from a green to an air-dry condition are shown in Table II.

TABLE II.—*Percentages of maximum, minimum and mean longitudinal shrinkage or swelling for each density class during seasoning from a green to an air-dry condition.*

Wt. per Cub. Ft. in Lbs.	Shrinkage %.				Swelling %.			
	Max.	Min.	Mean.	No.	Max.	Min.	Mean.	No.
20–30	0·13	0·01	0·063	4	0·07	0·05	0·060	2
30–40	0·14	0·01	0·067	40	0·06	0·01	0·028	6
40–50	0·31	0·01	0·090	40	0·12	0·01	0·036	21
50–60	0·42	0·01	0·093	94	0·10	0·01	0·031	35
60–70	0·27	0·01	0·046	22	0·13	0·01	0·038	19
70–80	—	—	—	—	0·07	0·01	0·041	7

It is obvious that in the classes of 30-60 lbs. density the mean percentage of shrinkage is much higher than the mean swelling percentage; the discrepancy in the lowest density class can be discounted, since too few samples were measured. In the 60-70 lbs. class the difference between the shrinkage and swelling figures is comparatively small, and in the highest density class absence of shrinkage prevents any comparison being made. Although it is evident that many more observations are required before any generalisation can be made, on the actual material examined the greatest mean shrinkage occurred in the 40-60 lbs. classes, and the greatest mean swelling in the 70-80 lbs. class, the apparent anomaly of the two light-weight *Sterculia* samples being again neglected.

In some samples of the same species the maximum movement occurred during seasoning to the f.s.p., the subsequent variation in length being negligible; in other samples of the same species the movement was chiefly after the f.s.p. had been reached. In some species all the

samples were consistent in their behaviour, but no doubt anomalies would have been found if a larger range of material had been examined.

The maximum shrinkages for each density class were much higher than the maximum swelling, and in general high shrinkages amounting to as much as 0·42% were associated with collapse.

Whilst longitudinal shrinkage can be explained by the theory that water is removed from the interstices between the spirally arranged longitudinal fibrils of the cell walls, longitudinal swelling cannot be accounted for in this way. In Part I the view was expressed that possibly internal stresses produced during seasoning are responsible for the elongation. A piece of apparatus was designed whereby it was possible to measure the movement of wood in three planes, and small blocks of green and air-seasoned Blue Gum, *Eucalyptus saligna* (approx. 13% moisture) measuring 4 in. × 4 in. × 2 in. were subjected to compression at right angles to the grain. The wood was free to expand in a plane at right angles to the direction of the application of the load. It was found that elongation occurred within the proportional limit, the ratio of longitudinal extension to compression varying from 1 : 8 for green timber to 1 : 5 for air-dry timber, at the proportional limit. The lateral expansion was approximately equal to the compression. Beyond the proportional limit there was a tendency for the amount of longitudinal extension to decrease in green timber.

That severe internal stresses may be produced in timber during seasoning is well known, and it seems obvious that, due to surface drying, if the moisture gradient is steep, a compressive stress may occur within the green timber before the fibre saturation-point is reached. This stress apparently may result in an elongation, or may possibly counterbalance any shrinkage so that the length remains stationary, since it was found that out of 268 samples 66% did not shrink during the transition from a green condition to the f.s.p. After the fibre saturation-point is passed, timbers of medium and low density (20-60 lbs.) showed a greater tendency to shrink, possibly due to a redistribution or even reversal of the internal stresses, whereas the denser woods, together with a smaller proportion of the woods of medium density, continued to elongate ; in such cases the internal compressive stress evidently persists. Since the test samples are being used in connection with other

investigations it has not been practicable to cut them up to determine whether case-compression is present.

Several samples of air-seasoned Tallowwood and Blackbutt measuring 10 in. × 4 in. × 1 in. were accurately measured, and planed on both sides until the thickness was reduced to ½ in. It was thought that possibly internal stresses which might be present would be released, and so longitudinal movement would occur. Although the results were negative, the experiment might be repeated on wood showing severe internal stresses.

It was thought that by increasing the rate of drying internal compressive stresses would be increased, resulting in greater elongation. However, a comparison between green Tallowwood air-dried and dried at 140° F. did not give conclusive results.

Summary.

An examination was made of the longitudinal variation of some 300 samples of a large number of different woods in relation to their densities. It was found that whilst 66% of the total samples swelled or remained stationary during drying from a green condition to the fibre saturation-point, only 33% behaved similarly from the fibre saturation-point to an air-dry condition. In general, woods of low density showed the greatest tendency to swell, and heavy woods were more prone to remain stationary during the initial drying period. Below the fibre saturation-point light timbers showed the greatest liability to shrinkage, and heavy woods were inclined to remain stationary or to swell. In a number of timbers the longitudinal movements were irregular, expansion and contraction occurring several times during seasoning, an indication that length is not always a function of the moisture content of the wood.

It is suggested that severe internal compressive stresses resulting from the shrinkage of the outer part of the wood may be responsible for the elongation or longitudinal swelling during seasoning.

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

May 2nd, 1934.

The Annual Meeting, being the five hundred and twenty-fourth General Monthly Meeting of the Society, was held in the Hall of Science House, Gloucester and Essex Streets, Sydney, at 7.45 p.m.

Mr. R. W. Challinor, President, was in the chair. Forty-two members were present. The minutes of the general monthly meeting of 6th December, 1933, were read and confirmed.

The President announced the deaths of David Carment, who had been elected a member in 1891, served as Honorary Treasurer between 1901 and 1912, was Vice-President in 1913 and 1914, and was a member of Council from 1915 to 1919 ; and of David Thomas, who was elected a member in 1923.

The certificates of two candidates for admission as ordinary members were read for the first time, and Professor Walter Howchin was elected an honorary member of the Society.

The following gentlemen were elected officers and members of Council for the coming year :

President :

R. J. NOBLE, M.Sc., Ph.D., B.Sc.Agr.

Vice-Presidents :

Prof. O. U. VONWILLER, B.Sc., F.Inst.P.
EDWIN CHEEL.
Sir EDGEWORTH DAVID, K.B.E., C.M.G., D.S.O., F.R.S.
R. W. CHALLINOR, F.I.C., F.C.S.

Hon. Treasurer :

H. G. CHAPMAN, M.D.

Hon. Secretaries :

Major EDGAR H. BOOTH, M.C., B.Sc., F.Inst.P.
Assist.-Prof. W. R. BROWNE, D.Sc.

Members of Council:

C. ANDERSON, M.A., D.Sc.
E. C. ANDREWS, B.A., F.G.S.
Prof. L. A. COTTON, M.A., D.Sc.
Prof. C. E. FAWSITT, D.Sc., Ph.D.
JAMES NANGLE, O.B.E., F.R.A.S.
A. R. PENFOLD, F.A.C.I., F.C.S.
Assoc.-Prof. H. PRIESTLEY, M.D., Ch.M.
Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.
W. L. WATERHOUSE, M.C., D.Sc.Agr., D.I.C.
M. B. WELCH, B.Sc., A.I.C.

The Annual Financial Statement for the year ending 31st March, 1934, was submitted to members and, on the formal motion of Major Booth, seconded by Mr. Penfold, was unanimously adopted. The Honorary Treasurer was absent.

ROYAL SOCIETY OF NEW SOUTH WALES.

Statement of Receipts and Payments for the Year ended 31st March, 1934.

GENERAL ACCOUNT.

RECEIPTS.

	£ s. d.	£ s. d.
To Balance—31st March, 1933		84 7 2
„ Revenue—		
Subscriptions	400 1 0	
Sundry Receipts	117 18 6	
Government Subsidy	200 0 0	
Interest—Government Bonds and Stock and Loan	282 14 6	
Donation	10 0 0	
		1,010 14 0
„ Royal Society's Fund—Interest added		270 5 0
„ Science House		730 0 0
„ Repayment—Institution of Engineers ..		1,000 0 0
„ Building Investment Loan Fund ..		269 2 6
		£3,364 8 8

PAYMENTS.

	£ s. d.	£ s. d.
By Administrative Expenses—		
Salaries and Wages—		
Office Salaries and Accountancy Fees	344 15 0	
Caretaker (Cleaning)	24 0 0	
		368 15 0
Printing, Stationery, Advertising and Stamps—		
Stamps and Telegrams	44 19 10	
Office Sundries and Stationery ..	2 10 6	
Advertising	10 13 0	
Printing	174 16 7	
		232 19 11

	£ s. d.	£ s. d.
Rents, Rates, Taxes and Services—		
Rent	159 1 4	
Electric Light and Gas	14 5 11	
Insurance	20 12 1	
Telephone	15 6 6	
		209 5 10
Printing and Publishing Society's Volume—		
Printing, etc.		135 6 10
Library—		
Bookbinding		100 9 6
Sundry Expenses—		
Repairs	1 5 11	
Bank Charges	0 5 6	
Sundries	24 11 5	
		26 2 10
„ Interest—		
Royal Society's Fund	270 5 0	
Loans	78 9 0	
		348 14 0
„ Bonds		737 10 0
„ Liversidge Bequest		37 10 0
„ Clarke Memorial Fund		0 11 6
„ Balance—31st March, 1934—		
Cash on Hand	8 8 1	
Union Bank of Australia	1,158 15 2	
		1,167 3 3
		£3,364 8 8

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D.,
Hon. Treasurer.

(Sgd.) W. PERCIVAL MINELL, F.C.A. (Aust.),
Auditor.

Queensland National Bank Chambers,
27 Hunter Street,
Sydney, 28th April, 1934.

BALANCE SHEET AS AT 31st MARCH, 1934.

LIABILITIES.

	£ s. d.	£ s. d.
Investment Fund—		
Clarke Memorial Fund	1,543 16 1	
Walter Burfitt Prize Fund	615 10 9	
Investment Fund	4,271 8 1	
Liversidge Bequest	557 15 4	
		6,988 10 3
On Loan		1,898 0 1
Sundry Liabilities		43 5 5
Accumulated Fund		29,943 10 5
		£38,873 6 2

ASSETS.

	£	s.	d.	£	s.	d.
Cash—						
Union Bank of Australia Ltd. ..	1,158	15	2			
Cash in Hand	8	8	1			
				1,167	3	3
Government Bonds and Stock—						
Nominal Value—£7,200				7,073	18	6
Science House Management Committee—						
Payments to date				14,533	18	4
Sundry Debtors—						
Institution of Engineers	3,283	6	8			
Sundries	21	14	10			
For Subscriptions in Arrears ..	864	11	0			
				4,169	12	6
Library—						
Balance—31st March, 1933	9,746	14	3			
Add Expenditure during year ..	100	9	6			
				9,847	3	9
Office Furniture				1,741	9	10
Pictures				180	0	0
Microscopes				120	0	0
Lantern				40	0	0
				£38,873	6	2

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D.,
Hon. Treasurer.

(Sgd.) W. PERCIVAL MINELL, F.C.A. (Aust.),
Auditor.

Queensland National Bank Chambers,
27 Hunter Street,
Sydney, 28th April, 1934.

INVESTMENT FUND.

Statement of Receipts and Payments for the Year ended 31st March, 1934.

RECEIPTS.

Dr.	£	s.	d.	£	s.	d.
To Balance—31st March, 1933				6,756	6	9
„ Interest—						
Clarke Memorial Fund	59	7	11			
Walter Burfitt Prize Fund	23	13	6			
Liversidge Bequest	22	17	11			
Investment Fund	164	5	8			
				270	5	0
				£7,026	11	9

PAYMENTS.

Cr.	£	s.	d.
By Expenditure—			
Clarke Memorial Fund	0	11	6
Liversidge Bequest	37	10	0
„ Balance—31st March, 1934	6,988	10	3
	£7,026	11	9

On the motion of the President, seconded by Mr. Andrews, Messrs. W. P. Minell & Co. were duly elected Auditors for the coming year. Professor Stewart asked for information with regard to the payment of auditors, and was informed that they received £15 15s. per annum. Mr. Penfold recommended that it be a suggestion to the incoming Council that the auditors should be changed every four years, and Mr. Finnemore suggested that the Council should consider the practicability of publishing on the General Account and Balance Sheet the corresponding figures for the previous year.

It was recommended by Professor Stewart and supported by Mr. Finnemore that the Council should consider the form of the certificate to be provided by the auditors, as the statement provided was inadequate.

The Annual Report of the Council was read and, on the motion of Mr. Challinor, seconded by Mr. Sussmilch, was adopted.

Report of the Council for the Year 1933-34.
(1st May to 24th April.)

We regret to report that we have lost by death three ordinary members. By resignation we have lost twelve members and, in addition, two members have been struck off the roll for non-payment of subscriptions. On the other hand, seventeen ordinary members have been elected. To-day (24th April, 1934) the roll of members stands at 288.

During the Society's year there have been eight general monthly meetings and fourteen council meetings.

Twenty papers were read at the general monthly meetings and covered a wide range of subjects.

Lecturettes were given at the general monthly meetings in August, September and November by Dr. R. J. Noble and Messrs. F. R. Morrison and A. S. Le Souef respectively. At the October meeting addresses on the past activities of the Medical Section of the Royal Society of New South Wales were given by Drs. Cecil Purser and W. F. Burfitt.

For the afternoon of Friday, 14th July, 1933, a reception was arranged conjointly with the Australian National Research Council and the Royal Society of New South Wales to enable members to meet Dr. Kimura, Director of the Misusawa Observatory, Japan. Dr. Kimura addressed the members present.

Popular Science Lectures.—Four popular science lectures were given, namely :

July 20 : " Aborigines of the Australian Desert ", by Rev. A. P. Elkin, M.A., Ph.D.
August 17 : " Useful Products of the Australian Bush ", by A. R. Penfold, F.A.C.I., F.C.S.
September 21 : " The Age of the Earth ", by G. D. Osborne, D.Sc.
October 19 : " The Effects of Radium upon Cancers ", by H. G. Chapman, M.D., B.S.

Second Liversidge Research Lecture.—Under the terms of the Liversidge Bequest the second Liversidge Research Lecture was delivered before the Royal Society at Science House, Sydney, on Wednesday, 8th November, 1933, by Professor W. J. Young, D.Sc., M.Sc., of the University of Melbourne, entitled : " The Function of Phosphates in Fermentations of Sugars ".

Clarke Memorial Medal.—At its meeting on Wednesday, 28th March, 1934, the Council awarded the Clarke Memorial Medal to Edward Sydney Simpson, D.Sc., B.E., F.A.C.I., of South Perth, Western Australia.

Annual Dinner.—The Annual Dinner will be held on Thursday, 26th April, 1934, at 6.45 p.m., at the University Club, Phillip Street, Sydney.

Member Honoured by His Majesty the King.—The honour of knighthood was conferred on Mr. F. D. McMaster.

Science House.—During the year additional tenants have been obtained for Science House, which is reported to be in good repair and condition ; additional ventilation on the ground floor has been provided.

Institution of Engineers, Australia.—Some difficulty having arisen in connection with the interpretation of the agreement between the Institution of Engineers, Australia, and the Royal Society of New South Wales in respect to the moneys lent by the Royal Society to enable the Institution of Engineers to take a one-third interest in Science House, Sydney, a new agreement has been prepared, based on an interest charge at the rate of 5% per annum on all moneys on loan to the former body, initiating with the first loan made (1930), and taking into account moneys

already returned to the Society as principal. This new agreement has been ratified by the council of the Institution of Engineers, Australia, and by the Royal Society of New South Wales.

It may be noted that the payments by the Institution of Engineers, Australia, to the Royal Society of New South Wales in connection with the loan had already returned almost 5% per annum.

Resignation of Honorary Secretary.—At the Council meeting of 14th March, 1934, the resignation of Mr. C. A. Sussmilch as one of the Honorary Secretaries was received with regret. Mr. Sussmilch had been an Honorary Secretary since 1929, but now found that the burden of his other public duties compelled him to seek relief.

By order of the Council, an appreciation of the valuable services rendered by Mr. Sussmilch to the Society was put on record in the Minutes of the Council.

Major Edgar H. Booth was elected unopposed to fill the temporary vacancy thus caused, and Mr. Sussmilch was then elected to fill the new vacancy on the Council.

The Library.—The donations to the library have been as follows : 71 volumes, 1,326 parts, 97 reports and 1 calendar.

During the year the catalogue of periodical literature has been brought up to date, and with it has been incorporated a location index, so that reference to any periodical in the library is now possible for users. It is still necessary to introduce satisfactory cross-references, but this will be done when the catalogue is transcribed on to new cards.

Binding has been proceeded with up to the limit of the finance available, and in this connection acknowledgment is made of a gift of £10 from Dr. H. G. Chapman for this purpose.

All duplicates have now been removed from the shelves, and will be used as opportunity offers as exchanges for volumes which are missing from our sets. A number of missing parts and volumes have been received following on requests to the various publishers.

The Library Committee has considered all outstanding requests from other societies and institutions for exchanges. A number of new exchanges have been sanctioned, and others discontinued for various reasons. A few additional important periodicals are now being purchased.

The non-periodical literature in the library is now in the course of classification and arrangement.

A gift of eighty volumes was received from the Pharmaceutical Society of New South Wales early in the year.

On behalf of the Council,
R. W. CHALLINOR,
President.

The President announced that the following popular science lectures would be delivered during the session:

July 19: "Television", by Mr. E. T. Fisk.
August 16: "Old Coins and Some Ancient Men of Science", by G. H. Abbott, B.A., M.B., Ch.M.
September 20: "Tick Paralysis in Men and Animals", by I. Clunies Ross, D.V.Sc.
October 18: "Infra-Red Spectroscopy", by Professor O. U. Vonwiller, B.Sc., F.Inst.P.

The following donations were received: 776 parts, 42 volumes, 45 reports and 1 calendar.

The President, Mr. R. W. Challinor, then delivered his address.

Mr. Challinor, the outgoing President, then installed Dr. R. J. Noble as President for the ensuing year, and the latter briefly returned thanks. On the motion of Professor Earl a hearty vote of thanks was accorded to the retiring President, both for his valuable address, and for his services during the year. Mr. Challinor briefly acknowledged the compliment.

June 6th, 1934.

The five hundred and twenty-fifth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Dr. R. J. Noble, President, was in the chair. Fifty-two members were present. The minutes of the general monthly and annual meeting of 2nd May, 1934, were read and confirmed.

The President reported the deaths of Frederick Henry Moore, who had been a member of the Society since 1879; Dr. Henry George Chapman, a member since 1909; and Richard Ford Jenkins, who had been a member since 1917.

The following donations were laid upon the table: volumes, 5; parts, 153; reports, 14; reprint, 1.

The certificates of three candidates for admission as ordinary members were read, one for the first, and two

for the second time. The following gentlemen were duly elected ordinary members of the Society: Francis Devere Kelly and George Arnot Mort.

The Council communicated the information that Mr. Penfold had been elected as Honorary Treasurer until the next annual general meeting of the Society.

The President then briefly announced the position arising out of the sudden death of Dr. H. G. Chapman, the late Honorary Treasurer, and asked Major Booth, Honorary Secretary, to read to the meeting the report submitted by him on behalf of the Council. In the report the information was made available that the Balance Sheet adopted at the Annual General Meeting had not been signed and released by the auditors, and that Dr. Chapman had permitted the Balance Sheet to be presented to the Annual General Meeting as a properly audited statement, knowing both previously and subsequently that it had not been signed by the auditors.

The action of the Council to obviate possibilities of misappropriation of funds in the future was also set out in the report.

Major Booth then formally moved that the motion adopting the Balance Sheet of 31st March, 1934, passed at the Annual General Meeting of 2nd May, 1934, be rescinded.

This motion was seconded by Sir Edgeworth David.

Mr. Ollé, speaking to the motion, suggested that the Council should consider the appointment of an honorary assistant-treasurer. Dr. Harker asked for information as to whether the bonds of the Royal Society had been sighted in 1932 because, if such were the case, they would then be able to believe that all was well until a year ago, and they knew that Dr. Chapman had been a sick man during this last year.

Mr. Finnemore suggested that the Council should consider the formation of a finance committee. Dr. Wiesener suggested that it would be preferable to keep the liquid assets of the Society in inscribed stock in future, rather than in bearer bonds.

Mr. Mellor desired to know if the bonds represented the only loss from the assets of the Society. Mr. Stephen endorsed the suggestion that liquid assets should be in inscribed stock, because the possession of bearer bonds gave opportunities for a double presentation on behalf of different societies.

Dr. Harker was informed that the bonds had been sighted at the 1932 balance, and Mr. Mellor that the bonds represented the only loss from the assets of the Society. The other gentlemen speaking to the motion were informed that the whole matter was under review by the Council, and that their suggestions would be attended to.

The motion was carried unanimously.

Mr. Ollé congratulated the Council on its activities on the Society's behalf, and offered them his sympathy in their unpleasant task. He begged to thank them for what they had done for the benefit of the members.

Professor Stewart also spoke to the subject and asked that the services of Major Booth should be specially noted in this connection.

Mr. Penfold then presented, and moved the adoption of, a duly audited Balance Sheet as at 25th May, 1934. Mr. Cheel seconded the adoption.

Mr. Finnemore asked whether the Council was satisfied with the present form of the Auditors' certificate. He was informed that the Council was not satisfied, and was considering the form of certificate to be used in future.

Dr. Wiesener commented on the large amount, included as an asset, representing subscriptions in arrears, and suggested the inclusion of a separate account for doubtful subscriptions. Mr. Penfold replied, stating that the matter was being attended to, and that he hoped that the next balance sheet would be in a better form. Professor Cotton asked whether the £1,190 Subscriptions in Arrears included subscriptions for the current year which had just commenced. On being informed that such was the case, he asked that members should bear in mind that that represented a very considerable sum, as most members did not pay their subscriptions during the first month of a new financial year.

Sir Henry Barraclough spoke as Chairman of the Executive of the Institution of Engineers, Australia, and offered his sympathy to the Royal Society on behalf of the Institution of Engineers, Australia. He appreciated the difficult task that the Council had had, and congratulated them on the way they had met the situation.

Dr. Anderson, speaking on behalf of the Linnean Society, as its immediate past president, expressed the sympathy of that Society towards the Royal Society of New South Wales.

The President then thanked Sir Henry Barraclough and Dr. Anderson for what they had said, and asked them to convey to the Institution of Engineers, Australia, and to the Linnean Society, respectively, the thanks of the Royal Society for their sympathy at the present time.

The new Balance Sheet, as at 25th May, 1934, was adopted unanimously.

ROYAL SOCIETY OF NEW SOUTH WALES.

BALANCE SHEET AS AT 25th MAY, 1934.

LIABILITIES.

	£ s. d.	£ s. d.
Investment Fund—		
Clarke Memorial Fund	1,543 4 7	
Walter Burfitt Prize Fund	615 10 9	
Investment Fund	4,271 8 1	
Liversidge Bequest	557 15 4	
		6,987 18 9
On Loan—		
Australian National Research Council	815 12 7	
C. A. Sussmilch	50 0 0	
H. G. Chapman	30 7 6	
		896 0 1
Sundry Liabilities—		
As per list attached		206 3 7
Accumulated Fund..		27,058 4 1
		£35,148 6 6

ASSETS.

	£ s. d.	£ s. d.
Cash—		
Union Bank of Australia Ltd. ..	229 3 11	
Petty Cash on Hand	4 5 0	
Cash on Hand (Unbanked Receipt)..	2 2 0	
		235 10 11
Government Bonds and Stock—Nominal Value		3,940 0 0
Science House Management Committee—		
Payments to date		14,533 18 4
Sundry Debtors—		
Institution of Engineers	3,283 6 8	
Sundries, as per list attached ..	16 0 6	
For Subscriptions in arrears ..	1,190 1 0	
		4,489 8 2
Library—		
Balance—31st March, 1934	9,847 3 9	
Add Expenditure during period ..	20 15 6	
		9,867 19 3

	£	s.	d.
Office Furniture	1,741	9	10
Pictures	180	0	0
Microscopes	120	0	0
Lantern	40	0	0
	£35,148	6	6

Compiled from the Books and Accounts of the Royal Society of New South Wales and certified to be in accordance therewith, subject to the non-inclusion of accrued Interest on Liabilities and Assets.

(Sgd.) W. PERCIVAL MINELL, F.C.A. (Aust.),
Auditor.

Queensland National Bank Chambers,
27 Hunter Street,
Sydney, 29th May, 1934.

ROYAL SOCIETY OF NEW SOUTH WALES.

SUNDRY DEBTORS—25th MAY, 1934.

	£	s.	d.	£	s.	d.
Shoalhaven Co-op. Milk and Ice Co. Ltd. ..				0	15	10
Reprints—						
Technological Museum	10	6	9			
David Nutt	0	7	10			
Faxon & Co.	0	15	8			
Stevens & Brown	0	7	10			
Oregon State Agricultural College ..	0	10	6			
Stechert & Co.	0	15	9			
Dawson & Sons	0	7	10			
Wheldon & Wesley	2	8	11			
				16	1	1
				£16	16	11
Less Credit Balance—Dawson & Sons..				0	16	5
				£16	0	6

SUNDRY CREDITORS—25th MAY, 1934.

	£	s.	d.
Australasian Medical Publishing Co., Ltd.	199	8	8
Periodicals	6	14	11
	£206	3	7

The following paper was read :

" The Identity of Darwinol with *d*-Myrtenol ", by A. R. Penfold, F.A.C.I., G. R. Ramage, M.Sc., Ph.D., and J. L. Simonsen, D.Sc., F.I.C., F.R.S.

In thanking Mr. Penfold for the paper which he had presented, the President commented on the fact that it was the sixty-fourth paper presented to the Society by him, either individually or in collaboration with others.

The following exhibits were shown:

Specimens and cultures of *Polyporus mylittæ*, the so-called "Black-fellows' Bread", by Dr. R. J. Noble.

The solubility in water of the saponin from the poisonous plant *Sarcostemma australe*, by Professor J. C. Earl.

July 4th, 1934.

The five hundred and twenty-sixth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Dr. R. J. Noble, President, was in the chair. Thirty-one members and five visitors were present. The minutes of the preceding meeting were read and confirmed.

The President announced that Dr. W. H. Love, B.Sc., Ph.D., had been awarded a special prize in the Garton Prize Essay Competition by the British Empire Cancer Campaign, and offered the Society's congratulations to Dr. Love.

The certificates of three candidates for admission as ordinary members were read, two for the first and one for the second time. The following gentleman was duly elected an ordinary member of the Society: Stanley Charles Baker.

The following donations were laid upon the table: parts, 131; volumes, 15; reports, 4; and reprints, 2.

The President then introduced the speakers for the evening: Mr. Max Henry, M.R.C.V.S., B.V.Sc., Dr. Ida A. Brown, D.Sc., and Mr. M. S. Benjamin, D.I.C., A.A.C.I., who discussed "The Relation Between Diseases in Livestock, Geological Formations and Soil Composition".

Dr. G. H. Briggs, B.Sc., Ph.D., F.Inst.P., delivered a short talk on "New Units of Matter and New Atoms". This was the first of a series to be given from time to time, under a general heading of "Short Talks on Current Topics".

The following exhibits were shown:

A brick from the Great Wall of China, by A. E. Stephen, F.C.S.

A copy of a work entitled "Toadstools and Mushrooms and other larger Fungi of South Australia", by J. B. Cleland, exhibited by E. Cheel.

August 1st, 1934.

The five hundred and twenty-seventh General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Dr. R. J. Noble, President, was in the chair. Twenty-five members and five visitors were present. The minutes of the preceding meeting were read and confirmed.

The President announced that Mr. E. C. Andrews had been elected an honorary member of the Royal Society of New Zealand, and offered him the Society's congratulations.

The certificates of five candidates for admission as ordinary members of the Society were read, three for the first and two for the second time. The following gentlemen were duly elected ordinary members of the Society: Herbert Richard Harrington and H. L. Carruthers.

The following donations were received: parts, 336; reprints, 14; reports, 12; and volumes, 15.

The following papers were read:

"Some Tetra-covalent Compounds of Platinum with Tertiary Arsines", by G. J. Burrows, B.Sc., and R. H. Parker, M.Sc.
"An X-ray Study of Opals", by F. P. Dwyer, M.Sc., and D. P. Mellor, M.Sc.

A short talk on "Chemiluminescence" was delivered by D. P. Mellor, M.Sc., and a Blinker Moisture Meter was exhibited by M. B. Welch, M.Sc., A.I.C.

September 5th, 1934.

The five hundred and twenty-eighth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. R. W. Challinor, Vice-President, was in the chair. Thirty members and thirty-five visitors were present. The minutes of the preceding meeting were read and confirmed.

The Chairman announced the death of Sir T. W. Edgeworth David, K.B.E., C.M.G., D.S.O., M.A., D.Sc., F.R.S., F.G.S., who was elected a member in 1886, and who had been President in 1895 and 1910. The members and visitors standing, a resolution carried by the Council, as follows, was read:

"The members of the Council of the Royal Society of New South Wales record their profound sorrow at the death of their beloved colleague, Sir T. W. Edgeworth David, K.B.E., C.M.G., D.S.O., F.R.S., Vice-President. The Council records its appreciation of his innumerable services rendered to the Society over a period of forty-eight years of membership, including many terms as a member of Council and two terms as President.

"His contributions to the cause of scientific research, both directly through his own labours and indirectly through the inspiration of his work and personality, have been incalculable.

By his colleagues he was justly held in honour for his pre-eminence in the scientific field, and no less for his tact, ripe wisdom, sound judgment and scrupulous fairness; and to all he endeared himself by his unfailing courtesy and kindly consideration, and by the spirit of selflessness and service that marked his whole life.

"Among the scientific workers of Australia his name will ever be had in grateful and affectionate remembrance."

On the motion of the Chairman, the meeting endorsed and adopted the resolution.

The certificates of four candidates for admission as ordinary members of the Society were read, one for the first and three for the second time. The following gentlemen were duly elected ordinary members of the Society: Francis P. J. Dwyer, William Dale Leech, and John G. Tibbett.

The following donations were received: parts, 278; reports, 2; and volumes, 12.

The following papers were read:

"The Volumetric Micro-Determination of Ortho-Nitrophenols with Methylene Blue", by A. Bolliger, Ph.D.

"The Action of Nitrous Acid on Dimethylaniline. Part III", by J. C. Earl, D.Sc., Ph.D., and A. W. Mackney, B.Sc.

The following exhibits were shown:

An ornamental chimera in Cavendish banana, by H. J. Hynes, B.Sc.Agr., on behalf of Dr. R. J. Noble.

Some examples of broaching Bakelite moulds, by E. G. Bishop.

Professor Cotton gave a short talk on the life and work of the late Sir Edgeworth David, illustrating his remarks by lantern slides, and covering the activities of our late Vice-President, in brief, up to the period of the Great European War. Professor Browne continued from that stage, referring very briefly, owing to the lateness of the hour, to the Professor's activities during the war and subsequently.

October 3rd, 1934.

The five hundred and twenty-ninth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Dr. R. J. Noble, President, was in the chair. Thirty members and four visitors were present. The minutes of the preceding meeting were read and confirmed.

The certificate of one candidate for admission as an ordinary member of the Society was read for the second time. The following gentleman was duly elected an ordinary member of the Society: William Lyall Hayes.

The following donations were received: parts, 242: volumes, 13; reports, 4; and reprints, 16.

Notice of Motion.—The Honorary Secretary gave notice of motion for the next general meeting, with regard to proposed alterations to the Rules.

The following papers were read:

"A Theory of Association", by L. W. O. Martin, B.Sc.
"Some Hydroxy Salts of Secondary and Tertiary Arsines", by G. J. Burrows, B.Sc.
"The Essential Oils of the Genus Calythrix. Part II. *Calythrix tetragona* (Labillardière), variety 'A'", by A. R. Penfold, F.A.C.I., J. L. Simonsen, D.Sc., F.R.S., and G. R. Ramage, M.Sc., Ph.D.
"The Physiography of the Middle North Coast District of N.S.W.", by A. H. Voisey, B.Sc.

A short talk on "Some Aspects of the Biological Control of Insects and Weeds" was given by N. S. Noble, M.Sc., B.Sc.Agr., D.I.C.

November 7th, 1934.

The five hundred and thirtieth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Dr. R. J. Noble, President, was in the chair. Twenty-five members were present. The minutes of the preceding meeting were read and confirmed.

The certificates of four candidates for admission as ordinary members of the Society were read for the first time.

The following donations were received: parts, 225; reports, 57; volumes, 14; reprints, 7; calendar, 1.

Motions from the last Meeting.—Major Edgar Booth moved that certain alterations to the Rules of the Society, submitted in printed form to members, as follows, be approved:

PROPOSED ALTERATIONS TO RULES:

Rule V.—Fourth paragraph, page xii, the words "or of new members" to be deleted.
Rule VII.—The words "of Management" in the first line to be deleted and a similar deletion to be made of the same words wherever they occur in other Rules.
Rule VIII.—Second paragraph, page xiii, the sentence "The date of birth is to be stated in the case of candidates claiming a reduced subscription as being under twenty-eight years of age," to be added after the word "candidate," and in the

fifth paragraph the words "and immediately after such reading" in the last line to be deleted and the following clause to be added: "No ballot for the election of new members shall be valid unless twenty members at least shall record their votes."

Rule IX.—A third paragraph to be added as follows: "Members who have paid the annual subscription for forty years or more may be elected by the Council to life membership without payment of further subscriptions."

Rule X.—The first annual subscription shall accompany the prescribed form of admission.

Rule XI.—To be amended to read as follows:—"Composition fees shall be treated as capital and invested."

Rule XIV.—Second sentence to be deleted.

Rule XV.—Everything following the word "year" in the third line to be deleted.

Rule XVI.—In the fourth line the words "paid his first annual subscription and have" to be deleted.

Rule XVII.—The last paragraph to be deleted.

Rule XXI.—To be amended to read as follows:—"The Honorary Members of the Society shall be persons of eminent scientific attainments or persons who have been eminent benefactors to this or some other of the Australian States or distinguished patrons or promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and approved by the Society at a General Meeting. Honorary Members shall be exempted from payment of fees and contributions; they may attend the meetings of the Society and they shall be furnished with copies of the publications of the Society but they shall have no right to hold office, to vote or otherwise take part in the business of the Society.

"The number of Honorary Members shall not at any time exceed twenty and not more than two Honorary Members shall be elected in any one year."

Rule XXII.—To be entirely deleted.

Rule XXIII.—"8 p.m." in the second line to be altered to "7.45 p.m." and "eight", in the third line, to be altered to "nine".

Rule XXIV—Section 12 to read "Papers to be read and discussed".
Section 13 to read "Exhibits".
Section 14 to read "Lecturettes".

Rule XXXII.—Section 4 to be eliminated.
Section 5, the word "Transactions" to be altered to "Journal and Proceedings".
Section 6, the words "arrangement and" in the first line to be deleted.
Section 10, the word "cause" to be altered to "give" and the words "to be given" to be deleted.
Section 11 to be deleted.
Section 12, all words after "Council Meetings" to be deleted.

Rule XXXIII.—The word "Contributions" in the heading of this Rule to be altered to "Communications".

Rules XXXIII, XXXIV and XXXV to be redrafted as follows :

Rule XXXIII.—" Papers offered by members for communication to the Society must be sent, for submission to the Council, to one of the Honorary Secretaries at least fourteen days before the date of the General Monthly Meeting at which the paper is proposed to be read. It shall be the duty of the Council to decide which of the papers offered are suitable for communication to the Society, and/or for publication in the Society's Journal, and to arrange for the promulgation and discussion of those papers accepted at an ordinary monthly meeting of the Society."

Rule XXXIV.—" The original copy of every paper offered for communication to the Society, together with its illustrations, drawings, etc., shall become the property of the Society. Papers which have been offered to the Society, but not accepted for publication in the Journal, shall be deposited in the Society's archives, so as to meet any claim with regard to priority."

Rule XXXV.—" The author of a paper which has been accepted for communication and publication shall not be at liberty, save by permission of the Council, to publish such paper elsewhere until the paper or an abstract thereof shall have appeared in the Journal, or other publication of the Society."

Rule XXXVII.—To be redrafted as follows :—" At the beginning of each year the Council may invite applications for grants of Funds for scientific purposes."

Rule XXXVIII.—To read " Such grants of money shall be for one year only but if not expended at the end of the year may at the discretion of the Council be revoted."

Rule XXXIX.—To be amended as follows :—The words " an Ordinary " in the second line to be altered to " the Annual ".

Rule XL.—The present heading to disappear and the Rule to be amended as follows :—" The Council shall have control over the disbursements of the funds and the management of the property of the Society."

Rule XLI.—The last two lines to be amended as follows :—" Sections or Committees may be established in such branches of pure and applied sciences as the Council may decide."

Rule XLII.—The words " of four " in the third line to be altered to " if deemed necessary ".

Rule XLIX.—Under the heading " The Library " the following new Rule to be added :—

" The Council shall appoint an Honorary Librarian who shall be responsible for the care and arrangement of the books, maps, etc., and who shall present an Annual Report to the Council as to the condition of the Library."

Rule L.—Existing Rule XLIX is now Rule L.

Rule LI.—Rule L, which becomes Rule LI, to be amended as follows :—

The word " Annual " in the third line to be altered to " Ordinary " and the last two words " be present " to be altered to " vote ".

This was seconded by Mr. Penfold and carried unanimously.

Major Booth then moved, and Mr. Ollé seconded, that two additional alterations to the Rules, as follows, be approved :

Rule XXXII.—The heading of this Rule to be altered to " Duties of Honorary Secretaries and Treasurer ".

To be added after the last paragraph :—" The duties of the Honorary Treasurer shall be to receive all moneys paid to the Society, and to pay such moneys immediately into the current account of the Society ; to make such disbursements as shall duly be authorised by warrant from the Council ; to keep all financial books and financial records of the Society ; to arrange for a regular and periodic audit of the Society's accounts as required by Rule XXXIX and on such other occasions as the Council may require ; and to prepare and present a duly audited annual balance sheet and statement of accounts."

Rule IX.—To be added after the last paragraph :—" The Council shall have the power to suspend from membership temporarily, for a period not exceeding two years, any member who may in writing make such application to it on the grounds of financial difficulties."

This was carried unanimously.

The President announced that these alterations would require to be confirmed at the next Annual General Meeting.

The following papers were read :

" A Note on the Occurrence in N.S.W. of Black Chaff of Wheat caused by *Bacterium translucens* var. *undulosum* S. J. and R ", by J. G. Churchward, B.Sc.Agr., M.Sc. (Communicated by Dr. W. L. Waterhouse.)

" Compounds of Palladium with Benzildioxime ", by F. P. J. Dwyer, M.Sc., and D. P. Mellor, M.Sc.

" The Fastness of Certain Amino Azo Dyes to Washing ", by J. C. Earl, D.Sc., Ph.D., and H. M. Parkin, B.Sc.

" The Moisture Equilibrium of Timber in Different Parts of New South Wales. Part II. Murwillumbah ", by M. B. Welch, B.Sc., A.I.C.

" Stone Scrapers. An Inquiry concerning a certain type found along the coast of N.S.W. ", by C. C. Towle, B.A. (Communicated by Dr. W. R. Browne.)

December 5th, 1934.

The five hundred and thirty-first General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Dr. R. J. Noble, President, was in the chair. Forty members and three visitors were present. The minutes of the preceding meeting were read and confirmed. The President announced the death of Mr. Henry Montague Stephen, B.A., LL.B., a member since 1921.

The President announced that three members of the Society, Dr. Cecil Purser, Dr. J. J. C. Bradfield, and

Mr. A. J. Gibson, had been elected as members of the University Senate, Dr. Purser and Dr. Bradfield having been re-elected. The President said he felt sure that the members joined with him in offering their congratulations to these gentlemen.

The certificates of five candidates for election as ordinary members of the Society were read, one for the first and four for the second time. The following gentlemen were duly elected as ordinary members of the Society: Norman Frederick Blake Hall, Adolphus Peter Elkin, Keith Eric Wellesley Salter, and Richmond Kerslake.

The following donations were received: parts, 272; volumes, 10; reports, 13; map, 1; and calendars, 2.

The following papers were read:

"*Myoporum deserti*. A preliminary Investigation", by Adrien Albert, B.Sc. (Communicated by H. Finnemore, B.Sc., F.I.C.)

"A Chemical Examination of Blackfellow's Bread, the Sclerotum of the Fungus *Polyporus mylittæ* Cke. and Mass.", by J. C. Earl, D.Sc., Ph.D., and G. H. McGregor, B.Sc.

"A Note on the Decomposition of Cobalt Amalgam", by J. W. Hogarth. (Communicated by F. P. J. Dwyer, M.Sc.)

"Brown Rot of Fruits and Associated Diseases of Deciduous Fruit Trees. II. The apothecia of the causal organisms", by T. H. Harrison, D.Sc.Agr.

"The Chemistry of the Constituents of the Wood-Oil of the 'Callitris' Pines. Part II. Guaiol", by V. M. Trikojus, B.Sc., and D. E. White, M.Sc.

"A Summary of the Changes noted in the Allantoic Membrane of the Chick in Five Hundred Experiments", by Elinor S. Hunt, M.B., Ch.M. (Communicated by O. U. Vonwiller, B.Sc., F.Inst.P.)

"Note on the Determination of Traces of Prussic Acid in Tissues", by G. Harker, D.Sc., F.A.C.I.

"Volumetric Micro-Determination of Picrolonic Acid in Organic Picronolate with Methylene Blue", by Adolph Bolliger, Ph.D.

"Geology of the Cudgegong District", by P. M. Game, B.Sc. (Communicated by W. R. Browne, D.Sc.)

"Testing a Lummer-Gehrcke Interferometer", by S. C. Baker, M.Sc.

"Notes on Wattle Barks. Part IV. The Tannin Content of a variety of *Acacia mollissima* Willd.", by F. A. Coombs, A.A.C.I., W. McGlynn, and M. B. Welch, B.Sc., A.I.C.

"The Longitudinal Variation of Timber during Seasoning. Part II", by M. B. Welch, B.Sc., A.I.C.

A Hanovia Analytical Quartz Lamp (lent by Messrs. W. Watson & Sons) was exhibited by D. P. Mellor, M.Sc.

At the conclusion of the meeting the President wished the members the compliments of the season.

ABSTRACT OF PROCEEDINGS
OF THE SECTION OF
INDUSTRY.

OFFICERS :

Chairman : A. D. Ollé, F.C.S., A.A.C.I.

Hon. Secretary : H. V. Bettley-Cooke, F.C.S., A.A.C.I.

During the year the following works were visited by the members :

Tuesday, 15th May.—Reckitts (Oversea) Ltd., 145 Bourke Street, Redfern.

Tuesday, 19th June.—Amalgamated Wireless (A/asia) Ltd., Parramatta Road, Ashfield.

Tuesday, 17th July.—The New Cambridge Delicacies Ltd., Bourke and Phillip Streets, Redfern.

Tuesday, 18th September.—*Sydney Morning Herald* Office, Pitt and Hunter Streets, Sydney.

Tuesday, 16th October.—Cinesound Productions Ltd., 65 Ebley Street, Waverley.

ABSTRACT OF PROCEEDINGS

OF THE SECTION OF

GEOLOGY.

Office-Bearers for the Year 1934.

Chairman: Professor L. A. Cotton.

Honorary Secretaries: Dr. G. D. Osborne and Mr. R. O. Chalmers.

Eight ordinary meetings and one special meeting were held during the year, the average attendance being nine members and nine visitors.

April 20th.—(*a*) "Twenty-five Years of the Geological Section—A Retrospect", by Dr. G. D. Osborne. (*b*) "Notes on Possible Modes of Extrusion and Intrusion of some Tertiary Acid-Alkaline Rocks of East Australia", by Mr. C. A. Sussmilch.

May 18th.—"Geology of the Trunkey-Tuena District", by Mr. H. G. Raggatt, illustrated by specimens. Exhibits: (1) By Prof. L. A. Cotton: Oligocene limestone from Malta. (2) By Dr. G. D. Osborne: Quartz-calcite geode in basalt inclusion from Hornsby volcanic neck.

May 30th.—Special joint meeting with the Geographical Society of N.S.W.—"Some Geographical and Other Problems of Central Australia and Western Queensland", by Dr. F. W. Whitehouse.

June 15th.—"A Geochronology of the last 17,000 Years", by Dr. C. C. Caldenius, of Stockholm.

July 20th.—(*a*) "Some Aspects of the Geology of the Upper Palæozoic Rocks of the Currabubula District", by Mr. S. W. Carey. (*b*) "The Upper Palæozoic Rocks of the Kempsey District", by Mr. A. H. Voisey. Exhibits: By Mrs. Sherrard: *Monograptus colonus* (Barrande) var. *compactus* (Wood), and *Monograptus* cf. *nilssoni* (Barrande), from Parish of Derrengullen, Yass district.

August 24th.—"Notes on Sub-surface Waters in N.S.W.", by Mr. L. F. Harper. Exhibits: (1) By Mr. G. F. K. Naylor: Upper Silurian fossiliferous limestone from Chatsbury, N.S.W. (2) By Mr. C. A. Sussmilch: Water-worn pebbles of obsidian, from New Guinea. (3) By Dr. G. D. Osborne: Glaciated pebble of Lower Marine (Kamilaroi) chert from Upper Marine beds of Paterson district. (4) By Mr. L. F. Harper: Ore from Tullamore goldfield. (5) By Mr. H. O. Fletcher: Trilobite specimens from

Templeton River, Queensland, and *Lingulella* from Northern Territory. (6) By Mr. R. O. Chalmers: (*a*) Photographs of "fossil forest" exposed at Arapuni Dam, New Zealand. (*b*) Sphæro-cobaltite from Cobar.

September 21st.—"Notes on the Palæozoic Rocks of the Upper Wollondilly Valley near Marulan", by Mr. G. F. K. Naylor, illustrated by specimens.

October 19th.—"Marshall's Theory Concerning the Extrusion of Acid Volcanic Products, with Special Reference to the Formation of 'Ignimbrites'." Discussion introduced by Dr. G. D. Osborne, and illustrated by specimens.

November 16th.—Exhibit and description by Dr. G. D. Osborne of a series of contact-metamorphosed limestones including rare monticellite-custerite-spinel-vesuvianite rocks from Carlingford, Co. Louth, Ireland.

ABSTRACT OF PROCEEDINGS

OF THE SECTION OF

PHYSICAL SCIENCE.

OFFICERS.

Chairman: Professor J. P. V. Madsen.

Hon. Secretary: Dr. W. H. Love.

Committee: Professors O. U. Vonwiller, V. A. Bailey G. H. Briggs, Major E. H. Booth, Mr. G. Hurst and Mr. G. H. Godfrey.

Ten meetings were held during 1934, the average attendance being about 20.

April 18th.—Dr. G. Builder: "Thermionic Voltmeters."
May 2nd.—Prof. V. A. Bailey and Dr. F. Martyn: "The Influence of Electric Waves on the Ionosphere."
June 6th.—Prof. V. A. Bailey: "A Solution of Algebraic Equations by Means of Logarithm Tables."
June 20th.—Prof. V. A. Bailey and Mr. Healy: "On the Motion of Electrons in Chlorine."
July 4th.—Prof. G. H. Briggs: "Recent Work on Induced Radio-Activity."
July 18th.—Mr. F. J. P. Wood: "Heavy Hydrogen."
August 1st.—Mr. J. H. Scarr: "Isotopes and the Constitution of the Atomic Nucleus."
September 5th.—Dr. G. Builder: "Transients in Electrical Circuits."
September 19th.—Prof. V. A. Bailey: "An Alternative Method for the Study of Electron Attachments to Molecules."
October 3rd.—Prof. O. U. Vonwiller: "On the Duration of the Excited States in Atoms."
October 17th.—Dr. Martyn: "Recent Developments in the Technique of Ionospheric Research."

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NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society", by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

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1906		‡Dixson, William, "Merridong," Gordon-road, Killara.
1913	P 3	Doherty, William M., F.I.C., F.A.C.I., "Jesmond," 36 George-street, Marrickville.
1928		Donegan, Henry Arthur James, A.S.T.C., A.A.C.I., Analyst, Department of Mines, Sydney; p.r. 18 Hillview-street, Sans Souci.
1935		Dunbabin, Thomas, 25 Musgrave-street, Mosman.
1924		Dupain, George Zephirin, A.A.C.I., F.C.S., Director Dupain Institute of Physical Education and Medical Gymnastics, Manning Building, 449 Pitt-street, Sydney; p.r. "Rose Bank," 158 Parramatta-road, Ashfield.
1924		Durham, Joseph, c/o Pacific Manufacturing Co. Ltd., 121 Mullens-street, Rozelle.
1934	P 7	Dwyer, Francis P. J., M.Sc., Lecturer in Chemistry, Technical College, Sydney.
1923	P 16	Earl, John Campbell, D.Sc., Ph.D., Professor of Organic Chemistry in the University of Sydney.
1924		Eastaugh, Frederick Alldis, A.R.S.M., F.I.C., Associate Professor in Chemistry, Assaying and Metallurgy in the University of Sydney.
1934	P 1	Elkin, Adolphus Peter, M.A., Ph.D., Professor of Anthropology in the University of Sydney.
1935		Ellis, Leon Macintosh, B.Sc.F. *Toronto*, Union Buildings, Bond-street, Sydney.
1935		England, Sidney Willis, 29 Queen-street, Mosman.
1916	P 2	Enright, Walter John, B.A., Solicitor, High-street, West Maitland; p.r. Regent-street, West Maitland.
1908		Esdaile, Edward William, 42 Hunter-street, Sydney.
1935		Evans, Silvanus Gladstone, A.I.A.A. *Lond.*, A.R.A.I.A., 6 Major-street, Coogee.

Elected.		
1921		Farnsworth, Henry Gordon, Government Stores, Harrington-street, Sydney; p.r. "Rothsay," 90 Alt-street, Ashfield.
1910		Farrell, John, A.S.T.C., Riverina Flats, 265 Palmer-street, Sydney.
1909	P 7	Fawsitt, Charles Edward, D.Sc., Ph.D., Professor of Chemistry in the University of Sydney. (President, 1919.)
1923		Fiaschi, Piero, O.B.E., V.D., M.D. *Columbia Univ.*, D.D.S. *New York*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 178 Phillip-street, Sydney.
1927	P 4	Finnemore, Horace, B.Sc., F.I.C., Lecturer in Pharmacy in the University of Sydney.
1935		Firth, Francis Williamson, Elliotts and Australian Drug Ltd., O'Connell-street, Sydney.
1935		Firth, John Clifford, B.Sc., "Avoca," Huntley's Point-road, Gladesville.
1920		Fisk, Ernest Thomas, F.Inst.R.E., A.M.I.E., (*Aust.*) Chairman of Directors, Amalgamated Wireless (Australasia) Ltd., Wireless House, 47 York-street, Sydney; p.r. 16 Beaconsfield-parade, Lindfield.
1888		Fitzhardinge, His Honour Judge G. H., M.A., "Red Hill," Pennant Hills.
1933		Fletcher, Harold Oswald, Assistant Palæontologist, Australian Museum, College-street, Sydney.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R.C.P. *Edin.*, "The Astor," Macquarie-street, Sydney.
1932		Forman, Kenn. P., M.I.Refr.E., 13 Market-street, Sydney; p.r. "Wyreema," Alison-road, Randwick.
1920		Fortescue, Albert John, "Benambra," Loftus-street, Arncliffe.
1905		Foy, Mark, c/o Geo. O. Bennett, 133 Pitt-street, Sydney.
1935		Fraser, Lilian Ross, M.Sc., 25 Bellamy-street, Pennant Hills.
1935		Garretty, Michael Duhan, B.Sc., c/o J. H. H. Millett, Suva, Fiji.
1926		Gibson, Alexander James, M.E., M.Inst.C.E., M.I.E.Aust., Consulting Engineer, 906 Culwulla Chambers, Castlereagh-street, Sydney; p.r. "Wirruna," Belmore-avenue, Wollstonecraft.
1935		Goddard, Roy Hamilton, F.C.A. *Aust.*, Royal Exchange, Bridge-street, Sydney.
1921		Godfrey, Gordon Hay, M.A., B.Sc., Lecturer in Physics in the Technical College, Sydney.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., "Eynesbury," Edgecliff-road, Edgecliff.
1934		Hall, Norman Frederick Blake, M.Sc., Chemist, Council for Scientific and Industrial Research (Tobacco Section), Dept. of Organic Chemistry, University of Sydney; p.r. 4 Whatmore-street, North Sydney.
1880	P 5	‡Halligan, Gerald Harnett, L.S., F.G.S., Retired Civil Engineer and Hydrographer, "Coniston," Marian-street, Killara.

Elected.		
1912		Hallman, Edward Francis, B.Sc., Assistant Mathematica Master, Fort Street Boys' High School, Petersham : p.r. 15 Harrington-street, Marrickville.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street, Sydney.
1919		Hambridge, Frank, Adelaide Steamship Co. Chambers, 22 Bridge-street, Sydney; p.r. "The Chalet," Lucinda-avenue, Wahroonga.
1909		Hammond, Walter L., B.Sc., High School, Wollongong.
1933		Hancock, Francis Charles, B.Sc. (Hons.), Dip.Ed. (*University of Bristol*), St. John's C. of E. Grammar School, Forbes-street, Darlinghurst.
1905	P 6	Harker, George, D.Sc., F.A.C.I., Cancer Research Department, University of Sydney ; p.r. 75 Prospect-road, Summer Hill.
1913	P 1	Harper, Leslie F., F.G.S., Government Geologist, Department of Mines, Sydney; p.r. 8 Alviston-street, Strathfield.
1934		Harrington, Herbert Richard, Teacher of Physics and Electrical Engineering, 4 Epping-avenue, Eastwood.
1923	P 3	Harrison, Travis Henry John, D.Sc.Agr., D.I.C. (*London*), Lecturer in Botany and Entomology, Hawkesbury Agricultural College, Richmond.
1929		Hawley, J. William, J.P., Financial Agent, 46 Martin-place, Sydney; p.r. 12 King's-road, Vaucluse.
1934		Hayes, William Lyall, A.S.T.C., A.A.C.I., Works Chemist, c/o Messrs. Wm. Cooper & Nephews (Aust.) Ltd., Phillip-street, Concord; p.r. 30 Cormiston-avenue, Central Concord.
1919		Henriques, Frederick Lester, 208 Clarence-street, Sydney.
1935		Hewitt, Frank Rupert, 45 Shirley-road, Wollstonecraft.
1918		Hindmarsh, Percival, M.A., B.Sc.Agr., Principal, Agricultural High School, Yanco.
1928		Hirst, George Walter Cansdell, B.Sc., A.S.T.C. (Sc.), A.M.I.E. (*Aust.*), A.M.Inst.T., c/o Chief Mechanical Engineer's Office, N.S.W. Railways, Wilson-street, Redfern; p.r. "St. Cloud," Beaconsfield-road, Chatswood.
1930		Hodson, John S., Assoc.I.E.E., Electrical Engineer, H.M. Naval Establishments, Garden Island, Sydney.
1916		Hoggan, Henry James, A.M.I.M.E. (*Lond.*), A.M.I.E. (*Aust.*), Consulting and Designing Engineer, "Lincluden," 81 Frederick-street, Rockdale.
1930		Holmes, James Macdonald, Ph.D., F.R.G.S., F.R.S.G.S., Associate Professor of Geography in the University of Sydney.
1919		Hoskins, Arthur Sidney, Engineer, Steel Works, Port Kembla; postal address, P.O. Box 36, Wollongong.
1919		Hoskins, Cecil Harold, Engineer, c/o Australian Iron & Steel Ltd., Kembla Building, 58 Margaret-street, Sydney, Box 3375 R, G.P.O.
1935		Howarth, Mark, Grange Mount, Bull-street, Mayfield, Newcastle, N.S.W.

Elected.		
1936		Howie, Archibald, 7 Wynyard-street, Sydney.
1923	P 2	‡Hynes, Harold John, M.Sc., B.Sc.Agr., Senior Asst. Biologist, Department of Agriculture, Box 36A, G.P.O., Sydney; p.r. "Belbooree," 10 Wandella-avenue, Roseville.
1935		James, Hugh, A.C.I.S., Australian Essential Oils Ltd., 115 Pitt-street, Sydney.
1929		Jeffrey, Robert Ewen, A.A.C.I., Managing Director, Bardsley's Ltd.; p.r. 9 Greycliffe-avenue, Vaucluse.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., C.M.Z.S., Professor of Zoology in the University of Adelaide. (Cor. Mem., 1912.)
1924		Jones, Leo Joseph, Geological Surveyor, Department of Mines, Sydney.
1935	P 1	Joplin, Germaine Anne, B.Sc., Ph.D., Curator of the Geological Department Museum, University of Sydney; p.r. 18 Wentworth-street, Eastwood.
1930		Judd, William Percy, 123 Wollongong-road, Arncliffe.
1911		Julius, Sir George A., Kt., B.Sc., B.E., M.I.Mech.E., M.I.E.Aust., Culwulla Chambers, Castlereagh-street, Sydney.
1932		Keeble, Arthur Thomas, B.Sc., Science Master, Sydney Grammar School; p.r. 55 Carlotta-street, Greenwich.
1935		Kelly, Caroline Tennant (Mrs.), "The Old Parsonage," Castle Hill, N.S.W.
1935		Kelly, Francis Angelo Timothy, "The Old Parsonage," Castle Hill, N.S.W.
1934		Kelly, Francis de Vere, Pharmacist, The Sydney Drug Stores, 264 Elizabeth-street, Sydney; p.r. c/o Masonic Club, 169 Castlereagh-street, Sydney.
1924		Kenny, Edward Joseph, Geological Surveyor, Department of Mines, Sydney; p.r. 17 Alma-street, Ashfield.
1887		Kent, Harry C., M.A., F.R.I.B.A., 491 New South Head-road, Double Bay.
1934		Kerslake, Richmond, A.S.T.C., A.A.C.I., Industrial Chemist, c/o Australian Paper Mfrs. Ltd., Macauley-street, Matraville; p.r. 55 Harold-street, Matraville.
1896		King, Sir Kelso, K.B., Underwriter, 117 Pitt-street, Sydney; p.r. "Quambi," Albert-street, Edgecliff.
1920		Kirchner, William John, B.Sc., A.A.C.I., Manufacturing Chemist, c/o Messrs. Burroughs, Wellcome & Co. (Australia) Ltd., Victoria-street, Waterloo; p.r. "Wanawong," 27 Thornleigh-road, Beecroft.
1919		Kirk, Robert Newby, Company Manager, 25 O'Connell-street, Sydney; p.r. 8 Lauderdale-avenue, Manly.
1935		Lawrence, Elizabeth Frances, B.A., Demonstrator in Geography, University of Sydney.
1936		Leach, Stephen Laurence, B.A., B.Sc., A.A.C.I., 69 Lithgow-street, Crows Nest.
1924		Leech, Thomas David James, B.Sc., B.E. *Syd.*, P. N. Russell School of Engineering, University of Sydney; p.r. 57 Clanalpine-street, Mosman.

Elected.		
1934		Leech, William Dale, Director of Research, Australasian Food Research Laboratories, Cooranbong, N.S.W.
1920		Le Souef, Albert Sherbourne, Curator, Taronga Park, Mosman; p.r. 3 Silex-road, Mosman.
1916		L'Estrange, Walter William, 7 Church-street, Ashfield.
1909		Leverrier, Frank, B.A., B.Sc., K.C., c/o Austral Malay Tin Ltd., Challis House, Martin-place, Sydney; p.r. Wentworth-road, Vaucluse.
1929	P 10	Lions, Francis, B.Sc., Ph.D., A.I.C., Lecturer in Organic Chemistry in the University of Sydney; p.r. 31 Chesterfield-road, Epping.
1906		Loney, Charles Augustus Luxton, M.Am.Soc.Refr.E., National Mutual Building, 350 George-street, Sydney.
1927	P 1	Love, William Henry, B.Sc., Ph.D., Cancer Research Department, University of Sydney.
1921		McDonald, Alexander Hugh Earle, H.D.A., Director of Agriculture, Department of Agriculture, Sydney.
1935		McDonald, Charles Mylne, "The Astor," Macquarie-street, Sydney.
1906	P 2	McIntosh, Arthur Marshall, "Moy Lodge," Hill-street, Roseville.
1891		‡McKay, R. T., L.S., M.Inst.C.E., Commissioner, Sydney Harbour Trust, Circular Quay, Sydney.
1930		Mackenzie, William Donald, F.I.C., M.I.Chem.E., F.A.C.I., Chairman and Managing Director, Messrs. Lever Brothers Ltd., Balmain; p.r. 5 Tivoli-avenue, Rose Bay.
1932		McKie, Rev. Ernest Norman, B.A. *Syd.*, St. Columba's Manse, Guyra, N.S.W.
1927		McMaster, Sir Frederick Duncan, Kt., "Dalkeith," Cassilis, N.S.W.
1916		McQuiggin, Harold G., M.B., Ch.M., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 11A Frenchman's-road, Randwick.
1924		Mance, Frederick Stapleton, Under Secretary for Mines, Mines Department, Sydney; p.r. "Binbah," Lucretia-avenue, Longueville.
1880	P 1	Manfred, Edmund Cooper, Architect, Belmore-square, Goulburn.
1920	P 1	Mann, Cecil William, M.A., Lecturer, Teachers' College, University Grounds, Newtown; p.r. 68 Middle Harbour-road, Lindfield.
1914		Martin, Alexander Hutton, F.R.A.I.A., Architect and Lecturer in Charge, School of Architecture, Sydney Technical College: p.r. "Silverdene," 23 Victoria-street, Roseville.
1933	P 2	Martin, Lyster Waverley Ormsby, B.Sc., Chemical Engineer, Dept. Public Works, N.S.W.; p.r. 13 Carlos-road, Artarmon.
1929	P 1	Matheson, Alexander James, Teacher, the High School, Dubbo.

Elected.		
1926		Mathews, Hamilton Bartlett, B.A., F.I.S., F.C.I.V., Surveyor-General of N.S.W., Department of Lands, Sydney.
1935		Maze, Wilson Harold, B.Sc., Demonstrator in Geography, University of Sydney.
1933		Mears, Arthur Cyril Weeks, A.S.A.S.M. (Electrical and Mechanical Engineering), Engineer Commander, Royal Australian Navy, Navy Office, St. Kilda-road, Melbourne, S.C.1, Victoria.
1912		Meldrum, Henry John, B.A., B.Sc., Lecturer, The Teachers' College, University Grounds, Newtown; p.r. 98 Sydney-road, Manly.
1929	P 7	Mellor, David Paver, M.Sc., Lecturer and Demonstrator, Chemistry Department, University of Sydney; p.r. 35 Oliver-road, Roseville.
1928		Micheli, Louis Ivan Allan, M.Sc., Ph.D., Research Chemist, c/o Colonial Sugar Refining Co., Pyrmont.
1926		Mitchell, Ernest Marklow, A.M.I.E. *Aust.*, Civil Engineer, Metropolitan Water, Sewerage and Drainage Board, 341 Pitt-street, Sydney; p.r. 106 Harrow-road, Bexley.
1922	P 22	Morrison, Frank Richard, A.A.C.I., F.C.S., Assistant Chemist, Technological Museum, Sydney.
1924		Morrison, Malcolm, Curator, Mining Museum, Sydney; p.r. "Tayan," Herbert-street, Rockdale.
1934		Mort, Francis George Arnot, Chemist, c/o Lewis Berger & Sons Ltd., Rhodes; p.r. 16 Grafton-street, Woollahra.
1879		Mullins, John Lane, M.L.C., M.A. *Syd.*, Barrister, 7 Greenknowe-avenue, Potts Point.
1915		Murphy, Robert Kenneth. Dr.Ing., Chem.Eng., A.S.T.C., M.I.Chem.E., A.A.C.I., Lecturer in Charge of Chemistry and Head of Science Department, Sydney Technical College.
1923	P 2	Murray, Jack Keith, B.A., B.Sc.Agr., Principal, Queensland Agricultural College, Gatton, Queensland, and Professor of Agriculture in the University of Queensland.
1893	P 4	Nangle, James, O.B.E., F.R.A.S., F.R.A.I.A., Government Astronomer, The Observatory, Sydney; Room 706, Australia House, Carrington-street, Sydney. (President, 1920.)
1930	P 3	Naylor, George Francis King, M.A., M.Sc., Dip.Ed., Assistant Director, Australian Institute of Industrial Psychology, 12 O'Connell-street, Sydney; p.r. "Kingsleigh," Ingleburn, N.S.W.
1932		Newman, Ivor Vickery, M.Sc., Ph.D., F.R.M.S., F.L.S., Linnean Macleay Fellow in Botany of the Linnean Society of N.S.W., Botany Department, University of Sydney; p.r. "Whitehaven," 5 Llandilo-avenue, Strathfield.
1924		Nickoll, Harvey, L.R.C.P., L.R.C.S., Barham, *via* Mudgee, N.S.W.
1935		Nicol, Phyllis Mary, M.Sc., Sub-Principal, The Women's College, Newtown.

Elected.		
1891		‡Noble, Edward George, L.S., Local Government Engineer, 8 Louisa-road, Balmain.
1920	P 3	‡Noble, Robert Jackson, M.Sc., B.Sc.Agr., Ph.D., Biologist, Department of Agriculture, Box 36A, G.P.O., Sydney: p.r. "Warrah," 51 Boundary-street, Roseville. (Vice-President.) (President, 1934.)
1935		O'Connell, Daniel J. K., S.J., M.Sc., F.R.A.S., Riverview College Observatory, Sydney.
1903		‡Old, Richard, "Waverton," Bay-road, North Sydney.
1930		O'Leary, Rev. William J., S.J., Seismologist, St. Ignatius' College, Riverview, Sydney.
1913		Ollé, A. D., F.C.S., A.A.C.I., "Kareema," Charlotte-street, Ashfield.
1932		O'Neill, John Patrick, F.I.I.A., F.C.I. (*Eng.*), Chief Timber Inspector, Department of Railways, Bridge-street, Sydney; p.r. 38 Wilberforce-avenue, Rose Bay.
1921	P 3	Osborne, George Davenport, D.Sc., Lecturer and Demonstrator in Geology in the University of Sydney.
1928		Parsons, Stanley William Enos, Analyst and Inspector, N.S.W. Explosive Department; p.r. Shepherd-road, Artarmon.
1935		Payne-Scott, Ruby Violet, Assistant Physicist, Cancer Research Department, University of Sydney.
1920	P 67	Penfold, Arthur Ramon, F.A.C.I., F.C.S., Curator and Economic Chemist, Technological Museum, Harris-street, Ultimo; p.r. 25 Ramsay-road, Pennant Hills. (President.)
1933		Penman, Arthur Percy, B.E. *Syd.*, Mining Engineer, 10 Water-street, Wahroonga.
1935		Phillips, Orwell, "Linlithgow," 4 Wentworth-street, Point Piper.
1919		Poate, Hugh Raymond Guy, M.B., Ch.M. *Syd.*, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, F.R.A.C.S., Surgeon, 225 Macquarie-street, Sydney; p.r. 38 Victoria-road, Bellevue Hill.
1896		Pope, Roland James, B.A. *Syd.*, M.D., Ch.M., F.R.C.S. *Edin.*, 185 Macquarie-street, Sydney.
1935		Potts, Charles Vickers, 28 O'Connell-street, Sydney.
1921	P 2	Powell, Charles Wilfrid Roberts, F.I.C., A.A.C.I., Company Executive, c/o Colonial Sugar Refining Co., O'Connell-street, Sydney; p.r. "Wansfell," Kirkoswald-avenue, Mosman.
1918		Powell, John, Managing Director, Foster Clark (Aust.) Ltd., 17 Thurlow-street, Redfern; p.r. "Elgarth," Ranger's-road, Cremorne.
1927		Price, William Lindsay, B.E., B.Sc., Teacher of Physics, Sydney Technical College; p.r. 60 McIntosh-street, Killara.
1918		Priestley, Henry, M.D., Ch.M., B.Sc., Associate Professor of Physiology in the University of Sydney.

Elected.		
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, Physician, 185 Macquarie-street, Sydney; p.r. "The Astor," Macquarie-street, Sydney.
1929		Pyke, Henry George, A.S.T.C., Assistant Works Chemist, Australian Gas Light Company, Mortlake; p.r. 29 Maple-avenue, Pennant Hills.
1935	P 1	Quodling, Florrie Mabel, Demonstrator in Geology, University of Sydney.
1922	P 5	Raggatt, Harold George, M.Sc., Geologist, c/o Mines Department, Sydney; p.r. 83 Epping-avenue, Epping.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1936		Randall, Harry, 7 Selbourne-street, Burwood.
1931	P 1	Rayner, Jack Maxwell, B.Sc., A.Inst.P., Physicist to the Department of Mines, Sydney; p.r. 125 William-street, Granville.
1935		Reid, Andrew, "Neringah," Wahroonga.
1935		Reid, Cicero Augustus, 11 Robertson-road, Centennial Park.
1928		Reidy, Eugene Nicholas, A.S.T.C., Analyst, Department of Mines, Sydney.
1932		Richardson, Henry Elmar, Chemist, Chase-road, Turramurra.
1933		Roberts, Richard George Crafter, Electrical Engineer, "Redcliffe," Liverpool-road, Ashfield.
1935		Robinson, Albert Jordan, Managing Director, S. T. Leigh & Co. Ltd., Raleigh Park, Kensington.
1935		Room, Thomas G., Professor of Mathematics in the University of Sydney.
1928		Ross, Allan Clunies, B.Sc., F.C.A. (*Aust.*), Chartered Accountant (*Aust.*), 54A Pitt-street, Sydney; p.r. The Grove, Woollahra. (Member from 1915 to 1924.)
1895		Ross, Herbert E., Govt. Savings Bank Building, 14 Castlereagh-street, Sydney.
1925		Roughley, Theodore Cleveland, B.Sc., F.R.Z.S., Economic Zoologist, Technological Museum, Sydney; p.r. Coolong Flats, Coolong-road, Vaucluse.
1929		Royle, Norman Dawson, M.D., Ch.M., 185 Macquarie-street, Sydney.
1907		Ryder, Charles Dudley, D.Eng. *Vienna*, Assoc.I.R.S.M. *Lond.*, Assoc.A.C.I., F.C.S. *Lond.*, Public Analyst (by appointment), Box 2263 G.P.O., Sydney; p.r. 17 Chorley-crescent, Cheltenham.
1934		Salter, Keith Eric Wellesley, B.Sc., Entomologist, Curator Macleay Museum, The University of Sydney; p.r. "Hawthorn," 48 Abbotsford-road, Homebush.
1935		Savage, Clarence Golding, Director of Fruit Culture, Department of Agriculture, Sydney.

Elected.		
1920		Scammell, Rupert Boswood, B.Sc. (*Syd.*), A.A.C.I., F.C.S., c/o F. H. Faulding & Co. Ltd., 98 Castlereagh-street, Redfern; p.r. 10 Buena Vista-avenue, Clifton Gardens.
1933		Selby, Esmond Jacob, Dip.Com., Sales Manager, "Marley," Werona-avenue, Gordon.
1936		Sellenger, Brother Albertus, Marist Brothers' College, Randwick.
1918		Sevier, Harry Brown, Chairman of Directors, c/o Lewis Berger & Sons (Australia) Limited, Box 23, P.O., Burwood; p.r. 7 Albyn-road, Strathfield.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		‡Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1933		Slade, George Hermon, B.Sc., Director, W. Hermon Slade & Co. Ltd., Manufacturing Chemists, 23 Rosebery-avenue, Rosebery; p.r. "Raiatea," Oyama-avenue, Manly.
1922	P 1	Smith, Thomas Hodge, Australian Museum, College-street, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc., B.Sc.Agr., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, "Araboonoo," Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, M.C.I.P.A., F.I.A.P.A., c/o Spruson & Ferguson, Patent Attorneys and Consulting Engineers, 66 Pitt-street, Sydney; p.r. "Bengalala," Neutral Bay.
1916		Stephen, Alfred Ernest, F.C.S., c/o Box 1158 HH, G.P.O., Sydney.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 135 Macquarie-street, Sydney; p.r. Captain Piper's-road and New South Head-road, Vaucluse.
1920	P 1	Stephens, John Gower, M.B., 135 Macquarie-street, Sydney.
1913		Stewart, Alex. Hay, B.E., "Yunah," 22 Murray-street, Croydon.
1900	P 1	Stewart, J. Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; p.r. "Berelle," Homebush-road, Strathfield. (President, 1927.)
1909		Stokes, Edward Sutherland, M.B., Ch.M. *Syd.*, D.P.H. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street, Sydney; p.r. 15 Highfield-road, Lindfield.
1916	P 1	Stone, Walter George, F.S.T.C., A.A.C.I., Senior Analyst, Department of Mines, Sydney: p.r. 14 Rivers-street, Bellevue Hill.
1918		‡Sullivan, Herbert Jay, Director in Charge of Research and Technical Department, c/o Lewis Berger & Sons (Australia) Ltd., Rhodes; Box 23, P.O., Burwood; p.r. "Stonycroft," 10 Redmyre-road, Strathfield.
1918		Sundstrom, Carl Gustaf, Managing Director, Federal Match Co. Ltd., Park-road, Alexandria; p.r. 74 Alt-street, Ashfield.

Elected.		
1901	P 15	‡Sussmilch, C. A., F.G.S., F.S.T.C., A.M.I.E. *Aust.*, Acting Superintendent, Sydney Technical College; p.r. 11 Appian Way, Burwood. (Vice-President.) (President, 1922.)
1919		‡Sutherland, George Fife, A.R.C.Sc. *Lond.*, Assistant Professor of Mechanical Engineering in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M.D., D.P.H. *Melb.*, B.Sc. *Oxon.*, Professor of Preventive Medicine and Director, School of Public Health and Tropical Medicine, University of Sydney; p.r. "Lynton," 27 Kent-road, Rose Bay.
1915	P 3	Taylor, Harold B., M.C., D.Sc., F.I.C., F.A.C.I., Second Government Analyst, Department of Public Health, 93 Macquarie-street, Sydney; p.r. 44 Kenneth-street, Longueville.
1935		Tennant, Thomas Henry, Manager, Government Stores Department; p.r. 2 Borrodale-road, South Kensington.
1919		Thorne, Harold Henry, M.A. *Cantab.*, B.Sc. *Syd.*, F.R.A.S., Lecturer in Mathematics in the University of Sydney; p.r. 55 Railway-crescent, Beecroft.
1923		Tindale, Harold, General Manager, The Australian Gas Light Company, Haymarket, Sydney.
1935		Tommerup, Eric Christian, M.Sc., A.A.C.I., 4 John-street, Ashfield.
1923		Toppin, Richmond Douglas, A.I.C., 22 Miller-street, Hurstville.
1879		Trebeck, P. C., Church-street, Bowral, N.S.W.
1932	P 7	Trikojus, Victor Martin, B.Sc., D.Phil., Lecturer in Medical Organic Chemistry, University of Sydney; p.r. "Buxton," Tusculum-street, Potts Point.
1925		Tye, Cyrus Willmott Oberon, Director of Development and Executive Officer of the Unemployment Relief Council, Treasury Building, Bridge-street, Sydney; p.r. 19 Muston-street, Mosman.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George B., 9th Floor, Barrack House, Barrack-street, Sydney; p.r. "Inveresk," Coventry-road, Homebush.
1935		Vickery, Joyce Winifred, M.Sc., Demonstrator in Botany, University of Sydney; p.r. 6 Coventry-road, Homebush.
1933	P 1	Voisey, Alan Heywood, B.Sc., Geologist, Northern Australia Survey, Alice Springs, N.T.
1903	P 7	Vonwiller, Oscar U., B.Sc., F.Inst.P., Professor of Physics in the University of Sydney; p.r. "Appenzell," Castle Hill, N.S.W. (President, 1930.)

Elected.		
1910		Walker, Charles, F.C.S., A.A.C.I., 802 Culwulla Chambers, 67 Castlereagh-street, Sydney; p.r. "Lynwood," Terry-road, Ryde.
1910		Walker, Major Harold Hutchison, Vickery's Chambers, 82 Pitt-street, Box 1723 JJ, G.P.O., Sydney.
1919	P 1	Walkom, Arthur Bache, D.Sc., Science House, Gloucester-street, Sydney; p.r. 45 Nelson-road, Lindfield.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, Lond.; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Barrack House, 16 Barrack-street, Sydney; p.r. "Walsholme," Centennial Park.
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, F.A.C.I., Lecturer and Demonstrator in Physiology in the University of Sydney.
1921		‡Waterhouse, Gustavus Athol, D.Sc., B.E., F.R.E.S., F.R.Z.S., Science House, Sydney; p.r. 39 Stanhope-road, Killara.
1924		Waterhouse, Leslie Vickery, B.E. *Syd.*, Mining Engineer, Wingello House, Angel Place, Sydney; p.r. 4 Bertha-road, Neutral Bay.
1919		Waterhouse, Lionel Lawry, B.E. *Syd.*, Lecturer and Demonstrator in Geology in the University of Sydney.
1919	P 3	Waterhouse, Walter L., M.C., D.Sc.Agr., D.I.C., Faculty of Agriculture, University of Sydney; p.r. "Hazelmere," Chelmsford-avenue, Lindfield.
1910		Watson, James Frederick, M.B., Ch.M., Canberra, F.C.T.
1911	P 1	Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney; p.r. 64 Wentworth-road, Vaucluse. (President, 1925.)
1936		Wearne, Harold Wallis, 6 Collingwood-street, Drummoyne.
1920	P 39	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum, Sydney.
1920	P 1	Wellish, Edward Montague, M.A., Associate-Professor of Applied Mathematics in the University of Sydney; p.r. 15 Belgium-avenue, Roseville.
1921		Wenholz, Harold, B.Sc.Agr., Director of Plant Breeding, Department of Agriculture, Sydney.
1935		Wentworth, William Charles, 17 Wentworth-street, Point Piper.
1881		‡Wesley, W. H., London.
1931		Wheatley, Frederick William, C.B.E., B.Sc. *Oxon.*, D.Sc., B.A. *Adel.*, A.S.A.S.M., 4 "Rhodesia," Macleay-street, Potts Point.
1922		Whibley, Harry Clement, c/o Box 1860 W, G.P.O., Brisbane, Queensland.
1909	P 3	‡White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teachers' College, University Grounds, Newtown.
1928		Wiesener, Frederick Abbey, M.B., Ch.M., D.O.M.S., Ophthalmic Surgeon, 143 Macquarie-street, Sydney; p.r. Jersey-road, Strathfield.

Elected.		
1921		Willan, Thomas Lindsay, B.Sc., Field Office, Bhamo, Upper Burma.
1920		Williams, Harry, A.I.C., A.A.C.I., Chief Chemist, c/o The Lanoleen Co., Arlington Mills, Lord-street, Botany; p.r. "Southerndale," Burke-street, Oatley.
1935	P 1	Wilson, Ralph Dudingston, B.Sc.Agr., Department of Plant Pathology, University of Wisconsin, Madison. Wis., U.S.A.
1935		Wolstenholme, Edmund Kay, "Petarli," New South Head-road, Double Bay.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, "Redcliffe," Liverpool-road, Ashfield.
1906	P 11	Woolnough, Walter George, D.Sc., F.G.S., Department of the Interior, Canberra, F.C.T.; p.r. "Callabonna," Park-avenue, Gordon. (President, 1926.)
1916		Wright, George, Company Director, c/o Farmer & Company Limited, Sydney; p.r. "Wanawong," Castle Hill, N.S.W.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, Seedsman, c/o Arthur Yates & Co. Ltd., 184 Sussex-street, Sydney; p.r. Boomerang-street, Turramurra.

Honorary Members.

Limited to Twenty.

Elected.	
1914	Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, Gower-street, London, W.C.1, England.
1934	Howchin, Walter, F.G.S., Professor, "Stonycroft." Goodwood Park, S.A.
1931	Lyle, Sir Thomas Ranken, K.B., C.B.E., M.A., D.Sc., F.R.S., "Lisbuoy," Irving-road, Toorak, Melbourne, Victoria.
1915	Maitland, Andrew Gibb, F.G.S., "Bon Accord," 28 Melville-terrace, South Perth, W.A.
1912	Martin, Sir Charles J., C.M.G., D.Sc., F.R.S., Roebuck House, Old Chesterton, Cambridge, England.
1930	Masson, Sir David Orme, K.B.E., M.A., D.Sc., LL.D., F.R.S., 14 William-street, South Yarra, S.E.1, Victoria.
1935	Murray, His Excellency Sir John Hubert Plunkett, K.C.M.G., B.A., Lieutenant-Governor of Papua, Government House, Port Moresby.
1928	Smith, Grafton Elliot, M.A., M.D., F.R.S., F.R.C.P., Professor of Anatomy, Institute of Anatomy, University College, Gower-street, London, W.C.1, England.

Elected.

1915 Thomson, Sir Joseph J., O.M., M.A., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.

1922 Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Cambridge; p.r. 31 Grange-road, Cambridge, England.

OBITUARY 1935-36.

Ordinary Members.

1904 Adams, William John.
1891 Brennand, Henry J. W.
1886 Crago, W. H.
1932 Goulder, Francis.
1913 Hudson, George Inglis.
1881 Poate, Frederick.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.

Vice-President from 1866 to 1878.

To be awarded from time to time for meritorious contributions to the Geology or Mineralogy of Australia. The prefix * indicates the decease of the recipient.

Awarded.

1878 *Professor Sir Richard Owen, K.C.B., F.R.S.
1879 *George Bentham, C.M.G., F.R.S.
1880 *Professor Thos. Huxley, F.R.S.
1881 *Professor F. M'Coy, F.R.S., F.G.S.
1882 *Professor James Dwight Dana, LL.D.
1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.
1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1886 *Professor L. G. De Koninck, M.D.
1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.
1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892 *Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc.D., F.R.S., F.L.S.
1893 *Professor Ralph Tate, F.L.S., F.G.S.
1895 *Robert Logan Jack, LL.D., F.G.S.. F.R.G.S.
1895 *Robert Etheridge, Jnr.
1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.
1900 *Sir John Murray, K.C.B., LL.D., Sc.D., F.R.S.
1901 *Edward John Eyre.
1902 *F. Manson Bailey, C.M.G., F.L.S.
1903 *Alfred William Howitt, D.Sc., F.G.S.
1907 Professor Walter Howchin, F.G.S., University of Adelaide.
1909 *Dr. Walter E. Roth, B.A.
1912 *W. H. Twelvetrees, F.G.S.
1914 Sir A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History), London.
1915 *Professor W. A. Haswell, M.A., D.Sc., F.R.S.
1917 *Professor Sir Edgeworth David, K.B.E., C.M.G., D.S.O., M.A., Sc.D., D.Sc., F.R.S., F.G.S.
1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.
1920 *Joseph Edmund Carne, F.G.S.
1921 *Joseph James Fletcher, M.A., B.Sc.
1922 Richard Thomas Baker, The Crescent, Cheltenham.
1923 *Sir W. Baldwin Spencer, K.C.M.G., M.A., D.Sc., F.R.S.
1924 *Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., J.P.
1925 *Charles Hedley, F.L.S.
1927 Andrew Gibb Maitland, F.G.S., "Bon Accord," 28 Melville Terrace, South Perth, W.A.
1928 Ernest C. Andrews, B.A., F.G.S., 32 Benelong Crescent, Bellevue Hill.

Awarded.

1929 Professor Ernest Willington Skeats, D.Sc., A.R.C.S., F.G.S., University of Melbourne, Carlton, Victoria.

1930 L. Keith Ward, B.A., B.E., D.Sc., Government Geologist, Geological Survey Office, Adelaide.

1931 Robin John Tillyard, M.A., D.Sc., Sc.D., F.R.S., F.L.S., F.E.S., Canberra, F.C.T.

1932 Frederick Chapman, A.L.S., F.G.S., Melbourne.

1933 Walter George Woolnough, D.Sc., F.G.S., Department of the Interior, Canberra, F.C.T.

1934 Edward Sydney Simpson, D.Sc., B.E., F.A.C.I., Carlingford, Mill Point, South Perth, W.A.

1935 George William Card, A.R.S.M., 16 Ramsay-street, Collaroy, N.S.W.

1936 Sir Douglas Mawson, Kt., O.B.E., F.R.S., D.Sc., B.E., University of Adelaide.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled "The Aborigines of New South Wales."

1882 Andrew Ross, M.D., Molong, for paper entitled "Influence of the Australian climate and pastures upon the growth of wool."

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled "Water supply in the Interior of New South Wales."

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled "The Tin deposits of New South Wales."

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled "Orig[illegible] and mode of occurrence of gold-bearing veins and [illegible] the associated Minerals."

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, fo[illegible] paper entitled "The Anatomy and Life-history of [illegible]ollusca peculiar to Australia."

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entit[illegible]d "List of the Marine and Fresh-water Invertebrate Faun[illegible] of Port Jackson and Neighbourhood."

1889 Rev. John Mathew, M.A., Coburg, Victoria, for pap[illegible] entitled "The Australian Aborigines."

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper enti[illegible]led "The Microscopic Structure of Australian Rocks."

1892 Alexander G. Hamilton, Public School, Mount K[illegible]mbla, for paper entitled "The effect which settlement i[illegible] Australia has produced upon Indigenous Vegetation."

1894 J. V. De Coque, Sydney, for paper entitled the "Timbers of New South Wales."

1894 R. H. Mathews, L.S., Parramatta, for paper entitled "The Aboriginal Rock Carvings and Paintings in New South Wales."

Awarded.

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled "The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*)."

1896 Rev. J. Milne Curran, Sydney, for paper entitled "The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found."

AWARDS OF THE WALTER BURFITT PRIZE.

Bronze Medal and Money Prize of £50.

Established as the result of a generous gift to the Society by Dr. W. F. BURFITT, B.A., M.B., Ch.M., B.Sc., of Sydney. Awarded at intervals of three years to the worker in pure and applied science, resident in Australia or New Zealand, whose papers and other contributions published during the past three years are deemed of the highest scientific merit, account being taken only of investigations described for the first time, and carried out by the author mainly in these Dominions.

Awarded.

1929 Norman Dawson Royle, M.D., Ch.M., 185 Macquarie Street, Sydney.

1932 Charles Halliby Kellaway, M.C., M.D., M.S., F.R.C.P., The Walter and Eliza Hall Institute of Research in Pathology and Medicine, Melbourne.

1935 Victor Albert Bailey, M.A., D.Phil., Associate-Professor of Physics, University of Sydney.

AWARDS OF LIVERSIDGE RESEARCH LECTURESHIP.

This Lectureship was established in accordance with the terms of a bequest to the Society by the late Professor Archibald Liversidge. Awarded at intervals of two years, for the purpose of encouragement of research in Chemistry. (This JOURNAL, Vol. LXII, pp. x-xiii, 1928.)

Awarded.

1931 Harry Hey, c/o The Electrolytic Zinc Company of Australasia, Ltd., Collins Street, Melbourne.

1933 W. J. Young, D.Sc., M.Sc., University of Melbourne.

PRESIDENTIAL ADDRESS

By R. J. NOBLE, Ph.D., M.Sc., B.Sc.Agr.,
Biologist, Department of Agriculture, Sydney.

(*Delivered to the Royal Society of New South Wales, May 1, 1935.*)

PART I. GENERAL.

Gentlemen, it has been customary for your President at this meeting to comment on matters which have been of interest to us as members of the Royal Society of N.S.W. during the past twelve months, and on this occasion, at the risk of slight reiteration, it is proposed to follow the course set by so many of my predecessors.

The year was one of the most eventful in the long history of the Society. Reference has been made this evening to the financial situation which confronted your Council within a few weeks of its election to office, a situation which, it is hoped, will never occur again. We have recorded appreciation of the services of our Hon. Secretary, Major E. H. Booth, who was our representative in the proceedings which became necessary and were initiated in accordance with the powers conferred by our Act of Incorporation, and who has devoted so much of his time and energy to the conduct of the general business of the Society. To him also we owe a further debt of gratitude for the reorganisation of the Society's office, which is now in such a satisfactory condition.

To our Hon. Treasurer, Mr. A. R. Penfold, we are specially indebted for the energetic and efficient manner in which he has carried out the duties of his position. I wish, also, on your behalf, to express our appreciation to Dr. W. R. Browne, Hon. Secretary, who, in addition to his other duties, has devoted long hours of service to the editorial work associated with the publication of the Journal; some of us know just what is involved in this connection.

No position on Council can be regarded as a sinecure, and all members this year once again have been most

strenuously engaged in the consideration of the affairs of the Society; to them all I am personally most deeply indebted for their active and helpful co-operation on all occasions.

Members will have gathered from the report on the Library some idea of the work which has been done for us by our Hon. Librarian, Professor J. C. Earl. This work was done at much personal inconvenience, and I wish to record our grateful appreciation of his services. The Library has never been in a better condition, and its usefulness to members and other accredited persons is now apparent. The exchange position is very satisfactory and our Proceedings are now most widely distributed to scientific organisations throughout the world; in addition, arrangements have been made for the purchase of a certain number of periodicals of general as well as of specialised scientific character, which, it is hoped, will be of very real interest to members.

It is considered, however, that there is still great need for a complete examination of the situation existing in the scientific libraries of various departments and other scientific organisations in the city of Sydney. Better use might be made of existing resources if our efforts were more closely co-ordinated, and I venture to suggest that we shall need to devote much more time to the formulation of a definite policy to meet our own requirements. Our library space is not unlimited, and our very wide interests in the field of science will intensify a position which must be met within a very few years. We read of such possible developments as that of the photomicrographic reproduction of documents,[1] enabling selected papers to be filed in card series, but such a possibility may not have any material effect on the shelving space requirements of a library.

I feel also that we should give some consideration to the permanency of the papers which are published in our Journal. Some which may not appear to be of extraordinary merit at the time of presentation may contain records of exceptional interest to investigators in subsequent generations. Certain scientific organisations elsewhere now issue special limited editions of their publications

[1] Seidell, A.: The Photomicrographic Reproduction of Documents. *Sci.*, *80*, 184–185, 1934.

on rag paper,[2] in view of the fact that the average life of the wood-pulp edition is little more than fifty years, and I feel that our Society and other scientific bodies in Australia might give some thought to the possibility of thus extending the period of usefulness of the publications for which they are responsible.

To revert to more general matters, I believe, in spite of early misadventure, that our work has gone forward satisfactorily. Our membership is still much smaller than it should be, possibly for the reason that so many members of the community do not realise that our proceedings are not the dull and incomprehensible affairs which might be expected from the mere perusal of titles of technical papers presented at each meeting. It is perhaps becoming more difficult for one specialist to speak in any language other than that of his chosen branch of science, but that this is not an impossible achievement has been demonstrated by the fact that we have had many interesting presentations during the year. I am reminded, in this connection, of some of the ideals discussed by Dr. W. G. Woolnough in his Presidential Address in 1927, and more recently by Professor O. U. Vonwiller, and the increased attendances at our monthly meetings would appear to indicate a measure of appreciation of the arrangements which were made during the year in connection with the presentation of papers, exhibits, demonstrations and short discourses on topics of current scientific interest.

I had hoped that more would have been possible in the way of short explanatory notes on the notice paper, and I have suggested to Council that this is a matter which might be considered more closely. Some members may be unable to attend meetings and others may wish to know just a little more, in advance, concerning the papers, lecturettes and exhibits which are to be presented to us.

It is regretted that we were able to arrange for only one symposium, as members will remember the interesting session provided for us on that occasion. The meeting was memorable, also, for the fact that this was the first occasion on which a voice other than that of the mere male was heard in our assemblies. So far as I am aware, no one has suggested publicly that, in spite of our rules, women should not be elected to membership in the Society ;

[2] Farquhar, S. T.: The Use of Permanent Paper in Scholarly Publishing. *Sci.*, *79*, 522–523, 1934.

they are members of even more august organisations elsewhere, and the question is one which is entirely in the hands of members themselves.

Reference has been made in the Council's report to the action of our Society in initiating proposals for the provision of an appropriate memorial to our distinguished teacher, colleague and friend, the late Sir Edgeworth David. This action has been endorsed by many representative sections of the community, and it is hoped not only that still further support will be provided by citizens of this State, but that the truly national character of the appeal will be more generally recognised. I feel sure that members of scientific organisations and of the community generally, in this as well as in the other States, will wish to ensure that there is an adequate recognition of the value of his work as a scientist and as a man, and of the place which he held in our esteem and affection. May we not hope that the memorial which will enable work to be continued in his chosen branch of science will be worthy of the man whom we are so proud to honour?

We record our grateful appreciation of the action taken by the Premier, the Hon. B. S. B. Stevens, and Cabinet in arranging for the purchase of the manuscript of Sir Edgeworth David's monumental work on the geology of Australia, and for the provision of facilities for its ultimate publication.

At our meeting in August reference was made to the fact that it was the 50th anniversary of the presentation to our Society of the first paper of Lawrence Hargrave's series of pioneering researches in aeronautics. A few days later, in co-operation with other bodies, we participated in celebrations at the University of Sydney to commemorate this event. It is a coincidence that the year was marked by a record aeroplane flight from Mildenhall, England, to Darwin in the almost incredible period of fifty-two and a half hours, a flight which, when continued, made Melbourne only seventy-one hours distant from the heart of the Empire.

The year was notable, also, for the very successful meeting of the Australian and New Zealand Association for the Advancement of Science, held in Melbourne last January, and it is perhaps not inappropriate to record that seven members of our Society occupied presidential chairs at sectional meetings of the Association. This is not only an indication of the wide interests covered by the

Society, but also a very definite testimony to the scientific status of many of our members in this community.

During the course of the Association meeting delegates from the Society attended a conference of representatives of scientific societies called by the Australian National Research Council to consider proposals for the federation of scientific bodies in Australia. At a somewhat similar meeting held in 1932 our representatives supported the view that some type of federation was desirable, and on this occasion a similar principle was endorsed, provided that adequate safeguards were adopted to preserve the autonomy of the societies concerned. Detailed proposals are to be formulated by the Executive Committee of the Australian National Research Council in collaboration with representatives of other scientific bodies, and we may expect further information in respect of these at an early date.

In closing this portion of my address I wish to refer to the very severe losses which we have suffered in the death of ten of our members during the past year.*

HUBERT VERNON BETTLEY-COOKE, F.C.S., A.A.C.I., died on 29th October, 1934, in his 50th year. He was technical chemist on the staff of Messrs. Abel, Lemon & Co., and was actively interested in the chemistry of oils, waxes and dyestuffs. He joined this Society in 1919, and was Hon. Secretary of the Industrial Section for seven years.

HENRY GEORGE CHAPMAN, M.D., B.S., died at Sydney on 25th May, 1934, in his 54th year. He was born in England and was educated in Melbourne, where he had a distinguished academic career. Dr. Chapman was appointed acting professor of physiology at the University of Adelaide in 1901, he was demonstrator in pathology at the University of Melbourne in 1902, and was lecturer and demonstrator in physiology at the University of Sydney during the period 1903–1912. He was subsequently appointed to the Chair of Physiology at the University of Sydney, and this position he held until he was appointed Director of Cancer Research, Sydney. He was chairman of the Commission on Miners' Diseases in 1920, and was for a long period lecturer on the technology of bread-making at the Sydney Technical College. He became a

* For statements in respect of Sir Edgeworth David and Mr. W. S. Dun I am indebted to Dr. W. R. Browne and Dr. C. Anderson.

member of this Society in 1909, and was Honorary Treasurer for twenty-two years.

TANNATT WILLIAM EDGEWORTH DAVID, K.B.E., C.M.G., D.S.O., M.A., D.Sc., Sc.D., F.R.S., Professor Emeritus of Geology in the University of Sydney, and a Vice-President of this Society, died on August 28, 1934, at the age of 76 years. Born near Cardiff, in South Wales, he was educated at New College, Oxford, where he distinguished himself as a classical scholar and an athlete. He studied geology at Oxford and later at the Royal School of Mines, London, came to New South Wales in 1882 as a geological surveyor in the Department of Mines, and for nine years was engaged principally in economic geology, his most important investigations being in regard to the very extensive and valuable Greta coal-measures of the Lower Hunter Valley. In 1891 he was selected to fill the Chair of Geology and Physical Geography in the University of Sydney, and under his guidance what had been a very small department grew to be one of the most important and progressive schools in the University. In addition to teaching he engaged extensively in research and published many important papers dealing with various aspects of the geology of this State and of Australia generally. In 1897 at the request of the Royal Society of London he successfully undertook the task of putting down diamond-drill bores at the atoll of Funafuti with the object of throwing light upon the origin of coral islands. He was a member of the British Antarctic Expedition of 1908 under Shackleton, and his exploratory work included an ascent of Mt. Erebus and an epic sledge journey to the South Magnetic Pole, ending with a providential rescue of the exploring party. A large quantity of geological and other scientific data was accumulated during the course of the expedition.

On the outbreak of the Great War he was instrumental in raising a mining corps, with which in 1915 he proceeded to Europe as geological expert. Eventually he became Chief Geological Adviser to the whole of the British armies on the Western Front, an onerous and arduous post which he filled with characteristic thoroughness and conspicuous success. He was very seriously injured in an accident at Vimy Ridge, from the effects of which he never fully recovered. For his military services he was awarded the D.S.O., and in 1921 received the honour of knighthood. After the War he resumed his work at Sydney, but at the end of 1924 resigned from the Chair of Geology to devote

himself to the writing of his book on the geology of the Commonwealth. In spite of failing physical powers he continued steadily at this gigantic task, but at the time of his death it was still incomplete, though a first instalment, in the shape of a New Geological Map of the Commonwealth with Explanatory Notes, was published in 1932. His last, and perhaps most important, contribution to geological science was the discovery a few years ago of evidence of animal life in the strata of the pre-Cambrian Adelaide Series of South Australia.

The influence of Sir Edgeworth David upon geology, and indeed upon science generally, in Australia is beyond all reckoning. As a teacher he had the rare gift of gripping the imagination of his students and of imbuing them with some of his own glowing enthusiasm. His personal researches, extending over more than half a century, are monumental, and cover nearly every branch of geological science, while his indirect contributions, through the workers he inspired, cannot adequately be told. Science was to him the eager quest for truth, a joyous adventure in which fresh wonders and delights were ever appearing to reward the diligent searcher, and one of the secrets of his success was the unwearying patience and tenacity of thought and effort he brought to bear upon all his work. To the advancement of science he gave unsparingly of his time and energy, and he was a prominent member of many scientific bodies. In 1892 and again in 1895 he was president of Section C of the Australasian Association for the Advancement of Science, and he presided over the Association's meetings in 1904 and 1913. He was a foundation member and first president of the Australian National Research Council, and was on its Executive till the time of his death. He was for many years on the Council of the Linnean Society of N.S.W., and was President in 1893 and 1894. He joined this Society in 1886, served many terms on the Council, and was President in 1895 and again in 1910.

In recognition of his labours for science, academic degrees, medals and other honours were conferred upon him from time to time by universities and scientific bodies both in Australia and outside it. Notable among these were the Conrad Malte-Brun Prize (1905) of the Geographical Society of France, the Mueller Memorial Medal (1909) of the A.A.A.S., the Wollaston Medal (1915) of the Geological Society of London, and the Clarke

Memorial Medal (1917) of this Society. He was elected a Fellow of the Royal Society in 1900, and was a Corresponding Member of the Geological Society of America and an Honorary Fellow of the Royal Society of South Australia.

But it is not merely as a scientist that Sir Edgeworth David will be remembered. Never has man deserved better of his country and his colleagues and his friends, for honour and duty were his watchwords, and service and the love of his fellowmen were to him as the very breath of life. With his death there passed from among us one of earth's rarest and noblest souls.

WILLIAM SUTHERLAND DUN died on 7th October, 1934, after an illness extending over some months. Born at Cheltenham, Gloucestershire, in 1868, he arrived in Australia when about a year old, and was educated at Newington College and the University of Sydney, where he studied geology under Professor Stephens and later under Professor David. Entering the service of the Department of Mines in 1890, he was made Assistant Palæontologist to the Geological Survey three years afterwards, and Palæontologist and Librarian in 1899. In 1902 he was also appointed Lecturer in Palæontology at the University of Sydney, a position which he held till the time of his death. He resigned from the Geological Survey in 1933.

Gifted with much natural ability and with a phenomenal memory Dun profited greatly by his very thorough, not to say rigorous, training under his chief, Robt. Etheridge, Jun., the foremost palæontologist of his time in Australia, and as a result he acquired an unrivalled knowledge of palæontology generally, and in particular of the fossil fauna of this State, on which he became a recognised authority, and of Australia as a whole. His knowledge was not merely accurate, it was very extensive, since the duties of his position required his investigations to range over a wide field. Palæontologically his chief interest was perhaps in the lamellibranchs and brachiopods, and on the stratigraphical side he had devoted particular attention to the fauna of the Permo-Carboniferous (Kamilaroi) System. His studies also embraced the fossil floras of Australia. He was the author of several papers, particularly in the Records of the Geological Survey of N.S.W., and was constantly being consulted by fellow geologists in this and other States. Many of his views were

communicated in personal discussion with other workers, and in this way his influence in shaping stratigraphical thought was very considerable. A loyal colleague and a warm-hearted friend, he was always ready to place his extensive knowledge both of palæontology and of geological literature at the disposal of all inquirers. He was for a number of years on the Council of the Linnean Society of N.S.W., and served as President in 1913 and 1914. He joined this Society in 1908, and occupied the presidential chair in 1918. He took a prominent part in the activities of the Section of Geology from the time of its revival in 1909, and acted as Hon. Secretary, and later as Chairman.

JAMES LAURENCE GALLAGHER, M.A., A.A.C.I., died in January, 1935. He was born in Sydney in 1885, and was educated at St. Joseph's College. He was appointed chief chemist and manager of the glycerine department of Lever Bros. in 1911, and in 1917 became manager of the edible fats department. In 1934 he was appointed production manager, and at the time of his death was acting works manager. He conducted research on the hardening of oils, and was a member of various sub-committees of the N.S.W. branch of the Australian Chemical Institute.

RICHARD FORD JENKINS, who died on 22nd of January, 1934, was born at Yass in 1866. He joined the Public Works Department in 1891 and subsequently occupied positions as road superintendent and district works officer in several country districts. He was recognised as an authority on all matters relating to artesian and shallow boring. He was associated with the sinking of many trust bores which furnished water for stock throughout large areas in the north-west of this State, and was responsible for suggesting the inauguration of a scheme of shallow boring which has been of great value to many settlers on small holdings. He was a member of Australian conferences on Artesian Water held during the period 1912–1928, and when the Water Conservation and Irrigation Commission was inaugurated in 1913 he was appointed Engineer for Boring, a position which he held until his retirement in 1932.

FREDERICK H. MOORE, who died in 1934, was one of our oldest members, as he joined the Society in 1879. He was born near Perth, W.A., in 1839. He completed his early education in England, and joined the staff of Dalgety

& Coy. in London. He was sent to New Zealand in 1864, and in the following year became manager of the Invercargill branch of Dalgety, Rathay & Coy. A few years later he was transferred to Launceston, and the firm subsequently became Dalgety, Moore & Coy. After another short period in New Zealand he was sent to open the Sydney branch of Dalgety, Blackwood & Coy., in which he subsequently became a partner. He was a director of the Imperial Insurance Coy., and was the last Australian director of the Union Bank of Australia. He was a member of the Union Club of Sydney from 1877, and of the Melbourne Club from 1881.

CHISHOLM ROSS, M.D. (*Syd.*), M.B., Ch.M. (*Edin.*), died in October, 1934. He was a native of Inverell, N.S.W., and received his early education at Armidale and at The King's School. He left for Edinburgh in 1879 and on his return accepted a position on the Lunacy Board of N.S.W. He was associated with the mental hospitals at Gladesville and Newcastle, and founded the institution at Kenmore. He was Medical Superintendent at Callan Park for some time, and after twenty years of service to the State entered into private practice at Sydney. He was an eminent nerve specialist, and was regarded as a leader in his profession. His abilities as a psychiatrist were recognised when he was offered the Chair of Psychology and Psychological Medicine at the University of Sydney.

HENRY MONTAGU STEPHEN, B.A., LL.B., died on 4th November, 1934, in his 56th year. He was a member of a family traditionally associated with the N.S.W. Bar, at which he also practised for a number of years. He had been a member of this Society since 1921.

PART II.

SOME ASPECTS OF PROBLEMS ASSOCIATED WITH THE PRESERVATION OF HEALTH IN PLANTS.

A. GENERAL.

Introduction.

As far as I am aware, this is the first occasion on which your President was one whose major interests were concerned with that branch of science known as plant pathology, and in this address it is not proposed to present a technical discussion of any specialised phase of the

subject, but rather to deal in a somewhat general manner with certain aspects of some of the problems in which we are interested.

We are all aware of the main objective of our Society, which is that of receiving " original papers on Science, Art, Literature and Philosophy "—an indication, perhaps, that these subjects are not entirely unrelated, or at least were of interest to members at one stage in our history—but, furthermore, that the Society is concerned with papers " especially on such subjects as tend to develop the resources of Australia and to illustrate its natural history and production ". Our rules, it is true, do not contain any instruction to the effect that the President shall deliver an address, but such a practice is hallowed by precedent and tradition throughout the years. There is, however, a very practical, economic significance associated with the reference to the development of our natural resources. We may, at times, appear to take a merely academic interest in the papers which are presented and discussed at our ordinary meetings, but behind it all there is the belief, subconscious or otherwise, that the added knowledge will have some direct or indirect bearing on our existence and that it will contribute in some way to the welfare of mankind.

Science has bestowed many gifts on agriculture ; many former difficulties have been removed, but great as the need is still for the practical solution of many existing problems, a solution which may be expected from the application of existing knowledge or the utilisation of established principles, there is perhaps an equally great need for studies of a more fundamental character. It is true, unfortunately, that we need very much more information on the actual character of plant processes and on the principles underlying plant relationships. Although academic research or fundamental research may perhaps be best pursued in cloistered seclusion, so many questions arise during the investigation of a problem of economic importance and have to be disregarded temporarily, if not entirely, by the investigator, that one feels that the economic problem itself might be used more frequently as a basis for the academic research.

Some eight years ago our President, Professor R. D. Watt, spoke of the influence of science on the progress of the land industries in Australia, and indicated the very practical benefits which had resulted from this association.

To many of us the practical aspects of an agricultural problem are very real, even though it is realised that epoch-making discoveries are made when the investigator, in some glorious intuitive flight of imagination, forgets all save his interest in the purely technical aspects of the problem itself. It is still true, however, that our very existence is dependent on the living plant, or one may go further and agree that " all human life and consequently all human thought depends in the last resort upon agriculture ".

The modern philosophers inform us that some of the secrets of nature may be withheld until we are able to develop entirely new conceptions, but it is felt also that many practical problems may be solved by the adoption of existing technique and by the utilisation of such mental processes as form part of the equipment of the present-day investigator.

During these critical years there have been an increased realisation of the national importance of our agricultural industries and some increased measure of appreciation of the problems which are being faced by our primary producers. It is not proposed to attempt even a brief survey of these problems, but they are such as to have resulted in the development of various forms of State assistance in the interests of the national welfare. Special emergency measures have been enacted here as elsewhere, and have been subjected to a more or less well-informed criticism, but it may be accepted as a tribute to the efficiency, resource, and independence of our primary producers that the assistance now provided was not urgently needed in the past.

In this delicately balanced, or unbalanced, world of ours we are struggling for some measure of stability ; without it we can hope for little. Crop production will continue to be affected directly or indirectly by weather conditions, but at least we can hope, by a greater measure of control over some of the other factors in production, to make our primary industries more secure and less a speculative gamble than they are so frequently at the present time.

Appalling losses result each year from the incidence of plant diseases alone, but perhaps even more appalling, in view of existing conditions, is the fact that many of these losses result from diseases for which adequate control measures are available, and although the producer suffers directly, the whole community eventually is affected.

Furthermore, while it may be agreed that a relatively high degree of efficiency is evident in our production methods as judged by the volume and type of production and the small percentage of our population which is actively engaged in primary industry, this efficiency is relative only to that of other countries. While most primary producers today know infinitely more than their predecessors of fifty years ago, still too small a proportion of them is in a position to take full advantage of modern methods.

Not only do plant diseases constitute formidable hazards throughout the growing period of the crop; they are also of considerable importance during the period of transportation and distribution of many perishable agricultural products to local and overseas markets. Market demands are changing and, contradictory as it may seem, competent observers state that standards of living are improving; *e.g.*, there is a gradually increasing demand for fresh fruit in satisfactory condition. This may appear strange in view of some of our Australian fruit export experiences: these to a very large extent have resulted from the fact that it is not generally recognised that fruit is still part of a living organism, that its metabolism continues after picking, and is profoundly affected by the storage environment, and that its diseases of parasitic and non-parasitic character also depend on the previous history of the fruit as well as on the conditions to which it is subjected during storage. Until there is such an appreciation of these aspects of this problem our growers cannot expect to receive the reward that should be theirs. It is realised that the plant pathologist must play an increasingly important part in the elucidation of problems associated with this phase of production, and it is gratifying to learn that more attention is to be given to such problems in Australia.

Our present knowledge of plant diseases, remarkable as it is when compared with the blackness and the superstitions of the past, but yet so incomplete according to our present needs, is merely the development of much less than a century, yet we know that the incidence of disease was a matter of very deep concern to the ancients, that it had the most profound effects on past civilisations, and that it has resulted in bankruptcy and ruin to many an unfortunate farmer struggling for existence in the present century.

Although recently we have surveyed the plant disease situation in this State, our records on the first occurrences of individual diseases are in many cases incomplete. The early records of colonisation in Australia may contain more information than is apparent at the moment, but for the most part they appear to contain references only in the most general terms. Geo. Caley, who was employed by Sir Joseph Banks as a botanist and collector, wrote in 1803 that " potatoes were very bad and stinking on my coming here . . . but if the seed is exchanged often, they will improve ". A definite diagnosis on such meagre data is not possible, but as the symptoms so closely approximate those of the bacterial rots which follow infection by the Late Blight fungus, one may speculate as to whether the Late Blight disease was actually present in this country at that early period. Evidence to the contrary is provided by the fact that this destructive disease was not widespread in Europe until the 40's of last century, and our first official record of its occurrence in N.S.W. was obtained only in 1909.

Our early agricultural literature contains numerous references to the occurrence of smut and rust in barley and wheat, which are recorded as causes of " disaster and disappointment " to our early cultivators. Incidentally, it is of interest to note that Atkinson, in a discussion of agricultural methods in vogue in 1822, reports that he always " steeped any seed wheat in strong brine and had never had smut ". The first use of brine as a seed treatment dates back to the time of Jethro Tull (1650), even though the method was not strongly endorsed, but as indicated previously the first reliable facts concerning the nature of plant disease were not secured until about the middle of last century.

Health and Disease.

Today, as in the past, we recognise with ease the obviously diseased plant. We believe, also, from our general experience, that we have a very good idea as to what constitutes the healthy plant and as to what its growth and development should be under normal environmental conditions. For all practical purposes this is true for most plants and for the many thousands of plant diseases which are now on record, but academically we cannot differentiate sharply the conditions of health and disease. Marshall Ward, some thirty-five years ago,

in a discussion of this aspect of the subject, stated that " disease, like health, is an extremely complex phenomenon, involving many reactions and interactions between the plant and its environment ", and while disease may be specified as " a variation in directions dangerous to the life of the plant ", in health there is " a variation more or less about a mean . . . the normal in all cases being the state of the plant characteristic of the species ". Today we are more inclined to agree with the physicians who say more precisely that " disease is the correlative of health and is incapable of a more penetrating definition " and that " the healthy are really invalids unaware of their illness ".

The normal or the healthy is what we choose to designate as such in the absence of knowledge to the contrary, yet we know now, from carefully controlled experiments, that plants may suffer from " submerged infections ", as in the case of at least some of the cereal smut diseases ; we may see no development of the symptoms usually associated with the specific disease, yet appropriate tests may demonstrate that yield is affected adversely as a result of the unseen, and, under ordinary circumstances, undetected infection. Citrus fruits harvested when relatively low temperatures are experienced towards the end of the maturity period may show no indication of Black Spot (*Phoma citricarpa*) and at the time of picking may appear to be completely normal and healthy, yet at a later period, perhaps in some distant market, under the influence of higher temperatures, the fruits may suddenly develop the blemishes which owe their origin to infections of the young fruits in the previous spring or summer. We know that certain tulip varieties owe their prized characteristics to the presence of a virus infection—one named variety may actually be turned into another at will merely by the addition of the appropriate virus. We know, too, that that which we considered normal in the variegated leaves of many abutilons and other ornamental shrubs, and which moved taxonomists to provide them with varietal and even specific rank, is, in fact, abnormal in so far as the distinguishing characteristics are again the result of virus infection.

Still more disturbing to our sense of security is the much more recently determined fact that many plants are apparently normal in every respect, resemble their close relatives in all general foliar characteristics, and in

the main conform to our standards of normality for plants in general, but are nevertheless diseased. Such plants are represented by the symptomless virus carriers now recognised in certain widely grown potato varieties and other plants, which may yet constitute plant pathological problems of the first importance. We may no longer assume that such plants are healthy simply because we do not detect in them any of the usual symptoms of disease.

Apart from such considerations as the foregoing, obviously diseased conditions in plants have been so striking in appearance, and have been so important economically, that they have long been the subject of observation and study. Concepts have changed considerably as new facts have become available, and the history of the development of the science of plant pathology is itself of absorbing interest.

While we realise now that the health of the plant may be affected directly and adversely by an unfavourable environment, it is accepted that most diseases result from the operation of various pathogenic fungi, bacteria, or other infective agencies. Environment, however, still plays an all-important part in the development of such diseases. The importance of climatological factors was appreciated long before there was any knowledge of the ætiological significance of the fungi, and even now we may speak of wheat-rust weather, potato-blight weather and so on, but modern studies are providing us with more adequate data on which we may evaluate the relative importance of the major and minor variables represented in the complex of host, parasite and environment.

Physiological Forms.

Variability and plasticity of the host plant have enabled marked progress to be made in the development of disease-resistant varieties, and this progress has been perhaps most conspicuous in those instances where variation in the associated parasitic fungus has been recognised and adequately determined, as, for example, in the cereal rusts.

As is the case with higher plants, the Linnean species concept is no longer tenable; mycologists will continue to have their taxonomic difficulties, but the plant pathologist is more than ever concerned with the physiological, and particularly the parasitic, capabilities of the various entities which for convenience are included

in the morphological species. The use of the term *entity* at times may be misleading, for its determination depends so much on the criteria which for the moment are considered as being adequate for the purpose. The recognition of the existence of physiological forms or strains of parasitic fungi in ever-increasing numbers in an ever-increasing multitude of genera and species, however, is a feature of modern plant pathological activity. Furthermore, as a result of developments in the very recent past, we know now that new forms may originate by mutation and, even more significantly, by hybridisation; new forms have been synthesised and previously known forms have been reconstituted by this means. The demonstration of the manner in which hybridisation may occur constitutes a very real achievement in plant pathological research; the facts are of intense academic interest and of considerable practical significance, but on this occasion it is proposed only to touch very briefly on certain practical aspects of the phenomenon.

While current thought is to the effect that the physiological entity itself is stable—it is not subject at least to influences which enable it to change readily its parasitic capabilities—yet there is ample evidence that variability may be a feature of many groups of parasitic fungi which we recognise as species.

In our discussions on the antiquity of disease we are accustomed to state that plant diseases are probably as old, or at least almost as old, as the plants in which they are now known to occur. While, generally speaking, this may be true, in the more restricted sense we have to recognise that some diseases may be new in that they have resulted from the development of new physiological forms of a pathogen. On the other hand, although new forms are being recognised and recorded from time to time, fortunately all are not more virulent than those with which we are already acquainted; in fact, the variants in some species may be non-pathogenic, and the phenomenon apparently is one which is more characteristic of some species and genera than of others. For instance, there may be many variants of such genera as *Puccinia*, *Ustilago*, *Helminthosporium*, *Fusarium* and *Fusicladium*, whereas in a species such as *Urocystis occulta*, as suggested by Stakman[3] and others, there may be relatively few, if

[3] Stakman, E. C., Cassell, R. C., and Moore, B. M.: The Cytology of *Urocystis occulta*. *Phytopath.*, *24*, 889, 1934.

any—no such variants have been demonstrated as yet—possibly because of the few opportunities which exist for development of new associations of sex nuclei. This probably is also the position in respect of the flag-smut fungus, *Urocystis tritici*, and, if so, a complication is removed from the plant breeder's programme.

Furthermore, there is evidence to the effect that circumstances may not favour the persistence of forms. Stakman[4a, b] has shown that the prevalence of forms of *Puccinia graminis*, the cereal black stem rust fungus, may vary in different years in the United States, and Waterhouse[5a, b] has recorded a similar phenomenon in this country. Not only is this the case for the rusts, but it is recorded also in the case of some cereal smuts, and it is probable that examples have yet to be noted in respect of other parasitic fungi.

The position can only be accounted for in the most general terms by suggesting that it is dependent on the operation of factors in the environmental complex, although the significance of the individual variables which are of importance in this connection has yet to be elucidated more completely.

Such a situation, however, indicates some of the difficulties which have to be faced by plant breeders, but these difficulties are perhaps not so serious as appears to be the case at first sight; variability may be characteristic of the pathogen, but significant variations in many instances apparently do not occur with great frequency in nature, or the plant breeder would not have been able to achieve his present measure of success in the synthesis of disease-resistant varieties.

Environment and Plant Disease.

Although there may be a tendency from time to time to over-emphasise the importance of one factor or another

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[4a] Stakman, E. C.: Physiological Specialisation in Pathogenic Fungi. *Proc. Int. Congr. Pl. Sciences* (1926), *2*, 1320, 1929.

[4b] Stakman, E. C. *et. al.*: Population Trends of Physiologic Forms of *Puccinia graminis tritici*, 1930 to 1934. *Phytopath.*, *25*, 34, 1935. (Abstract.)

[5a] Waterhouse, W. L.: Some Aspects of Cereal Rust Problems in Australia. *Proc. Fifth Pacific Sci. Congr.* (1933), 3169–3176, 1934.

[5b] Waterhouse, W. L.: Australian Rust Studies. 5. On the Occurrence of a new Physiologic Form of Wheat Stem Rust in N.S.W. *Proc. Linn. Soc. N.S.W.*, *60* (in press), 1935.

in any discussion of plant-pathological relationships, there is little danger of over-emphasis of the importance of factors which are, or are to be recognised as, environmental influences. The development of the host plant may be so affected by external conditions, *e.g.*, by soil or climatic influences, that it becomes predisposed to disease of parasitic origin, although such a statement is subject to qualification in accordance with the particular disease under consideration. Environmental factors may affect viability and distribution of the pathogen and may have a very direct influence on infection phenomena and the subsequent development of the pathogen in the host. The plant-pathological literature of our period contains the record of many investigations on these ecological or, more precisely, epidemiological or epiphytological relationships. Difficulties are experienced in the correct assessment of the importance of critical factors, since it is so difficult in experimental work to modify one factor without influencing others, but many positive correlations have been determined and have contributed in no small measure to our knowledge of the phenomena associated with the development of disease in plants.

Not only is this true for such diseases as the rusts and mildews, in which infection and development of disease may be closely correlated with climatological factors, but it is increasingly true for diseases of the root-rot type in which infection and development are so closely associated with environmental conditions in the soil.

Although, literally, environment may be considered to comprise " all the external circumstances of an organism ", we have tended to restrict our conceptions largely to the meteorological influences of moisture and temperature, but there is now an added appreciation of the fact that many other factors may be considered in this connection. Not the least important of such factors are those represented by other organisms. Intensification of disease may result from the combined effects of several organisms in the well-recognised phenomenon of synergism, whereas on the other hand antagonistic or antibiotic effects may result in reduction in intensity of disease. Somewhat analogous conditions are encountered in certain virus diseases, although, as will be indicated later on, we are not yet certain whether the viruses are living organisms or not.

There are many records of synergism among the fungi, and additional data are being accumulated in respect of some of our Australian problems. Two of these at least possess some features of interest. Geach[6] has reported on the importance of flag smut infections in accentuating damage caused by root-rots in wheat, and in our laboratories we have noted, on occasion, the extremely close association of *Alternaria* and *Glœosporium* in the development of lesions of the Brown Spot disease of passion-fruit. In the latter instance exceedingly small lesions, little more than 1 mm. in diameter, have frequently yielded cultures of both organisms even at this early stage in the development of the disease.

Antagonistic effects are of considerable practical significance in the development of a number of soil-borne diseases and are well exemplified in cereal root-rots which now have assumed an economic importance exceeding such formerly devastating diseases as the rusts and smuts. One of the aims of the agriculturist now is to ensure, in the absence of the host plant, that the root-rotting organisms may fight a losing battle in their competition with other organisms.

Reinking[7] has recently discussed the influence of soil type in relation to the development of the Fusarium diseases of the banana, and although the exact nature of the environmental influence in this case has not yet been elucidated completely, significant correlations have been established between soil type and the development of disease. The relationship is such, as he has pointed out, that one may now assess the suitability or otherwise of areas proposed for new plantings and determine the rotational period required before replanting may be undertaken in old areas.

Adequate data on the nature of environmental relationships may have a very important bearing on such questions as the need or otherwise for protective measures. The farmer himself may decide that his soil-moisture conditions are such that he may sow his grain without treatment for prevention of smut, although he may or may not realise

[6] Geach, W. L.: Foot and Root Rots of Wheat in Australia. The Influence of the Combined Action of *Fusarium culmorum* (W.G.Sm.) Sacc. and *Urocystis tritici* Koern. on the Occurrence of Seedling Blight. *Jour. C.S.I.R. Australia*, *6*, 269–278, 1933.

[7] Reinking, O. A.: Soil and Fusarium Diseases. *Zentralbl. für Bakt.* etc., Abt. II, *31*, 243–255, 1935.

the risks that are run in this connection in the absence of any reliable meteorological forecast covering the whole critical period up to the time of seed germination. His action may thus represent the exercise of good judgment or may be purely a speculative gamble according to one's point of view.

Spray-forecasting programmes have been of some value in certain favourably situated localities in which the circumstances permit of suitable organisation for the collection of essential data and broadcasting notification of the need for immediate and appropriate action, and where suitable facilities and equipment are available for adoption of the recommendations. Pierstorff[8] has recorded the success of such measures in the control of apple scab (Black Spot—*Venturia inaequalis*) in areas of eastern United States, in which economies up to 50% of spraying costs have been effected. In spite of comparative failures of spray-forecasting services in other parts of the world in the past, it is considered that conditions in some of our eastern mainland apple-growing areas are now such that a service of this type would prove of value in reducing costs of protection against our Black Spot disease.

Plant Quarantines.

A knowledge of the factors which are of importance in the establishment and development of disease is of the utmost value in an even more difficult phase of crop protection, *viz.*, the development of appropriate quarantine measures. The pathologist may find it difficult enough to attempt any forecast of the possibilities of development of disease in crops at the commencement of a season, but it is more difficult still to indicate the type of restrictive measures which are considered necessary to prevent the introduction of diseases which, as yet, have not been established in a new country.

All too frequently, however, we are receiving first-hand information to the effect that new and serious diseases, particularly those of seed-borne character, have found a congenial environment in Australia. We believe that such diseases as Potato Wart, Fire Blight of apples and pears and Citrus Canker, although not present in this country, could result in losses if once introduced and

[8] Pierstorff, A. L.: A Centralised Scab-spray Service. *Phytopath.*, *22*, 759–766, 1932.

established here. Our data in respect of the means of distribution of Fire Blight, however, appear to justify the opinion that risks of introduction of disease might be quite real if stocks were imported indiscriminately from affected areas overseas, but that there is no sound basis for assuming that there is a real risk of introduction of the disease by means of the fruit.

Although citrus growers need not anticipate any suggestion that there should be relaxation of existing measures for prevention of the introduction of Citrus Canker, one may suggest with some justification, on the basis of the world survey of the present distribution of the disease in relation to climatic conditions,[9] that it would not be so serious in N.S.W. as some of our existing citrus troubles. If the unexpected should occur, eradication might be effected more readily than has been the case in more tropical areas such as those of Florida, U.S.A.

As time has gone on, more and more information has become available, so that the plant pathologist is able to make even sounder assessments of the risks of introduction of new diseases and is able to formulate regulatory measures on a more satisfactory basis. Misunderstandings, inadequate as such a term may be as an expression of the situation, have given rise to serious repercussions in Australian trade relationships in the recent past and, as expressed at the recent Australian and New Zealand Association for the Advancement of Science meeting,[10] have again emphasised the still further need for the very close study of the technical and economic bases which may guide us in the future. Plant pathologists elsewhere are amazed that implications of restraint of trade should still be matters for reference to our courts when the questions involved are essentially those of technical character, which are capable of adequate determination by the technical specialists.

Control of Disease.

It is not proposed on this occasion to deal in any detail with the measures which are adopted to control disease in plants, beyond stating that they are of the type designed mainly for preservation of health in the plant. The health

[9] Peltier, G. L. and W. F. Frederick: Effects of Weather on the World Distribution and Prevalence of Citrus Canker and Citrus Scab. *Jour. Agr. Res.*, *32*, 147–164, 1926.

[10] Plant Quarantine. *Jour. Austn. Inst. Agric. Sci.*, *1*, 21–26, 1935.

of the plant, and even more particularly the preservation of health in massed populations of plants, is the major concern of the pathologist. Control of diseases of parasitic origin depends on many features of the plant, pathogen and environmental relationship, but for the most part the measures aim at destruction of the pathogen by means appropriate to the circumstances of any particular instance. In its simplest form this is expressed by sanitation procedures which involve destruction of diseased plants or plant parts, and the value of such measures even in the more complicated control programmes sometimes tends to be overlooked. The amount of inoculum or original spore-load may have a most important bearing on the efficacy of measures subsequently adopted for protection of the plant.

Therapeutical measures play an inconspicuous part in most plant disease control problems at the present time. Interesting possibilities in the development of immunity are envisaged by investigations such as have been conducted by Leeman[11] with parasitic fungi, and by Kunkel[12] in his studies on acquired immunity to virus infections, but in this latter group of diseases we are still mostly concerned with the unspectacular methods of control represented by sanitation or eradication measures.

B. Virus Diseases.

In the studies on fungi and bacteria the investigator at least has had the satisfaction of knowing that he is working with some tangible entity, something which can be readily observed and measured and, furthermore, in most cases, which can be cultivated and still further studied apart from the host plant itself.

Important as fungi and bacteria still are in relation to the development of disease in plants, we are perhaps at the moment even more concerned with yet another group of infectious conditions—the virus diseases. Various positive and negative characterisations have been suggested for the infectious agencies themselves but, as suggested by K. M. Smith, it is agreed that we might, for all practical purposes, accept Gardner's definition that they are " agents

[11] Leeman, A. C.: The Problem of Active Plant Immunity. *Zentralbl. für Bakt.* etc., Abt. II, *85*, 360–376, 1932.

[12] Kunkel, L. O.: Studies on Acquired Immunity with Tobacco and Aucuba Mosaics. *Phytopath.*, *24*, 437–466, 1934.

below or on the border-line of microscopical visibility which cause disturbance of the function of living cells and are regenerated in the process ".

Virus diseases are of widespread occurrence throughout the animal kingdom, and many of them cause serious trouble in man, but we have not yet a full realisation of their distribution and importance in plants; however, since the investigations of Iwanowski and Beijerinck—who demonstrated that the infectious qualities of the sap were not removed by passage through a porcelain filter—the latter's prediction that these conditions would indeed be found to be of very general occurrence has been more than amply justified.

Such is the importance of the group, and so intensely interesting are the relationships which are involved, that the past decade particularly has seen the publication of an enormous volume of literature on the subject. Also, as in other cases where the frontiers of knowledge are rapidly advancing but in which a full and satisfactory explanation of observed phenomena cannot yet be provided, the existing position has been reviewed from time to time in some detail.

When a plant pathologist speaks of virus diseases, possibly his first thoughts are concerned with the symptomatic picture. One thinks of such obvious features as the mosaics and chloroses, of stunted development of plant parts, reduced leaf-size, shortening of internodes, of malformations such as irregularly-shaped leaves, curling and puckering of the leaf-blade, gall formations, proliferation of shoots or production of so-called witches' brooms, of necrotic spots or streaks on leaves and stems, and so on. One of more of these symptoms we associate with a disease which, under field conditions, may be transmitted from plant to plant by an appropriate insect vector or by other means.

Although symptoms of this character may frequently be accepted as diagnostic, it is true that some of them are of the type which may result from causes other than that of virus infection. Certain chloroses, leaf-spot symptoms, leaf-malformations, lignification of tissues, gall-production, or witches' broom developments may be induced by one or other of such agencies as insect injury, mineral deficiency, abnormal climatic factors, fungous or bacterial infection—symptoms which from their very nature are also plant responses to destructive, inhibitory or stimulatory forces.

While one may remark on the inherent capacity for variation in plant tissues[13] in response to many apparently different agencies, one may conjecture whether the plant is indeed limited in its response to what are essentially different fundamental causes, or whether there is some basic activating cause of the same physiological character in all cases of any particular group. Are the witches' brooms, for example, which result from one or another of the virus infections on tomato, potato, lucerne, or other plants, and the witches' broom conditions caused by fungous attack comparable in any way physiologically with the bushy type of twig growth associated with some types of cell starvation or lack of an essential mineral nutrient?

Economic Importance of Virus Diseases.

The economic position which has resulted from the incidence of virus diseases in N.S.W. in the past has been the cause of considerable alarm. Mosaic and Fiji disease from time to time have caused very severe losses in our sugar-cane areas. The former disease is now known to have occurred here in 1904, and the latter was observed prior to 1885. Both diseases may be controlled by drastic eradication of affected plants as soon as the early signs of infection are observed. More recently, however, difficulties have arisen because of the fact that some of the cane varieties now in favour on account of their resistance to bacterial gumming are more susceptible to, or are more severely affected by, these virus troubles than was the case with the older varieties.

Our banana industry furnishes another example of the destructive effects of a plant virus in the history of the Bunchy Top disease. Although the disease itself undoubtedly occurred here more than twenty years ago, it reached epidemic proportions during the great expansion of planted areas in the early post-war years. Peak production of more than 650,000 bushels of bananas was reached in the 1921–22 season, but it fell rapidly to approximately 91,000 bushels in 1924–25. The outlook was apparently hopeless, and many plantations were deserted.

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[13] Butler, E. J.: Some Aspects of the Morbid Anatomy of Plants. *Ann. Appl. Biol.*, *17*, 175–212, 1930.

Spectacular losses are still incurred as a result of the incidence of the Spotted Wilt disease of tomatoes, a disease which first became prominent in this State in 1920 and which now not only seriously affects many commercial areas but is also very prevalent in the home garden.

Other instances of this type are on record, but the forty virus diseases or suspected virus conditions which we have recorded on so many different plants of economic importance in this State are by no means an indication of the position, nor do they indicate the number of distinct viruses which may be operative, because of the difficulties associated with the determination of the specific agency in each case.

As is the case elsewhere, rarely do any of these diseases cause complete destruction of the affected plant. Although the diseases may appear to vary in intensity from season to season—just as the intensity of symptoms may be correlated to a certain extent with prevailing climatic influences—productivity of vegetatively propagated stocks and of plants which are of perennial character is frequently reduced to a certain basic level which tends to be maintained year after year. This is particularly true of some of the potato diseases which are so largely responsible for the low yields in many of our potato areas. If these virus diseases had been more completely destructive in the past, our growers would not only have appreciated the position more readily, but would automatically have been denied the possibility of continued propagation of low-quality infected " seed ".

More precise information is available in connection with the passion-fruit virus disease known to us as Woodiness or Bullet. As reported to this Society[14] in 1928, the disease was in evidence in this State prior to 1893, but for many years nothing was known of its true character. Passion-fruit production figures supplied by the records of the N.S.W. Government Statistician are illuminating and distressing. Commencing in 1913 the average yield per vine during each subsequent five-yearly period has been 0·4, 0·46, 0·31 and 0·27 bushel per vine in bearing. In 1933 there were approximately 256,000 vines in bearing, more than twice the number recorded in 1916, yet production of 59,000 bushels was the same. During

[14] Noble, R. J.: Some Observations on the Woodiness or Bullet Disease of Passion Fruit. THIS JOURNAL, *62*, 79–98, 1928.

the past two years the annual average yield has been only 0·23 bushel per vine. This is an exceedingly low figure, and surveys of our passion-fruit areas in recent years have shown that this low level of production is closely associated with the widespread distribution of the Woodiness disease.

The extension of planted areas and the perennial nature of the vine appear to have resulted in a condition similar to that in crops propagated by cuttings, and if this disease also had been immediately and consistently destructive in character the economic position of most passion-fruit growers probably would not be so serious as it is at the moment.

Antiquity of Virus Diseases.

The question sometimes arises as to whether the plant virus diseases are of relatively recent origin or not. To a certain extent this question is associated with the problem of the living or non-living character of the virus itself; from the pathological standpoint, however, there is no doubt as to the infectious qualities of the virus, whether or not it is an extremely small organism fundamentally of the same type as other forms of life, or whether it is an agency derived *de novo* from the protoplasm of the cell as a result of appropriate stimulatory forces, as is occasionally suggested in such a challenge to existing thought on the subject of spontaneous generation.

Apart from such considerations, however, diseases now known to be caused by distinct viruses were on record for many years prior to the accumulation of any knowledge as to their true character. Quite recently it has been determined that definite symptoms of the Tulip Mosaic or Tulip Break were present in tulips introduced into Europe from Turkey in the middle of the 16th century, and a similar situation may have existed with respect to many other plant virus diseases but, since these conditions were not recognised as diseases comparable with the smuts and rusts of cereals, there is but little information of diagnostic value concerning them in the literature of the past.

During the past fifty years particularly, however, not only has there been an enormous increase in the volume of trade in plants, plant parts and seeds throughout the world, but there have been considerable extensions of areas planted to one crop in individual countries. Whereas isolation was characteristic of our own production areas in the past,

such a condition is no longer in existence. Many of the virus diseases known here were once present in other parts of the world and have been introduced in infected plant parts and subsequently widely distributed in this country. The relative importance of the development of appropriate insect vectors is not yet known completely, but it is possible that there have been also introductions of new vectors which have facilitated distribution of some of these diseases under our conditions.

It is far more difficult to attempt any assessment of the importance of one crop in its relationship to the development of virus diseases in other crops. Although, for example, tobacco production has had a rather chequered history in this country, the crop was under cultivation as far back as the 20's of last century. Tomatoes, on the other hand, although referred to in at least one Herbal of the 16th century, were grown for many years purely as ornamental plants, and it was not until the latter part of last century that there was any beginning of an appreciation of the food value of the fruit, with a resultant increase in the areas devoted to production of this crop. The tomato Spotted Wilt disease may now be carried over under our conditions in tomato plants which are to be found in growth practically throughout the year or in virus reservoirs such as are provided by infected nasturtiums and a number of other garden plants. Although the tomato may not have been the original host for the Spotted Wilt virus, it has directly and indirectly facilitated its distribution in this country, and appears to have made possible the occasional serious development of the Spotted Wilt infections in tobacco and other plants.

There is thus evidence to the effect that virus diseases as a group are not necessarily new diseases, but that modern conditions have enabled them to become more widespread and have made possible the development of new manifestations of such diseases in crops previously not known to be affected.

Control of Virus Diseases.

At one time it was thought that when symptoms of virus infection were observed in a plant all portions of the plant soon became infected. This is actually the case in many instances, and an appreciation of the fact has made it possible for success to be achieved in the control of several of our major virus diseases by the adoption of field sanita-

tion measures involving the roguing or eradication of plants at the first sign of disease. These measures, however, are effective only when the disease is of the type which spreads slowly in a crop, or in which the situation is not seriously complicated by the existence of other host plants. They are measures which, as a rule, are particularly applicable to stud plots or areas devoted to the production of certain types of seed or vegetative parts used for plant propagation, and have been very successfully adopted in potato improvement work, but at the same time they are of little value in commercial crops when the extent of infection exceeds some 5% or 10% of the total number of plants in the crop.

Even in those instances which respond to treatment by roguing, as is the case with Bunchy Top of bananas, where the virus is restricted, so far as we know, to the banana plant itself, it is doubtful whether existing methods will ever eliminate the disease entirely. A certain low level of incidence of the disease may be expected through the exercise of existing measures which involve only removal of plants as soon as symptoms of disease are noted.

There are a number of factors which operate against the practical application of eradication measures in many cases. The insect vector phase cannot be completely controlled, and although insect infestation may be reduced by climatic and other environmental influences or by artificial means, diseases may be spread from plant to plant before symptoms of infection become obvious, and environmental influences may even result in the masking of symptoms of disease in infected plants. Difficulties such as these have resulted in the intensive examination of means which might be of practical value in detecting the presence of infection in plant parts before they are used for propagation purposes. Folsom[15] has reviewed this position with particular reference to the potato diseases, and has indicated that in spite of the effects of the virus on the physiological condition of the tissues as judged by staining reactions, viscosity of the sap, electrical conductivity, X-ray patterns, fluorescence and luminescence with ultra-violet light, tests based on such reactions are not applicable for determinative purposes. Plants must still be grown under appropriate environmental conditions to determine whether virus diseases are present or not.

[15] Folsom, D.: Potato Virous Diseases in 1933. *Amer. Potato Jour.*, *11*, 235–236, 1934.

One realises, however, that the development of suitable tests for detection of diseased tissues could not fail to be of great practical value.

Although individual viruses cause diseases of more or less serious character in a specific host plant, even more serious symptoms frequently result from mixed virus infections. In such cases the plant already affected with one disease is subjected to additional infection by another virus which itself may have been evident as a disease or may have been carried in a masked condition by another variety of the same plant or in an entirely unrelated plant. Under appropriate conditions this synergic effect may be maintained by the transference of both viruses from plant to plant within a crop as though they constituted a single entity. On the other hand, the presence of one virus may confer some protection against the effects of other virus infections. In such cases the reduction in severity of symptoms, which is accepted as an expression of acquired immunity in the plant, may be considered as a form of antibiosis, although as indicated by Kunkel (*loc. cit.*, p. 464) the exact nature of the phenomenon is not yet established.

The possibilities for development of new types of disease, the presence of disease in related or unrelated plants in a masked or unmasked condition, the generally systemic nature of infection, the impracticability of control of insect vectors or of the development of usual protective measures, have made the problems of control the despair of many plant pathologists. While such difficulties are realised we may, however, take heart from the fact that it so happens that there are no serious complicating factors to be considered in some cases, as local eradication measures fortunately have shown in the commercial control of such diseases as Bunchy Top of bananas and Leaf Roll of potatoes. There is a basis for optimism also in the fact that although a disease such as Spotted Wilt of tomatoes has such a wide host range, some plants affected by the specific virus respond only by the production of local lesions and the disease does not become systemic.

It is a most fortunate circumstance, also, that true seeds are so rarely infected. Even in the Leguminosæ, where infection is common, rarely more than 50% of the seed from diseased plants carries any infection; in other cases the phenomenon apparently does not occur, or else the percentage of infected seed is extremely low. Finally,

in cases where systemic infection is the rule and where plants are propagated by vegetative parts, environmental influences may so check the progress of infection that certain portions of the plant may escape infection.

Investigation of Virus Diseases.

Satisfactory reasons cannot yet be offered in explanation of such phenomena. No plant virus has yet been isolated in the pure condition, although for all practical purposes this has been effected in certain infection experiments, nor has any plant virus been cultivated *in vitro*. There is evidence only of its multiplication in the living plant and in certain tissue culture experiments. Although successful cultivation in the absence of plant tissues has been reported, the results have not been confirmed by subsequent tests, and if the virus is indeed a living entity, and even if it does not differ fundamentally from the forms of living matter with which we are acquainted, difficulties of propagation *in vitro* may be as real as those associated with the attempted culture on artificial media of such obligate parasites as the rust and mildew fungi.

Purification of virus suspensions is providing useful information in cases where the virus is of the type which can be transferred readily in infection experiments. Precipitation methods and still further improvement in technique in filtration may yet provide a virus free from all trace of extraneous plant protein or other plant products, and will enable more critical studies to be completed. Skilful preparation and utilisation of membranes have enabled calculations to be made of the probable size of virus particles associated with specific diseases, although one cannot yet be certain that the particles have indeed been free from the protective action of other colloids, and still more critical studies have yet to be made on the effects of controlled environmental conditions on the viruses themselves. Thus the data already accumulated for the viruses in respect of such phenomena as ageing, resistance to temperature and chemicals, electrical conductivity, and reaction to high frequency sound radiation are of comparative value only, and do not provide us with data on the exact nature of the infective agency.

Perhaps at the moment even still further from solution are the problems associated with the nature of the real or apparent resistance to infection. The specificity which is characteristic of certain viruses can be appreciated in view

of our conceptions of obligate parasitism, but it is harder to account for the fact that so many unrelated plants may be affected by such a virus as that of tomato Spotted Wilt. Certainly in the case of the wide host range virus there are differences in the type of reaction—the local lesion and the type of local lesion in some hosts seem to represent evidence of the existence of a certain degree of incompatibility between host and virus as compared with the systemic reaction itself. We may for long have to be content with the evidence of observation alone, just as in the case of such a fascinating phenomenon as that of heteræcism in the rust fungi.

Masking of Symptoms and the Metabolism of Affected Plants.

Apart from the specificity or otherwise of the insect vector phase, of intense academic interest and practical importance is the phenomenon of masking as it occurs in so many instances of virus infection. This may be of either the high or the low temperature type, although light intensity is of importance in some cases. As reported on a previous occasion, our Woodiness disease of passion-fruit is typically a low temperature disease—fruit lignification and leaf abnormality symptoms may be non-existent in the new growth which develops on diseased vines during the warmer months. We cannot conjecture whether the environment in such a case exercises a greater effect on the virus than it does on the host.

Studies have been made on the metabolism of many plants affected with one or other of the virus diseases. Physiological changes are recorded and, although characteristic of an individual virus infection in some instances, they are not of the type which may be attributable to the activities of a specific group of infective agencies. Variations are recorded in respect of respiration and transpiration rates, in the quantities and types of photosynthetic products within the cell and, as in other cases of endophytic infection or in malnutrition, proteolytic processes frequently are more in evidence.

The development of inclusion bodies in such infections as those of Fiji disease of sugar-cane and in many mosaic diseases is not known except in association with virus infections, and although the bodies have been examined in some detail no more precise designation can be provided

for them than that they are products of cytoplasmic condensation.

In view of the fact that no plant virus has yet been studied in the pure condition, no data are available in respect of the metabolic activities of the virus itself although, indeed, it is a question as to whether such information can ever be obtained by such direct means. Whatever the nature of the virus, it is accepted that it is of colloidal character, and this feature may yet be correlated even more closely with such reactions as are found to occur within the cell.

Conclusion.

Difficult as it is at the moment to form any satisfying picture of the fundamental features of the plant host and virus relationship, it is clear from the purely practical standpoint that there is much yet to be done to clarify the position in respect of some of the diseases which are known to exist in this country. Time and again investigators throughout the world have stressed the need for systematisation of reports which record the occurrence of plant virus diseases. Existing criteria are admitted to be inadequate for the complete characterisation of all known viruses and the diseases with which they are associated, but with few exceptions most of the plant virus diseases recorded in this country are incompletely designated, even in accordance with such standards as are of value at the moment. Apart from a more or less complete description of external and internal symptoms, and in some cases records of transmission, we have few data on the associated insect vectors and, where several appear to be involved, on the relative importance of those which are operative. It is hoped that few of our viruses have such a wide host range as that already indicated for the tomato Spotted Wilt, but more exhaustive examinations may show whether present difficulties in control are associated with the existence of virus reservoirs other than those of the infected hosts themselves.

More information is desirable in respect of varietal responses under controlled environmental conditions, and more extensive use might be made of " purified " virus suspensions in cases where artificial transmission of the disease is practicable. Not only are observations of routine type desirable in respect of the Australian virus disease situation, but it is conceivable that more intensive

examination may be of value in an interpretation of the problem of the nature of virus infections generally.

Some biologists claim that the mere accumulation of facts by adoption of a generally accepted routine procedure may tend to dull the perceptions to such an extent that fundamental principles are obscured or overlooked. It is difficult enough to be sure of facts in any case, particularly when one is dealing with complex relationships of one or more organisms in an environment which is recognised as being infinitely more complex than was ever anticipated in the past, but established technique in plant disease investigation, with all its limitations, has contributed definitely to the development of some measure of stability in agricultural production, and its possibilities are not yet exhausted.

A DETAILED REGIONAL MAGNETIC SURVEY AS AN AID TO GEOLOGICAL INTERPRETATION.

DISTRICT: MITTAGONG-BOWRAL.

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(With Plates I and II and four text-figures.)

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INTRODUCTION.

Objects of the Survey.

The research covered by this paper originated in an endeavour to assist geologists in an interpretation of the igneous intrusion forming Mt. Gibraltar or "The Gib", situated between Mittagong and Bowral, in the parish of Mittagong, County of Camden, N.S.W. It was not definitely known whether it was a volcanic plug or a subhorizontal intrusion, and the author considered that a magnetic survey, occupying a relatively short time, might indicate the true nature of the mass. It was soon found, however, that the surrounding country included such a complexity of magnetic formations, mostly not apparent from the surface, that a detailed survey of the entire Mittagong-Bowral district would be required before a definite statement could be made; also, that such a survey would be valuable, in that purely local anomalies would fall into place in the general district survey, so that the superposed effects might be observed and noted for comparison and use in other areas.

Whereas simple and uncomplicated anomalies may be considered as problems in mathematics, a consideration of a given region as a whole and of experimental results in other regions forms the only practicable basis for interpretation where there are many unknown quantities affecting the field strengths and gradients.

This district is particularly rich in "negative anomalies", a fact likely to enhance the value of the results to be obtained from a regional survey; consequently

particular attention has been paid to localities where these features appear.

The author has established a private geophysical research station, " Hills and Dales ", in a ten-acre area covering portions of X33, X34, X41, X42, X43, X44, X49 and X50.

Map Co-ordinates.

The district included in this survey is shown in Plate I, and covers an area of some twelve square miles, The Gib itself being towards the centre. In this map each side of a large square (A, B, C, 2A, etc.) represents half a mile, so that the side of a small square represents five chains. In the text a large square is referred to by its letter, as A, 2B, α ; a small square by the appropriate letter followed by a numeral, as A1, B3, 2N26. When it is desired to fix a position to the nearest chain, a map-reference such as A1.32, or 2N26.24 is given. The origin of co-ordinates of each small square being its south-western corner, the first reference above is to a position in square A1, *three* chains east and *two* chains north of its south-western corner ; the second reference is to a point *two* chains east and *four* chains north of the south-western corner of square 2N26. The map is orientated to magnetic north.

Topography.

The Gib trig. station is at W57.00, the feature forming The Gib rising as much as 800 feet in the general area V, W, 2D, and 2E, above the surrounding country.

The area K, L, T, U is occupied by a hill of sandstone rising from Gibber-Gunyah Creek on its east, falling to the main Berrima-Mittagong road (in the extreme north of Plate I), and through J and S to the continuation of that road to the west (not shown).

Running approximately north-and-south in 2J and 2A up to the east-west road is a basalt-capped ridge which falls to the west off the map, and to the east into 2K and 2L towards Mittagong Creek.

The Gib itself rises, almost perpendicularly in parts, along the line 2E33.00, V63.00, V40.00 ; thence it rises fairly steeply from a line running north-east from that last point, falls fairly steeply on its north-eastern face into the creek running north in W, and falls more gently towards the east and south-east. The altitudes of certain points (by aneroid) are given on p. 44.

Three accepted altitudes are those of Mittagong railway station (2,070 ft.), The Gib trig. station (2,830 ft.), and Bowral railway station (2,210 ft.). The general slope of the country is to the north.

The north-to-south roads (King Street and Earl Street) in W and 2E exist only as tracks on the ground; they run into precipices. The same applies to the western portion of Count Street in W. Cliff Street in 2D runs into a precipice at the quarry in 2E33.10 (about its junction with Ellen Street), and has no existence to the east. Though The Gib itself is a tourist feature, the roads to the top from both Bowral and Mittagong are very rough, and at present impassable for cars in wet weather.

The area 2F, 2G, 2H, 2I is high land, falling towards the east from The Gib, and is mostly basalt-capped in the southern halves of those sections.

Plate II will help to make clear the nature of the topography

Geology of the District with Notes on Magnetic Intensities.

The geology of this district has been studied in part by several writers, the most complete descriptions being those of Jaquet[1] and Taylor and Mawson.[2]

Syenite.

The eruptive mass of The Gib itself is of fine-grained syenite (popularly referred to as "Bowral trachyte") probably of Middle Tertiary age.[3] According to Taylor and Mawson this is the denuded plug of an old volcano; those authors consider it improbable that it represents a denuded laccolith, though that is the conclusion drawn from the results given in this present paper. The stone varies in colour, in general darker stone being quarried from the Mittagong end, the stone from the south-eastern quarries being light grey to green-grey. It has been assumed by Taylor and Mawson that the light-coloured (leucocratic) syenite is the marginal rock, whilst the dark (melanocratic)

[1] Jaquet, J. B.: The Iron Ore Deposits of N.S.W. *Mem. Geol. Surv. N.S.W. Geology* No. 2, 1901.

[2] Taylor, T. G., and D. Mawson: The Geology of Mittagong. This Journal, 1903, *37*, 306.

[3] Browne, W. R.: Presidential Address, Roy. Soc. N.S.W. This Journal, 1933, *67*, 49.

syenite represents the more central portion. Analyses of both types are given in the work of Taylor and Mawson.

Browne[3] describes The Gib as "composed of ægirine-microsyenite with pneumatolytically-altered phases, intersected by narrow segregation-veins of pegmatitic aspect".

Intensity of Magnetisation of the Syenite.

Tests for susceptibility showed a wide variation, undoubtedly due to the difficulty of obtaining small specimens that were not weathered. Tests of small blocks recently quarried gave the same discrepancies, it being apparent that the edge material is far from uniform so far as intensity of magnetisation is concerned, even for specimens within a few yards of one another; but it must be remembered that all specimens available were either marginal rock, or from exposed rock surfaces up on The Gib itself where the degree of leaching is unknown. In many cases the stone quarried is taken from very large blocks separated from the main body by decomposed rock.

It is apparent, however, from readings taken on the mass itself, that in places the field is uniform over large areas of the flat, exposed rock-surface, so that either the mean value of intensity of magnetisation thus presented is uniform, or the intensity of magnetisation is fairly uniform away from the peripheral zone of leached and fallen material. (This does not apply to a length of about ten chains along an east-west line through The Gib trig. station itself; see p. 51.)

Specimens, picked for apparent freshness, gave values for intensity of magnetisation (I) ranging from 10^{-3} to 10^{-2} c.g.s. units. An average value for I for freshly quarried specimens was 3×10^{-3} c.g.s. units; this may be taken as the value in the magnetic field, the vertical component of which is 0·6 gauss. If we assume that the intensity of magnetisation is that due to the specimens being magnetised in a field of that order (the magnetic dip is 65° S.), the susceptibility may be taken as being of the order 5000×10^{-6} c.g.s. units. Since the rock-content so varies from zone to zone that the applied geophysicist is generally working on mean values, and since the history of the magnetisation of the rock is quite unknown, it is very doubtful if laboratory determinations of the susceptibility of specimens gives results which can be applied to the interpretation of magnetic surveys. We are presented

with rocks *in situ*, and can calculate the intensity of magnetisation (taken as a surface polarity of σ per sq. cm.) over extensive plane areas; we can collect samples of rock, and determine their magnetic moments, and hence their intensity of magnetisation. These values the author has found in good accord over a wide diversity of conditions. It seems that values of I are of much greater interest than values of μ (permeability) or of K (susceptibility), usually quoted. Determinations of values of K for different fields in the laboratory, for comparison with values of K for specimens *in situ*, are of definite interest in discussions of the magnetic history of the rocks; but that subject, particularly with regard to permanency of magnetic effects, is still extremely controversial. The applied geophysicist is generally concerned with mapping geological formations, etc., in terms of variations in existing intensities of magnetisation of the materials in position in the earth's crust.

The approximate area occupied by the syenite outcrop is enclosed within crosses (xxx) on Plate I. To the north, west and south the actual boundary is masked by syenitic talus-material, but to the east it is quite distinct, as there is no abrupt change of level.

Triassic Shales and Sandstones.

To the south and west the syenite of The Gib intrudes Wianamatta shales; to the north and east, Hawkesbury sandstone. The shales have their greatest known local thickness of about 80 feet near the northern end of the railway tunnel (V50). According to Taylor and Mawson, the sandstone is 600 feet thick.

Both these series of strata may be regarded as the main non-magnetic rocks of the district, the intensity of magnetisation being negligible in all specimens examined. Exceptions to this are in places where the soil appears of a definite red colour, possibly due to some small local occurrence of superficially decomposed igneous rock (see p. 56).

Basalt.

Probably the whole of this district has been covered by one or more extensive flows of late Tertiary basalt. This rock is found abundantly in the south-east of the area surveyed, overlying both sandstone and shale, with a line of contact through 2F, 2G, 2H and 2I; also to the south-west through 2A and 2K. Another, though smaller, area

occurs in W and X, overlying sandstones ; this portion is dealt with in greater detail on p. 49.

Small basalt caps are found in K10 and vicinity, and in M34 (this latter is thin and leached). Two little knolls protected by thin basalt caps stand up in 2F5 and 2F51.

All the basalt which could be collected for examination was considerably weathered. Small specimens, broken out of the central portions of larger boulders, gave values for I of the order 3×10^{-3} c.g.s. units. This is high compared with values found for larger boulders removed to Base and examined under the magnetometer ; they displayed definite polarity, north-seeking polarity being associated with the upper surfaces as found *in situ*. These boulders were surrounded by and separated from their neighbours by decayed basalt, and probably have never moved from their original positions. Browne (*loc. cit.*) considers that the basalt is of later date than the syenite, which had been laid bare by erosion prior to the effusion of the basalt.

Volcanic Necks.

A volcanic breccia-neck lies in V58 ; this has been cut through by the railway tunnel, so that the highest value found above it (1,874γ) represents the effect after subtracting a mass of material removed during the excavation of the tunnel. No good specimens of this material were found to test for intensity of magnetisation. A tuff-neck of some interest occurs in 2C and 2D ; it is described in detail on p. 57.

Minor Features.

The above represent the major rock-features of the area ; smaller occurrences of trachyte, dolerite, limonite, etc., will be dealt with under the appropriate section of the magnetic summary.

According to Jaquet (*loc. cit.*) layers of Tertiary material, " sandstones and shales for the most part highly ferruginous, with bands of concretionary iron ore " underlie the basalt flows. This material crops out on the lower slopes of the geophysical research area, " Hills and Dales " ; it is non-magnetic, so that its presence is not of interest in this survey. It is of interest to note in passing that specimens of limonite collected from the vicinity of a chalybeate spring at E40 acted as nearly non-magnetic material (see p. 58). Taylor and Mawson say of these Tertiary deposits : " The drifts and gravels occur almost invariably

wherever the basalt caps have protected them from denudation. They consist of rounded fragments of quartz and basalt cemented together by ferruginous material so as to form a conglomerate, which usually occurs as rounded blocks around the edges of the overlying basalt. The contained basalt indicates that the drift was partially derived from lavas earlier than the basalt capping. The iron cement was either leached out from the later covering of basalt or, as at the time of deposition these gravels occupied the river beds, it may have been derived from contemporaneous chalybeate springs."

The Magnetic Survey.

Instruments, Corrections, Bases.

Observations were made of the variations in the vertical component of the earth's field. The apparatus used[4] was a vertical field balance of the Adolf Schmidt type, constructed by the Askania-Werke Coy. The instrument is No. 88057, and the sensitivity on its present adjustment (checked regularly during the survey) is 40γ per division. The temperature correction is 8·5γ per centigrade degree.

The Main Base for the area was established at 2D61.24, a point on the shales (which there dip gently west) being pegged and spit-locked. Readings over several square yards in this vicinity, and with varying reasonable heights of magnets above ground level, were practically identical, varying by less than 4γ. This spot is referred to as Base Luxembourg in all records, from the private hotel " Luxembourg " conveniently situated up the slope on the opposite side of Clarke Street. Sub-bases were established as required, and were locked in with Base Luxembourg by repeated check readings. Much of the work was carried out under very difficult conditions; many traverses had to be repeated on the western face of The Gib, as it was feared that unavoidable slight shocks to the instrument during work on the steep, and in parts nearly precipitous, slopes might have caused an error. Readings, and check readings on later occasions, agreed very well, and it is considered that the important readings out to the west and east of the outcrop of The Gib syenite are correct to within 5γ.

[4] The apparatus used and its method of employment are described in many books and articles. Reference may be made to Edge and Laby: " Geophysical Prospecting ", Camb. Univ. Press, 1931.

Where big magnetic anomalies occur the readings are more accurate than the determined positions; the relative magnetic values, on which are based the closed curves, are correct to within 5γ.

The temperature correction was checked regularly, the observed variation from the mean value taken (8·5γ per centigrade degree) being less than 0·5γ per centigrade degree over twenty centigrade degree changes. Precautions were taken to protect the instrument from direct sunlight, and as far as possible from rapid changes of temperature.

To allow for variations in the vertical field due to diurnal changes or atmospheric magnetic disturbances, reference was continuously made to the sub-base concerned, at which generally at least four sets of readings a day were taken. On sections of the work where the variation from station to station was small, the sub-base was locked in with Base Luxembourg at the beginning and end of each traverse.

The interlocking of intersecting traverses was in all cases within 5γ of the previous reading, or of the interpolated reading, except over zones of big differential variation.

The observations have been corrected to allow for the normal northward gradient of 8γ per mile over the area.

Interpretation of Observations.

The Main Anomaly.

Base Luxembourg is recorded arbitrarily as 600γ, and is on shale, just off the talus from The Gib, on ground sloping gently to the west; its altitude is 2,280 feet.

Values over a large area to the north in Section E, in the vicinity of the Berrima-Mittagong Road, are uniform at 535γ. This is the lowest uniform value over a large area, which is thus considered to be that under which the magnetic rocks are at greatest depth; so that 535γ may be taken as the value over "non-magnetic" areas of the district.

According to Jaquet a bore sunk in 1887 in a position about F9.22 passed through 650 feet of sandstone to the coal-seams immediately underlying and conformable with the Hawkesbury sandstones. He reports the upper formation as being "coarse-grained sandstones and occasional narrow bands of shale". The sandstones there are either horizontal or dipping at a low angle. Jaquet adds: "The coal-measures would seem to have a thickness

of about 650 feet, having regard to observations which we made lower down the valley, where the Upper Marine formation can be seen cropping up from underneath them ". The small magnetic fluctuations over this area are due to igneous intrusions which are known to have penetrated the coal-measures as sills and dykes. The country here is flat.

To the east of the area (see Plate I) values fall below 600γ in Section α (on shale) and continue to drop further east; actually readings have been taken far to the east, the value decreasing to 553γ at the station three and one-eighth miles on a magnetic bearing 71° E. of N. from The Gib trig. station. (This station is at the position shown on parish maps as the junction of the *old* Bong Bong Road and the *old* Main Southern Road.) Even out here there is evidence of volcanic activity; for example, volcanic breccia is exposed in the grounds of the Marist Brothers, in a position about 20 chains east of the 553γ-station first mentioned. A chalybeate spring is found some 50 chains further east again. Readings were taken up the old Southern Road (running generally north-east, and approximately along the same 71° line from The Gib trig. station) for a further mile. They fluctuated very slightly (under 10γ) as far as the last station, where the reading was 528γ; half a mile further on (now a total distance of four and a half miles on 62° from the trig. station) another chalybeate spring exists. It would, however, require a detailed survey of this far-eastern area to correlate minor fluctuations with the main features dealt with in this paper. To avoid extending the map unnecessarily these eastern stations are not shown.

Isodynamic lines are drawn on Plate I at intervals of 100γ; the 600γ-lines are of greatest interest, because the spaces between 600γ-lines associated with different systems of closed curves represent zones of greatest depth of magnetic rock, and the areas where boundaries possibly exist at depth between different types of igneous formations. The 600γ-curve in α, Q, P, O, N, etc. (which would presumably be closed if the basalt cover were stripped off in the south-east portion in 2I, 2H, 2P) indicates the configuration of the magnetic body associated with The Gib itself; and since values are dropping slowly to the east, the material causing this magnetic disturbance presumably continues still to drop deeper, or to become gradually thinner, for at least a further three miles.

The creek running north in W has cut its way through the syenite; the sandstone begins within 50 yards of that creek on its right bank. In the vicinity of the junction of Whinstone Road and Duke Street (2E5) there is no abrupt change in surface slope, but, to judge from the isodynamic lines, the syenite passes below the sandstone, falling fairly steeply in 2E5 and 2E6; beyond that it continues to fall gradually to the east.[5] Sandstone encountered in a shaft in W62 dips at about 45°.

The whole of the eastern and north-eastern sandstones have been tilted by the intrusion, the effect being noticeable on strata in X2, 2G29 and as far out as Z26. The intrusion falls, or thins, beyond the 600γ-line, gradually to the north and to H and G, and much more gradually, as has already been noted, to the east. In the north-east matters are complicated by the proximity of an intrusive mass of dolerite in H, which is surrounded by trachytic or syenitic material. A house has been built on the higher portion of the outcrop, so that it cannot be surveyed completely. A reading on rock, northern slope, gave 532γ; five chains further south from this up slope, 861γ; five chains further south, nearer crest, 1,209γ; on the far side of the house ("Drumeevin"), highest ground, about eight chains on, back to 517γ.

The ground to the south-east of the area is high (2G, 2H, 2I); unfortunately it is covered by basalt, and this cannot be mathematically "skinned" from the surface without carrying the survey over a very much bigger area to the south and south-east, on to lower ground; it is considered that this would involve undue expenditure of time.

Immediately to the north of The Gib trig. station, and along the western side of The Gib, the ground falls precipitously into zones of negative anomalies; these negative anomalies lie on the lower slopes on talus, and are probably associated with big inverted and jumbled masses of magnetised material in juxtaposition to the cliffs of magnetised material *in situ*. The isodynamic lines are crowded together on the steep slopes. The syenite has a steeply plunging contact with the shales to the west and

[5] Actual altitudes in this area are: The Gib trig. station, 2,830 feet; 2E2.22, 2,765 feet; 2E3.20, 2,730 feet; 2F4.41, 2,695 feet; W55.24, 2,615 feet; 2F10.02, 2,615 feet; 2F3.14, 2,515 feet; 2F52.12, 2,565 feet (the hill drops fairly steeply down the road to Merrigang Street beyond this point); X36.20, 2,405 feet; X38.02, 2,290 feet Mittagong railway station, 2,070 feet.

with the sandstones to the immediate north ; indications are that it falls fairly steeply to the south also, but readings could be taken for a short distance only, owing to the proximity of the town of Bowral.

The negative anomalies are discussed in more detail below.

Whilst the country has not been contoured, a large number of altitudes have been taken. Attention should be drawn, in this connection, to two points as examples : W55.24 and 2F10.02 are places separated from one another by the dropping hill crest running west to east between them, but are at the same altitude ; they are both also just within the 800γ-curve.

In general, decreasing values are associated with decreasing altitudes ; exceptions are in creeks and valleys. It should here be noted that the bulge in the 800γ- and 700γ-curves (towards the north-west) in the north-eastern portion of W is in a deep depression between the basalt-capped ridge in the east of W and the main mass of the syenite to the west ; the main creek and its three chief branches occupy this depression. Values *rise* from 800γ to 941γ in the descent of 280 feet (aneroid) from W55.24 to the creek junction at W14.10, a horizontal distance of some 20 chains ; in a continuation of the traverse down the creek to the north, along the edge of the syenite (probably talus), a descent of 160 feet is accompanied by a *drop* in values from 941γ to 503γ in 16 chains ; in a further 11 chains to the final station (six chains off the railway line) there is a fall of 15 feet only, with a rise to 567γ, an expected value for that position.

Figure 1 is an isodynamic graph from F64.00 to 2O64.00, the readings on the basalt which caps portion of 2F and 2O being neglected. This section from north to south across the country to the east of The Gib is seen to give values rising from 590γ to 780γ in about a mile, and falling to 590γ again in another mile. There seems no reason to doubt that this magnetic anomaly is due to the same igneous intrusion that is exposed about a mile to the west as The Gib itself.

The Anomalies on the Western and Southern Side of the Gib.

The irregular shape of the area bounded by the 600γ-contour will be noticed on the map. The author believes that it is in accord with corresponding irregularities of shape in the intrusive mass. A valley eroded through

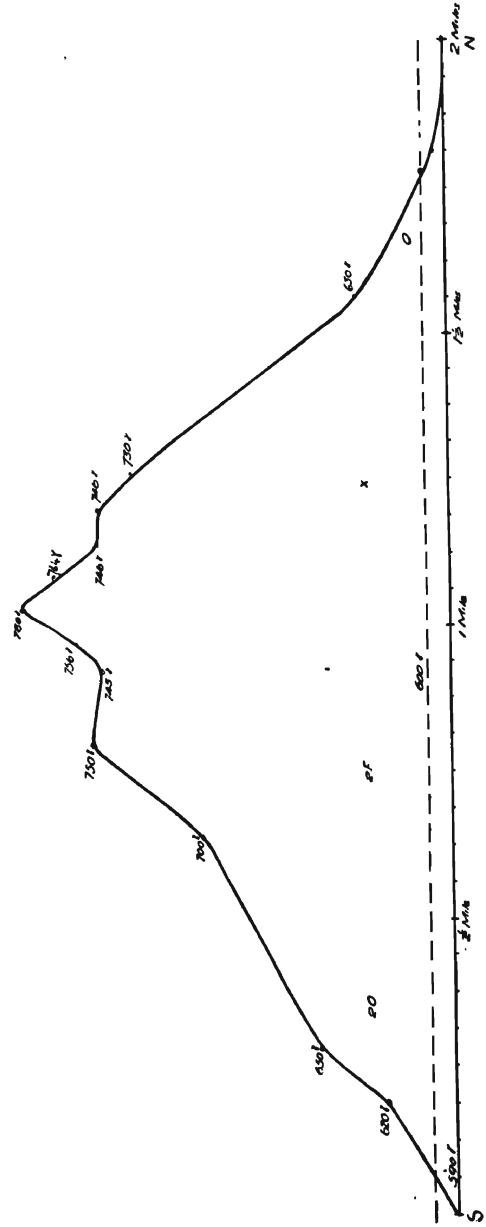


Fig. 1. N.-S. Magnetic Profile, one mile E. of The Gib trig. station.

sandstone runs from 2E into 2O. The tongue of (presumably) syenite running from 2E into 2N has caused the tilting of the shales exposed at 2N20.33.

The eastern edge of the main syenite mass in Section 2E has risen to a much greater height through the surrounding material than has the still concealed rock further east; Taylor and Mawson postulated that the magma had actually been erupted at the surface, though, as it is a microsyenite, and for other reasons, Browne believes that it remained covered by Triassic deposits through which it did not break, and that this covering, in part, has subsequently been denuded. Whichever happened, the magnetic readings suggest that the syenite welled up to a greater height and extends down to greater depths in the area bounded by the more congested isodynamics.

Nature of the Gib Intrusion.

The igneous mass appears to be somewhat like a partially buried lion lying on its side, portion of the syenite head being now uncovered and the body, still covered, sloping back therefrom some three or more miles to the east. It has forepaws (buried) protruding down through 2E into 2N and down through 2F into 2O and 2N; whether hind paws exist we do not know.

A consideration of all the facts set forth above leaves little room for doubt that, if minor irregularities be neglected, The Gib intrusion is essentially of the nature of an asymmetrical laccolith having its greatest thickness, and probably an elongated feeding-channel, to its west, thinning rapidly to north and south, and having its greatest extension to the east.

The Major Anomaly to the West.

To the west of The Gib, after the steep fall to the 600γ-curve and the zone occupied by negative anomalies, there is an area with values generally around 550γ, and in small localised zones below 500γ. Then begins another magnetic feature, with a 600γ-line running approximately north-and-south in M, V, 2D, and 2M; this line swings back to the north-west through L and B. The 700γ-line is nearly a mile further west, with a small area rising to 900γ immediately behind this, in S. An investigation of this locality led to the discovery of an outcrop of quartz-dolerite in the vicinity of S24, S32, and S40, not yet recorded by geologists. Just south of this point is the

peak of a positive anomaly, a closed curve with an observed enclosed maximum of 928γ ; no rock outcrop is seen there, but the soil is a very bright red where rabbits have excavated it from beneath the darker surface soil and humus.

To judge from the magnetic features, this anomaly to the west should be referred to a different geological feature from The Gib itself. Sandstone in A and C respectively has dips of 25° and 30°, and the dip directions at these points and in K33 and T64 indicate that the strata have been tilted from the direction of the quartz-dolerite in S. The general conclusion to be drawn from the tilting of the strata is that this western anomaly is due to magnetic disturbances associated with the outcrop of dolerite referred to above. There can be no doubt, however, that the whole of the area is underlain by an assortment of intrusive igneous rocks of varying magnetic content and at varying depth, forming superimposed minor anomalies which would require detailed survey ; an instance of such (exposed in this case) is the isolated patch of trachyte in C, breaking through a small patch of shale. The whole district abounds in such minor problems, which should present small difficulty in observation and interpretation when the survey of the whole area is considered.

Some few readings were taken well to the north-west, and to the west of this western anomaly, along the Berrima Road where it runs south-west again off the map. A reading at the sharp road-turn one mile ten chains on a magnetic bearing N. 19° W. from the basalt at K10.00 was 564γ. Southwards down the road, and thus at an approximately constant distance from that same reference position, readings ranged rapidly up to 670γ in the first half mile, and up to 674γ by the end of the next half mile. The 700γ-contour would be crossed about 15 chains on, the reading at the junction of this road with the road out from Bowral (one mile 15 chains about W. 20° S. from the basalt at K10.00) being 760γ. From these few readings out to the far west the general positions of the 600γ- and 700γ-curves, continued, can be visualised.

Special Anomalies.

Basalt Flows.—Reference has already been made to the basalt flows ; remnants of these, probably of considerable thickness in places, appear on the high ground, the only exception being the cap in M34. A reading of 1,326γ was recorded on solid basalt in 2K57, in the vicinity of

Mt. Oxley; the highest value on the knoll (rock) in the grounds of "Hopewood" (2A40) was 884γ; the basalt-covered ridge slopes down from the first position (highest altitude) to the second, which is near the northern limit of this basalt; readings just north, off the basalt, are about 750γ.

A reading of 1,158γ was made on the small cap in K10 (not necessarily the highest value there).

The small cap in M34 is leached, and no reading taken in the vicinity showed an increase of as much as 10γ above the adjacent sandstone values.

The outcrop of basalt to the south-east of The Gib was not examined, traverses ceasing as soon as the basalt boundary was crossed; crossing the boundary resulted in increases in the vertical component by amounts varying from 200γ to 400γ in a few chains; surface indications were the red soil, strewn with small basalt boulders.

A considerable number of readings were taken on and about the basalt knoll in 2F51, in a search for a high reading, but this feature persisted in being a negative anomaly, all readings being far below that of the surrounding sandstone; a value as low as 60γ was obtained. There is the surrounding sandstone, the values on which are 660γ to 680γ; on this is perched the small basalt cap, which forms a definite knoll some three chains by two; it is an outlier from the larger basalt sheet, from which it is well isolated; and it is a negative anomaly. This is not merely a reversal effect at an edge. In spite of arguments advanced by other writers that structures must be magnetised in the direction of the existing field and that "reverse" effects due to invasion of magnetised masses, for instance, cannot persist, here definitely is a reversed polarity. The author would suggest that it may be a reversal due to strong local currents, the basalt (possibly then a cap standing up above the surrounding ground) having been struck by lightning. A similar explanation is suggested below for other negative anomalies. In this isolated feature the lower surface of the basalt would be of positive polarity; possibly a positive anomaly originally existed in its immediate vicinity.

The Basalt in W and X.—The remaining basalt in Sections W and X is difficult to map by surface indications, as much of the area that appears to be basalt, to judge by red soil and stones, is wash from higher areas. As it is possible in the general scheme to "strip off" the basalt

flow by calculation, this has been the subject of a more detailed survey, to be shown later. Solid rock *in situ* runs along the ridge in an east-west direction in 2E7 and 2E8, and in 2F1 and 2F2. Thence it runs towards the north, ending in a cap in X9 and X17, which has resulted in the preservation of a ridge falling steeply into X1 and X2 (" Green Hills ").

Notes on Water Supply, etc.—Readings indicate that there is still some unleached basalt *in situ* in W32, W40, and W48. There are isolated patches of basalt in the vicinity, and considerable thicknesses of clay underlie the basalt and crop out around its margins, as marked on the map. The geophysical research station (" Hills and Dales ") is situated at X41.23, and many excavations have been made in the vicinity to check the observations. The layer of sandy soil and basalt wash between the more impermeable basalt and the clays forms a temporary reservoir for water flowing from higher up the hill, so that water seeps out continuously from springs just north of Whinstone Road in W47 and W48. A number of pits dug in X41 to a depth of three feet disclose springs in wet weather, and during periods of heavy rain the water-level rises, and water pours out freely over the eastern side of this basalt barrier. The author has had a large dam dug in the impervious clay (found, as expected, about two feet below the surface) in X34, on the eastern slope of the anomaly ; this is filled by water pouring down the watershed and by seepage.

On the higher levels south of Whinstone Road, in W62, W63 and W55, there are two clay layers, the water being trapped and flowing north and east between them. A shaft sunk in W62 (" Perry's ") down about 66 feet passes through : (i) 28 feet of clay and rotten basalt ; (ii) eight feet of very soft sandstone, white to yellow, iron-stained in bands, and dipping at about 45° away from the trig. station ; (iii) 30 feet of white clay ; (iv) what is possibly an igneous rock, leached, and fairly rotten. The sandstone was moist, and could readily be cut with a knife. It is apparently Triassic, so that no basalt can be expected underneath it.

A shaft sunk many years ago at X44.11 (for diamonds, not found) passed for 100 feet, so the author is informed, through sands and sandstone.

The Anomaly on the Summit of The Gib.

The readings along and near the line east from the trig. station seem to be inexplicably erratic. The area is a large, flattish surface of broken rock gently sloping towards the east; there is nothing from surface indications to suggest that such irregularities should exist as are shown in Figure 2.

The magnetic gradients are quite what are expected to the west of this, and also beyond a point some eight chains to the east; but readings along that eight chains range from 3,596γ just clear of the trig. cairn to the west, through fluctuating high positive values down suddenly to 658γ at 25 yards to the east; some 30 yards of these relatively low values lead to another peak of 3,261γ, and so on, as may be seen from the figure. The biggest change is from +4,559γ to −991γ, a variation of 5,550γ, in a distance of five yards; ten yards further on the value has dropped to −1,128γ, after which it rises steadily for 25 yards to a reasonably expected value for that position, 1,156γ. Further fluctuations occur for the next two chains, after which no such erratic readings are found.

This all occurs across exposed rock surface.

Four hypotheses are presented: (i) There might be a very localised concentration of magnetite close to the surface at positions of maximum intensity, the corresponding negative anomalies being corollary effects. This is quite improbable, and is rejected; there is no apparent change in the surface of leached syenite, which must be weathered (to judge by rocks broken on the area) to a depth of several feet. The effects are very sharply defined, and it is not reasonable to suppose that just at the summit of an intrusion and nowhere else there should be a sharp division into small zones very rich and others very poor in magnetic material. Nowhere is there any sign of mineral banding in the rock. In the circumstances it is not thought that the effect might have been due to differential cooling, giving local concentrations of magnetite, as suggested by Heiland[6] in his article on abnormal polarisation. The area is nearly plane, the effect is very local, and the distances involved between positive and negative anomalies are very small. It does not seem reasonable to suggest differential cooling here. (ii) The effect may be due to

[6] *Zeitschrift für Geophysik*, Jahrb. 6, Heft 4-7 (Ad. Schmidt-Festschrift).

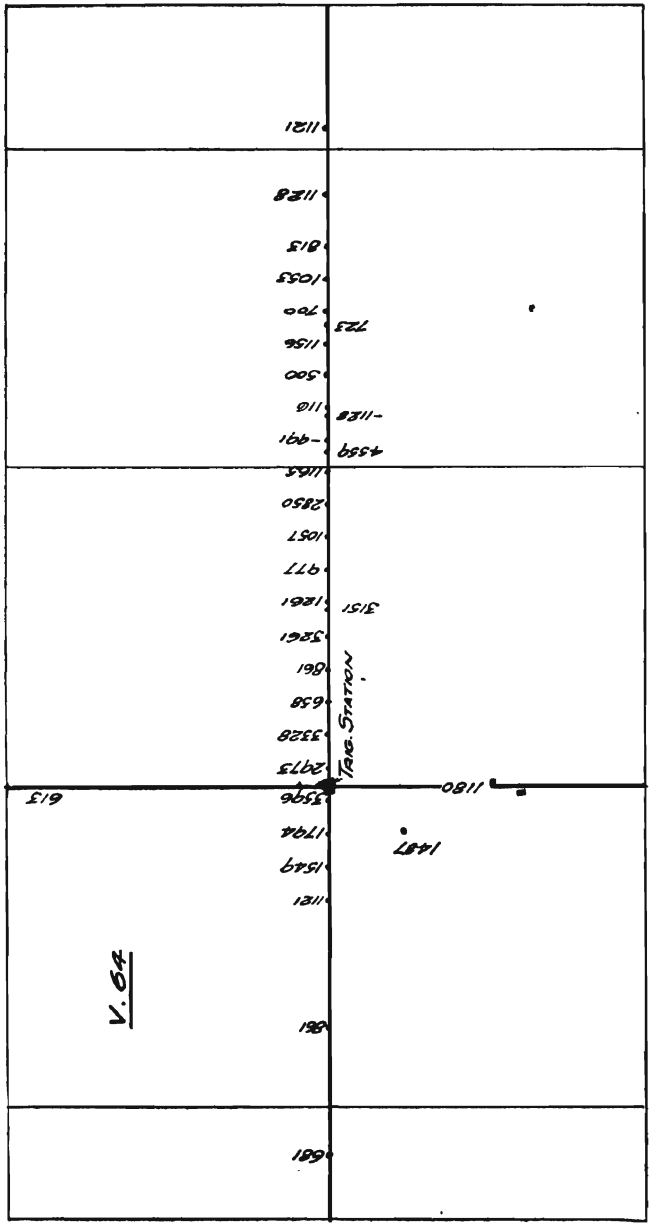


Fig. 2. E.-W. Variations in Vertical Intensity adjacent to The Gib trig. station.

mechanical stresses; but when the magnitude of the anomalies and the sharpness of the changes are considered, the formation of "poles" due to mechanical stresses produced either during or after crystallisation does not seem a tenable hypothesis. (iii) The rock might have been fissured, and leached to a considerable depth by water passing down the fissures, whilst leaching occurred only to a very small depth in the rock mass on either side of the fissures; but there are no surface indications of such fissures (the rock is bare, though broken) and the anomalies are again considered too large and too sharply defined to be in accord with this hypothesis. (iv) The effect may be due to lightning; this is the hypothesis that commends itself. The area is exposed rock surface, at the highest altitude in the district. Abnormally big positive and correspondingly big negative anomalies in the immediate vicinity are to be expected, if the magnetic material has been traversed by big currents. The Gib is reported to be struck by lightning frequently, and the author has had personal experience of thunderstorms on top, and has seen the effect of lightning striking the earth on two occasions during the two years of these observations—once on the syenite surface, and once on a tree growing on soil on the eastern slope in X49. Unfortunately, the author was several hundred yards away, and could not find the exact spot where the lightning appeared to strike the rock. It seemed to pour on to the surface and run out in all directions; no effects of the lightning could later be found, except that leached surface rocks were cracked and scattered round. This occurred before the anomaly had been observed, so little attention was paid to the matter, the place of striking not even being sought until six months later; it is hoped that some more observations may be made here. Heiland considers the lightning hypothesis also in the article referred to above, and a similar case is examined by Levings.[7]

In view of the greater uniformity of magnetisation over lower and less exposed surfaces, and the sharpness of the variation here considered, it seems far more reasonable to account for the effect by magnetisation through such abnormal means as lightning, than by simple induction

[7] Levings, Wm. S.: A Magnetic Survey of the Ralston Dyke, Jefferson Co., Colo. *Colorado School of Mines Quarterly*, *27*, No. 3, 38, July, 1932.

due to the earth's field, with or without subsequent " folding in " and inversion of earlier cooled portions.[8]

The Anomalies in 2N.

There is an interesting negative anomaly shown on the map with its centre (86γ) in area 2N5. Associated with this is a positive anomaly (maximum reading 1,171γ)

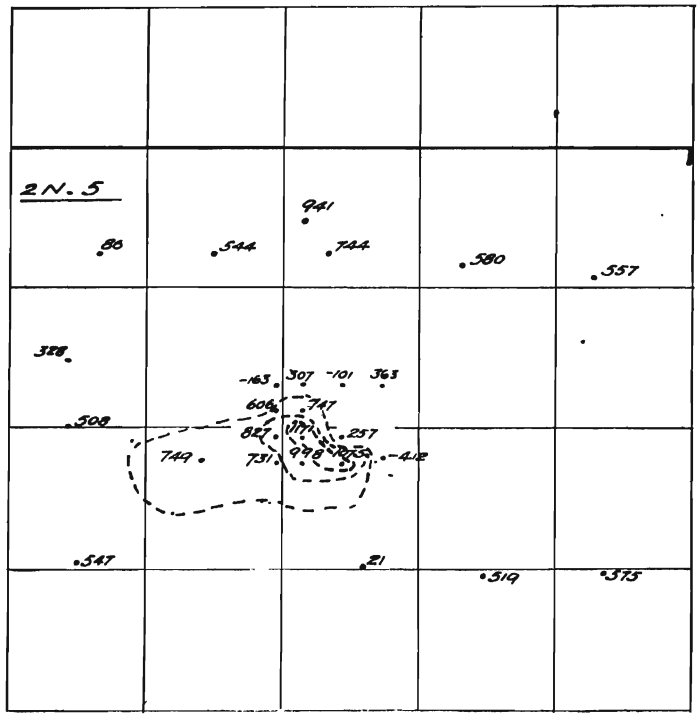


Fig. 3. Map of Anomaly in 2N.

in 2N23 and vicinity, which is illustrated in Figure 3; isodynamics in that figure are drawn at 200γ intervals. Unfortunately, it has not been possible to complete the

[8] It is of interest to note here that although the magnetometer (with one auxiliary magnet only in one case, and complete in its box in the other case) has twice been within 300 to 400 yards of a lightning discharge to earth, the sensitivity has not been changed, and the auxiliary magnets have merely increased slightly in magnetic moment at an unchanged rate, as seems to be their habit.

survey of this anomaly, as houses occur to the immediate south and west; but it is ringed to the north and east with low values, the lowest observed (at about 2N23.44) being −412γ. These anomalies are placed well down the southern slope of The Gib; they are not associated with any apparent surface abnormalities, the slope continuing to fall to the south, but not steeply. The position is such as to warrant its rejection as a "terrain anomaly" due to steeply rising cliffs, etc. The positive anomaly might well be due to a plug of magnetic material which has welled up close to the surface in 2N23; it may have broken through, though now weathered or covered by material fallen from the high land to the north. It is interesting to compare the tuff-neck (dealt with later, Figure 4) with this. The negative anomaly with its centre in 2N5 is, then, a "relative low", an area covered with non-magnetic material, or rather with magnetic material which, magnetised in the first instance by induction in the earth's field, subsequently fell in disorderly fashion to form the present hill slope, and is now surrounded by positively magnetised bodies.

The Anomalies at the Quarry (2E33) and on the Near Western Side of the Gib.

At the junction of Cliff Street and Ellen Street the syenite has been quarried, leaving a practically vertical wall of rock. Readings on the steep slope immediately down to the west from the quarry pit are all negative, giving the lowest values recorded for the area (excluding The Gib crest-line shown in Figure 2). Values decrease from −274γ to −608γ as the steep slope is climbed. The original form of the isodynamics in this vicinity has undoubtedly been considerably altered by the removal of great masses of the magnetic material from 2E33 and the north of 2E41; it is an exaggerated case of "terrain" effects which account for abnormally low values immediately below the cliffs on the western face of The Gib.

The other relatively negative anomalies along the western side of the syenite intrusion are in accord with observations in other districts. There exists here a trough-like depression or valley between the igneous masses, which is cut through shale intersected in places by narrow dykes and by small volcanic necks. The negative anomalies cover relatively big areas on the lower slopes of The Gib, the magnetic contours here being widely separated. The

surface valley (through which run the railway and the Mittagong Road) passes over isodynamic "flats".

Red Soil Anomalies.

At the junction of Soma Avenue and Cliff Street (2D39.00 and vicinity), just off the eastern boundary of the exposed shale, there is a patch of red soil, showing out clearly against the surrounding grey of the syenite soil. This patch is some four chains in diameter; unfortunately the presence of cottages in the vicinity prevents a more detailed survey, but a weak local anomaly is associated with it, with a maximum of 882γ and a minimum of 377γ, observed. The natural value for that zone is about 550γ. The anomaly is possibly associated with a neck.

There is a similar anomaly in 2L25, where the ground is definitely magnetic. Handfuls of the wet soil picked at random and moulded into balls had an intensity of magnetisation of approximately 2×10^{-3} c.g.s. units. The area of red soil here covers several acres, extending into 2K; but the magnetic anomaly itself is associated with a very small zone of less than two chains diameter, the maximum value being 883γ and the minimum 685γ, where the expected uniform reading would have been slightly over 700γ. The surrounding surface is Wianamatta shale; it is possible that the magnetic material marks the site of a volcanic neck, or of portion of a sill.

It is probable that the adjacent positive and negative anomalies in S and T are not associated with the quartz-dolerite to the north, but are in the same category as the other "red soil" anomalies. Further, considering the large number of such isolated eruptions, the author merely *suggests* the association of the major western anomaly with the exposed quartz-dolerite, which is apparently portion of a flattish laccolith.

A small anomaly occurs in V36 and V44, extending over an area about 10 chains across. The maximum value observed here is 818γ, and the minimum 323γ, the high zone being of some hundred square yards only (within an apple orchard) and being surrounded by low readings. This is associated with a spring, constantly running; another spring exists on slightly higher ground across the road in V37; apparently soakage is directed here by the underground contours of The Gib itself.* There is

* The road shown on Plate I is the old, or lower road.

no evidence here of a neck. It is too far from the precipices of The Gib to make a large fallen, slanting, inverted, magnetised mass a rational explanation, though much stone fallen and rolled from The Gib lies about. There is material in the immediate vicinity which appears to be volcanic breccia. The road here crosses a ridge.

Tuff Neck, Vicinity of 2C32 and 2D25.

The isodynamics in the vicinity of the tuff-neck in the general area 2C32 and 2D25 are illustrated in Figure 4.

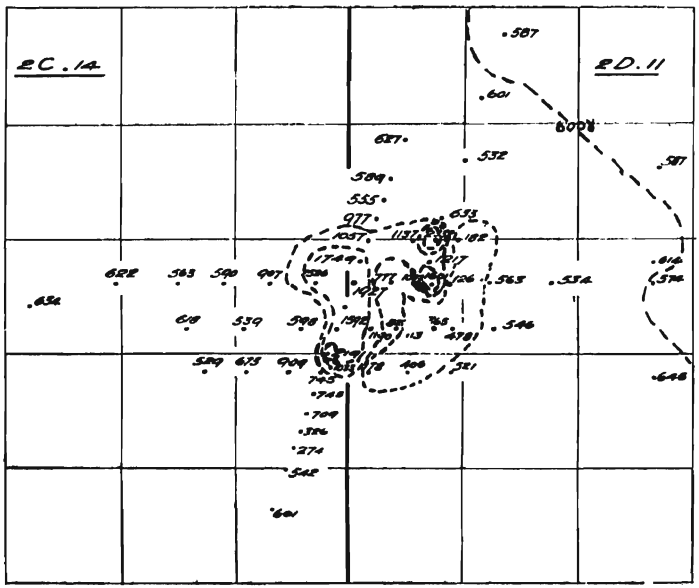


Fig. 4. Map of Tuff Neck Anomaly near Bowral Tunnel.

The lines shown are the 600γ-line of the main map, and the 500γ, 1,000γ, 1,500γ and 2,000γ-lines of this anomaly. The neck forms a little hill, the top of which is fairly flat and about 100 feet above the ground level to the south; the general slope of the country from which it emerges is to the north.

The neck is composite; on the eastern slope the material is (Taylor and Mawson, *loc. cit.*) "decomposed syenitic breccia and vesicular lavas in which the steam-holes have been filled with calcite". The rock on the south is darker,

and is "composed largely of fragments of trachyte". The south-west end is "a light-coloured rock of a tuffaceous character", whilst on the north-west slope "more vesicular lava (much decomposed) occurs". Jaquet gives a section of this neck, in which the eastern slope is shown as consisting of trachytic lava, whilst the bulk of the hill is of volcanic breccia.

The zone in Figure 4 has two strong positive centres, one at the north-east end (2,332γ), and one at the southern end (2,191γ). There is also a little knoll on its top at 2D25.03 approximately, where occurs another magnetic peak, of 1,927γ.

A dyke of trachyte is exposed by the railway cutting just to the west of the neck (at 2D26.40), and runs towards it.

The neck as a whole is a positive anomaly, with three peaks. There is a re-entrant low on the eastern slope, practically the whole of the eastern face being occupied by a negative anomaly, the lowest recorded value being 113γ; there is also a small negative anomaly to the immediate south. There is no need to seek for further explanation here than lies in the diversity of materials, and the unequal leaching, in different parts, of the magnetite-bearing trachyte.

Attention has already been directed to the similarity between the isodynamics here and those of Figure 3.

Dykes.

The district abounds in dykes, mainly trachytic, running in all directions for considerable distances.

They have in general been avoided during this survey so far as detailed observations are concerned, as they are very local in their magnetic effects, and can easily be picked out against the surrounding magnetic values.

Limonite.

The chalybeate spring (Lady Fitzroy's Spring) in E40 and E48 comes up through the limonite masses it has produced. The limonite itself is very feebly magnetic, a large lump close to the magnetometer being required to produce an observable movement. A reading taken on top of the rock, twenty yards west of the spring, gave a value of 736γ, some 150γ higher than a "non-feature" value for that position; the reading is slightly affected by the proximity of a small iron hut. A reading on

limonite on the northern slope of the small mound was 292γ, so that variations of over 400γ total are associated with the phenomenon, of which no detailed survey was made.

General Conclusions and Summary.

1. The isodynamics having been mapped over a wide area, this can be extended as required over the surrounding fields of geological interest. Moreover, local anomalies within the area can readily be examined against the background of the general district anomalies.

As an instance of the possible economic value of the regional magnetic survey, it should be practicable to select areas under which the coal-seams have probably not been ruined by igneous intrusions.

2. The whole district is underlain by igneous intrusions, which are probably more than 2,000 feet below the surface in parts. There are two main disturbances :

(*a*) that due to The Gib itself, an asymmetrical laccolith which :

(i) falls steeply for over a thousand feet under the surface on its western side,

(ii) falls steeply at first and then gradually back for several miles on the eastern side, and

(iii) falls less steeply on the north and south, though of a total extent of slightly over a mile in that direction ;

(*b*) that due to an intrusion to the west, of which the quartz-dolerite exposed on the boundary of T and S probably forms a part.

3. Even where the magnetic rock lies at greatest depth, the overlying strata have been intruded by dykes, sills, and volcanic necks, which in many cases are not apparent from surface geological indications ; some of the visible necks have ejected volcanic breccia and others may have been outlets for the lava flows over the district.

4. The whole district seems to have been covered by one or more lava flows subsequent to the main intrusions ; most of the lava has now been eroded, being represented in places by caps (in some parts, just off this area, up to 400 feet in thickness). It is possible to allow for the magnetic effects due to this ; it may mask local anomalies.

Acknowledgments.

The author is indebted to Assistant Professor W. R. Browne, D.Sc., of the University of Sydney, for assistance in geological interpretation and for the identification of rock specimens.

Acknowledgments are also gratefully made to the Council for Scientific and Industrial Research and to the Australian and New Zealand Association for the Advancement of Science, for placing at the disposal of the author the magnetometer owned by those two bodies, which was used throughout this survey ; and to the latter organisation for research grants, part of which has assisted in covering the expenses of this survey.

Explanation of Plates.

Plate I.

Map of the Mittagong-Bowral district, showing the isodynamic lines of the vertical components of magnetic intensity, superposed on a general outline of geological areas. An explanation of the grid system is given on page 36.

Plate II.

Fig. 1.—The Gib, and the country to the east, north, and west of it, taken from a position on the hill slope in the sector to the immediate north of G, off the map. Reference points are indicated by arrows. The high land in 2G, 2H and 2I can also be seen, and part of the sandstone hill west of The Gib.

Fig. 2.—The Gib from a position about E57, looking south.

Fig. 3.—The Gib from a position in C, looking south-east. The elevated sandstones to the east of The Gib are also seen, the valley in N and W being in shadow. This figure also shows the precipitous nature of the eastern face of The Gib, better seen in the next figure.

Fig. 4.—The cliff face on the north-eastern portion of The Gib. It is taken from V37, looking east.

Fig. 5.—The volcanic neck in 2C and 2D, photographed from 2D35.

Fig. 6.—Mainly the area in the western half of X, being the elevated ground on " Green Hills " protected by the basalt cap, described on page 49. The geophysical research station is also seen. The view is from X50.00, looking north-north-west.

Fig. 7.—From X42, looking east across the lower land in Y, Z and α, and including portion of the basalt-capped high land in 2H and 2I.



Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Fig. 7.

THE CONSTITUTION OF MATAIRESINOL.

By L. H. BRIGGS, M.Sc., D.Phil., D. A. PEAK, M.Sc., and J. L. D. WOOLLOXALL, M.Sc.,*
University College, Auckland, N.Z.
Communicated by Dr. F. LIONS.

(*Manuscript received, May 7, 1935. Read, June 5, 1935.*)

In the heart shakes or cracks of the wood of *Podocarpus spicatus* (Maori name—matai) a resinous but often crystalline substance occurs which has been isolated and characterised by Easterfield and Bee (*Trans. N.Z. Inst.*, 1910, *43*, 51; *J.C.S.*, 1910. *97*, 1028). The pure substance, to which the name of matairesinol was given, has a m.p. of 119° and was shown to have the molecular formula $C_{19}H_{20}O_6$.

Of the six oxygen atoms two were shown to be present as hydroxyl groups by the formation of a monoacetyl derivative, m.p. 110°, and a dibenzoyl derivative, m.p. 133°. A Zeisel determination indicated two methoxyl groups. The remaining two oxygen atoms were present in a lactone ring which underwent fission on solution in dilute sodium hydroxide from which the free hydroxy acid, matairesinolic acid, $C_{19}H_{22}O_7$, was precipitated by acidification with dilute acetic acid. A disulphonic acid derivative was also prepared. From their investigations matairesinol possessed the partial formula

$$C_{16}H_{13}(O\,CO)(OH)_2(O\,CH_3)_2$$

and was assumed to be of the phenanthrene type.

With Professor Easterfield's kind permission we have continued the investigation of this resin, and we are now able to present a full formula.

Further analyses of matairesinol supported by analyses of derivatives have shown it to possess the formula $C_{20}H_{22}O_6$.† It is thus isomeric with pinoresinol which

* One of the authors (D.A.P.) is indebted to a Duffus Lubecki Scholarship, which has enabled him to take part in the investigation.

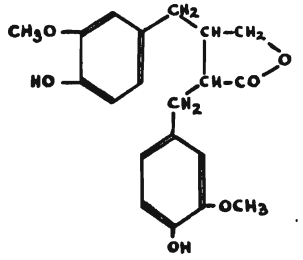
† Professor Easterfield, in a private communication, intimated that Mr. McClelland had found the original molecular formula to be incorrect.

also has now been shown to have the formula $C_{20}H_{22}O_6$, and not $C_{19}H_{20}O_6$ as previously supposed (Erdtman: *Svensk. Kem. Tidskr.*, 1934, *46*, 229). The analysis of the acetyl compound agrees for a diacetyl derivative on the new formulation instead of a monoacetyl derivative.

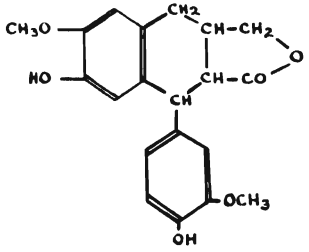
The benzoyl compound also gives an analysis still in agreement with a dibenzoyl derivative. Strange to say, it is precipitated from the alkaline solution with the lactone group still intact. Methylation with dimethyl sulphate and alkali yields a dimethyl ether, m.p. 126·5-127°, which still retains a lactone group since dimethyl matairesinolic acid may be obtained similarly to the free resinolic acid. The two free hydroxyl groups must therefore be phenolic and the lactonic hydroxyl aliphatic.

Matairesinol contains no aliphatic double bonds and is recovered unchanged from attempts to hydrogenate it with Pd-norite and hydrogen.

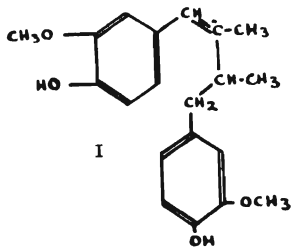
Dimethylmatairesinol on oxidation with alkaline permanganate yields veratric acid in over 50% yield. Since a compound containing one veratryl residue could only give a theoretical yield of 47% of veratric acid, it is apparent that two veratryl residues are present in the methylated resin. No trace of the stable veratroyl formic acid could be obtained from the oxidation mixture or in other oxidation experiments using smaller quantities of oxidising agent. It is clear therefore that the groups adjoining the veratryl residues are methylene groups and not attached to the lactonic oxygen. Compounds like olivil give good yields of veratroyl formic acid on similar oxidation (Vanzetti: *Monats.*, 1929, *52*, 163). The substance shows all the properties of a γ lactone, so that on the above evidence supported by phytochemical considerations matairesinol may be formulated as:



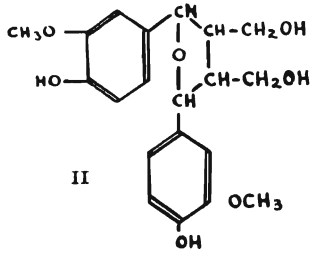
A similar formulation has been given by Emde and Schartner (*Naturwiss.*, 1934, *22*, 743) to sulphite liquor lactone which is identical with tsugaresinol (Kawamura: *Bull. Imp. Forestry Exp. Stat. Tokyo*, 1932, No. 31, 73), but this substance has since been shown to possess the molecular formula $C_{20}H_{20}O_6$ and the following structural formula (Erdtman: *Ann.*, 1934, *513*, 229):



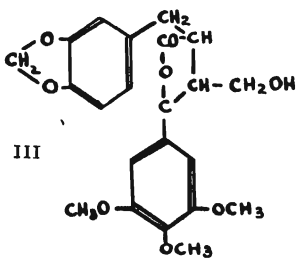
The carbon skeleton of matairesinol is also the same as that of guairetic acid (I) (Schroeter, Lichenstadt and Irineu: *Ber.*, 1918, *51*, 1587; *cf.* Haworth, Mavin and Sheldrick: *J.C.S.*, 1934, 1423), olivil (II) (Vanzetti and Dreyfuss: *Gazzetta*, 1934, *64*, 381), podophyllotoxin (III)



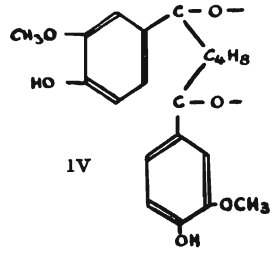
I



II



III



IV

(*cf.* Borsche and Niemann: *Ann.*, 1933, *499*, 59; Spath, Wessely and Nadler: *Ber.*, 1932, *65*, 1773; Robertson and Waters: *J.C.S.*, 1933, 83), and probably pinoresinol (IV) (Erdtman, *loc. cit.*).

Some of the above substances are active physiologically, due probably in the main to the lactonic grouping. The physiological activity of matairesinol is being investigated while further degradative work is in progress. From the mother liquors of the purification of matairesinol a second resinol has been isolated, m.p. 212·5-213°, but it has not yet been fully investigated.

Experimental.

Matairesinol—The chips from the heart shakes containing the crystalline and amorphous material were twice extracted with hot alcohol. On cooling or after concentration the resin separated in needles. Recrystallisation from alcohol gave a product, m.p. 78°, containing alcohol of crystallisation which is lost on warming *in vacuo*. From 60% acetic acid it crystallised in large anhydrous rhombic crystals, m.p. 119°. For analysis a sample was recrystallised three times from alcohol and three times from 60% acetic acid. Found: C=66·7, 66·7; H=6·0, 6·0%. Calculated for $C_{20}H_{22}O_6$: C=67·0, H=6·1%; calculated for $C_{19}H_{20}O_6$: C=66·3, H=5·8%.

Matairesinolic Acid.—Matairesinol (2 grams) was dissolved in just sufficient 5% sodium hydroxide to dissolve it, diluted to 50 cc. and dilute acetic acid (1 : 3) added until faintly acid. Matairesinolic acid crystallises almost immediately in hexagonal plates. After recrystallisation three times by solution in alcohol and precipitation with water, the crystals shrank at 78° and melted imperfectly at 81°, due to lactone formation. Found: C=55·9; H=6·9%. Calculated for $C_{20}H_{24}O_7 . 3H_2O$, C=55·8, H=6·9%; calculated for $C_{19}H_{22}O_7 . 3H_2O$, C=54·8, H=6·7%. The lactone is regenerated by heating or by precipitation with mineral acids from its solution in alkali.

Diacetyl Matairesinol (*cf.* Easterfield and Bee, *loc. cit.*).—Found (E. and B.): C=65·4; H=5·8%. Calculated for $C_{20}H_{20}O_6 . (CO\,CH_3)_2$: C=65·2, H=5·9%.

Dibenzoyl Matairesinol.—Matairesinol (5 grams) was dissolved in sodium hydroxide solution (7 mols.), and benzoyl chloride (5 mols.) added and shaken. The only product which separated from the alkaline solution was twice washed with water and dried on a porous tile *in*

vacuo. After two crystallisations from alcohol the needles shrank at 133° and melted at 134·5°, unchanged on further recrystallisation (Easterfield and Bee, *loc. cit.*, m.p. 133°). Found in dried material: C=71·4; H=5·3%. Calculated for $C_{20}H_{20}O_6(COC_6H_5)_2$: C=72·1; H=5·3%. (E. and B.: C=71·6, 71·8; H=5·1, 5·0%.)

It is remarkable that the benzoyl derivative is precipitated from the alkaline solution, a fact which would appear to be due to the opening of the lactone ring and the formation of a benzoic acid anhydride by the action of benzoyl chloride on the sodium salt of the resinolic acid. Such is not the case, however, since the dibenzoyl derivative, although insoluble in cold dilute aqueous potassium hydroxide, is soluble in cold alcoholic or aqueous alcoholic potassium hydroxide (compare the similar properties of dimethylmatairesinol especially in attempted ester formation).

Dimethylmatairesinol.—Matairesinol (1 gram) was dissolved in sodium hydroxide solution (25 cc. of 10%, 21 mols.), shaken in the cold with dimethyl sulphate (5·3 grams, 15 mols.) and finally heated for five minutes at 100°. The cooled solution was acidified with hydrochloric acid and the sticky precipitate crystallised from alcohol in double wedged crystals. After three recrystallisations from alcohol it had m.p. 126·5-127°, not raised by further recrystallisation. A less pure product was obtained by using smaller quantities of dimethylsulphate. The substance lost no weight on drying *in vacuo* at 100°. Found: C=67·8; H=6·8; OCH_3=32·8%. Calculated for $C_{18}H_{14}O_2(OCH_3)_4$: C=68·4; H=6·8; OCH_3=32·1%.

The substance is still a lactone, being insoluble in sodium carbonate, but slowly soluble on boiling with aqueous sodium hydroxide, easily soluble in alcoholic sodium hydroxide. Its alcoholic solution is neutral to litmus, and no coloration is given with ferric chloride or concentrated sulphuric acid. The molecular weight was estimated by solution in excess standard sodium hydroxide solution and back titration with standard hydrochloric acid, phenolphthalein being used as indicator. Found: mol. wt.=383. Calculated for $C_{22}H_{26}O_6$: mol. wt.=386.

Dimethyl Matairesinolic Acid.—Dimethyl matairesinol (1 gram) was dissolved in excess of sodium hydroxide solution and neutralised with dilute acetic acid. The colourless crystalline precipitate was recrystallised by solution in cold alcohol and precipitation with water,

yielding needles, m.p. 80-84°, indefinite due to lactone formation. The m.p. rises on standing. When the alkaline solution was made acid with hydrochloric acid the lactone was regenerated. The free acid dissolves easily in sodium hydroxide and slowly in sodium carbonate solution, while its alcoholic solution is acid to litmus.

Attempts to form the methyl ester of dimethyl matairesinolic acid by solution in a minimum amount of sodium hydroxide or sodium carbonate solution and treatment with excess of dimethyl sulphate gave only the lactone, even in the presence of a large excess of sodium carbonate.

Oxidation of Dimethylmatairesinol with Permanganate.—Dimethylmatairesinol (1 gram) was dissolved in sodium hydroxide solution (20 cc. of 1%), heated to 100°, and potassium permanganate solution (120 cc. of 3%, i.e., slight excess over 12 atoms of oxygen) run in slowly. The cooled solution was saturated with sulphur dioxide, when a clear yellow solution was obtained which gradually deposited clusters of needles homogeneous under the microscope (0·51 g.), m.p. 173-178°. After several recrystallisations from benzene it had m.p. 178·5-179·5° (veratric acid m.p. 179·5°). Found: no loss of weight on drying at 100° *in vacuo*. Found: C=59·2; H=5·5%. Calculated for $C_6H_3(OCH_3)_2COOH$: C=59·3; H=5·6%.

Attempt to Hydrogenate Matairesinol.—Matairesinol (1 gram) dissolved in glacial acetic acid (10 cc.) was shaken in an atmosphere of purified hydrogen in the presence of Pd-norite. Only a small amount of hydrogen was absorbed, probably by the norite. The catalyst was filtered off and the filtrate concentrated and diluted with water, when the unchanged resin crystallised out, giving no depression of m.p. of the pure resin.

Tetrabromo Matairesinol.—Matairesinol (2 grams) was dissolved in chloroform (20 cc.) in a stoppered bottle and bromine (1·77 grams, 8 atoms) in chloroform (35 cc.) gradually added. The reaction was complete after standing for thirty-six hours. The chloroform solution was washed with dilute sodium carbonate solution, again with water, and dried over calcium chloride. After removal of the solvent the gummy mass was recrystallised from alcohol and then from chloroform to give colourless needles, m.p. 169·0-169·5° (yield nearly theoretical). The bromo-derivative was recovered unchanged after treatment with alcoholic potash. The recovered product after recrystal-

lisation from alcohol had m.p. 171°, but a m.p. 169-169·5° after a further crystallisation from chloroform, unchanged on mixture with the untreated material. Found on material dried at 70° *in racuo*: C=35·7; H=2·8%; Br (Robertson's method)=48·1, 46·7%. Calculated for $C_{20}H_{18}O_6Br_4$: C=35·6; H=2·7; Br=47·5%.

THE VOLUMETRIC MICRODETERMINATION OF MAGNESIUM WITH METHYLENE BLUE FOLLOWING ITS PRECIPITATION AS MAGNESIUM PICROLONATE.

By ADOLPH BOLLIGER, Ph.D.*

(*Manuscript received, June 18, 1935. Read, July 3, 1935.*)

Magnesium, as well as calcium, forms a sparingly soluble picrolonate which, however, in contrast with calcium picrolonate, is not precipitated from dilute solutions at room temperature. In the following experimental study, the question is examined as to whether it is possible for magnesium to be precipitated quantitatively as magnesium picrolonate and then determined volumetrically.

The analytical principle applied is as follows: A known excessive amount of lithium picrolonate is added to the aqueous solution containing the magnesium, precipitation is brought on by heating and evaporation, and the excess of picrolonate added is determined by titration with methylene blue.

REAGENTS.

1. 0·05N lithium picrolonate. 6·6 gm. of picrolonic acid are dissolved in 500 cc. of a 0·05N solution of lithium carbonate. The solution must be neutral or slightly acid. It is filtered after standing overnight and is then standardised against methylene blue.

2. 0·01N methylene blue. This is best prepared by dissolving 3·74 gm. of methylene blue, chemically pure (Merck), in water and diluting to a volume of one litre. It is standardised against a picric acid solution of known titre, as described in a previous communication (Bolliger, A., THIS JOURNAL, 1933, *67*, 240).

PROCEDURE.

The solution to be analysed should be neutral or of slightly acid reaction. The presence of large amounts of alkali

*Acknowledgments are due to Miss Dorothy Dark for valuable technical assistance.

salts should be avoided, if possible. Barium, strontium and heavy metals should be absent.

The samples to be analysed have to be treated somewhat differently, according to whether:

A. No calcium is present, or calcium and magnesium are precipitated together; or

B. Calcium and magnesium are determined separately on the same sample.

A. *Where calcium is absent or calcium and magnesium are precipitated together.*

In this group one has to differentiate further, according to whether:

(1) The concentration of the alkali salts present does not exceed 0·01N approximately. Under these circumstances no alkali metals are precipitated with the alkaline earth metals.

(2) The concentration of alkali salts present ranges from approximately 0·01N up to 0·1N. In these samples, according to the amount of alkali salts present and according to the excess of lithium picrolonate added, alkali metals are precipitated together with the magnesium in varying amounts.

(3) The concentration of alkali salts present is above 0·1N. In these cases most of the excess picrolonate is precipitated as alkali picrolonate.

(1) Where concentration of alkali salts present does not exceed 0·01N.

A measured amount of the solution to be analysed is transferred to a test tube or centrifuge tube graduated in tenths of a cubic centimetre. A known excessive amount of the standardised lithium picrilonate solution is added. The tube is then transferred to a boiling-water bath. As soon as evaporation of the mixture takes place, precipitation occurs on the top of the fluid in contact with the wall of the vessel in the form of a ring. This precipitate is pushed down into the hot fluid with a glass rod; at the same time the mixture is stirred vigorously for a few seconds. This procedure, if repeated several times, will bring on abundant flocculent precipitation of magnesium picrolonate if the fluid does not contain magnesium below a concentration of approximately 0·01N. If there is considerably less magnesium present, further evaporation will be necessary

till a marked precipitation is permanently present in the hot fluid. However, as with more concentrated solutions, precipitates formed on the wall of the tube, on the surface of the mixture, have still to be pushed down into the fluid. One then allows the mixture to cool at room temperature, with occasional stirring, then—noting the total volume of the mixture when it has reached room temperature, or making up to a certain volume with a small amount of water—lets it stand in the ice-box for at least three hours. The precipitate is then filtered off and afterwards an aliquot part of the filtrate is transferred to a conical separatory funnel containing chloroform and some calcium carbonate.

The titration of the picrolonic acid present in the filtrate is the same procedure as that described for organic picrolonates (Bolliger, A., This Journal, 1934, *68*, 197), and calcium picrolonate (Bolliger, A., *Austral. J. Exp. Biol. Med. Sci.*, 1935, *13*, 75).

The determination may also be executed as described in the next paragraph. Alternatively, one may also determine the picrolonic acid content of the precipitated magnesium picrolonate. In this case the precipitate collected in a small fritted glass plate funnel is washed several times with small amounts of water. The precipitate is then dissolved in a small amount of hot pyridine and the pyridine solution transferred with water to a separatory funnel containing chloroform. The titration with methylene blue is the same as that for the excess of picrolonate.

(2) Where the concentration of alkali salts ranges between 0·01N and 0·1N, and alkali picrolonates have been precipitated.

In these cases one preferably evaporates the sample to be analysed, together with a known excessive amount of lithium picrolonate, in a short wide tube. The technique for precipitation is the same as that described in the previous paragraph. Thorough stirring is essential, and sufficient of the volume should be evaporated to lead to a heavy permanent precipitate in the hot fluid. One should, however, be careful not to be misled by a precipitate of alkali picrolonate which may appear before the magnesium has been precipitated, but a naked-eye examination of the more or less thick precipitate will usually reveal the pale yellow clumps and flakes of magnesium picrolonate besides the darker yellow crystals of the alkali picrolonates.

After letting the mixture stand in the ice-box, one pours the entire contents into a separatory funnel containing dry chloroform. The particles of the precipitate clinging to the wall of the tube are washed into the separatory funnel with minimal amounts of water and finally with chloroform. Since any excessive dilution has to be avoided, one titrates with 0·01N methylene blue. Immediately after every addition of portions of methylene blue from the micro-burette one shakes vigorously. The methylene blue picrolonate, formed from the action of the picrolonate and present in solution with the methylene blue, dissolves in the chloroform to form a green solution. Following the removal of the picrolonates in solution, the alkali picrolonates which have been precipitated dissolve in the aqueous layer. Magnesium picrolonate, on account of its small solubility, hardly reacts with the methylene blue so long as more soluble picrolonates are present. The titration has to be stopped as soon as a greenish-blue tinge appears in the aqueous layer. However, the appearance of a bluish-green tinge in the aqueous layer depends on the total amount of chloroform present for extraction, but one will hardly be misled if one increases the amount of chloroform simultaneously with the amount of methylene blue added during the titration. As a working rule it may be said that for every cc. of 0·01N methylene blue at least 15 cc. of chloroform are required. If the titration has reached this point one removes the chloroform and filters by suction the aqueous layer which contains the magnesium picrolonate in suspension. One finally terminates the titration on the whole or an aliquot part of the filtrate with 0·01N or 0·001N methylene blue.

(3) Where the concentration of alkali salts present is above 0·1N.

With an alkali concentration approximating 0·1N the observation of the preliminary end-point, as mentioned in the previous paragraph, requires considerable care. With higher alkali concentrations, the precipitated alkaline picrolonates dissolve slowly and incompletely, and the methylene blue is salted out into the chloroform. It is therefore necessary to remove the greater part of the alkali salts present in the concentrated fluid before the titration can be executed.

The contents of the test tube in which the precipitation has taken place are poured on a small filter in a Buchner

funnel, as completely as possible. However, the mixture should not touch the wall of the funnel. The yellowish precipitate, consisting of alkaline earths and alkali picrolonates, together with the filter, is transferred to the separatory funnel containing dry chloroform. The titration with 0·01N methylene blue is the same as that described under (2) above. The filter paper present does not interfere, inasmuch as it is broken up into fibres with vigorous shaking of the mixture. After reaching the preliminary end-point, one separates the aqueous fluid from the chloroform and filters it as described previously. For the final titration, however, one combines with this filtrate the first filtrate containing the alkali salts and a small amount of picrolonate.

B. *Where calcium and magnesium are determined separately on the same sample.*

In a previous communication the precipitation of calcium with lithium picrolonate and the limitations of this method have been discussed (Bolliger, A., *Austral. J. Exp. Biol. Med. Sci.*, 1935, *13*, 75). Lithium picrolonate is added till a distinct excess, but not large in relation to the calcium present, is present, and then the solution is kept in the ice-box for at least five hours. The precipitate of calcium picrolonate formed is then filtered off. Immediately afterwards an aliquot part of the filtrate is transferred to a conical separatory funnel containing chloroform and the picrolonate present is titrated with standardised methylene blue. The remaining filtrate is then used for the determination of magnesium. However, the excess lithium picrolonate remaining in the solution is usually not sufficient for the precipitation of the magnesium, and more of the reagent has to be added.

In order to have the whole of the filtrate at one's disposal for the magnesium estimation, one may determine the picrolonate content of the calcium precipitate. For this purpose the precipitate of calcium picrolonate is washed with as little water as possible, and the wash-water is combined with the filtrate. The precipitate on the filter is then dissolved with small amounts of hot pyridin, and the pyridin solution of calcium picrolonate diluted with water is titrated with methylene blue.

Discussion.

The solubility of magnesium picrolonate is slightly smaller than the solubility of calcium picrolonate, a

compound whose analytical usefulness has already been mentioned by several authors. According to Robinson and Scott (*Ztschr. Anal. Chem.*, 1932, *88*, 417) the solubility of magnesium picrolonate in water at 25° C. is only 0·3 mgm. per cent. At 10° C. I found the solubility to be approximately 0·1 mgm. per cent. As in the case of calcium picrolonate, the titration of dissolved magnesium picrolonate or the titration of an excessive amount of picrolonate added to a solution of magnesium salts is accurate. Also the precipitation of magnesium with lithium picrolonate is satisfactory if the alkali salts present do not exceed 0·01N in concentration. If more alkali salts are present, the method loses in accuracy and also simplicity when the concentration of alkali salts exceeds 0·1N in concentration. But in any case the amount of alkali salts should not exceed a maximum concentration of 0·5N. With higher concentrations the methylene blue added is salted out before it reacts properly with the picrolonates present. These remarks apply primarily to the presence of sodium salts. Potassium picrolonates and ammonium picrolonate are less soluble than sodium picrolonate, and consequently the difficulties are increased if the alkali salts present consist chiefly of potassium and ammonium salts. If calcium is precipitated together with the magnesium one has to keep in mind, as already mentioned in a previous communication, that alkali salts, if present in a concentration above 0·01N, may inhibit to a certain extent the precipitation of calcium picrolonate.

Therefore it is quite evident that the method described for the determination of magnesium is limited in its application. It will be found useful in problems where the amount of alkali metals present is smaller than the amount of alkaline earth metals, such as the determination of magnesium in fæces. Results with an error not exceeding 2% were obtained on known magnesium solutions containing 0·2 to 1·0 mgm. of magnesium when the amount of alkali salts present did not exceed 0·01N. If one uses the method as described in A (2) above, results are invariably somewhat too low. However, if one avoids an excessive dilution, the error will not exceed 4%. In the presence of alkali salts exceeding 0·1N in concentration, a larger error up to 6% was frequently encountered.

Picrolonic acid in its analytical properties resembles oxalic acid, and like it is not very selective. Picrolonic acid has the further disadvantage that its alkali salts are

considerably less soluble than those of oxalic acid. On the other hand, salts of picrolonic acid important in analysis are easily distinguished by the appearance of their respective crystals, and on microscopic examination of a precipitate of picrolonates its composition will be revealed. Magnesium picrolonate forms pale yellow needles which are in marked contrast to the deeper yellow and highly refractive prisms of calcium picrolonate. The crystal form of sodium picrolonate is that of long hair-like needles which are frequently bunched together in irregular clusters. The other alkali picrolonates also form needles which may be distinguished from magnesium picrolonate by their shape and their deeper yellow colour.

Summary.

A method has been described for the volumetric micro-determination of magnesium as magnesium picrolonate. The limitations of the method have been discussed.

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NOTE ON THE GEOLOGY OF THE GOULBURN DISTRICT, WITH SPECIAL REFERENCE TO PALÆOZOIC STRATIGRAPHY.

By G. F. K. Naylor, M.A., M.Sc.

(With Plate III and three text-figures.)

(*Manuscript received, June 19, 1935. Read, July 3, 1935.*)

Introduction.

The area dealt with in the present paper may be described as that surrounding the city of Goulburn, but extending further towards the north and east than to the south and west.

It is the writer's intention that this paper shall form the first of a series dealing progressively with various aspects of the geology of this district but having special relation to the Palæozoic stratigraphy. In this first paper an attempt will be made to suggest the probable structure of the Palæozoic rocks in this area and to outline briefly the evidence which has come to hand concerning the ages of the different series. Except where relevant to the above object, detailed descriptions of a palæontological and lithological nature will be omitted. They will be more adequately treated in future papers of a more specific nature.

The writer would like here to express his indebtedness to many friends who have assisted him in the field and laboratory, and to many residents who have supplied much useful local information ; also to the various members of the University Geological Staff with whom the substance of this paper has been discussed from time to time.

Physiography.

The area is situated largely in the basin of the Upper Wollondilly River, but in the south extends across the watershed of the Shoalhaven. The country is approximately 2,000 feet above sea-level and is in the main mature. On the north the steep hills of the Cookbundoon Range

rise to a height of about 800 feet above the valley-floor; to the south the plateau is incised by the steep gorges of the Shoalhaven and its tributaries. Minor relief is presented by numerous isolated hills and ranges representing cappings of Kamilaroi (Permian) rocks in the northern and eastern margins of the area, and resistant masses of older Palæozoic rocks further to the south and west.

Special reference is made to the Cookbundoon Range by Craft.[1] He is of the opinion that this range represents a fault scarp or a fault-line scarp. The present writer has found no direct evidence for the existence of a fault, and is satisfied that differential erosion as determined by geological structure is quite adequate to account for the

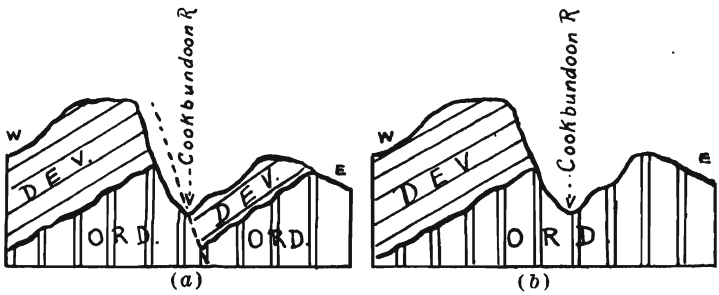


Fig. 1. Alternative Interpretations of the Cookbundoon Scarp.

feature. Cookbundoon Mountain is composed in its upper part entirely of Devonian strata, lying unconformably on older Palæozoic rocks. If the eastern slope of the Cookbundoon Range were the locus of a fault throwing to the east, as suggested by Craft, then one would naturally expect to find the younger rocks at a lower level on the eastern side of the fault plane, as in Fig. 1 (*a*). However, as the actual state of affairs approximates more nearly that indicated in Fig. 1 (*b*), it seems much more probable that the scarp is purely erosional.

Igneous Rocks.

Only brief mention will be made of the various igneous units.

A. *Marulan Batholith.*

This is by far the most important of the igneous masses. It is a somewhat complex intrusion injected into Palæozoic

[1] Craft, F. A.: Physiography of the Wollondilly River Basin, *Proc. Linn. Soc. N.S.W.*, 1928, *53*, 618.

sediments, and having an outcrop definitely elongated in a meridional direction. It stretches northwards from a good deal south of Bungonia, and is practically unbroken in its course as far as the Cookbundoon River. It crosses this, and is apparently continuous with the huge igneous mass occurring in the vicinity of Wombeyan Caves and the Upper Burragorang Valley. The principal rocks are granites, granodiorites and fairly acid porphyritic types. Some of these have been described by Woolnough.[2] It is generally assumed that the various phases are comagmatic. So little is definitely known, however, that some may ultimately prove to have been injected at a much later period than others. The contact effects of such a huge mass are naturally very considerable and will be mentioned in connection with each series which the batholith intrudes.

B. *Tertiary Basic Rocks.*

The only other important igneous rocks in this district are the Tertiary basic series, which occur for the most part as considerably eroded lava-flows. They are chiefly olivine-basalts, such as have been described by Browne.[3] At one or two points, notably at Billyrambija, occur the remains of what must have been originally sills, laccoliths or plugs. In these the rock is of a much coarser texture, and would be described as an olivine-dolerite.

C. *Other Intrusions.*

South and south-west of Goulburn on the Gundary Plains is an extensive outcrop of what appears to be a plutonic igneous rock of intermediate composition, which, so far as the writer is aware, has not yet been investigated. To the north of Goulburn also igneous rocks of the nature of dolerite are known to occur.

Sedimentary Rocks.

Ordovician.

There is no evidence that rocks of Lower Ordovician age occur in this district. It must be recognised, however, that the belt to which at the present time an Upper

[2] Woolnough, W. G.: The General Geology of Marulan and Tallong, N.S.W., *Proc. Linn. Soc. N.S.W.*, 1909, *34*, 782.

[3] Browne, W. R.: An Account of Post-Palæozoic Igneous Activity in N.S.W., This Journal, 1933, *67*, 9.

Ordovician age is assigned is so extensive as to render it quite possible that part may be of Lower or Middle Ordovician age. Rocks of Upper Ordovician age have long been known to occur near Tallong in and near the Shoalhaven Gorge. A collection of graptolites obtained, amongst other places, from Ballanya Hill were figured and described by Hall[4]; these rocks are also referred to by Woolnough (*loc. cit.*). More recently the present writer has found graptolites at numerous other localities in the area under consideration. These localities are indicated in the accompanying map (Plate III) and serve to extend very considerably the boundaries of the known Ordovician rocks in this district. For the most part the Upper Ordovician series consist of quartzites and claystones, but in many places there are slates and phyllites. Where these have been intruded by the Marulan batholith very considerable metamorphism has taken place, in some instances with the production of chiastolite crystals over an inch in length. It is interesting to note that even in the rocks resulting from such contact metamorphism graptolite remains are often comparatively well preserved, so that it is by no means unusual on the margins of the batholith to find specimens showing both graptolites and chiastolites.

The Upper Ordovician strata dip steeply and are all rather altered by regional metamorphism. The strike is in general meridional; the dip is more often westerly than easterly. There is very considerable folding of the softer types where they appear to have been crushed between more competent bands of quartzite.

The rocks from which the graptolites have been collected are mainly grey and bluish slates, claystones and shales. There is no doubt whatever that the fauna is typically Upper Ordovician. The dominant genera are of a scandent biserial type including *Climacograptus* and *Diplograptus*, with subordinate *Dicranograptus* and *Dicellograptus*.

Though no definite zones have yet been worked out, it is important to note that the types mentioned above vary in abundance according to the locality. Thus to the south of the Cookbundoon Mountain near Towrang *Dicranograptus* (probably *D. zic-zac*) is comparatively abundant, the

[4] Hall, T. S.: Notes on a Collection of Graptolites from Tallong, N.S.W., *Rec. Geol. Surv. N.S.W.*, 1909, *8*, 339. *Idem*: On a Further Collection of Graptolites from Tolwong, N.S.W., *Rec. Geol. Surv. N.S.W.*, 1920, *9*, 63.

remainder of the fauna being large biserial forms. At another locality near the Greenwich Park-Towrang road, the forms collected were all of a minute type, being principally leptograptid forms, such as *Dicellograptus*. Further east, near Brayton, the graptolites are almost exclusively scandent biserial forms.

There is every hope, therefore, that work in the near future will result in the determination of zones, and that the correlation of these will reveal the general structure of the Upper Ordovician strata.

Silurian.

Until recently no rocks of Lower Silurian age had been discovered in New South Wales. About a year ago the writer collected numerous graptolites at a point on the Bungonia-Goulburn road about three miles west of Bungonia, which appeared to be types of *Monograptus* and of Silurian, not Ordovician, age. A detailed study of the thecal development of these forms showed that they were closely allied to forms occurring near the base of the Silurian system in England. The thecæ were generally of an isolate and lobate nature, to the exclusion of almost every other type. Since it is recognised that forms having thecæ of this variety are almost entirely restricted to the base of the Silurian system, this study rendered the writer confident that a Lower Silurian age should be assigned to these types. This view has recently been confirmed by Mr. D. E. Thomas, of the Victorian Government Geological Survey. He has assured the writer that the forms collected here are without doubt Lower Silurian, probably *Monograptus barrandei* and *M. exiguus*, and suggests that the zone represented is that of *Monograptus crispus*, i.e., the lower horizon at Keilor and at Sydenham in Victoria. The relation of the beds to the Upper Ordovician strata on the one hand and the Upper Silurian on the other has not yet been determined, but the writer is inclined to the belief that they are more likely to be conformable with the former than with the latter.

The presence of rocks of Upper Silurian age has been known for some considerable time. Woolnough has described an unconformable junction between the Upper Silurian limestones and the Ordovician slates near the Limekilns south of Marulan. Woolnough's discovery was recently confirmed by Dr. G. D. Osborne, who found the exact junction between these two series. The time-

break represented by this unconformity may be accounted for by the deposition of the Lower Silurian rocks previously described. In earlier work elsewhere in this area the presence of Upper Silurian rocks was suspected by the writer but was not confirmed by palæontological evidence. However, more recently graptolites were discovered in bluish claystones on the main Sydney road near the Towrang turnoff. These proved to be a variety of *Monograptus* which appeared to be of an Upper Silurian type. Subsequently this supposition was verified in two ways. In the first place *Pentamerus knighti* was collected from the associated beds, and secondly the graptolites were determined as Upper Silurian types by Mr. Thomas. He suggests that the fossil referred to him was *M. bohemicus*, which is confined to the zone of *M. nilssoni*, and that the beds are probably contemporaneous with those at Melbourne. This is interesting because another form collected more recently by the author was tentatively determined by him independently as *M. nilssoni*, so that mutual confirmation is afforded. The junction between the Upper Silurian and the Upper Ordovician rocks in this particular area is sharply defined by a belt of intense folding and shearing. This the writer assumes to represent a special phase of an unconformable junction, though it is difficult to demonstrate a precise angular unconformity. It is safe to remark, however, that the folds in the Ordovician strata closed before the deposition of the Upper Silurian sediments. Folding of the latter could then only be accomplished by considerable shearing of the former. The distance between the point at which the Upper Ordovician graptolites have been discovered and the locality where *Pentamerus knighti* occurs is approximately 100 yards, while *Monograptus* occurs about 100 yards further on in the Silurian series. These distances do not represent stratigraphical thickness. In general there is a definite lithological difference between the Silurian and Ordovician strata. The former include large quantities of greenish and fawn-coloured slates, whereas the prevailing colours in the Ordovician are shades of grey and blue. Nevertheless, where graptolites occur the prevailing colour is a bluish-grey, whether in Ordovician or Silurian. The Silurian series are in general more argillaceous than the Ordovician. This lithological difference is sufficiently definite to enable one to extend the boundary determined palæontologically, as just described, in a northerly direction

for some miles, to the point where it is concealed by overlying Devonian rocks.

Associated with the Silurian rocks in this part of the area are a series of lamprophyric rocks and breccias. Similar rocks occur in association with the limestone at Brayton, which appears to be good evidence for the Silurian age of the rocks of that locality. A little to the west of Goulburn, at Baw Baw, occur limestones from which *Pentamerus knighti* has been collected. At Kingsdale also the limestone appears to be of Upper Silurian age. Fifteen miles further north, near the Chatsbury slate quarries, is another prominent bed of limestone, highly fossiliferous, and containing *Pentamerus knighti*. The relation of these to the Chatsbury slate beds is such as to suggest strongly the possibility that the latter are Upper Silurian instead of Upper Ordovician, as previously supposed. This suggestion, however, can scarcely be regarded as proved.

Devonian.

No rocks of definite Lower or Middle Devonian age have so far been recognised. Near Goulburn, however, a heavy conglomerate similar to that which marks the base of the Upper Devonian further to the north appears to occur above the base of the Devonian series. Should these two conglomerates prove, as seems likely, to be one and the same horizon this would indicate that the series overlaps to the north-east. If this heavy conglomerate is really basal to the Upper Devonian series proper, then some of the beds near Goulburn must necessarily be a little older. No fossils have yet been obtained from these doubtful beds.

The Upper Devonian rocks throughout the district are essentially quartzitic. Conglomerates occur, principally in the basal stages, but also with finer texture and less frequency at higher horizons. There is some evidence for assigning a thickness of about 2,000 feet to the whole series.

The great mass of the Cookbundoon Mountain represents the most characteristic and dominant phase of the Devonian outcrop. The steep southern and eastern slopes are crowned with cliffs of massive white quartzite, silicified grit, and conglomerate. The lower slopes are covered mostly with talus, or with the outcrop of Upper Silurian and Upper Ordovician strata, but at several points,

notably on the bank of the Cookbundoon River near Emerton's farm, the unconformable junction between the Upper Devonian and Upper Ordovician is exposed on a grand scale. At other places the relations are equally clear, though less spectacular. Towards the south-western end of the range a definite unconformable junction between the Devonian and the underlying Upper Silurian has been observed.

Beyond the stratigraphical considerations described above there is also direct palæontological evidence for assigning an Upper Devonian age to this series of strata. From the white quartzites on top of the Cookbundoon Mountain near Towrang specimens of *Lepidodendron australe* have been collected. Further, brachiopods including *Spirifer disjunctus* were pronounced by the late Mr. W. S. Dun to be unquestionably of Upper Devonian (Lambian) age.

The main structures of the Upper Devonian strata of the Cookbundoon district appear to be fairly gentle folds pitching to the north. Dips of 25° to 35° are most common, though in some cases the latter figure is exceeded by as much as 10° or 15°, while in others the beds are so nearly horizontal as to be mistaken at first sight for the Kamilaroi strata that occur abundantly further east.

There is as yet no direct evidence as to whether the Marulan batholith is intrusive into the Upper Devonian. The rocks of that series are highly silicified, but suggest regional rather than contact metamorphism.

Palæozoic Rocks of Uncertain Age.

North and east of Marulan, separated from the main outcrop of Palæozoic sediments by the Marulan batholith, are considerable outcrops of old sedimentary rocks from which no fossils have been collected. They include tuffaceous types, as well as claystones and quartzites. As yet one can only surmise that they may prove to be of Silurian or Ordovician age. They are marked on the map as Ordovician.

Kamilaroi.

The only other Palæozoic formations in the district are the Kamilaroi strata which overlie the older rocks in the eastern part of the area. Their age has been determined beyond doubt by the presence of *Glossopteris*. In the main they are composed of heavy conglomerates, breccias

and sandstones representing shoreline deposits along the margin of the area of sedimentation. In part they may be fluvio-glacial. No marine fossils have been found except near Tallong.

In most places these beds have a definite initial dip to the east, but as this rarely exceeds two or three degrees, the outcrops appear in general horizontal. From their form and composition, the constituent fragments seem to have been derived from rocks outcropping in the immediate locality.

Tertiary.

There are no extensive Tertiary sediments in this area. Minor occurrences of ferruginous rocks bearing Tertiary leaves have been noted, as at Billyrambija; these are usually associated with the basalts. In many places the terrace gravels of the Wollondilly, which may be Tertiary, are cemented into a hard conglomerate.

General Relations and Structure of the Palæozoic Rocks.

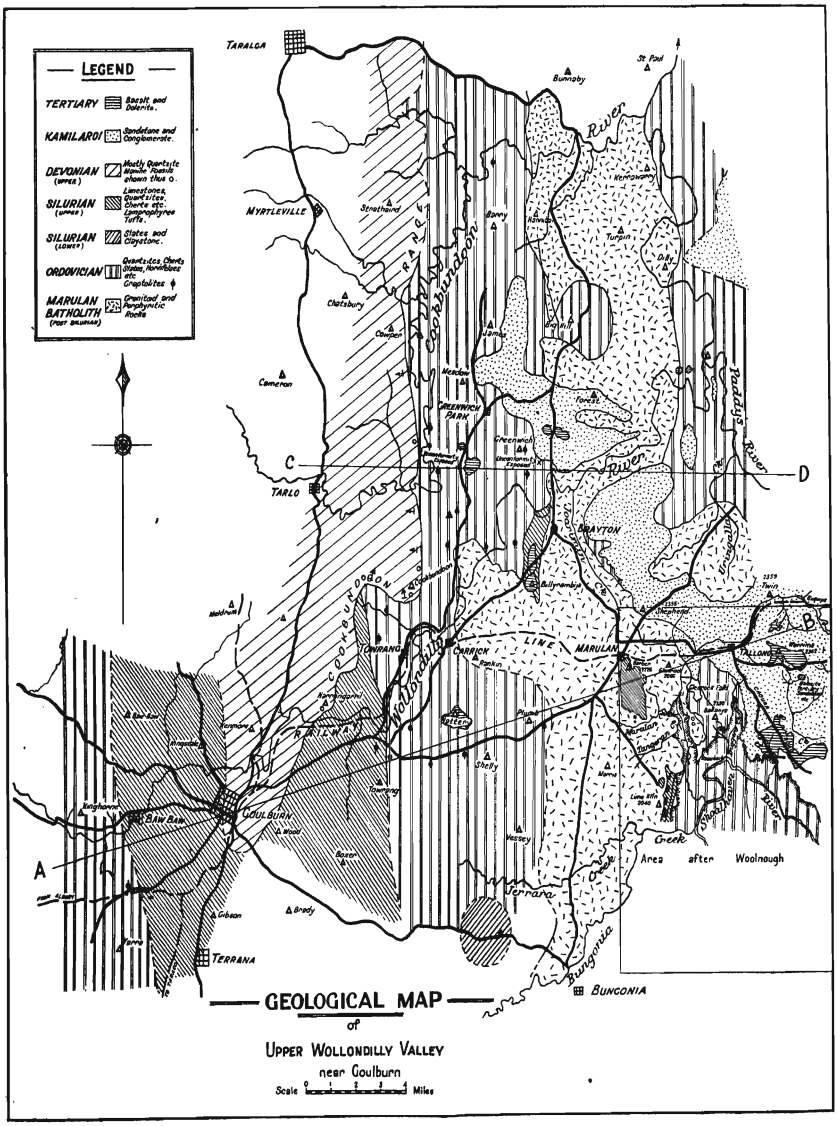
The general structural relations of the rocks of the area are illustrated by the sketch-sections (Fig. 2).

The Palæozoic group is represented by rocks of Upper Ordovician, Lower and Upper Silurian, Upper Devonian and Upper Kamilaroi age. On the palæontological evidence this much appears beyond doubt. The principal missing strata are those of the Lower and Middle Devonian, and the entire Carboniferous.

The general disposition of the outcrops of these strata seems to suggest a broad syncline with axis trending meridionally through Goulburn. This structure is indicated in the accompanying sketch-section A-B. On the eastern margin of this syncline lies the Marulan batholith, and, eastward again, what might well be a downfaulted continuation of the eastern limb of the folded zone. The elongation of the Marulan batholith seems to suggest that the magma may have been injected along a zone of weakness, which might well have been associated with heavy faulting. While there is as yet no direct proof of such faulting, there is certainly no evidence to the contrary, and this assumption seems to offer a possible explanation of the phenomena so far observed.

It appears that extensive marine sedimentation occurred over the whole of the district during Upper Ordovician

Fig. 2. Sketch-sections across the geological map (Plate III). Geological units indicated as on the map.


LEGEND
TERTIARY
Basalt and Dolerite.
KAMILAROI
Sandstone and Conglomerate.
DEVONIAN (upper)
Mostly Quartzite Marine Fossils shown thus o.
SILURIAN (upper)
Limestones, Quartzites, Shales etc. Lamprophyres Tuffs.
SILURIAN (Lower)
Slates and Claystone.
ORDOVICIAN
Quartzites Cherts Shales, Hornfelsed etc. Graptolites
MARULAN BATHOLITH (Part Granite)
Granitoid and Porphyritic Rocks
TARALGA
MYRTLEVILLE
Strathaird
Bunnaby
St Paul
Kenmowry
Turpin
Oak
Barry
Rosslyn
Lamb
Clatsbury
Cameron
Meadow
GREENWICH PARK
Greenwich
Tarlo
Brayton
Ballyrambla
Currandooley
Marulan
Carrion
Limestone
Tallong
Bungonia
Goulburn
Bell Bair
Terrana
Area after Woolnough
GEOLOGICAL MAP
of
UPPER WOLLONDILLY VALLEY
near Goulburn
Scale 0 1 2 3 4 Miles

time. This was followed, in some parts at least, by continued marine sedimentation in Lower Silurian time. Then, perhaps, followed a period of folding, uplift and erosion, so that when submergence again occurred at the beginning of the Upper Silurian period, the sediments then deposited assumed unconformable relations with the underlying Ordovician strata. One cannot yet say for certain whether this break in sedimentation occurred before or after the deposition of the Lower Silurian strata, as the relations of these to Upper Ordovician and Upper Silurian are not known.* The sea had temporarily retreated, but advanced again to permit of the subsequent widespread deposition of Upper Silurian strata.

At the close of the Silurian period there was a very considerable amount of orogeny followed by extensive peneplanation. A further transgression of the sea occurred at the close of the Middle Devonian, so that extensive marine and estuarine deposits of Upper Devonian age were laid down with pronounced unconformity upon the older Palæozoic strata. Again there followed a period of folding, but not of such an intense nature as that marking the close of the Upper Silurian. This folding produced the series of comparatively gentle anticlines and synclines characteristic of the Devonian rocks at the present day, as distinct from the intensive closed folding of the Ordovician and Silurian. It was probably in association with this orogeny that the Marulan batholith was injected.

After the deposition and folding of the Upper Devonian sediments the sea retreated, and the area remained dry land throughout the whole of Carboniferous and early Kamilaroi time. Extensive, though by no means perfect, peneplanation took place before the next transgression of the sea, this time to deposit the Upper Kamilaroi strata on a somewhat irregular land surface.

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* The fact that there is a marked unconformity between Upper Silurian and Ordovician strata near Marulan, whereas Lower Silurian beds occur a few miles away, west of Bungonia, is a matter that has not yet been satisfactorily explained.

VEGETATIVE REPRODUCTION IN NEW ZEALAND MOSSES.

By G. O. K. SAINSBURY, F.L.S.

Communicated by E. CHEEL.

(*Manuscript received, July 12, 1935. Read, August 7, 1935.*)

From time to time there have been brought to my notice unreported instances of asexual reproduction in New Zealand mosses or additional facts about already known cases which deserve record. This method of reproduction, i.e. by means of buds, protonema, etc., is especially common amongst the mosses, and its study, whether from a morphological or a physiological standpoint, is full of interest. In a work of the highest excellence on the subject Correns[3] occupies himself mainly with the morphology of the various organs of asexual reproduction, and also describes numerous cultural experiments made by him to ascertain the manner of their development. Correns was strongly of opinion that the organs in question could be turned to account in systematic bryology, but systematists generally show little inclination to do so. In the following notes the bracketed words in inverted commas are part of the terminology employed by Correns to describe the organ or tissue mentioned. The distribution of the species dealt with is according to Brotherus[1] and Dixon,[5] supplemented by my own observations and records. The following notes do not pretend to furnish a full and accurate account of the brood-organs mentioned or of their development.

CAMPYLOPUS CLAVATUS (R.Br.) H.f. & W.

Distribution.—Common in Australia and New Zealand.

Material examined.—Leg.: G.O.K.S.; October, 1933; on earth, near Wairoa, Hawkes Bay, North Island; fruiting.

This species is dioicous, but fruits freely. Asexual reproduction where present is brought about by brittle buds ("bruchknospen") at the end of a stem or branch.

Each annual growing period ends with the production of such a bud, the next year's growth being provided for by an innovating shoot which commences usually immediately under the break in the stem or branch. When the plant fruits the terminal cluster of shoots consists of branches or branchlets ending either in female flowers or in bruchknospen. It appears therefore that fertility in this species does not influence the asexual propagation one way or the other. Where the bruchknospen are present the young innovations form the club-shaped branches from which the specific name is derived; where they are absent we have the form known as *C. appressifolius* Mitt. In some seasons the bruchknospen are very plentifully produced, and the detached buds can be seen in the spring conspicuously scattered over the surface of the tufts. Vertical sections through the bud and stem show that the brittle tissue at the place of fracture ("trennschicht") consists, as is usual, of an area of short cells which in this particular instance are dark in colour. The bud consists of from ten to twenty leaves, and from its basal part rhizoids freely germinate in contact with the soil, a new plant resulting by continuation of the growing point. The leaves of the bud do not differ in size or structure from those of the ordinary branches. The inner tissue of the bud is rich in oil-drops; this is a common occurrence in brood-organs, and is a provision for the storage of nutriment. The shortening of the cells is explained as a device for mitigating the loss of living substance from the stem when the break takes place.[3], p. 372. Often, also, these cells are thinner walled, thus facilitating the fracture, but I have not noticed that they are so in *C. clavatus*. Occasionally the brittle bud, though broken off, escapes displacement from the parent branch, and in this case it puts out rhizoids and grows epiphytically, forming a pseudo-branch which is very easily detached. A similar method of reproduction apparently takes place in the European *C. schimperi* Milde,[3], p. 38 which, unlike our species, practically never fruits.

CAMPYLOPUS TORQUATUS (Mitt.) Jaeg.

Distribution.—Tasmania and New Zealand.

Material examined.—Leg.: K. W. Allison; No. 555; October 18, 1932; on Sphagnum mound in swamp near Atiamuri, North Island; fruiting. Leg.: E. A. Hodgson; No. 673; October 10, 1932; on old burnt-out Totara

stump, in remnant of bush, near Wairoa, North Island; barren.

The brood-organs present here are deciduous leaves of simplified structure ("brutblätter"). I have not found them *in situ* in Mr. Allison's specimen, though they are present in small quantity in the detritus. In Mrs. Hodgson's gathering the detached brutblätter are strikingly numerous, and the material throughout provides but few stems bearing only normal leaves, as against a vast majority where brutblätter or leaves of intermediate structure are present in abundance. The brutblätter are borne on thin branches which are either produced singly here and there from the stem or terminate it in a cluster of three or four. The branches themselves are not deciduous, but the leaves are extremely so. The detritus furnishes brutblätter of all lengths from 0·5 mm. or less to about 3 mm., the normal leaves being about 4 mm. in length. Apart from structural differences the brutblätter are readily distinguishable by being conduplicate, much more shortly pointed, and more or less bent forward at the middle in the shape of a boomerang. The supra-basal part of the lamina in this species consists of a small area of oblong hyaline cells, which soon gives place above to shorter and more obscure ones. In the brutblätter the area of oblong cells is continued far up the leaf, and the cross walls of the cells are conspicuously thickened. This renders more striking still the difference in its appearance. Oil-drops are abundant in the tissue of the nerve, and sections through it show that its development has been arrested at an early stage, in the same way as that described[3], p. 39 in two European species, *C. fragilis* B. & S. and *C. turfaceus* (*Bry. eur.*). The undivided branches which bear the brutblätter, the thickening of the cell walls mentioned above, and the structure of the nerve are all interesting points of resemblance between the New Zealand species and, in particular, *C. turfaceus*. In the European mosses mentioned the reproduction is effected by the further development of special thin-walled cells ("initials") which are present on the surface of the nerve of the brood-leaf and which produce a protonema from which new plants arise. These initials which, as they function specially for the propagation of new plants, are called *nematogones* are reported by Correns to be rare and difficult to find in the species investigated. I have failed to find them in *C. torquatus*, but have little doubt that they are present.

Rhizoid initials, i.e. those that develop from the nerve or lamina of the ordinary leaves the rhizoids which are so common on moss stems, are present plentifully on the nerve surface of the ordinary leaves of the New Zealand species, as they are in the case of the two European species. I have failed to find in the detritus any brutblätter showing germinating nematogones. In *C. fragilis* germination is infrequent, and confined to the large brutblätter.[3], p. 41 Apparently the production of young plants from the resulting protonema has not been observed.

PLEURIDIUM NERVOSUM (Hook.) Par.

Distribution.—Australasia.

Material examined.—Leg.: G.O.K.S.; October 23, 1927; on bare earth in open pasture, near Wairoa, Hawkes Bay, North Island; barren.

The exact taxonomic position of this plant is doubtful. The habit indicated an *Anomobryum*, but a stem that I found (and subsequently mislaid, unfortunately) showed a lateral perichætium of typical *P. nervosum* character, and as this species also grows abundantly near Wairoa in an exactly similar habitat it is probable that our plant belongs there. As in *Campylopus clavatus*, the adaptation for reproduction is here a deciduous terminal bud. The very slender julaceous stems are usually simple, but in the rare cases where a single branch is produced it, as well as the stem, ends with a bud and is then incapable of further development. The stem leaves for the greater part are bluntly acute and entire, tightly packed round the slender stem. The nerve vanishes below the leaf apex, and the cells of the lamina are subquadrate and thin-walled. At the apex of the stem, i.e. immediately under the deciduous terminal bud, and on the bud itself, the leaves are more sharply acute, mostly nerveless, with the cells longer, somewhat sinuate, and distinctly incrassate. The axis of the bud is appreciably thickened, and this, with the yellowish tinge of its leaves, makes it quite conspicuous. The moss is only about 5 mm. long, and longitudinal sections through the stem and bud are somewhat difficult to make, but I have been able to ascertain from a fairly satisfactory section that there is a distinct trennschicht consisting of a decrease in the diameter of the stem with an area of short cells. The thickening of the axis of the bud is obviously an adaptation for storage of nutriment, and the lax internal cells contain a

strikingly large number of oil-drops. Rhizoid initials are present at the base of the bud, and though I have not observed it there can be no doubt that a new plant originates by growth of rhizoids at the base and further development of the apical growing point, as in *Campylopus clavatus*. If this plant really belongs to *P. nervosum*, it furnishes an interesting case of dimorphism in the fertile and brood-plants respectively, because the leaves of the latter, as already mentioned, are bluntly acute and weakly nerved, whilst in the former it is only the lowest rudimentary stem leaves that exhibit these characters, the other leaves being ovate-lanceolate with a strong excurrent nerve.

HOLOMITRIUM PERICHÆTIALE (Hook.) Brid.

Distribution.—Australasia, and some Pacific islands.

Material examined.—Leg.: G.O.K.S.; January 1, 1932; Ketetahi, Mt. Tongariro, North Island; barren. Leg.: O. Buchanan; March, 1935; on bark, Tangiwai, near Mt. Ruapehu, North Island; fruiting sparingly.

Flagellate shoots ("bruchäste"), which often terminate the stem and the innovating branches in clusters of three or four or more, are present in these specimens, and occur, too, on some of the fruiting stems of Mrs. Buchanan's gathering. The shoots are brittle throughout their length, and usually break just above the insertion of a leaf. The brittleness is not greatly pronounced, however. The leaves of the bruchäste are very small, and being unaltered when dry and appressed to the stem of the shoot, contrast strongly with the larger curled leaves of the normal branches. Correns[3], p. 7 cites several authors from whose statements it would appear that brittle flagellate branches occur in other species of *Holomitrium*, but no plants of the genus were examined by him. Another dicranaceous moss, however (*Dicranum flagellare* Hedw., a European species), was investigated and the bruchäste and leaves fully described. In *D. flagellare* the bruchäste are clothed with leaves which, though thickened in the middle, have no differentiated nerve, and which contain oil as reserve nutriment. The leaves, unlike the ordinary ones, are conspicuously distichous. The shoot breaks readily into as many fragments as there are leaves, and reproduction is brought about by the outgrowth of protonemal filaments from nematogones on the surface of the internodes. The young plants arise on the protonema at some distance from the broken-off fragments. There is a defined trennschicht

at the place of fracture. In *Holomitrium perichætiale* the process of differentiation has not gone nearly so far as that above described by Correns. As a corollary with the decreased brittleness of the shoot a defined trennschicht is not present. The arrangement of the leaves on the flagellate shoot, instead of being distichous, is the same as that of the ordinary leaves. In the latter the deuter cells of the nerve are usually six in number, and there is a layer of three to four stereid cells above and below them. In the leaf-nerve of the brittle shoot the deuter cells have usually on each side one row only of sub-stereid cells, and, corresponding to the decrease in size of the leaf, its nerve is reduced to about half the width of that of the ordinary leaf. The leaves of the bruchäste are not adapted for storage of nutriment; they contain no oil, and are merely reduced in size and structure without acquiring any special properties for the furtherance of reproduction. Initials are plentiful on the surface of the internodes, and are readily distinguishable by the colourless and thin outer wall, the other peripheral cells having the same wall thicker and red-brown in colour. The detritus shows numerous cases where these initials have produced protonemal threads, and they can often be seen on flagellæ *in situ*. Cultural experiments would be required to show whether the development proceeds further to the formation of new plants on the protonema, or whether on the other hand the reproductive process is not yet sufficiently evolved to allow of this. In *D. bonjeani* De Not. there is a somewhat similar approach to the bruchäste of *D. flagellare*.[3], p. 13

DICRANOLOMA MENZIESII (H.f. & W.) Par. var *rigidum* (H.f. & W.) Par.

Distribution.—Australasia, Chile, Norfolk Island, Chatham Islands and subantarctic islands.

Material examined.—Leg.: Simpson and Thomson; No. 232; August 5, 1933; on tree-fern, Morrison's Creek, near Dunedin, South Island; barren.

In *D. robustum* (H.f. & W.) Par. var. *setosum* (H.f. & W.) Sainsb., broken-off portions of the leaf subula occasionally produce a protonema of rhizoid nature as an outgrowth from the deuter cells at the broken end.[10] The same thing happens in the above variety of *D. Menziesii*, and, as in *D. robustum*, the capacity to produce a protonema is practically confined to the basal end of the fragment.

The leaves in the variety *rigidum* are more or less brittle, and are very finely setaceous. They are evidently "bruchblätter", i.e. brittle leaves which serve to propagate the moss by the formation of young plants on the protonema. The species is usually fertile, but I have never seen any but barren plants of the variety, so presume that the capacity to form fruit has been totally suppressed here in favour of asexual reproduction.

DICRANUM TRICHOPODUM Mitt.

Distribution.—New Zealand and Tasmania.

Material examined.—Leg.: G.O.K.S.; April, 1931; on bark of subalpine scrub, Waiopehu, Tararua Mountains, *ca.* 3,000 ft., North Island; barren.

In this specimen there are present very striking bruchäste which probably generate new plants. The upper part of the stem bears numerous exceedingly long and very brittle branchlets whose leaves have long filiform prolongations of the nerve. The branchlets are readily broken into small fragments, the place of fracture, as in *Holomitrium perichætiale*, being usually just above a leaf insertion. There does not appear to be any consistently defined trennschicht, but the superficial cells of the stem are often shortened just above the leaf insertion where the break takes place, and this points to a stage of evolution towards a specialised tissue. Initials are plentiful on the surface of the internode, and can be found developing protonemal threads both on the plants and on the broken-off fragments. It is probable that young plants germinate on the protonema as in other species of *Dicranum*. In addition to the long prolongation of the nerve the leaf of the brittle branch differs from the ordinary leaf in being narrower and having a narrower nerve, but there is no adaptation for storage of nutriment.

FISSIDENS ASPLENIOIDES (Sw.) Hedw.

Distribution.—Sub-tropical parts of the Southern Hemisphere. Common throughout north island of New Zealand.

Material examined.—Leg.: J. H. McMahon; 1928; Marlborough, South Island. Comm.: E. A. Hodgson; No. 264; fruiting.

According to Correns,[3], p. 54 adaptations for asexual reproduction are, in the Fissidentaceæ, either unreported or very rare. Multicellular bodies borne on rhizoids from

the stem (" wurzelknollchen ") are mentioned as having been observed by him on one occasion in the European *F. taxifolius* Hedw., and he cites Lorentz[9] as having described them from that species. I have not had access to the latter's account, and am unable to say in what respect the bulbils there dealt with differ from those I have found in the Marlborough plant. At any rate they have in common the somewhat significant character of being produced *above* the ground, and not as a subterranean organ, as is usually the case with wurzelknollchen. In Correns's opinion[3], p. 337 the subterranean variety at any rate can only be considered as a food reservoir, and not as an organ of reproduction; he expresses, moreover, the view that even where the bulbils are produced above the ground it is only those of *Bryum erythrocarpum* Schwaegr.—which are homologous with reduced moss-plants themselves—that can be definitely recognised as being capable of functioning as true brood-organs. Obviously, therefore, it would be unsafe to draw any conclusion about the wurzelknollchen in *F. asplenioides* without clear evidence of their function. They are produced on long, plentifully-branched stem rhizoids which mat the plants together for a great part of their length. The Marlborough plant is the only gathering that I have seen from the mainland of the South Island, and in none of the numerous North Island specimens examined are the stems at all densely beset with rhizoids. The bulbils are about 0·1 mm. long, oval or obovate or sub-globular, narrowed at the base to a stalk consisting of two thin-walled cells, the upper of which is much shorter than the lower. The bulbils, like the rhizoids, are ruby red in colour. The surface is boldly reticulated. Here and there one or two cells at the apex have the outer wall nearly colourless, and this is usually also the case with the basal cell surmounting the stalk. I have occasionally found that these cells have commenced to germinate with the protrusion of the outer wall, but whether the germination would result in the formation of a reproductive protonema or merely in the multiplication of the cells of the organism is quite uncertain. The facts that differentiated outer cells occur and that the bulbils are readily detached from the rhizoids go to show that reproduction from them is a possibility, but until something more is known of them it would be unsafe to form any definite opinion. I have found starch and oil present at times in the bulbils, but

this is as consistent with the nature of a food-reservoir as with that of a brood-organ.

LEUCOBRYUM CANDIDUM (Brid.) H.f. & W.

Distribution.—Australasia.

Material examined.—Leg.: K. W. Allison: April 4, 1931; on forest floor, Mt. Messenger, Taranaki, North Island; fruiting. Leg.: G.O.K.S.; January, 1935; near Dawson Falls, Mt. Egmont, North Island; fruiting.

In the mosses not only specialised deciduous leaves ("brutblätter"), but also the ordinary leaves, or portions of them, can often reproduce the plant by functioning as slips or cuttings. Such detached leaves or fragments produce, from the lamina or nerve, rhizoid growth on which young plants are subsequently formed by direct budding on the filaments. The stimulus to reproduce, however, is furnished by separation from the stem, and although the leaf, when still attached, often produces a protonema, the resultant growth rarely generates new plants except indirectly through the prior formation of brood-bodies. The family of Leucobryaceæ supplies some interesting exceptions to this general rule. Correns[3], p. 50 describes in *Ochrobryum Gardnerianum* Mitt. the formation on the leaf apices of a rhizoid mat on which appear rudimentary plants that simultaneously produce multicellular brood-bodies. Dixon[6] says of *Leucobryum glaucum* Schp. that "the apical leaves often produce at their tips a tuft of radicles, whence are developed a cluster of minute plants, these subsequently falling off and giving rise to new colonies". Something resembling the latter form of propagation takes place in *L. candidum*, though I think quite infrequently, because I have only seen evidence of it in the two specimens above mentioned, and even there in but a few stems. What happens is that young plants are produced on rhizoid growth from the inner (ventral) surface of leaves borne on short branchlets. The leaves in question were of normal shape and structure and not at all deciduous, as they sometimes are in the species. The rhizoids on which the new plants germinate usually, but not invariably, have their origin in the lower part of the leaf. In *Leucobryum* the leaf consists almost entirely of a modified nerve formed by layers of hyaline cells which enclose a central layer of individually isolated and narrow chlorophyllose cells. In *L. candidum* some of the latter often run out to the surface towards the tip

of the leaf on the inner face, and then function as initials which develop a rhizoid growth that can usually be seen on leaves of the older part of the stem. A similar extrusion of chlorophyllose cells also frequently occurs towards the base of the leaf on the same face. One would expect, therefore, that the rhizoids on which the young plants are formed would originate only from these exposed chlorophyllose cells, but I cannot feel sure as to this, because the rhizoid filaments penetrate the hyaline cells in every direction and it is difficult to trace them to their starting points. With regard to the deciduous leaves that are occasionally met with in this species, I have not found that they differ from the ordinary leaves in any way, and do not know whether they are capable of generating a reproductive protonema when detached.

TORTULA ABRUPTINERVIS Dixon.

Distribution.—New Zealand.

Material examined.—Leg.: E. A. Hodgson; October, 1928; on bark, near Wairoa, Hawkes Bay, North Island.

This species has never been found in fruit. The remarkable brood-body present here is stated in the diagnosis[5], p. 150 to be axillary, but Mrs. Hodgson ascertained that it originates at the apex of the nerve. It has been described and figured by her.[8] The brood-body is evidently a metamorphosed nerve arista, and I find that nematogones are numerous on its surface. They are sunk below the level of the other superficial cells and are readily distinguishable, especially in transverse section, by their outer walls being colourless and only slightly papillose. The only germinating brood-body found in the detritus showed two embryonic plants budding directly out from the surface, one near one end and the other near the other. The protonemal outgrowth from the nematogones has evidently been reduced here to one or two cells. The method of propagation in this species—by means of a modified nerve arista—is quite different from anything hitherto observed in the genus *Tortula*, or indeed in any other moss, except certain species of *Macromitrium*.

MACROMITRIUM CADUCIPILUM Lindb.

Distribution.—New Zealand.

Material examined.—Leg.: G.O.K.S.; December, 1934; on bark, Tangiwai, near Mt. Ruapehu, North Island.

Leg.: Simpson and Thomson; No. 189; July, 1933 on bark, Otago, South Island.

As in the last-mentioned species, there is here a striking adaptation of the leaf arista as a brood-organ. Correns[3], p. 121 describes and figures it from the original material. The deciduous arista, which is often even longer than the leaf itself, breaks off at the leaf apex through a trennschicht of small, thin-walled cells. Correns found the arista to be frequently brittle throughout its length, but I suspect that this may be due to the age of the material examined, which was at least fifty years old. In my specimens the great majority of detached aristas are entire, and there is no marked fragility. Examination of fresh material also supplements his observations by showing that the tissue of the arista (when the latter is *in situ*) is green and chlorophyllose, in fact strikingly so, and that starch is present in it. Nematogones are plentiful on its surface, and Correns's confident assumption that rhizoid protonemata would be produced from these cells is borne out by the commencements of such growth that I have found in the detritus. In each case the only nematogones to germinate were situated in the lower central part of the arista. *M. caducipilum* has not been found in fruit.

MACROMITRIUM RETUSUM H.f. & W.

Distribution.—New Zealand.

Material examined.—Leg.: O. Buchanan; March, 1935; on bark, Tangiwai, near Mt. Ruapehu, North Island.

This species is close to *M. caducipilum*, though separable by fairly satisfactory characters. The same peculiar thickened arista is present, and here, as in that species, it is quickly shed by all but the youngest leaves, so that the end of the branch usually shows a characteristic penicillate tuft. As in the last species, the arista breaks off at the leaf apex (where there is a similar trennschicht), and in all other respects I have found an exact agreement between the two species so far as the brood-body is concerned. Also in the only germinating arista found in the detritus there were several short rhizoid filaments situated in its lower central part. *M. retusum* has not been found in fruit, but it is doubtful whether it is specifically distinct from the fertile *M. gracile* (Hook.) Schwaeg.[5], p. 367 So far as the brood-body is concerned there is a closer connection with *M. caducipilum*.

MACROMITRIUM GRACILE (Hook.) Schwaegr.

Distribution.—New Zealand.

Material examined.—Leg.: G.O.K.S.; September, 1931; on bark, Lake Waikaremoana, Hawkes Bay, North Island; var. *proboscideum* Dixon; barren. Leg.: R. Mundy; Ohakune, near Mt. Ruapehu, North Island; fruiting.

In the two last-mentioned species of *Macromitrium* there is no pronounced fragility of the leaf lamina, and the term "bruchblätter" is not so fitly applicable to their leaves as it is in the present species. Here the nerve is, except in the variety *proboscideum*, seldom very far excurrent. The leaf is brittle, especially in its upper portion, and the detritus usually contains a varied assortment of leaf fragments. Initials are present both in the excurrent nerve and also, more frequently, adjacent to it in the upper part of the leaf subula. The cells in question are distinguishable by their colourless outer walls, less papillose than those of the ordinary cells. I have not been able to find any trace of outgrowth from the initials in any of my specimens, so am unable to say whether the leaves are true bruchblätter or not.

BRYUM INCURVIFOLIUM C.M.

Distribution.—South Island.

Material examined.—Leg.: J. H. McMahon; Marlborough. Comm.: E. A. Hodgson. Det.: H. N. Dixon; No. 617 in Herb. G. O. K. Sainsbury.

I submitted this interesting plant to Mr. Dixon, who determined it as above somewhat doubtfully, so its systematic position must be considered as uncertain. The species may in any event come within the scope of the variable *B. lævigatum* H.f. & W.[(5), p. 216] Amongst the leaves, especially in the upper part of the stem, are conspicuously long brown filaments which in the terminal tuft nearly reach the leaf apices. It will be found that these brood-filaments ("brutfäden") are borne on single or branched stalks which are produced from the leaf axils throughout the length of the stem. The cylindrical brood-filaments consist of up to twenty or more cells, which are divided by transverse walls. They are dark brown, papillose and obscure, and contain oil-drops. The terminal cell is rounded and colourless, but, being papillose too, is somewhat obscure. The cells usually vary in length from one and a half times to twice their

thickness, but towards the apex of the filament they become shorter and relatively wider. The filament is connected with the stalk by a very short brittle cell (" brachytmema ") whose function is to bring about the dehiscence of the filament. This disc-like cell is only about one-sixth the length of the adjoining basal cell of the filament. When the fracture takes place the remnants of the wall of the brachytmema remain attached to the adjoining cells of the stalk and filament respectively. Occasionally a filament can be found in the detritus showing an internal cell conspicuously shorter than its neighbours, but I am doubtful whether such a cell is a brachytmema or the dormant foundation cell of a branch. The cells of the stalk usually resemble those of the filament, being also brown and papillose, with transverse walls. They are, however, somewhat longer, and often show forms of transition to the ordinary stem rhizoids which are much thinner, faintly papillose only, and composed of much longer cells with slanting walls. Owing to the earlier dehiscence of the filaments in the lower and older part of the stem they are only to be found *in situ* in the upper part. I have not found any trace of germination in the filaments, but there can be no doubt that the terminal rounded cell can function as a nematogone, and probably the basal cell also, to judge by what happens in the European species *B. capillare* L.,[3], p. 185 where the form and development of the brutfäden are, in the main, very similar. In that species either one or both of the terminal cells of the filament were found to be capable of developing protonemal growth on which young plants arose. In the detritus of Mr. McMahon's specimen there are numerous rudimentary buds (" bruchknospen ") and also red multicellular bodies resembling the wurzelknollchen before described in *Fissidens asplenioides*. Unlike the latter, however, they often show traces of development at the apex, in the shape of what appear to be leaf-foundations. Oil-drops are plentiful in their tissue. These bodies have evidently been produced on a protonema, but the remnants of the threads, where present, are in too bad a condition to show whether the bodies have originated on ordinary stem rhizoids or on a protonema of a reproductive nature. In any event their appearance indicates that they are wurzelknollchen of the kind produced by *B. erythrocarpum* Schwaegr., and capable of development into new moss plants. If, then, they originated in the specimen itself, we should have in this

plant the occurrence of two forms of asexual reproduction, which could only be matched by the bryoid moss *Leptobryum pyriforme* (L.) Wils., where brood-filaments and bulbils have been found on the same plant.[3], p. 150 The bruchknospen, which are in the form of bulbils 0·3 mm. to 0·4 mm. long and crowned by more or less well-developed leaves, are of the type often met with in bryoid mosses. They must have been produced from leaf axils to which they were attached by a very brittle basal tissue. They contain starch as reserve nutriment, and would evidently develop into new plants by an extension of the growing point coupled with the outgrowth of rhizoids from the initials that are clearly visible at the base. The occurrence of *three* forms of asexual reproduction in a moss plant (and fertile at that) would be too remarkable to justify such a conclusion from the presence in the detritus of the organs in question, but it must be conceded that their being found loose in the packet is very puzzling, more especially as both kinds of brood-organ are practically confined to bryoid mosses. A careful search failed to reveal either bruchknospen or wurzelknollchen in organic attachment to the plant. It is possible that the knollchen have been formed on a protonema originating from the germination of nematogones in the brood-filaments. In that case they would be " secondary " brood-bodies, i.e. those that are occasionally produced directly from other brood-bodies,[3], p. 348 but nothing resembling this particular case seems to have been recorded. It is perhaps too much to hope that further material will be found to throw light on this interesting specimen.

ERIOPUS CRISTATUS (Hedw.) Jaeg.

Distribution.—New Zealand, and possibly Tasmania.

Material examined.—Leg.: G.O.K.S.; October, 1934; on damp rock in dense shade, Marumaru Caves, near Wairoa, Hawkes Bay, North Island; fruiting.

The vegetative plant of this species consists of a dorsi-ventral flattened shoot, the leaves being closely imbricated as in many other Hookeriaceous mosses. I have not found brood-organs in any gathering other than the above. They are present here in the form of brood-filaments which dehisce by typical brachytmema from long branched virgate stalks that spring in dense tufts from the dorsal side of the stem. Some of the plants are densely beset with the stalks, whilst others have but few, and others

again none at all. The stalks are coloured light brown, except in their lower part, where they tend to become more red. The outer walls are thin, and the cell division walls all more or less transverse. The brood-filament has a peculiar appearance, being always approximately L-shaped. When mature it attains 0·3 mm. or more in length. When it is not strictly L-shaped the lower limb slopes down at an obtuse angle. The main limb consists of five or six cells, which are long in relation to their breadth. The lower limb or branch is developed from the cell on the main limb next above the brachytmema when the brood-body is still attached to the stalk. Probably the branch does not always attain its full growth, i.e. three to four cells, before the brood-body breaks off, but the greater part of its development certainly takes place before separation. A further interesting and curious extension of the brood-filament consists of the outgrowth from the first cell of the branch (next to the angle cell of the "L") of yet another branch which grows out vertically to the plane of the filament and thus forms a second "L" with the original branch as its main limb. I have not been able to ascertain whether this secondary development ever commences when the brood-body is attached to the stalk. The remains of the wall of the brachytmema can be seen attached to the somewhat truncate basal cell of the filament in the form of a projecting rim or collar. The cells are usually densely packed with chloroplasts, and contain large quantities of starch grains but no oil. The apical cells of the main limb and branches are bluntly tapered and much more translucent. No further development was observed. A somewhat similar L-shaped brood-filament is shortly described by Correns[3], p. 235 in the case of an East Indian species *E. remotifolius* C.M., where the method of reproduction on stalks from the stem appears to be exactly the same, but where the branch of the filament constantly slopes down at a wide angle from the limb, and, moreover, frequently equals the latter in length. No particulars of the number of cells are given, but it is mentioned that they too are long for their width. Nothing is said of the formation of a secondary "L" which takes place not only in *E. cristatus* but also in the Hookeriaceous moss *Pterygophyllum dentatum* next dealt with. Correns states that he has observed no trace of germination of the filament, but that probably the apical cells of both limbs are capable of development.

PTERYGOPHYLLUM DENTATUM (H.f. & W.) Mitt.

Distribution.—Australasia, southern parts of South America, and subantarctic islands.

Material examined.—Leg.: V. D. Zotor; September 3, 1933; Tararua Mountains; No. 6914 in Herb. New Zealand Plant Research Station; barren. Leg.: K. W. Allison; No. 92; August 23, 1928; very rotten logs and earth, Puaiti Bush, near Rotorua, North Island; fruiting. Leg.: E. A. Hodgson; No. 533; September, 1930; Puketitiri, Hawkes Bay, North Island; fruiting.

The brood-organs in this species were first mentioned by Colenso[2] in the publication of his *Hookeria obtusata* which is not separable from *Pterygophyllum dentatum*. He refers to them as follows: "Leaves often fringed at or within the margins on the under side with minute jointed cylindrical cellular bodies". From the context it might seem that he considered them to be foreign bodies. Their true nature is recognized by Dixon,[5], p. 289 who mentions that they stand out on the leaf usually round the margin, and are frequently so abundant as to form a perfect *cheval de frise*. I find that they are produced on either surface of the leaf from initials that are separated from the margin by only one or two cells, and that they occur on fruiting as well as on barren plants. The initials are readily recognisable by their small size, the diameter being only about one-half of that of the adjoining cells of the lamina. When present in the leaf at all they may be in any number from a few scattered groups towards the apex to a continuous band within the margin. From the initials are produced short brood-filaments of the L-shape of those of *Eriopus cristatus*, an interesting point of resemblance in two species of related genera. The likeness is accentuated by the lower limb of the filament being often set on at a similarly wide angle, and still more so by the later development of a subsidiary limb. The main limb consists of a cylinder of four to six cells, whilst the lower limb has one to three. The cells are if anything rather broader than their length, instead of being narrower as in *Eriopus cristatus*, so although the number of cells is approximately the same as there, the brood-body in *Pterygophyllum dentatum* is much shorter, i.e. scarcely 2 mm., with a proportionately far wider diameter, and its appearance is altered accordingly. It tends to be short and squat rather than long and slender. The cells contain chloroplasts and oil-drops, but only a trace of starch.

The organism grows directly out of the initial from the surface of the leaf, cuts off the brachytmema from its base by a dividing wall, and ultimately dehisces by rupture of the brachytmema, the remains of whose walls can be seen as a collar or ridge on the outside of the initial and of the basal cell of the main limb. The lower limb is apparently often fully developed, by lateral outgrowth of the basal cell, before dehiscence. Where it is seen to consist of but one cell this is probably due to immaturity. The basal cell of the main limb is somewhat truncate, but the apical cells of both limbs are bluntly tapered, contain fewer chloroplasts, and are more translucent. They are capable of functioning as nematogones, but nevertheless do not germinate at once in the further development of the brood-filament, because the first cell to bud is nearly always the angle cell of the lower limb adjacent to the basal cell, and the commencement of this growth often takes place before the filament dehisces. The same peculiar double L-form results from this process as has been described in *Eriopus cristatus*. Subsequent commencements of protonemal growth in a straight line from the apical cells of either limb were noticed here and there in detached brood-bodies in the detritus. The only embryonic plant seen appeared to have developed on the branch of the *secondary* "L", and there was in this case a very short extension of both limbs by protonemal growth. In the specimens examined the older leaves sometimes showed quite a vigorous rhizoid growth from the initials, but I cannot say whether the same initials had already produced brood-filaments which had broken off when the plant was younger. The brood-bodies are evidently therefore metamorphosed rhizoids which in their phylogenetic development have retained the distinctive shape of the modified stem-rhizoids that form the brood-filaments in *Eriopus cristatus*.

GLYPHOTHECIUM ALARE Dix. & Sainsb.

Distribution.—New Zealand.

Material examined.—Leg.: G.O.K.S.; November, 1933; on bark of small trees, Panikeri Range, Lake Waikaremoana, Hawkes Bay, North Island; barren. January, 1935; on bark of twigs and small branches; near Dawson Falls, Mt. Egmont, North Island; fruiting.

The position of this interesting moss is very doubtful, and it may have to form the type of a new genus.[7] The brood-filaments present are densely tufted in great

quantities in the axils of the upper leaves. They are borne on short stalks, formed of two to four cells, which are either simple or branched at the base. The stalks in the lower section of the gemniferous part of the stem tend to be of rhizoid character, with thickened and coloured outer walls and oblique inner walls. They resemble there the short axillary rhizoids that sometimes appear still lower down. Higher up the stem, however, towards the apex, the stalks have their outer walls thinner and more faintly coloured, and their cells approximate, both in structure and contents, to those of the brood-filaments. The latter are separated from the stalks by a disc-like brachytmema about 4μ long. The filament is slightly tapered from the middle to both ends. Mature filaments are composed of from twenty to twenty-five cells which vary from 45μ to 90μ in length by 20μ to 30μ wide. Their walls are transverse or slightly oblique and quite colourless, contrasting strongly with the green chlorophyllose cell contents. The apical cell is as a rule nearly hyaline, and its tapered distal end has a thickened wall. Treatment with suitable reagents discloses the presence of oil-drops in the cells. In the detritus, especially that of the Lake Waikaremoana specimen, a number of germinating filaments were found. In one case a long branch consisting of similar cells had grown out from about the middle. In other cases a colourless and thin rhizoid protonema had been produced from cells in various parts of the filament. Although the apical cell had sometimes put out two or three such protonemal threads, it did not seem that the capacity to produce them was accentuated in this part of the filament. No doubt cultural experiments would show that young plants arise on the protonema.

TETRAPHIDOPSIS PUSILLA (H.f. & W.) Dixon.

Distribution.—New Zealand.

Material examined.—Leg.: K. W. Allison; No. 155; January 21, 1929; Puaiti Bush, near Rotorua, North Island; on dead trunks; fruiting.

This remarkable moss was described and figured by Dixon[4] as *T. novæ-seelandiæ* Broth. & Dix., but later it was found to be the same thing as *Meteorium pusillum* H.f. & W., so the specific name reverted accordingly. The short brood-filaments present are densely crowded on a capitulum terminating the stem or branch, and are sometimes also axillary in the upper leaves. As the

description states, they are fusiform or narrowly clavate, and consist of four to six chlorophyllose cells. I can add from my observations that the filament, which is often slightly curved, is borne on a stalk consisting of a single thin-walled colourless cell from which it dehisces by a brachytmema. Reserve nutriment is present in the form of oil-drops. As is often the case where a brood-filament separates by the rupture of a brachytmema, the stalk here appears to be capable of growing up through the broken wall of the brachytmema and forming another brood-organ. The filaments are evidently metamorphosed stem-rhizoids, as are those of *Glyphothecium alare*, and this is an interesting link between the two mosses, which belong to related genera. The only germinating filament found in the detritus had put out the commencement of protonemal growth at a right angle from the apical cell.

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THE OXIDATION OF COBALT AMALGAM.

By F. P. Dwyer, M.Sc.,
and J. W. Hogarth.

(*Manuscript received, August 20, 1935. Read, September 4, 1935.*)

The rapid atmospheric oxidation of cobalt amalgam, leading to the production of a fine, intensely black, powder, which was suggested tentatively to be a suboxide of cobalt, was noted by Hogarth (This Journal, 1934, *68*, 153).

Considerable doubt exists as to the authenticity of the suboxides of many metals, notably lead, silver and copper, the last two of which are claimed to have the form M_4O (H. Rose, *Pogg. Ann.*, 1863, *120*, 1; Van Arkel, *Rec. Trav. Chim., Pays Bas*, 1935, *44*, 652; Ferrari, *Gazzetta*, 1926, *56*, 630; Darbyshire, *J.C.S.*, 1932, 211; *et al.*).

Since a preliminary analysis showed that the decomposition product of the amalgam was of the form M_4O, it seemed of interest to investigate the substance further.

In the series of experiments described below the composition and conditions of oxidation of cobalt amalgam are set down. It was found that, although the chemical analyses leading to the formula Co_4O were reasonably consistent in view of the ease of oxidation of the substance to higher oxides, X-ray powder photographs showed the lines of cobalt metal, indicating a mixture of metal and oxide.

The decomposition product was found to be a powerful reducing agent, converting the nitrites and nitrates of metals into ammonia in neutral or even alkaline solution. It could be caused to reamalgamate with mercury by treatment with dilute acids or ammonium salts, although simple shaking or grinding with mercury failed to make it do so. This result is interesting in that claims for the existence of lead suboxide were substantiated by the failure of the alleged suboxide to give any lead amalgam on rubbing with mercury (P. Bolley, *Dingler's Journ.*, 1850, *116*, 358; *et al.*). By removal of the oxide with ammonium salts in an inert atmosphere an extremely

active, spontaneously inflammable form of cobalt metal was isolated.

Experimental.

Cobalt Amalgam.

The amalgam was prepared from a slightly acid solution of purified cobalt sulphate by electrolysis, a purified mercury cathode being used. It was freed from adherent mercury by pressure, and preserved under dilute (N) sulphuric acid. The analyses were carried out by distillation of the mercury at red heat in a current of hydrogen, the distillate being collected under water.

Co_2Hg_3 requires Hg : 83·6%; Hg found : 83·8%.

Tests on the cobalt residue after distillation showed it to be free from mercury.

In the hope of isolating other forms of cobalt amalgam a large number of experiments were carried out. Specimens were prepared at 350, 200, 150, 90, 20 and 10 amps./sq. ft.; the cobalt was preoxidised to the cobaltic state, then electrolysed at different current densities, and finally the cathode was isolated with a porous membrane to keep the cobalt in the cobaltous state. In all cases the only compound isolated was the substance Co_2Hg_3. It seems therefore that the compound $Hg_{10}Co_3$ recorded by other workers contained excess mercury (J. Newton Friend, " Textbook of Inorganic Chemistry ", Vol. III, Pt. 2, 221).

Owing to the difficulty of freeing the amalgam completely from adherent mercury before decomposition set in, the mercury figures were consistently a little high.

The amalgam as prepared is a brittle, crystalline solid which decomposes without melting. It is magnetic. Exposure to the atmosphere leads to rapid oxidation, the temperature of the mass rising in 10 to 15 minutes to 50–60° C., while a black powder separates. The decomposition does not occur *in vacuo*, nor with the dry amalgam in dry air, nor under water free from air. It is stable also in hydrogen, nitrogen and carbon dioxide, and under dilute acids.

Analyses of the Oxidised Amalgam.

The oxidation product, freed as completely as possible from mercury by levigation with water, was stirred vigorously with amalgamated copper strips, washed with alcohol and dried over phosphorus pentoxide. Tests on

the substance after three days showed that it still contained water and traces of mechanically enclosed mercury. Special methods of analysis were therefore necessary.

The substance was heated in a porcelain boat in nitrogen and the adherent water removed at 300–400° C. The nitrogen was then replaced with hydrogen and the oxide reduced to the metal at dull red heat. The gas after passing over a long spiral of silver gauze to trap mercury vapour was collected in weighed absorption tubes.

O (found): 6·55% (mean of 11 determinations* on different preparations). Co_4O requires O: 6·35%.

The percentage of adherent water after drying varied from 4·07 to 2·81. Very freshly prepared specimens gave results close to Co_4O.

A gradual oxidation by the air took place in this substance, so that after some months it was a mixture of cobaltous and cobaltic oxides, and evolved chlorine with hydrochloric acid.

The oxide is in an extremely fine state of division, part of it passing in alcohol into a greenish colloidal suspension. It burns easily in air on being heated to about 200°. It is magnetic, and decomposes hydrogen peroxide vigorously. On treatment with dilute acids hydrogen is evolved readily, but in the presence of mercury no hydrogen is given off and part of the substance reamalgamates, the remainder forming a cobalt salt. The re-formed amalgam has the same composition as the original, and decomposes in the same way.

Solutions of nitrites and nitrates are vigorously reduced in neutral or alkaline solution. If the temperature of the mixture is kept for about two minutes at 80° C. the whole suddenly boils, the temperature rises to 90–100°, and volumes of ammonia are liberated. The residue contains cobalt ammines, and is strongly alkaline. In the same way mercuric, stannic, cupric and ferric salts are reduced in the cold to the lower valency state or to the metal. Further work on the reduction of nitrites and nitrates is intended with a view to isolating intermediates.

X-Ray Examination.

In view of the striking properties of the substance Debye-Scherrer powder-photographs were taken, the

* 6·66%, 6·53%, 5·94%, 6·00%, 6·15%, 6·28%, 7·21%, 6·60%, 6·73%, 7·09%, 6·85%.

filtered radiation from an iron target at 30 kv. being used. Owing to the state of division of the powder and the presence of traces of mercury, considerable difficulty was experienced. Eventually with a specimen prepared by the slow oxidation of the amalgam, under reduced pressure, a number of faint lines were obtained, which were identified as corresponding with the most intense lines of α (low) cobalt. The analysis of the photograph is shown in Table I, with the spacings of α cobalt for comparison (Hull, *Phys. Rev.*, 1921, *17*, 577). Lines due to cobaltous oxide were probably obliterated by the heavy background due to general scattering from the mercury impurity.

TABLE I.—*Analysis of Powder-photograph.**

Cobalt Suboxide.	α Cobalt.	Index.
A.U.	A.U.	
2·218	2·176	$10\bar{1}0$
2·041	2·051	0001 (2)
1·921	1·920	$10\bar{1}1$
1·260	1·257	$11\bar{2}0$
1·075	1·072	$11\bar{2}2$

* Lines produced by the CoO calibrant are omitted.

The decomposition product is therefore a mixture of cobalt metal and oxide in the ratio of 3 : 1. This ratio was directly determined by separation of the constituents of the mixture. The oxide was treated with ammonium sulphate and ammonia in an atmosphere of nitrogen, and mercury added. In this way the cobaltous oxide dissolves as an ammine and the metal passes into an amalgam. The ammoniacal solution and the amalgam were then analysed for cobalt.

$$\frac{\overline{Co(Hg)}}{\overline{Co(NH_4CH)}} = \frac{\cdot 5575}{\cdot 1762} = \frac{3 \cdot 16.}{1}$$

The ratio is a little high owing to inclusion of a little of the oxide in the amalgam.

Pyrophoric Cobalt.

This was prepared from the oxidation product of the amalgam by removal of the oxide. The oxidation product (5 g.) was freed as completely as possible from mercury

with amalgamated copper, then stirred vigorously with a mixture of ammonium sulphate (30 g.) and ammonium hydroxide concentrated (10 ml.) in 100 ml. of air-free water in an atmosphere of nitrogen for 15 minutes. The reddish ammoniacal solution was drawn off and replaced with fresh solution until no further colour was given. The black powder remaining was washed with ammonium sulphate solution, water, alcohol and ether and dried *in vacuo*. On coming in contact with air the powder spontaneously ignites, burning with a dull red glow. Even damp specimens are quite active, while traces of alcohol on the surface are oxidised to acetaldehyde. The metal is magnetic, and is readily soluble in mercury, re-forming the original amalgam, and in acids. Like the oxidation product it reduces nitrites and nitrates to ammonia.

Discussion.

From a consideration of the properties of the oxidation product of cobalt amalgam, the ease with which an amalgam is re-formed, and the consistency over many experiments of the cobalt/cobalt oxide ratio, it is suggested that the suboxide is the primary product of oxidation. The mechanism is most probably a reaction between the condensed film of oxygen on the surface of the amalgam and the compound Co_2Hg_3 to form the insoluble Co_4O, which separates out, decomposing to form the insoluble CoO and cobalt metal. Rapid surface oxidation of the cobalt metal prevents its reamalgamation. This is shown by the fact that the decomposition of the amalgam can be slowed down by rubbing or stirring. Separation of cobalt metal as such, followed by oxidation, is unlikely in view of the stability of the amalgam in an inert atmosphere over nearly two years.

The reducing properties of the oxidation product are due no doubt to the fine state of division of the powder, which should make it catalytically active for hydrogenation. It is hoped to investigate this point.

The period of induction in the reduction of nitrites and nitrates is probably caused by the small initial cobalt metal surface until sufficient ammonia is formed to dissolve the oxide film, since the reaction seems to be accelerated by traces of ammonium salts. The reduction is then caused by reaction of the cobalt with the water, forming hydrogen and cobaltous hydroxide.

SUMMARY.

(1) Cobalt amalgam has the composition Co_2Hg_3.

(2) The decomposition product is a mixture of metal and oxide in the ratio 3 : 1.

(3) The latter substance is a powerful reducing agent, and on treatment with ammonium salts gives a pyrophoric form of cobalt.

The authors wish to thank the Chemistry Department of the University of Sydney for the use of the X-ray plant, also Dr. R. K. Murphy of the Chemistry Department of this College for some of the apparatus necessary for the research.

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THE ESSENTIAL OILS OF *EUCALYPTUS AUSTRALIANA* (BAKER & SMITH) AND ITS PHYSIOLOGICAL FORMS.

PART I.

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(With Plate IV.)

(*Manuscript received, September 25, 1935. Read, October 2, 1935.*)

This species and its essential oil were first described by Messrs. Baker and Smith in a paper read before this Society in 1915.* It is known vernacularly as the Narrow-leaved Peppermint or Black Peppermint, and is found growing in the southern districts of N.S.W. (Nerrigundah, Nelligen, Eden, etc.), and the Bathurst district (Black Springs, Burraga, Tarana, Oberon, etc.).

The authors of this species referred to the morphological and other characters which differentiate it from *Eucalyptus amygdalina* of Labillardière, a name which is now confined to the Narrowleaved Peppermint of Tasmania. Messrs. Baker and Smith, on p. 280 of their publication issued in 1920 by the Sydney Technological Museum, entitled "A Research on Eucalypts and Their Essential Oils", described another species of Narrowleaved Peppermint from Braidwood and other southern districts of N.S.W. as *E. phellandra*. They stated that the species was morphologically difficult to distinguish from *E. amygdalina* and *E. Australiana*, and also that "it is one of the few species that has been founded almost entirely on the chemical constitution of the oil".

One of us (A.R.P.) was consulted by Messrs. Baker and Smith at the time *E. phellandra* was described. Their decision was supported because it was desirable at that

* THIS JOURNAL, 1915, *49*, 514.

time to distinguish the two kinds of Eucalyptus oils for commercial purposes.

The oil of *E. Australiana* was much in demand on account of its high content of cineol (70%) and absence of phellandrene when examined by the B.P. test. *E. phellandra* contained only about 35% to 50% of cineol and much phellandrene (about 40%), consequently it could be used only for industrial purposes as it did not meet the requirements of the various pharmacopœias, which demanded a minimum of 70% of cineol.

The essential oils of *E. Australiana* from Nerrigundah and Yowrie districts have, since their discovery, been noted for their constancy of composition. Many hundreds of tons have been distilled from material from the South Coast and Bathurst districts, and there is no record of the terpene phellandrene having been detected, although Messrs. Baker and Smith in their original paper (p. 519) referred to the variation in the content of both cineol and phellandrene in the oil obtained from trees grown in different districts. They also stressed the necessity for keeping the first-hour distillate separate (p. 518) in order to keep the content of phellandrene at a minimum.

The investigation described in this paper shows that the variable content of phellandrene in *E. Australiana* oil referred to by Messrs. Baker and Smith was apparently due to admixture of variants shown to be rich in phellandrene and relatively low in cineol content. The oil obtained in commerce contains invariably 70% of cineol. The terpene phellandrene is not detected by the B.P. test.

Since 1920 we have studied intensively the physiological forms of such well-known species as *E. dives*, *E. radiata* Baker & Smith, *E. hæmastoma* and *E. micrantha*.

In the course of studying *E. dives*, the Broadleaved Peppermint, we availed ourselves of the opportunity of studying the Narrowleaved Peppermint which occurred in many instances in close proximity to *E. dives*. We have made reference to the study in some of our writings and in the Annual Reports of the Technological Museum for the years 1928–1934 inclusive. We have, during the past three years, made a very close study of the Narrowleaved Peppermints of N.S.W. in conjunction with Mr. E. Cheel, Curator and Botanist, National Herbarium, Sydney, and Mr. M. B. Welch, Economic Botanist, Technological Museum, Sydney. The results of the investigation will be published at an early date. Meanwhile, we have deemed

it advisable to summarise the chemical data in order to pave the way for the subsequent critical discussion of the botanical classification.

As a result of the chemical investigation of the essential oils of the Narrowleaved Peppermints we have come to the conclusion that there are several physiological forms of *E. Australiana* and that *E. phellandra* is one of them. The evidence in support of this contention is given in Tables I and II.

A special search was conducted in September, 1934, for the purpose of ascertaining if physiological forms of *E. Australiana* yielding phellandrene in traceable amounts could be found in the Moruya district, which is noted for the absence of this terpene in the commercial oil. No difficulty was experienced in picking out variants by crushing the leaves of many trees and observing the odour. These observations were confirmed by collecting small quantities of leaves from selected trees and examining the essential oils, full particulars of which are given in Table II.

The essential oils of the type, Nos. 1 and 4, were almost water-white in colour, with a pronounced camphoraceous odour of cineol modified by small quantities of citral. The variants, Nos. 2, 3, 5 and 6, varied from a water-white to a pale lemon-coloured oil and possessed a pronounced odour of phellandrene and alcoholic bodies of the terpineol-terpinenol type. Similar observations were made in the Tumut district during the year 1933.

The distillation of medicinal Eucalyptus oil rich in cineol and free from the terpene phellandrene had never been successful in the Tumut district. On practically every occasion the oils were found to be low in cineol and high in phellandrene. We were very surprised, therefore, to observe large numbers of magnificent trees of *E. Australiana* type in the Bago State Forest, the essential oils of which were found to be identical in cineol content and freedom from phellandrene with those obtained from the Moruya district. (See Table I, Nos. 1, 5, 5A and 9.)

The variant now called Variety A was usually considered to be the preponderating tree. Large areas of this variety still exist, although it is being cut out at a very rapid rate for utilisation of the timber. The essential oils of this variety are pale to dark lemon-yellow in colour and contain very little cineol. The composition of the essential oil is quite different from that of other Eucalyptus oils in this series which have so far been described.

TABLE I.

Eucalyptus Australiana *from Laurel Hill and Batlow Districts, N.S.W., Nov. 27 to Dec. 2, 1933.*

No.	Locality and Description.	Yield of Oil.	$d\frac{15^\circ}{15^\circ}$	$\alpha_D^{20^\circ}$	$n_D^{20^\circ}$	Solubility in 70% Alcohol.	Ester No.	Ester No. after Acetylation.	Cineol.	Phellandrene.	Citral.	Remarks.
		%				vols.			%		%	
1	Three miles outside Batlow (Gilmore side).	1·4	0·9239	+3 5°	1·4665	1·0	13·9	68·9	69	Not detected.		Type.
2	Leaves from a variety containing phellandrene from Kunama.	1·2	0·9081	+11·4°	1·4694	1·2	7 0	60·0	37	Abundance.		Variety B.
3	" " " "	1·8	0·8945	−27·15°	1·4766	6·0	18·0	74·9	19	"		Variety B.
4	" " " "	2·35	0·9168	−5·85°	1·4664	1·0	7·4	59·3	58	Small quantity.		Variety B.
5	Leaves from utmost top of tree 90 feet in height, at Swift's Camp, Bago Forest, on road to Pilot Hill.	3·4	0 9267	+2·3°	1·4634	1·0	20·7	55·3	75	Not detected.	3·7	Type.
5A	Leaves from bottom of tree No. 5.	2·54	0·9248	−3·5°	1·4644	1·0	26·0	59·7	71	"	3·4	"
6	Leaves from tree considered to be Variety A from Swift's Camp, Bago Forest, for comparison with No. 5.	2·3	0·8762	−58·75°	1·4787	5·0 80% alcohol.	8·9	72·3	Trace only.	Abundance.		Variety A.
7	Leaves from tree on left side of road at Williogobung on road to Tumbarumba.	1·5	0·9013	−19·6°	1·4772	1·8 70% alcohol.	32·0	95·5	16	"		Variety A.
8	Leaves from tree near hotel at Laurel Hill (heavy fruiting type.)	1·7	0·8989	−21·15°	1·4762	1·8	22·0	69·7	7	"		Variety A.
9	Leaves very rich in cineol from tree on road to Tumut two miles on Gilmore side of Batlow (large tree with abundance of fruit).	3·25	0·9226	+3·25°	1·4640	1·0	17·9	71·8	70	Not detected.	3·5	Type.

TABLE II.

Eucalyptus Australiana *from Moruya District, N.S.W., Sept. 3–7, 1934.*

No.	Locality and Description.	Yield of Oil.	$d\frac{15^\circ}{15^\circ}$	$\alpha_D^{20^\circ}$	$n_D^{20^\circ}$	Solubility in 70% Alcohol.	Ester No.	Ester No. after Acetylation.	Cineol.	Phellandrene.	Remarks.
		%				vols.			%		
1	Leaves from saplings on road from Nerrigundah to Cadgee.	3·2	0·9228	+2·75°	1·4635	1·0	1·0	56·7	71	Not detected.	Type.
2	Leaves from variant growing alongside No. 1.	2·4	0·9104	−5°	1·4679	1·2	10·1	100 6	44	Moderate quantity.	Variety B (*E. phellandra*).
3	Leaves from top of ridge (Sutherland's Country) at Yowrie (suckers only); apparent variant selected.	1·9	0·9135	−4·75°	1·4670	1·1	3·7	77·5	48	Small quantity.	Variety B (*E. phellandra*)
4	Leaves from typical *E. Australiana* from Sutherland's country for comparison with No. 3.	2·1	0·9193	+1·75°	1·4642	1·0	9·1	74·5	69	Not detected.	Type.
5	Leaves from selected variant—sucker growth. Country beyond Woodford's Still at Yowrie.	2·4	0·9122	−5·75°	1·4675	1·2	12·5	80·4	48	Small quantity.	Variety B (*E. phellandra*).
6	Leaves from another tree growing close to No. 5.	1·4	0·9083	−8°	1·4722	1·3	14·7	74·2	36	Moderate quantity.	Variety B (*E. phellandra*).

E. phellandra occurs in a very luxuriant condition in the Tumut district, notably at Batlow, Laurel Hill and Tumbarumba. It was probably this factor and the better quality of timber obtained from trees grown in that district that impelled Mr. W. H. Blakely to describe it as a new species.*

The composition of the essential oil showed that it differed considerably from the oil of *E. phellandra* grown in other districts. It was found to contain in addition to phellandrene, γ-terpinene and the alcohol terpinenol-4 in quantity (about 20%). Cineol was found to occur in comparatively small quantities from traces to approximately 10%. The ordinary *E. phellandra* oil contains from 35% to 50% cineol and the principal alcohol appears to be α-terpineol. Terpinenol-4 has not yet been shown to be a normal constituent of this oil.

We have made a very intensive study of this tree in the field and have come to the conclusion that it cannot be differentiated from *E. Australiana* type. Wide variations in foliage and fruits were found to exist in the type and all varieties; this phase of the subject will be dealt with more fully in a paper to be published in conjunction with Messrs. Cheel and Welch, who have made a very exhaustive study of the trees. Meanwhile, we are able to state that it is not possible to separate the varieties from the type in the field except by crushing the leaves and determining the odours of the respective essential oils.

As a result of this intensive study we are convinced that the new species described by Mr. Blakely under the name of *Eucalyptus Robertsoni* is merely a physiological form of *E. Australiana*; it is called by us *E. Australiana* variety A. The naming of this new species was criticised in a paper read at the meeting of the Australian and New Zealand Association for the Advancement of Science held in Melbourne, Jan., 1935, and published in *The Australasian Journal of Pharmacy*, Feb., 1935, pp. 168–171.

At Laurel Hill, opposite Kopsen's boat-oar factory (see Plate IV), we found Variety A growing less than 3 ft. away from the type and Variety B. Soil or climatic conditions could not, in the circumstances, be responsible for the wide variation in the chemical composition of the essential oils.

* This Journal, 1927, *61*, 167.

Conclusive evidence of the physiological nature of Variety A was obtained when the leaves and terminal branchlets of a cultivated tree of *E. Robertsoni* were examined. This tree had been raised from seed of *E. Robertsoni* collected at Tumbarumba. We are indebted to Mr. W. L. Fox, of Bowral, for supplying 13½ lbs. weight of the leaves referred to, which were received on April 20, 1933.

The leaves on distillation yielded 3% of a pale lemon-yellow oil with a pronounced odour of cineol and phellandrene. This oil on examination gave the following chemical and physical constants:

Specific gravity $\frac{15}{15}°$	0·9078
Optical rotation	−11°
Refractive Index at 20° C. ..	1·4696
Solubility in 70% alcohol (by weight)	1·3 vols.
Cineol	50%
Phellandrene	Present in quantity
Saponification No.	7·2
Saponification No. after acetylation	65·3

The result of the examination of this essential oil shows that it resembles most closely the oil of *Eucalyptus phellandra*, now called Variety B, and that it bears little resemblance to the oil of Variety A (*E. Robertsoni*), although it probably contains a percentage of the alcohol terpinenol-4.

The examination of the essential oils supported by field experience brings very forcibly under notice the fallacy of describing new species of closely allied Eucalypts on very slender evidence. Our illustration (Plate IV) demonstrates this beyond question. The leaves from the clump of trees shown on the right-hand side of the illustration were cut for distillation purposes. Whilst one operator on the left side of the bush gathered leaves of Variety A, another was cutting foliage of Variety B from the opposite side.

The present position in regard to *E. Australiana* and its various forms may be summarised as follows:

Eucalyptus Australiana type. Essential oil contains cineol, 70%; phellandrene not detected by B.P. test; principal alcohol α-terpineol with small quantities of citral.

Eucalyptus Australiana var. A. Essential oil contains phellandrene and γ-terpinene with very little cineol,

usually under 10%; principal alcohol terpinenol-4 (about 20%).

Eucalyptus Australiana var. B. Essential oil contains cineol 35% to 50%; phellandrene 35% to 40%; principal alcohol α-terpineol.

Although the essential oils of *E. Australiana* and *E. phellandra* (now Variety B) have been very closely examined by Baker and Smith and others, there is still need for a critical examination of the constituents occurring in small quantities. This work is proceeding, but some time must elapse before it is completed. Similar remarks apply to the very interesting essential oil obtained from Variety A. So far the terpene fraction has been found to consist essentially of an unidentified terpene with large quantities of β-phellandrene and γ-terpinene. The principal alcohol is δ-terpinenol-4 which, so far, has not been found to occur to the same extent (20%) in any other Eucalypt.

Messrs. Schimmel and Co. of Miltitz, near Leipzig, Germany, showed the presence of this alcohol to the extent of 3% to 4% in the commercial oil of *E. dives*.

Advantage was taken of the foliaceous nature of a very beautiful and large tree of *E. Australiana* growing in the Tumut district (see Table I, No. 9), a district in which the type was thought not to occur, to secure collections of foliage every month during one year with a view to determining any variation in- yield and quality of oil. The results are set forth in Table III.

We wish to thank the Forestry Commission of New South Wales, and particularly the officers of the Field Staff, as well as Messrs. C. W. Slater of Quaama, and W. E. Guest of Nerrigundah, for assistance rendered to us in our field investigations. We are indebted to Mr. G. Boyd of the Forest Office, Tumbarumba, for collecting and dispatching the monthly supplies of *E. Australiana* from the Tumut district and to Mr. Martin Kinstler, also of Tumbarumba, for supplies of oil and leaves of *E. Australiana* var. A.

Experimental.

The various collections of leaves and terminal branchlets cut as for commercial purposes were subjected to steam distillation in the usual manner. The chemical and physical constants of these various distillates are set forth in Tables I, II and III.

A very sharp line of demarcation is provided in the chemical composition of the oils from the type and

TABLE III.

Essential Oils from Monthly Collections of Foliage of Eucalyptus Australiana, *Tree No. 9 of Table I.*

Date.	Yield of Oil.	$d\frac{15}{15}°$	$\alpha_D^{20°}$	$n_D^{20°}$	Solubility in 70% Alcohol.	Ester No.	Ester No. after Acetylation.	Cineol.	Phellandrene.	Citral.	Remarks.
	%				vols.			%		%	
13/2/1934	3·0	0·9215	+3·6°	1·4637	1·0	16·3	63·1	67–68	Not detected.	3·85	Tree in full fruit.
19/3/1934	3·9	0·9217	+3·25°	1·4629	1·0	19·7	63·2	71	,,		
13/4/1934	4·0	0·9221	+2·2°	1·4629	1·0	18·5	59·6	69	,,		
14/5/1934	3·6	0·9233	+3·0°	1·4633	1·0	20·4	67·7	69	,,		
11/6/1934	3·3	0·9288	+3·15°	1·4628	1·0	20·0	59·2	70	,,		
16/7/1934	3·85	0·9208	+3·0°	1·4633	1·0	16·4	66·5	69	,,		
17/8/1934	4·3	0·9232	+2·65°	1·4628	1·0	17·3	54·0	71	,,		
21/9/1934	3·9	0·9226	+2·85°	1·4636	1·0	21·1	59·6	70	,,		
10/10/1934	3·7	0·9230	+3·0°	1·4630	1·0	24·1	59·6	70	,,		
13/11/1934	3·7	0·9234	+3·0°	1·4630	1·0	14·6	59·3	70	,,		
6/12/1934	3·65	0·9224	+3·3°	1·4624	1·0	15·6	57·7	70	,,		
14/1/1935	4·33	0·9219	+3·4°	1·4634	1·0	15·6	59·1	67	,,		

TABLE IV.

Eucalyptus Australiana *Variety A, from Tumbarumba, N.S.W.*

Date.	Source of Supply.	Yield of Oil.	$d\frac{15}{15}°$	$\alpha_D^{20°}$	$n_D^{20°}$	Solubility in 70% Alcohol.	Ester No.	Ester No. after Acetylation.	Cineol.	Phellandrene.	Percentage of Terpinen-4-ol.
		%				vols.					
15/12/1932	One gallon of oil from Mr. Martin Kinstler, Tumbarumba.		0·8902	−17·35°	1·4795	10	17·8	85·4	Trace.	Moderate quantity.	25
14/1/1935	88 lbs. weight of leaves and terminal branchlets from Mr. M. Kinstler.	2·1	0·8862	−18·35°	1·4794	10	8·0	71·7	,,	,,	21

Variety A. Although the chemical composition of the essential oils of most Eucalyptus oils is comparatively well known, particularly those of the Narrowleaved Peppermints, it was deemed advisable definitely to identify the principal constituents of *E. Australiana* var. A.

Essential Oil of Eucalyptus Australiana *var. A.*

The essential oil of this species varies from a pale straw to a deep yellow in colour, and possesses a distinctive odour of terpinene and terpinenol-4 ; it was thus readily distinguished from the oils obtained from *E. Australiana* and its Variety B.

Mr. Kinstler kindly supplied one gallon of this oil for investigation as far back as December 15, 1932. The oil was of a clear, pale-yellow colour, with a characteristic fragrant odour, and gave the chemical and physical constants shown in Table IV. It was decided to confirm the results by securing a parcel of leaves from Mr. Kinstler, which he collected from a locality known as Nichol's Country, near Tumbarumba. The result of the distillation of the oil is also given in Table IV.

Although the oil supplied on December 15, 1932, was exhaustively investigated, it was deemed advisable for the purpose of this paper to record the results obtained by the examination of the oil distilled by ourselves on January 14, 1935. 400 cc. of crude oil distilled at 10 mm. gave the results shown in Table V.

TABLE V.—*Distillation of Crude Oil, Jan. 14, 1935.*

No.	Fraction.	Volume in cc.	$d_{15}^{15°}$	$\alpha_D^{20°}$	$n_D^{20°}$
1	50 – 53°	17	0·8405	+1°	1·4645
2	53 – 55°	13	0·8477	−13·6°	1·4703
3	55½– 59½°	21	0·8501	−17·1°	1·4723
4	60 – 65°	100	0·8603	−20·6°	1·4793
5	65½– 67°	25	0·8586	−17·2°	1·4813
6	67½– 79°	25	0·8822	−17·8°	1·4799
7	80 –88°	23	0·9036	−20·25°	1·4796
8	88 –100° (Principally 92–96°)	83	0·9355	−23·1°	1·4810
9	100 –113°	4	0·9392	−14°	1·4866
10	113 –130°	14	0·9560	+5·5°	1·5008

Unidentified Terpene.

Fraction No. 1 was thought to contain α-pinene, but this terpene, sabinene and β-pinene could not be identified.

Many attempts have been made to identify this terpene, but up to the present without success on account of the relatively small quantities obtainable. It is of interest to record that on oxidation with potassium permanganate it yielded a liquid acid very closely resembling pinonic acid. A number of preparations of the semicarbazone, recrystallised from methyl alcohol, melted at 194°. The semicarbazone of pinonic acid melts at 207°.

Determination of β Phellandrene.

The chemical and physical constants of the first four terpene fractions are those of the terpenes distilled over metallic sodium. This accounts for the difference of 75 cc. between the total volume shown in Table V, 325 cc., and the volume of the oil taken for examination, 400 cc.

All the terpene fractions, viz., Nos. 2, 3 and 4, were examined for sabinene, β-pinene and δ-4-carene, but with negative results.

Fraction No. 3 gave a nitrosite of m.p. 102°; $[\alpha]_D^{20°}$ −46·9°.

α and γ Terpinene.

Fractions 2, 3 and 4 were oxidised by potassium permanganate according to the method described in This Journal, 1925, *49*, 310, and yielded a δ-dihydroxy-α-methyl-δ-isopropyladipic acid, of m.p. 189–190°. A good yield of the erythritol, $C_{10}H_{16}(OH)_4$, of m.p. 237–238° was also obtained. The isolation and identification of both these substances is conclusive evidence of the presence of α and γ terpinene.

Cymene.

This hydrocarbon was found to be present in traces only in all the terpene fractions examined by us.

Determination of Terpinen-4-ol.

Fraction No. 8 on redistillation was found to have a b.p. of 93–96° at 10 mm. The alcohol was definitely identified as terpinen-4-ol by the preparation of the naphthylurethane of m.p. 104–105°. Its identity was confirmed by oxidising the alcohol to the glycol, 1, 2, 4, trioxyterpane, $C_{10}H_{17}(OH)_3$, according to the procedure described in This Journal, 1925, *59*, 315.

The glycol on repeated purification from a mixture of chloroform and ether in which it was sparingly soluble in the cold, but dissolved readily on heating to boiling, was obtained in white rosettes of m.p. 114–115°. 0·3296 gm. in 10 cc. absolute alcohol gave a reading of 0·65°; $[\alpha]_D^{20°}$ −19·81°. The fluffy crystals obtained by sublimation melted at 128°.

Explanation of Plate IV.

Eucalyptus Australiana, varieties A and B, Laurel Hill, N.S.W.



Eucalyptus Australiana, varieties A and B, Laurel Hill, N.S.W.

THE PALÆOZOIC SEDIMENTS NEAR BUNGONIA: THEIR FIELD RELATIONS AND GRAPTOLITE FAUNA.

By G. F. K. NAYLOR, M.A., M.Sc.*

(With three text-figures.)

(*Manuscript received, September 20, 1935. Read, October 2, 1935.*)

INTRODUCTION.

In a recent paper dealing in outline with the geology of the Goulburn district,[1] the writer referred to the identification of a group of Lower Silurian strata about three miles west of Bungonia. Though the age then assigned to them appeared beyond doubt, no evidence as to the relation between them and the other Palæozoic sediments had been obtained, nor was the writer in a position fully to figure and describe the graptolite fauna upon which the determination of geological age was based. In view of the absence of other recognised strata of Lower Silurian age in this State it was felt that a short paper in which, as a result of recent field work, these matters could be more definitely discussed, would be of general interest.

FIELD RELATIONS.

In 1934 the writer, endeavouring to trace southward a belt of Upper Ordovician rocks which had been observed to outcrop along the main road between Marulan and Goulburn, collected graptolites from thin blue bands in a series of greenish-grey clay-shales outcropping on the Bungonia-Goulburn road between the third and fourth mile-posts from Bungonia. These were provisionally regarded as Ordovician, but subsequent laboratory examination showed that the forms were younger than the Upper Ordovician types. Mr. D. E. Thomas of the

* The author wishes to acknowledge valued assistance rendered in field and laboratory by Miss A. Stewart.

[1] "Note on the Geology of the Goulburn District, with special reference to Palæozoic Stratigraphy", THIS JOURNAL, 1935, *69*, 75.

Victorian Geological Survey, after examining the specimens then available, was positive as to their Lower Silurian age and suggested that the forms included *Monograptus exiguus* and *M. barrandei*, an association common in the zone of *Monograptus crispus* of the British Llandovery Stage (the Keilorian of Victoria).

Since then more material has been obtained, and, in addition to the two forms mentioned by Mr. Thomas, others, including *M. undulatus*, *M.* cf. *decipiens* and *M.* cf. *tortilis*, have been noted. (See below, pp. 132-134 and Figures 2 and 3.)

It will be noted that the horizon represented by these fossils is by no means at the base of the Llandovery Stage, but as only a very small portion of the series contains graptolites there seems no reason to doubt that the equivalents of lower (and possibly higher) horizons are also present, though not here fossiliferous.

The outcrop of the Jerrara Series, as it is proposed provisionally to denominate the Lower Silurian shales referred to above, extends along the main road between Bungonia and Goulburn for about a quarter of a mile, a little to the east of the fourth mile-post from Bungonia.[2] The road here runs approximately east-west, and the strike of the series varies about the meridian. Good sections are therefore given in the road-cuttings, which, however, are not extensive. The series can be traced along the strike for at least half a mile on either side of the road. Throughout the dip is westerly, ranging from 60° to 70°, but in some of the cuttings there is direct evidence of isoclinal overfolding. One can do little more in the way of measurement, therefore, than assign a maximum thickness of about 1,000 feet, while bearing in mind that this may well be an overstatement.

On the western margin the shales appear to dip under a more arenaceous formation of Upper Ordovician age. The age of these rocks is deduced beyond doubt from a relatively abundant graptolite fauna. Many of the Diplograptid forms occurring here appear to have strong affinities with Lower Llandovery types, but the presence of well-preserved specimens of *Diplograptus quadri-mucronatus* and *D. calcaratus* var. *tenuicornis* is sufficient to show that these rocks cannot be later than the upper zones

[2] The position is shown approximately in the map given with the previous paper.

of the Ordovician. This conclusion is further strengthened by the presence of generically identifiable forms of *Dicellograptus*, a genus which is not known to occur in the Silurian system.

So far as the writer is aware the exact junction between the Jerrara Series and the Ordovician beds is not exposed, but it is undoubtedly marked in part by the course of a small gully a little to the north of the road. Here the Silurian shales outcrop on the eastern and the Ordovician beds on the western slopes. The bed of the gully is occupied by talus derived from both series. The variation in strike between the two series at this point (amounting only to a few degrees) is certainly not great enough to suggest unconformable relations between them. Nor is there any evidence of faulting to account for the rather unusual inversion of the sequence. One can only suggest that the two series are conformable, their apparently inverted position being brought about by overfolding. There is, indeed, further evidence of such an overfolded structure. The graptolite-bearing horizon in the Jerrara Series has been found to outcrop only near the eastern margin of the belt, i.e. away from the Ordovician boundary. As previously pointed out, this horizon would appear on palæontological grounds to be considerably removed from the base of the series, a position which would be more naturally explained on the assumption of inversion.

East of the Jerrara Series, and separated from it by a band of quartzites, are three isolated outcrops of limestone occurring in portion 46, parish Jerrara, at a point about half a mile north of it in por. 160, and about a mile and a half south in por. 18. These limestones obviously belong to the same horizon, though each outcrop is lenticular in itself. They are mentioned in the report on Limestones by Carne and Jones.[3] These writers suggest a Devonian age, but give no palæontological evidence, and may have been influenced by the occurrence near by of fossiliferous quartzites which are rather like recognised Devonian strata found elsewhere. The writer has recently examined these limestones closely. The northern one is highly marmorised, and shows little in the way of fossils, while the southern one is very limited in extent, and its fossil content appears to be limited to *Favosites*, crinoid remains,

[3] "The Limestone Deposits of N.S.W.", by J. E. Carne and L. J. Jones. Dept. of Mines, N.S.W., Min. Res. No. 25, 1919.

and an unusually large specimen of *Orthoceras*. The middle and most extensive outcrop, however, is more fossiliferous, and several examples of brachiopod remains were noted. Nearly all of these were quite indefinite, but one specimen, weathered out into partial relief, bore such a strong resemblance to *Pentamerus knighti* that the writer is provisionally classing these limestones as of Upper Silurian (Ludlow) age. The fact that, though limestones are fairly common in the Bungonia district, none has been shown conclusively to be Devonian, while most are undoubtedly Silurian, is further evidence (though admittedly circumstantial) for assigning an Upper Silurian age to those now under consideration. These limestones dip to the west along with all the other series in this part of the district. They therefore appear to underlie the Jerrara Series, and though the latter has not yet been traced so far north as por. 46, the overlying Upper Ordovician belt has been identified (both lithologically and palæontologically), in portions 270 and 271, ph. Jerrara, a little to the west of the most northerly outcrop of limestone.

East of this limestone horizon there is a thick series of shales, sandstones and tuffs, dipping west, which has been regarded by Mr. Garretty as of Upper Devonian age.* Nevertheless, one can hardly offer this as further evidence of a complete inversion of sequence, for the dip of this series is rather more gentle than that of those previously mentioned, and the upward sequence from conglomerates through sandstones to shales appears the normal rather than the inverted one. The writer feels that if they are of Devonian age a strike-fault of considerable magnitude must be postulated satisfactorily to account for their presence. The position with regard to the age of these rocks does not yet appear to be quite definite. Mr. Garretty is understood to have based his conclusion on the occurrence of marine fossils within the series. The writer has recently collected and examined what are presumably the same fossils from the locality indicated by Mr. Garretty, and it is his present opinion that the faunal assemblage does not correspond exactly either with that of the Upper Devonian type area at Mt. Lambie, or with that occurring nearer at hand in association with the *Lepidodendron*-bearing quartzites on the Cookbundoon Mountain. It is just possible, then, that this series may ultimately prove to be

* Verbal communication.

older than Upper Devonian, but the writer is prepared to accept provisionally the view that it is Devonian. It will be recognised that the presence of a strike-fault tending to displace the Bungonia limestone series to the east would support rather than contradict the conception of structure here suggested.

In the vicinity of Bungonia itself the Palæozoic sediments are intruded by the Marulan batholith, whose outcrop is here about three miles in width. East of this are the numerous bands of limestone mapped and recorded by Carne and Jones in the report referred to above. There is no evidence of the presence of Lower Silurian strata here, as the limestones have a distinctly Upper Silurian fauna, and appear to overlie graptolite-bearing Upper Ordovician rocks with some approach to unconformity. In at least one case, it is true, a large outcrop of Silurian limestone on the eastern margin of the belt dips steeply to the east in the direction of, instead of away from, the Ordovician strata, but this limestone is certainly not the basal member of the Upper Silurian series, as would appear to be the case at Marulan. It is separated from the Ordovician strata by a band of dense, grey cherts some few hundreds of feet in thickness, which are conformable with the limestone but apparently not with the Ordovician graptolite-bearing series.

West of the outcrop of the Ordovician rocks which appear to overlie the Jerrara Series, the cuttings on the Goulburn-Bungonia road reveal a succession of slates, quartzites and cherts of considerable apparent thickness. Careful search has failed so far to reveal any fossils, but the presence of a band of black cherts, such as are elsewhere associated with Ordovician strata, would indicate that at least some of this series is of that age. Near Goulburn for the last few miles the rocks are mostly igneous, so that the sedimentary structure of what may well be a critical zone is obliterated. However, it is only reasonable to assume that the sequence noted in the previous paper as occurring on the Main Southern road, about five or six miles to the north, would be substantially repeated but for the intrusion of the igneous mass.

The foregoing considerations suggest as a general structure for the whole area something akin to that indicated in Fig. 1, while the table on p. 129 may be regarded as a first attempt at a provisional correlation with sequences elsewhere. It will be noted that the biggest

gaps in our local record are due to the absence of the Arenig and Llandeilo divisions of the Ordovician and the Wenlock division of the Silurian.

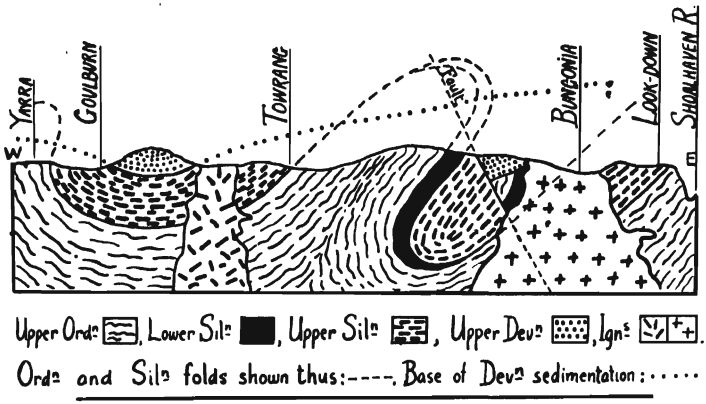


Fig. 1.—Sketch-section to show the geological structure in the Goulburn-Bungonia area.

The Graptolite Fauna.

Graptolite-bearing beds are comparatively numerous in the Bungonia-Goulburn district, but on account of the regional and contact metamorphism to which the rocks have been in most places subjected, the degree of preservation is for the most part poor. In this section of the paper only those forms will be described which can be recognised with some certainty and which present direct evidence in support of the structure suggested in the preceding section.

The specimens have been studied in the usual manner by means of a specially constructed low-power microscope with universal stage, and the drawings (Figs. 2 and 3) have been rendered exact in proportion by the use of a camera lucida.

It should be noted that in one or two cases there has been some difficulty in assigning a specific name to the form, and while the writer fully believes that the determinations here given are correct, he would emphasise that in such cases it has only been a question of differentiating between species of exactly the same recognised zonal range. Hence this element of doubt cannot invalidate the stratigraphical arguments deduced from the identifications.

	Gt. Britain. (Type Area.)		Victoria.	New South Wales. (Goulburn District.)
SILURIAN	Ludlow	U M L	Yarravian	Various series, including limestones with *Pentamerus knighti* and shales with *M. bohemicus*.
	Wenlock	U M L	Yeringian	
	Llandovery	U M L	Keilorian	Jerrara Series with *M. exiguus*.
ORDOVICIAN	Caradoc	U M	Bolindian	Various series of graptolite-bearing Upper Ordovician rocks outcropping throughout district.
		L	Eastonian	
	Llandeilo	U M L	Gisbornian Darriwil	
	Arenig	U M L	Castlemaine Bendigo Lancefield	

N.B.—Correlation of British and Victorian Lower Ordovician series only approximate.

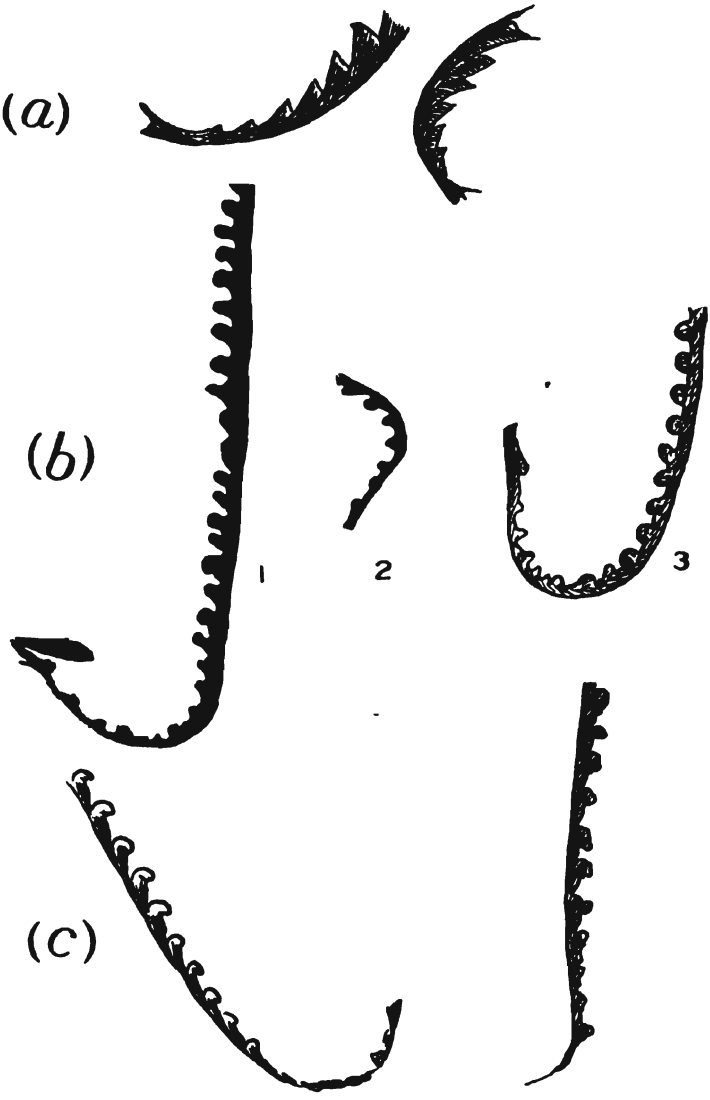


Fig. 2.

(*a*) *Monograptus bohemicus*, showing sicula and virgella.
(*b*) *M. exiguus*.
1 Usual mode of preservation without detail.
2 Proximal portion.
3 Good specimen showing lobing, sicula, etc.
(*c*) *M. undulatus*.
All drawings six times natural size.

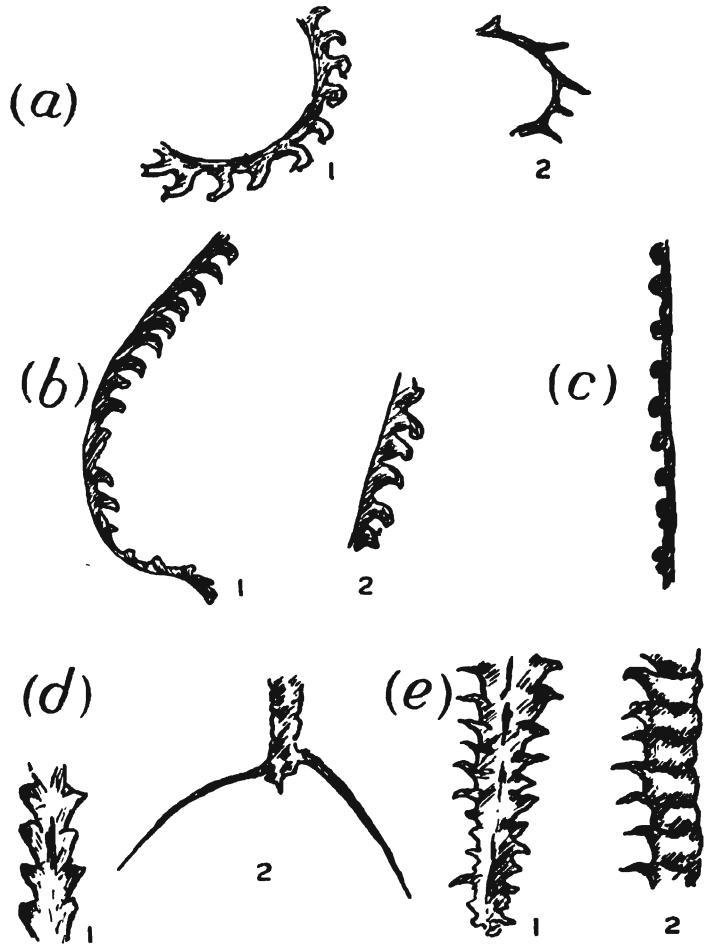


Fig. 3.

(*a*) *Monograptus decipiens.*
1 Recurved distal thecæ.
2 Isolate proximal thecæ.
(*b*) *M.* cf. *tortilis.*
1 Proximal end showing sicula.
2 Distal thecæ.
(*c*) *M. barrandei*, distal thecæ isolate and lobate.
(*d*) *Diplograptus* (*Orthograptus*) *calcaratus* var. *tenuicornis.*
1 Distal thecæ.
2 Proximal end showing end of sicula and spines.
(*e*) *Diplograptus* (*Orthograptus*) *quadrimucronatus.*
1 Biprofile view.
2 Sub-scalariform view.
All drawings six times natural size.

Monograptus bohemicus Barrande.

Polypary uniserial, short, and ventrally curved. Thecæ simple subcylindrical tubes, overlapping for about half their length, apertural margins somewhat introverted but not introtorted. Thecæ about twice as long as wide, ventral walls straight, inclined at 30° to general direction of polypary, about 10 in 10 mm. Sicula and virgella conspicuous.

This form has been collected from road-cuttings on the Main Southern road between its junctions with the Carrick and Towrang roads.

Monograptus exiguus Nicholson.

Polypary flexed, slender, with proximal portion showing marked ventral curvature, maximum width less than 1 mm. Thecæ small and closely set, 16 to 12 in 10 mm. barely in contact, with apertural portion coiled into a conspicuous lobe which occupies about one-half of the breadth of the polypary. The sicula is slender but conspicuous Th. 1 originates a little above its base and terminates within its length, Th. 2 arising at about the same level as the apex.

This is by far the most abundant form in the Jerrara Series, where it is not uncommon to find a hundred polyparies on one small slab.. Owing to the extensive collection and examination of well-preserved specimens, there seems no doubt at all about this identification.

Monograptus barrandei Lapworth.

Polypary very slender, straight or slightly flexed, width not exceeding 0·6 mm. Thecæ straight and slender, 9 to 8 in 10 mm., not overlapping and not inclined to the direction of the polypary except at the apertural margin, which is retroverted into a conspicuous lobe occupying more than half the breadth of the polypary. The only specimens examined were distal fragments, but since the species was first described from similar material, the absence of proximal portions does not place the identification in any doubt.

Collected from the Jerrara Series.

Monograptus cf. *decipiens* Tornquist.

Polypary short and rather slender, with strong dorsal curvature. Maximum width about 1 mm. Thecæ biform,

about 12 in 10 mm. Proximal thecæ markedly isolate and slender, of *Rastrites* type. More distally the thecæ are in contact but do not overlap. They are also more robust and the apertural margin is somewhat reflexed in the form of a barb. The thecæ appear to be somewhat more numerous than in the typical *M. decipiens*, for which reason the determination is queried. In the general form of the polypary and thecæ, however, the specimens appear to agree more closely with this form than with any other of which the writer is aware.

Only two or three fragmentary proximal portions have been collected, all coming from the Jerrara Series.

Monograptus undulatus Elles & Wood.

Polypary about 2 cm. in length, very slender, very thin at the proximal end, not more than 1 mm. in width at distal extremity. Thecæ about 10 in 10 mm. with practically no overlap, ventral walls straight at first then retroverted aperturally. Straight portion of ventral wall conspicuously inclined outward from the main axis of the polypary at an angle of 30°. Retroverted portion of thecæ constitutes about three-quarters of the total width of the polypary. Sicula slender and slightly more than 1 mm. in length.

There seems no doubt that this form should be referred to *M. undulatus* described by Elles & Wood. The form which they figure has a recurved proximal extremity, whereas this is incurved in one of the specimens here described; but the agreement in all other respects is perfect and the difference just mentioned would scarcely appear to be of specific value.

The general form of the polypary is somewhat like that of *M. exiguus*, but the thecæ are less numerous and markedly different in shape. Three specimens only have been collected, in one of which the proximal extremity is missing.

Collected from the Jerrara Series.

Monograptus cf. *tortilis* Perner.

Polypary with ventral curvature at proximal end, straight distally (?). Thecæ about 13 to 11 in 10 mm. scarcely overlapping, more than half the thecal length free and reflexed. Lower part of ventral wall straight and inclined at 50°–60° to the direction of polypary. Slight lobing in apertural region, but not always marked. Sicula

short and stout, rather less than 1 mm. in length, virgella absent.

The width of the polypary increases, but as only relatively proximal parts have been collected, the maximum may be greater than that indicated in the drawings, i.e. about 1 mm. Ignorance of the distal breadth causes some doubt as to the identification, but in the proximal portion the characters appear to agree more closely with those of *M. tortilis* than those of any other known form.

Collected from the Jerrara Series.

Diplograptus (*Orthograptus*) *quadrimucronatus* Hall.

Polypary biserial, straight and tapering proximally. Maximum width about 3 mm. Thecæ 10 in 10 mm., of simple prismatic type, overlapping for about one-half of their length, ventral margins inclined at 20°–30° somewhat concave, with the apertural extremity furnished with a short, stout lip and spines. An examination of both profile and scalariform views seems to place this identification beyond doubt.

Collected from the Ordovician series immediately to the west of the junction with the Jerrara Series.

Diplograptus (*Orthograptus*) *calcaratus* var. *tenuicornis* Elles & Wood.

Polypary biserial, straight length several cm., maximum width about 2·5 mm. Thecæ simple tubes about 10 to 8 in 10 mm. inclined at an angle of 30°, overlapping to about one-half their length. Virgula produced distally. Proximal end blunt, with short but conspicuous virgella projecting from an almost concealed sicula and two slender basal spines originating from the ventral margins of Th. 1^1 and Th. 1^2.

The characteristic proximal end seems to remove any doubt as to the identity of the species. The spines at first sight suggest *Climacograptus bicornis*, but the character of the thecæ shows that it is not referable to that genus.

Collected from the Ordovician beds immediately to the west of the Jerrara Series.

THE ENDOGENOUS CONTACT-ZONE OF THE MAGNESIAN LIMESTONES AT BEN BULLEN, N.S.W.

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(With five text-figures.)

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INTRODUCTION.

Ben Bullen is situated on the Mudgee-Wallerawang railway line at a distance of 121 miles from Sydney.

The general geology of the area has been described by Carne[1] and Carne and Jones,[2] and they have shown that a small boss has invaded a sedimentary series consisting of quartzites, tuffs, shales and limestones. The plutonic complex shows a range from quartz-mica-diorite to olivine-norite, and the limestones contain magnesian and non-magnesian types.

The writer[8] has recently described contaminated rocks which have been formed by reaction between the non-magnesian limestones and the intrusive diorite. In the present paper the types produced by the assimilation of magnesian limestones are described.

FIELD RELATIONS.

Magnesian limestones occur in the Main Quarry in Portions 45, 46 and 47, Parish of Ben Bullen. Non-magnesian types are often interbedded. The limestone mass is somewhat lenticular in shape and the longer axis measures 4¼ chains. On the north, south and west it is surrounded by quartz-mica-diorite, and on the east alluvium and quarry *débris* obscure all field relations.

A wide zone of contaminated rocks surrounds the limestone mass (see Fig. 1), and gradually merges into the

diorite. Quarrying has extended into the inner margin of this zone, and the section (Fig. 2) shows that the field

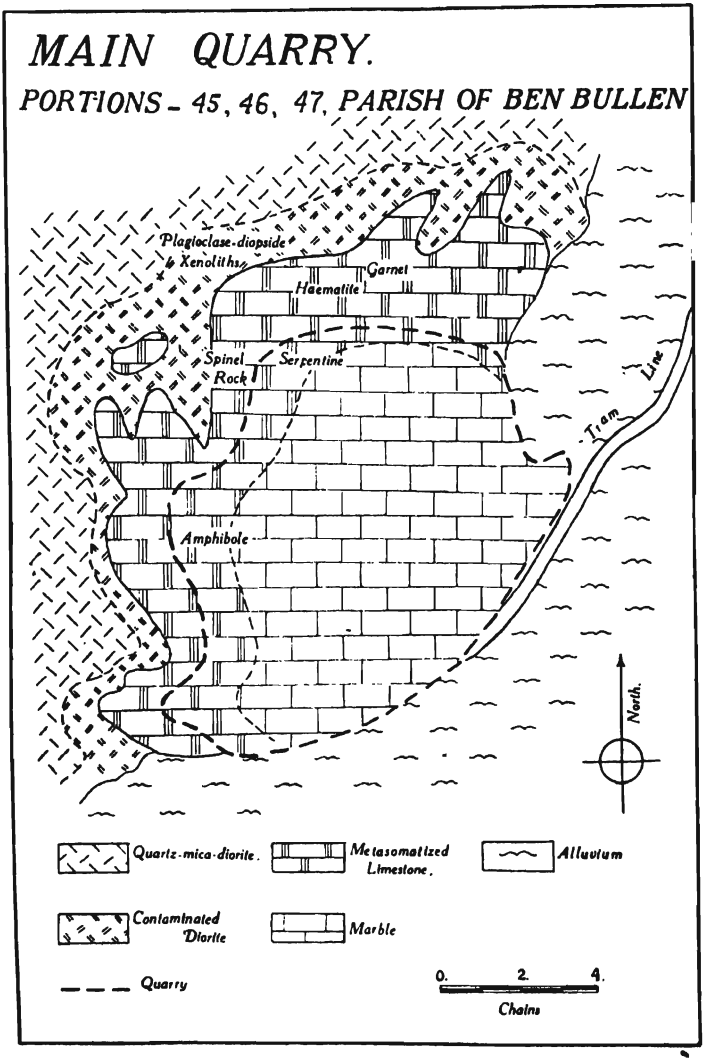


Fig. 1.

relations are very complicated within this area. Numerous sills and tongues of contaminated igneous rock pierce the limestone, and it is impossible to measure distances from

any one contact. It is obvious that the contaminated zone may be divided roughly into an inner and an outer ring. The inner part is essentially a metasomatized limestone, and in this serpentine-, chlorite-, prehnite- and actinolite-bearing types occur as veins and irregular masses. The outer zone has the appearance of a light-coloured, coarse-grained diorite, and is characteristically a contaminated igneous rock. Veins of calcite and serpentine often occur in the outer zone.

The boundaries of the limestone mass are more complicated than shown in the map (Fig. 1), but in a general way this indicates the disposition of what can be recognised in the field as a contaminated igneous rock and a metasomatized limestone.

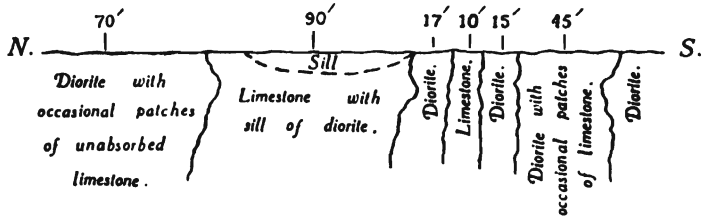


Fig. 2.

Section of the face of the Main Quarry. This was drawn about twenty years ago when quarrying was in operation. (From *Geol. Surv. N.S.W.*, Min. Res. 25, p. 316.)

To the north of the quarry the limestones are less magnesian, and on the northern slope of the hill veins of andradite skarn and nodular masses of hæmatite have been noted.

PETROGRAPHY.

(I) The Magnesian Limestones.

Calcite-dolomite-marbles, brucite-marbles and forsterite-marbles occur in the Main Quarry, and in these the magnesia content is very variable.[9] No true dolomites are known, but it is possible that they occur in restricted bands.

Analyses of the magnesian limestones from this locality are given below.

	I.	II.	III.
$CaCO_3$	96·76	95·60	85·85
$MgCO_3$	2·46	3·42	12·10
$MnCO_3$	—	0·06	0·07
$Fe_2O_3+Al_2O_3$ ..	0·22	0·18	0·58
P_2O_5	—	0·03	—
Gangue	0·50	0·96	1·34
	99·94	100·25	99·94

I. Forsterite-spinel Marble, Pors. 45, 46 and 47, Ph. Ben Bullen, *Geol. Surv. N.S.W.*, Min. Res. 25, p. 378.
II. Forsterite Marble, Top Quarry, Por. 47. *Ibid.*
III. Sampled Specimen (mixture of Brucite-forsterite-spinel Marble and Calcite-dolomite Marble), Main Quarry, Por. 45–46. *Ibid.*

(ii) The Quartz-Mica-Diorite.

This will be dealt with more fully when the plutonic complex is described in a later publication. The rock is hypidiomorphic granular, subophitic to poikilitic, with a grainsize averaging 2 mm. The constituent minerals are plagioclase, hornblende, biotite, quartz, iron ores and apatite. Small quantities of epidote, prehnite, chlorite and white mica may occur as alteration-products. The plagioclase varies from $Ab_{52}An_{48}$ to $Ab_{59}An_{41}$, and occasional zoned phenocrysts show a range from $Ab_{49}An_{51}$ to $Ab_{63}An_{37}$. Green hornblende has a mean refractive index of about 1·670. The chemical composition is :

			Norm.	
SiO_2	55·30			
Al_2O_3	20·87			
Fe_2O_3	3·62			
FeO	5·20			
MgO	2·75			
CaO	7·44			
Na_2O	2·49	Quartz		16·44
K_2O	0·82	Orthoclase		5·00
H_2O+	0·76	Albite		20·96
H_2O-	0·08	Anorthite		34·19
TiO_2	0·90	Corundum		3·37
P_2O_5	0·41	Hypersthene		12·05
MnO	0·10	Magnetite		5·34
		Ilmenite		1·67
	100·74	Apatite		1·01
Sp. Gr.	2·83			

Anal. G. A. Joplin.

(III) The Contaminated Rocks.

It has already been shown that the field evidence gives no clue as to the degree of contamination, and that the relations between some of the types are unknown. The petrography, however, provides some evidence, and in the following section the various assemblages are described in the order which is believed to represent a gradually increasing lime-magnesia content.

(1) *Diopside-bearing Quartz-aiorite and Included Xenoliths.*

Rocks of this type occur above the N.W. end of the Main Quarry in Portion 47. The xenoliths vary from ½″ to 6″ in diameter and have sharply defined outlines. They are fine-grained, greyish-green rocks with a high density. The rock-mass in which they are included usually has the appearance of a normal diorite, but may be coarser grained, with large hornblende individuals in a ground mass of felspar, quartz and sage-green diopside.

The xenoliths are granoblastic rocks consisting either of a mosaic of diopside and plagioclase or of diopside alone. Occasional patches of quartz occur, and around these the diopside forms slightly larger subidioblastic prisms. " Pools " and veins of plagioclase grains and large poikilitic crystals of hornblende are not infrequent, and their occurrence suggests mechanical introduction from the magma (Fig. 3). Apatite and sphene are usually abundant, and a little iron ore may occur.

The diopside grains average 0·2 mm. The mineral is very pale green, with $\alpha'=1\cdot692$, $\gamma'=1\cdot717$ and $Z\wedge c=43°$. This indicates $Di_{64}He_{36}$. Plagioclase occurs in small laths or in minute xenoblasts which form a granular mosaic. Twinning is not well developed. The extinction on 010 is 34½°, $\alpha'=1\cdot558$, $\gamma'=1\cdot568$, and the composition would thus appear to be $Ab_{40}An_{60}$.

The smaller xenoliths show a great deal of breaking up and veining by quartz and felspar. Resorption is evidently effected by the mechanical invasion of a quartz-plagioclase magma (see p. 150).

The diopside-bearing quartz-diorite, which surrounds the xenoliths, consists of plagioclase, hornblende, diopside, quartz, apatite, sphene and iron ores.

The plagioclase forms tabular crystals which may measure up to 1·5 mm. It is often zoned, and oscillatory zoning is sometimes developed. The bulk of the felspar has an extinction angle of 26° on 010, with $\alpha'=1\cdot552$, $\gamma'=1\cdot560$.

The composition is, therefore, $Ab_{53}An_{47}$. Plagioclase may show alteration to epidote or clino-zoisite, and small veins of white mica sometimes occur.

The hornblende is rather poikilitic and may include plagioclase, iron ores, apatite and diopside. X=light yellowish green, Y=olive green, Z=olive green; $Z \wedge c = 14°$; $\alpha' = 1 \cdot 660$, $\gamma' = 1 \cdot 683$.

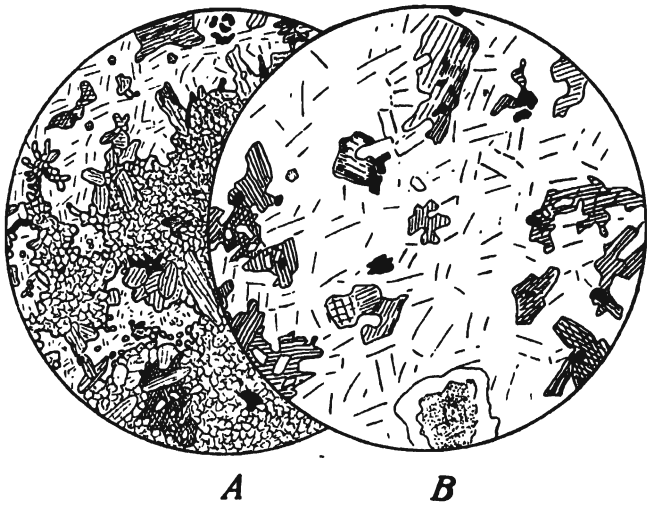


Fig. 3.

A. Diopside-plagioclase xenolith enclosed in diopside-bearing quartz-diorite. × 12.

Note diorite at top left with larger crystals of diopside bordering the margin of the xenolith. A poikilitic crystal of hornblende is shown at the bottom of the figure, and just above it an irregular "pool" of plagioclase is fringed with larger crystals of diopside.

B. Diopside-bearing quartz-diorite. × 12.

Note diopside crystals fringed with amphibole and also independent crystals of hornblende. At the top of the figure amphibole and pyroxene are in parallel intergrowth. Note also large crystal of plagioclase with the centre entirely altered to clinozoisite.

The amount of diopside present is very variable. In one slice it is very abundant and in another, at the same distance from a xenolith, it is but poorly developed. It may form the core of a hornblende crystal, it may show parallel intergrowth with hornblende, or it may arise as

independent prisms measuring about 0·8 mm. It is pale green, with $Z \wedge c = 44°$.

As in the parent quartz-mica-diorite, quartz is interstitial.

(2) *Diopside-zoisite-plagioclase Rocks with White Mica.*

These rocks occur above the quarry at a short distance south of the diopside-bearing diorite. They are also met with amongst the quarry *débris*.

In the hand specimen they resemble igneous rocks, but are lighter coloured and slightly coarser grained than the normal diorite. White mica may usually be detected in the hand specimen.

Under the microscope they are seen to consist of diopside, β-zoisite, plagioclase, white mica, albite, sphene and a little apatite and actinolite. Small quantities of calcite, chlorite and serpentine are often present in veins.

Diopside forms subidiomorphic prisms measuring about 1·5 mm. and is often twinned. $Z \wedge c = 43°$, $\alpha' = 1·688$, $\gamma' = 1·710$. This indicates $Di_{58}He_{42}$. Actinolite and calcite are often developed along cracks in the pyroxene.

The labradorite ($Ab_{41}An_{59}$) forms large tabular crystals which measure about 2 mm. In the less altered types it shows flecking with white mica, and a little granular zoisite and albite is often associated. In the more altered types the felspar is entirely replaced by white mica and the felspar areas are now occupied with criss-cross flakes which measure about 0·2 mm. The mica is biaxial and negative, with a fairly small 2V. The elongation along the cleavage is positive; $\alpha' = 1·562$, $\gamma' = 1·600$. According to Kunitz[10] this indicates an aluminous mica with about 2·5% of iron. The analysis given below is of a completely altered rock very rich in white mica, and the percentage of alkalis would indicate that both muscovite and paragonite are present.

The zoisite forms short subidiomorphic prisms which are aggregated into clusters. These often fringe the diopside crystals (Fig. 4A), but they may occur as isolated masses within the areas of white mica. The zoisite is biaxial and positive, the elongation is negative and the extinction is straight. The birefringence is very low, but the mineral does not show anomalous interference tints. It is therefore β-zoisite which, according to Winchell[14] may contain up to 5% of iron. A little clinozoisite is sometimes associated.

Sphene occurs in fairly large idiomorphic crystals or as minute granules; it is usually well developed. Actinolite is present in small amount and may fringe the diopside crystals or occur as small independent prisms. It is usually crowded with granular sphene. Sometimes it occurs in veins. Apatite occurs as small idiomorphic inclusions but is not abundant.

An analysis of the most completely altered rock of this type is given below.

SiO_2	47·62
Al_2O_3	18·21
Fe_2O_3	0·72
FeO	6·46
MgO	5·47
CaO	13·67
Na_2O	2·49
K_2O	1·16
H_2O+	1·81
H_2O-	0·12
TiO_2	1·36
P_2O_5	0·23
MnO	0·12
CO_2	0·43
Cl	0·03
	99·90
Less O for Cl	0·007
	99·89
Sp. Gr.	3·00

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(3) *Actinolite-albite-clinozoisite Rocks.*

These rocks occur sporadically at various places within the endogenous contact-zone. In the hand specimen they have the appearance of light coloured rather felspathic diorites. Carbonates are usually present in thin sheets along joint-planes.

Under the microscope the rock is hypidiomorphic granular and the grainsize averages about 2 mm. The constituent minerals are albite, diopside, actinolite, clinozoisite, calcite, sphene, apatite and traces of iron ore. Calcite, acicular actinolite and prehnite occur in veins, and the latter often replaces the albite in the vicinity of the vein. Small patches of spherulitic chlorite may also occur.

Albite forms irregular grains measuring from 0·8 to 3 mm. It is optically positive, with $\alpha'=1·530$, $\gamma'=1·540$, and the extinction on 010 is $-13°$. The composition is

therefore $Ab_{97}An_3$. The mineral is rather brown and turbid, and encloses granular masses of clinozoisite and occasionally a little epidote. When adjacent to veins of prehnite it is often replaced by clear subidiomorphic crystals of that mineral. Alteration to chlorite is sometimes noted.

Diopside forms subidiomorphic prisms averaging 2·5 mm., and these are often fringed with actinolite. The amphibole may entirely replace the pyroxene and also may arise as independent crystals in the contaminated rock. When primary it occurs in slender prisms measuring about 2 mm. It is optically negative, $Z \wedge c = 19°$, $\alpha' = 1 \cdot 628$, $\gamma' = 1 \cdot 655$. The colour shows a peculiar patchy distribution and may vary from colourless to green in a single crystal. X=pale yellowish green, Y=pale yellowish green, Z=pale bluish green ($Z > Y \geqslant X$). This corresponds fairly closely to an actinolite described by Ford[5] which has a mean R.I. of 1·637 and contains about 2·7% of alumina. When the actinolite occurs in veins it is developed in acicular crystals.

Clinozoisite occurs in small granular masses within the albite, but is not abundant. Sphene forms subidiomorphic crystals up to 0·8 mm., and often contains a core of iron ore. In the larger crystals a good cleavage on 110 may be developed.

(4) *Actinolite-chlorite-epidote Rocks.*

These rocks are essentially similar to those described above, but diopside is absent, actinolite is well developed, epidote is far more abundant than clinozoisite and the place of albite is taken by spherulitic chlorite.

It has already been stated that albite shows incipient alteration to chlorite, and it would appear that this mineral has arisen directly from the felspar. The chlorite has a very low birefringence and shows ultra-blues. It is optically negative and the elongation of the small spherulitically arranged needles is positive. It therefore appears to be pennine.

The actinolite occurs in subidiomorphic prisms from 1 to 3 mm. It is optically negative and the elongation is positive. $\alpha' = 1 \cdot 622$, $\gamma' = 1 \cdot 647$; $\triangle = 0 \cdot 025$; X=very pale yellowish green, Y=pale yellowish green, Z=bluish green ($Z > Y > X$); $Z \wedge c = 16°$. According to Ford[5] this would indicate a small percentage of alumina.

The epidote is well developed in subidiomorphic crystals and a fairly well-marked pleochroism indicates a moderately high iron content. Epidote and actinolite are sometimes intergrown in a mosaic and form small skarn-like patches. A little calcite and sphene may be associated with these patches.

Sphene, apatite and iron ores are accessory, but the first is often well developed.

(5) *Actinolite-serpentine-epidote Rocks.*

This type appears as veins and irregular dark, fine-grained patches in the actinolite-albite-clinozoisite rocks.

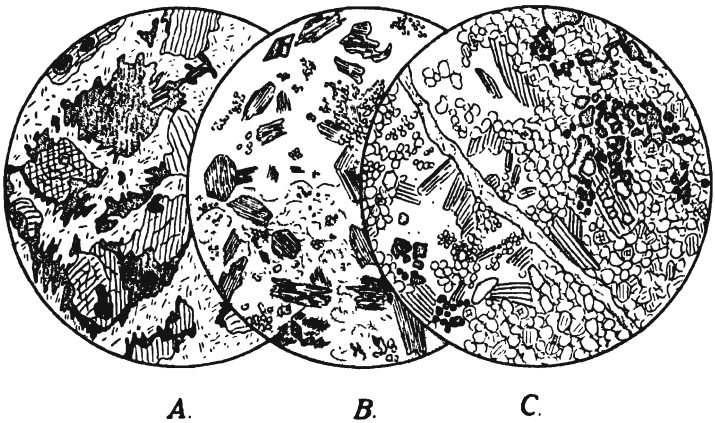


Fig. 4.

A. Diopside-plagioclase-zoisite rock with plagioclase entirely replaced by white mica. × 9.

Zoisite builds prismatic crystals about diopside and also forms larger isolated masses. White mica occurs in criss-cross flakes and sphene surrounds iron ores. Inclusions of apatite occur in the diopside and zoisite.

B. The lower half of the figure represents an actinolite-albite-clinozoisite rock showing turbid albite and small granular clusters of clinozoisite.

The upper part of the figure shows the adjacent actinolite-serpentine-clinozoisite rock occurring as a wide vein in the albite-bearing assemblage. Clear plates of serpentine enclose granules of clinozoisite.

Ragged prisms of actinolite and crystals of sphene occur in both rocks. × 9.

C. Diopside-chlorite-spinel rock. × 9.

Note large area of chlorite with some sections showing one cleavage. The remainder of the rock consists of a mosaic of diopside and spinel with some apatite. The vein consists of clinozoisite.

It is obvious that the serpentine is taking the place of albite, and at the junction of the two assemblages plates of clear serpentine enclose small, turbid remnants of the felspar. The serpentine has a very low birefringence, it is optically positive, and $\alpha'=1\cdot562$, $\gamma'=1\cdot567$.

Actinolite occurs as in the other assemblages and may show polysynthetic twinning. $\alpha'=1\cdot628$, $\gamma'=1\cdot650$; $Z\wedge c=19°$; X=yellowish green, Y=yellowish green, Z=bluish green ($Z>Y\geqslant X$).

Epidote forms granular masses and stout subidiomorphic prisms. It is yellowish green and markedly pleochroic, $\alpha'=1\cdot732$. According to Winchell[14] this indicates $Fe_2O_3=25\%$. Clinozoisite is sometimes associated but is not abundant. Near the junction of the albite assemblage, however, it occurs in small granules and epidote is rare (Fig. 4B).

(6) *Prehnite-bearing Rocks.*

This type occurs in a wide dyke-like mass associated with serpentine. It is also met with in smaller veins. In the hand specimen it is a streaky pink-and-green rock, and white mica is clearly visible.

Under the microscope the rock shows considerable variation in texture and in the relative proportions of the minerals present. The constituent minerals are prehnite, diopside, serpentine, white mica, sphene, zoisite and sometimes a little albite, chlorite and iron ore. Garnet has been noted in one slice. The prehnite usually forms fairly large interlocking grains, which are brown and turbid and sometimes appear rather fibrous. When the prehnite surrounds areas of serpentine it often develops clear subidioblastic crystals.

The other minerals show characters similar to those in the assemblages described above.

(7) *Pyroxene-chlorite-spinel Rock.*

Only one example of this type is recorded. It occurs near the edge of the quarry above its north-west end (Fig. 1). In the hand specimen it might be mistaken for an igneous rock, but closer examination shows an abundance of spinel and small areas of calcite. The density is far above that of a normal igneous rock.

Under the microscope the rock shows considerable variation in the distribution of the constituent minerals,

and a mineral which may be very abundant in one slice may be scarcely represented in another cut from the same hand specimen.

The structure is granoblastic and intersertal and the constituent minerals are pyroxene, spinel, chlorite, calcite and apatite. Small grains of iron ore sometimes occur, and a little clinozoisite may be present.

Pyroxene occurs in small xenoblasts, but when it surrounds areas of chlorite or calcite it may develop large subidioblastic prisms. It is very pale green, $Z \wedge c = 40°$, $\alpha' = 1 \cdot 700$, $\gamma' = 1 \cdot 720$. Its association would suggest that it contained alumina.

Spinel is well distributed throughout the rock, but may show local segregations. It often occurs in large arc-shaped aggregates of small grains, or several large crystals may form a compact mass measuring about 3 mm. across. The usual occurrence is as small xenoblasts in a mosaic of pyroxene. When adjacent to areas of chlorite or calcite subidioblastic outlines may be developed and the spinel often shows a narrow rim of serpentine which separates it from calcite. The spinel is bright green, but the depth of colour is variable; $n = 1 \cdot 750$. The spinel sometimes shows a separation of finely-divided iron ores. Larsen and Berman[11] quote a green spinel with a R.I. of $1 \cdot 730$; this contains ferric iron and some alkalis.

Two varieties of chlorite are developed, but one is much more abundant than the other. It is usually interstitial, and single crystals may measure up to 4 mm. One good cleavage is developed (Fig. 4c) and the extinction is parallel to this. The well-developed chlorite is optically negative, with a fairly small 2V. The elongation is positive; X= pale brown, Y=pale green, Z=pale green ($X > Y = Z$); $\alpha' = 1 \cdot 630$, $\gamma' = 1 \cdot 645$. According to Winchell[14] this indicates a ferroantigorite with about 20% daphnite and 20% of antigorite.

The less well-developed chlorite is optically positive, the elongation is negative and the R.I. is lower than the above. It is evident that it contains more alumina and less iron and magnesia.

Calcite is developed in large irregular grains and is usually interstitial. In some of the slides it is not represented, and in others it is very abundant. It may occur in small grains in a granular mosaic with diopside. Apatite is also sporadic in its distribution. When present it usually forms subidioblastic crystals up to $0 \cdot 5$ mm. These have a

somewhat stout prismatic habit and may form small clusters of two or three crystals.

An analysis of this rock is given below.

SiO_2	29·66
Al_2O_3	24·51
Fe_2O_3	3·99
FeO	3·27
MgO	14·56
CaO	18·05
Na_2O	0·14
K_2O	0·13
H_2O+	2·02
H_2O-	0·05
TiO_2	0·90
P_2O_5	0·31
MnO	0·17
CO_2	1·91
	99·67
Sp. Gr.	3·29

Anal. G. A. Joplin.

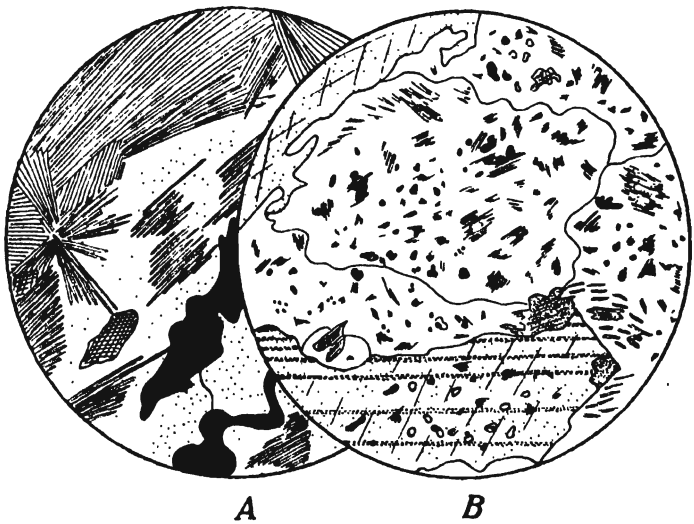


Fig. 5.

A. Actinolite Skarn. × 12.
Note radiating needles of actinolite which pierce large irregular grains of calcite, and vein-like occurrence of iron ore.

B. " Pegmatite." × 12.
Large allotriomorphic grains of quartz and calcite with inclusions of actinolite, diopside, sphene and iron ores. Small masses of chlorite are interstitial.

(8) *Actinolite Skarn and Associated "Pegmatite".*

This type occurs both in the Main Quarry and in the quarry on Cleared Hill. The "pegmatite" is ore-bearing and occurs as a coarse-grained dyke rock. The skarn forms a border about three inches wide on either side of the dyke, and crystals of actinolite penetrate the adjacent limestone.

The skarn consists of actinolite, quartz, calcite, sphene, iron ore and a trace of epidote. The actinolite is very abundant and forms large fan-shaped masses of radiating crystals which may measure up to 1″ in length (Fig. 5A). Calcite and quartz are developed in large (6 mm.) grains, and no reaction is apparent at the junction of the two minerals.

Both calcite and quartz enclose needles and radiating mats of actinolite. Granular sphene, epidote and iron ores are also included.

Actinolite is optically negative; the elongation is positive; X=colourless, Y=Z=yellowish green; $\alpha'=1\cdot631$, $\gamma'=1\cdot660$. According to Ford[5] this indicates about 4·4% of alumina. Actinolite and iron ores often form intergrowths from which quartz and calcite are absent.

Iron ores consist of both magnetite and pyrites, and the former shows alteration to hæmatite.

The "pegmatite" consists of large (6 mm.) grains of calcite and quartz (Fig. 5B). These contain inclusions of actinolite, sphene, iron ore, diopside and epidote. Chlorite is sometimes interstitial.

Petrogenesis.

(i) The Circulation of Hydrothermal Solutions.

It is evident from the field occurrence and from the petrography that some of the rocks have suffered alteration after having reached a certain stage of contamination. Thus the actinolite-serpentine-epidote assemblage occurs in veins and irregular patches in the actinolite-albite-clinozoisite rock, and the latter has the appearance of having been permeated by serpentine-bearing solutions. From the petrography it is evident that the serpentine replaces albite, and it is possible that the resulting serpentine contains a trace of alumina. Some of the alumina of the albite may join with lime and iron to form epidote, a mineral which is very well developed in

this rock. The hydrothermal solutions would, therefore, appear to have contained magnesia, iron, silica and lime. Syromyatnikov[12] has shown experimentally that silica and iron may be transferred by water vapours, and he concludes that not only are these oxides transferred in solution, but also there is a molecular migration in the gaseous medium. In the case of the late-hydrothermal stage at Ben Bullen it is likely that water vapour played a very important part.

The vein-like occurrence of the prehnite-bearing assemblage suggests that it has had a similar origin, and in this instance the solutions contained less magnesia and more lime. It is also possible that the initial contamination was brought about by a less magnesian limestone.

The status of the actinolite-chlorite-epidote rock is rather uncertain, but its texture suggests that chlorite represents the hydrothermal alteration of albite, and this suggestion is strengthened by the occurrence of veins and small patches of chlorite in the actinolite-albite-clinozoisite rocks.

The spinel-bearing assemblage contains interstitial calcite and chlorite, and this mode of occurrence suggests deposition from solution, but the genesis of this rather unique type is dealt with more fully on page 153.

These hydrothermally altered rocks represent extreme cases of contamination, and the solutions responsible for their alteration have been derived in part from the magma and in part from the limestone. The rocks are thus allied to metasomatized limestones, but their origin is indirect. Metasomatized limestones are formed by the action of late-magmatic solutions upon solid limestone. These assemblages appear to have arisen by the action of late-magmatic solutions *plus* limestone solutions upon rocks that have been contaminated by limestone.

(II) Mineralogical Interpretation of Magnesian Limestone Assimilation.

In the case of the endogenous contact of the non-magnesian limestones[8] the field relations are such that each stage in the contamination process can be traced. In this contact-zone, however, the field evidence gives no clue to the degree of contamination, but the petrography indicates that the various assemblages have arisen by gradual increments of magnesia and lime to the quartz-mica-diorite magma. It is shown above that these

increments have not been brought about by a direct increase in the amount of solid limestone, and that contamination is partly due to the action of late hydrothermal solutions.

Regardless of how these changes have been brought about, it is of interest to trace the mineralogical response to a gradually increasing magnesia content.

As the amount of dolomite present in the magnesian limestones is very variable, further complications arise with regard to this contact-zone.

The first stage in the contamination of the quartz-mica-diorite is the formation of a diopside-bearing quartz-diorite in which biotite is not developed. Diopside-plagioclase xenoliths are enclosed in this contaminated diorite, and it is evident that they represent metasomatized limestones.

No true dolomites are known at Ben Bullen, and most of the marbles have a low alumina content. It must be assumed, therefore, that the excess lime has passed out to the magma, and that the plagioclase of the xenoliths has been mechanically derived from the igneous rock. This is supported by the petrography (see page 139).

C. E. Tilley[13] has shown that masses of pure diopside rock may be formed by the simple addition of silica to dolomite, and it is probable that the diopside of the Ben Bullen xenoliths and of the contaminated rocks enclosing them arose in this way. The excess lime from the magnesian limestone further reacted with the magma and inhibited the formation of biotite.

In the endogenous contact-zone of the non-magnesian limestones the disappearance of hornblende preceded that of biotite, and at a later stage biotite gave place to orthoclase. In this contact-zone, however, hornblende persists for a time, magmatic potash and alumina rapidly decrease and no orthoclase occurs. A little potash and alumina may enter the hornblende molecule, and it is possible that lime combines with part of the potential biotite molecule to form hornblende.

With a further increase in lime and magnesia and a concomitant decrease in potash and alumina, hornblende passes to actinolite, and at the same stage in the contamination process diopside passes to actinolite by the addition of magnesia, silica and water.

At the initial stage of contamination the plagioclase becomes more calcic, but at the stage when hornblende gives place to actinolite the felspar also suffers a change,

and with addition of lime, breaks up into clinozoisite (or epidote) and albite. Later by reaction with magnesia, the albite passes to chlorite according to the following equation :

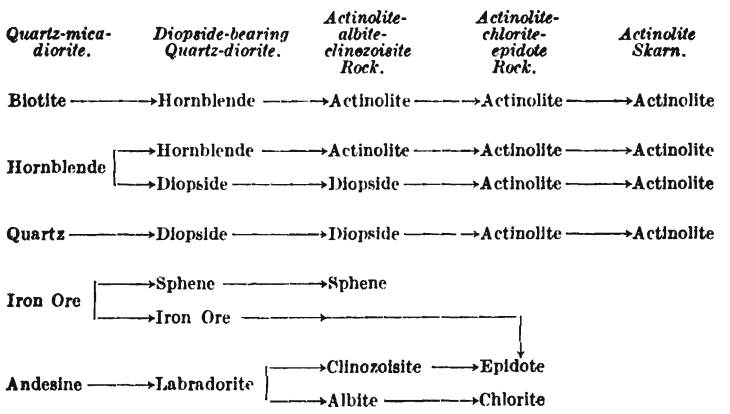
$$2\{Na[AlSi_3O_8]\}+5MgO+4H_2O=(OH)_8Mg_5Al[AlSi_3O_{10}]+3SiO_2+Na_2O.$$

Finally magnesia displaces alumina and the resulting rock is an actinolite-serpentine-epidote assemblage.

In the chlorite- and serpentine-bearing assemblages the excess lime possibly combines with the displaced alumina to give a further quantity of epidote, which is abundant in these rocks. The prehnite-bearing rocks also indicate addition of lime.

In the following table the entry of magnesia and/or lime from the right is assumed.

TABLE I.



(iii) The Genesis of the Exceptional Types.

(1) *Diopside-plagioclase-zoisite Rock with White Mica.*

The calculated analysis (column III of Table II) suggests that there has been but little selective diffusion during the formation of this contaminated rock, and that it has arisen by the simple addition of magnesian limestone to the quartz-mica-diorite magma.

Brucite-marble occurs abundantly in the Main Quarry and the density (2·64) indicates a mixture of 24% brucite and 76% calcite. Actually there is a little dolomite and iron ore in the rock, so it is probable that calcite is slightly

lower in the actual rock, and this is confirmed by the excess of lime in the calculated analysis.

TABLE II.

	I.	II.		III.	
SiO_2	55·35	48·84		48·95	
Al_2O_3	20·89	18·67		18·45	
Fe_2O_3	3·62	0·74	8·10	3·20	8·31
FeO	5·22	6·63		4·63	
MgO	2·75	5·61		5·68	
CaO	7·45	14·03		14·95	
Na_2O	2·49	2·55		2·20	
K_2O	0·82	1·18		0·73	
TiO_2	0·90	1·39		0·79	
P_2O_5	0·41	0·24		0·35	
MnO	0·10	0·12		0·07	
	100·00	100·00		100·00	

I. Quartz-mica-diorite, corrected to 100% with water omitted.

II. Diopside-zoisite-mica rock corrected to 100% with water omitted.

III. Calculated contaminated rock consisting of 9 parts of I and 2 parts of (MgO/CaO = 16·56/42·56) and corrected to 100%. The MgO/CaO ratio is equivalent to 24% brucite and 76% calcite.

From the analyses it would appear that there has been a little selective diffusion of the alkalis, particularly of potash, but it is difficult to interpret this mineralogically, as the conversion of felspar to mica implies an addition of alumina or a subtraction of alkalis.

It is evident that in some cases plagioclase has crystallized from the contaminated magma and has been altered to white mica at a later stage, but in other cases the white mica appears to have crystallized directly. The first stage seems to be the splitting of the actual or potential plagioclase molecule into albite and anorthite, and the subsequent conversion of anorthite into zoisite by the addition of lime and water. The albite molecule then joins with the potential hornblende molecule to give white mica (possibly paragonite and muscovite) and diopside. The resulting rock is, therefore, a diopside-zoisite-white mica assemblage.

The fundamental mineralogical changes thus appear to have been brought about by the addition of lime, and the added magnesia simply implies a higher diopside content. These changes may be represented by the equations:

(1) Plagioclase + Water + Lime = Zoisite + Albite.

(2) Hornblende + Albite + Water + Lime = White Mica + Diopside.

(2) *Pyroxene-spinel-chlorite Rock.*

The intersertal texture of this rock would suggest that chlorite (with perhaps some of the calcite) has been derived from hydrothermal solutions, and that the original rock consisted of a granoblastic mosaic of pyroxene and spinel with large areas of calcite against which the other minerals show idioblastic outlines.

It has been shown that the chlorite is a highly ferruginous type and that it contains only small amounts of alumina and magnesia, so it is evident that the hydrothermal solutions carried iron, silica and water. It is therefore necessary to postulate that most of the alumina (24·51%) was contained in the original rock. It is difficult to see how a spinel-pyroxene assemblage could have arisen by contamination, as the quartz-mica-diorite magma itself contained only about 20% of alumina. It is possible that alumina may have been segregated, but the body of the rock does not suggest crystallization from an aqueous solution or melt.

The association spinel-diopside is characteristic of the high-grade thermal metamorphism of magnesian limestones which contain alumina and a little silica,[6] and though no such sediments are known at Ben Bullen, the very restricted occurrence of this type suggests that there may have been one seam of this composition.

The assemblage may therefore be regarded as a metasomatized limestone.

(iv) The Absence of Certain Silicate Minerals.

Hatch and Rastall[7] and du Toit[3] have described the endogenous contact of magnesian limestones with granite at Port Shepstone, Natal, and certain differences between the mineral assemblages of this contact-zone and that of Ben Bullen are noteworthy.

At Port Shepstone phlogopite is abundantly developed, and scapolite is also prominent. At Ben Bullen neither

of these minerals occurs. It is evident that halogens were almost lacking in the Ben Bullen magma and the absence of these common lime and magnesian minerals may be ascribed to this deficiency. The absence of vesuvianite from the non-magnesian limestone contact may be similarly accounted for.

(v) Reciprocal Reaction and Prevailing Physical Conditions.

In the case of the endogenous contact of the non-magnesian limestone tongues of diorite have given rise to definite contaminated zones. In dealing with a single tongue, therefore, it was possible to trace the stages of contamination of that tongue alone. The limestones of this contact, moreover, had a fairly constant composition, and it was obvious that the final stage in the contamination process was the production of a metasomatized limestone, which probably represented a volume-for-volume change. There was thus some basis upon which a series of analyses might be compared.

In the contact-zone of the magnesian limestones, however, it is useless to make a series of analyses. First, the field relations are such that the contaminated rocks cannot be collected about a single igneous mass, and it is uncertain whether two different mineral assemblages represent different admixtures of the same limestone and the same igneous rock. Secondly, the limestones vary in their CaO/MgO ratio. Thirdly, there are further complications brought about by hydrothermal solutions carrying ingredients from the limestones themselves, and it is doubtful whether the interchanges have been volume replacements.

Reciprocal reaction, therefore, cannot be deduced from chemical analyses, but it may be inferred from the mineralogical discussion and from Table I. It is evident that the limestones have contributed lime and magnesia to the igneous rock, and that during the first stages of contamination all the common oxides of the igneous rock have played a part. At a later stage there is a marked diminution of alumina and alkalis, and finally there has been selective diffusion of silica, iron and water from the igneous rock. It is probable that the actinolite-skarn has a small alumina percentage, so the final solution probably carried a little alumina as well.

The physical conditions prevailing during assimilation in this contact-zone are much the same as those of the

non-magnesian limestone contact. It has been pointed out in connection with the latter that the occurrence of microperthite indicates a fairly high temperature.[4] This mineral occurred in the least contaminated rocks, and it is obvious that high-grade conditions also prevailed at the initial stage of assimilation on the magnesian limestone. The mineralogical response to this was the production of a more basic plagioclase, and splitting of the plagioclase molecule into albite and clinozoisite did not occur until the next stage was reached, when temperatures were obviously lower and water more abundant. The presence of actinolite is also indicative of such conditions.

Pyrites and magnetite occur in the skarn and its associated pegmatite, and these minerals indicate a moderately low temperature—a temperature low enough to inhibit the reaction between quartz and calcite.

The prehnite-, serpentine- and chlorite-bearing rocks probably belong to a slightly later stage, when the temperature was still lower and water vapour was more concentrated.

It is thus evident that contamination took place at low temperatures and in the presence of volatiles, of which water was the most active. Halogens were entirely absent.

(vi) Comparison of the Endogenous Contacts of the Magnesian and Non-Magnesian Limestones.

It has already been pointed out that the field relations are not well defined in the contact of the magnesian limestones, and that matters are further complicated by the variability of the magnesian content, and by the action of hydrothermal solutions. It must also be pointed out that the igneous rock at the contact of the magnesian limestones is a quartz-mica-diorite, whilst that responsible for altering the non-magnesian limestones is a little more basic and contains pyroxene.

In a general way, however, certain similarities are brought out by a comparison of the mineral assemblages of the two contact-zones. Both have arisen under somewhat similar physical conditions. In the one case contamination is brought about by the assimilation of lime, in the other by increasing magnesia and lime; and it is possible to compare the degree of contamination in each case, as is done in Table III.

TABLE III.

Degree of Contamination.	Increasing Lime.	Increasing Lime and Magnesia.
I	*Diorite Core.* Diopside, plagioclase, orthoclase, iron ore and some quartz.	*Diopside-bearing Quartz-diorite.* Diopside, plagioclase, hornblende, iron ore and quartz.
II	*Clinozoisite Zone.* Diopside, clinozoisite, and albite.	*Actinolite-albite-clinozoisite Rock.*
III	*Prehnite Zone.* Diopside, prehnite, clinozoisite. (Soda of albite replaced by lime.)	*Actinolite-chlorite-epidote Rock.* (Soda of albite replaced by magnesia.)
IV	*Garnet Zone.* (Sometimes skarn.) Garnet, diopside, wollastonite, quartz, calcite.	*Actinolite Skarn.* Actinolite (with some alumina), quartz, calcite.

SUMMARY.

It has been shown that a mass of limestone of variable magnesia content has been invaded by a quartz-mica-diorite magma, and that a certain amount of assimilation has taken place.

The parent rocks and the contaminated types are described in detail, and it is concluded that all the contaminated rocks may be accounted for by a gradual increase in the amount of MgO and CaO added to the magma.

It is shown, however, that these gradual increments do not take place directly, but that certain rocks have been contaminated first by the assimilation of solid limestone and then by solutions derived from the sedimentary rock as well as from the magma.

Two somewhat exceptional types have been analysed and their genesis is discussed in some detail.

It is pointed out that the absence of certain silicate minerals may be accounted for by the deficiency of halogens in the magma, and it is concluded that the prevailing physical conditions were those of low temperature and

an abundance of water. Reciprocal reaction is believed to have taken place, but some of the primary interchanges have been masked by later reactions.

Finally, the endogenous contact-zones of the magnesian and non-magnesian limestones are compared with regard to the degree of contamination that each assemblage represents.

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The laboratory work was done in the Department of Mineralogy and Petrology, University of Cambridge.

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THE EFFECT OF CHEMICAL SOLUTIONS ON SOME WOODS.

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For many purposes such as vats, pipe lines, impellers, scrubbers, hoppers, trucks and battery separators, wood is required to resist chemical action, and it has long been known that all timbers are not equal in this respect. Thus for many purposes, especially vats, Kauri is preferred, whilst for battery separators Port Orford Cedar is largely used.

In order to gain some knowledge of the resistance of certain Australian timbers compared with that of Port Orford Cedar (*Cupressus Lawsoniana*), twenty-five local woods, all being commercially available, were selected, and one board of each was cut into twenty-four thin slats measuring approximately $2'' \times 0 \cdot 15'' \times 10''$ long. The timbers used were: Celery Top Pine (*Phyllocladus rhomboidalis*), Huon Pine (*Dacrydium Franklinii*), Port Macquarie Pine (*Callitris Macleayana*), Hoop Pine (*Araucaria Cunninghamii*), Queensland Kauri (*Agathis* sp.), Radiata Pine (*Pinus radiata, P. insignis*), Tallowwood (*Eucalyptus microcorys*), Blue Gum (*Eucalyptus saligna*), Spotted Gum (*Eucalyptus maculata*), Blackbutt (*E. pilularis*), Turpentine (*Syncarpia laurifolia*), Brush Box (*Tristania conferta*), Rosewood (*Dysoxylum Fraseranum*), Teak (*Flindersia australis*), Coachwood (*Ceratopetalum apetalum*), Red Carabeen (*Geissois Benthami*), Crab Apple (*Schizomeria ovata*), Corkwood (*Ackama Muelleri*), Bolly Gum (*Litsea reticulata*), Silver Sycamore (*Cryptocarya glaucescens*), Beech (*Gmelina Leichhardtii*), Yellow Carabeen (*Sloanea Woolsii*), Sassafras (*Doryphora sassafras*), N.S.W. Maple (*Villaresia* (*Chariessa*) *Moorei*), and Port Macquarie Beech (*Euroschinus falcatus*).

* Acknowledgment is made to Messrs. F. B. Shambler and J. Hodges, of the Museum staff, who assisted very materially during the investigation.

The timbers were weighed, measured to 0·001″, and immersed in water and in the following aqueous solutions, all at atmospheric temperatures: 10, 25 and 50% sulphuric acid; 5, 10, 25, and 50% nitric acid (sp. gr. 1·42); 10, 25, 50 and 100% hydrochloric acid (sp. gr. 1·16); 5, 10, 20, and 40% caustic soda; 50 and 100% ammonia (sp. gr. 0·880); 50 and 100% glacial acetic acid; saturated solutions of sodium carbonate, ammonium sulphate, sodium chloride, and 35% sodium sulphite. The experiment was commenced in February, 1933, and the slats were examined at intervals. The majority were left until August, 1935, when they were again weighed and measured.

The percentage swellings given in Table I were calculated on the original air-dry size with a moisture content of approximately 13%, and the results obtained with the different solutions can be compared with what may be regarded as the normal figures, namely those obtained by soaking in water. No measurements were made of the timbers immersed in 50% nitric acid, and in a number of other instances measurements were not practicable. Many of the figures obtained appear to be irregular; thus with varying concentrations of, for example, sulphuric acid, swelling may vary directly or indirectly with acid strength, or the intermediate strength may produce a maximum or minimum swelling. Working with certain American timbers Hauser and Bahlman[1] also found irregular swelling at different concentrations with sulphuric acid and caustic soda. Caustic soda (40%) caused an increase of over 29% in the width of several woods, whereas with other timbers the swelling was under 2%. Consistently low swelling figures were obtained with ammonium sulphate.[2]

In comparing the figures for the different timbers it should be noted that they were not all cut in the same vertical plane; the normal shrinkage and swelling of wood is approximately twice as much tangentially or "backed-

[1] S. J. Hauser and C. Bahlman: "Effect of Chemical Solutions on Various Woods Used in Tanks", *Chem. and Metall. Eng.*, 1923, *28*, 159-162.

[2] A. J. Stamm ("Effect of Inorganic Salts upon the Swelling and Shrinkage of Wood", *Jour. Am. Chem. Soc.*, 1934, *56*, 1195) has shown that the degree of swelling varies with different salts, depending largely upon their solubility, but in no case is any reduction of swelling between water and inorganic salt solutions indicated.

TABLE I.

Percentage Lateral Swelling Based on Air-dry Size, Obtained by Immersing Slats in Different Aqueous Solutions.

Timber.	H_2SO_4.			HNO_3.			HCl.				NaOH.				NH_4OH.		Acetic Acid.		Na_2CO_3.	NaCl.	Na_2SO_3.	$(NH_4)_2SO_4$	H_2O	Cut.*
	10%	25%	50%	5%	10%	25%	10%	25%	50%	100%	5%	10%	20%	40%	50%	100%	50%	100%	Sat. Sol.	Sat. Sol.	35%	Sat. Sol.		
Celery Top Pine ..	1·0	2·4	0·5	3·3	1·8	1·4	3·4	3·5	3·5			0·9	0·9	1·2	1·3	1·0	2·5	2·8	0·8	0·6	2·0	0·4	1·2	Q
Huon Pine ..	1·7	1·6	0·3	1·9	2·0	1·4	1·9	1·7	1·5	1·5	2·4	2·1	0·9		2·5	2·2	2·8	2·3	2·2	1·7	1·9	0·2	2·1	Q
Port Macquarie Pine	1·8	1·6	2·3	4·6	2·2	2·1	3·1	3·4	3·8	2·0	3·4	4·5	3·5		5·4	1·9	3·2	4·4	6·2	2·6	2·2	1·0	2·2	O
Hoop Pine ..	3·2	2·7	3·9	3·6	3·6	3·3	3·8	3·5	3·7	5·3	5·7	5·1	4·7	2·6	5·8	5·0	4·8	4·5	3·1	2·7	3·5	2·1	4·4	B
Queensland Kauri ..	3·6	3·5	1·6	4·1	2·8	2·0	2·2	3·8	2·6		3·4	2·1	6·2	1·6	3·9	2·5	4·3	6·5	2·0	2·9	2·5	1·6	3·6	O
Radiata Pine	3·5	4·0	3·8	5·1	2·8	4·3	2·8	3·4	3·9		4·6	3·2	4·9	5·8	5·2	5·8	5·2	6·5	4·0	3·0	3·4	2·3	4·8	O
Port Orford Cedar ..	2·7	2·2	2·1	2·9	3·1	2·2	1·6	2·4	2·7	2·9	2·6	2·5	1·9	1·7	3·3	3·1	3·4	3·0	2·8	2·3	2·3	2·0	2·7	Q
Tallowwood	4·7	5·1	7·0	4·9	4·7	7·2	4·1	4·3	7·3		7·2	14·9		12·6	7·7	9·8	8·7	8·9	4·8	5·0	6·9	3·0	6·4	Q
Blue Gum ..	8·2	5·6	5·4	11·5	9·4	12·8	9·3	9·7	8·9		12·9	10·4	12·5	18·1	7·5	4·0	4·1	6·4	10·7	4·0	5·3	2·0	7·0	Q
Spotted Gum	3·2	2·2	2·1	2·7	2·8	6·3	6·4				10·9	3·9	6·2	5·4	3·2	4·2	3·2	5·2	2·9	2·5	3·2	1·2	2·9	Q
Blackbutt ..	6·1	5·1	7·2	7·4	7·5	6·3	8·8	7·1	7·7		9·6	11·8	24·2	29·5	10·3	10·9	8·6	10·7	7·2	5·0	6·9	3·6	6·0	Q
Turpentine ..	6·8	3·3	3·7	6·5	7·5	7·7	6·3	6·5	6·7		6·7	6·5	3·4	7·0	7·2	7·4	7·0	6·1	6·7	4·7	6·7	3·3	7·1	Q
Brush Box ..	2·9	1·5	3·6	3·4	5·2	6·8	10·0	6·5	6·9		8·7	4·8	13·2	29·3	7·9	8·9	7·3	9·1	6·6	5·1	7·4	1·8	6·5	Q
Rosewood ..	1·8	2·0	1·5	2·9	2·0	5·0	3·6	3·2	4·1		6·4	5·3	9·0		4·5	4·6	5·6	4·0	4·9	2·8	3·7	1·1	4·0	Q
Teak ..	4·1	2·3	2·4	4·2	3·4	4·7	2·6	2·8	3·8		5·4	3·9	6·8	10·4	4·6	4·4	3·9	5·8	3·6	3·5	4·0	1·6	4·7	Q
Coachwood ..	2·7	2·3	2·2	3·3	2·8	2·4	4·0				2·5	3·9			3·9	2·7	5·8	5·7	4·2	3·3	3·2	1·7	3·2	Q
Red Carabeen	2·9	2·2	3·7	3·0	3·3	3·1	3·2				4·5	7·0	4·3		4·4	2·6	3·2	5·8	4·1	2·3	2·7	1·6	5·6	Q
Crab Apple ..	4·1	2·3	1·0	2·7	2·6	2·5	3·0				1·7	0·6		3·2	3·7	2·4	3·3	3·0	2·8	2·3	2·7	1·3	3·1	Q
Corkwood ..	9·8	3·7	3·3	5·3	4·3	5·7	4·0	4·5	4·8		13·7	12·9			3·6	3·0	3·6	3·4	4·2	7·6	1·9	0·6	8·0	Q
Bolly Gum	5·2	1·5	3·2	4·0	2·9	5·9	3·7				8·1	6·3	6·7	15·8	2·7	6·2	3·7	4·2	3·6	3·4	5·7	1·0	4·0	Q
Sycamore ..	5·7	5·3	4·8	7·0	7·3	6·7	6·8	6·2	5·6	9·0	9·5	9·8	11·8	10·0	8·8	8·5	8·1	8·9	8·4	7·0	6·4	3·2	7·4	Q
Beech ..	1·3	3·7	2·9	7·0	2·8	3·5	3·1	2·2	2·8		2·1	8·8	6·6	7·7	4·8	5·0	6·2	6·3	5·3	4·3	7·5	1·7	3·2	Q
Yellow Carabeen ..	5·4	5·9	9·3	5·6	6·2	5·1	5·9	7·0	7·4		10·1	9·0	5·5	9·1	8·6	7·7	8·1	7·1	6·1	4·6	6·5	2·9	6·9	B
Sassafras ..	4·9	3·9	3·7	4·8	4·6	4·2	3·8	3·9	4·3		6·6	5·8	10·3	5·9	5·8	5·8	5·0	5·2	5·5	3·9	6·3	2·4	5·5	B
N.S.W. Maple	7·8	4·5	4·3	8·5	7·6	7·9	3·3				10·4	8·4	14·1	5·6	2·1	8·8	7·8	9·3	3·6	3·8	6·7	2·4	2·4	Q
Port Macquarie Beech ..	4·0	3·3	3·7	4·4	4·2	4·3	4·2						6·9	7·2	6·9	6·2	5·4	6·3	5·0	4·7	3·3	2·4	3·9	B
Mean ..	4·2	3·2	3·4	4·8	4·2	4·8	4·4	4·5	4·8	4·1	6·6	6·2	7·5	9·5	5·2	5·2	5·2	5·8	4·7	3·6	4·4	1·8	4·6	

* Q = Quarter-cut. O = Oblique. B = Tangentially cut or "backed-off."

off " as it is when quarter-cut. The direction of cut is shown in the table.

Apart from caustic soda, the highest mean figure was obtained with glacial acetic acid.

In Table II are given the various degrees of firmness of the woods after different periods of immersion. This determination was purely empirical, and was based on the resistance of the slats to bending in the fingers, but it can be regarded as affording an indication of the relative rigidity of the woods.

It is obvious that in general the " pine " timbers showed the greatest resistance to chemical action, and compare very favourably with Port Orford Cedar, whilst the majority of the " non-pine " woods were definitely inferior, notably Port Macquarie Beech, which failed lamentably.[3] The rigidity or otherwise of the slats as shown in the table does not tell the whole story ; many woods, including the Eucalypt hardwoods, and especially Tallowwood, which might have been expected to possess some resistance, became cracked and warped, particularly in caustic soda. Apart from the " pines ", Teak, Sassafras and Sycamore seemed to be generally most satisfactory. The effect of ammonia, acetic acid and the various inorganic salts was so little that it was not possible to discriminate between the different woods ; the results have therefore been omitted from the table. Any of the woods could be used satisfactorily in contact with these solutions, at any rate at atmospheric temperatures.

The effect of the more corrosive solutions can be summarised as follows, based on an examination of the slats after washing and drying :

Sulphuric Acid, 10%. Very little alteration noticeable ; all woods stiffened up and appeared to be strong.

Sulphuric Acid, 25%. Little external effect apparent, except that all woods darkened ; some of the hardwoods inclined to check.

Sulphuric Acid, 50%. All woods discoloured, and had appearance of being partially carbonised ; the " pines ", together with Teak, Sassafras, Coachwood, Beech, and Corkwood affected least in shape, others more or less warped. Tallowwood also badly split

[3] C. S. Robinson (" Wood as a Chemical Engineering Material ", *Jour. Ind. and Eng. Chem.*, 1922, *14*, 607) states that in general coniferous woods are most resistant to hydrochloric and other acids.

TABLE II.

Comparative Stiffness of Different Woods after Immersion for Varying Periods.

1 = Firm. 2 = Moderately firm. 3 = Brittle. 4 = Very brittle.

Timber.	H_2SO_4.			HNO_3.							HCl.							NaOH.						
	10%	25%	50%	5%	10%	10%	25%	25%	50%	50%	10%	25%	25%	50%	50%	100%	100%	5%	10%	10%	20%	20%	40%	40%
Celery Top Pine ..	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	2	3	1	2	3	1	3	2	3
Huon Pine ..	1	1	1	1	1	1	1	1	1	4	1	1	1	1	2	1	3	2	2	2	3	4	2	3
Port Macquarie Pine	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	2	2	2	3	3	4
Hoop Pine ..	1	1	1	1	1	1	1	1	1	3	1	1	1	2	2	1	3	1	2	2	3	4	2	4
Queensland Kauri	1	1	1	1	1	1	1	1	1	3	1	2	3	1	2	2		1	2	2	2	3	3	
Radiata Pine ..	1	1	2	1	1	1	1	1	1	3	1	1	1	1	2	2	3	2	2	2	2	3	2	4
Port Orford Cedar	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1		1	2	2	1	3	2	3
Tallowwood ..	1	1	3	1	1	1	2	3	4		1	1	2	1	2	3		1	1	1	4	4	4	
Blue Gum ..	1	1	2	1	1	2	4	3	4		1	1	2	1	1	3		1	2	2	2	2	4	
Spotted Gum ..	1	2	3	1	1	2	3	3	4		1	3	3	4	4	3		1	2	2	1	2	3	
Blackbutt	1	1	2	1	1	2	2	2	4		1	1	2	2	2	3		1	1	2	1	2	4	
Turpentine ..	1	1	2	1	1	1	2	4	4		1	1	2	1	2	3		1	2	2	2	2	3	
Brush Box ..	1	1	3	1	1	1	3	3	2		1	1	2	3	3	3		1	1	2	1	2	4	
Rosewood	1	1	3	1	1	2	3	3	3		1	1	2	2	3	3		2	3	3	3	4	3	
Teak	1	1	1	1	1	1	1	2	2		1	1	2	1	3	3		1	1	1	1	2	4	
Coachwood ..	1	3	3	1	2	2	4	3	3		1	3	3	4	4	4		1	2	4	3	3	3	
Red Carabeen ..	1	2	3	1	1	2	3	4	3		1	1	3	4	4	4		1	2	2	3	3	4	
Crab Apple ..	3	3	4	2	2	3	3	4	4		1	3	3	4	4	4		1	2	3	3	3	3	
Corkwood	1	2	3	2	2	2	3	3	4		1	2	2	3	3	3		1	3	3	3	3	3	
Bolly Gum ..	1	3	3	2	2	2	4	4	4		1	3	3	4	4	4		2	3	3	4	4	3	
Sycamore	1	2	3	1	1	2	1	2	1	4	1	1	2	1	2	1	3	2	2	3	3	3	2	4
Beech	2	1	3	1	1	2	4	3	2		1	2	3	2	3	3		2	2	2	4	4	3	
Yellow Carabeen ..	1	2	3	2	2	3	4	4	4		1	2	3	3	3	3		2	3	3	4	4	2	4
Sassafras	2	1	3	1	1	2	1	3	3		1	1	2	2	2	3		1	2	3	3	3	3	
N.S.W. Maple ..	1	3	3	1	1	3	3	3	3		1	3	3	4	4	3		1	2	2	4	4	3	
Port Macquarie Beech	4	4	4	3	3	4	4	4	4		4	4	4	4	4	4		4	4	4	4	4	4	
Period of immersion in months ..	30	30	30	30	14	30	7	30	3	14	30	14	30	14	30	14	30	30	14	30	14	30	7	30

and to a smaller extent Rosewood, Yellow Carabeen, Blue Gum, Blackbutt and New South Wales Maple.

Nitric Acid, 5%. All timbers bleached to a yellow colour; Port Macquarie Beech and Yellow Carabeen seriously warped, others scarcely affected and all appeared rigid, although some were inclined to be brittle.

Nitric Acid, 10%. Blue Gum and Spotted Gum roughened and checked; Bolly Gum badly corrugated; Port Macquarie Beech, Yellow Carabeen and New South Wales Maple considerably warped; remainder not altered in shape.

Nitric Acid, 25%. Practically all timbers cracked and distorted, with excessive shrinkage evident in Port Macquarie Beech, Blackbutt and Brush Box. All woods dried out rigid and stiff, but were brittle.

Nitric Acid, 50%. After three months the majority of the woods were so weak, when wet, that they were unable to support their own weight when held at one end horizontally, and they were removed. The coniferous woods and Sycamore were still firm, whilst timbers such as Tallowwood, Blue Gum and Crab Apple were so soft and spongy that they could not be handled without falling to pieces. All woods were bleached to a pale yellow. On drying all woods were more or less distorted and cracked.

Hydrochloric Acid, 10%. Little apparent effect except in Blackbutt, which was warped and cracked. All woods hard and rigid.

Hydrochloric Acid, 25%. Little alteration except Blue Gum, which showed slight corrugations.

Hydrochloric Acid, 50%. Most woods inclined to be brittle. Bolly Gum showed excessive shrinkage; Blue Gum and Blackbutt checked and warped; all timbers darkened and the majority became brittle, especially Port Macquarie Beech.

Hydrochloric Acid, 100%. All woods darkened considerably and appeared carbonised. Tallowwood and Blackbutt badly checked and warped, and Blue Gum and Spotted Gum to a somewhat less degree. The conifers, together with Sassafras and Corkwood, seemed to be least affected in shape.

Caustic Soda, 5%. The conifers and Teak were in best condition, whilst Rosewood, Port Macquarie Beech and Crab Apple were worst, being badly warped. Bolly

Gum and Brush Box showed excessive uneven shrinkage, amounting to over 32% and 20% respectively. All the timbers appeared tough and strong.

Caustic Soda, 10%. The conifers, with the exception of Celery Top Pine, which was warped, and Port Macquarie Pine, which showed considerable uneven shrinkage, appeared in fair condition. Port Macquarie Beech and Bolly Gum had shrunk badly, the latter by 46%, on the air-dry size. Rosewood, Corkwood and Coachwood were much warped and the remainder to a greater or less extent.

Caustic Soda, 20%. Practically all woods showed excessive shrinkage, especially Port Orford Cedar, Port Macquarie Beech, Bolly Gum and Huon Pine; all distorted and more or less warped, especially Tallowwood.

Caustic Soda, 40%. Excessive shrinkage evident in the majority of the woods, particularly in those mentioned previously. Queensland Kauri and Sassafras appeared to be least affected, but all were more or less distorted. Tallowwood was the worst of all, the surface being extremely broken and ragged, whilst Rosewood, Teak and Corkwood were not quite so roughened.

Ammonia, 50%. All woods darkened, but not otherwise seriously affected. Bolly Gum and Port Macquarie Beech showed excessive shrinkage and these, together with Rosewood, Crab Apple, Beech, Spotted Gum and Yellow Carabeen, were also warped.

Ammonia, 100%. As for 50% except that Bolly Gum was also corrugated. All woods appeared to be rigid and strong.

Acetic Acid, 50%. Woods practically unaffected except for slight corrugating of Bolly Gum and the "grain" being raised in Blue Gum and Spotted Gum.

Acetic Acid, 100%. Woods apparently unaffected and appeared to be even better than in 50%.

No special comment appears to be necessary for the other solutions, except that sodium sulphite had a moderate bleaching action, whilst ammonium sulphate ebonised some of the woods, especially Turpentine, Blackbutt, Tallowwood and Yellow Carabeen. Sodium carbonate in a few instances caused the wood surface to lift in small areas, particularly where the surface was cut with the stamps used for marking the slats. It has been noted on other occasions that where wood has been exposed to

washing soda under alternately wet and dry conditions it has become frayed and woolly.

Summary.

A number of woods, Australian with one exception, were immersed in various acids, alkalis and inorganic salts. In general the coniferous woods proved to be the most resistant to chemical action, whilst many of the hardwood and brush timbers were very inferior.

THE BIREFRINGENCE OF POTASSIUM CHLOROPALLADITE AND POTASSIUM CHLOROPLATINITE.

By D. P. Mellor, M.Sc.,
and Florence M. Quodling, B.Sc.

(*Manuscript received, October 24, 1935. Read, November 6, 1935.*)

Within the last few years increased attention has been paid to the relation between optical properties and crystal structure, and sufficient has been done in the way of correlating the two to enable optical properties to be used as a valuable check on structure-determinations (W. A. Wooster, *Zeit. f. Krist.*, 1931, Bd. *81*, 495). For example, all crystals of the type $R_x MX_4$ in which X-ray analysis has shown that the MX_4 ion has a tetrahedral configuration exhibit little or no birefringence. The origin of the low or zero birefringence is to be sought in the optical isotropy of the tetrahedral MX_4 ion. On the other hand crystals of the type $R_x MX_3$ in which the MX_3 ion is planar are strongly birefringent and optically negative. When a ray is so polarised that its electric vector lies in the plane of the MX_3 ion it travels more slowly than one polarised at right angles.

The object of this note is to present optical data relating to those unique structures of the $R_x MX_4$ type in which the MX_4 ion is planar, *viz.* K_2PdCl_4 and K_2PtCl_4. These structures are of special interest in view of their bearing on the stereochemistry of 4-covalent palladium and platinum. If the atomic arrangements deduced for K_2PdCl_4 and K_2PtCl_4 by Dickinson (*Journ. Am. Chem. Soc.*, 1922, *44*, 2404) are correct the crystals should be optically negative and strongly birefringent. Measurements described below show this to be the case for both compounds.

Experimental.

Refractive index measurements on the crystals were made in sodium light by the usual immersion method.

Those liquids whose refractive indices lay outside the range of the Abbé refractometer were measured by the method of minimum deviation. Crystals of K_2PdCl_4 were prepared by slow evaporation of solutions containing $PdCl_2$ and KCl in the proper proportions, while crystals of K_2PtCl_4 were prepared from K_2PtCl_6 by reduction with $K_2C_2O_4$.

K_2PdCl_4.

Thin sections parallel to *c* are light brownish-yellow and show strong pleochroism (Groth: *Chem. Kryst.*, *1*, 351). O=cinnamon brown; E=greenish yellow; absorption O>E.

$\omega_D = 1{\cdot}710 \pm 0{\cdot}001$, $\varepsilon_D = 1{\cdot}523 \pm 0{\cdot}001$.

Double refraction=0·187 (negative).

Molecular refraction, $R_{K_2PdCl_4} = 44{\cdot}6$.

Using Wasastjerna's values (*Soc. Sci. Fenn. Comm. Phys.-Math.*, 1922-3, *1*, 37, 1) for the ionic refraction of K^+ and Cl^- we find R_{PdCl_4} to be 38·9 and R_{Pd} 5·1.

*K_2PtCl_4.**

Very small (0·7 mm.) pale wine-red tapering crystals were examined. Their pleochroism is distinct but less marked than in K_2PdCl_4. O=light pinkish brown; E=pale wine-red.

$\omega_D = 1{\cdot}683 \pm 0{\cdot}001$, $\varepsilon_D = 1{\cdot}553 \pm 0{\cdot}001$.

Double refraction=0·130 (negative).

Molecular refraction $R_{K_2PtCl_4} = 44{\cdot}2$.

$R_{PtCl_4} = 38{\cdot}4$; $R_{Pt} = 4{\cdot}6$.

From the optical data relating to K_2PtCl_6† (Winchell: The Optic and Microscopic Characters of Artificial Minerals, p. 26) $R_{K_2PtCl_6}$ is found to be 60·84, $R_{PtCl_6} = 55{\cdot}1$ and R_{Pt} 4·4.

Discussion.

Such strong birefringence as is found could not arise from a tetrahedral configuration or from the bisphenoidal

* The optical measurements listed by Winchell under K_2PtCl_4 and stated to have been made on "potassium platinum chloride" of unknown formula cannot refer to potassium chloroplatinite.

† The value of *n* used in this calculation refers to 577μμ, but the difference introduced by assuming this value of *n* to be the same as for 589μμ will not seriously affect the values of R.

arrangement proposed by Hermann, Rosenheim and Gerb (*Zeit. f. anorg. Chem.*, 1933, *218*, 289). While the optical resolution of meso-stilbenediamino-isobutylene-diamino platinous salts by Mills and Quibell (*J. Chem. Soc.*, 1935, 839) has definitely eliminated the possibility of a tetrahedral orientation of electron pair bonds about 4-covalent platinum, a pyramidal configuration is not excluded. These authors consider, however, that there are no reasons for inferring a pyramidal rather than the more symmetrical planar configuration. If the optical resolutions of bis-isobutylenediamine platinous salts (Reihlen and Huhn, *Ann.*, 1931, *489*, 42) and other 4-covalent compounds of palladium and platinum are valid and a tetrahedral configuration is excluded, a pyramidal configuration does satisfactorily account for all types of isomerism observed in 4-covalent platinum and palladium compounds (Dwyer and Mellor, *J. Amer. Chem. Soc.*, 1934, *56*, 1551). A small displacement of the Pd (or Pt) atom out of the plane of the four chlorine atoms in the structure deduced by Dickinson would produce a structure in which marked birefringence should still be found and at the same time would introduce a polar axis. The forms observed for K_2PdCl_4—{110} and {111} or {110} and {001}—and the absence of pyroelectric properties, for which a search was made by the liquid-air method due to Martin (*Min. Mag.*, 1931, *22*, 519), show that the crystal does not possess a polar axis. All the evidence points, therefore, to a planar arrangement of the chlorine atoms about platinum and palladium in K_2PtCl_4 and K_2PdCl_4. It is not clear why the birefringence of K_2PtCl_4 is less than that of K_2PdCl_4. The figures for the atomic refractivity of Pt and Pd show that in calculating the birefringence of these crystals (K_2PtCl_4 and K_2PdCl_4) it will not be permissible to neglect the refractivity of the central atom of the planar ion as was done by Bragg when calculating the birefringence of calcite.

One other similar but rather complicated structure, $MgPt(CN)_4 7H_2O$, has been analysed by Bozorth and Haworth (*Phys. Rev.*, 1927, *29*, 223). These authors state that:

"Possible arrangements for the C and N atoms include those placing them at the corners of squares of undetermined sizes which lie in planes parallel to the 001 planes and which have platinum atoms at their centres."

The crystals are uniaxial positive[1] and very strongly birefringent $\varepsilon-\omega=0\cdot35$ (Gaubert, *Bull. Soc. Fr. Min.*, 1917, *40*, 177). It seems reasonable to suppose that the strong birefringence of $MgPt(CN)_4 7H_2O$, of monoclinic $RbLiPt(CN)_4 3H_2O$ and orthorhombic $KNaPt(CN)_4 3H_2O$ is largely due to the planar $Pt(CN)_4$ ions. With the suggested orientation of the square $Pt(CN)_4$ ions parallel to 001 planes one would expect the crystals of $MgPt(CN)_4 7H_2O$ to be optically negative. The optical properties suggest that the $Pt(CN)_4$ groups are parallel to the *c* axis.

Since completing the above investigation two gold compounds of the type RMX_4 [$N(CH_3)_4AuCl_4$ and $KAuBr_4$] have been examined. Both are very strongly birefringent, and this suggests that $AuCl_4^-$ and $AuBr_4^-$ ions are planar as predicted by the quantum mechanical calculations of Pauling [*J. Amer. Chem. Soc.* (1931), *53*, 1367]. Further work on these compounds is being carried out.

SUMMARY.

The optical characteristics of potassium chloropalladite and potassium chloroplatinite accord qualitatively with those expected from the structures assigned by X-ray analysis. For a ray polarised so that its electric vector lies in the plane of the MX_4 ion the refractive index is much higher than for the ray whose electric vector is perpendicular to the plane of the ion.

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[1] These crystals were examined and the positive optical sign as well as the strong birefringence were confirmed.

THE OCCURRENCE OF LINALOOL IN THE ESSENTIAL OIL OF *MELALEUCA ERICIFOLIA*.

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(*Manuscript received, November 8, 1935. Read, December 4, 1935.*)

Messrs. Baker and Smith (THIS JOURNAL, Vol. 56, 1922, p. 115) published the results of an investigation into the chemistry of the essential oil of *Melaleuca ericifolia*. They showed the principal alcohol to be α-terpineol.

The wide distribution of this "Tea Tree" has caused many enquiries to be made about the economic possibilities of its essential oil. The occurrence of so common an alcohol as α-terpineol, obtainable in commercial quantities at an extremely low price, has precluded any attention being given to the exploitation of the essential oil of *Melaleuca ericifolia*. The extensive areas of this shrub and the various enquiries received caused us to re-examine the principal odoriferous constituent, for on crushing the leaves between the fingers the pleasant odour of linalool was detected.

The influence of this alcohol upon the probable commercial exploitation of the shrub renders it advisable for a preliminary note of its occurrence to be recorded as soon as possible.

Leaves and terminal branchlets were first submitted by Mr. S. J. Gaw of Laughtondale, and it was from the consignment received on 6th August, 1934, that the alcohol linalool was isolated and its identity confirmed. Further supplies of material were collected at Narrabeen and Kogarah, the last-named locality being the one from which Messrs. Baker and Smith obtained their material in 1922. The presence of terpineol has not been detected in any of the oils examined by us.

TABLE I.

Date.	Locality.	Weight of Leaves.	Yield of Oil.	$d\frac{15}{15}°$	$a_D^{20°}$	$n_D^{20°}$	Solubility in 70% Alcohol.	Ester No 1½ hrs. Hot Sap.	Ester No. after Acetylation.	Cineol Contents.	Remarks.
		lbs.	%				Vols.			%	
6/8/34	Laughtondale.	42	0·74	0·9069	+9·5°	1·4763	1·4	9·1	128·1	16	Leaves supplied by Mr. G. J. Gaw.
8/11/34	,,	120	0·45	0·9086	+9 0°	1·4831	0·7 (80% alcohol)	11·0	89·3	13	,, ,,
29/8/35	Narrabeen.	218	0·79	0·9002	−11·2°	1·4740	1·2	10·7	135·3	18	
10/9/35	Kogarah.	308	0·7	0·8997	+13·2°	1·4730	1·3	10·1	114·9	16	

TABLE II.

Oil Examined.	Volume of Crude Oil.	Volume of Alcohol Fraction.	Boiling Point at 10 mm.	$d\frac{15}{15}°$	$a_D^{20°}$	$n_D^{20°}$
	c.c.	c.c.				
Laughtondale, 6/8/34	60	17	80° to 87°	0·8816	+13·4°	1·4672
Laughtondale, 8/11/34	160	20	84° to 86°	0·8865	+13·0°	1·4711
Narrabeen, 29/8/35	80	18	80° to 88°	0·8829	+14·8°	1·4681
Kogarah, 10/9/35	200	44	80° to 88°	0·8804	+15·0°	1·4666

Experimental.

The leaves and terminal branchlets were collected from the various localities enumerated above and the essential oils obtained therefrom by steam distillation. These oils gave the chemical and physical constants shown in Table I.

The essential oils were brownish yellow in colour, and varied from very mobile to viscous liquids according to the percentage of sesquiterpenes present. The odour of the crude oils was particularly pleasant, due to the presence of linalool.

Determination of Linalool.

All four lots of oil were examined by distillation at 10 mm. and the fractions distilling at 80° to 90° at 10 mm. separated and examined. These fractions gave the following chemical and physical constants. (See Table II.)

Linalool of a high degree of purity is very difficult to obtain by the ordinary methods of fractional distillation. The high specific gravity of the various fractions was found to be due to admixture of the linalool with sesquiterpenes.

On further distillation fairly pure linalool was obtained possessing the following characters:

Boiling point at 10 mm. 84° to 86°, d^{15}_{15}° 0·8760,

a^{20}_{D} +15·5°, n^{20}_{D} 1·4645.

The identity of this alcohol was confirmed by the preparation of the α-naphthyl urethane, melting point 53° to 54°, the phenyl urethane, melting point 65° to 66°, and citral by oxidation, melting point of semicarbazone, 135°. On recrystallisation the melting point was raised to 164°.

The chemistry of the other constituents, particularly the sesquiterpenes, will be dealt with in a subsequent communication.

Our thanks are due to Mr. S. J. Gaw, Laughtondale, for providing two consignments of material.

NOTES ON THE SHRINKAGE OF WOOD.

PART II.

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(*Manuscript received, November 20, 1935. Read, December 4, 1935*)

The results of a number of shrinkage and density determinations were published a few years ago.[1] Since then, chiefly through the courtesy of the Forestry Commission of New South Wales, further samples of green timber have been received for examination. In general the procedure was similar to that already described, except that the small sections measuring 1 inch along the grain, 4 inches in width and 1 inch in thickness were allowed to air-season before oven-drying, and the air-dry and oven-dry shrinkages were determined from the same section, whereas in the earlier paper the air-dry and oven-dry shrinkages were measured from separate sections cut from the same board. The moisture content of the air-dry material was approximately 13%.

No attempt was made to eliminate collapse, and whilst such a condition is evident in timbers such as Brush Box, Turpentine, Murray Red Gum, in the majority it is apparently absent or occurs only to a minor degree.

It is sometimes assumed that the shrinkage, green to air-dry, is half the green to oven-dry shrinkage, but an examination of the figures in columns 4 and 5 indicates that the ratio is usually much greater, the air-dry shrinkage being commonly from 0·6 to 0·8 times the oven-dry shrinkage. A shrinkage factor of 0·5 for an air-dry moisture content of 13% presupposes a fibre saturation point of about 26%, and if the factor is greater than this, it indicates either that the fibre saturation point is above

* Acknowledgment is due to Messrs. F. B. Shambler and J. Hodges of the Museum staff, who assisted very materially during the progress of the work.

[1] M. B. Welch, Notes on the Shrinkage of Wood, *Jour. Roy. Soc. N.S.W.*, 1932, *65*, 235-250.

		1	2	3	4	5	6	7	8	9
Angophora Bakeri	Narrow-leaved Apple	44·6	74·5	34·4	4·8	7·2	11·8	17·2	116	Q
" "	" "	43·3	72·7	34·1	7·2	10·9	9·8	15·5	113	B
Baloghia lucida	Brush Bloodwood	47·9	62·3	38·0	4·0	6·4	11·3	16·9	64	Q
" "	" "	46·0	61·1	37·4	7·6	11·1	9·0	14·0	63	B
Callitris glauca	Cypress Pine	41·9	46·0	35·9	2·6	4·4	5·7	10·1	28	Q
" "	" "	41·7	46·9	35·9	2·7	4·6	5·5	10·1	30	Q
" "	" "	45·9	49·5	38·0	3·6	6·1	7·1	11·6	30	Q
" "	" "	38·5	42·3	32·6	3·3	5·5	5·8	9·9	30	B
" "	" "	41·9	47·0	35·3	3·0	5·3	5·4	10·3	33	B
" "	" "	38·1	42·9	32·2	3·4	5·7	5·9	9·8	33	B
" "	" "	42·0	47·3	35·4	3·0	5·3	5·1	10·0	34	B
" "	" "	44·1	50·2	37·2	3·4	5·6	6·4	10·5	35	B
" "	" "	41·2	48·0	35·1	3·6	5·9	6·1	10·2	37	B
" "	" "	40·4	48·2	33·9	3·1	5·4	6·2	10·4	39	B
Cedrela Toona	Red Cedar	34·1	55·6	28·3	1·7	3·3	4·7	9·0	96	Q
" "	" "	27·6	43·8	23·7	3·1	5·1	5·1	8·7	84	B
Cryptocarya erythroxylon	Pigeon Berry Ash	44·9	47·4	36·5	7·5	10·8	10·9	16·6	30	Q
Daphnandra micrantha	Sassafras	42·2	59·6	34·7	2·0	3·6	8·7	13·9	72	B
" "	"	42·7	61·5	35·9	6·9	10·3	7·6	12·1	71	Q
Diploglottis Cunninghamii	Tamarind	42·1	55·1	34·8	2·7	4·5	8·4	13·3	58	B
" "	"	43·2	54·7	35·6	6·3	9·5	8·5	13·4	54	Q
Doryphora sassafras	Sassafras	32·1	44·0	26·0	1·9	3·3	8·0	12·6	69	B
" "	"	37·8	51·5	30·7	6·9	10·4	9·4	15·3	67	Q
Dysoxylon Fraseranum	Rosewood	47·4	55·0	38·3	2·6	4·6	7·2	12·3	40	B
" "	"	44·0	47·0	36·1	3·4	6·3	5·4	10·7	30	Q
" "	"	49·3	58·1	39·3	3·3	5·4	8·3	13·5	48	B
Endiandra Palmerstoni	Queensland Walnut	40·5	65·8	34·7	1·8	3·1	4·9	9·6	90	Q
" "	" "	44·0	65·0	36·7	4·6	7·6	6·8	11·3	77	B
Endiandra virens	N.S.Wales Walnut	53·0	63·0	42·5	4·2	6·5	11·0	16·8	48	Q
" "	" "	51·5	64·3	41·7	7·4	10·7	9·8	15·6	54	B
Eucalyptus acmenioides	White Mahogany	57·0	71·2	47·6	3·7	5·9	7·1	15·8	50	Q
" "	" "	62·1	72·6	49·8	6·4	9·5	10·7	16·3	46	B
" *amplifolia*	Cabbage Gum	67·2	77·6	46·8	7·9	11·1	20·8	26·6	66	Q
" "	" "	64·0	74·5	43·3	10·1	13·0	23·4	28·7	72	B

		1	2	3	4	5	6	7	8	9
Eucalyptus Andrewsi	New England Blackbutt	54·0	72·4	41·8	4·3	6·9	12·4	19·1	74	Q
" "	" " "	52·5	71·8	41·8	7·3	11·2	9·5	17·9	72	B
" *botryoides*	Bangalay	55·5	71·2	43·3	4·8	7·2	13·3	18·3	64	Q
" "	"	50·8	73·6	42·1	2·9	4·9	7·8	12·1	75	Q
" "	"	58·7	63·9	47·2	5·1	7·8	10·6	16·2	35	O
" "	"	62·3	72·3	44·0	7·7	10·7	14·6	19·8	52	B
" "	"	61·8	72·5	46·8	9·0	11·9	15·5	20·2	55	B
" "	"	57·7	65·7	46·2	7·0	10·0	11·3	16·6	42	B
" "	"	63·0	69·9	47·1	10·5	13·9	17·3	23·0	48	B
" "	"	58·7	67·8	44·8	9·1	12·0	15·4	20·8	52	B
" "	"	56·7	71·2	44·6	8·1	11·4	12·7	17·9	59	B
" *carnea*	White Mahogany	63·8	79·1	51·0	4·8	7·6	10·5	16·6	56	Q
" "	" "	66·8	78·8	52·9	7·3	10·8	11·9	18·2	49	B
" *corymbosa*	Bloodwood	62·1	74·9	52·9	2·9	5·2	6·5	11·2	42	Q
" "	"	63·5	73·3	54·2	3·9	7·3	5·9	10·9	35	B
" *crebra*	Red Ironbark	68·2	72 7	54·9	3·7	6·4	9·5	15·8	32	Q
" "	"	71·6	75·0	57·5	5·5	9·0	10·0	16·4	30	B
" *Dalrympleana*	Mountain Gum	50·2	71·2	35·5	6·5	8·6	21·6	26·2	100	Q
" "	" "	49·7	70·9	32·4	9·4	12·0	28·0	32·2	119	Q
" "	" "	40·9	69·2	31·6	4·0	5·8	14·7	19·0	119	Q
" "	" "	44·8	71·5	34·3	9·8	12·7	14·9	18·9	108	B
" "	" "	42·1	70·7	33·5	8·0	11·0	11·6	16·4	111	B
" "	" "	42·8	70·3	32·9	9·6	12·3	14·4	18·4	114	B
" "	" "	39·0	67·4	30·0	9·5	12·1	15·3	19·6	125	B
" *delegatensis*	Alpine Ash	41·8	64·9	33·2	4·1	6·2	12·1	17·5	96	Q
" "	" "	41·1	65·6	32·7	3·8	5·7	11·8	16·9	101	Q
" "	" "	41·5	64·9	51·9	7·6	10·6	12·1	16·9	96	B
" "	" "	40·8	64·7	32·6	7·2	10·2	11·3	16·6	98	B
" *Dunnii*	White or Ribbon Gum	50·3	52·1	41·5	3·5	6·3	8·9	14·6	26	Q*
" "	" " "	46·1	46·7	38·8	3·6	7·0	6·0	11·3	24	B*
" *eugenioides*	White Stringybark	49·6	66·0	39·9	5·0	7·2	11·3	16·1	66	Q
" "	" "	46·7	64·8	37·3	5·1	7·3	14·4	20·1	83	Q
" "	" "	48·4	72·1	37·8	3·9	6·2	11·8	17·7	88	Q
" "	" "	52·9	68·9	41·2	5·6	8·1	10·6	15·7	64	O

		1	2	3	4	5	6	7	8	9
Eucalyptus eugenioides	White Stringybark	51·9	64·9	41·9	6·1	9·3	9·2	14·2	55	B
" "	" "	50·2	64·8	41·1	5·5	8·5	9·0	13·7	57	B
" "	" "	49·3	63·4	26·2	7·7	11·4	12·1	18·3	75	B
" "	" "	48·6	73·8	38·5	5·8	9·5	9·3	15·0	92	B
" *fastigata*	Brown Barrel	52·0	73·4	39·5	3·7	6·5	11·6	19·2	85	Q
" "	" "	44·6	72·3	34·3	3·9	6·0	11·5	17·2	110	Q
" "	" "	50·2	69·9	38·9	7·3	11·1	11·3	18·1	80	B
" "	" "	45·6	69·3	34·0	9·2	12·4	15·1	20·8	103	B
" *globulus (bicostata)*	Eurabbie	52·4	69·2	40·0	9·3	12·4	15·4	20·3	73	B
" *grandis*	Flooded Gum	50·8	67·4	39·5	4·2	6·2	14·2	19·4	70	Q
" "	" "	51·4	72·0	41·7	7·0	9·8	10·2	15·0	73	Q
" *macrorhynca*	Red Stringybark	50·1	72·9	41·4	2·5	4·3	7·9	12·4	76	Q
" "	" "	50·4	74·0	41·8	2·9	4·8	7·7	12·0	77	Q
" "	" "	50·3	74·8	41·6	2·7	4·9	7·9	12·2	80	Q
" "	" "	51·7	73·1	41·6	6·4	9·1	10·8	15·1	75	B
" "	" "	49·1	71·8	40·7	5·5	8·2	8·6	12·9	77	B
" "	" "	49·4	71·9	40·7	5·6	8·2	8·8	13·2	77	B
" *maculata*	Spotted Gum	59·7	73·5	46·0	6·1	9·0	14·7	20·8	60	Q
" "	" "	57·1	73·5	44·4	6·5	9·3	13·8	19·3	65	Q
" "	" "	54·7	76·2	44·9	4·4	7·1	10·8	16·8	70	Q
" "	" "	58·2	60·2	48·2	4·6	7·8	8·1	14·7	24	Q*
" "	" "	65·0	73·3	52·2	6·3	9·8	10·4	16·7	40	B
" "	" "	62·5	71·3	49·1	7·3	11·0	12·7	19·2	46	B
" "	" "	57·2	70·0	44·3	7·4	10·5	14·4	20·4	58	B
" "	" "	54·9	69·1	43·4	7·8	10·7	12·8	18·3	59	B
" "	" "	56·9	75·2	45·2	6·9	10·0	12·4	18·1	67	B
" *microcorys*	Tallowwood	59·0	68·2	46·1	5·2	7·7	13·0	18·5	48	Q
" "	"	60·4	72·4	48·3	3·3	5·5	10·2	15·5	50	Q
" "	"	65·2	77·6	51·5	5·5	8·5	12·5	18·9	51	Q
" "	"	62·6	78·9	49·5	4·0	6·8	10·8	17·3	60	Q
" "	"	63·3	74·8	51·0	6·4	10·2	10·1	16·3	46	B
" "	"	60·9	71·2	48·3	6·7	10·0	12·0	17·1	48	B
" "	"	62·1	78·6	50·3	5·8	9·1	9·0	15·9	56	B
" "	"	63·9	79·4	50·9	6·1	9·6	10·7	16·8	56	B

		1	2	3	4	5	6	7	8	9
Eucalyptus paniculata	Grey Ironbark	66·5	71·2	52·9	5·1	8·0	11·3	17·4	35	Q
" "	" "	76·0	79·8	58·4	6·5	10·0	14·7	21·7	37	Q
" "	" "	71·3	76·2	55·6	4·3	6·9	13·3	19·6	39	Q
" "	" "	74·2	77·4	58·6	6·5	10·0	11·5	17·3	32	B
" "	" "	76·8	79·5	58·8	8·8	12·4	15·3	22·2	35	B
" "	" "	69·0	77·5	57·2	4·9	8·3	7·5	13·1	36	B
" *phellandra*	White Top Messmate	48·5	73·1	36·6	4·1	5·8	15·8	19·9	100	Q
" "	" " "	49·8	73·6	36·2	4·3	6·0	18·6	22·8	103	Q
" "	" " "	43·7	63·6	30·6	7·8	10·4	20·6	26·4	107	Q
" "	" " "	51·1	75·3	40·1	8·0	10·7	12·5	16·8	88	B
" "	" " "	50·2	74·3	37·1	12·5	15·0	17·5	21·4	100	B
" "	" " "	43·8	66·2	30·2	13·4	16·2	21·2	27·6	119	B
" *pilularis*	Blackbutt	62·3	73·0	48·9	6·4	9·3	12·4	19·8	49	Q
" "	"	55·9	72·4	44·0	5·4	7·8	12·4	17·9	54	Q
" "	"	64·3	78·8	50·7	6·1	9·4	12·8	19·5	55	Q
" "	"	55·2	69·9	44·7	3·8	6·2	9·0	14·3	56	Q
" "	"	52·1	66·4	41·3	4·9	7·2	11·4	16·6	61	Q
" "	"	60·6	69·2	48·6	7·0	10·6	10·7	16·7	43	B
" "	"	59·9	68·0	46·6	7·5	10·9	13·3	19·1	46	B
" "	"	61·9	76·3	49·3	6·8	10·0	11·5	17·1	55	B
" "	"	57·6	70·5	44·3	7·0	9·7	15·0	17·4	59	B
" "	"	55·7	71·9	44·8	6·1	9·9	8·4	14·5	61	B
" "	"	53·3	69·4	42·3	7·5	10·0	12·2	17·9	64	B
" "	"	60·5	77·4	46·3	8·4	11·5	14·3	20·1	67	B
" *piperita*	Sydney Peppermint	57·6	69·5	43·5	4·8	7·0	15·3	20·4	60	Q
" "	" "	55·2	66·2	38·2	7·4	9·7	24·3	28·4	74	Q
" "	" "	43·8	70·0	34·9	6·7	9·2	11·8	14·3	101	B
" *propinqua*	Grey Gum	60·8	69·2	47·8	5·9	8·7	13·0	18·3	45	Q
" "	" "	71·9	78·5	56·5	6·0	9·5	11·7	18·1	39	Q
" "	" "	68·1	75·8	54·4	6·2	9·7	10·3	16·1	39	B
" "	" "	65·2	73·5	51·5	7·0	10·3	11·9	17·4	43	B
" *resinifera*	Red Mahogany	61·6	67·0	47·8	6·3	9·5	12·3	19·8	40	Q
" "	" "	60·9	72·5	48·4	6·1	8·9	12·0	17·8	51	Q
" "	" "	55·0	75·5	45·9	3·7	5·9	7·6	11·9	64	Q

		1	2	3	4	5	6	7	8	9
Eucalyptus resinifera	Red Mahogany	65·0	74·3	53·4	4·9	8·2	8·6	15·2	28	B*
" "	" "	59·9	71·1	49·0	4·3	7·2	8·3	13·7	45	B
" "	" "	60·7	69·3	47·6	7·6	10·3	13·3	18·8	46	B
" "	" "	61·4	69·4	46·7	8·5	11·6	15·5	21·2	49	B
" "	" "	64·2	77·0	51·4	6·9	9·9	11·1	16·9	50	B
" "	" "	57·7	70·0	46·3	6·2	8·9	10·9	16·5	52	B
" "	" "	56·4	75·0	46·8	4·5	7·2	8·3	13·1	60	B
" *rostrata*	Murray Red Gum	59·5	69·9	46·4	4·4	6·7	12·2	17·2	53	Q
" "	" " "	62·5	72·7	46·8	5·7	8·5	16·5	22·7	55	Q
" "	" " "	58·7	73·7	46·8	4·5	7·1	10·3	16·0	57	Q
" "	" " "	60·8	72·3	45·6	5·5	8·4	15·6	22·2	58	Q
" "	" " "	60·6	64·9	45·0	7·3	10·1	15·5	21·4	58	Q
" "	" " "	57·1	69·6	43·4	4·5	6·6	13·0	18·8	60	Q
" "	" " "	59·4	73·5	45·7	5·0	6·8	12·8	17·3	60	Q
" "	" " "	57·2	71·1	42·8	6·0	8·1	14·7	19·3	66	Q
" "	" " "	59·3	72·4	46·3	6·7	9·9	10·4	15·8	56	B
" "	" " "	55·9	72·4	44·0	7·9	11·1	11·6	17·2	65	B
" "	" " "	57·7	68·0	41·6	11·4	14·3	17·4	23·2	67	B
" "	" " "	52·1	71·8	42·6	9·5	11·9	14·7	18·0	69	B
" "	" " "	55·1	74·3	43·7	7·0	9·4	10·5	15·5	70	B
" "	" " "	58·2	74·2	43·5	11·6	14·0	15·3	19·6	71	B
" "	" " "	56·2	75·5	43·1	6·6	9·5	10·7	15·9	75	B
" "	" " "	47·4	70·8	37·6	4·3	6·4	8·6	12·8	83	B
" *saligna*	Blue Gum	59·6	70·5	46·5	5·1	7·7	13·1	18·7	51	Q
" "	" "	57·4	64·6	42·6	7·8	10·6	17·2	22·0	52	Q
" "	" "	54·5	72·4	44·6	6·5	9·2	8·2	14·6	62	Q
" "	" "	53·4	68·0	40·8	4·9	7·7	13·2	19·5	66	Q
" "	" "	55·7	69·5	43·6	5·7	8·4	11·6	16·5	59	Q
" "	" "	55·8	62·3	44·3	6·3	9·3	11·0	16·5	40	O
" "	" "	57·7	69·9	45·4	7·8	11·1	12·8	18·6	54	B
" "	" "	60·6	75·5	45·6	9·1	12·6	14·0	19·7	65	B
" "	" "	52·1	63·4	37·1	7·1	9·6	19·1	24·2	71	B
" *Sieberiana*	Coast Ash	60·5	73·3	43·1	5·2	8·4	18·2	25·2	71	Q
" "	" "	63·2	75·8	43·9	13·3	16·7	20·5	27·7	73	B

		1	2	3	4	5	6	7	8	9
Eucalyptus tereticornis	Red Gum	65·6	78·8	50·4	4·7	6·8	8·0	14·8	56	B
,, ,,	,, ,,	63·9	79·0	52·2	5·2	6·7	8·0	13·7	51	B
,, *viminalis*	Ribbon Gum	50·0	67·5	35·2	5·8	8·5	20·0	26·8	93	Q
,, ,,	,, ,,	41·7	65·5	32·8	7·4	10·6	11·3	16·9	99	B
Flindersia acuminata	Putt's Pine	33·7	47·6	27·9	3·2	4·9	8·6	13·1	71	Q
Litsea reticulata	Bolly Gum	33·8	36·8	28·9	2·6	4·3	5·5	9·6	27	Q
,, ,,	,, ,,	42·2	46·0	34·0	6·5	9·5	11·2	17·4	35	Q
,, ,,	,, ,,	28·7	39·4	24·3	5·3	7·8	7·0	11·5	62	B
Melaleuca leucadendron	Broad-leaved Tea Tree	47·0	64·3	37·6	3·1	5·3	10·6	16·4	71	B
,, ,,	,, ,, ,,	43·9	60·1	35·1	6·9	10·6	9·4	15·2	76	Q
Schizomeria ovata	Crab Apple ,, ,,	37·6	46·2	31·1	4·7	7·0	9·3	13·2	49	B
Sloanea Woolsii	Yellow Carabeen	35·8	54·8	29·6	2·7	4·1	8·9	13·1	85	O
,, ,,	,, ,,	36·6	55·9	30·6	7·5	9·9	8·4	12·2	83	Q
Sterculia acerifolia	Flame Tree	27·8	54·6	26·0	3·1	4·4	8·4	14·9	109	B
,, ,,	,, ,,	29·4	58·0	26·9	7·5	9·3	9·9	13·7	107	Q
Syncarpia laurifolia	Turpentine	59·4	62·1	41·5	6·3	8·9	21·4	26·8	50	B
,, ,,	,,	60·2	69·0	45·1	7·0	9·7	14·7	19·8	53	Q
,, ,,	,,	60·4	71·6	41·1	10·3	13·2	23·2	29·0	74	Q
,, ,,	,,	66·1	68·2	51·4	7·1	10·2	13·1	18·0	33	Q
,, ,,	,,	65·9	69·3	49·9	8·9	11·9	15·6	20·8	39	B
,, ,,	,,	52·2	55·9	38·9	6·0	9·0	15·8	20·5	44	B
,, ,,	,,	55·5	60·7	39·6	13·2	16·9	19·9	25·2	54	B
,, ,,	,,	62·7	74·2	45·6	11·0	14·3	18·4	23·8	63	B
Tarrietia actinophylla	Stavewood	56·7	68·0	44·6	4·4	7·0	12·7	18·3	52	Q
,, ,,	,,	53·2	69·3	42·3	9·3	12·8	11·5	17·7	64	B
,, *peralata*	Red Tulip Oak	50·7	66·0	37·3	5·2	7·8	16·5	22·8	77	Q
,, ,,	,, ,, ,,	53·0	66·0	41·1	7·5	11·3	11·6	18·0	61	B
,, ,,	,, ,, ,,	50·2	67·1	38·4	7·7	11·8	11·7	18·4	75	B
Tristania conferta	Brush Box	55·6	69·8	44·4	3·1	4·8	12·1	16·2	57	Q
,, ,,	,, ,,	62·9	75·6	44·0	9·3	12·1	22·6	28·2	72	Q
,, ,,	,, ,,	53·3	69·9	44·0	6·5	9·0	8·8	12·8	59	B
,, ,,	,, ,,	54·2	71·3	43·8	8·3	11·5	12·1	17·5	63	B
,, ,,	,, ,,	53·6	67·0	40·9	10·9	13·9	15·2	20·3	64	B
,, ,,	,, ,,	52·9	75·5	43·4	5·7	8·4	9·0	13·5	74	B
Villaresia Moorei	N.S.Wales Maple	47·4	61·0	39·8	2·1	3·8	6·6	11·8	53	Q
,, ,,	,, ,,	47·9	61·5	40·3	5·2	8·4	6·5	11·9	57	B

26% or that collapse has occurred during the initial seasoning.

Although the results are too few for any attempt to be made to correlate density and shrinkage (in general in the same species shrinkage should vary directly as density), it is evident that many anomalies occur. Again, in a number of species the tangential is greater than the radial shrinkage for different samples, although collapse may have influenced the results in some instances. It is recognised that shrinkage may be modified, apart from density, by the conditions of drying and by the size and shape of the material, and is undoubtedly so variable that mean results must be used with great caution.

Whilst the ratio of radial to tangential shrinkage is usually less than 2 : 1, Sassafras again shows a high ratio of approximately $3\frac{1}{2}$: 1, a result which might have been anticipated when the warping tendencies of this wood are known, yet quarter-cut material should be quite suitable for joinery. The tangential shrinkage of Cedar was again shown to be as little as 3%. The tangential shrinkage of Cypress Pine also ranges between 3% and 4%, indicating the value of this wood for flooring, since even when it is used in a partially seasoned condition shrinkage is not excessive.

The figures given in the table are self-explanatory, and apart from shrinkage give some indication of the moisture content in freshly sawn timber, and also of the weight per cubic foot of green and air-dry timber.

The volumes of the sections were determined by the displacement of mercury, a method which has given very satisfactory results ; in the most open textured wood used, no penetration of mercury could be detected by weighing before and after immersion.

Explanation of Table.

1. Weight per cubic foot, air-dry volume and weight.
2. Weight per cubic foot, green volume and weight.
3. Weight per cubic foot, green volume and oven-dry weight.
4. Lateral shrinkage green to air-dry.
5. Lateral shrinkage green to oven-dry.
6. Volumetric shrinkage, green to air-dry.
7. Volumetric shrinkage, green to oven-dry.
8. Moisture % on oven-dry weight.
9. Direction of cut. Q=radial or quarter cut, B=tangential or "backed off", O=oblique (45° to rays). 15° tolerance permitted.

* Possibly below fibre saturation point.

COMPOUNDS FORMED FROM COPPER SALTS AND TERTIARY ARSINES.

PART I.

By G. J. BURROWS, B.Sc.,
and E. P. SANFORD, B.Sc.

(*Manuscript received, November 19, 1935. Read, December 4, 1935.*)

The tendency of arsenic to pass from the tervalent to the 4-covalent condition is well shown by the ease of formation and the stability of compounds of tertiary arsines with salts of platinum, gold and silver (Cahours and Gal, *Jour. prakt. Chem.*, 1870, *110*, 460; Mann and Pope, *J.C.S.*, *121*, 1758; Burrows and Parker, *J.A.C.S.*, 1933, *55*, 4133; *Proc. Roy. Soc. N.S.W.*, 1934, *68*, 39). The formation of addition compounds of tertiary arsines with the iodides of phosphorus, arsenic, antimony, tin and bismuth, and with compounds such as methyl diiodo arsine (Burrows and Turner, *J.C.S.*, 1920, *117*, 1373; 1921, *119*, 1448) is to be attributed to the same tendency.

Ehrlich and Karrer (*Ber.*, 1915, *48*, 1634) obtained addition compounds of salvarsan with two molecules of cupric chloride. These authors concluded that in compounds formed by salvarsan and other arseno-derivatives with metallic salts, the metal is attached to the arsenic atom, and is not coordinated with amino or hydroxyl groups.

The present communication contains a report on compounds obtained by acting on cuprous and cupric salts with phenyl dimethyl arsine and diphenyl methyl arsine. It was observed that cuprous iodide could be dissolved in a hot alcoholic solution of phenyl dimethyl arsine, and that on cooling the solution colourless prisms separated. Recrystallisation from acetone yielded two products, containing one and two molecules of arsine respectively to one of cuprous iodide. The other cuprous derivatives of this arsine that were isolated were bis-phenyl dimethyl arsine cuprous chloride and phenyl dimethyl arsine cuprous bromide; only in the case of cuprous iodide were

both types obtained. The cuprous chloride compound was obtained from cuprous chloride itself, and also from cupric chloride; presumably by reduction with excess of the arsine. The cuprous bromide compound was obtained from cupric bromide. No coordination compound corresponding to a cupric halide could be isolated. With diphenyl methyl arsine similar compounds were obtained from cupric chloride, cupric bromide, and also from cupric nitrate.

The three derivatives isolated are all cuprous derivatives with one molecule of arsine combined with one of the cuprous salt. When freshly prepared all of the above derivatives are white crystalline substances with characteristic melting points. On long standing in the atmosphere they slowly become light blue in colour. On treatment with sodium hydroxide they yield cuprous oxide, indicating that they are cuprous derivatives. They have a distinct odour of the arsine, and in most cases on boiling a solution of the compound for some considerable time it decomposes, with the separation of the cuprous halide. These facts led to the belief that these compounds were of the types [R.Cu]X and [R_2Cu]X, where R represents a molecule of the arsine and X an atom of halogen. On the other hand these derivatives are insoluble in water but soluble in alcohol, acetone, benzene, and chloroform, which would indicate that they are non-polar compounds rather than salts, and correctly formulated as $\left[\mathrm{Cu}<\begin{matrix}\mathrm{R}\\\mathrm{X}\end{matrix}\right]$ and $\left[\mathrm{Cu}<\begin{matrix}\mathrm{R}_2\\\mathrm{X}\end{matrix}\right]$ respectively. In solution in benzene they have molecular weights agreeing fairly closely with those calculated from the formulæ, but their behaviour on heating or towards reagents can be attributed to the fact that they are not very stable in solution.

In addition to the above, a third type of derivative has been isolated. If cupric chloride in alcoholic solution is treated with excess of arsine a cuprous chloride derivative rapidly separates as mentioned above. The filtrate on standing exposed to the air slowly deposited crystals, which on analysis were found to contain two atoms of copper, three of chlorine, and three molecules of arsine ($Cu_2R_3Cl_3$). In the case of phenyl dimethyl arsine the derivative was blue in colour, did not melt sharply, but could not be separated into two compounds. With diphenyl methyl arsine, however, a mixture of brown and blue crystals separated. Subsequently it was found

possible to prepare these derivatives separately by varying the conditions. Both the blue and the brown compound are crystalline, and have the same composition, $Cu_2(Ph_2MeAs)_3Cl_3$. They both melt at 245° C. to deep green liquids, and the melting point of a mixture is the same. Unfortunately they are almost insoluble in the ordinary solvents, being only slightly soluble in hot acetone and alcohol. It has not been possible to carry out a molecular weight determination. On treatment with sodium hydroxide the crystals appear to become coated with cuprous oxide. There is little doubt that these compounds are formed by the oxidation of the simple cuprous derivatives, $\left[Cu<\begin{matrix}R\\Cl\end{matrix}\right]$, and valency considerations lead to the conclusion that one of the copper atoms is in the cuprous condition and the other in the cupric.

It is interesting to note that Ritthausen (*Journ. prakt. Chem.*, 1853, *59*, 373) obtained a white crystalline compound of $CuCl.NH_3$ by the action of a solution of ammonia on copper. This corresponds to the compounds of the type $\left[Cu<\begin{matrix}R\\Cl\end{matrix}\right]$ described in the present communication. This author also observed that a solution of this cuprous compound in aqueous ammonia, on standing exposed to the air, deposited blue crystals of a compound to which he assigned the formula $Cu_2Cl.NH_3.CuCl.NH_3.HO$. From the analytical data actually published in that paper the atomic ratio $Cu : Cl : NH_3$ is $1 : 1{\cdot}34 : 1{\cdot}37$, which would suggest the formula $Cu_2Cl_3(NH_3)_3H_2O$, one of the copper atoms being in the cuprous and the other in the cupric condition. Such a compound would be analogous to the arsine derivative $Cu_2Cl_3(Ph_2MeAs)_3$ isolated during the present investigation.

As regards the constitution of the two compounds $Cu_2Cl_3(Ph_2MeAs)_3$ it is possible that one may be a polymer of the other. As mentioned above, it has not been possible to decide this point by determining molecular weights, owing to the insolubility of the compounds. The very marked difference in colour cannot be attributed to the presence in one of a small quantity of impurity, as crystals of both substances separate together from the same solution, and very fine crystals of the blue form appeared to change very slowly to the brown when kept in specimen bottles for many months. Furthermore, the two forms

apparently become identical on heating to the melting point.

As pointed out above, valency considerations require that one of the copper atoms is cuprous and the other cupric, and the behaviour of the compounds towards reagents is consistent with this. Assuming that the compounds are monomolecular, three formulæ suggest themselves: (1) $[Cu(Ph_2MeAs)_2]\left[Cu^{(Ph_2MeAs)}_{Cl_3}\right]$, (2) $\left[Cu^{(Ph_2MeAs)_3}_{Cl}\right][CuCl_2]$ and (3) $Cu\left[Cu^{(Ph_2MeAs)_3}_{Cl_3}\right]$. In the first the cuprous atom loses an electron to the cupric atom and is coordinated with two molecules of arsine, becoming a univalent positive ion, the cupric atom becoming a 4-covalent ion. In the second the cupric atom loses one electron to the cuprous and at the same time is attached covalently to three molecules of arsine and one chlorine atom. In other words that compound may be regarded as a derivative of $H[CuCl_2]$ in which the H is replaced by the complex 4-covalent cupric ion. In the third the cuprous atom becomes a simple cuprous ion, and the cupric atom is coordinated with the three molecules of arsine, passing into the 6-covalent state. In most complex cupric compounds the copper has a covalency of four, but several six-covalent derivatives have been described, such as $[Cuen_3]Cl_3$. The six-covalent groups in such compounds would be arranged octahedrally, and Wahl (*Acto. Soc. Sci. Fennica*, 1928, *14*, 1) prepared from cupric halides and ethylene diamine, compounds of the type $[Cuen_2(H_2O)_2]X_2$. The tartrate of this complex ion was separated into two different optically active fractions, and these in turn were converted into active iodides.

The formula $Cu\left[Cu^{(Ph_2MeAs)_3}_{Cl_3}\right]$ is consistent with the insoluble nature of the compounds, and furthermore it would explain the isomerism. In one form the three arsine groups are in the 1, 2, 3 positions, whilst in the other they are in the 1, 2, 6. It is interesting to note that the isomeric cobalt triammines $\left[Co^{(NH_3)_3}_{X_3}\right]$ usually show a marked difference in colour.

Further experiments are in progress with other tertiary arsines, and it is hoped that they will enable us definitely to establish the constitution of these compounds.

Experimental.

Phenyl dimethyl arsine cuprous iodide: $\left[\mathrm{Cu}_{\mathrm{I}}^{(\mathrm{PhMe_2As})}\right]$ was obtained by boiling an alcoholic solution of phenyl dimethyl arsine with excess of cuprous iodide for about half an hour. After removing the excess of cuprous iodide, the filtrate was concentrated on the water bath until crystallisation commenced, a few c.c. of hot alcohol were added, and the solution allowed to crystallise in the air. Pale yellow crystals separated, and after drying in the air were found to melt at 127° C. The compound is readily soluble in cold alcohol, benzene, carbon tetrachloride and acetone, and sparingly soluble in ether. It could be crystallised (without change of the melting point) by dissolving in cold ether and allowing the cold solution to concentrate at the ordinary temperature. The solution, unless very dilute, was found to decompose on heating, with the precipitation of cuprous iodide and formation of bis-phenyl dimethyl arsine cuprous iodide.

Found: Cu=17·0, I=33·8 per cent.

$C_8H_{11}AsCuI$ requires Cu=16·9, I=34·1 per cent.

Bis-phenyl dimethyl arsine cuprous iodide: $\left[\mathrm{Cu}_{\mathrm{I}}^{(\mathrm{PhMe_2As})_2}\right]$ was prepared by digesting an alcoholic solution of the arsine with a slight excess of cuprous iodide on the water bath for a few minutes. The solution was decanted into a dish and allowed to crystallise. White prisms were obtained, and these were dried on porous plate and then recrystallised from acetone. The compound melts at 94° C. It is soluble in alcohol, benzene, ether, ethyl acetate, carbon tetrachloride, and acetone. After keeping for a few weeks a specimen had a strong odour of the arsine, but the melting point and composition remained unchanged after many months.

Found: Cu=11·5, I=22·7, As=27·0 per cent.

$C_{16}H_{22}As_2CuI$ requires Cu=11·4, I=22·9, As=27·1 per cent.

Bis-phenyl dimethyl arsine cuprous chloride: $\left[\mathrm{Cu}_{\mathrm{Cl}}^{(\mathrm{PhMe_2As})_2}\right]$ was prepared from the arsine and cuprous chloride in the same manner as the corresponding iodide. The cuprous chloride was freshly precipitated and was dried as quickly as possible by washing with alcohol and ether. The compound separated in white prisms, melting at 127° C. On keeping for a few days the colour changed

to a pale green, but on long standing it becomes definitely blue. It is soluble in methyl or ethyl alcohol, acetone, benzene, and chloroform, but decomposes on heating in solution.

Found: Cu=13·6, Cl=7·9, As=32·0 per cent.

$C_{16}H_{22}As_2CuCl$ requires Cu=13·5, Cl=7·8, As=32·4 per cent.

Phenyl dimethyl arsine cuprous bromide: $\left[Cu^{(PhMe_2As)}_{Br}\right]$.

When cupric bromide was treated in alcoholic solution with phenyl dimethyl arsine it underwent reduction, giving a cuprous derivative. For the preparation of this compound freshly prepared cupric bromide (1 mol) was dissolved in alcohol, and to the warm solution phenyl dimethyl arsine (2 mols) was added. The solution became colourless, and white prisms separated. The air-dried compound melted at 106° C. The compound appears to oxidise slowly on exposure to air, changing to blue, and ultimately to deep green. It is readily soluble in benzene and chloroform, and also in alcohol, but is insoluble in water.

Found: Cu=19·8, Br=24·7, As=22·8 per cent.

$C_8H_{11}AsBrCu$ requires Cu=19·4, Br=24·6, As=23·1 per cent.

Diphenyl methyl arsine cuprous nitrate: $\left[Cu^{(Ph_2MeAs)}_{NO_3}\right]$

was obtained in the form of white prisms melting at 107° C. by adding an alcoholic solution of the arsine (1 mol) to a concentrated aqueous solution of copper nitrate (1 mol) and recrystallising from alcohol. This compound is readily soluble in benzene and insoluble in water. The molecular weight in benzene, determined cryoscopically was found to be 378.

Found: Cu=17·0, As=20·0 per cent.

$C_{13}H_{13}O_3AsNCu$ requires Cu=17·2, As=20·3 per cent. M.wt., 370.

Diphenyl methyl arsine cuprous bromide: $\left[Cu^{(Ph_2MeAs)}_{Br}\right]$

was prepared by adding excess of arsine (4 mols) to a hot alcoholic solution of cupric bromide (1 mol) and cooling, the compound separating in white prisms melting at 133° C. Like the corresponding nitrate, it is readily soluble in benzene and insoluble in water.

Found: Cu=16·1, As=19·0, Br=20·4; m.wt. in benzene, 399.

$C_{13}H_{13}AsBrCu$ requires Cu=16·4, As=19·4, Br=20·6 per cent. M.wt., 388.

Ter-diphenyl methyl arsine cuprous cupric bromide: $\left[Cu_2^{(Ph_2MeAs)_3}Br_3\right]$ was obtained by modifying the procedure adopted for the previous compounds. Cupric bromide was dissolved in alcohol and the arsine added drop by drop with stirring until the solution became colourless. More cupric bromide was then added to the solution (heated on the water bath) until a permanent brown colour was obtained. The liquid was filtered and the filtrate allowed to crystallise exposed to the air. After many hours the crystals which had separated were removed by filtration and air-dried. In the finely divided state the crystals were dark green, but large crystals appeared to be black. The substance melted at 202° C. It is very slightly soluble in hot acetone, but insoluble in all other liquids.

Found: Cu=11·5, As=19·1, Br=21·5 per cent.

$C_{39}H_{39}As_3Br_3Cu_2$ requires Cu=11·5, As=20·5, Br=21·9 per cent.

Diphenyl methyl arsine cuprous chloride: $\left[Cu_{Cl}^{(Ph_2MeAs)}\right]$ was prepared by adding the arsine (4 mols) to a concentrated hot alcoholic solution of cupric chloride (1 mol) and allowing to cool. The compound separated in white prisms melting at 116° C. It is soluble in benzene but insoluble in water.

Found: Cu=18·0, Cl=10·3, As=20·6 per cent. M.wt. in benzene, 350.

$C_{13}H_{13}AsClCu$ requires Cu=18·5, As=21·8, Cl=10·4 per cent. M.wt., 343.

Ter-diphenyl methyl arsine cuprous cupric chloride: $\left[Cu_2^{(Ph_2MeAs)_3}Cl_3\right]$ was first obtained as a mixture of brown and blue crystals by treating a warm alcoholic solution of cupric chloride with the arsine and allowing to stand overnight. Subsequently the two forms were prepared separately as follows:

Brown Form.—Diphenyl methyl arsine (1 mol) was added slowly with stirring to cupric chloride (1 mol) dissolved in the minimum quantity of hot alcohol, and the solution allowed to stand for 12 hours. The brown crystals which had separated were removed, and after being dried in the air were found to melt at 245° C. The compound is practically insoluble in all solvents; it is

decomposed by mineral acids and by sodium hydroxide solution.

Found : Cu=13·2, As=22·6, Cl=10·9 per cent.

$C_{39}H_{39}As_3Cl_3Cu_2$ requires Cu=13·1, As=23·3, Cl=10·9 per cent.

Blue Form.—The brown solution was prepared as before and allowed to stand for an hour. Water was then added until a green solution was obtained, which was allowed to stand overnight. The substance separated in the form of blue crystals having the same melting point as the brown form, and resembling it in its insolubility in all solvents.

Found : Cu=13·1, As=22·1, Cl=10·8 per cent.

$C_{39}H_{39}As_3Cl_3Cu_2$ requires Cu=13·1, As=23·3, Cl=10·9 per cent.

A mixture of the two forms containing a trace of arsine was found to change slowly to the brown form on long standing.

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INITIATION IN THE BARD TRIBE, NORTH-WEST AUSTRALIA.

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INTRODUCTION.

The Bard tribe occupies the northern portion of Dampier Land Peninsula, commencing from Pender Bay on the west and Cunningham Point on the King Sound side. The rest of the Peninsula was formerly, for the most part, the territory of the Nyul-Nyul tribe; three small tribes, the Djabera-Djaber, the Ngormbal and the Djukan occupied the coast between Beagle Bay and Broome. The Bardi have been in contact with whites for forty years, though not very intensively until about twenty-five years ago. They usually live in five local groups, each of which is associated with a small centre of white settlement. These groups are at Pender Bay and Cygnet Bay, at each of which there is, or was in 1928, a white settler; at Lombardina, where there is a Roman Catholic mission; at Bulgin just north of Cape Levêque Lighthouse, the headquarters of a capable "half-caste" who employed the natives on luggers; and finally at Sunday Island, which is occupied by a Protestant mission—a branch of the United Aborigines' Mission. This island, one of the Buccaneer Archipelago, really belonged to the Irwundjun or Djaui-speaking tribe, but there were very few Djaui left, and they mixed freely with the northern group of the Bardi; the members of the latter spent a lot of their time at the mission or working on its luggers.

The Bardi retained their kinship system as an effective social mechanism, and also remained faithful to the dictates of the secret life, with its rites, symbols, and myths. I was taken to a secret ground at Bulgin, and with due caution and reverence was shown the bullroarers which were stored there. The myths about the culture-hero who is symbolised by the bullroarer, were narrated to me, and other matters connected with this symbol,

such as the rules governing its making and revealing, were explained. Finally, I was presented with a bullroarer.

Initiation.

I received accounts of the stages and details of initiation from several informants, all of which agreed, the one with the other. But, in addition, I had the good fortune to witness on Sunday Island one series of ceremonies which included the operations of tooth-knocking and circumcision. These ceremonies lasted from Monday night, February 20, to Friday morning, March 2, 1928. They must always be performed in *Erelp*, the wet season.

The Bardi and Djaui natives concerned were " civilised " and were in close touch with the Sunday Island Mission, being camped only a short distance from the mission buildings. But this did not prevent them from following their old customs, though only a few discarded their European clothes and painted themselves in the old fashion. These few had special parts to play in the ceremonies, and, moreover, stood in significant relationships to the novice. Those in control, too, raised no objection to inviting the missionary to be present at the circumcision, and even asked him to perform the operation, knowing that he would have a better instrument for the purpose than they possessed. He declined to be the surgeon, though he did witness the operation.

Initiation consists of a number of stages or degrees, each with its rites and distinctive status designation. A special term is also usually applied to the candidate while passing through the principal stages.

Preliminary Ceremonies.—I did not see, nor was I told of any rite by which the youth was formally taken from the general camp, but as he was attending the mission school this was hardly practicable. But I was definitely informed that in this tribe it was not the custom to send the candidate round with the messengers who summoned the various groups to the ceremonies. The messengers, who are sent out by the oldest headman, do not even carry a token, but simply announce to each group *angui inlandjen amba*, " ceremony to make man ", that is, " an initiation is to be held ".

The ceremonies on the first eight nights, which were of a preliminary nature, were held on the camp corroboree ground. They are called *Kundaldja*. The novice was painted each evening with charcoal and turtle-oil by his

alabel (tribal sister's husband), who acted as his guardian, adviser, and supporter throughout the rites and operations. The proceedings were very monotonous. The orchestra sat in a ring in the middle of the dancing ground, singing songs taught by the culture-hero Mino and tapping their boomerangs in even measure at the rate at which the dancers ran round them. One musician blew into a drone pipe. This formerly consisted of a piece of hollow wood, but on this occasion a two-inch iron pipe was used. Each song lasted only about five minutes or a little more. As soon as it was begun, the women and girls came from their corner of the corroboree ground and ran round the singers. Most of them carried a bunch of twigs in each hand and ran with their elbows bent up so that the twigs were shoulder high. The novice's mother was always prominent. Young boys, not yet old enough for initiation, generally formed a second ring and ran round the women, carrying toy shields and boomerangs. Then, on the average, about every third song, the men with the novice formed an outer ring and ran round twice, after which they went to their part of the ground. Sometimes they mingled with the small boys. They did not all bother to paint themselves during the preliminary corroborees; it was a matter of personal feeling, but some did so in the manner to be described later. They all carried their shields in their left hands but held across their chests so that one end of the shield was under the right arm; they held boomerangs in their right hands. The novice, who is called *Neminem* until his teeth have been knocked out, always carried two bushes about four feet long, one in each hand, in such a manner that with his two arms extended straight out in front the bushes swept the ground; as he ran his arms would fall to his side and then be quickly extended again.

Joking formed a marked feature of the intervals between the dances, especially on the part of the women, some of whom danced and jumped about. The novice's mother and father's sister were especially prominent in this. On two nights, two women dressed as men and carrying spears imitated the men, to the great amusement of the women. The men apparently took no notice of their antics, and the singing would sometimes begin in the midst of the joking and laughing. A most interesting means of diversion consisted of the persons who stood to each other in the relation of son-in-law and mother-in-law, sneaking

up and throwing water over one another, to the delight of all present. Normally, persons so related must avoid each other. Jokes of the kind mentioned may only be performed at this ceremonial time.

The only other noteworthy incident during these preliminary days was that on one occasion (Monday, 27th) a number of men, including the novice's father, father's brother, mother's brother, and guardian, went to the circumcision ground and drew blood from their subincised penes. This blood must run down their thighs and on to their calves before it touches the ground.

Tooth Avulsion.—At about 4.30 p.m. on Tuesday, the 28th, the men gathered on the corroboree ground one by one in quite an unconcerned manner, as though it was just by accident that they were passing that way and happened to stop there. Some of the women also gathered near by. The novice, having been painted black by his guardian, arrived next and was encouraged by his father. Three parallel lines were marked on the ground about two feet apart, while a rug, instead of the bushes of former days, was placed about the same distance in front of the third line. The novice knelt at the first line and at a given signal, consisting of a shout and the crack of a waddy on the ground, hopped on his hands and knees to the second line, and, at two similar signals, to the third line and then on to the rug. He knelt up there, holding his forearms bent up to his shoulders. His guardian clasped him round his bent arms and chest and supported him.

The operator, the novice's tribal mother's brother and a *djungagor* (medicine-man), who had been kneeling in front of the rug all this time, then came up to the novice. He first of all tied some cotton, instead of the native opossum twine, round the two central incisors, working it up into the gum as he did so. Then taking a piece of pointed pearl-shell, the *bindji-bindj*, or ornament worn in a man's forehead-band or hanging from his upper-arm band, he pushed the cotton further up, at the same time separating the gums from the teeth. He next took a round stick about six inches long and three-quarters of an inch thick, and placed one end of it on the teeth and hit the other end four times with a piece of stone just large enough to be comfortably gripped. The knocks appeared to be quite hard.

During the various parts of the operation the men had been shouting, one droning in the pipe, and the women,

who were quite near, rattled stones in tins. This was done to heighten the effect and also to drown any cries the novice might make. He, however, never whimpered. After the fourth knock one tooth was loosened enough to come out, and at the first sign of the blood from this wound the boy's mother picked up a boomerang which had been placed on the ground near him for her use, and hit her head several times until blood came. She then dropped the boomerang and ran off the ground, crying loudly; the other women at once threw down all the stones which they had been rattling and rushed away with her, crying. This all seemed to happen in the space of half a minute.

The operator then completed his work; he had to dig out the second tooth with his shell. The two teeth came out without being broken. Unfortunately a third tooth was snapped off at the gums. The root of this was extracted the next day by the missionary.

The teeth, string, and blood were spat into a little hole that had been made between the novice and the operator. The mother now returned to the ground with a small firestick, which one of the men took and dropped on top of this hole. The boy warmed his thumb and pressed it on his gum. His guardian then assisted him to pick up a boomerang and hit the proffered head of his operator; the hits were very light.

Soon after this a man who stood to the novice in the relation of *kalingord*, father's father, painted him all over with red ochre and added white vertical stripes on his chest and abdomen, and black ones on his back. His appearance was very ghostly. His father, father's brother, and father's father then took him away some distance and had a meal. These three men then cut their subincised penes again. In the meantime the boy's mother and another woman had cleared the stones off the corroboree ground ready for the night's ceremony. Although this had a special name, *ker-ker*, it was just the same as those held on the previous nights, except that the men took more trouble over painting themselves, almost all discarding their European clothes. The novice still carried his bushes. He was now called *Lainyar*.

Ceremonies between Tooth-Avulsion and Circumcision.—On the afternoon after the tooth-avulsion, the novice's father, father's brother, guardian, and two mother's brothers, painted themselves with red and white paint on their chests and round their eyes, and put on their fore-

head-bands, arm-strings, and human hair waist-belts, from which pearl shells hung in front and behind. Further adornment was procured by making tassels of wood shavings; a stick, six inches in length, was very finely shaved, or rather split, for about three-quarters of its length, and the shavings fluffed out like a tassel. The novice now had a big human hair belt, and carried a fire-stick. The latter showed that he was being distinguished as a man and had his own fire. The five men and the novice then moved away slowly from the camp and separated as though they were going to different places. When well out of sight and in a part where circumcision is performed, the boy sat down at his own fire, while the men stood a little distance off with their backs to him and again cut their subincised penes. Neither on this nor on any of the previous occasions could the novice see this cutting. The men say that they must hurt themselves because they are hurting the boy. They state that there is no rule as to who must thus cut themselves, but certainly the father, father's brother, and mother's brother did it on several occasions, and the guardian and father's father once each. One of the older men was very loath to tell me about this cutting, fearing that there would be great trouble for him if it became known that he had spoken about it. He did not go out himself on this occasion, and was not aware that I knew all about it. The five men and the novice returned to the camp for tea.

The ceremonies on this night were of a special nature, they are called *mitjo*. All the men were fully painted and adorned with their hair-belts and shells. The novice wore his hair-belt with pointed pieces of pearl-shell hanging from it. The women were present. The ceremonies can be divided into several parts:

(*a*) All the young men from the higher stages of *Djaminayga* to *Buŋin* inclusive, five in this case, knelt down one behind the other. Each one extended his arms on to the shoulders of the one in front of him, and, when the singing commenced, the mother of each one caught hold of her son by one shoulder. A similar row was formed of fully initiated men. As soon as the singing commenced the novice was lifted up in such a position that his legs were round the neck of his guardian, who was kneeling in front of him, while his head was supported by the man behind him. He held his two bushes erect in the air. At this instant his mother ran in and took hold

of him by one shoulder, and it was then, too, that the women already referred to ran in and grasped their sons' shoulders. The action suggested that the mothers, who cried loudly, were endeavouring to prevent their sons being taken away by the men. The men in both rows swayed from side to side during the singing, which continued for about five minutes. The following are the words of the song: no meaning could be obtained for them, nor for the words of the other songs sung on this night: *Mitdjomi djägära djo kudai.*

(*b*) A few minutes later the young men, together with the novice and his guardian, stood up one behind the other. The guardian stood behind the boy and held in one hand the bushy ends of the two bushes, the other ends of which were passed between the novice's sides and arms and were held in his hands. A number of women, mothers, sisters and cross-cousins, got as close as they could on one side of the particular young man who was related to them, and touched his arm. After the singers had sat down in the centre of the corroboree ground and commenced the following song: *Kundoro male bäpai djonai baiiŋain*, this procession moved slowly round and round the singers. The novice's guardian turned his head in the direction of the singers and held his shield over his face. Each of the young men held a shield across the back of his neck. The mother of the novice kept one hand on his shoulder, and with the other hand held some leaves on his head. The women wailed. This doleful procession continued for about fifteen minutes, after which the other women and the children ran round them, and, later, a few men did the same. The ceremony then ended.

(*c*) The next half hour was occupied in running round the singers as on the previous nights.

(*d*) The final ceremony on this night consisted of carrying the young men round and round the singers and moving them up and down. This is called *kundubel.* There were two groups in each procession, a group consisting of two fully initiated men with a young man, in one case the novice, between them, and with the mother of the young man or novice concerned alongside. They commenced by walking slowly and dolefully round, the mother wailing. Then at a given moment each pair of men hoisted their particular young man on to their shoulders, his thighs being round the neck of the man in front and his head being supported by the other. They carried him round in this

position, and, quickening their pace to a run, they moved him up and down as they ran. The two groups sometimes ran in opposite directions. The novice was carried by his guardian and a man who stood to him in the relation of mother's father. Each of these acts lasted about five minutes or so. The night's ceremonies were concluded at about 11.30. The song for this ceremony was *babau alerima gulganyar.*

The Night before Circumcision.—The ceremony commenced with the young men—as before, those belonging to the stages from *Djaminaŋga* to *Gambel*—the novice and, next to him, his guardian, all standing in a line facing west. They stretched out their arms from their sides and gripped each other's hands. Their mothers stood behind them. On their left a similar line of fully initiated men was formed and linked up with the young men. When the singing commenced the young men and novice pulled, as it were, against the older men, and succeeded, by arrangement, in pulling the latter around the singers. All then joined in a circle and proceeded round in a slow walk, the mothers hanging on to their sons and crying.

After a few minutes the fully initiated men broke away to their own corner, while the young men and the novice formed up behind one another as on the previous night, their mothers, sisters, and cross-cousins standing on the outside and hanging on to their shoulders. These then proceeded round and round with little cessation in a slow and doleful manner, for about fifteen minutes, after which the running-round type of ceremony, like that before tooth-avulsion, was carried on until almost midnight.

Circumcision, Bria, *and making the Novice* Palil.—This same running-round ceremony was commenced about an hour before sunrise. All the men and women gradually gathered on to the camp corroboree ground. A little before sunrise all the fully and partially initiated men and the novice went off in two files, one of which was led by the novice, up a hill not far from the camp. The women returned to the camp crying.

On arriving on top the men lined up along the edge of the hill, waiting for the first rays of the sun to appear above the hill on the opposite side of the valley. The novice was made to sit facing the east, on an upturned shield which was placed on a rock. A man in the relation of cross-cousin sat behind him and supported him. The novice put his arms back behind his head and around the neck of his

supporter who, in his turn, put one arm across the novice's chest and the other across his chin and mouth. The operator, who was the same person who had knocked out the teeth, was kneeling opposite the boy. As soon as the sun was considered to have arisen—it was a very cloudy morning—he commenced by pulling the foreskin as far forward as possible and then making a cut across the top of the penis almost back at the base, continued this slit right round the organ, just cutting the skin of the scrotum. He then worked the skin forward, cutting under it all the time, and in a few minutes had removed it in a single piece. All his actions were deliberately carried out. He used two flakes from a glass bottle, which were prepared just before the operation; stone knives were formerly used. The operator then hit his own head hard a few times, and the assistant who held the boy tapped himself lightly on the head. Only about eight of the men had stood near by during the operation; the others remained in silence along the brow of the hill. The reason they gave for this was that they were too sorry for the boy to come up close. The boy never whimpered, a fact which pleased his father very much.

As soon as the skin had been removed it was put on the ground between the boy's feet, and a small sandalwood smoke fire was placed on top of it. The smoke was believed to aid the healing. After a little while the boy, now a *Palil*, was led to an ordinary camp fire, a few yards from the scene of the operation, and left there.

The men then descended the hill, the operator leading, followed by the man who held the boy. As soon as the camp was sighted these two threw boomerangs, the sign that all was over; the women immediately set up a wailing which lasted for about ten or fifteen minutes.

Seclusion of the Candidate.—On the night following the circumcision the men go out to the new *Palil* and, sitting down, sing the tooth-song which was taught by Mino:

Kumberi midjera tariyai taumeritaua
Knocking out tooth, "sing", hit

and then the special circumcision song called *Larabik*, taught by Maral:

Marala inara bulgarinya mida
Maral sings *bulgarinya mida.*

These two words were used by Maral, but have no meaning for the present-day natives. The singing is repeated each

night during the seclusion of the novice, which lasts for two or three weeks until the next new moon, by which time his wound is properly healed. During this time his father provides him with food from which all fish is excluded. This tapu on fish commenced at the time of the tooth-knocking, and continues until he is made *Djaminaŋga.*

He is now taught a few secret names which the initiates use amongst themselves. I give the ordinary names in parentheses: Women, *didjigalin* (*oraŋ*); married men, *korada* (*amba*); young fellows who are *Palil*, *budjeda* (*wolalaŋ*); dogs, *nindjagin* (*ilal*).

This period of seclusion is brought to an end at the next new moon with two ceremonies, which, like circumcision, form part of the *angui* and were instituted by the culture-hero Mino:

(1) A post ceremony: A straight tree is chosen and its bark and limbs are removed. The *Palil* sits at the foot of what is now a post, while the younger boys climb up, the men singing a special Larabik: *Didji malaŋbernanya.* The women see neither this nor the second ceremony.

(2) A fire ceremony: One afternoon, near sundown, the *Palil* is made to sit close to a big fire away from the camp, while all the men stand round holding long sticks in the fire until these light, when they point them towards the west, at the same time singing a Larabik: *Djui bangarna ubala.* This is performed away from the camp.

After this all get ready to return with the novice to the general camp. The young men who are already *Djaminaŋga*, but not yet *Mambaŋaŋa*, wear special bark belts called *munk*, which were first made by the culture-hero Maral, the composer of the Larabik. The belt is from two to four inches in width and covered with human blood. Although the women see the belt after the blood is dry, they do not know how it is fastened round the boys. The belts are worn for two or three weeks and then buried in the ground or put in a tree, the spot becoming tapu to the uninitiated.

On the return to the camp corroboree ground the novice is painted red. The women receive him with crying, and then all partake of a meal prepared by them. The crying is on this occasion an expression of joy comparable to that shown by a mother on the return of her son after a long absence.

I did not see these two ceremonies nor the ritual reaggregation of the novice. Nor did I witness the later

stages of the initiation rites. I was invited to be present at the *Djaminaŋga* ceremony, but I could not arrange my Kimberley journeyings so as to make this possible. But the various accounts which I received agree and can be relied upon.

Djaminaŋga.—The most important initiation ceremony is held a few weeks after circumcision, in the south-east or cold season, known as *Pargan*; the time is fixed by "law". It does not follow, however, that the same youth is both circumcised and made *Djaminaŋga* the same year, though this does sometimes happen, especially these days when it is hard to get hold of the boys for circumcision as young as before the advent of whites and missions. The principal features of this ceremony are the use of human blood for anointing and drinking, and the making and showing of sacred bullroarers. It is not held at the place where circumcision is performed. The *Djaminaŋga* ground is called *Kundjeriŋ* and is tapu to all uninitiated persons. The bullroarers are kept on this site, just lying uncovered on the ground

The ceremony is called *Ulaloŋ*. It was instituted by the culture-hero Djamar, who came out of the ground in the northern part of the Bard territory at Swan Point. The coals of his camp-fire and the hole out of which he came can be seen there, and there is a similar site on Jairi, or Jackson Island, near by. A Bard headman informed me that he was told by a Port Darwin black that Djamar really started from the latter's country.

When Djamar first came out of the ground in the north he knew nothing. After remaining at Swan Point for some years he travelled south. He made some *kalakor*, bullroarers, but did not put a hole in their ends. He carried them in a bundle. He camped for about a month on a creek just south of Cape Levêque. When fishing one morning he took hold of a black fish, the spine of which pierced his hand, causing the blood to flow. He went on to a level stony place and let the blood run on to it. Noticing a little later that the blood had dried there, he decided to taste it; finding it agreeable he ate it all. His appetite being whetted, he decided to follow the accidental example set by the fish. He tied a ligature on his upper arm, and, when the veins were swollen up, he pierced the biggest one with a pointed kangaroo bone and let the blood flow into a *gurndu* or wooden dish. When it

had dried he cut it into blocks and ate it all.[1] It was so good that he decided to make this blood-eating an initiation law, and so his performance is repeated at every *Djaminayga* time. He did it, and therefore it must now be done. Djamar then went into the bush and made some bull-roarers, this time putting the holes[2] in them and swinging them. The noise proving satisfactory, he made the law of making new *Kalakor* and swinging them every *Djaminayga* time. Djamar walked on to the sandhills just north of Lombardina, where he swung his bullroarers, but his further movements are not known.

After preliminary corroborees for a couple of nights, two or three of the older men who stand in the relation of mother and mother's brother and mother's father to the novice, tie their upper arms very tightly, thus causing the veins of the lower arm to swell up. They then pierce a vein, generally the main one, with a kangaroo bone point, and let the blood spurt over the novice's head and chest. His eyes are closed, for he is not yet allowed to see this sacred blood which is called *wolb*.[3] Women do not know this word. The ordinary word is *gruär*. He holds a bark dish, *gurndu*, close to his abdomen to catch the blood as it flows down. When the blood first spurts out the following song is sung: *Wolba nymbalbala, wolba djulyabana* (*Wolba*, sacred arm-blood, *nymbalbala*, splash all over, *wolba djulyabana*, blood drop down). This is followed by another song: *Bininiy mamara bininiy wongurbaguna*. The first two words of this signify the squirting of the blood from the pierced arm. The last word has no meaning for the present-day natives.

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[1] One informant said that Djamar also tasted the blood obtained by cutting his subincised penis, but found it "no good".

[2] One informant said that Djamar made his arm blood spurt through the hole in the bullroarer.

[3] If the bleeding continues too long, the hole is plugged with a stick, the name of which, *banyan*, is tapu to the uninitiated. I met one case in which the main vein is no longer visible. The native says that it burst; he had severe headache after it. A couple of the veins in the upper arm now look rather swollen. One black is said to have bled to death. Generally, the bleeding stops of its own accord. Human blood is sometimes given to weak men to strengthen them. Every man has several marks of punctures in his arms. The blood is not used as a gum with which to stick decorative material on to the body as in Central Australia, nor is it put on to the ground or on to any objects as a ground for decoration. I am told that old men might pierce the upper arm instead of the lower.

After the blood-letting which takes place on the *Kundjeriŋ* ground, the novice comes out some distance from it and kneels down, holding the *gurndu* in his two arms next to his abdomen, within sight of the women who have been lying down covered up. An old woman[4] now comes up behind the novice and puts a fire stick between each of his upper arms and his sides. She returns to the women, and he gets up and goes again to the *Kundjeriŋ*, still holding the *gurndu* and the fire sticks. The novice is then given some of the congealed blood to eat, the remainder being eaten by the old men present. The dish is buried in the ground, after which all go out of the sacred ground to partake of a meal which the women have prepared.

They then return to the *Kundjeriŋ* and the candidate casts a throwing stick at a tree, hitting it amidst the approbations of the men. His spirit is believed to be thrown at the tree along with the stick, and one or more medicine men then catch it again with movements of their hands, and restore it to the new man, who as a result will not get sick again. Only the old men get sick.

Having thus been made a man by eating, and being anointed with, blood, and having been given a strengthened spirit, the young man can be shown the bullroarer. He is now called *Djaminaŋga*, instead of *Djurdu*, the term applied to him during the ceremony.

The bullroarers symbolise Djamar, who is also known as Maratj, their first maker. Some must be freshly made for each occasion, but at no other time, or else sickness would follow. Further, only a fully initiated man, a *Mambaŋaŋa*, may make them. An initiated man, previous to reaching that stage, is permitted to go on to the ground and see or whirl them, but not to make them. He does not know the song and the ritual attitude which must be observed when making them. The latter, like the showing, is a social and not an individual matter.

The bullroarer is from twelve to eighteen inches long and from two to four wide. It is either painted all over with red ochre, or else has about five red stripes, half an inch broad, across it. No carving of any sort may be made on it. Whenever the bullroarers have been used or handled, they must be left pointing north and south, with the ends, the " eyes " or holes for the string, all placed in the one

[4] Only an old woman can approach this sacred blood which is in the *gurndu*.

direction. The latter appears to be generally, if not always, south, though one of the men says the eyes could all point north. The reason for the orientation of the bullroarers is that Djamar came from the north and travelled to the south. Thus the bullroarer itself and the position in which it is placed serve as a record and symbol of the culture-hero. This is true also of its making.

Making the Bullroarer.—This is done on *Djaminaŋga* day. After the blood ritual a number of fully initiated men, *Mambaŋaŋa*, generally three, are selected by the general consent of the old men, to go out into the bush and make some bullroarers. The tree from which they are made is described as a black one, and is called both *ŋalŋora* and *kadga*. No one may visit, under penalty of sickness and death, the tree, or the place where the bullroarers are made, except at *Djaminaŋga* time, and then only for the purpose of making them. From the moment that the tree is cut and all the time that the bullroarers are being shaped and completed, two special *Ulaloŋ* or ceremonial songs, composed by Djamar, must be sung alternately without ceasing. The words of these, to which no meaning can be given, are: (1) *Milya elyara wianwiaŋga wianiaŋgara* and (2) *Kormaniŋan waibandjo*. When finished, the bull-roarers are laid on some bushes and carried on to the *Kundjeriŋ* ground. The ceremony then proceeds as described.

The bullroarers are shown to the novice, who is first warned not to tell any woman or child anything of what he sees or learns. The various names of this symbol are told to him, namely *kalakor*, *kudi kudi*, *ramadjer bilibil*, *bangoridjak*, and *naldja*; the noise made by it is called *bibu bibu*, the real nature of which he now learns for the first time. The connection of the bullroarer with Djamar is explained to him, after which he is made to swing it until he is very tired.

The ceremony is now over and the "new man" has to remain in the bush for some weeks along with some other young fellows who are already *Djaminaŋga*, but are not yet *Mambaŋaŋa*. The tapu on fish is lifted, and he is taught about Kalalong, a sky culture-hero.

Subincision.—This operation, called *lardj*, may be performed either before or after *Djaminaŋga*. It is not a separate ceremony, but is done at a circumcision meeting. It is more correct to say that the cut is only commenced on the first occasion, and is extended a little at each

circumcision meeting until by the time a man is *Mambayaya* the cut extends for the whole length of the organ. The important thing is to have the full extension of the cut complete by that time. The operation is in the first instance performed on a human table consisting of several men lying on the ground.

Cicatrisation.—The cicatrices, *bauer*, are made in camp, the women, however, not looking, by a man's mother's mother's brother, after he has reached the *Djaminaŋga* stage. They are made across the abdomen and chest and on the shoulders in the order mentioned. There are usually three or four in each place. It is exceptional for a Bardi or Sunday Islander to have any on the back; the latter is a Nyul-Nyul practice. The places to be cut are first marked with charcoal. The scars are frequently half an inch in width. The tapu on the women in this instance is no doubt associated with the sacredness of man's blood when ritually drawn.

Gambel.—Some time, weeks or months, after having been made *Djaminaŋga*, the young man is taken to the *Kundjeriŋ* ground, where his guardian ties ligatures of human hair string very tightly on his arms. When the veins are sufficiently swollen blood is taken from the novice and caught in a *gurndu* and then drunk by him and all those present. If the young man is in much pain, his guardian loosens the ligatures after a few hours. They must be left on for at least several days. The ligatures are called *gangul*, a word which is not secret. The young fellow is now called *Gambel*, and has the privilege of wearing arm ligatures at corroborees and also of giving blood at ceremonies.

Rungor.—Some time later his guardian puts the wing of a bird in the *Gambel's* head-band, after which the latter is called *Rungor*. This is done openly in camp.

Buŋin.—On a later occasion, again openly in camp, a pearl-shell pubic pendant is hung on the young man's hair-belt by his guardian, after which he is called *Buŋin*. This shell must bear the peculiar key pattern or *ram* called *ris*, of the Karadjeri tribe, south of Broome, or else the person is not a proper *Buŋin*. Shells can be obtained on the coast of the Bard territory, but they will not do without the Karadjeri pattern, which means that the required shells must be obtained from the south.

Mambayan.—Finally, at some time decided on by the senior men, that is when they think the young man is old

enough to marry, he is made *Mambayan*, after which he is a complete man. The simple ceremony is carried out openly in camp. His guardian paints him with red ochre and fat, gives him a plain shell, *korn*, to wear, and puts a stick adorned on both ends with white feathers through his hair on the back of his head. He now looks, and is, a man.

The Significance of the Rites.

There is very little variation between the Bard rites and those of other Kimberley tribes which I was able to study, namely, the Karadjeri in the La Grange district, Nyul-Nyul at Beagle Bay, Ungarinyin at Walcott Inlet, the Yeidji on the Forrest River, and the Wolyamidi and Lunga of East Kimberley.[5] This identity of pattern and remarkable similarity of detail is quite natural, for two or more tribes, or groups of several tribes, often meet for initiation rites and assist one another in them; moreover the secret life of the aborigines, like that of the great secret societies of our own culture, is inter-tribal, or as we should say with reference to the latter, is inter-state and even inter-national. Thus, whether a man witnessed the initiation rites in South or Central or North-West Australia, he would have no difficulty in following the general pattern and in interpreting the significance of the various rites. He would, however, find some important differences in Eastern Australia, such as the absence of circumcision and an insistence on the belief in a sky-being, an all-father; but even though this might be referred to as an eastern "use" as distinct from the western and central "use", our aboriginal traveller would still recognise that he was taking part in a ritual passing to manhood as from death to life, and to union with the hero or heroes of the tribe.

To return to the Bard rites. There are three series: the first is denoted by the terms *Neminem-Lainyar-Palil*, the second, *Djurdu-Djaminayga*, and the third *Gambel-Rungor-Buyin-Mambayaya*. The first series, which includes the operations of tooth-knocking and circumcision, clearly serves to separate the youth from his previous life, and indeed, it is the prelude to a period of seclusion from the

[5] My research work in the Kimberley division was carried out in 1927-28 for the Australian National Research Council. Mr. R. Piddington continued my work amongst the Karadjeri, and Miss P. Kaberry amongst the Forrest River and East Kimberley tribes. Some reports of their work have appeared in *Oceania*.

general camp. This is the obvious meaning of the ceremonies between these two operations. The youths are carried in mournful procession, while the mothers wail and cling on to their sons, as though loath to let them go to their ritual death; the wailing after the operations points the same way. And so the novice passes into seclusion, during which, in former days before the mission and its school intervened, he lived dead to the "world", at least to the general camp. He is forbidden to eat certain foods, and is taught the secret words which belong to the life apart. At the end of the time, about a month, the novice is painted red, the symbol of life, and ceremonially received into ordinary life again. It would be interesting to know the meaning of the post and fire ceremonies which immediately precede this, and why the sticks in the latter are pointed towards the setting sun.

In the Ungarinyin, on the north of King Sound, the newly circumcised youth, before returning to the camp, jumps through the smoke arising from a number of smoke fires. The men do likewise. The probable significance is one of purification, that is, to make sure that nothing of the sacred world is brought into the profane. In the same tribe the tree or pole ceremony, which takes place a stage later than in the Bard tribe, is described as follows: The novice and any men who are not yet subincised, have to sit touching the base of a tall thin green tree which is called by a secret name, *uryanyin*, and must not be seen by the uninitiated. The young fellows have to remain there with their heads bowed from early morning until sundown; one informant told me that he thought his neck would have broken. During the day all the subincised men climb up the tree, and while there cut their subincised penes to make them bleed. The blood runs down the tree on to the youths. If any of the latter notices a man approaching the tree, he calls out *krada* or *kuradi*, that is, flying fox, the term which is also applied to the novice. While the men are up the tree they whisper *ye . . . ye . . . ye*, and after they have come down they stand in a line and sing *kuradi djabinbai kuradi ambana djabinban*. This song was imported from the south, and the meaning of the words is not known. Whatever be the significance of this tree, the rite as a whole serves to give life to the newly initiated and to aggregate them into full male membership of the tribe by a sacramental application of sacred blood. Such tree and fire ceremonies are widespread in Australia,

and a comparative study would no doubt give us much insight into their meaning. The difficulty, however, is to get reliable and full descriptions of them with the aborigines' own interpretations.

In the Bard tribe the significant blood rite is that which makes a candidate *Djaminaŋga*; this not only unites him to the full members by sharing their sacred blood, but also gives him strength to receive the supreme revelation which is about to be given. Through this, namely, the bullroarer, he realises his fellowship with the tribal culture-hero, and in it he sees the symbol of the sacred world, from which this world has derived its culture and on which it still depends for life. During the period of seclusion he is taught much of the tribal mythology.

The casting of the throwing stick is a most interesting ceremony, for it gives a ritual interpretation of the aboriginal belief that sickness is unnatural and is always caused by magic. Medicine men naturally play a part in the rite, but once again, why the tree?

I have grouped the remaining operations and rites together in one series, for, with the occasional exception of subincision, they all occur after *Djaminaŋga*, and serve to add what might be called the finishing touches to, and signs of, a man's initiation. The account shows that subincision is not a rite in itself, but finds its significance in the letting of blood from the organ of generation at circumcision ceremonies. The tying of arm ligatures at the *Gambel* stage is likewise a preparation for parts to be played in later blood rites, more particularly in the *Djaminaŋga*. It is interesting that cicatrices are not made on the back, for in many tribes, from the Great Australian Bight up to the Timor Sea, the pattern on the back is a sign that the person is fully initiated—a "pass-sign". The fastening-on of the pearl-shell pubic pendant is probably not the casual action that the account suggests; details were no doubt omitted. Amongst the Forrest River tribes, for example, the young man is asleep, while a number of men tie the human hair girdle and shell on him. He is then awakened and goes off to camp by himself. He makes gifts of food to the men who invested him with the shell, and stays in seclusion for a few days during which he uses a secret term for the shell, namely, *yagaula* instead of *djagala*. He then returns to ordinary life. This use of the pearl-shell as a kind of "lodge" apron is widespread

in the circumcision area of Australia, and is not found outside of that area.

There is no need here to emphasise the function of initiation. It is a series of rites which form a transition from boyhood to manhood and to full membership of the tribe, with its privileges and responsibilities. It provides a valuable method of controlling, guiding, impressing, and inspiring the young fellow during adolescence and the years that follow. And, finally, it is the door to the secret world of myth, symbol, and rite, in which is found the sanction and inspiration for daily life.

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CYANOGENETIC GLUCOSIDES IN AUSTRALIAN PLANTS.

PART 3.—EUCALYPTUS CLADOCALYX.

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Eucalyptus cladocalyx, syn. *E. corynocalyx*, a Sugar Gum, is a large tree, native to Victoria and South Australia and cultivated in New South Wales. It belongs to the group of eucalypts which yield the smallest amount of volatile oil, Baker and Smith having recorded the extremely low yield of one part of oil from 1,000 parts of fresh leaf. Perhaps this may account for the fact that the branches are sometimes lopped for fodder in times of drought, although it has long been recognised that the leaves evolve hydrocyanic acid when they are crushed.

During 1928 one of the present writers (H.F.), with C. B. Cox, published the figures for the analysis of a single South Australian sample which yielded 0·17 per cent. of hydrocyanic acid (THIS JOURNAL, *62*, p. 369). Nine other specimens gave positive tests when examined qualitatively; eight of these were herbarium specimens of varying age, the other was a fresh specimen grown at Ashfield, N.S.W., for which we were indebted to the courtesy of Mr. Edwin Cheel, Government Botanist. The existence of a cyanogenetic substance in a species of eucalyptus, associated as we now show with the presence of benzaldehyde, seems to be unique, although Baker and Smith suspected, but did not prove, the presence of benzaldehyde in the oil from *Eucalyptus viminalis*. This point is dealt with at a later part of this paper.

In February, 1929, through the kindness of Mr. Cheel, a quantity of the Ashfield material was obtained. It consisted of the loppings from the youngest branches of an ornamental grove. In the fresh condition it gave 0·32 per cent. of hydrocyanic acid, or calculated on the material

dried at 100° C., approximately 0·50 per cent. This amount was obtained by merely macerating the cut leaves in water; the fact that no additional quantity was obtained when enzyme from sweet almonds was added seemed to show that the fresh leaves contained sufficient enzyme to decompose the whole of the glucoside present. This sample was dried in the air and used for the experiments described in Section A of this paper. When the leaves are stored there is a gradual diminution in the hydrocyanic acid, and to ascertain its extent the leaves were recently re-examined, that is, after a lapse of seven years. Without additional enzyme they now yield 0·06 per cent., with added enzyme, 0·105 per cent. of hydrocyanic acid, showing that the glucoside has been reduced to one-fifth its original amount. It is also shown that the enzyme, under the conditions of our quantitative experiment, is now able to hydrolyse only two-thirds of this reduced amount of glucoside.

During 1929 Dr. H. R. Seddon, Director of the Veterinary Research Station at Glenfield, in supplying four samples for trial, brought to the notice of the Poison Plants Committee of the C.S.I.R. information to the effect that this plant had on several occasions been definitely proved to be responsible for losses in stock—cows, horses and sheep having all been fatally poisoned. Dr. Seddon pointed out that particular care should therefore be taken when lopping these trees that the branches be collected and burnt as soon as they are dry enough, and that stock should not have access to them.

A. The Identification of Prunasin.

(With Miss Reichard.)

It seemed desirable that in addition to studying the quantitative aspect of this problem an attempt should be made to identify the glucoside. In order to extract it, two methods were tried, one using boiling acetone, the other extracting with alcohol. As the acetone method was not successful in the first instance, and as a modification of it was used in the experiments described in Section B of this note with striking success, it is only proposed to give here an outline of the extraction with alcohol, by which a small amount of crystalline glucoside was isolated in the pure condition.

Extraction with Alcohol.

An alcoholic extract was prepared from 2·9 kilos of the crushed leaves by three successive macerations of thirteen hours each. After distillation of the alcohol the residual extract was treated with water, which caused the separation of a fairly large amount of waxy material. Gummy and other indefinite matter was then precipitated from the aqueous solution with lead acetate in the usual way ; after removal of the excess of lead the cyanogenetic substance was extracted from the aqueous liquid by shaking out repeatedly (23 times) with amyl alcohol. This solvent was then removed by distillation under reduced pressure, and the residual extract was treated with acetone, which left undissolved a small amount of sticky matter. After the acetone solution had deposited some colourless non-cyanogenetic material, it was concentrated and mixed with a small quantity of benzene, whereupon a syrup was precipitated which, after re-solution in acetone and re-precipitation with benzene, gradually became crystalline. In order to purify this it was extracted with dry ethyl acetate, the solution allowed to cool, and mixed with a small quantity of chloroform, when 0·35 gram of crude glucoside was obtained. After purification this amounted to 0·126 gram. It melted at 148° C., and was identified as prunasin (*d*-mandelonitrile glucoside) by comparison with an authentic sample and by the mixed melting point method.

B. The Rapid Extraction of Prunasin.

(With Miss Large.)

During July, 1935, further cases of the poisoning of sheep in the Wagga district were brought to the notice of the Poison Plants Committee by Dr. Seddon, who was good enough to send an ample supply of the suspected material. This consisted mostly of young sucker growth with ovate leaves and coloured tips ; some separate dried leaves were also sent. The results of the analyses are given in the following table. It should be noted that Seddon and King consider a plant potentially poisonous if the quantity of hydrocyanic acid available from it amounts to 50 milligrams per 100 grams. The sucker leaves of this eucalypt contain a fatal dose for a sheep in 20 grams, or slightly more than two-thirds of an ounce.

Amount of Hydrocyanic Acid from Eucalyptus cladocalyx.

Ref. No.	Date.	Percentage Loss in Weight at 100°.	HCN per Cent. Calculated on the Leaves Dried at 100°.
3393, air-dried ..	18/7/35	8·1	0·14
3394, fresh suckers	18/7/35	37·1	0·59
3395, air-dried suckers	11/11/35	7·5	0·53
3395, re-examined	11/2/36	6·2	0·48
3395, with added enzyme ..	11/2/36	6·2	0·41

The usual process of estimation by titration with iodine was modified by a second steam distillation of the sodium cyanide solution in order to remove the small trace of volatile oil which would otherwise interfere.

Sample 3395 was used in the following experiments. It had been found in this laboratory that prunasin, which occurs to the extent of nearly 10 per cent. in the leaves of *Eremophila maculata*, the native fuchsia, could be extracted from it by means of ether. We have now found that acetone may be more economically used as a solvent. It has the advantage over alcohol that its solvent action is more limited, and therefore sugars, which may interfere with the subsequent purification of the glucoside, are not extracted to any great extent. Three methods of extraction were used: (*a*) extraction in a Soxhlet apparatus, (*b*) cold percolation, and (*c*) boiling under reflux. Cold percolation is very convenient, and need only be described.

Extraction with Acetone.

One kilo of the sucker leaves ground to No. 20 powder was packed in a percolator and covered with acetone. After standing for two days the solvent was allowed to percolate slowly until the solution no longer gave a significant test for glucoside when incubated with crushed sweet almonds. The solvent was then distilled off and the residual soft green extract washed repeatedly with petroleum ether to remove material of the nature of fixed oils, etc. The insoluble residue, which was at first plastic, became somewhat powdery. The petroleum ether removed in suspension a greenish solid which gave the reaction for the phytosterols and seemed to be of the same nature as the product which had been separated from the alcoholic extract previously mentioned in this paper.

The Glucosidal Fraction.

After washing with petroleum ether the insoluble residue contained practically the whole of the extracted glucoside uncontaminated with reducing sugars. When it was extracted with boiling ethyl acetate and the solution cooled and filtered, crystals of prunasin separated at once. The weight was 29·5 gram, and a further 7·0 gram was obtained by re-extracting the residue with boiling ethyl acetate. The crystals were purified by first washing with petroleum ether, which removed the green mother liquor containing chlorophyl, and then dissolving in the minimum quantity of boiling ethyl acetate, adding a little chloroform to the hot solution and allowing to cool. Two recrystallisations gave a pure product.

Its identity was established by analysis (C=57·0, H=5·9; theory requires C=56·95, H=5·76), and by the mixed melting point method. Its tetracetyl derivative was prepared by boiling one hour with acetic anhydride in the usual way and recrystallising from diluted alcohol. Melting point 136° to 137° (C=57·0, H=5·40; theory C=57·0, H=5·5).

Eucalyptus viminalis.—In their account of this species Baker and Smith describe two variants: variety A from the Crookwell district of New South Wales, and Manna or White Gum, widely distributed in all the States except West Australia. These workers suspected the presence of benzaldehyde in the volatile oil distilled from the former of these and obtained a crystalline compound with sodium hydrogen sulphite, but they were unable to prepare benzoic acid from it by oxidation. As it appeared to us that benzaldehyde, if present, might have arisen from the decomposition of a cyanogenetic glucoside, it was decided to test the leaves for the presence of hydrocyanic acid. Application was therefore made to Mr. A. R. Penfold, Curator of the Technological Museum, who kindly supplied an authentic specimen of the leaves from the Braidwood district. These were found to be negative for hydrocyanic acid, nor could any evidence of the presence of benzaldehyde be obtained from the oil or the aqueous distillate from them. Application was simultaneously made to the Secretary of the Forestry Commission, by whose courtesy a sample of leaves from the Tumbarumba district was supplied. These, with their accompanying flowers and fruits, were submitted to Mr. E. Cheel, the Government Botanist, who reported that some uncertainty existed as to their identity.

He was inclined to believe that they resembled *E. Dalrympleana*, a closely related species. A second supply from the same district, with juvenile leaves, was pronounced by Mr. Cheel to consist of *E. viminalis*. Both these samples were positive for hydrocyanic acid. The former, examined quantitatively, gave 0·09 per cent. of hydrocyanic acid, calculated on the material dried at 100°, and is therefore to be considered a potentially poisonous leaf. It is intended to examine further samples.

ACKNOWLEDGMENTS.

Our thanks are due to Professor J. C. Earl for the facilities for the above combustions; to Mr. J. T. Tippett for the many estimations of hydrocyanic acid involved in these experiments. The work was begun under the auspices of the Poison Plants Committee of the C.S.I.R. and continued under the Poison Plants Committee of the University of Sydney and the State Department of Agriculture, the members of which agree to the publication of this note.

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A BACTERIAL DISEASE OF SNAKE BEANS.

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With Plate V.

(*Manuscript received, March 17, 1936. Read, April 1, 1936.*)

INTRODUCTION.

Gardner and Kendrick,[5] in their account of a bacterial spot disease of cow-pea (*Vigna sinensis* (L.) Endl.) caused by *Bacterium vignæ* Gardner and Kendrick, state that a bacterial disease of asparagus bean (*Vigna sesquipedalis* Wight, known also as snake bean and yard-long bean) was observed in Indiana and was probably caused by *B. vignæ*. Burkholder[2] recorded a bacterial disease on the same host and determined the causal organism as a strain of *Phytomonas* (*Bacterium*) *vignæ* var. *leguminophila* Burkholder.

In Australia there is no previous record of the occurrence of a bacterial disease of snake bean, although a bacterial disease was recorded on cow-pea at Glen Innes, N.S.W., in 1932.[7] The causal organism was on the basis of symptoms assumed to be *B. vignæ*.

OCCURRENCE, DISTRIBUTION, AND SYMPTOMS.

In January, 1935, snake beans grown near Mudgee, N.S. Wales, came under notice on account of a condition associated with considerable leaf damage. Microscopic examination of affected leaves showed large numbers of bacteria in the leaf spots. On plates of beef-extract peptone agar prepared from dilutions of macerated tissue in sterile water, numerous bacterial colonies, creamy white in colour, made their appearance. Needle-prick inoculations of the stems of snake bean seedlings with cultures from these colonies resulted in the collapse and death of the seedlings within four days. Re-isolations were made from the stems of infected seedlings about one inch above the point of inoculation. The re-isolated organism was also pathogenic to snake beans.

In the field the disease was evident as reddish-brown spots of varying size on the leaves (Plate V, A). Similar lesions were observed on the petioles, stems, and pods. A narrow zone of yellowish-green leaf tissue frequently occurred around these leaf spots, in the centre of which the tissue later became thin, dry, and brittle, and often fell out. On the underside of the leaf the disease sometimes caused a blackening of the veins or portions of the veins.

Identity of the Causal Organism.

These symptoms agree closely with those described and illustrated by Gardner and Kendrick[5] in the case of the bacterial spot disease of cow-pea caused by *B. vignæ*. Clara[3] in a recent study of some of the green fluorescent bacterial plant pathogens concluded that *B. vignæ* was synonymous with *Bacterium syringæ* (Van Hall) E. F. Smith, the cause of the lilac blight and citrus pit diseases.

For purposes of comparison with the locally isolated organism, the following cultures were obtained:

(i) A culture of *B. vignæ*, from Dr. M. W. Gardner, of the University of California.

(ii) A culture of *B. syringæ*, isolated from lilac, from Dr. W. H. Burkholder, of Cornell University.

(iii) Two cultures of *B. syringæ*, isolated from citrus, from Mr. A. T. Pugsley, Department of Agriculture, Victoria. One of these had been isolated from lemon and the other from orange.

These four cultures were used for the inoculation of young snake bean seedlings and were recovered from the inoculated plants about one inch above the point of inoculation. The original and re-isolated cultures of these organisms were used in morphological, cultural, and host range studies in comparison with the locally isolated snake bean pathogen.

Morphological and Cultural Characteristics.

Morphologically and culturally the various cultures of *B. syringæ*, *B. vignæ*, and the locally isolated organism did not differ significantly from each other except in the fermentation of raffinose. The results obtained by the writer were similar to those recorded by Clara[3] for *B. syringæ* and *B. vignæ* except in the reduction of nitrate.

Clara[3] recorded no reduction of nitrate to nitrite, using the α-naphthylamine and dimethyl-α-naphthylamine

tests, but the writer found a very slight production of nitrite within two days at 30° C. in the case of all the organisms studied. This nitrite could be detected by the use of α-naphthylamine and sulphanilic acid but not by the use of Tromsdorff's reagent. Bryan[1] recorded similar results in the study of *B. syringæ* from lilac. Most of the other workers on these organisms used Tromsdorff's reagent and recorded no nitrate reduction.

In these studies perceptible differences were noted in the ability of the various organisms to ferment raffinose. A synthetic peptone-free medium was prepared according to the slightly modified formula of Ayres, Rupp and Johnson in the *Manual of Methods for the Pure Culture Study of Bacteria*. One per cent. of raffinose was added to this basic medium. Brom cresol purple was used as the indicator. The raffinose medium was sterilised by filtration through a Berkefield filter and by heating in the autoclave at 15 pounds pressure for five minutes. After inoculation the tubes were kept at 30° C. The action of the organisms on raffinose is shown in Table I.

TABLE I.

The Action of the Organisms Studied on Raffinose.

Organism Used.	Effect on Medium Sterilised by	
	Filtration.	Heat.
B. syringæ from citrus	+	+
B. syringæ from lilac	−	+
B. vignæ	−	±
Local snake bean organism	−	±

NOTE.—All media were kept at 30° C. after inoculation.
+ = acid reaction (a bright yellow colour) within seven to ten days.
± = acid reaction in some cases within fifteen to twenty days. In other cases, growth, but no acid reaction within twenty days.
− = growth, but no acid reaction within twenty days.

No differences were noted between the various organisms in their action on starch, dextrose, sucrose, maltose, lactose, galactose, arabinose, xylose, lævulose, rhamnose, glycerol, mannitol, dulcitol, salicin, acetic acid, formic acid, succinic acid, lactic acid, and tartaric acid. The results obtained by the writer agreed with those obtained by Clara.[3] In dulcitol, which was not used by Clara, no growth was noted in the case of any of the organisms.

Host Range Studies.

Inoculations were made with cultures of the various organisms into stems, shoots, pods, or fruits of a number of different plants (see Table II). The method of inoculation consisted of puncturing the stem, fruit or other plant

TABLE II.

Comparison of Results of Inoculating Various Plants with the Organisms Studied.

Host.		Pathogen.			
Plant Used.	Part of Plant Inoculated.	Local Snake Bean Organism.	*B. vignæ.* From California.	*B. syringæ.* From Victoria from Citrus.	*B. syringæ.* From Cornell from Lilac.
Snake bean (*Vigna sesquipedalis*) ..	y. st. m. st. p.	+ + + +	+ + + +	+ + + +	+ + +
Cow-pea (*V. sinensis*)	y. st.	+ +	+ +	+	
Lima bean (*Phaseolus lunatus*)	y. st p.	+ + +	+ + +	+ + +	
French bean (*P. vulgaris*)	y. st. p. m. f.	+ + + —	+ + + —	+ + + —	+ +
Scarlet runner bean (*P. multiflorus*) ..	y. st.	+	+	+	
Soy bean (*Soja max.*) ..	y. st.	+ +	+	+	
Tick bean (*Vicia faba.*)	y. st.	+ +	+	+	
Lucerne (*Medicago sativa*)	y. sh.	+	+ —	+	
Pea (*Pisum sativum*) ..	y. st.	—	—	—	
Lemon (*Citrus limonia*)	m. f. i. f.	— +	— +	+ — +	
Orange (*C. sinensis*) ..	m. f	—	—	+ —	
Mandarin (*C. nobilis* var. *deliciosa*)	m. f.	—	—	+	
Lilac (*Syringa vulgaris*)	y. sh	+ —	+ —	+	+
Cabbage (*Brassica oleracea* var. *capitata*)	y. st.	—	—	—	
Cauliflower (*B. oleracea* var. *botrytis*) ..	y. st.	—	—	—	

NOTE.—Abbreviations are as follows: y. = young; m. = mature; i. = immature st. = stems; sh. = shoots; p. = pods; f. = fruits; l. = leaves.
+ + indicates death of plants in the case of stem inoculations.
+ indicates infection.
+ — indicates slight infection.
— indicates no infection.
All inoculations made by needle puncture under comparable conditions.

part with a sharp needle, flame-sterilised before use, and dipped in an agar slope culture so as to cover the point of the needle with a mass of bacteria. In every case adequate control plants or plant parts were pricked with a sterile needle. The Cornell culture of *B. syringæ* from lilac was used for the inoculation of only a few of the plants.

The results of these inoculation studies are summarized in Table II. The results obained with the organisms from lemon and orange from Victoria were very similar and are grouped together.

Discussion.

The only differences noted between the various organisms were in the fermentation of raffinose and their pathogenicity to various hosts. The snake bean organism agreed entirely with *B. vignæ* except in the degree of pathogenicity to tick bean, soy bean, and lucerne. If the citrus pit and lilac blight organisms are both designated *B. syringæ*, Clara[3] is justified in placing the cow-pea organism in the same species. If *B. vignæ* is to continue as a separate species, the citrus pit organism should also be regarded as a distinct species and should be designated *Bacterium citriputeale* Smith. The differences between these organisms is slight, however, and, for the present, the writer is of the opinion that the citrus pit, lilac blight, and cow-pea spot organisms, and the snake bean pathogen should all be designated *Bacterium syringæ* (Van Hall) E. F. Smith.

The Occurrence of a "Rough" Strain of the Locally Isolated Organism.

In the cultural and morphological studies of the snake bean organism, it was observed that, after repeated subculturing on agar slopes, the cultures had altered somewhat in appearance. Dilution plates of both beef-extract peptone agar and potato dextrose agar were prepared from these cultures. On these plates, the majority of the colonies had a rough-contoured surface (Plate V, B) raised above the surrounding medium. A few of the colonies, however, were of the original smooth type, smaller in size, with a non-contoured surface, only very slightly raised above the surrounding medium (Plate V, C). Dilution plates prepared from the "rough" colonies

showed all rough colonies, whilst dilution plates prepared from the " smooth " colonies showed all smooth colonies.

At the same time, dilution plates made from three relatively old beef-extract peptone agar slope cultures each showed all smooth colonies. These were sub-cultures of the re-isolated organism five and twelve weeks old respectively, and one from the original isolation which was three weeks old. This suggested that the " rough " organism had made its appearance during the almost daily sub-culturing of the preceding three to five weeks. It seemed that the " rough " type must be either a " rough " mutant of the snake bean pathogen or a contaminant introduced in the sub-culturing operations.

The occurrence of " rough " mutants of bacterial organisms has been recognised for a considerable time. Link[6] has reviewed some of the most important contributions relating to the occurrence of this phenomenon in the case of several bacterial plant pathogens. It is of interest to note that Bryan[1] has recorded a " rough " strain of the lilac blight organism (*B. syringæ*).

Single cell isolations of both the " smooth " and " rough " organisms were made, using the method recommended by Orskov.[8] Cultures derived from these single cells were used for stem inoculations of snake bean seedlings. The " smooth " strain was more virulent than the " rough ", although the latter was definitely pathogenic and caused wilting and death of the inoculated plants. Dilution plates prepared from the stems of infected seedlings one to two inches above the point of inoculation showed either all rough colonies or all smooth colonies, depending on the nature of the initial culture used for inoculating the plant. Cultures derived from rough and smooth colonies in these plates and the cultures derived from single cells were studied morphologically, culturally, and in their reaction to various plants.

The four cultures agreed entirely in the following characteristics: size, staining reactions (including the Gram stain), action on milk, litmus milk, gelatin, and starch, ammonia production in beef-extract peptone broth, indol production, nitrate reduction, and in the fermentation of 19 sugars, alcohols, and acids.

The " rough " and " smooth " strains differed in motility, the appearance of the growth on agar and in beef-extract peptone broth, and in pathogenicity to various hosts.

The " rough " strain showed only slight motility compared with the active motility of the " smooth " strain. In contrast with the one or two flagella of the " smooth " strain, no flagella were observed in the case of the " rough " strain, although this may possibly have been due to the technique rather than to entire absence of flagella.

The character of " roughness " was much more marked on potato dextrose agar than on beef-extract peptone agar. In beef-extract peptone broth and in most liquid media in which the " smooth " and " rough " strains were grown, a much denser precipitate was produced by the " rough " strain.

The " rough " strain was pathogenic when used for inoculating stems of those leguminous plants listed in Table II to which the " smooth " strain was pathogenic. The virulence was, however, perceptibly less.

After repeated sub-culturing of the " rough " strain derived from a single cell, it was found that the culture lost its homogeneous " rough " nature and became a mixture of " smooth " and " rough " types. No evidence was obtained concerning the factors which influenced the changes from the " rough " to the " smooth " form or *vice versa*.

Transmission, Economic Importance, and Control.

The crop of snake beans in which the disease occurred was grown on land which had not, as far as could be ascertained, grown any snake beans or other species of *Vigna*, or, indeed, any cultivated leguminous crop within the preceding four or five years. Consequently there was good reason for believing that the disease had been introduced with the seed. The seed used had been obtained from a Sydney firm of seed merchants, who stated that practically all their snake bean seed was imported from the United States. Seed harvested from the diseased crop was planted in previously sterilised pots of soil in the glasshouse. On some of the resulting plants, leaf lesions, similar to those observed on plants of the preceding generation, were evident. From these lesions an organism was isolated which proved to be identical with the original isolation. It is considered that this is fairly conclusive evidence that the disease can be seed-borne. It is probable that this is the main method of transmission from one season to the next.

In the crop in which the disease was observed, the leaf damage would probably result in an appreciable reduction in yield. Snake beans are grown only as a garden crop by a relatively small number of growers in this country, but the wide host range of the causal organism suggests that it may become an important disease of other cultivated crops.

Measures suggested by Gardner and Kendrick[5] for the control of the bacterial spot disease of cow-pea and by Tisdale and Williamson[9] for the control of the disease caused by the same organism on lima beans, include the use of disease-free seed as the most important means of combating the disease. Clayton[4] found that the spread of the bacterial spot disease of lima bean was materially reduced by spraying the plants with Bordeaux mixture and other fungicides. However, in the absence of knowledge of resistant types, the use of disease-free seed is suggested as the most effective method of control.

Summary.

A bacterial disease was recorded on snake beans (*Vigna sesquipedalis*) in New South Wales in 1935.

Comparative studies of the causal organism and cultures of the cow-pea spot, the lilac blight, and citrus pit organisms were carried out. Culturally and morphologically the snake bean organism and the other organisms were identical, except in the fermentation of raffinose. Slight differences were recorded in the degree of pathogenicity to various plants. None of the differences were considered sufficient to warrant placing the various organisms in separate species. The locally isolated organism is therefore designated *Bacterium syringæ* (Van Hall) E. F. Smith.

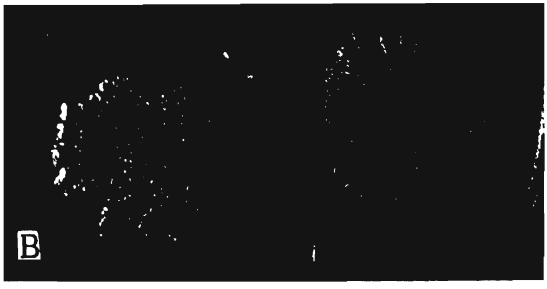
A " rough " strain of the snake bean pathogen arose as a mutant and comparisons were made with the normal " smooth " form.

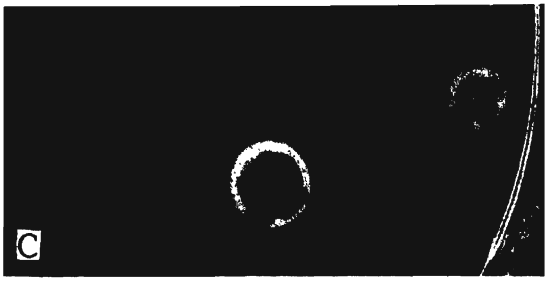
The disease was shown to be seed-borne.

Acknowledgments.

The writer wishes to acknowledge his indebtedness to Dr. W. L. Waterhouse and Dr. R. J. Noble for helpful suggestions and criticism concerning the investigation; to Mr. A. T. Pugsley, Department of Agriculture, Victoria; Dr. M. W. Gardner, University of California; Dr. W. H. Burkholder, Cornell University, New York; and Dr.


A


B


C

Charlotte Elliott, United States Department of Agriculture, for the provision of cultures.

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EXPLANATION OF PLATE.

A. Natural infection of snake bean leaf. Plants grown in the glasshouse from seed harvested from the originally observed crop.

B. Two weeks old colonies of the "rough" strain of the snake bean pathogen on potato dextrose agar. (×1½.) (Photograph by P. R. Maguire.)

C. Two weeks old colonies of the "smooth" strain of the snake bean pathogen on potato dextrose agar. (×1½.) (Photograph by P. R. Maguire.)

ON A NEW REACTION FOR THE DETERMINATION OF CREATININE.

By ADOLPH BOLLIGER, Ph.D.*

(*Manuscript received, March 17, 1936. Read, April 1, 1936.*)

INTRODUCTION.

In 1886, Jaffe (*Ztschr. f. physiol. Chem.*, *10*, 391), discovered the colour reaction of creatinine with picric acid, which in 1904 was elaborated by Folin (*Ztschr. f. physiol. Chem.*, *41*, 223) into a colorimetric method for the determination of creatinine. This method up till now, in spite of its shortcomings, remained the only convenient reaction for the qualitative and quantitative determination of this important biological constituent.

In connection with some work on the mechanism of the Jaffe reaction for creatinine, a large number of other o-nitrophenols besides picric acid were tested for their ability to form typical coloured compounds with creatinine. Substances such as o-nitrophenol, di-nitrophenols, di-nitrocresols, di-nitro and tri-nitroresorcinol, mono- and di-halogenated mono-nitrophenols, and mono-halogenated di-nitrophenols were investigated. The general observation was that practically all the o-nitrophenols investigated (15 specimens) gave, under suitable experimental conditions, a colour reaction with creatinine similar in nature to that of picric acid. But all these o-nitrophenols were found to be in a varying degree inferior to picric acid. In the investigation were then also included nitrated benzoic acids, and it was found that 3-5 dinitro-benzoic acid in the presence of creatinine in alkaline solution gives a purple colour reaction which was found to be analytically useful.

THE REACTION OF CREATININE WITH 3-5 DINITRO-BENZOIC ACID.

In 1894 Victor Meyer (*Ber. d. chem. Ges.*, *27*, 3159) observed that solutions of 3-5 dinitro-benzoic acid in alkali show colour variations according to certain experimental conditions.

* Acknowledgments are due to Miss Dorothy Dark for valuable technical assistance.

1. Nearly colourless, if dissolved in a dilute solution of the equivalent amount of alkali or less.

2. Yellow-red, when excess of dilute alkali is present.

3. Deep purple, but for a short period only, in concentrated alkali solutions.

4. Nearly colourless again, if one lets the solution prepared under 3 stand for a short time, because the purple colour formed at first fades quickly.

5. Fuchsin red, if solution as prepared under 3, stands for more than an hour.

As already mentioned, 3-5 dinitro-benzoic acid forms with creatinine in the presence of alkali a markedly coloured solution. This reaction, however, may be strongly influenced by the colours formed between 3-5 dinitro-benzoic acid and alkali in the absence of creatinine. According to the observations of V. Meyer, experimental conditions as mentioned under 1 or 4 (see above) would not interfere. Condition 1, however, is out of question, because an excess of alkali is necessary for the reaction with creatinine. But if the excess of alkali is present in sufficient dilution, viz., 0·2N–0·5N, at first a practically colourless mixture is obtained by using a dilute solution of the sodium salt of dinitro-benzoic acid. This solution remains practically colourless for about 5–10 minutes, then it turns into canary-yellow, which in the case of more concentrated alkali is reddish-yellow (see experimental conditions as under 2). However, the formation of the yellow colour may be retarded for almost an hour by keeping the mixture near freezing temperature. On the other hand, in spite of the low temperature in the presence of creatinine, a purple colour is produced which gains in intensity for the next 5 to 20 minutes, according to the concentration of the creatinine present. Then it becomes reddish respectively pinkish, and after several hours it ultimately turns yellow. If, however, a similar mixture is kept at room temperature the interfering reaction between dinitro-benzoic acid and alkali will be noted much sooner, particularly in the case of very dilute creatinine solutions.

The Determination of Creatinine with 3-5 Dinitro-benzoic Acid.

Reagents.

1. A 10% solution (approx.) of 3-5 dinitro-sodium-benzoate. This is prepared by adding slowly under

constant stirring 20 cc. 0·5N sodium hydroxide to 2·2 gm. of 3-5 dinitro-benzoic acid. Most of the dinitro-benzoic acid goes into solution, which, after some standing, changes from orange to yellow. Then filter.

2. Normal sodium hydroxide.

3. Creatinine standard. A stock solution is prepared by dissolving one gramme of creatinine in one litre of water. Suitable standards containing 20, 10, 5, and 2·5 mgm. per cent. of creatinine are prepared by diluting with water.

A. Qualitative.—Transfer about 2 cc. of the fluid to be examined, which preferably should be colourless and of neutral reaction, to a test tube, and add 0·2 cc. of a 10% solution of 3-5 dinitro-sodium benzoate and 0·4 cc. of normal sodium hydroxide. If the creatinine is present in a concentration of more than 5 mgm. per cent., immediately after adding the sodium hydroxide, a purple colour will appear, which deepens considerably on further standing. After about 15 minutes the colour will change towards red or pink, depending on the concentration of the creatinine present, and will ultimately become yellow.

If, however, on adding the sodium hydroxide no purple colour appears, one immediately cools the tube in ice and observes the contents for about 10–25 minutes. If the concentration of creatinine is less than about 3 mgm. per cent. a pinkish colour will be obtained, whilst stronger concentrations show an outspoken purple shade. By this test the presence of 0·5 mgm. per cent. creatinine will still be detected.* With such small amounts the colour of the mixture will be a pinkish-yellow. It takes about 25 minutes to develop fully.

B. Quantitative.—The solution whose creatinine content has to be determined should if possible be colourless and of approximately neutral reaction. Best results are obtained with concentrations ranging from 5 to 15 mgm. per cent. of creatinine, and solutions containing more than about 20 mgm. per cent. have to be diluted accordingly.

2 cc. of the fluid to be examined as well as 2 cc. of the standard solutions are each transferred into a test tube and 0·2 cc. of the dinitro-sodium benzoate solution are added to each tube. Then the tubes are cooled in an ice-

* In a subsequent publication it will be shown that better results will be obtained by using thoroughly purified dinitro-benzoic acid.

water mixture for a few minutes. Afterwards 0·4 cc. of normal sodium hydroxide are added and then the tubes in the cooling mixture are immediately transferred into the ice chest. After letting stand in the ice chest for 15 minutes the unknown is compared against the standard in the colorimeter, which is equipped with non-transparent cups. If the colour of the unknown is faint one lets stand in the ice chest for 25 minutes.

Discussion.

The reaction of creatinine with 3-5 dinitro-benzoic acid is probably of a similar nature to that with picric acid. But in both instances nothing definite can yet be said with regard to the mechanism of the reaction. They both, that with dinitro-benzoic acid as well as that with picric acid, take place only in an alkaline medium, and they are about equally specific for creatinine. Both reagents give also a marked colour reaction with acetone, acetophenon, ethylmalonate, etc. Therefore, such ketone bodies have to be absent in a solution to be examined. On the other hand, the dinitro-benzoic acid as applied in the present test described is only slightly coloured, while the deep yellow-orange colour of the picric acid in alkaline solution makes the detection and estimation of small amounts of creatinine difficult. The purple colour, as produced with dinitro-benzoic acid and creatinine, is very marked, but, however, as in the case of picric acid, is not perfectly uniform in the different concentrations. Small creatinine concentrations give a more reddish colour than concentrated solutions. In order to obtain a good match of colours between standard and unknown, the creatinine content of standard and unknown should not differ more than 50%.

The application of this test to some specific biological problem such as determination of creatinine and creatine in urine will be dealt with on another occasion.

Summary.

Creatinine gives with 3-5 dinitro-benzoic acid in an alkaline medium a purple colour reaction which is useful for the detection and colorimetric estimation of creatinine.

The Gordon Craig Urological Research Laboratory,
Department of Surgery,
University of Sydney.

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales

May 1st, 1935.

The Annual Meeting, being the five hundred and thirty-second General Monthly Meeting of the Society, was held in the Hall of Science House, Gloucester and Essex Streets, Sydney, at 7.45 p.m.

Dr. R. J. Noble, President, was in the chair. Forty-four members were present. The minutes of the general monthly meeting of the 5th December, 1934, were read and confirmed.

The President announced the death of James Laurence Gallagher, M.A., who was elected a member in 1918.

The certificates of two candidates for admission as ordinary members were read for the first time. The following gentleman was elected an ordinary member of the Society: John Gordon Churchward. His Excellency Sir John Hubert Plunkett Murray was elected an honorary member of the Society.

The following gentlemen were elected officers and members of Council for the coming year:

President:

A. R. PENFOLD, F.A.C.I., F.C.S.

Vice-Presidents:

R. J. NOBLE, M.Sc., Ph.D., B.Sc.Agr.
R. W. CHALLINOR, F.I.C., F.C.S.
C. A. SUSSMILCH, F.G.S.
E. C. ANDREWS, B.A.

Honorary Treasurer:

EDWIN CHEEL.

Honorary Secretaries:

Major EDGAR H. BOOTH, M.C., B.Sc., F.Inst.P.
Assist.-Prof. W. R. BROWNE, D.Sc.

Members of Council:

C. ANDERSON, M.A., D.Sc.
Prof. J. C. EARL, D.Sc., Ph.D.
Prof. C. E. FAWSITT, D.Sc., Ph.D.
H. FINNEMORE, B.Sc., F.I.C.
Assoc.-Prof. H. PRIESTLEY, M.D., Ch.M.
Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.
L. L. WATERHOUSE, B.E.
W. L. WATERHOUSE, M.C., D.Sc.Agr., D.I.C.
Prof. R. D. WATT, M.A., B.Sc.
M. B. WELCH, B.Sc., A.I.C.

The Annual Balance Sheet and Revenue Account were submitted to members by the Honorary Treasurer and, on the motion of Mr. Penfold, seconded by Mr. Sussmilch, were adopted.

ROYAL SOCIETY OF NEW SOUTH WALES.

BALANCE SHEET AS AT 31st MARCH, 1935.

LIABILITIES.

	£ s. d.	£ s. d.
Trust Funds—		
Clarke Memorial Fund	1,604 18 11	
Walter Burfitt Prize Fund.. ..	640 3 2	
Liversidge Bequest	580 1 6	
		2,825 3 7
Sundry Liabilities		15 12 6
Accumulated Fund		30,562 16 5
		£33,403 12 6

ASSETS.

	£ s. d.	£ s. d.
Cash—		
Union Bank of Australia Ltd.— Credit balance after allowing for unpresented cheque	458 8 0	
Cash on Hand	2 12 1	
		461 0 1
Commonwealth Bonds and Inscribed Stock—		
Bonds (nominal value £3,140) ..	3,089 15 0	
Inscribed Stock (nominal value £1,000)	990 10 0	
		4,080 5 0
Science House Management Committee—		
Payments to date		14,533 18 4
Sundry Debtors—		
Institution of Engineers	2,283 6 8	
Sundries	8 5 3	
Subscriptions unpaid £635 16 0		
Less—		
Bad Debts Reserve 466 19 4		
	168 16 8	
		2,460 8 7
Library		9,979 1 0
Office Furniture		1,582 19 6
Pictures		162 0 0
Microscopes		108 0 0
Lantern		36 0 0
		£33,403 12 6

I have examined the books and vouchers of the Royal Society of N.S.W. for the period ended the 31st March, 1935, and certify that the above Balance Sheet and attached Revenue Account are in agreement therewith. I certify that to the best of the information given me the above Balance Sheet correctly exhibits the position of the Society's funds at this date.

(Signed) W. PERCIVAL MINELL,
Chartered Accountant (Aust.).

Queensland National Bank Chambers,
27 Hunter Street,
Sydney, 23rd April, 1935.

REVENUE ACCOUNT FOR THE YEAR ENDED 31st MARCH, 1935.

	£	s.	d.
To Office Salaries and Accountancy Fees	278	7	9
,, Rent	232	2	0
,, Printing	58	1	3
,, Advertising	2	19	0
,, Stamps and Telegrams	51	0	0
,, Office Sundries and Stationery	43	6	0
,, Electric Light and Gas	5	8	11
,, Insurance	21	12	9
,, Telephone	15	5	8
,, Printing and Publishing Society's Volume ..	228	11	0
,, Repairs	6	0	0
,, Miscellaneous Expenses	58	17	7
,, Cleaning	21	2	6
,, Interest	115	3	8
,, Depreciation of Furniture, Pictures, Microscopes, and Lantern—10%	208	3	0
,, Balance, being Net Revenue for the year ..	88	0	11
	£1,434	2	0
By Members' Subscriptions	545	12	8
,, Government Subsidy	200	0	0
,, Interest Received	322	16	3
,, Science House Receipts	270	0	0
,, Miscellaneous Receipts	95	13	1
	£1,434	2	0

This is the Revenue Account referred to in my certificate of even date.

(Signed) W. PERCIVAL MINELL,
Chartered Accountant (Aust.).

Sydney, 23rd April, 1935.

Mr. Clunies Ross asked how the shortage of funds had been shown, and Mr. Penfold replied that the balance sheet drawn up on the 25th May last had shown the corrected value of the bonds. Mr. Finnemore queried the amount shown under the heading Office Furniture, and

asked how this asset was valued. It was stated that the amount shown for this item was the purchase price, on which a 10 per cent. depreciation had been allowed this year, for the first time. In answer to a question, Mr. Penfold stated that the statement signed by the auditor, at the foot of the balance sheet, had been altered at the request of the Society.

The only nomination received for the position of Auditor was that of Mr. C. F. Horley, of Messrs. Horley & Horley, public accountants. Mr. Penfold proposed, and Mr. Welch seconded, that he be elected, and this motion was carried.

The Annual Report of the Council (1934-1935) was read and, on the motion of Major Booth, seconded by Mr. Challinor, was adopted.

REPORT OF THE COUNCIL FOR THE YEAR 1934-35.
(1st May to 24th April.)

We regret to report that we have lost by death ten ordinary members. By resignation we have lost seven members, and, in addition, eleven members have been struck off the roll for non-payment of subscriptions. On the other hand, thirteen ordinary members have been elected. Today (24th April, 1935) the roll of members stands at 273.

During the Society's year there have been eight general meetings and ten council meetings.

Twenty-seven papers were read at the general monthly meetings, and covered a wide range of subjects.

A new series of short lectures on current topics was begun, and the following talks were given:

4th July: "New Units of Matter and New Atoms", by G. H. Briggs, B.Sc., Ph.D., F.Inst.P.
1st August: "Chemiluminescence", by D. P. Mellor, M.Sc.
3rd October: "Some Aspects of the Biological Control of Insects and Weeds", by N. S. Noble, M.Sc., B.Sc.Agr., D.I.C.

At the July meeting there was a discussion on the subject of "The Relation between Diseases in Livestock, Geological Formations, and Soil Composition", the principal speakers being Mr. Max Henry, M.R.C.V.S., B.V.Sc., Dr. Ida A. Brown, and Mr. M. S. Benjamin, D.I.C., A.A.C.I.

Four popular science lectures were given, as follows:

19th July: "Television", by Mr. E. T. Fisk.
16th August: "Old Coins and some Ancient Men of Science", by G. H. Abbott, B.A., M.B., Ch.M.
20th September: "Tick Paralysis in Man and Animals", by I. Clunies Ross, D.V.Sc.
18th October: "Infra-Red Spectroscopy", by Professor O. U. Vonwiller, B.Sc., F.Inst.P.

The Annual Dinner was held on Thursday, the 11th April, 1935.

Death of the Honorary Treasurer.—Following the death of Dr. H. G. Chapman, the Honorary Treasurer, on the 25th May, 1934, a shortage

of £3,260 was found in the funds of the Society, and it was discovered that the balance sheet presented at the annual meeting had not been released by the auditors. Steps were taken to have Dr. Chapman's estate administered in bankruptcy, and to prevent any such discrepancy occurring in the future.

Mr. A. R. Penfold was elected as Honorary Treasurer, and action taken to place the Society's finances again in a sound position. Professor J. C. Earl was elected a member of Council to fill the vacancy caused by Mr. Penfold's election as Honorary Treasurer.

Alterations to Rules.—A sub-committee consisting of Dr. Noble, Major Booth, Dr. Browne and Messrs. Penfold, Challinor and Sussmilch was appointed to consider recommendations for the alteration of the Rules of the Society. A draft of the proposed alterations was submitted to the Council for approval, and later approved at a general monthly meeting. The alterations have still to be ratified at the next annual meeting.

Visit of H.R.H. the Duke of Gloucester.- On the 24th November, 1934, an Address of Welcome was presented to the Duke of Gloucester by the President (Dr. Noble), Dr. Brown and Mr. Penfold, on behalf of the Society.

In January, 1935, the Society's Vice-Patron, His Excellency Air Vice-Marshal Sir Philip Woolcott Game, G.B.E., K.C.B., D.S.O., relinquished his position as Governor of New South Wales and returned to England. The President, on behalf of himself and the Council, presented a farewell letter to him, to which Sir Philip graciously replied.

Science House.—The Society has regularly been represented at the Science House Management Committee meetings. Accounts, which have been tabled regularly, show that there are still considerable possibilities of increased revenue to this Society as one of the owner-bodies, provided that space at present unoccupied can be let. The building and fittings are in good order and condition and a depreciation account has been opened.

Clarke Memorial Fund.—The question of the capital and the interest on the Clarke Memorial Fund and its allocation having been raised, the matter was referred to the Society's solicitors, Messrs. Allen, Allen & Hemsley, who state that, in their opinion, the moneys now representing the Clarke Memorial Fund cannot be lawfully applied except for the purpose of defraying the expense of the award from time to time of a medal for distinction in geology and mineralogy, and of the provision from time to time of free lectures on geology. The Council decided that a permanent advisory committee should be formed to advise as to the disbursement of income from the Clarke Memorial Fund. This committee is to consist of the Executive Officers of the Society for the time being, together with Professor L. A. Cotton, Dr. W. R. Browne, Mr. E. C. Andrews and Mr. C. A. Sussmilch.

Clarke Memorial Medal.—At its meeting on the 29th March, 1935, the Council awarded the Clarke Memorial Medal to George W. Card, A.R.S.M.

On the 28th August, 1934, the Society suffered the loss by death of a Vice-President, Sir Edgeworth David. The Royal Society was instrumental in forming a committee to consider proposals for the formation of a memorial fund, and the President (Dr. Noble) presided over several meetings of a general and an executive committee, which resolved "(1) that a fund to be known as the David Memorial Fund

be raised, that it be handed over to the University of Sydney, and that the income from it be applied in such manner as the Senate thinks will best aid in the advancement of the science of geology; and (2) that the Senate be requested to associate the name of Sir Edgeworth David permanently with the Chair of Geology". A committee, of which Dr. Noble is chairman and Dr. A. B. Walkom honorary secretary, was entrusted with the direction of the raising of the fund.

Mr. C. A. Sussmilch was elected as a Vice-President to fill the vacancy caused by the death of Sir Edgeworth David.

The Library.—The donations to the library from December, 1935, to March, 1935 (inclusive), have been as follows: 3,650 parts, 151 reports, 177 volumes, 62 reprints, and 7 calendars. In addition, a number of periodicals have been purchased at a cost of £81 15s. 3d. This amount is unusually large, as no payments had been made for subscriptions for the year 1933-34, and in some cases subscriptions for previous years were overdue. £48 18s. 6d. has been spent on binding periodicals, the grant for this purpose being £50.

The work of transcribing the catalogue on to new cards, following the system adopted by Pitt's "Catalogue of Scientific Periodicals in Australian Libraries", has now been completed.

During the year a revision of the exchange list has been undertaken. A number of additional exchanges have been entered into and others have been discontinued. The number of societies and institutions receiving the "Journal and Proceedings" on an exchange basis now stands at 328, compared with 320 on 31st March, 1934. It has been the policy to complete, as far as possible, the library's sets of periodicals and, in response to requests made during the year, approximately 850 back numbers have been received. Duplicates have been disposed of in exchange for some of these parts, and in only a few cases has it been necessary to purchase missing numbers.

An extension telephone connection has been made to the library; this facilitates the work of the staff, and enables better service to be offered to members.

Four meetings of the Library Committee were held during the year, and a report was submitted to the Council for approval in September, 1934. The report adopted was as follows:

"The question of the use of the library by non-members was considered and it was decided to recommend to the Council the adoption of the following policy:

"(*a*) Issue of reader's tickets at a fixed annual charge to persons known to the executive officers as fit to make proper use of the library, such tickets to be valid for one year only, and to be personal to the holder. The current charge is fixed at 10s. 6d. per ticket.

"(*b*) Issue of reader's tickets in bulk at a reduced charge by special arrangement to other approved societies, for re-issue as personal tickets to their members.

"(*c*) Free use of the library by members of the Linnean Society of N.S.Wales and the Institution of Engineers, Australia, under a reciprocal arrangement.

"(*d*) No volumes to be lent to non-members except through another approved library, of which they are members or ticket-holders.

"(*e*) Occasional free use of the library to non-members vouched for individually in writing on each occasion by a member of the Society.

"It was decided to adhere strictly to the existing rule (No. 4) regarding the removal of unbound parts from the library.

"The Honorary Librarian called the attention of members of the Committee to the unsatisfactory arrangements for filing of current periodicals, and it was decided to ask Council to provide, if possible, a suitable piece of furniture for the Reception Room, in which most of the current periodicals could be filed and made available to members of the Society for consultation.

"The question of opening the library on some evenings was also considered, and it was decided that the experiment might be made at any convenient time after the completion of the catalogue."

An agreement with the Australian Chemical Institute, to operate under clause (*b*) of these recommendations, has been completed.

At present current numbers of the more popular periodicals are displayed on tables in the library. This method is not wholly satisfactory, but other arrangements are to be made in the near future.

On behalf of the Council,

R. J. NOBLE,
President.

The President announced that the following popular science lectures would be delivered during the session:

July 18th: "Recent Advances in Veterinary Research in Australia", by Dr. H. R. Carne.

August 15th: "Study of Growth in the Human Being", by Professor Harvey Sutton.

September 19th: "Measuring the Stars", by Rev. W. J. O'Leary.

October 17th: "Volcanoes of the Pacific", by Mr. C. A. Sussmilch.

The following donations were received: 1,396 parts, 103 volumes, 3 calendars, 23 reprints and 1 map.

On the motion of Major Booth, seconded by Mr. Penfold, the alterations to the Rules of the Society, approved by the general meeting of the 7th November, 1934, were approved by the Annual Meeting.

The President, Dr. R. J. Noble, then delivered his address.

Dr. Noble, the retiring President, then installed Mr. A. R. Penfold as President for the year 1935-36, and the latter briefly returned thanks. On the motion of Professor Watt, a vote of thanks was enthusiastically accorded to the retiring President for his valuable services to the Society during his term of office. Dr. Noble briefly thanked the members for their expression of appreciation.

June 5th, 1935.

The five hundred and thirty-third General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Fourteen members were present. The minutes of the general monthly and annual meeting of 1st May, 1935, were read and confirmed.

As there was not present a sufficient number of members to make an election valid, the election of two proposed members, Hugh James and Michael Duhan Garretty, was not held.

The Council communicated the information that Room 514 in Science House had recently been made available as a common room for the use of the members of the societies and institutions which are tenants of the building.

The following donations were received: 787 parts, 55 volumes, and 13 reprints.

The following papers were read:

"A Detailed Regional Magnetic Survey as an Aid to Geological Interpretation. District: Mittagong-Bowral", by Edgar H. Booth, M.C., B.Sc., F.Inst.P.

"The Constitution of Matairesinol", by L. H. Briggs, M.Sc., D.Phil., D. A. Peak, and J. L. D. Woolloxall. (Communicated by F. Lions, B.Sc., Ph.D., A.I.C.)

July 3, 1935.

The five hundred and thirty-fourth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Thirty-two members were present. The minutes of the preceding meeting were read and confirmed.

The President announced the death of William John Adams, M.I.Mech.E., who had been a member since 1904.

The certificates of three candidates for admission as ordinary members of the Society were read, one for the first, and two for the second time. The following gentlemen were duly elected ordinary members of the Society: Hugh James and Michael Duhan Garretty.

The Council communicated the information that, in the opinion of the Society's solicitors, women were eligible to become members of the Society.

The President announced that the third award of the Walter Burfitt Prize would be made in November, 1935, and that nominations should be submitted to the Society not later than 31st August, 1935. It was also announced that a Conversazione would be held on Monday, 12th August.

Members were informed that the Society's library would be open until 7.45 p.m. on the first Wednesday in each month, this arrangement to be continued until the Council decided whether it was justified by the use made of the library on these evenings.

The following donations were received: 259 parts, 18 volumes, 2 reprints.

The President introduced the speakers for the evening, Professors L. A. Cotton and R. D. Watt and Mr. J. C. Firth, who each gave a short talk on "Sulphur", dealing with the subject from the point of view, respectively, of Geology, Agriculture, and General Industry. Mr. R. F. Boan, who was to have dealt with the subject from the point of view of Pigments, was absent owing to illness, and his contribution to the discussion was read by the President.

The following papers were read:

"The Volumetric Micro-determination of Magnesium with Methylene Blue, following its Precipitation as Magnesium Picrolonate", by Adolph Bolliger, Ph.D.

"A Note on the Geology of the Goulburn District, with special reference to Palæozoic Stratigraphy", by G. F. K. Naylor, M.A., M.Sc.

August 7th, 1935.

The five hundred and thirty-fifth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Seventeen members were present. The minutes of the preceding meeting were read and confirmed.

The certificates of sixteen candidates for admission as ordinary members of the Society were read for the first time.

As there was not present a sufficient number of members to make an election valid, the election of the proposed member, Daniel J. K. O'Connell, was not held.

The following donations were received: 447 parts, 58 volumes, 11 reprints.

The following paper was read:

"Vegetative Reproduction in New Zealand Mosses", by G. O. K. Sainsbury, F.L.S. (Communicated by E. Cheel.)

A short talk on "Chemical Warfare" was delivered by Mr. H. Finnemore, B.Sc., F.I.C.

September 4th, 1935.

The five hundred and thirty-sixth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Thirty-two members were present. The minutes of the preceding meeting were read and confirmed.

The certificates of twenty-two candidates for admission as ordinary members of the Society were read, five for the first time, and seventeen for the second time. The following persons were duly elected ordinary members of the Society: Catherine Dorothy Jean Back, Ida Alison Brown, Alma Gertrude Culey, Francis Williamson Firth, John Clifford Firth, Lilian Ross Fraser, Frank Rupert Hewitt, Germaine Anne Joplin, Elizabeth Frances Lawrence, Wilson Harold Maze, Phyllis Mary Nicol, Daniel J. K. O'Connell, Ruby Violet Payne-Scott, Florrie Mabel Quodling, Eric Christian Tommerup, Joyce Winifred Vickery, and Edmund Kay Wolstenholme.

The following donations were received: 286 parts, 27 volumes, 1 reprint, 1 map.

The following paper was read:

"The Oxidation of Cobalt Amalgam", by F. P. Dwyer, M.Sc., and J. W. Hogarth.

A short talk, entitled "Aerogels", was given by D. P. Mellor, M.Sc.

The following exhibits were shown:

"An illustration of Vernalisation, a new method of activating seeds", by J. G. Churchward.

"The essential oil of *Myoporum deserti*", by H. Finnemore, B.Sc., F.I.C.

October 2nd, 1935.

The five hundred and thirty-seventh General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Forty members were present. The minutes of the preceding meeting were read and confirmed.

The certificates of nineteen candidates for admission as ordinary members of the Society were read, fourteen for the first time and five for the second time. The following gentlemen were duly elected ordinary members of the Society: Sidney Willis England, Charles Mylne McDonald,

Cicero Augustus Reid, Albert Jordan Robinson, and Ralph Dudingston Wilson.

The following donations were received: 283 parts, 32 volumes, 1 reprint, and 1 map.

The following papers were read:

"The Essential Oils of *Eucalyptus australiana* (Baker & Smith) and its Physiological Forms. Part I", by A. R. Penfold, F.A.C.I., F.C.S., and F. R. Morrison, A.A.C.I., F.C.S.

"The Palæozoic Sediments near Bungonia. Their field relations and Graptolite Fauna", by G. F. K. Naylor, M.A., M.Sc.

A short talk on "Plant Genetics" was given by Edwin Cheel.

November 6th, 1935.

The five hundred and thirty-eighth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Sixty members were present. The minutes of the preceding meeting were read and confirmed.

The certificates of eighteen candidates for admission as ordinary members of the Society were read, four for the first time, and fourteen for the second time. The following persons were duly elected ordinary members of the Society: Michel Francois Albert, Percy Arthur Ash, Arthur Bayley, Reginald Marcus Clark, Thomas Dunbabin, Leon Macintosh Ellis, Silvanus Gladstone Evans, Roy Hamilton Goddard, Mark Howarth, Caroline Tennant Kelly, Francis Angelo Timothy Kelly, Andrew Reid, Clarence Golding Savage, and William Charles Wentworth.

The President announced that the Walter Burfitt Prize for 1935 had been awarded to Associate-Professor V. A. Bailey, M.A., D.Phil., for his research work in Physics, Radio, and the application of mathematical and statistical methods in Biology.

It was announced that Dr. W. R. Browne, D.Sc., had resigned from the position of an Honorary Secretary, and that the Council had elected Dr. C. Anderson, M.A., D.Sc., to fill this position. It was also announced that Dr. Browne had been elected as a member of the Council to fill the vacancy caused by the election of Dr. Anderson as an honorary secretary.

The following donations were received: 413 parts and 23 books.

Notice of Motion.—The President gave notice that, at the next General Meeting, he would move that certain alterations to the Rules, regarding the date of the Annual General Meeting, be made, to permit the Annual General Meeting to be held in April in 1937 and subsequently.

The following papers were read :

"The Endogenous Contact-zone of the Magnesian Limestones at Ben Bullen, N.S.W.", by Germaine A. Joplin, B.Sc., Ph.D.
"The Effect of Chemical Solutions on Some Woods", by M. B. Welch, B.Sc.
"The Birefringence of Potassium Chloropalladite and Potassium Chloroplatinite", by D. P. Mellor, M.Sc., and F. M. Quodling, B.Sc.

A symposium, entitled "A Discussion on the Upper Atmosphere" then took place, the speakers being Dr. D. F. Martyn, Ph.D., Professor O. U. Vonwiller, B.Sc., F.Inst.P., Dr. T. Iredale, D.Sc., Associate-Professor V. A. Bailey, M.A., D.Phil., Dr. J. E. Mills, M.Sc., Ph.D., and Mr. G. H. Godfrey, M.A., B.Sc.

December 4th, 1935.

The five hundred and thirty-ninth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Sixty-one members were present. The minutes of the preceding meeting were read and confirmed.

The President announced the death of Frederick Poate, F.R.A.S., L.S., who had been a member since 1881.

The certificates of nine candidates for admission as ordinary members of the Society were read, five for the first time, and four for the second time. The following gentlemen were duly elected ordinary members of the Society : Orwell Phillips, Charles Vickers Potts, Thomas G. Room, and Thomas Henry Tennant.

The Council communicated the information that a Clarke Memorial Lecture had been arranged, to be delivered by Dr. W. G. Woolnough, the date being tentatively fixed for Friday, 20th March, 1936, and the title to be "Aerial Survey as an Assistance in Geology".

The President presented to Associate-Professor Victor Albert Bailey, M.A., D.Phil., the Walter Burfitt Prize and Medal for 1935. Professor Bailey briefly thanked the Society for the honour done him in awarding him this prize.

The following donations were received: 288 parts, 7 books, and 1 calendar.

Motions from the Last Meeting.—Mr. Penfold's motion, "That certain alterations to the Rules be approved", was withdrawn.

The following papers were read:

"The Occurrence of Linalool in the Essential Oil of *Melaleuca ericifolia*", by A. R. Penfold, F.A.C.I., F.C.S., and F. R. Morrison, A.A.C.I., F.C.S.

"Notes on the Shrinkage of Wood. Part II", by M. B. Welch, B.Sc., A.I.C.

"Compounds Formed from Copper Salts and Tertiary Arsines. Part I", by G. J. Burrows, B.Sc., and E. P. Sanford, B.Sc.

"Initiation in the Bard Tribe, North-West Australia", by A. P. Elkin, M.A., Ph.D.

An exhibit of "crystalline boron" was made by D. P. Mellor, M.Sc.

At the conclusion of the meeting the President wished the members the compliments of the season. Mr. Ollé, on behalf of the members, expressed appreciation of the work done by the Council during the past year, and wished the President and Council the compliments of the season.

April 1st, 1936.

The five hundred and fortieth General Monthly Meeting was held in the Hall of Science House, Gloucester Street, at 7.45 p.m.

Mr. A. R. Penfold, President, was in the chair. Forty members were present. The minutes of the preceding meeting were read and confirmed.

The President announced the death of W. H. Crago, M.R.C.S. (Eng.), L.R.C.P. (Lond.), a member since 1886.

The certificates of seven candidates for admission as ordinary members of the Society were read, two for the first time and five for the second time. The following gentlemen were duly elected ordinary members of the Society: Archibald Howie, Stephen Laurence Leach, Harry Randall, Brother Albertus Sellenger, and Harold Wallis Wearne.

The President announced that the Clarke Memorial Medal for 1936 had been awarded by the Council to Sir Douglas Mawson, Kt., O.B.E., F.R.S., D.Sc., B.E., of the University of Adelaide.

The following donations were received: 117 books and 1,056 parts.

The following papers were read :

"A Bacterial Disease of Snake Beans", by R. D. Wilson, B.Sc.Agr.

"Cyanogenetic Glucosides in Australian Plants. Part III. *Eucalyptus cladocalyx*", by H. Finnemore, B.Sc., F.I.C., Miss S. K. Reichard, B.Sc., and Miss D. K. Large, B.Sc.

"On a New Reaction for the Determination of Creatinine", by Adolph Bolliger, Ph.D.

A short talk, entitled "Ergot in Paspalum", was given by R. J. Noble, M.Sc., Ph.D., B.Sc.Agr.

A demonstration of "The Presence of Alkaloids in the Ergot of Paspalum" was given by H. Finnemore, B.Sc., F.I.C.

ABSTRACT OF PROCEEDINGS OF THE SECTION OF INDUSTRY.

OFFICERS :

Chairman : A. D. Ollé, F.C.S., A.A.C.I.

Hon. Secretary : E. G. Bishop.

A number of industrial and other establishments were visited during the year, and the management in every case went to considerable trouble in explaining their processes and entertaining the visitors. The following places were visited :

Tuesday, 21st May.—Deaf Aids Ltd., Watson House, Bligh Street, Sydney.

Tuesday, 11th June.—Bradford, Kendall Ltd., 340 Botany Road, Alexandria.

Tuesday, 9th July.—Metters Ltd., Alexandria.

Tuesday, 13th August.—Goodyear Tyre and Rubber Co. (Australia) Ltd., Granville.

Tuesday, 10th September.—Taronga Zoological Gardens, Mosman.

Tuesday, 8th October.—Colonial Sugar Refining Co. Ltd., Bowman Street, Pyrmont.

Tuesday, 12th November.—Slazengers (Australia) Ltd., 496-512 Crown Street, Sydney.

ABSTRACT OF PROCEEDINGS
OF THE SECTION OF
GEOLOGY.

OFFICERS :

Chairman : Dr. C. Anderson.

Hon. Secretaries : Dr. G. D. Osborne and Mr. R. O. Chalmers.

Eight meetings were held during the year, the average attendance being eleven members and ten visitors.

Dr. C. Anderson was elected Chairman, and Dr. G. D. Osborne and Mr. R. O. Chalmers were elected Hon. Secretaries for the year 1935.

April 26th.—Mr. C. A. Sussmilch addressed the Section on "The Cainozoic Volcanic Rocks of Victoria, with special reference to the Western District." Exhibits : By Miss F. M. Quodling and Dr. G. D. Osborne : Comprehensive set of specimens from the Western District of Victoria to illustrate the address.

May 17th.—Exhibits : (1) By Miss F. M. Quodling : Crystals of selenite from Tertiary sediments, Balcombe Bay, Victoria, showing interesting habit variation. Some crystals were strongly flattened parallel to (001), and some twinned on $(\bar{1}03)$. (2) By Mr. R. O. Chalmers : (*a*) Rutilated quartz from Tingha, N.S.W. (*b*) Tobacco tin, encrusted by iron oxide, from Sawtell Ck., North Coast, N.S.W. (3) By Mr. G. F. K. Naylor : (*a*) Hydroid ancestors of graptolites from Lancefield District, Victoria, formation being Upper Mid-Cambrian. (*b*) Graptolites from the base of Lower Ordovician, 30 miles N.W. of Melbourne. (*c*) Typical Lower Silurian graptolites from three miles west of Bungonia on road to Goulburn. (4) By Mr. L. L. Waterhouse : (*a*) Collapsed brick made from pyritic shale, Thornleigh Brick Works. (*b*) Pyritic shale (Wianamatta) used in making of the bricks. (*c*) Vesicular glassy olivine basalt, from Rabaul. (*d*) Actinolite schist which is the country of low-grade copper ore, and represents a metamorphosed impure limestone. Locality, Cow Flat, near Bathurst. (*e*) Malachitic and azuritic gossan, also cupriferous iron pyrites from Cow Flat Copper Mine. (*f*) Pebbles of "Older" basalt cemented by Bryozoal Miocene limestone from "The Clyde",

Russell's Bridge, Moorabool River, Victoria. (5) By Dr. G. D. Osborne: Comprehensive suite of mica specimens from Central Australia, Madagascar, India, Africa and Canada. Also "Micanite", used in the electrical industry.

June 21st.—Mr. H. G. Raggatt addressed the Section on "Recent Investigations in the N.W. Division of Western Australia, with special reference to the stratigraphy of the Kamilaroi System".

July 19th.—Exhibit: By Dr. G. D. Osborne: Geode in dolerite from Prospect, N.S.W., the constituents comprising analcite, quartz, and a colloidal mass consisting of sodium, silica, aluminium, and water, thus probably being of analcitic composition.

Discussion: Subject, "Intrusive Tuffs". This was opened by Professor L. A. Cotton, and continued by Professor Browne. Drs. Anderson and Osborne, and Messrs. Naylor, Sussmilch, Andrews, Raggatt and Chalmers.

August 23rd.—Exhibits: By Prof. W. R. Browne: (*a*) Hawkesbury sandstone with inclusion of phyllite from Woronora River. (*b*) Recent sandstone with pumice fragments from a bench a little above sea-level at Garie Beach. (*c*) (Collected by Major Booth) pisolitic iron ore underlying basalt with lignite forming the nuclei, from Mittagong.

Discussion: Subject, "Earth movements and sedimentation in N.S.W. from the close of the Silurian to the close of the Palæozoic, with special reference to the development of geosynclinal conditions in the eastern part of the State". This was opened by Dr. G. D. Osborne and continued by Dr. Brown, Professor Browne, Dr. Walkom, and Mr. Andrews.

September 20th.—Exhibits: (1) By Dr. C. Anderson: Large fossil insect wing in beautiful state of preservation, from Brookvale, N.S.W. (2) By Mr. W. E. Clark: (*a*) Fossil seed-pod in laterite underlying Tertiary basalt, from Armidale. (*b*) Tertiary conglomeratic ironstone containing large fossil leaves of late Tertiary age. Locality, Armidale. (*c*) "Grey Billy" with fossilised rootlets from underneath basalt in Armidale district. (3) By Dr. G. D. Osborne: Radial aggregates of molybdenite from Cairns District, Queensland. Mr. C. A. Sussmilch gave a brief address on the Canoblas District, near Orange.

October 18th.—Dr. Germaine A. Joplin addressed the Section on "The Ring-Dyke Complexes of Ardnamurchan, Scotland", illustrating her remarks by an excellent model showing the geology and physiography of the Ardnamurchan Peninsula. Mr. G. A. V. Stanley read a letter recently received from New Guinea giving an account of a very severe earthquake which occurred in the Torricelli Ranges on September 20th.

November 15th.—Exhibits: (1) By Mr. W. E. Clark: Lignite with fossil resin in portion of 40 ft. log from Tertiary Deep Lead, 40 miles N.E. Armidale. (2) By R. O. Chalmers and G. F. K. Naylor: Photographs of peculiar bare ring-like structures observed on the ground in the neighbourhood of Bylong, N.S.W. Mr. E. C. Andrews addressed the Section on "Some Fundamental Conceptions Concerning Geosynclines".

ABSTRACT OF PROCEEDINGS
OF THE SECTION OF
PHYSICAL SCIENCE.

OFFICERS :

Chairman : Assistant-Professor G. H. Briggs.

Hon. Secretary : W. H. Love, B.Sc., Ph.D.

Ten meetings were held during 1935.

April 10th.—"Our Recent European Experiences of Interaction of Radio Waves", by Professor and Mrs. V. A. Bailey.

May 1st.—"The Pulse Method of Ionospheric Investigation", by O. O. Pulley, B.Sc., B.E., Ph.D.

May 8th.—"Methods of Investigation of Atmospherics", by G. H. Munro, M.Sc., A.M.I.E.E.

June 26th.—"The Absolute Velocities of β Particles from Radium B+C", by A. Harper, B.Sc.

July 3rd.—(1) "A Note on the Absolute Determination of the Ampère", by Dr. G. H. Briggs. (2) "The Influence of the Radiation Field of a Lightning Flash on the Ionosphere", by R. H. Healey, M.Sc.

July 17th.—(1) "Applications of Negative Resistances", by R. E. B. Makinson, B.Sc. (2) "Demonstration of a Method of Obtaining Response Curves of Radio Receivers by Means of the Cathode Ray", by W. G. Gordon, B.Sc.

August 7th.—"A New Basis for Electrodynamics", by R. E. B. Makinson, B.Sc.

September 18th.—"Temperature Effects in the Upper Atmosphere", by D. F. Martyn, Ph.D.

October 9th (at the Works of Amalgamated Wireless (Australasia) Ltd., Ashfield, at 8 p.m.).—"Frequency Control with Piezo-electric Crystals", by G. Builder, Ph.D. This address was followed by an inspection of the laboratories.

October 16th.—"The Search for Invariants in Geometry", by Professor T. G. Room.

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