JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1920.

VOL. LIV.

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

SYDNEY
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET, SYDNEY.

1920

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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 of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. × $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

ERRATA.

Page 54, line 20, for *germination*, read *gemmation*.
,, 56, line 14, for *Petrificate Derbiencia*, read *Petrificata Derbiensia*.
,, 60, line 28, for *lateseptatum*, read *latiseptatum*.
,, 62, line 27, for *helotype*, read *holotype*.
,, 124, line 33, for *assimulation*, read *assimilation*.
,, 131, in analysis (A), for MgO 2·12, read MgO 9·12.
,, 132, line 1, for 70·56%, read 70·36%.
,, 133. line 12, for *bastite*, read *enstatite*.
,, 137, Total for Norm of (A), for 100·09, read 100·03.
,, 154, line 30, for *areole*, read *areola*.
,, 191, line 11, for Fig. 2, read Fig. 3.

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

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

Vol.	I	Transactions of the Royal Society, N.S.W.,	1867,	pp. 83,	,,
,,	II	,, ,, ,, ,, ,,	1868,	,, 120,	,,
,,	III	,, ,, ,, ,, ,,	1869,	,, 173,	,,
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,,	XI	,, ,, ,, ,, ,,	1877,	,, 305,	,,
,,	XII	Journal and Proceedings ,, ,,	1878,	,, 324,	price 10s.6d.
,,	XIII	,, ,, ,, ,, ,,	1879,	,, 255,	,,
,,	XIV	,, ,, ,, ,, ,,	1880,	,, 391,	,,
,,	XV	,, ,, ,, ,, ,,	1881,	,, 440,	,,
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,,	XXVII	,, ,, ,, ,, ,,	1893,	,, 530,	,,
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,,	XXX	,, ,, ,, ,, ,,	1896,	,, 568,	,,
,,	XXXI	,, ,, ,, ,, ,,	1897,	,, 626,	,,
,,	XXXII	,, ,, ,, ,, ,,	1898,	,, 476,	,,
,,	XXXIII	,, ,, ,, ,, ,,	1899,	,, 400,	,,
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,,	LII	,, ,, ,, ,, ,,	1918,	,, 624,	,,
,,	LIII	,, ,, ,, ,, ,,	1919,	,, 414,	,,
,,	LIV	,, ,, ,, ,, ,,	1920,	,, 312,	price £1 1s.

Royal Society of New South Wales.

OFFICERS FOR 1920-1921.

Patron:
HIS EXCELLENCY THE RIGHT HONOURABLE HENRY WILLIAM, BARON FORSTER, P.C., K.C.M.G.
Governor-General of the Commonwealth of Australia.

Vice-Patron:
HIS EXCELLENCY SIR WALTER EDWARD DAVIDSON, K.C.M.G.
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H. G. SMITH, F.C.S.
C. A. SUSSMILCH, F.G.S.
J. VICARS, M.E.
Prof. W. H. WARREN, LL.D., WH.Sc.

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.*]

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 Transactions or 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; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1877	P 5	Abbott, W. E., 'Abbotsford,' Wingen.
1918		Adam, George Hyslop, 'Lintrose,' Warren Road, Marrickville.
1904		Adams, William John, M. I. MECH. E., 175 Clarence-street.
1898		Alexander, Frank Lee, William-street, Granville.
1905	P 2	Anderson, Charles, M.A., D.Sc. *Edin.*, Director of the Australian Museum, College-street.
1919		Anderson, Robert Gladstone, c/o Chas. Anderson & Co., Ltd., Albion-street, Surry Hills.
1909	P 8	Andrews, Ernest C., B.A., F.G.S., Government Geologist, Department of Mines, Sydney.
1915		Armit, Henry William, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, B.M.A. Building, Elizabeth-street.
1919		Aurousseau, Marcel, B.Sc., Department of Geology, University of Western Australia, Perth, W.A.
1878		Backhouse, His Honour Judge A. P., M.A., 'Melita,' Elizabeth Bay.
1919		Baker, Henry Herbert, 15 Castlereagh-street.
1894	P 26	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1919		Bardsley, John Ralph, "The Pines," Lea Avenue, Five Dock.
1896		Barff, H. E., M.A., Warden of the University of Sydney.
1908	P 1	Barling, John, L.S., 'St. Adrians,' Raglan-street, Mosman.
1918		Barr, Robert Hamilton, Australasia Chambers, 2 Martin Place.
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; p.r. 'Marmion,' Victoria-street, Lewisham.
1894		Baxter, William Howe, L.S., Chief Surveyor, Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1919		Benjamin, David, c/o Sweet Bros., King-street, Newtown.
1909	P 2	Benson, William Noel, D.Sc. *Syd.*, B.A. *Cantab.*, F.G.S., Professor of Geology in the University of Otago, Dunedin, N.Z.
1919		Bettley-Cooke, Hubert Vernon, 225 Castlereagh-street.

Elected		
1916		Birrell, Septimus, "Florella," Dunslaffnace-st., Hurlstone Park.
1929		Bishop, Eldred George, Belmont-street, Mosman.
1915		Bishop, John, 24 Bond-street.
1913		Bishop, Joseph Eldred, Killarney-street, Mosman.
1905		Blakemore, George Henry, 4 Bridge-street.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L R.C.P. *Lond.*, 'Gundaroo,' Wallaroy Road, Double Bay.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1898		Blunno, Michele, Licentiate in Science (Rome), 'Havilah,' No. 1, Darlinghurst Road, Darlinghurst.
1907		Bogenrieder, Charles, M.A., No. 2 Little's Avenue, Balmain.
1879		‡Bond, Albert, 64 Wentworth Court, Elizabeth-street.
1917		Bond, Robert Henry, 'Elfindale,' Croydon Avenue, Croydon Pk.
1920		Booth, Edgar Harold, B.Sc.. Lecturer and Demonstrator in Physics in the University of Sydney.
1910		Bradley, Clement Henry Burton, M.B., Ch.M., D.P.H., 'Nedra,' Little-street, Longueville.
1876		Brady, Andrew John, L.K. and Q.C.P. *Irel.*, L.R.C.S. *Irel.*, 175 Macquarie-street, Sydney.
1916		Bragg, James Wood, B.A., c/o Gibson, Battle &Co. Ltd.,Kent-st.
1917		Breakwell, Ernest, B.A., B.Sc., Government Agrostologist, Botanic Gardens, Sydney.
1891		Brennand, Henry J. W., B.A., M.B., Ch.M. *Syd.*, 203 Macquarie-street; p.r. 'Wobun,' 310 Miller-steet, North Sydney.
1919		Bretnall, Reginald Wheeler, The Australian Museum, Sydney.
1919		Briggs, George Henry, B.Sc., Lecturer and Demonstrator in Physics in the University of Sydney.
1914		Broad, Edmund F., 'Cobbam,' Woolwich Road, Hunter's Hill.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Aberdour,' Daniel-street, Granville.
1913	P 1	Browne, William Rowan, B.Sc., Lecturer and Demonstrator in Geology in the University of Sydney.
1898		‡Burfitt, W. Fitzmaurice, B.A., B.Sc., M.B., Ch.M. *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1890		Burne, Alfred, D.D.S., Buckland Chambers, 183 Liverpool-st.
1919	P 2	Burrows, George Joseph, Lecturer and Demonstrator in Chemistry in the University of Sydney; p.r. Watson-street, Neutral Bay.
1907		Burrows, Thomas Edward, M. INST. C.E., L.S., Metropolitan Engineer, Public Works Department; p.r. 'Balboa,' Fern-street, Randwick.
1909		Calvert, Thomas Copley, ASSOC. M. INST. C.E., Department of Public Works, Sydney.
1904	P 17	Cambage, Richard Hind, L.S., F.L.S., Under Secretary for Mines, Department of Mines, Sydney; p.r. Park Road, Burwood. (President 1912). *Hon. Secretary.*
1907		Campbell, Alfred W., M.D., Ch.M. *Edin.*, 183 Macquarie-street.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliff Road, Edgecliff.
1897	P 4	Cardew, John Haydon, M. INST. C.E., L.S., Commercial Bank of Australia Chambers, George and Margaret-streets.
1920		Carleton, George Brabason, B.E. *Syd.*, ASSOC. M. INST. C.E., Public Works Department, Sydney.

Elected		
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F.F.A., *Scot.*, 4 Whaling Road, North Sydney.
1909		Carne, Joseph Edmund, F.G.S., 'Dimlands,' Dickson-street, Homebush.
1920		Carruthers, Sir Joseph Hector, M.L.C., M.A. *Syd.*, LL.D. *St. And.* Scotland, 'Highbury,' Waverley.
1903	P 3	Carslaw, Horatio S., M.A., Sc. D., Professor of Mathematics in the University of Sydney.
1913	P 3	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 2	Chapman, Henry G., M.D., B.S., Professor of Physiology in the University of Sydney. *Hon. Treasurer.*
1913	P 10	Cheel, Edwin, Botanical Assistant, Botanic Gardens, Sydney.
1909	P 20	Cleland, John Burton, M.D., Ch.M., Professor of Pathology in the University of Adelaide. (President 1917.)
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.* and *Edin*, 'Roseneath,' 8 Wallis-street, Woollahra.
1906		Colley, David John K., 'Kaskie,' Abbey-street, Leura.
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. INST. C.E., Burroway-street Neutral Bay.
1920		Cooke, Frederick, c/o Meggitt's Limited, Parramatta.
1913	P 1	Cooke, William Ernest, M.A., F.R.A.S., Government Astronomer and Professor of Astronomy in the University of Sydney, The Observatory, Sydney.
1904	P 2	Cooksey, Thomas, Ph.D., B.Sc. *Lond.*, F.I.C., Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman.
1913		Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. 55 Willoughby Road, North Sydney.
1882		Cornwell, Samuel, J.P., Brunswick Road, Tyagarah.
1919		Cotton, Frank Stanley, B.Sc, Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 3	Cotton, Leo Arthur, M.A., D.Sc., Assistant Professor of Geology in the University of Sydney.
1919		Cowdery, Edward Henry, L.S., 6 Castlereagh-street, Sydney.
1892	P 1	Cowdery, George R., ASSOC. M. INST. C.E., Blashki Buildings, Hunter-st.; p.r. 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 185 Macquarie-st.
1912		Curtis, Louis Albert, L.S., 'Redlands,' Union-street, Mosman.
1920		Danes, Jiri Victor, Ph.D. *Prague*, 40 Bayswater Road, Darlinghurst.
1875		Dangar, Fred. H., c/o W. G. Deuchar, Loftus-street.
1890		Dare, Henry Harvey, M.E., M. INST. C.E., Commissioner, Water Conservation and Irrigation Commission, Union House, George-street.
1876	P 3	Darley, Cecil West, M. INST. C.E., Australian Club, Sydney.
1910	P 1	Darnell-Smith, George Percy, D.Sc., F.I.C., F.C.S., Department of Agriculture, Sydney.
1886	P 22	David, Sir Edgeworth, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., Professor of Geology and Physical Geography in the University of Sydney. (President 1895, 1910.) *Vice-President.*

Elected		
1885	P 3	Deane, Henry, M.A., M. INST. C.E., F.L.S., F.R. MET. SOC., F.R.H.S., 'Campsie,' 14 Mercer Road, Malvern, Victoria. (President 1897, 1907.)
1919		de Beuzeville, Wilfrid Alex. Watt, Forestry Assessor, Forest Office, Tumbarumba.
1894		Dick, James Adam, C.M.G., B.A. *Syd.*, M.D., Ch.M., F.R.C.S. *Edin.*, 'Catfoss,' Belmore Road, Randwick.
1915	P 1	Dick, Thomas, J.P., Port Macquarie.
1916		Dixon, Jacob Robert L., M.R.C.S., L.R.C.P., Demonstrator in Physiology in the University of Sydney.
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
1876		Docker, His Honour Judge E. B., M.A., 'Mostyn,' Billyard Avenue, Elizabeth Bay.
1913		Dodd, Sydney, D.V.Sc., F.R.C.V.S., Lecturer in Veterinary Pathology in the University of Sydney.
1913	P 2	Doherty, William M., F.I.C., F.C.S., Second Government Analyst, 'Jesmond,' George-street, Marrickville.
1920		Downing, Reginald George, B.Sc., (Agr.) Field Branch, Department of Agriculture, Sydney.
1908	P 4	Dun, William S., Palæontologist, Department of Mines, Sydney. (President 1918.) *Vice-President.*
1919		Earp, George Frederick, C.B.E., M.L.C., 8 Spring-street.
1918		Elliott, Edward, c/o Reckitts' (Oversea) Ltd., Bourke-street, Redfern.
1916	P 2	Enright, Walter J., B.A., High-street, West Maitland, N.S.W.
1908		Esdaile, Edward William, 54 Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, c/o Iceton, Faithfull and Maddocks, 25 O'Connell-street.
1902		Faithfull, William Percy, 'The Monastery,' Kurraba Road, Neutral Bay.
1910		Farrell, John, Riverina Flats, 265 Palmer-street, Sydney.
1909	P 5	Fawsitt, Charles Edward, D.Sc., Ph.D., Professor of Chemistry in the University of Sydney. (President 1919).
1920		Ferguson, Eustace William, M.B., Ch.M., 'Timbrabongie,' Gordon Road, Roseville.
1881		Fiaschi, Thos., M.D., M.Ch. *Pisa*, 'Beanbah,' 235 Macquarie-st.
1920		Fisk, Ernest Thomas, Wireless House, 97 Clarence-street.
1888		Fitzhardinge, His Honour Judge G. H., M.A., 'Red Hill,' Beecroft.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'Wyoming,' Macquarie-street.
1920		Fortescue, Albert John, 'Benambra,' Loftus-street, Arncliffe.
1905		Foy, Mark, Elizabeth and Liverpool-streets.
1904		Fraser, James, C.M.G., M. INST. C.E., Chief Commissioner for Railways, Bridge-street; p.r. 'Arnprior,' Neutral Bay.
1907		Freeman, William, c/o A. Freeman, Byron Arcade, Inverell.
1899		French, Sir J. Russell, K.B.E., General Manager, Bank of New South Wales, George-street.
1881		Furber, T. F., F.R.A.S., L.S., c/o Dr. R. I. Furber, 'Sunnyside,' Stanmore Road, Stanmore.

Elected		
1917		Galbraith, Augustus Wm., C.E., City Engineer, Perth, W.A.
1918		Gallagher, James Laurence, B.A. *Syd.*, Unwin's Bridge Road, Marrickville.
1920		Gilbert, Sydney Joseph, M.R.C.V.S.,
1897		Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.
1916		Green, Victor Herbert, 7 O'Connell-street, Sydney.
1899	P 1	Greig-Smith, R., D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay. (President 1915.)
1912		Grieve, Robert Henry, B.A., 'Langtoft,' Llandaff-st., Waverley.
1912		Griffiths, F. Guy, B.A., M.D., Ch M., 'Woolgan,' Lane Cove Road, Killara.
1919		Grutzmacher, Frederick Lyle, Church of England Grammar School, North Sydney.
1891	P 16	Guthrie, Frederick B., F.I.C., F.C.S., Department of Agriculture, 137 George-street. (President 1903).
1919		Hack, Clement Alfred, Collins House, 360 Collins-street, Melbourne.
1880	P 4	Halligan, Gerald H., L.S., F.G.S., Avenue Road, Hunter's Hill.
1912		Hallmann, E. F., B.Sc., 75 Hereford-street, Forest Lodge.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1919		Hamblin, Charles Oswald, B.Sc., Department of Agriculture, Sydney.
1919		Hambridge, Frank, 58 Pitt-street.
1916	P 1	Hamilton, Arthur Andrew, 'The Ferns,' 17 Thomas-st., Ashfield
1912		Hamilton, Alexander G., 'Tanandra,' Hercules-st., Chatswood.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; 'Glendowan,' Glenbrook, Blue Mountains. B.M.A. Building, 30 Elizabeth-st. (President 1899, 1908).
1909		Hammond, Walter L., B.Sc., High School, Broken Hill.
1919		Hardie, Robert Walter, J.P., 'Coombe-Martin,' Park Road, Burwood.
1916		Hardy, Victor Lawson, 'The Laurel,' 43 Toxteth Rd., Glebe Pt.
1912		Hare, Arthur J., Under Secretary for Lands, 'Booloorool,' Monte Christo-street, Woolwich.
1905	P 3	Harker, George, D.Sc., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1913	P 1	Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1919		Harrison, Launcelot, B.Sc., *Syd.*, B.A. *Cantab.*, Lecturer and Demonstrator in Zoology in the University of Sydney.
1918		Hassan, Alex. Richard Roby, c/o W. Angliss & Co. Ppty. Ltd., 64 West Smithfield, London, E.C.
1884	P 1	Haswell, William Aitcheson, M.A., D.Sc., F.R.S., Emeritus Professor of Zoology and Comparative Anatomy in the University of Sydney; p.r. 'Mimihau,' Woollahra Point.
1919		Hay, Alexander, M.H.R., Coolangatta, N.S.W.
1916		Hay Dalrymple-, Richard T., L.S., Chief Commissioner of Forests, N. S. Wales; p.r. Goodchap Road, Chatswood.
1914		Hector, Alex. Burnet, 481 Kent-street.

Elected.		
1891	P 3	Hedley, Charles, F. L. S., Australian Museum, Sydney. (President 1914.)
1899		Henderson, James, F.R.E.S., 'Wahnfried,' Drummoyne.
1916		Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.
1919		Henriques, Frederick Lester, 56 Clarence-street.
1919		Henry, Max, D.S.O., B.V.Sc., M.R.C.V.S., 'Coram Cottage,' Essex-street, Epping.
1884	P 1	Henson, Joshua B., ASSOC. M. INST. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1918		Hindmarsh, Percival, M.A., Teachers' College, The University, Sydney.
1920		Hinds, Herbert Henry, 484 Kent-street, Sydney.
1916		Hoggan, Henry James, 'Lincluden,' Frederick-st., Rockdale.
1901		Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.
1905	P 3	Hooper, George, Assistant Superintendent, Sydney Technical College; p.r. 'Branksome,' Henson-street, Summer Hill.
1920		Hordern, Anthony, c/o Messrs. A. Hordern & Sons Ltd, Brickfield Hill.
1919		Horsfall, William Nichols, M.B., B.S. *Melb.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1919		Hoskins, Arthur Sidney, Eskroy Park, Bowenfels.
1919		Hoskins, Cecil Harold, Windarra, Bowenfels.
1891		Houghton, Thos. Harry, M. INST. C.E., M.I. MECH. E., 63 Pitt-st. (President 1916), *Vice-President.*
1919		Houston, Ralph Liddle, 'Noorong,' Cooper-street, Strathfield.
1906		Howle, Walter Cresswell, L.S.A. *Lond.*, 'Lugano,' 244 Military Road, Mosman.
1913		Hudson, G. Inglis, J.P., F.C.S., 'Gudvangen,' Arden-st., Coogee.
1920		Hulle, Edward William, Commonwealth Bank of Australia.
1919		Hunt, Charles James, B.A., Trinity Grammar School, Dulwich Hill.
1917		Hurse, Alfred Edward, A.M.I.C.E., Dumbuck Hotel, near Dumbarton, Scotland.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines, Sydney.
1917		Jenkins, Richard Ford, Engineer for Boring, Irrigation Commission, 6 Union-street, Mosman.
1905	P 8	Jensen, Harold Ingemann, D.Sc., Treasury Chambers, George-street, Brisbane.
1918		Johns, Morgan Jones, A.M.I.E.E. *Lond*, M.I.E. *Aust.*, M.I.M. *Aust.*, Mount Morgan Gold Mining Co., Mount Morgan, Queensl'd.
1916	P 1	Johnston, Stephen Jason, B.A., D.Sc., Professor of Zoology in the University of Sydney.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., F.L.S., C.M.Z.S., Professor of Biology in the University of Queensland, Brisbane.
1911		Julius, George A., B.Sc., M.E., M.I. MECH. E., Culwulla Chambers, Castlereagh-street, Sydney.

Elected		
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.
1873	P 4	Keele, Thomas William, L.S., M. INST. C.E., Commissioner, Sydney Harbour Trust, Circular Quay; p.r. Llandaff-st., Waverley,
1914		Kemp, William E., A.M. INST. C.E., Public Works Department. Coff's Harbour Jetty.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, 58 Pitt-st.
1919	P 1	Kesteven, Hereward Leighton, D.Sc., M.D., Ch.M., Bulladelah, New South Wales.
1901		Kidd, Hector, M. INST. C.E., M. I. MECH. E., Cremorne Road, Cremorne.
1896		King, Kelso, 14 Martin Place.
1920		Kirchner, William John, B.Sc., 'Clyde,' Cavendish-street, Concord West.
1919		Kirk, Robert Newby, 25 O'Connell-street.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 'Maibenbrook,' Longueville Road, Longueville.
1881	P 23	Knibbs, G. H., C.M.G., F.S.S., F.R.A.S., L.S., Member Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; Commonwealth Statistician, Melbourne, 'Rialto,' Collins-st., Melbourne. (President 1898.)
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1911	P 3	Laseron, Charles Francis, Technological Museum.
1913		Lawson, A. Anstruther, D.Sc., F.R.S.E., F.L.S., Professor of Botany in the University of Sydney.
1906		Lee, Alfred. 'Glen Roona,' Penkivil-street, Bondi.
1920		Le Souef, Albert Sherbourne, Taronga Park, Mosman.
1916		L'Estrange, Walter William, 55 Albert Road, Homebush.
1909		Leverrier, Frank, B.A., B.Sc., K.C., 182 Phillip-street.
1883		Lingen, J. T., M.A. *Cantab.*, K.C., University Chambers, 167 Phillip-street, Sydney.
1906		Loney, Charles Augustus Luxton, M. AM. SOC. REFR. E., Equitable Building, George-street.
1884		MacCormick, Sir Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street.
1887		MacCulloch, Stanhope H., M.B., Ch.M. *Edin.*, 24 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co., Ld., Hunter-street, Sydney.
1876		Mackellar, The Hon. Sir Charles Kinnaird, K.C.M.G., M.L.C., M.B., C.M. *Glas.*, 183 Liverpool-street, Hyde Park, Sydney.
1903		McDonald, Robert, J.P., L.S., Pastoral Chambers, O'Connell-st.; p.r. 'Lowlands,' William-street, Double Bay,
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.S. *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1920		McDowall, James Campbell, B.Sc., *N Z.*, 264 Botany Road, Alexandria.
1919		McGeachie, Duncan, 'Craig Royston,' Toronto, Lake Macquarie.
1919		McGlynn, William Henry, 'Wybara,' Doncaster Avenue, South Kensington.

Elected		
1906		McIntosh. Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., M. INST. C.E., Commonwealth Engineer for Wheat Storage. 'Rialto,' Collins-street Melbourne.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. INST. C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.
1917		McLean, Archibald Lang, M.D., Ch.M., B.A.. 'Gartfern,' North Abbotsford.
1901	P 1	McMaster, Colin J., L.S., Chief Commissioner of Western Lands; Box 20, G.P.O. Sydney.
1894		McMillan, Sir William, K.C.M.G., 281 Edgecliff Road, Woollahra ; 79 York-street.
1916		McQuiggin, Harold G., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 'Berolyn,' Beaufort-street, Croydon.
1909		Madsen, John Percival Vissing, D.Sc., B.E., Professor of Electrical Engineering in the University of Sydney.
1883	P 42	Maiden J. Henry, J.P., I.S.O., F.R.S., F.L.S., F.R.H.S., Hon. Fellow Roy. Soc. S.A.; Hon. Memb. Roy. Soc, W.A.; Netherlands Soc.for Promotion of Industry; Philadelphia College Pharm. Southern Californian Academy of Sciences; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Society Great Britain; Bot. Soc. Edin.; Soc. Nat. de Agricultura (Chile); Soc. d'Horticulture d'Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc. Tas.; Roy. Soc. Queensl.; Inst. Nat. Genévois; Hon. Vice-Pres. of the Forestry Society of California; Diplomé of the Société Nationale d'Acclimatation de France; Linnean Medallist, Linnean Society; N.S.W. Govt. Rep. of the "Commission Consultative pour la Protection Internat. de la Nature"; Corr. Memb. National Acclimatisation Society of France; Government Botanist and Director, Botanic Gardens, Sydney. (President 1896, 1911.) *Vice-President.*
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1920		Mann, Cecil William, 116 Crown-street, Darlinghurst.
1920		Mann, James Elliott Furneaux, Barrister at Law, 163 Phillip-street.
1908		Marshall, Frank, C.M.G., B.D.S., 141 Elizabeth-street.
1914		Martin, A. H., Technical College, Sydney.
1919		Martin, Robert, M.B., Ch.M. *Syd.*, Assistant Medical Officer, Mental Hospital, Gladesville.
1912		Meldrum, Henry John, p.r. 'Craig Roy,' Sydney Rd., Manly.
1905		Miller, James Edward, Albury, New South Wales.
1889	P 8	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Union Club, Sydney.
1879		Mullins, John Francis Lane, M.A. *Syd.*, M.L.C., 'Killountan,' Darling Point.
1915		Murphy. R. K., Dr. Ing., Chem. Eng., Lecturer in Chemistry, Technical College, Sydney.
1893	P 3	Nangle, James, O.B.E., F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; p.r. 'St. Elmo,' Tupper-street, Marrickville. *President.*

Elected

1917 Nash, Norman C., 'Ruanora,' Lucas Road, Burwood,
1891 ‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
1920 Noble, Robert Jackson, B.Sc., (Agr), 'Arleston,' Wallace-street, Burwood.

1919 Oakden, Frank, C.E., 33 Hunter-street.
1903 ‡Old, Richard, 'Waverton,' Bay Road, North Sydney.
1913 Ollé, A. D., F.C.S., 'Kareema,' Charlotte-street, Ashfield.
1896 Onslow, Col. James William Macarthur, B.A., LL.B., 'Gilbulla,' Menangle.
1919 Oram, Hector, 24 Upper Bay View-street, Lavender Bay, North Sydney.
1917 Ormsby, Irwin, 'Caleula,' Allison Road, Randwick.
1891 Osborn. A. F., ASSOC. M. INST. C.E., Water Supply Branch, Sydney, 'Uplands,' Meadow Bank, N.S.W.

1920 Paine, William Horace, State Abattoirs, Homebush Bay, N.S.W.
1880 Palmer. Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1920 P 2 Penfold, Arthur Ramon, Technological Museum, Harris-street, Ultimo.
1899 Peterson, T. Tyndall, F.C.P.A., E.S. & A. Bank Building, King and George-streets.
1918 Petrie, James Matthew, D.Sc., F.I.C., Research Fellow of the Linnean Society in Biochemistry, The University, Sydney.
1909 P 2 Pigot, Rev. Edward F., S.J., B.A., M.B. *Dub.*, Director of the Seismological Observatory, St. Ignatius' College, Riverview.
1879 P 8 Pittman, Edward F., ASSOC. R.S.M., L.S., 'The Oaks,' 65 Park-street, South Yarra, Victoria.
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.*, 225 Macquarie-street.
1887 P 12 Pollock, J. A., D.Sc., F.R.S., Corr. Memb. Roy. Soc. Tasmania; Roy. Soc. Queensland; Professor of Physics in the University of Sydney. *Hon. Secretary.*
1917 Poole, William, B.E., A.M. INST. C.E., L.S., 906 Culwulla Chambers, Castlereagh-street.
1896 Pope, Roland James, B.A., *Syd.*, M.D., C.M., F.R.C.S., *Edin.*, 183 Macquarie-street.
1910 Potts, Henry William, F.L.S., F.C.S., c/o Lindley Walker & Co., Ltd., Mark Lane, Sussex-street, Sydney.
1918 Powell, John, 170-2 Palmer-street.
1919 Pratten, Herbert E., Senator, 26 Jamieson-street.
1918 Priestley, Henry, B.Sc., M.D., Ch. M., Associate Professor of Physiology in the University of Sydney.
1914 Purdy, John Smith, D.S.O., M.D., C.M. *Aberd.*, D.P.H. *Camb.*, Metropolitan Medical Officer of Health, Town Hall, Sydney.
1893 Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 193 Macquarie-street.

Elected		
1876	P 1	Quaife, F. H., M.A., M.D., M.S., 'Yirrimbirri,' Stanhope Road, Killara.
1912	P 2	Radcliff, Sidney, F.C.S., B.M.A. Building, 30 Elizabeth-street.
1919		Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University.
1916	P 1	Read, John, M.A., Ph.D., B.Sc., Professor of Organic Chemistry in the University of Sydney.
1909		Reid, David, 'Holmsdale,' Pymble.
1914		Rhodes, Thomas, 'High Coombe,' Carlingford.
1920		Richardson, John James, A.M.I.E.E. *Lond.*, 'Kurrawyba,' Upper Spit Road, Mosman.
1915		Ross, A. Clunies, B.Sc., c/o G. R. W. McDonald, 32 Elizabeth-st.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 155 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1897		Russell, Harry Ambrose, B.A., c/o Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, ASSOC. M. INST. C.E., L.S., 12 Castlereagh-street.
1915		Sach, A. J., F.C.S., 'Kelvedon,' North Road, Ryde.
1919		Sandy, James Montague, 'Blenheim,' Minna-street, Burwood.
1917		Sawkins, Dansie T., M.A., "Brymedura,' Kissing Point Road, Turramurra.
1920		Sawyer, Basil, B.E. The Clyde Engineering Co., Granville.
1920		Scammell, Rupert Boswood, B.Sc., *Syd.*, 18 Middle Head Road, Mosman.
1913		Scammell, W. J., Mem. Pharm. Soc. *Grt. Brit.*, 18 Middle Head Road, Mosman.
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., Assistant Professor of Chemistry in the University of Sydney.
1919		Sear, Walter George Lane, 14 Roslyndale Avenue, Woollahra.
1904	P 1	Sellors, Richard P., B.A. *Syd.*, 'Mayfield,' Wentworthville.
1918		Sevier, Harry Brown, c/o Lewis Berger and Sons (Aust.) Ltd., 16 Young-street.
1883	P 4	Shellshear, Walter, M. INST. C.E., Mitchell-street, Greenwich Point, Greenwich.
1917		Sibley, Samuel Edward, 'Garnella,' Blenheim-st., Randwick.
1900		Simpson, R. C., Technical College, Sydney.
1910		Simpson, William Walker, 'Abbotsford,' Leichhardt-street, Waverley.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. 'Broomage,' Kangaroo-street, Manly.
1893	P 56	Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney; p.r. 321 Illawarra Road, Marrickville. (President 1913.)
1916		Smith, Stephen Henry, Department of Education, Sydney.
1919		Spencer-Watts, Arthur, 'Araboonoo,' Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, Daily Telegraph Building, King-st.
1892	P 2	Statham, Edwyn Joseph, ASSOC. M. INST. C.E., Cumberland Heights, Parramatta.

Elected		
1918		Steel, Frederick William, c/o General Chemical Co. Ltd., Parramatta Road, Auburn.
1916		Stephen, Alfred Ernest, F.C.S., 801 Culwulla Chambers, 67 Castlereagh-street, Sydney.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 13 Dover Road, Rose Bay.
1920		Stephens, John Gower, B.Sc, St. Andrew's College, The University, Sydney.
1913		Stewart, Alex. Hay, B.E., 165 Wardell Road, Dulwich Hill.
1900		Stewart, J. Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; 'Berelle,' Homebush Road, Strathfield.
1903		Stoddart, Rev. A. G., The Rectory, Manly.
1909		Stokes, Edward Sutherland, M.B. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1916	P 1	Stone, W. G., Assistant Analyst, Department of Mines, Sydney.
1919		Stroud, Sydney Hartnett, F.I.C., The University, Sydney.
1918		Sullivan, Herbert Jay, c/o Lewis Berger and Sons (Aust.) Ltd., Rhodes.
1920		Sulman, John, Warrung-st., McMahon's Point, North Sydney,
1918		Sundstrom, Carl Gustaf, c/o Federal Match Co., Park Road. Alexandria.
1901	P 8	Süssmilch, C. A., F.G.S., Technical College, Newcastle, N.S.W.
1919		Sutherland, George Fife, A.R.C.Sc., *Lond.*, Lecturer in Mechanical Engineering, in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M.D., D.P.H. *Melb.*, B.Sc *Oxon.*, 'Lynton,' Kent Road, Rose Bay.
1912		Swain, E. H. F., Director, Forestry Department, Brisbane.
1919		Swain, Herbert John, B.A. *Cantab.*, B.Sc., B.E. *Syd.*, Technical College, Ultimo.
1917		Tate, Herbert, Bridge Road, Stanmore.
1915	P 1	Taylor, Harold B., B.Sc., Kenneth-street, Longueville.
1893		‡Taylor, James, B.Sc, A.R.S.M. 'Cartref,' Brierly-st., Mosman.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1920		Tebbutt, Arthur Hamilton, B.A., M.B., D.P.H., 185 Macquarie-st.
1899		Teece, R., F.I.A., F.F.A., Wolseley Road, Point Piper.
1878		Thomas, F. J., 'Lovat,' Nelson-street, Woollahra.
1919		Thomas, John, L.S., Chief Mining Surveyor, Mines Department Sydney; p.r. 'Remeura,' Pine and Harrow Roads, Auburn.
1879		Thomson, The Hon. Dugald, Carabella-st., North Sydney.
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-street, Sydney.
1919		Thorne, Harold Henry, B.A. *Cantab.*, B.Sc. *Syd.*, Lecturer in Mathematics in the University of Sydney; p.r. Rutledge-st., Eastwood.
1913		Tietkens, William Harry, 'Upna,' Eastwood.
1916		Tilley, Cecil E., Demonstrator in Geology in the University of Sydney.
1916		Tillyard, Robin John, M.A., D.Sc., F.L.S., F.E.S., Biological Branch, Cawthron Institute, Nelson, New Zealand.
1879		Trebeck, P. C., 'Alameda,' Queen-street, Bowral.

Elected		
1900		Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st.
1919	P 2	Turner, Eustace Ebenezer, B.A. *Cantab.*, M.Sc. *Lond.*, A.I.C., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1916		Valder, George, J.P., Under Secretary and Director, Department of Agriculture, Sydney.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S. Guild; Challis House, Martin Place.
1892		Vickery, George B., 78 Pitt-street.
1903	P 4	Vonwiller, Oscar U., B.Sc., Associate Professor of Physics in the University of Sydney.
1919		Waley, Robert George Kinloch, 63 Pitt-street.
1910		Walker, Charles, 'Lynwood,' Terry Road, Ryde.
1910		Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, The Hon. J. T., F.R.C.I., Fellow of Institute of Bankers *Eng.*, 'Wallaroy,' Edgecliff Road, Woollahra.
1919		Walkom, Arthur Bache, D.Sc., Linnean Hall, 23 Ithaca Road, Elizabeth Bay.
1917		Wallas, Thomas Irwin, 175 Macquarie-street.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Memb. Patent Attorney Exam. Board Aust.; George and Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Syd.
1891	P 2	Walsh, Henry Deane, B.A.I. *Dub.*, M. INST. C.E., 'Fermagh,' Leura, N.S.W. (President 1909.)
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1918		Ward, Edward Naunton, Superintendent of the Botanic Gardens, Sydney.
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, 87 Macpherson-street, Waverley.
1883	P 17	Warren, W. H., LL.D., WH. SC., M. INST. C.E., M. AM. SOC. C.E., Member of Council of the International Assoc. for Testing Materials, Professor of Engineering in the University of Sydney. (President 1892, 1902.)
1919		Waterhouse, Lionel Lawry, B.E. *Syd.*, Lecturer and Demonstrator in Geology in the University of Sydney.
1919		Waterhouse, Walter L., B.Sc. (*Agr.*), 'Cairnleith,' Archer-st., Chatswood.
1919		Watkin-Brown, Willie Thomas, 24 Brown's Road, Kogarah.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Selbourne Chambers, Phillip-street.
1910		Watson, James Frederick, M.B., Ch.M., 'Midhurst,' Woollahra.
1911		Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney.
1910	P 1	Wearne, Richard Arthur, B.A., Principal, Central Technical College, Brisbane.

Elected		
1920		Welch, Marcus Baldwin, B.Sc., A.I.C., Technological Museum.
1907		Welch, William, F.R.G S., 'Roto-iti.' Boyle-street, Mosman.
1920		Wellish, Edward Montague, M.A., Lecturer in Applied Mathematics in the University of Sydney.
1881		‡Wesley, W. H., London.
1909		White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's College; p.r. 'Kooringa,' Robinson-street, Chatswood.
1918		White, Edmond Aunger, M.A.I.M.E., c/o Electrolytic Refining and Smelting Co. of Australia Ltd., Port Kembla, N.S.W.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p r. 'Quantox,' Park Road, Auburn.
1920		Williams, Harry, A.I.C., Challis Flats, Phillip-street.
1917		Willington, William Thos., O.B.E., King-street, Arncliffe.
1890		Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Cambridge, England.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 8	Woolnough, Walter George. D.Sc., F.G.S., c/o Geological Department, The University, Sydney.
1916		Wright, George, c/o Farmer & Company, Pitt-street.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry, Department of Agriculture, The University, Sydney.
1916		Youll, John Gibson, Water Conservation and Irrigation Commission, Leeton, N.S.W.
1918		Young, John Anthony, c/o Lewis Berger and Sons (Aust.) Ltd., 16 Young-street.

Honorary Members.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1914		Bateson, W. H., M.A., F.R.S., Director of the John Innes Horticultural Institution, England, The Manor House, Merton, Surrey, England.
1918		Chilton, Charles, M.A., D.Sc., M.B., C.M. etc., Professor of Biology at Canterbury College, Christchurch, N.Z.
1911		Hemsley, W. Botting, LL.D. (*Aberdeen*), F.R.S., F.L.S., Formerly Keeper of the Herbarium, Royal Gardens, Kew; Korresp. Mitgl. der Deutschen Bot. Gesellschaft; Hon. Memb. Sociedad Mexicana de Historia Natural; New Zealand Institute; Roy. Hort. Soc., London; Kew Lodge, St. Peter's Road, Broadstairs, Kent, England.
1914		Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, London.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. ENG., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1908	P 57	*Liversidge, Archibald, M.A., LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney, 'Fieldhead,' George Road, Coombe Warren, Kingston, Surrey, England. (President 1889, 1900.)

* Retains the rights of ordinary membership. Elected 1872.

Elected.		
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia.
1912		Martin, C. J., C.M.G., D.Sc., F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London, S.W.I.
1894		Spencer, Sir W. Baldwin, K.C.M.G., M.A., D.Sc, F.R.S., Emeritus Professor of Biology in the University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL.D., Sc.D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1915		Thomson, Sir J. J., O.M., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.

Obituary 1920-21.

Ordinary Members.

1912		Smart, Bertram James.
1915		Watts, Rev. W. Walter
1877		White, Rev. W. Moore.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. W. B. 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, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

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1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.

1920 Joseph Edmund Carne, F.G.S., late Government Geologist, N.S.W. 'Dimlands,' Dickson-street, Homebush.

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Awarded.

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

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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.'

Awarded.

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.'

PRESIDENTIAL ADDRESS.

By Charles Edward Fawsitt, D.Sc., Ph.D.

[*Delivered to the Royal Society of N. S. Wales, December 3, 1919.*]

Before proceeding with the particular subject of my address, I desire to congratulate the Society on the large and unprecedented increase in its membership during the past year. The success of this year has been largely due to the efforts of Mr. R. H. Cambage, whom I should like to mention specially on account of his valuable services in the interests of the Society. The Society is also much indebted to Professor Chapman, Professor Pollock, and Dr. R. Greig-Smith.

The Council of the Society has graciously consented to my accepting the Presidential Chair with the knowledge that I would not be able to deliver an address at the usual time for such an address, May 1920, and the Council agreed to this being delivered in December 1919. In accepting the position under these circumstances, I am trespassing, to some extent on the generosity of members, but if I am excused, I may say that I hoped to find men of this generous nature among members of the Royal Society of New South Wales. A scientific training has surely failed, if it does not inculcate in a man breadth of view, and charity in judgment on his fellows and in particular his fellow-scientists.

THE UNIFORMITIES OF NATURE.

We have all heard from time to time such expressions as "*The Uniformity of Nature,*" "*The Principle of Continuity,*" "*Nature never makes jumps,*" "*The Laws of Nature,*" "*The Law of Universal Causation.*"

Uniformities of Nature.

While each of these statements may be a true statement under certain conditions, it is rather misleading to talk of the *Uniformity* of Nature. "The *Uniformities* of Nature" however, may serve for our purpose as a title to express generally our belief (1) in the regularity of occurrence of many natural events, (2) that most phenomena in the natural world obey definite laws, (3) that every effect has its cause, and that the same cause always produces the same effect, other things being equal. It is, I believe, supposed by some, that, ultimately, with a perfect and all embracing grasp of the natural world, we could show many or all of the *Uniformities* of Nature to be parts of a *Uniformity* of Nature, but we are not yet within sight of the realisation of such a possibility.

The subject of "The Uniformities of Nature" is a philosophical as well as a scientific one, and I am indebted not only to scientific work for some of my subject matter, but also to a large extent to Mr. A. J. Balfour's "Gifford Lectures for 1914," a book which puts certain rather difficult philosophical questions very lucidly. Mr. Balfour after writing of the relation of cause and effect, summarises the position in regard to the Uniformities of Nature in his own way:(1)

"It is not enough that the course of Nature should be determined. It must be determined *after a particular pattern;* its uniformity must conform to a particular type. . . . . . It is not enough that the condition of the world should be strictly determined by its condition at the preceding moment. Such a world would, I suppose, completely conform to the doctrine of uniformity, and obey both in spirit and letter the law of universal causation. Yet, unless it conformed to the additional canon I have laid down, it would provide no basis either for scientific knowledge or for practical decision. . . . . . . Science requires uniformities more than uniformity."

We shall proceed then to consider some aspects of nature showing Uniformities and by contrast, other aspects showing Irregularities and Discontinuities.

Law and Order in Nature.

In a general survey of nature, our attention is arrested by becoming acquainted with the laws and regularities which have so far been shown to exist in regard to natural phenomena. But it is quite as arresting to examine certain phenomena and the results of observations of nature which indicate abruptness of change, discontinuity or irregularity. So anxious is the human mind to believe in the orderliness of nature, that all such cases of irregularity or abrupt change are usually considered to be cases which are only apparently irregular or abrupt, and that an intimate enough acquaintance and deep enough understanding of nature would show that this belief was justified. For example, where some apparent irregularity occurs, it may be sufficient that a certain law (which we thought should hold good) be altered in such a way as to include the new observation, or it may be that some new unsuspected condition exists in our observation which has not hitherto been taken into account. At any rate we all expect that the anomalous result of to-day will probably be cleared away before long on account of the discovery of other facts and sometimes of more comprehensive laws; and our expectations as a whole may be said to be justified. This desire to evoke order out of disorder is undoubtedly on the right lines.

Alteration of Laws to meet new facts.

One's first idea in discovering some new fact, which does not fit in to the known laws, is to discredit the accuracy of the observation or the deductions from it; if, however, the observation can be repeated and the deductions therefrom can be shown to be proper, the second thought to some of us is one of annoyance or impatience with nature, that she should be different from the scheme we had arranged for her to fit in to; this phase, however, does not last long, and we become aware that it is best to take nature as she is, and build up some new theory to cover the new observation. Our belief, then, in the uniformities of nature goes beyond our present knowledge, but it is in the best interests of scientific progress that we should hold to it. By examination of new facts showing apparent irregularities or by an examination of cases of abrupt change, new lines of investigation suggest themselves; and from a practical point of view, examination of the exceptional case is usually fruitful.

The Number of Conditions in an Experiment.

A novice at experimental work is usually taught, and taught rightly, to believe that if he keeps to the same conditions of work (as far as they are known) he should be able to repeat any experiment with identical results. If he cannot, then he is a bad experimenter. A little more experience, however, will bring to an experimenter in certain lines of work some uncertainty as to when all the conditions for an experiment are the same. For example, experience may suggest to me that provided the temperature and pressure are kept constant, or within narrow limits at any rate, in a given experiment, I may expect the results to be independent of other conditions, *e.g.*, light-radiation, but it is never possible to be absolutely certain that one is correct in regarding other influences as negligible. To quote again from Balfour:—(2)

"Choose the most perfect experiment on record, idealise the conditions to your heart's content; for greater security, suppose it repeated to weariness, how will you be advanced? There are, I suppose, millions of circumstances, for the most part utterly unknown, which have coexisted with all the experiments already tried, but will have vanished before the next experiment is undertaken. Does this disturb you? . . . Not at all. . . . You trust yourself to a feeling of antecedent probability, and your trust will sometimes be betrayed."

A Case of Discontinuity.

It is on record[3] that in order to show how the continuity of the longest sequences may be broken, Babbage devised a machine, "*which produced numbers according to a particular law for an indefinite period, then broke this uniformity by a single exception, and, thereafter reverted for ever to its original principle of action.*"

And so in all scientific work, although we may repeat experiments again and again with identical results, this may be for example, because some small quantity of impurity was present (or absent) in all cases, or because the surface of our vessels of experiment had in all cases approximately the same amount and kind of other matter absorbed at the outset; and possibly in the next time of experiment, the conditions may have altered, and the results with them. Any experimenter with a little experience is so well aware of these facts that he finds it advisable in some experiments to compare the results with other "check" experiments, carried out, if possible, on the same day. In this way we try to do all that is possible to guard against any unthought of condition arising as the experiments are in progress. It often strikes us as very strange that we may repeat an experiment many times with a certain definite result, and then on a further repeat obtain a slightly different result which after some reflection we may be able to ascribe to a slight alteration in procedure. It is in this way, however, that new discoveries are made.

Repetition of Experiments.

I believe the statement may well be made that *the repetition of an experiment is never superfluous.* When the personal factor comes into play as in the practice of medicine, the number of conditions involved is so great that we are never sure what all the conditions of the experiment are. In the matter of the effect of a drug on the human body, it is well known that personal idiosyncrasy is very marked. Not only will a dose of any drug (less than the lethal dose) have very different effects, in magnitude at least, on different people, but the same dose of a drug given to the same person at different times may have different effects. In this case we all recognise that the number of factors involved is so great that it is impossible to know them all.

Evolution of Matter.

I should like more particularly now to confine myself to such points of interest as arise in a consideration of the (terrestrial) *evolution of matter*, for even in that question alone there is much both of uniformity and of irregularity to arrest the attention.

Atoms—Matter is Discontinuous in Structure.

For over 2000 years the question was debated as to whether the structure of elements was continuous or discontinuous, *i.c.*, whether atoms existed or not. The existence of the atom was believed in at least as far back as Democritus, 500 B.C.

The atom, as the derivation of the word indicates, was formerly always considered to be indivisible, and was at first considered as simply the smallest conceivable particle of matter.

After Dalton (1803–1808) had launched his Atomic Theory, which is still accepted, the atom was defined as the smallest particle of an element which could take part in a chemical action. The atom has had to be believed in without our being able to see it or any effect resulting from its individual action, right down to this generation. Now, at last, the traces of the action of single atoms can be made visible to the eye, as in the Spinthariscope invented by the late Sir William Crookes.

It is then at last known positively that atoms do exist. Matter is not continuous in structure. While elementary matter has a structure of atoms, the atoms themselves have a structure which while not quite understood, involves the existence of electrons. "Atoms" are not the smallest things obtainable. The electron is now the smallest thing obtainable. It is a unit of negative electricity, and changes in the properties of the atom are caused by the entrance or expulsion of an electron or by the expulsion of a larger positively charged particle.

Structure of the Atom.

The exact number of electrons in any atom is not known but it is probably rather more than half the number representing the atomic weight, or rather more than the "*atomic number*" (see below). There is now considered to be in the atom of every element a positive nucleus and one or more surrounding shells in which the electrons revolve. Not only then is the structure of matter discontinuous in that it contains discrete particles (atoms), but the atoms themselves contain smaller discrete units—electrons.

Motion within the Atom.

According to Jeans[(4)] "The problem of determining how the constituents are arranged and move inside the atom is still far from solution. . . Some knowledge of a general kind can be obtained (from the spectrum),—in particular the laws of motion are necessarily discontinuous, for continuous laws of motion would lead to a continuous (atomic) spectrum. . . Planck's spectral formula (for the continuous spectrum of a solid) could not possibly be arrived at except from a system of laws which involved discontinuities of some kind."

Not only then is the atomic structure discontinuous but the motion of the radiation-emitting electrons is discontinuous.

The Creation of Atoms.

Again it may be asked how the atoms have come into being. While the atom of any element is an exceedingly complicated structure, and while this structure is only being unfolded with great difficulty, this much is certain, that the atoms of one and the same element are essentially similar in all properties which go to make up the *chemical* behaviour of the element; it is also supposed that the atoms and chemical properties of any element in the sun are similar to what we have on the earth's surface.

Now all our experience would teach us to believe that in evolution we have also variation, and that one of the factors in evolution (particularly in influencing variation) is the environment. The environment in the sun is very different from that of the earth, and yet the atom of any element in the sun appears to be the same or very nearly the same in regard to spectroscopic examination (a very searching test) as the atom of that element on the earth.

Certain characteristics of Atoms independent of Ordinary Environment.

The mass and the radioactivity of an atom are also independent of environment, at any rate independent of any change in the environment that we can create for them. Clerk Maxwell in 1873, said that the atom could not be self existent, and had the essential character of a manufactured article, and that it had not been made by any of the processes we call natural. Evolution in 1873 was not considered as a possibility in the domain of the atomic kingdom.

Evolution among the elements.

Now although there has not been an evolution in atoms comparable with evolution as understood in the Darwinian sense, we are now aware that the atoms of some elements are unstable, and that after a certain "life" the atom of the radioactive element *suddenly* explodes. For a single atom the rotation of the rings of electrons in their orbits and the eccentricity of the orbits are apparently such that at a certain moment the whole position is no longer stable, and the atom decomposes into one or more different atoms quite suddenly.

From one element we can thus in an instant get one or two other elements. The suddenness of the change makes us dislike to use the word evolution here, but at any rate, one species of matter does produce in this case either one new species or two new species. Granted that some might care to call this evolution, still, it applies to only a few of the elements as far as is known. It is true that change might occur in some of the other elements at so slow a rate as not to be detectable by any available means. Granted again that this is a possibility, we know that when an element changes, it is always (in our experience on the earth's surface) to an element or elements of equal or lower atomic weight. If every element has arisen by evolution, then we are led back ultimately to a parent of high atomic weight. Uranium is the element of highest known atomic weight. The question therefore arises as to where the uranium atom comes from. If it comes from the atom of some other element, there must at any rate have been one or more primary elements which disintegrated into the atoms of uranium and other elements. How do these primary elements arise? At this stage of the enquiry we are baffled. Some elements have arisen from other elements, but no means have yet been discovered of creating an atom of any kind of matter from electrons and a positively charged nucleus. The formation of the atoms, more particularly those of highest atomic weight is still a mystery.

It has been pointed out[16] that in the gaseous stars of highest temperature hydrogen and helium predominate, while in cooler stars there is no helium but oxygen, carbon, silicon, magnesium, manganese, calcium, iron, and other metals. One interpretation of this is that these elements—magnesium, manganese and so on—have arisen from elements of lower atomic weight and not from those of higher atomic weight.

Although it is suggested above that elements at present considered stable may be changing excessively slowly into others, there is no real proof that such is the case. The atom of an element like oxygen might be changing very slowly into carbon, but it would be impossible at present to accelerate this rate so as to make it evident, because there does not appear to be any method offering at present of altering the rate of decomposition of these which are *unstable* and decompose at a measurable rate. Even although oxygen atoms were ordinarily quite stable, the question arises as to whether instability could be caused in any way. This problem seems as hard of solution as the problem of accelerating the instability.

Transmutation of Elements.

Experiments undertaken by the late Sir William Ramsay and others to try and transmute the more stable elements by bringing these into contact with radium salts, are usually now not considered to have given positive results from which definite conclusions could be drawn, although at the time the results of these experiments were first described, transmutation by this contact process appeared to have some foundation in fact, and less surprise was manifested by chemists than might have been expected.

Utilisation of Atomic Energy.

Sir Charles Parsons in his British Association address in 1919 has drawn attention to the desirability of harnessing for the use of mankind atomic energy and other energies not at present immediately available.

It may be noticed that unless the energy within the atom were liberated quickly the energy would not be of much use to us. Radium on decomposing to Niton and Helium liberates energy of an order of about one million times greater than could be obtained by burning radium to radium oxide, but this large intra-atomic energy is only made available over a period extending to many thousands of years. In this particular case, however, the Niton is unstable and has a short life, so that its energy is given up rapidly, and this adds considerably to the energy more immediately obtainable from the radium.

Both these cases of transmutation are accompanied by the ejection of an α-particle (Helium). The energy liberated by the ejection of β particles is not quite so great as that involved in the production of α-particles, but would be well worth obtaining provided the energy were liberated quickly enough.

The sudden character of the change when an atom of one element changes into another is remarkable for its abruptness; a moment comes in the life of the atom when the situation is ripe for the explosion, but this moment is not the same for every atom of the same element, and the period of life for the atom does not depend on the time it has already been in existence. So far as is known, there is no variation in the properties of the atom up to the moment of explosion. When the explosion takes place there is the greatest precision(5) in this act, for when an α-particle is ejected, the α-particle is always detectable for the same distance (30 milimetres) and no further.

The Periodic Law.

It will repay us to study here the Periodic Classification of the elements, and the arrangement, as presently known, is given below, both in tabular form and in a spiral form. The present Table (I) is a great change on the table as known, say ten years ago.

Periodic Classification of Elements.

The possibility of naming definitely the vacant places (five) between aluminium and uranium would not have been thought of ten years ago, and it may also be said to be unlikely that there are vacant places between hydrogen and aluminium. The changes that are introduced here in the older Periodic Table are as follows:—

(1) It is not now possible to believe that there is any vacancy for an (inert) element between nickel and copper or between palladium and silver. It is therefore, I think, not advisable to retain a special column for the inert gases. They are here put in the same column as the elements iron, nickel, palladium, etc.

(2) Every element, or rather, each place for an element is numbered. This number is the "Atomic Number." There is no doubt that, in the light of recent work, iron, cobalt, nickel, and each of the platinum group of elements require a separate place or atomic number. The atomic number appears to correspond or to be closely related to the net positive charge on the nucleus of the atom.

(3) For the places numbered 81 to 92 inclusive, it is necessary to give, besides the more important element, other radioactive elements which have identical chemical properties. The atomic weights of some of these are not known with great accuracy and the atomic weights given are put in brackets.

(4) Hydrogen is placed in the same column as fluorine. This arrangement is not ideal, but is preferable to leaving it out of the table altogether, or putting it in the same column as lithium, and so suggesting without any evidence that there are elements (undiscovered) between hydrogen and helium.

N IN 1919—Table I.

7 or 1	From 8 down to 0		
No. 1 Hydrogen H=1·008			No. 2 Helium He=4·0
No. 9 Fluorine F=19·0			No 10 Neon Ne=20·2
No. 17 Chlorine Cl=35·46			No 18 Argon A=39·88
25 anese 54·93	No. 26 Iron Fe=55·84	No. 27 Cobalt Co=58·97	No 28 Nickel Ni=58·68
No. 35 Bromine Br=79·92			No. 36 Krypton Kr=82·92
43 —	No. 44 Ruthenium Ru=101·7	No. 45 Rhodium Rh=102·9	No. 46 Palladium Pd=106·7
No 53 Iodine I=126·92			No 54 Xenon X=130·2
61 —	No. 62 Samarium Sa=150·4		
o. 75 —	No. 76 Osmium Os=190·9	No. 77 Iridium Ir=193·1	No. 78 Platinum Pt=195·2
No. 85 ——			No. 86 Niton Nt=222·0 [Thorium Emanation] (220) [Actinium Emanation]

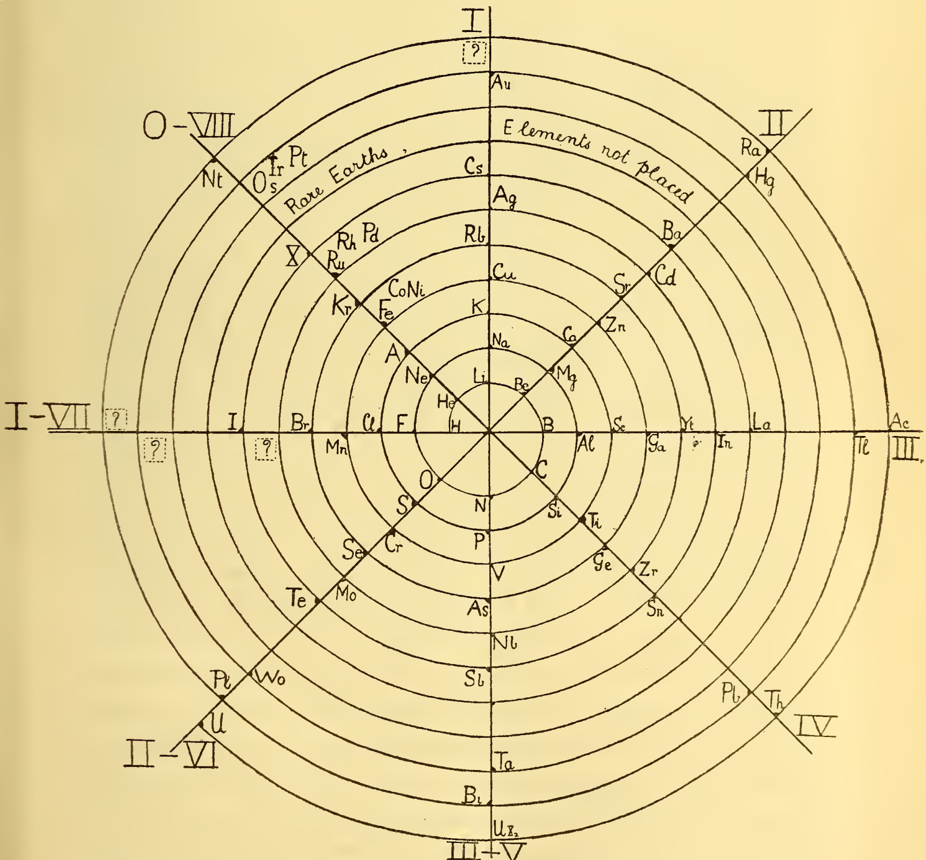
PERIODIC ARRANGEMENT OF THE ELEMENTS AS KNOWN IN 1919—Table I.

Usual Valency	1	2	3	4	5 or 3	6 or 2	7 or 1	From 8 down to 0		
							No. 1 Hydrogen H=1·008			No. 2 Helium He=4·0
	No. 3 Lithium Li=6 94	No. 4 Beryllium (or Glucinum) Be (or Gl)=9·1	No. 5 Boron B=11 10	No 0 Carbon C=12·0	No. 7 Nitrogen N=14·01	No 8 Oxygen O=16	No. 9 Fluorine F=19·0			No 10 Neon Ne=20·2
	No 11 Sodium Na=23·0	No. 1? Magnesium Mg=24·32	No. 3 Aluminium Al=27·1	No 14 Silicon Si=28·3	No. 15 Phosphorus P=31 04	No 16 Sulphur S=32·06	No. 17 Chlorine Cl=35·40			No 18 Argon A=39·88
	No. 19 Potassium K=39 1	No. 20 Calcium Ca=40·07	No. 21 Scandium Sc=44 1	No. 22 Titanium Ti=48·1	No. 23 Vanadium V=51·0	No. 24 Chromium Cr=52·0	No. 25 Manganese Mn=54·93	No 26 Iron Fe=55·84	No. 27 Cobalt Co=58·97	No 28 Nickel Ni=58·68
	No 29 Copper Cu=63·57	No. 30 Zinc Zn=65·37	No. 31 Gallium Ga=69·9	No. 32 Germanium Ge=72·5	No 33 Aasenic As=74·96	No. 34 Selenium Se=79·2	No. 35 Bromine Br=79·92			No. 36 Krypton Kr=82·92
	No 37 Rubidium Rb=85·45	No. 38 Strontium Sr=87·63	No. 39 Yttrium Yt=88·7	No. 40 Zirconium Zr=90·6	No 41 Niobium (or Columbium) Nb (or Cb)=93·1	No 42 Molybdenum Mo=96·0	No. 43 —	No. 44 Ruthenium Ru=101·7	No 45 Rhodium Rh=102·9	No. 46 Palladium Pd=106·7
	No. 47 Silver Ag=107·88	No. 48 Cadmium Cd=112·4	No. 49 Indium In=114·8	No 50 Tin Sn=118·7	No. 51 Antimony Sb=120 2	No. 52 Tellurium Te=127 5	No 53 Iodine I=126·92			No 54 Xenon X=130·2
	No. 55 Caesium Cs=132·81	No. 56 Barium Ba=137·37	No. 57 Lanthanum La=139·0	No. 58 Cerium Ce=140·25	No 59 Praesodymium Pr=140·9	No. 60 Neodymium Nd=144·3	No 61 —	No. 62 Samarium Sa=150·4		
	No. 63 Europium Eu=152·9	No. 64 Gadolinium Gd=157·3	No. 65 Terbium Tb=159·2	No. 66 Holmium Ho=163·5	No. 67 Dysprosium Dy=162·5	No 68 Erbium Er=167·7				
	No 69 Thulium Tm=168 5	No. 70 (Thulium II, ?)	No. 71 Ytterbium (or Neoytterbium) Yb=172	No. 72 Lutecium Lu=175	No. 73 Tantalum Ta=181·5	No 74 Tungsten W=184·0	No. 75 —	No. 76 Osmium Os=190·9	No. 77 Iridium Ir=193·1	No. 78 Platinum Pt=195·2
	No. 79 Gold Au=197·2	No. 80 Mercury Hg=200 6	No 81 Thallum Ti=204·0 [Thorium D (208)] [Actinium D] [Radium C_2 (210)]	No. 82 Lead Pb=207·2 [Radium B (214)] [Thorium B (212)] [Actinium B] [Radium D (210)]	No 83 Bismuth Bi=208·0 [Radium C (214)] [Radium E (10)] [Thorium C (212)] [Actinium C]	No. 84 Polonium (210) [Radium A (218)] [Thorium A (216)] [Actinium A] [Radium C_1 (214)] [Thorium C_1 (212)] [Actinium C_1] [Radium F (210)]	No. 85 —			No. 86 Niton Nt=222·0 [Thorium Emanation] (220) [Actinium Emanation]
	No. 87 —	No. 88 Radium Ra=226·0 [Mesothorium I (228)] [Thorium X (224)] [Actinium X]	No 89 Actinium [Mesothorium II (228)]	No. 90 Thorium Th=232·4 [Uranium X_1 (234)] [Ionium (230)] [Radiothorium (228)] [Radioactinium] [Uranium Y (230)]	No. 91 Uranium X2 (or Brevium) (234) [Eka-Tantalum 230)]	No. 92 Uranium. U=238·2 [Uranium II (234)]				

(5) The arrangement of any vertical column is designed to show that an element is similar in valency and other chemical properties not always to the element immediately below, but to the next but one.

(6) The large Roman numerals (I. – VIII.) in Table II. indicate the usual valency of the element.

Table II.



Discontinuity within the Periodic Table.

Discontinuity in connection with the periodic table has been commented upon in several directions, but in the light of recent research these discontinuities are not so numerous. It was for a long time a puzzle why so many elements had a value for the atomic weight which was not a whole number or even a multiple of 0·5. This is no longer so striking in view of the fact that we must now sometimes put several elements of different atomic weight into the same place of the table. A large proportion of the elements of low atomic number have atomic weights which are whole numbers or very nearly whole numbers, and this almost certainly not accidental. It has been suggested that the mass of the atom of many of these elements might be made up of the mass nuclei of hydrogen and helium, but no definite conclusion in regard to this can be stated yet. The striking difference in the chemical properties that is noticed as we go from one vertical column to another might have been looked upon at one time as a discontinuity; indeed, Soddy said(6) a few years ago that "The periodic law expresses a *per saltum* rather than a gradual change in chemical properties;" but the association of this difference, in some cases at any rate, with the loss of an electron in the inner nucleus of the atom, to some extent removes the surprise we might otherwise have in examining the difference in properties in the elements of two neighbouring columns. But one great difficulty remains. The periodic table gives us a great respect for the orderliness of Nature as we proceed from hydrogen (No. I) to lanthanum (No. 57). It is, however, not possible to place the elements Nos. 58 – 72 in any column definitely; if we were determined to do so, we would be forced to put a large number of these elements in one place on account of their similar valencies, which would also be erroneous, as the chemical properties of the individuals of the rare earth-group, while being very similar, are not identical. After this great lapse in regularity, the elements in the table may again be suitably placed from Nos. 73 to

92. The great regularities noticed at first between the properties of elements, like the halogens or the alkali metals, have resulted in the construction of one of the most interesting and useful diagrams available to the chemist; the use and interest remain, but it will not be possible to be content with the Periodic table until the great irregularity within the series of regularities is better understood.

Combination of elements to form compounds.

From the elements are obtainable, by combination, compounds; and only such compounds have arisen in nature as have not been unstable under the conditions obtaining for the time being. We can, however, prepare in the laboratory many compounds not found in nature. Each molecule of a compound is an aggregate of elementary atoms. The atom of an element retains unaltered its mass and, if radioactive, its radioactivity, when the atom enters a compound. All other properties are however liable to be altered; for example, the atomic volume is altered. The properties of a compound are not the mean of the properties of the composing elements. A student beginning to study chemistry must surely be impressed by the fact that whereas sodium and chlorine are separately extremely poisonous substances, sodium chloride, formed by burning sodium in chlorine, is essential to life.

The change in properties exhibited by an element when its atoms become ionised is very great. Ferrous ion differs markedly from metallic iron and from Ferric ion. The Ferrous ion is an iron atom with two positive charges of electricity, (or an iron atom minus two electrons from the outer shell, each electron being a unit of negative electricity). The Ferric ion carries three positive charges of electricity. The transformation $Fe^{++} \rightleftarrows Fe^{+++}$ is easily carried out, and yet the difference between the properties of Ferrous and Ferric ions as noticed by wetway tests is quite as great as, perhaps greater than, the difference between the properties of two different elements such as barium and strontium in their compounds. We cannot gradually alter the properties of ferrous ion when transforming it into ferric ion. The change involves a transference of a unit of electricity and nothing less than a whole unit (96540 coulombs for 56 grams of iron).

When the properties of an atom are altered as in ionic creations, the change is a sudden one. In producing ions from the uncharged atom the number of electrons in the *outer* ring alters; in radioactive changes the *inner* nucleus disintegrates and either a positive particle or electron is ejected.

Change from Passive to Active State.

A very interesting case of alteration, sometimes also believed to be a case of allotropism, is noticed in the change between the active and passive state in certain metals like iron. The change whether judged by the eye or by electrical tests is usually very sudden. A piece of passive iron lying in 1·2 spec. grav. nitric acid(7) or in concentrated sulphuric acid(8) becomes suddenly active on account of causes which have so far remained obscure.

In the production of compounds from elements, addition of any element to another or to a compound produces a fairly definite change in many of its properties. In these cases we look for continuity in the sense that chemical composition and constitution have an intimate relation to the physical properties.

The closeness of this correspondence is well shown, for instance by the following Table (III) taken from Smiles'(9) Text Book which gives the correspondence between Molecular Volume and Composition in the case of the members of the paraffin series.

Regularities observed on Composition.

Table III.

Molecular Values of the Normal Paraffins at their Melting Points.

Formula of Hydrocarbon.	Number of Valencies. [4 for each carbon.] [4 for each hydrogen	Molecular Volume.	Molecular Volume divided by Valency Number.
$C_{11}H_{24}$	68	201·4	2·962
$C_{12}H_{26}$	74	219·9	2·971
$C_{13}H_{28}$	80	237·3	2·966
$C_{14}H_{30}$	86	255·4	2·970
$C_{15}H_{32}$	92	273·2	2·970
$C_{16}H_{34}$	98	291·2	2·971
$C_{17}H_{36}$	104	309·0	2·971
$C_{18}H_{38}$	110	326·9	2·972
$C_{19}H_{40}$	116	344·7	2·971
$C_{20}H_{42}$	122	362·5	2·971
$C_{21}H_{44}$	128	380·3	2·971
$C_{22}H_{46}$	134	398·3	2·972
$C_{23}H_{48}$	140	416·2	2·971
$C_{24}H_{50}$	146	434·1	2·973
$C_{27}H_{56}$	164	487·4	2·972
$C_{31}H_{64}$	188	558·4	2·970
$C_{32}H_{66}$	194	576·2	2·970
$C_{35}H_{72}$	212	629·5	2·969

The precision with which an addition of CH_2 to the molecule increases the molecular volume is evident from the constancy of the numbers in the last column. This regularity is, however, not observed in all the properties, and by way of contrast with Table III, Table IV is next given for the melting points of the paraffins.

The connection between the rise of melting point and addition of CH_2 to the compound is not at first sight at all evident, but by splitting the members of the series into those with an odd and those with an even number of carbon in the molecule, and thus taking the difference of $2\,CH_2$ each time, a somewhat better correspondence is seen between this property and chemical composition. Carrying out the comparison in the case of certain other properties such as the rotation of the plane of polarisation, or the affinity constant of acids, the connection between the property and chemical composition and chemical constitution is so complicated that no definite connection has been established, and indeed the value of the property may first progress in one direction and then in the opposite direction.

Table IV.

Melting Points of the Paraffins.

Formula of Hydrocarbon.	Melting Point.		Difference in melting point for addition of CH_2	of 2 CH_2	
C_9H_{20}	− 51° C.				
$C_{10}H_{22}$		− 31° C.	20	25	
$C_{11}H_{24}$	− 26° C.		5		19
$C_{12}H_{26}$		− 12° C.	14	20	
$C_{13}H_{28}$	− 6° C.		6		16
$C_{14}H_{30}$		+ 4° C.	10	16	
$C_{15}H_{32}$	+ 10° C.		6		14
$C_{16}H_{34}$		+ 18° C.	8	13	
$C_{17}H_{36}$	+ 23° C.		5		10
$C_{18}H_{38}$		+ 28° C.	5	9	
$C_{19}H_{40}$	+ 32° C.		4		9
$C_{20}H_{42}$		+ 37° C.	5	8	
$C_{21}H_{44}$	+ 40° C.		3		7
$C_{22}H_{46}$		+ 44° C.	4	8	
$C_{23}H_{48}$	+ 48° C.		4		7
$C_{24}H_{50}$		+ 51° C.	3		

The building up of compounds from the elements is therefore not always attended by such a change in the properties as can be predicted; there are evidently here some other factors to be taken account of that are still unknown to us.

Living Matter.

While the creation of atoms of the elements still presents an unsolved problem, the same may also be said of the appearance of life from non-living matter. This question has been a subject of discussion in scientific addresses for many years, but we are still left facing the fact that living matter can only come from living matter. Progress has been made in the artificial generation of the unfertilised ovum in the case of invertebrates, and it is true that in many directions strong similarities may be noticed between living and non-living matter, but no creation of life from non-living matter has been recorded. The discontinuity of nature at this point remains therefore still unbridged.

As far as can be ascertained the principles of the Conservation of Mass and the Conservation of Energy hold good for processes in the living animal and plant with the same exactness as in the case of experiments on substances quite independent of any life process. Further, the laws of Chemical Mechanics, and the laws of Osmotic Pressure, worked out for matter in general, are quite applicable to living matter. It is however, I think, premature and unwarranted to draw the conclusion that there is nothing distinctive about the life process which places it on a different plane from that of other phenomena of matter. Prof. Sir Edward Schaefer has considered the question of a distinction between living and non-living matter in his Presidential Address to the British Association in 1912. He there takes the view that there is little or no fundamental distinction between living and non-living matter, but he does not carry every scientist with him to the same conclusion.

The chemical elements in (living) protoplasm are well known. Protoplasm has not yet been synthesised, but there is no *prima facie* reason why chemists should not some day be able to prepare synthetically a substance of the same chemical composition as protoplasm. This synthetic substance (which we may call neoprotoplasm) may or may not have all the properties of living protoplasm; Professor Schaefer however has decided opinions on the matter. He says that[10] "when the chemist succeeds in building up this compound, it will without doubt be found to exhibit the phenomena which we are in the habit of associating with the term life."

Simplest form of life.

Some of us would not consider we had made (living) protoplasm unless we could obtain a very simple form of life similar, say to an amœba or a bacterium, but Professor Schaefer is not immediately so ambitious as this, and expects the first synthetic protoplasm obtained to be something very much simpler than an amœba. Again, even granting that such a simple form of "protoplasm" as suggested by Schaefer could be made, there would still be a big task before us in evolving one of our known simple types from this neoprotoplasm; but there is, to my mind, considerable uncertainty as to whether a synthetic protoplasm would have all the essential properties of ordinary protoplasm. It was at one time considered a remarkable thing when Faraday (1825) found two substances of similar chemical composition but of different molecular weight and of different properties (polymerism). Again, in 1828, Wohler succeeded in preparing urea from its isomer, ammonium cyanate. Both these substances have the same chemical composition and the same molecular weight, but they have different properties.

Some types of Isomerism.

In 1848 Pasteur succeeded in producing the dextro- and lævo- forms of tartaric acid, (stereoisomers); these substances have the same molecular weight and the same chemical composition, and are similar in all physical properties save two,—a very slight difference in the crystals of the two modifications, and a difference in the action of the two modifications on polarised light.

Within the last few years we have come to discover elements which are identical in *all* chemical properties but have different atomic weights. It will therefore be no surprise to us if a first synthetic protoplasm which may be prepared, differs in some properties from the (living) protoplasm we know. In 1913, Sir Oliver Lodge,* who succeeded Sir Edward Schaefer as President of the British Association, took the view that[11] "Life introduces an incalculable element."

There is a power of adjustment to external circumstances in living things, a co-ordination of all the parts and their properties for the good of the whole, which may well make some of us despair about the creation of living from non-living matter.

In the living organism, plant or animal, the building up and breaking down of tissues are essentially chemical processes; if any difference is to be drawn between these and ordinary chemical processes outside the organism ("*in vitro*,") it is that the reactions in living things are carried out with such surprising ease on account of the catalytic enzymes present, and that we are unable as yet to produce the enzymes by any synthetic process in vitro.

Elements required by plants and animals.

The elements used by animals and plants in building up their tissues are comparatively few, and of low atomic number. They are Hydrogen (No. 1), Carbon (No. 6), Nitrogen (No. 7), Oxygen (No. 8), Sodium (No. 11), Magnesium (No. 12), Silicon (No. 14), Phosphorus (No. 15), Sulphur (No. 16), Chlorine (No. 17), Potassium (No. 19), Calcium (No. 20), Manganese (No. 25), Iron (No. 26).

Small quantities of other elements are found in special cases, but with the exception of iodine, elements of large atomic number are not usually found in living things, these elements and their compounds being more or less toxic to protoplasm. Some of the elements just quoted are indispensable for the growth of living things. These indispensable elements are however not the same in all cases.

Yeast, a very humble form of life, requires only hydrogen, carbon, nitrogen, oxygen, magnesium, potassium, and phosphorus.

For rats,[12] calcium and phosphorus are apparently indispensable, and are required in some quantity. With regard to the elements magnesium, sodium, potassium and chlorine it has been found that if only one of these was absent, growth continued at the normal rate.

It has been found that maize,[13] when supplied with the elements, hydrogen, carbon, nitrogen, oxygen, magnesium, silicon, phosphorus, sulphur, chlorine, potassium, calcium, manganese, iron and zinc would not develop, whereas when, in addition, very small quantities of compounds of boron (No. 5), fluorine (No. 9), aluminium (No. 13), and iodine (No. 53) were given, growth was obtained.

It is usually accepted without question that the "*Conservation of Mass*" holds good for all chemical changes in the life process, and it is assumed also that there is no transmutation of elements in living organisms. It has already been mentioned that there is apparently no method by which we can cause the ordinarily stable elements to change, and it does not yet appear that the introduction of the life factor helps us at all here. Plants starved in respect to what are apparently essential elements soon die, and animals and human beings subjected to complete starvation (with the exception of water) steadily lose weight. Catabolism must go on although in diminished measure.[14]

Possible Transmutation of Elements in Life.

If however, as Sir Oliver Lodge suggests, "Life introduces an incalculable element," it might seem to be an open question whether transmutation may not on occasion take place in the living organism. No evidence has yet appeared which suggests that there may be such a transmutation of ordinarily stable elements, in order to supply other elements lacking in the diet, but systematic experiments to test this would not, I think, be superfluous. If such transmutation takes place it would be most readily demonstrated in such plants as may be grown by water culture. On the other hand one would look for possible transmutation rather in the more complex creations of the animal world, say in man, where it would be extremely difficult to prove transmutation. The changes which one may be allowed to imagine as a faint possibility, are say, (*a*) carbon from oxygen, or (*b*) a meta-sulphur of atomic weight 31 from phosphorus (atomic weight 31).

The interest in finding that such a change could take place would be not only on account of the transmutation *per se*, but on account of the large amount of energy which would be set free.

In the case of starvation of a human being, it may be noticed that if oxygen atoms to the extent of one-hundredth of a gram changed into carbon atoms by loss of α-particles, the amount of energy liberated would probably be equal to considerably more than the energy given by an ordinary day's consumption of food.

The Future of the Earth.

While the beginning of both matter and life remains undiscovered, speculation may be made as to the future of the earth. The old idea of a gradually cooling earth, on which life would gradually become extinct, with a dissipation of energy and (to some extent also) dissipation of matter is not the only one now before us.

It has been suggested[15] that the temperature of the inner core of the earth may be increasing owing to the heat liberated in radioactive changes. This heat is retained as the outer surface shell of the earth is a very poor conductor of heat. If, therefore, the crust some day should succumb to the increased pressure within, the whole of the matter of the earth would probably become (again ?) a globe of glowing gas. This is surely the Discontinuity of Nature par excellence, and all the evolution of the atoms, the building up of stable compounds, and the evolution of living things, will have apparently been a grand "cul de sac."

Those who find "Uniformities" in Nature and believe in Uniformity as a guiding principle are right enough up to a certain point, but there are still irregularities and discontinuities sufficient to attract our interest and to fascinate our minds, and it looks as though this would continue as long as there is human life on this planet.

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Council's Report

Our membership now totals 348. Fifty-two new members have joined, while we have lost five members by resignation and six by death.

Dr. J. B. Cleland, a Vice-President, has withdrawn from the Council having been appointed to the Chair of Pathology at the Adelaide University.

The Council has awarded the Clarke Memorial Medal to Joseph Edmund Carne, F.G.S., late Government Geologist of New South Wales.

It is gratifying to know that two of our members have been honoured during the past year:—Professor T. W. E. David, in addition to previous honours, having been mentioned in Despatches by Sir Douglas Haig after the close of the war, and Professor S. H. Barraclough having received the Knight Commandership of the British Empire.

Early in the year a communication was received from the Secretary, Royal Society, London, intimating that Australia had been invited to join the International Research Council, and asking the Royal Society of New South Wales to take the necessary steps towards initiating the formation of some organization in Australia which could act as a National Research Council, for the promotion of scientific and industrial research in its various branches, including those of national defence.

Invitations were therefore issued to various scientific bodies to send representatives to discuss the matter, and as a result a Council was formed.

AUSTRALIAN NATIONAL RESEARCH COUNCIL.

Resolutions passed at the Conference held at the Royal Society's House, Sydney, on 21st August, 1919, for the purpose of forming an Australian National Research Council.

PRESENT:—

Professor C. E. Fawsitt (Chairman) and Professor H. G. Chapman delegates from Royal Society of New South Wales.

Mr. C. Hedley and Dr J. Shirley delegates from Royal Society of Queensland.

Professor T. W. Edgeworth David and Mr. C. Hedley delegates from Royal Society of South Australia.

Professor W. A. Haswell and Mr. C. Hedley delegates from Royal Society of Tasmania.

Professor Orme Masson delegate from Royal Society of Victoria.

Professor W. E. Cooke and Mr. J. H. Maiden delegates from Royal Society of Western Australia.

Professor T. W. Edgeworth David and J. H. Maiden delegates from Australasian Association for the Advancement of Science.

Mr. J. J. Fletcher and Dr. A. B. Walkom delegates from Linnean Society of New South Wales.

Professor Orme Masson delegate from Commonwealth Institute of Science and Industry.

RESOLUTIONS:—

1. That this meeting proceed to nominate a provisional Australian National Research Council.

2 That each important branch of science in Australia be represented on the Council.

3. That the branches of science to be represented include:—Agriculture, Anthropology, Astronomy, Botany, Chemistry, Engineering, Geography, Geology, Mathematics, Meteorology, Pathology, Physics, Physiology, Veterinary Science, Zoology.

4. That there be two representatives of each of these sciences on the National Council.

5. That the representatives of the provisional Australian National Research Council be:—

1. AGRICULTURE—
A. E. V. Richardson, M.A., B.Sc. (Victoria)
Professor R. D. Watt, M.A., B.Sc. (New South Wales)

2. ANTHROPOLOGY—
C. Hedley, F.L.S. (New South Wales)
Sir Baldwin Spencer, K.C.M.G., M.A., D.Sc., F.R.S. (Victoria)

3. ASTRONOMY—
J. M. Baldwin, M.A., D.Sc. (Victoria)
Professor W. E. Cooke, M.A., F.R.A.S. (New South Wales)

4. BOTANY—
J. H. Maiden, I.S.O., F.R.S., F.L.S. (New South Wales)
Professor T. G. B. Osborn, M.Sc. (South Australia)

5. CHEMISTRY—
   Professor Orme Masson, C.B.E., M.A., D.Sc., F.R.S. (Victoria)
   Professor N. T. M. Wilsmore, D.Sc., (Western Australia)
6. ENGINEERING—
   A. J. Gibson, A. M. Inst. C.E. (New South Wales)
   Professor W. H. Warren, LL.D., Wh. Sc., M. Inst. C.E.. M. Am. Soc. C.E. (New South Wales)
7. GEOGRAPHY—
   Sir Douglas Mawson, D.Sc. (South Australia)
   Captain S. L. Piesse, B.Sc., LL.B. (Tasmania)
8. GEOLOGY—
   Professor T. W. E. David, C.M.G., D.S.O., B.A., D.Sc., F.R.S. (N.S. Wales)
   Professor E. W. Skeats, D.Sc., F.G.S. (Victoria)
9. MATHEMATICS—
   Professor H. S. Carslaw, M.A., Sc.D. (New South Wales)
   Professor H. J. Priestley, M.A. (Queensland)
10. METEOROLOGY—
   H. A. Hunt, F.R.M.S. (Victoria)
   T. Griffith Taylor, B.A., B.E., D.Sc. (Victoria)
11. PATHOLOGY—
   Sir Harry B. Allen, M.D., B.S., LL.D. (Victoria)
   Professor D. A. Welsh, M.A., B.Sc., M.D., F.R.C.S. (New South Wales)
12. PHYSICS—
   Professor T. R. Lyle, M.A., D.Sc., F.R.S. (Victoria)
   Professor J. A. Pollock, D.Sc., F.R.S. (New South Wales)
13. PHYSIOLOGY—
   Professor H. G. Chapman, M.D., B.S. (New South Wales)
   Professor W. A. Osborne, D.Sc., M.B. (Victoria)
14. VETERINARY SCIENCE—
   Professor J. D. Stewart, B.V.Sc., M.R.C.V.S. (New South Wales)
   Professor H. A. Woodruff, M.R.C.V.S., M.R.C.S., L.R.C.P. (Victoria)
15. ZOOLOGY—
   Professor W. J. Dakin, D.Sc., F.Z.S., F.L.S. (Western Australia)
   Professor W. A. Haswell, M.A., D.Sc., F.R.S. (New South Wales)

6. That Mr. R. H. Cambage, F.L.S. (New South Wales) be a member of the Australian National Research Council and also its Honorary Secretary.

7. That the provisional Council hold office until the new Council shall have been appointed at the next meeting of the Australasian Association for the Advancement of Science, in January 1921.

8. That the election of the new Australian National Research Council be entrusted to the Council of the Australasian Association for the Advancement of Science at its meeting in January 1921.

9. That at least ten of the retiring members of the Council shall not be eligible for re-election, but that this provision shall not operate at the election of the first Australian National Research Council in January, 1921.

10. That a provisional Executive Committee consisting of a Chairman, the Honorary Secretary, and three other members be appointed to act at once in all matters considered urgent, and that the members of such Executive Committee be:—Professor David, (Chairman), Mr. R. H. Cambage. (Hon. Secretary), Professor Chapman, Mr. J. H. Maiden, and Professor Pollock.

11. That it be recommended to this provisional Executive Committee that the Commonwealth Government be requested to make the financial provisions necessary for carrying on the work of the Australian National Research Council, and that for this purpose representations be made to the Prime Minister.

12. In the event of any of the members of the provisional Council or the Executive Committee, declining to accept office, that the Executive be empowered to fill the vacancies.

Obituary.

ROBERT ETHERIDGE was one of the oldest members of this Society, having joined in 1879. He was the only child of a most distinguished geologist, Robert Etheridge, Senior, F.R.S., and was born at Cheltenham, Gloucestershire, and died at Colo Vale, on January 4th, 1920. In the middle sixties he was engaged with others on the first geological survey of Victoria. Returning to Europe he accepted the responsible position of palæontologist to the Geological Survey of Scotland, publishing much valuable work while in that capacity. Fresh and wider fields for research were opened to him by his removal to London, consequent on receiving an appointment in the British Museum. In the meantime, his old friend and colleague of Edinburgh, Dr. R. Logan Jack, was appointed Government Geologist to Queensland, and he revived Etheridge's interest in Australian geology, by forwarding for study extensive collections of fossils from Queensland. Eventually, their partnership resulted in the production of a large and very important work, "The Geology and Palæontology of Queensland and New Guinea," which was published in 1898, and which has formed the basis of all subsequent geological work in that State. The lure of the south grew more insistent, and yielding to it, Mr. Etheridge returned to Australia in 1887 to fill a dual post in the New South Wales Department of Mines and the Australian Museum. In his former service, he was associated with the late Mr. C. S. Wilkinson, Professor David, Mr. E. F. Pittman, and Mr. J. E. Carne, who has just retired from the control of the Geological Survey. Mr. Etheridge quickly gathered in from various nations standard geological works, which now form the nucleus of a fine library at the Geological Survey of our Mines Department. He next founded a new serial "The Records of the Geological Survey," and assisted to place our knowledge of the geological formations of the State on a firmer basis. Taking for his special subject the fossils of the older strata, he published numerous memoirs on that topic. On the retirement of Dr. Ramsay, in 1895, Mr. Etheridge received the appointment of Director of the Australian Museum. He threw his usual vigour into his new occupation. During the twenty-five years of his administration the institution has been greatly enlarged, the collections renovated, enriched and better displayed, and an excellent system of descriptive labels arranged. Under his guidance was initiated the serial production, "The Records of the Australian Museum," and a number of memoirs were produced, dealing with the fauna of this continent. Other educational efforts were the delivery of popular science lectures and the explanation of scientific problems to visitors and correspondents.

In later life he gradually enlarged his interest from palæontology to ethnology. He wrote largely on the manners and customs, weapons, utensils, etc., of the Australian aboriginals, and inaugurated the present magnificent display of native work in the museum galleries. It was also chiefly through his efforts that the remarkably fine ethnological exhibits from the Pacific Islands were gathered together. His efforts to advance Australian science were recognised by those best qualified to express appreciation. The Royal Society of New South Wales voted him the Clarke Memorial Medal in 1895, and the Australasian Association for the Advancement of Science bestowed on him, in 1911, the Mueller Memorial Medal. Numerous species in animals, both fossil and recent, have been named in his honour. One of the highest peaks of the Kosciusko Plateau and a glacier in Antarctica have been called after him.

Mr. Etheridge was of such a retiring disposition that he could seldom be induced to take part in any social or even scientific gathering, and he was specially averse to publicity of any kind; otherwise, his name would have been a household word throughout Australasia. He literally lived in his work, and he died in it, according to his wish. He has departed this life with his work well done, a true and faithful servant who has deserved well of his country, and of the scientific world at large. His work is monumental and will remain a perpetual help and inspiration. His two sons survive him.

Edward Noyes, who joined this Society in 1893, was a son of the late Rev. Thomas Edward Noyes. He was born at Creaton, Northampton in 1859, and died at Medlow on

5th March, 1920. He came to Australia about thirty-four years ago, and in conjunction with his brother, Mr. Henry Noyes, founded the firm of Noyes Brothers in Sydney in 1888, and became the first governing director, which position he held up to the time of his death. He was also a director of Noyes Brothers (Melbourne) Proprietary, Ltd. The late Mr. Noyes was always actively interested in engineering, particularly the electrical branch of it. He carried out numerous important contracts, including many for the Sydney electric tramways. For several years he was a member of the council of the Electrical Association of New South Wales, and was a vice-president in 1906-7. He had been an Associate of the Institute of Mechanical Engineers (London) since 1902, and of the Institution of Civil Engineers (London) since 1905. He was also well-known in New Zealand, where he carried out several important contracts, including the installation of the Dunedin electric tramways. Mr. Noyes has left a widow, but no family.

WALTER W. J. O'REILLY, M.D., Ch.M., M.R.C.S., had been a member of this Society for forty-four years having joined in 1875, and was one of its oldest members. He was born in America and educated at Newington College, New South Wales, and Dublin University. At the time of his death at Pymble, on 3rd July, 1919, he was 72 years of age. Dr. O'Reilly practised his profession for some years in England before returning to Australia, and afterwards practised for forty-six years in Sydney. For a long period he was on the honorary staff of the Sydney Hospital, and latterly was on the consulting staff. He was president of the Pymble committee dealing with matters arising in connection with the war, while two of his sons served at the front. He leaves a widow, five sons and four daughters.

Professor Sir THOMAS PETER ANDERSON STUART passed away at Lincluden, Double Bay, on February 29th, 1920, after a lingering illness borne with heroic courage. About twelve months before his death he learnt that he was suffering from what was, in all probability, a fatal malady. He determined to continue his usual occupations. With wonderful bravery he delivered his usual lectures at the Medical School of the University and attended the numerous meetings demanded by his many activities. As the disease progressed, increasing weakness limited his work; but he struggled to carry out his daily tasks until the end of the year preceding his decease. Even when it taxed his strength to the utmost he was driven slowly in his car to the University and he walked painfully with tottering steps over the short distance to his room. He mounted to the lecture theatre by resting once or twice in chairs on the way. He lectured from an easy seat and used an electric torch of his own design to point out what he wished on the diagrams mounted on the screens beside him. His mental powers remained unimpaired to the last, though bodily enfeeblement made it impossible for him to continue for long discussion and argument with others. The steadfastness of purpose which was so conspicuous a feature of his character, was never revealed with greater nobility than in these last months of life.

Thomas Peter Anderson Stuart was born at Dumfries in the South of Scotland on June 20th, 1856. He received his early education at the well known Dumfries Academy. For almost a year he was at school in Wolfenbottel, Hanover, where he acquired some considerable knowledge of the German language. In 1875 he entered upon medical studies at the University of Edinburgh. Each year he travelled abroad to extend his opportunities for learning European languages. In this way he obtained an acquaintance with the French, Italian, and German tongues. In 1880 he graduated in medicine and obtained the Ettles Scholarship, the blue ribbon of the University of Edinburgh.

After his graduation he proceeded to Strasburg, where he spent two years in the scientific laboratories of Schmiedeberg, Hoppe Seyler, and Golz. While he carried on investigations upon the medicinal effects of the salts of nickel and cobalt under the direction of O. Schmiedeberg, the father of modern pharmacology, he acquired that interest in the action of drugs which he maintained throughout his life. With Hoppe Seyler he made some observations upon the formation of crystals of hæmoglobin. With Golz he found himself in harmony through their common sympathy with the mechanical conception and explanations of bodily functions.

Returning to Scotland he presented his Alma Mater with a thesis for which he received the degree of Doctor of Medicine and a gold medal. He was appointed assistant to Professor William Rutherford in the department of physiology. He conducted the classes in practical histology and physiology. He also had the general direction of the laboratory. In 1883 he was successful in his application for the joint Chair of Anatomy and Physiology in the University of Sydney. In the same year he came to Sydney and commenced his life's work in the cause of medical education in New South Wales. He was elected Dean of the Faculty of Medicine, a position that he held for thirty seven years.

He was elected a member of this Society in 1883. In 1885 he was a member of the committee of the Medical Section of the Society, and in 1890 and 1891 he was chairman of the Section. In 1889 he was elected to the Council of the Society and retained his seat until 1902. In 1892 he served as Hon. Secretary, and in 1893 he was chosen to be President. From 1894 to 1899 he was one of the Vice-Presidents. In 1906 he was again elected President, and later served for two years as a Vice-President. In 1915 and 1916 he was chosen as Chairman of the newly formed

Section of Public Health and Kindred Sciences. Sir Thomas took much interest in the Society and was ever ready to advance its interests.

The organization of medical education in New South Wales was the chief aim of his life in Australia. He built up the Medical School of the University and he developed the clinical resources of the Royal Prince Alfred Hospital. Medical training commenced in 1883 with four students in a cottage. In 1887 he supervised the preparation of the plans of the Old Medical School, a magnificent building of Gothic design, which cost more than £80,000. Despite ridicule and criticism this edifice was completed in 1889. Before twenty years had elapsed, it had to be enlarged. Despite the addition of two massive wings the building was found too small for the thousand medical students who attended it in the year of his death. Thomas Anderson Stuart recognised clearly the growth of New South Wales, a development which has not ceased though many cry to-day that there is no need to extend the over crowded Medical School. At first he had charge of the instruction in anatomy and physiology. In 1889 the department of anatomy was placed under a separate teacher, and in 1918 the department of pharmacology was formed. From 1903 pharmacology had been taught under his general direction. In 1883 he joined the Board of Directors of the Royal Prince Alfred Hospital. In 1890 he became Honorary Secretary and in the same year Chairman of the Board of Directors, a position he retained until his death. He worked with ceaseless energy to make the hospital a pattern of what such an institution should be. His warm support led to the erection of the Queen Victoria Memorial Pavilions.

The improvement of the public health was another field to which he devoted much attention. From 1892 to 1896 he was President of the Board of Health, and remained a member until his death. He took an active share in inaugurating the School of Tropical Medicine in Townsville.

The transport of the sick and the care of the blind occupied part of his time for many years. In 1914 he received the honour of knighthood in recognition of his many public benefactions. His scientific activities were numerous in his early years. He had a keen insight into mechanical processes. He studied with great care the act of swallowing and contributed a number of original observations to the elucidation of this complicated movement. Particularly he described the position of the epiglottis and the movement of the larynx. He made some investigations concerning the accomodation of the eye and the structure and arrangement of the suspensory ligaments of the lens of the eye. He devoted much attention to the study of the voice. For many years he tried to improve his lectures by seeking for new models to enforce the teaching of his lectures. He showed such skill in his designs that a mere glance served in most cases to recognize the principle of mechanics that was illustrated. Future generations will bear testimony to the stateman's grasp of education that he possessed.

FREDERICK WILLIAM WEBB, C.M.G., was born in Sydney on 20th February, 1837, and died on 17th July, 1919, at Balgowlah, near Manly, at the age of 82 years. He was the only son of the late John Webb of H.M. Commissariat Department, and was elected a member of this Society in 1897. In 1853 he accepted employment in the Post Office, and remained there for six years. On April 19th, 1860, he obtained the position of Clerk in Charge of Parliamentary Papers in the Legislative Assembly, and from that time, as vacancies occurred, he received the promotion to which he was entitled. In 1877 he was appointed Acting Clerk of the Assembly during the absence of Mr. Stephen W. Jones, and filled that position again in 1886 in similar circumstances. On the retirement of Mr. Jones in 1888, under the provisions of the Civil Service Act, Mr. Webb received his commission as Clerk of the Assembly, and held that position till he retired in February 1904. When the Australasian National Convention assembled in Sydney in March 1891, Mr. Webb was unanimously elected its clerk. In 1894 he was created C.M.G. He is survived by his widow, one son and one daughter.

CHARLES SAVILL WILLIS, M.B., Ch.M., M.R.C.S., L.R.C.P., D.P.H., was born at Parramatta on 5th December, 1871, and died from the effects of pneumonic influenza, at Neutral Bay, on 23rd June, 1919. He joined this Society in 1908. After some years private practice in Queensland, he decided to study the science of public health and took up his residence in England, studying there at the University of Cambridge. Having secured the diploma of public health at Cambridge, and being appointed a member of the Royal College of Surgeons, London, he returned to Sydney, and entered the Public Health Department of the Government of New South Wales, where he rendered efficient service, being recognised as an officer of sound progressive views. Six years ago, when it was decided to develop and extend the medical service of the Education Department, Dr. Savill Willis was asked to undertake the work. The task proved one for which he was pre-eminently fitted, and, with judgment and organization, he established a State medical service in connection with the Public Schools in New South Wales. The system aims at securing the medical and dental inspection of every pupil of every Public School in the State at least once every three years, and more frequently in the metropolitan area. Specially good results have been attained by the system of dental clinics inaugurated by Dr. Savill Willis in connection with the Sydney Dental Hospital. Dr. Savill Willis made his last public appearance at the New South Wales Dental Congress less than a fortnight before his death, when he gave an interesting lecture on the subject of school clinics, and outlined new features, to be introduced into his Department's work in the near future. He leaves a widow but no family.

THE ACTION OF CUPRIC CHLORIDE ON ORGANO-METALLIC DERIVATIVES OF MAGNESIUM.

By EUSTACE EBENEZER TURNER, B.A., M.Sc., A.I.C.

[*Read before the Royal Society of N. S. Wales, June 2, 1920.*]

IT has been shown[1] that an ethereal solution of phenyl magnesium bromide reacts with anhydrous cupric chloride to give an almost theoretical yield of diphenyl:

$$2\,CuCl_2 + 2\,PhMgBr = Ph.Ph + Cu_2Cl_2 + MgCl_2 + MgBr_2.$$

This method of preparing diphenyl is preferable to that described previously[2] using chromic chloride, since the anhydrous cupric chloride may readily be made by dehydrating the commercial dihydrate. Moreover, in the case of o-tolylmagnesium bromide and iodide, chromic chloride gave a very poor yield of $1:1^1$-ditolyl, whereas it has now been found that anhydrous cupric chloride reacts with o-tolylmagnesium bromide to give the ditolyl in good yield. That the preparation of this hydrocarbon has presented some difficulty in other hands may be judged from the fact that Kenner and Turner[3] rejected the Fittig method in favour of that due to Ullmann.[4]

Attempts to couple two dissimilar groups by means of the cupric chloride reaction have met with no success, as was the case with chromic chloride. Since there is no obvious reason to expect a better yield of (say) toluene in the Fittig reaction:

$$Ph.I + 2\,Na + Me.I = 2\,NaI + Ph.Me,$$

[1] Trans. Chem. Soc., 1919, 115, 559.

[2] Trans. Chem. Soc., 1914, 105, 1057; this Journal. 1919, LIII, 100.

[3] Trans. Chem. Soc., 1911, 99, 2108.

[4] Annalen d. Chemie, 1904, 332. 28.

than in the still hypothetical reaction:

$$PhMgI + MeMgI + 2\,CuCl_2 = Ph.Me + Cu_2Cl_2 + MgI_2 + MgCl_2,$$

both being apparently quadrimolecular reactions, it is probable that the Fittig reaction is of a far more complex nature than is generally supposed. It is not commonly realised, moreover, that the Fittig reaction is by no means capable of universal application, and that actually it is useless in practice for the preparation of several of the more common diaryl-hydrocarbons in any quantity; in these cases either the chromic or cupric chloride method gives good yields, and (which is equally important) very pure products.

It would be expected that cupric chloride would react with the magnesium derivatives of halogen fatty acids to give succinic acids. Although, owing to lack of material, it has not been possible to investigate this matter fully, it is concluded that little success is likely to result from a more exhaustive examination. Thus in some preliminary experiments neither bromoacetic ester nor β-iodopropionic ester reacted in ethereal solution to give the expected succinic or adipic esters. With the simpler ester, a vigorous reaction was observed, but this was probably due to interaction between carbethoxymethyl magnesium bromide and unchanged bromoacetic ester. The iodopropionic ester, on the other hand, was recovered, for the most part, unchanged, a result which can be attributed, no doubt, to the slight reactivity of a halogen situated in the β-position with respect to a carbethoxy-group.

α-Bromobutyric ester, on the other hand, gave an appreciable quantity of s-diethylsuccinic diethyl ester when allowed to react in ethereal solution with magnesium and cupric chloride.

Experimental.

Preparation of 1 : 1[1] *Ditolyl.*

Anhydrous cupric chloride (60 grams) was added to a Grignard reagent made from 51·3 grams of o-bromotoluene, 7·3 grams of magnesium and 200 ccs. of ether. A vigorous reaction set in and was finally carried to completion by heating on the water bath. The orange-red solid (possibly an organometallic derivative of copper) was decomposed with water and dilute acid, the organic portion extracted with ether, and the extract dried, filtered and evaporated. The residue was distilled under diminished pressure and gave a yield of 1 : 1'-ditolyl corresponding to 30 per cent. of the theoretical. The hydrocarbon was very pure and melted at 18°.

Attempt to prepare α-Benzylnaphthalene.

Benzyl bromide and magnesium react in presence of ether to give not only benzyl magnesium bromide but also considerable quantities of s-diphenylethane, the formation of the latter being decreased if a large excess of magnesium is present. The mixed Grignard reagents were therefore prepared by allowing 34·2 grams of benzyl bromide to react with 9·73 grams of magnesium in presence of 200 ccs. of ether, 41·4 grams of α-bromonaphthalene being added when the whole of the benzyl bromide had reacted. To the solution finally obtained were added 60 grams of cupric chloride. A brisk reaction set in, was carried to completion by heating, and the product worked up as described above. Distillation under diminished pressure gave traces of toluene and naphthalene, but chiefly s-diphenylethane and α : α'-dinaphthyl. No α-benzylnapthalene could be detected.

Formation of s-Diethylsuccinic diethyl ester.

α-Bromobutyric ester (19·5 grams) was added to 2·43 grams of magnesium and 200 ccs. of ether. As soon as a vigorous reaction had set in, 20 grams of cupric chloride were added. Steady reaction proceeded for about half an hour and allowed to become complete at water bath temperatures. The resulting mixture, on decomposing in the usual manner, gave 3·5 grams of s-diethylsuccinic diethyl ester.

ON THE MANUFACTURE OF THYMOL, MENTHONE, AND MENTHOL, FROM EUCALYPTUS OILS.

By Henry G. Smith, F.C.S., and A. R. Penfold, F.C.S., Technological Museum, Sydney.

[Read before the Royal Society of N. S. Wales, June 2, 1920.]

Although a large number of crude Eucalyptus oils contain a crystallised phenol, yet this is not thymol, but quite a different substance, and thymol, as such, does not occur in any of them, although it may be readily prepared from the peppermint ketone, piperitone.

The individual constituents already determined as existing in the oils derivable from the various species of Eucalyptus number about 40, and among these are found numerous alcohols, esters, aldehydes, terpenes, etc., but only one ketone.

This constituent of peppermint odour was first isolated by one of us, (H. G. Smith), and the results of a preliminary chemical investigation presented to this Society in a paper read October, 1900.

In the Museum publication, "A Research on the Eucalypts and their Essential Oils" (Baker and Smith), 1902, p. 233, this ketone was recognised as new, and there named piperitone.

That the leaves of certain Eucalypts had an odour of peppermint was noticed soon after the first settlement in Australia in 1788, and in the "Journal of a Voyage to New South Wales," by John White, Surgeon General to the Settlement, published in 1790, the statement is made (p. 227) that the essential oil drawn from the leaves had a great resemblance to that obtained from the "Peppermint," *Mentha piperita*, which grows in England.

The species from which this "Peppermint oil" had been distilled was *Eucalyptus piperita*, a tree which must have been, at that time, quite common around Sydney.

Piperitone appears to be more generally distributed in the oils of species growing in the eastern and south-eastern portion of Australia and Tasmania, where the members of the whole group are generally known as "Peppermints." This ketone is usually associated in these oils with the secondary alcohol piperitol, and we have isolated this alcohol from the oil of *E. radiata*, and have determined its chemistry.

On the mountain ranges of the Main Divide the members of the "peppermint" group of Eucalypts form a large proportion of the natural vegetation, and are distributed over hundreds of square miles of country.

It is now recognised that all the principal constituents found in Eucalyptus oils increase in amount through a range of species, until a maximum is reached in one of them. Piperitone is no exception to this rule, and *Eucalyptus dives*, the "Broad-leaved Peppermint," appears to be the species in which it reaches the maximum content. The yield of oil from this Eucalypt is also large, from 3 to 4 per cent., according to the time of year, and provided the primary distillation has been somewhat extended, say from 6 to 8 hours, the oil will often contain as much as from 40 to 50 per cent. of piperitone. It is thus evident that this ketone could be obtained in great quantity, particularly as the species is one of the most plentiful of all the "Peppermint" group.

The remainder of the oil, which consists largely of phellandrene, would be useful for mineral separation by a flotation process, and it is already recognised as being the best of all the essential oils for flotation work, and is also in request for other economic purposes.

For the manufacture of thymol, piperitone could easily be supplied in ton lots if required, and as the molecular transformation from piperitone to thymol is not at all complex, and can be brought about in one operation, it should not be a difficult matter to devise methods for the preparation of thymol from piperitone on the manufacturing scale, and because of the great quantity available, probably more cheaply than from any other source, not even excepting Ajowan oil.

The formation of menthone by the reduction of piperitone is easily carried out if a catalyst be employed, and this result naturally leads to the preparation of menthol on further reduction.

Piperitone.

Piperitone under natural conditions is lævo-rotatory, as is also the corresponding alcohol piperitol, but the ketone readily forms the racemic modification if heated to its boiling point under certain conditions. The piperitone described in the original paper was shown to be inactive, for the reason that it had been separated by direct distillation from the crude oil under atmospheric pressure. If, however, the ketone be separated under greatly reduced pressure, this tendency to racemisation is overcome, and the lævo-rotatory form can thus be isolated. This alteration appears to be brought about by the influence of the acid split off from the esters at the temperature required to distil the ketone, because pure piperitone when distilled by itself alters its rotation but slightly, but if some geranyl-acetate be first added, the diminution in rotation is considerable.

Piperitone combines with sodium bi-sulphite without much difficulty, but the compound is very soluble in the aqueous solution, if, however, the combination be continued for some days, the saturated solution eventually forms a crystalline mass, from which the pure piperitone can be recovered.

A sample of pure piperitone, first obtained in the crude condition by distilling under greatly reduced pressure, and afterwards separated from the bi-sulphite compound, had specific gravity at 20° C. = 0·9348; optical rotation a_D −40·05°; and refractive index at 20° = 1·4837. It boiled at 229−230° C. (uncor.) at 760 millimetres, and at 106−107° at 10 millimetres pressure. The semicarbazone melted at 219−220° C.

Piperitone, which is an unsaturated ketone, forms both an oxime and an oxamino-oxime, which substances melted at 110−111° C. and at 169−170° C. respectively.

The molecular refraction for a $C_{10}H_{16}O$ ketone with one double linkage is 45·82; found 46·49. It has, however, been shown by Auwers and Hessenland [Ber. 41 (1908) 1812], that menthenones of this character, with a conjugated double bond, require an addition of 0·83 to the aggregate, and if this addition be made for piperitone the result is closely theoretical.

On oxidising piperitone with potassium permanganate, isobutyric acid is readily formed as one of the products; in fact it is difficult to prevent the formation of this substance even when the theoretical amount of permanganate is added in order to oxidise the carbonyl group, the temperature being kept down by the addition of ice.

The formation of thymol shows the carbonyl group in the piperitone molecule to be in the 3 position, and the results so far obtained suggest the double linkage to be in the 4 position, and that piperitone is Δ-4-menthenone-3; the only alternative to this being Δ-1-menthenone-3.

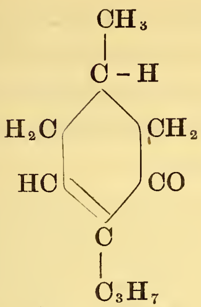
Wallach and Meister, [Ann. 362 (1908) 261] have, however, shown that menthenone with the double linkage in the 4 position boils at 212 – 213° C.; but Auwers [Ber. 41, (1908) 1801, and 42 (1909) 2408], has expressed doubts as to the correctness of this statement, although Wallach later confirmed his original determination. (Chem. Zentr. 1912, 11, 922 – 923).

The question as to the correct position of the double bond in the piperitone molecule does not affect the conclusions submitted in the present paper, as menthone would be the reduction product for both the 1 and 4 positions, with the CO group at 3.

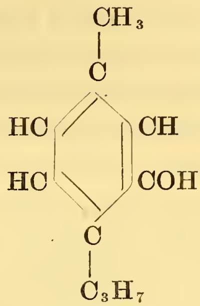
We hope eventually to be able to clear up this point, and to show beyond doubt the exact position of the double bond in piperitone.

Preparation of Thymol.

60 grams of pure piperitone were added to a solution of 175 grams ferric chloride, 160 c.c. glacial acetic acid, and 500 c.c. of water. The whole was then heated on the sand bath to boiling. The reaction takes place according to the equation $2\ FeCl_3 + H_2O = 2\ FeCl_2 + 2\ HCl + O$, and was completed at the expiration of about one hour. The reaction product was then steam distilled, the phenol separated and absorbed in a 5 per cent. solution of sodium hydrate, the unabsorbed oil removed by ether, and the aqueous layer decomposed by hydrochloric acid. The phenol was finally distilled under reduced pressure when the thymol came over at 110 – 111° C. at 10 millimetres. In this way we obtained a 25 per cent. yield of the weight of piperitone taken; but, no doubt, methods can be devised whereby almost a theoretical yield could be obtained. The change in molecular arrangement from piperitone to thymol is:—



Piperitone.



Thymol.

The thymol as thus prepared crystallised finely in large plates, melted at 49—50° C. and at the same temperature when mixed with ordinary thymol. The specific gravity at 20° = 0·975, and refractive index at 20° = 1·5226; the phenyl-urethane melted at 105° C. The phthalein fusion gave the characteristic blue colour for thymol, a reaction identical with that obtained with ordinary thymol when treated in a similar manner.

Preparation of Menthone.

Pure piperitone was subjected to the action of purified hydrogen, in the presence of a nickel catalyst, for six hours, the temperature ranging between 175—180° C. The double bond in piperitone was readily opened out with the formation of menthone, but further action of the hydrogen under these conditions did not reduce the carbonyl group, even after continued treatment for two days. Under correct conditions, however, the reduction to menthol should take place. The ease with which menthone is formed in this way is of special interest, not only in connection with the production of this ketone, but also as a stage in the manufacture of menthol.

The reduction of piperitone to menthone cannot well be brought about by the action of sodium or of sodium-amalgam in alcoholic solution, because, with the latter particularly, a solid bimolecular ketone is formed at once. This is a finely crystallised substance, melts at 148 – 149° C., and has the formula $C_{20}H_{34}O_2$. Piperitone thus follows the rule with substances having a conjugated double bond—Carvone for instance, which also forms a bimolecular ketone on reduction, melting at 148 – 149° C.

The menthone was prepared from piperitone in almost quantitative yield, and had the characteristic peppermint odour of this substance. It was colourless; boiled at 208° C., had specific gravity at 20° = 0·8978; optical rotation a_D – 0·15°, and refractive index at 20° = 1·4529. The oxime melted at 80° C., the more soluble semicarbazone at 156° C., while the least soluble melted at 187 – 188° C. Any unreduced piperitone can be removed from the menthone by the action of neutral sodium sulphite.

Preparation of Menthol.

Piperitone was partly reduced to menthol directly, by employing sodium in aqueous ethereal solution; a considerable quantity of the bimolecular ketone was, however, formed at the same time.

The reduction product from the piperitone was heated at 170 – 180° C. for two hours with an equal weight of phthalic anhydride, the melt dissolved in sodium hydrate, a small quantity of menthone removed by ether, and the phthalic acid compound regenerated by means of dilute hydrochloric acid. The phthalic acid ester was then decomposed by boiling with alcoholic potash, and the menthol separated and crystallised. The odour was excellent.

The menthol thus obtained from the lævo-rotatory piperitone melted at 34° C., and was optically inactive, thus following the general rule for synthetically prepared substances.

The preparation of menthol from piperitone by direct reduction does not, however, appear to be technically possible, owing to the ready formation of the bimolecular ketone, but piperitone is so readily reduced to menthone, that no difficulty in the manufacture of menthol from piperitone should be experienced if the production be carried out in two stages.

The menthone prepared from piperitone was treated with sodium in aqueous ether solution, repeatedly adding the metal in small quantity until the reduction was thought to be complete. The reduced product did not, however, solidify at room temperature, although it readily formed a solid mass when the vessel containing it was stood upon ice. As the melting point of menthol prepared in this way is only 34° C., it follows that a very small quantity of unreduced menthone would be sufficient to prevent crystallisation under atmospheric conditions. The menthol was, therefore, purified by the phthalic acid combination in the ordinary way, when a good return of crystallised menthol was obtained. It should not be difficult, however, to devise methods for the preparation of crystallised menthol, from the partly reduced menthone, by freezing out, and separating by mechanical means, similarly to those employed in the manufacture of cineol.

Although it might be a difficult matter to economically prepare the optically active components from the inactive menthol thus produced, yet this has been accomplished in the laboratory, and Pickard and Littlebury [Proc. Chem. Soc. 101, (1912) 111], have shown that when thus separated both the dextro- and lævo-menthols melted at 43° C.

A NEW SPECIES OF QUEENSLAND IRONBARK.

By R. H. CAMBAGE, F.L.S.

With Plate I.

[*Read before the Royal Society of N. S. Wales, June 6, 1920.*]

EUCALYPTUS CULLENI n. sp.

Arbor alta quadraginta vel quinquaginta pedes, trunci diametrum unciarum duodeviginti ad duo pedes habens.

Folia matura.—Linearia-lanceolata circiter sex ad quattuordecim cm. longa, octo mm. ad 1·5 cm. lata, cum apicibus directis vel uncis, interdum leviter falcata, utrobique cinerose viridia, glabrosa, costa media clara, venæ laterales aliquanto obscuræ et dispositæ angulo circiter 45° e costâ, margines plerumque quasi nervi, vena intra marginem juxta extremitatem, olei glandulæ parvæ sed numerosæ, petiolus a quinque mm. ad unum cm. longus.

Gemmæ globosæ, tubus calycis hemisphericalis duo mm. longus, diametrus quattuor mm. habens, operculum simile tubo calycis, terminatum cuspide brevi circiter ·5 mm. longa, pediculi circiter quinque mm. longi, pedunculi teretes a quinque mm. ad 1·1 cm. in parte inferâ paniculæ.

Flores pedicellati, umbellæ in paniculis terminalibus vel nonnullæ in axillis superioribus, cum floribus a tribus ad septem, antheræ parvæ patentes late laterale, glandula a tergo filum a fundamento.

Fructus hemisphericales tres ad quattuor mm. longi, diametrum a sex ad septem mm. habentes, ora excitata, circiter 1·5 mm. lati, valvæ exsertæ, pedunculi a quinque mm. ad 1·2 cm. longi.

Cortex dura, aspera et sulcata.

Lignum rubrum, durum et durabile, consuetissimum in fodinis apud "Chillagoe."

A tree of 40–50 feet high, with stem-diameter of 18 inches to 2 feet.

Mature leaves linear-lanceolate, from about 6–14 cm. long, 8 mm. to 1·5 cm. broad, with straight or hooked points, sometimes slightly falcate, greyish-green on both sides, glabrous, midrib distinct, lateral veins rather obscure, and arranged at an angle of about 45 degrees with the midrib, margins usually nerve-like, intramarginal vein close to the edge, oil glands small but numerous, petiole 5 mm. to 1 cm. long.

Buds globular, calyx-tube hemispherical, 2 mm. long, 4 mm. in diameter, operculum similar to calyx-tube, terminating in short point about ·5 mm. long, pedicels about 5 mm. long, peduncles terete, 5 mm. to 1·1 cm. in the lower portion of the panicle.

Flowers pedicellate, umbels in terminal panicles or some in the upper axils, with three to seven flowers, anthers small, opening widely laterally, gland at back, filament at base.

Fruits hemispherical, 3–4 mm. long, 6–7 mm. in diameter, rim raised, about 1·5 mm. broad, valves exserted, peduncles 5 mm. to 1·2 cm. long.

Bark hard, rough and furrowed.

Timber red, hard and durable, much used in the Chillagoe mines.

Habitat.—Alma-den, 121 miles by rail westerly from Cairns, tropical Queensland, about 1,600 feet above sea-level, growing on granite formation containing about 68–70% silica, and known as Ironbark. (No. 3905, collected August, 1913,) Mr. J. H. Maiden informs me that he received an incomplete specimen of this species from Chillagoe in 1911.

The species blooms in March, and I am indebted to Miss Ethel L. Maitland for flowers.

Reversion ("sucker") *foliage*—Ovate-lanceolate, 3–7 cm. long, 5 mm. to 2 cm. broad, so far as seen.

Seedlings—*Hypocotyl* terete, red, 3 mm. to 1 cm. long, 1 mm. thick at base, glabrous.

Cotyledons obtusely quadrilateral to reniform, entire, 2·5 – 3 mm. long, 4 – 7 mm. broad, upperside green, underside red; petiole 3 mm. long.

Stem brownish-red in lower portion, brownish-green in upper part.

Seedling foliage opposite for about two or three pairs, entire, glabrous, linear; petiole 2 – 4 mm. First pair 1·6 – 2·4 cm. long, 1 – 2 mm. broad, upperside green, underside purple; leaves Nos. five to ten up to 5 cm. long, 2 – 3 mm. broad.

A seedling about one foot high has an opposite pair of nodules or swellings[1] about the axils of the cotyledons or the first pair of leaves.

The species is named in honour of Sir William Portus Cullen, K.C.M.G., M.A., LL.D., Chief Justice of New South Wales and Chancellor of the University of Sydney, who has done much to encourage the preservation of our native flora.

Affinities.

Its closest affinity appears to be with *E. crebra* F.v.M., which it resembles in bark, timber and mature leaves, but differs in the shape of buds and fruits, and in the seedling foliage. It also resembles *E. paniculata* Sm. in its bark, but differs in the timber and other characters.

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[1] "On certain Shoot-bearing Tumours of Eucalypts and Angophoras," by J. J. Fletcher and C. T. Musson. Proc. Linn. Soc. New South Wales, Vol. XLIII, p. 191, (1918).

Eucalyptus Culleni n. sp., 1 – 4 three-fourths natural size. 3*a* Mature Leaf, natural size. 5 Tree nearly two feet in diameter.

EXPLANATION OF PLATE.

Eucalyptus Culleni n. sp.

1. Seedling plant with cotyledons. Alma-den.
2. Buds.
3. Fruits and mature leaves.

3a. Mature leaf, natural size.

4. Reversion ("sucker") foliage.
5. Bark on bole of tree nearly two feet in diameter.

ON APHROPHYLLUM HALLENSE, GEN. ET SP. NOV. AND LITHOSTROTION FROM THE NEIGHBOURHOOD OF BINGARA, N.S.W.

By STANLEY SMITH, M.A., D.Sc., F.G.S.

(Communicated by Professor W. N. BENSON.)[1]

With Plates II – V.

[*Read before the Royal Society of N. S. Wales, July 7, 1920.*]

THE remarks embodied in this brief contribution to Prof. W. N. Benson's comprehensive study of the geology of the Great Serpentine Belt, are based on the examination of a small collection of rugose corals obtained by Dr. Benson from the Carboniferous rocks within the Parish of Hall, some sixteen miles south of Bingara,[2] and are contributed in compliance with his request. The corals include a cyathophylloid form, which I have described under the name *Aphrophyllum hallense*, and representatives of the widely spread genus *Lithostrotion* which are referable to the species *L. arundineum* Eth. fil., and *L. stanvellense* Eth. fil.[3]

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[1] It was not possible for Dr. Smith to check the proofs of his paper, which had been carefully revised in MS. by Dr. W. D. Lang of the British Museum.

[2] For an account of the geology of this area see W. N. Benson, " A General Account of the Geology and Physiography of the Western Slopes of New England." Proc. Linn. Soc. N.S.W., 1917, esp. pp. 241-2.

[3] Corals from the Coral Limestone of Lion Creek Stanwell, near Rockhampton, Geological Survey of Queensland, Bulletin No. 12, 1900, pp. 19-20.

Mr. B. Dunstan, Government Geologist, Queensland, has at Prof. Benson's suggestion, very kindly furnished me with topotypes of the species named by Mr. Etheridge, and thus I have been able to compare the New South Wales material with the Australian types and the British forms.

For the opportunity given to me of gaining fresh knowledge concerning a group of fossils, in which I am very much interested, my thanks are cordially tendered to Prof. Benson and Mr. Dunstan.

Definition of Terms.

A precise definition of the terms employed is a very desirable preface to any palæontological contribution. Each group of fossils has its own extensive nomenclature to which additions are continually being made, moreover, authors are not in entire agreement in the use they make of the terms at their disposal.

The whole coral skeleton is here referred to as the **corallum.** A corallum may be simple, consisting of a solitary corallite, or may be composite, comprising many corallites. A **corallite** is the skeleton of a single individual, and in the case of a simple or solitary coral, the terms corallum and corallite are synonymous.

The Rugose Corallite can be divided into two areas, the intrathecal and the extrathecal. The former is built up of **tabulae** or **tabellae**, (*i.e.*, smaller and less regular plates ontogenetically derived from tabulæ), and the latter of **dissepiments.** The annular wall formed by the innermost layer of dissepiments against which the tabulæ or tabellæ abut is the **theca.**[1] This is usually rendered conspicuous by excessive deposition of calcium carbonate. The corallite

[1] The theca in the Rugose Coral is analogous rather than homologous with the theca in Aporose Corals, which is formed by the dilatation of septa and the union of the dilated portion to form an annual wall. Nevertheless, dilatation of septa does take place at the theca in a few Rugose forms, *e.g. Phillipsastraea.* Q.J.G.S., Vol. LXXII, (1917) pp. 288 – 291.

is with few exceptions bounded by a mural investment—the **epitheca.**

The composite corallum may be fasciculate in growth-habit, in which case the corallites are not in lateral contact, and are consequently circular in section. On the other hand, it may be massive, and the corallites in this case are contiguous and are polygonal in section through mutual pressure. The massive colony may be **basaltiform,** *i.e.* the corallites, though contiguous, are defined by epitheca; or may be **astraeiform,** *i.e.* the epitheca is absent, and the corallites are confluent.[1]

Preservation of Material.

The material is well preserved. The corals are embedded in dark limestone, and the interstices are filled by clear calcite. The tissue has re-crystallized to some extent, and when examined through the microscope is seen to have lost something of its definition.

APHROPHYLLUM HALLENSE gen. et sp. nov.
Plate II, figs. 1 – 5.

External Characters.—The corallum is composite, and of massive growth-habit. The corallites are contiguous but imperfectly so. They are turbinate in form.

Internal Characters.—The corallites as seen in transverse section are imperfectly polygonal in shape, for since their contiguity is not absolutely perfect, and the mutual pressure they exert is therefore not entirely uniform, their outline is partly angular, partly rounded. (Plate II, fig. 1) The largest corallites measured about 1·75 min. in diameter.

The septa do not reach the epitheca except in very early growth stages, in fact, in the mature stage they are not prolonged very far beyond the theca. The major septa extend to the centre of the corallum, and these give rise

[1] Q.J.G.S., Vol. LXXII, (1917) pp. 261 – 282.

to a loose retiform pseudo-columella. The minor septa attain a length from about one-half to two-thirds that of the major septa.

The number of septa in each cycle is about twenty-two;[1] they may therefore be described as not crowded. The fossulæ are not obvious, even in immature stages.

The tabulæ are numerous. I have counted about thirty plates in the space of one centimetre. They are flat or slightly arched, but are irregular and not consistently continuous across the intrathecal area. (Plate II, fig. 3.)

The dissepiments are medium-sized plates, and form a wide peripheral zone external to the septal cycle. Where fully developed, this constitutes about one-third of the radius of the corallite. In very many cases, the peripheral parts of the corallites are much crushed and broken.

The epitheca is strongly developed.

Observations concerning the development of corallite.

The young corallites make their appearance between the older ones, and are evidently attached to the epitheca of their parent; they are the product of lateral germination.[2]

The septa in the earliest stage observed are united with the epitheca; they are short and do not reach the centre of the corallite. Later, but nevertheless, still at an early stage, they become detached from the epitheca, and the intervening space becomes occupied by relatively large dissepiments; at the same time they advance into the pseudo-columella. (Plate II, figs. 4 and 5).

During the immature stages, much deposition of calcium carbonate takes place at the theca, and renders that part of the structure very dense. The feature becomes much less pronounced when maturity is attained. (Compare figs. 1 and 2 on Plate II.)

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[1] See note on an isolated corallite following description of *Aphrophyllum*.
[2] See Q.J.G.S., Vol. XLII, (1916), pp. 233 – 235.

The foregoing remarks are based on the examination of only a very limited amount of material, and are not made without reservation.

Comparison of Aphrophyllum with Endophyllum.

The internal structure of *Aphrophyllum* is distinctly cyathophylloid—a structure common to many rugose corals, not necessarily genetically related. In the wide zone of dissepiments, and in the general arrangement of the septa, it very closely approaches in appearance *Endophyllum*—a Devonian genus; in fact, the transverse section is very suggestive of *E. abditum* Edwards and Haime, as figured in the Monograph of British Fossil Corals, Pal. Soc. 1853, plate lii. fig. 6. It would, however, be unsafe to assume a congeneric connection between the Carboniferous species found in Australia and the Devonian genus of Europe. I have, therefore, described the coral under a new generic name, which can readily be relegated to synonymy should the affinity of the form to *Endophyllum* be established at any future date.

The material included two small colonial masses and several isolated corallites. In addition to these, there was one solitary corallite which resembled the rest in its general appearance, but differed from them in several respects. It possessed about 60 septa, 30 in each cycle, and the minor septa were longer than in the typical specimens of *A. hallense.* The major septa did not quite reach the centre of the corallite, but nevertheless, as in *Aprophyllum*, became twisted at their inner edge. In the section (the only one obtainable) the middle of the corallite was occupied by a tabula which rendered this part dense and rather obscure. The septa appeared to reach the epitheca, or to be separated from it only by a very narrow zone of dissepiments, but the peripheral portion was incomplete. It is not permissible to draw any definite conclusion from this solitary and imperfect specimen. It may be a large form of *Aprophyllum* (it measured two centimetres in diameter) or, as possibly another cyathophylloid form.

LITHOSTROTION Fleming, 1828.

(History of British Animals, p. 509).

Genotype. *L. basaltiforme* Conybeare and Phillips, 1822, ("Outlines of the Geology of England and Wales," p. 359) = "Lithostrotion sive Basaltes minus striatum et stellatum." Lhwyd, (Lithophylacii Britannici Ichnographia, 1699, p. 125 and pt. xxiii).

Fleming, under the name *Lithostrotion*, described four coral species, namely:—

L. striatum Flem., citing Lhwyd's figure.

L. floriforme Martin ("Petrificate Derbiencia," 1809, pt. xliii, figs. 3 and 4; pt. xliv, fig. 5).

L. oblongum Parkinson ("Organic Remains etc." 1808).

L. marginatum, Flem.

Although Fleming did not expressly state it, it is clear that he considered Lhwyd's form as the genotype of *Lithostrotion*, he adopted the name employed by Lhwyd for the genus, placed *L. striatum* first in the list, and definitely referred to Lhwyd's figure. To this form, Martin's species bears no close affinity.

William Lonsdale ("Description of some characteristic Palæozoic Corals of Russia," see R. I. Murchison et Alii. "The Geology of Russia in Europe and the Ural Mountains," Vol. I, p. 602 *et seq.*) selected Martin's species *Eusmatolithus Madreporites (floriformis)* as the genotype of Fleming's genus. The choice was an unfortunate one, and its legitimacy has been challenged by such eminent authorities as Milne Edwards and Haime (British Fossil Corals p. 206). Since Fleming did not, in so many words, fix Lhwyd's figure as his genotype, Lonsdale was at liberty to select any one of the four species as the type, and therefore, according to the strict interpretation of the laws of zoological nomenclature, *Lithostrotion* should be the name of the genus of which E. Martin's *floriforme* is the genotype. But, since there can be no doubt as to Fleming's intention (in taking the pre-Linnæan name) of making Lhwyd's figure the genotype, and since the name *Lithostrotion* has been identified for over sixty years with the genus that it universally signifies, and any alteration now will cause very considerable confusion, I propose to retain the name *Lithostrotion* as in the sense in which it is generally accepted.[1]

Description of Genus.

External Characters.—The corallum is composite, but may be either fasciculate or massive in habit, and the corallites are accordingly cylindrical or prismatic; these quickly attain their mature character and dimensions, but grow to a considerable length.

Internal Characters.—The septa are united to the epitheca, and the major septa or most of them reach the columella, the minor septa are prolonged only a small distance beyond the theca. The fossulæ are inconspicuous. The counter septum is dilated along its inner edge to form a styliform columella. The tabulæ are well-formed conical plates. The dissepiments are small of uniform size, and in the large species build up a wide extrathecal area.

With such a simple structure, it might be supposed that the range of variation would be limited, nevertheless the genus exhibits great variation. Exceptions may be found to all the above mentioned characters. In rare cases the septa fail to reach the epitheca. Very frequently among the fasciculate species, but only rarely among the massive the columella is absent, and correlatively the septa are

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[1] Q.J.G.S., (1916), Vol. LXXI, p. 220 - 221.

short, and the tabulæ flat or concave. Lonsdale *(op. clt.)* gave to the non-columate fasciculate forms of *Lithostrotion* the generic name *Diphyphyllum*, and to the similar massive types the name *Stylastraea.* The distinction was not accepted as of generic value by Milne Edwards and Haime, and with their view, I concur. It is true, that I have found at some particular horizon or locality *Diphyphyllum late-septatum* M'Coy [= non-columate form of *L. irregulare* (Phillips)] occurring in great abundance to the exclusion of the columate form; but on the other hand, I have observed both types of corallite present in the same corallum.

Systematic Classification.

Any classification of a coral genus based solely on the skeleton is highly unsatisfactory, and is permissible only in the case of fossil corals the soft parts of which are unknown. The researches of Prof. George Matthai,[1] and other workers have shown that the "hard parts" of recent corals afford no safe basis upon which to erect species.

Fossil "species" and "varieties" may have little biological value, and should, perhaps be merely regarded as necessary labels indicative of a close community of characters shared by members of such a "species" or "variety."

I have pointed out elsewhere[2] in discussing the classification of Rugose corals that "Inconsistency of detail but conservation of the general plan, is the most characteristic feature of the skeletal morphology of the Rugose genera, especially in the more specialised genera, since complexity of structure widens the scope of variation."

Lithostrotion has a comparative simple structure, yet within its limitations it presents a bewildering series of

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[1] A Revision of the Recent Colonial Astraeidae possessing Distinct Corallites. Trans. Linn. Soc., ser 2 (Zool.), Vol. XVII, 1914.

[2] Q.J.G.S., Vol. LXXI, 1916, p. 237.

variations, emphasised perhaps by the almost unwieldy mass of material available for study.

The growth-habit—whether fasciculate or massive, correlated with the diameter attained by the mature corallite and the corresponding complexity of structure, provide the most satisfactory basis of specific separation. This does not preclude the recognition of "species" distinguishable by other characters.

A corallum is rarely indefinite in its growth-habit, although there are semi-fasciculate and semi-massive forms connecting the two conditions. Again, both in the fasciculate and massive varieties, the "species" are linked up by forms intermediate in the size attained, but one does not find adult corallites of two very distinct sizes associated together in the same corallum.

A very large number of "species" have been described, but most of the specific names must be regarded as synonyms. Many of the earlier-named species are insufficiently described and inadequately illustrated.

A thorough revision of the genus is needed involving a careful re-examination of the type specimens by means of thin sections.

Pending this revision, and to serve present needs, I propose the following tentative classification for the British representatives.

	Dimensions.			Dimensions.	
	Corallites	Intrathecal Area.		Corallites	Intrathecal Area.
L. junceum (Fleming)	2 mm.	1 mm.	*L. m'coyanum* Edwards & Haime	2·5 mm.	1 mm.
L. irregulare (Phill.)	5 ,,	2·5 ,,	*L. portlocki* (Bronn)	7 ,,	2·5 ,,
L. martini Edwards & Haime	8 ,,	5 ,,	*L. basaltiforme* (Conybeare & W. Phillips)	10 ,,	5 ,,
L. affine (Fleming)	13 ,,	10 ,,	?*L. aranea* (M'Coy)	larger	forms.

The measurements given for the particular "species" are averages or means, the selection of which has been made according to the principle of priority.

In any scheme of classification ultimately adopted, the non-columate forms should for general convenience retain in some form or another, the specific name by which they are known as well as that of the columate species to which they belong, *e.g.*, *Diphyphyllum lateseptatum* M'Coy = non-columate "forma" of *L. irregulare* large variety, and of *L. martini* small variety.

Distribution.

Lithostrotion is the most prolific genus of the rugose class found in the British Carboniferous sequence, but has a limited range, namely, the Visean, *i.e.*, the higher part of the Lower Carboniferous. Within the particular zones it occupies, it occurs very abundantly, forming in many places vast coral growths incorporated in the limestones or covered by calcareous shales. It is, I believe, equally abundant in Belgium[1] and I have examined specimens from several localities in Russia. It has been recorded and described from Eastern Asia[2] and also from North America,[3] but none of the American forms which I myself have examined,[4] appear to be congeneric with the British types. I do not wish to imply that true *Lithostrotion* may not have been found within that continent.

I have been informed by Mr. J. Coggin Brown of the Indian Geological Survey that the genus has not yet been recorded in any of the publications of that body.

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[1] Arthur Vaughan. Correlation of the Dinantian and Avonian. Q.J.G.S., 1915, Vol. LXXI, pp. 1 - 52.

[2] Yabé Hisakatsu and Hayasaka Ichirô; Palæozoic Corals from Japan, Korea and China: Journ. Geol. Soc. of Tokyo, Vol. XXII, pp. 93 - 109, and pp. 127 - 142 (1915). These authors described some species as from the Permian.

[3] Citations too numerous to quote.

[4] Specimens in the British Museum South Kensington, and examples kindly sent to me by Dr. G. H. Girty of the U.S.A. Geological Survey.

The Australian Species.

The Australian species before me, namely those from New South Wales and Queensland, agree in all their essential characters with their European congeners. Yet as a group they present certain distinctive characters.

Tabulæ.—The most striking difference between the Australian, both New South Wales and Queensland, and the British forms is that in the tabular tissue. Here, smaller, much more arched and less regular plates (tabellæ) take the place of the larger more regular conical tabulæ characteristic of the British columate species, *cf.* figs. 3 and 6, Plate IV. A few forms do not show this character so strongly developed, as for example, the corallite reproduced in fig. 6, Plate III. I have noticed a tendency to this development among British forms, but never to the same degree.

The replacement of tabulæ by tabellæ is an interesting feature; it marks an intermediate stage in the evolution of a clisiophylloid form, *i.e.* one in which there is a central axial structure built up of tabellæ (the "Central Column")[1] distinctly differentiated from the rest of the tabular tissue which surrounds it. A clisiophylloid derivative of the *Lithostrotion* stock has been recorded by the author from Northumberland and described by the late Arthur Vaughan.[2]

Columella.—The stout columella is a very noticeable feature common to the Australian species, and distinguishes them as a group from the British type in which this axial rod is not usually so pronounced, and is often, in fact, weakly developed.

Dissepiments.—The dissepiments are larger and less regular than those characteristic of British species.

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[1] Q.J.G.S., Vol. LXIX, (1913) p. 59.

[2] Trans. Nat. Hist. Soc., Northumberland, N.S. Vol. III, 1910, p. 606 and 634, pl. XVI, fig. 10.

The New South Wales material shows yet another distinctive feature, not peculiar in itself, but a markedly prevalent character of the specimens as a whole, namely the tendency on the part of the septa to terminate within the dissepimental area and not quite reach the epitheca.

The massive form from Queensland "*L. columnare*" exhibits another character which calls for comment, namely the thinness of the epitheca. These divisional walls between the corallites are much weaker than in a more typical example of *Lithostrotion*, but stronger than in *Orionastræa (Lithostrotion) ensifer* (Ed. & H.) in which the epitheca between the corallites is reduced to a mere trace. *L. ensifer* links *Lithostrotion* with the typical forms of *Orionastræa*, a derivative of *Lithostrotion*, in which there is no epitheca at all, and in which the septa are perfectly confluent.[1]

All the characters I have brought to notice suggest that the forms are phylogenetically advanced ones.

Analysis and Comparison.

In the following table, I have set out a detailed and critical analysis of topotypes from Queensland and of the specimens from New South Wales from the sections I have had prepared. The measurements and the number of septa stated therein refer in each case to the largest corallites present in the section.

Disposal of Material.

The holotype of *Aphrophyllum hallense* and all figured sections of *Aphrophyllum* and *Lithostrotion* are in the Australian Museum, Sydney. Duplicates have been placed in the British Museum (Natural History) South Kensington, London.

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[1] Q.J.G.S., Vol. LXXII, (1917) pp. 294 – 303.

Reference No. of Specimen	Figure.	Measurements.		Septa.		Tabulae.	Columella.	Species.	Comparable British Species.
		Diameter of Corallite.	Diameter of Intra-thecal area	Number in each Cycle.					
D 11	Pl. IV, fig. 1	10 mm.	7 – 8mm.	28 – 30	united to epitheca.	as described p. 61.	stout, styliform.	*L. stanvellense*	*L. martini* large variety.
D 12	Pl. IV, fig. 3	9 mm.	7 mm.	28 – 30	united to epitheca.	as described p. 61.	stout, styliform.	*L. stanvellense*	*L. martini.*
D 4	Pl. IV, fig. 2	5 mm.	4 mm.	20	united to epitheca.	as described p. 61.	strong, rodlike.	*L. arundineum*	*L irregulare.*
B 1	Pl. III, figs. 5, 6	9 mm.	7 mm.	24 – 26	not entirely united to epitheca. Note corallites in upper portion of figure.	as in British forms.	not nearly so stout as in D 11 and D 12.	*L. stanvellense*	*L. martini,*
B 3	...	11 mm.	8 mm.	30	as B 1.	as described p. 61.	stout, not quite as prominent as D 11 and D 12.	*L. stanvellense* large variety.	approaches *L affine.*
B 5	Pl. III, figs. 1, 3	7 mm.	5 mm.	20	united to theca except in the case of some of the minor septa.	as described p. 61.	very stout in comparison to size.	*L. stanvellense* small variety approaching *L. arundineum*	*L. martini.*
B 6	Pl. III, fig. 2	6 mm.	4 mm.	16 – 20	not united to epitheca.	...	not particularly stout.	near *L. arundineum.*	*L. martini*, small variety approaching *L. irregulare.*
B 9	Pl. III, fig. 4	10 mm.	7 mm.	24 - 26	united to epitheca in most corallites, but not entirely so in all.	...	stout, and typical of species.	*L. stanvellense*	*L. martini.*
B 9 two other section	...	8 mm.	6 mm.	24	as above.	...	stout, and typical of species.	*L. stanvellense*	*L. martini.*

* Approximate only. ‡ Largest corallites.

Description of Plates II - V.

Plate II.

Aphrophyllum hallense gen. et sp. nov.

All figures magnified two diameters.

Fig. 1. *Aphrophyllum hallense.* Holotype. Transverse sections of mature corallites. Parish of Hall, Bingara, N.S.W. No. B 8.

Fig. 2. The same. Paratype. Transverse section of immature corallites, advanced neanic stage, No. B 10.

Fig. 3. The same. Holotype. Longitudinal section, B 8.

Figs. 4 and 5. The same. Holotype. Transverse section. Sections showing early neanic stages, B 8.

Plate III.

Lithostrotion.

Specimens from New South Wales, all figures magnified 2 diameters.

Fig. 1. *Lithostrotion stanvellense* Eth. fil., small variety approaching *L. arundineum.* Transverse section, Parish of Hall, Bingara, N.S.W. (B 5.)

Fig. 2. *Lithostrotion* near *L. arundineum* Eth. fil. Transverse section, same locality. (B 6.)

Fig. 3. *Lithostrotion stanvellense.* Longitudinal section. Same specimen as fig. 1. (B 5.)

Fig. 4. *Lithostrotion stanvellense.* Transverse section. Same locality. (B 9.)

Fig. 5. *Lithostrotion stanvellense.* Transverse section. Same locality. (B 1.)

Fig. 6. *Lithostrotion stanvellense.* Longitudinal section. Same specimen as fig. 5. (B 1.)

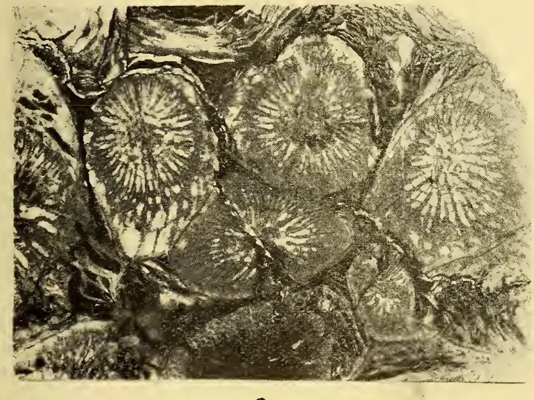
Plate IV.

Lithostrotion.

Specimens from Queensland and Great Britain.

Fig. 1. *Lithostrotion stanvellense* Eth. fil. Topotype. Transverse section, Lion Creek, Stanwell near Rockhampton. (D 11.) × 2.

1



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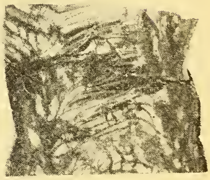

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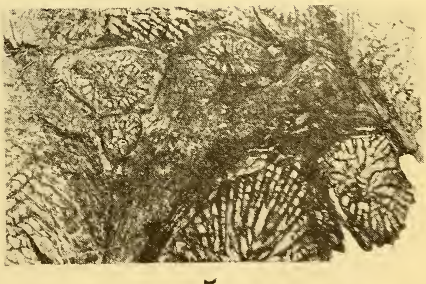

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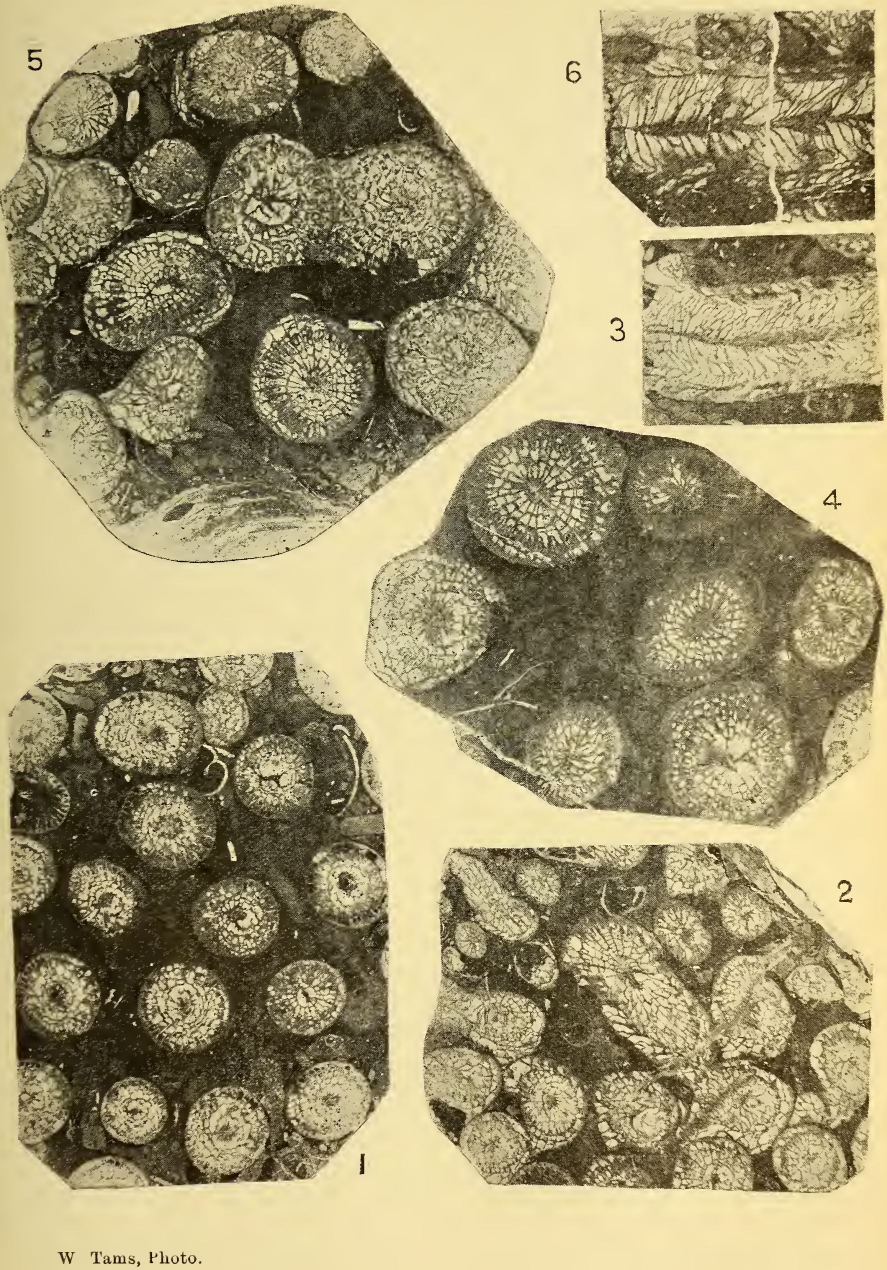
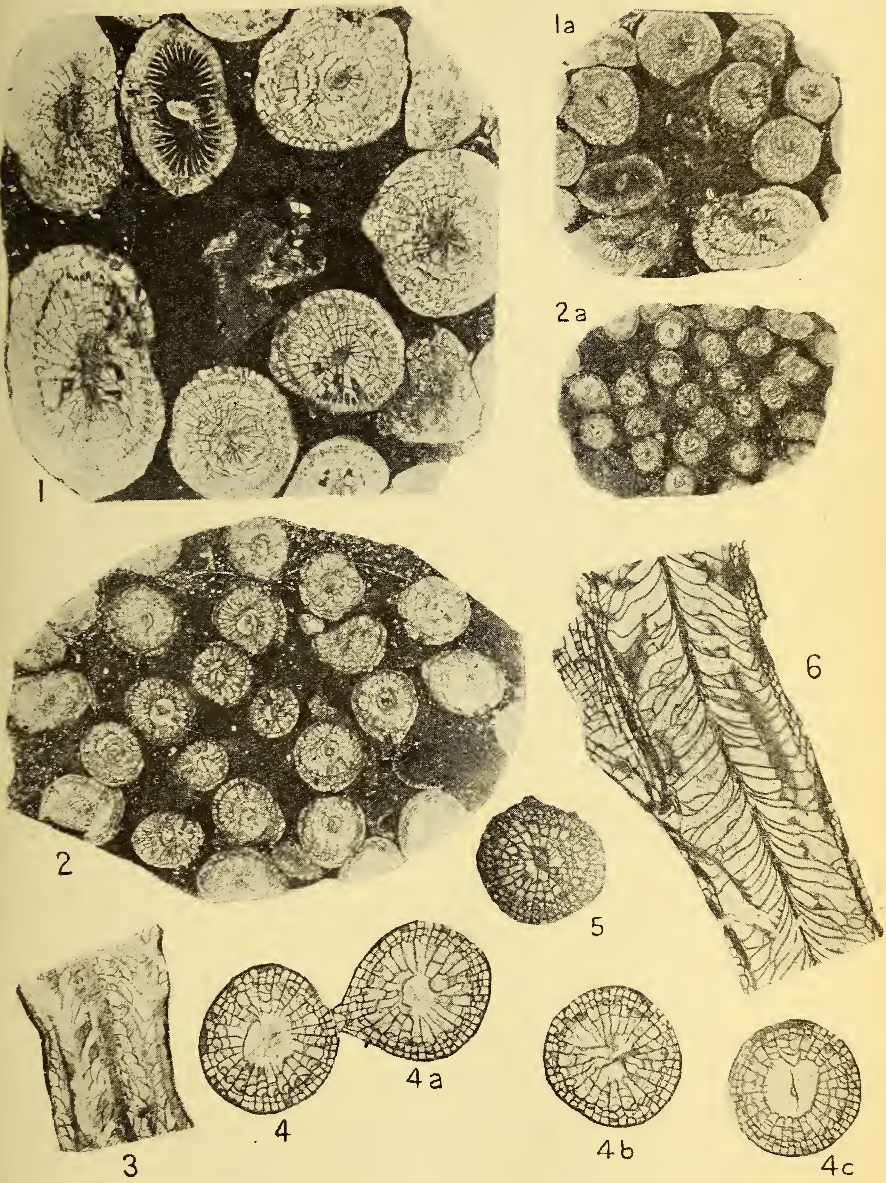
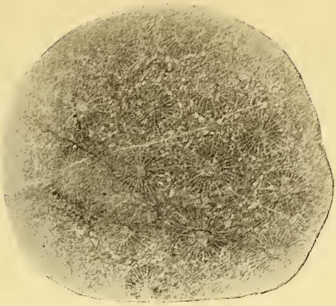


W Tams, Photo.



W. Tams, Photo.



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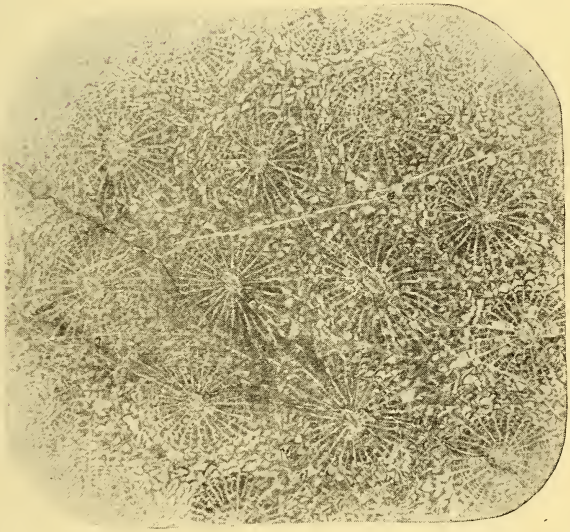
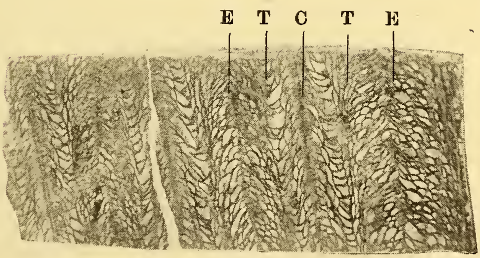


1a



2

Note.—The stout well-formed columella and the intrathecal area crowded with sections of tabellæ. Compare this with figs. 4, 4a, 4b, and 4c, British form, in which the columella is weakly developed or absent and few inter-sections of tabulæ.

Fig. 1a. The same, natural size.

Fig. 2. *Lithostrotion arundineum* Eth. fil. Topotype. Transverse section, same locality. (D 4.) × 2.

Fig. 2a. The same, natural size.

Fig. 3. *Lithostrotion stanvellense* Eth. fil. Topotype. Longitudinal section. (D 12.) × 2.

This section illustrates the most striking difference between Australian and British types. Compare the stout columella and small arched tabellæ with the more slender columella and simple tabula in Fig. 6, a specimen from the North of England.

Figs. 4, 4a, 4b, 4c. *Lithostrotion martini* Ed. & H. Transverse section, Narrowdale, Derbyshire, England. × 2.

Corallites from same corallum, see note on Fig. 1.

Fig. 5. *Lithostrotion martini.* Transverse section, Alston, Cumberland, England. × 2.

This form closely approaches the Australian type in its stout columella and numerous inter-sections of tabulæ or tabellæ.

Fig. 6. *Lithostrotion martini.* Longitudinal section, Settle, Yorkshire, England. See note on fig. 3.

Plate V.

Lithostrotion—Lithostrotion columnare.

Fig. 1. *Lithostrotion columnare* Eth. fil. Topotype. Transverse section, Lion Creek, Stanwell, near Rockhampton, Queensland. (D 13.) Natural size.

Fig. 1a. The same × 2.

Fig. 2. The same. Transverse section. C = columella, E = epitheca T = theca.

DESCRIPTIONS OF THREE NEW SPECIES OF EUCALYPTUS.

By J. H. MAIDEN, I.S.O., F.R.S., F.L.S.

[*Read before the Royal Society of N. S. Wales, July 7, 1920.*]

1. E. CAMFIELDI n. sp.

Frutex vel arbor pumila fere Mallee similis, statu immaturo pilis stellatis vestitis, cortice fibrosa; foliis junioribus scabrissimis, pilis stellatis dense vestitis, parvis, cordatis vel orbicularibus, sæpe emarginatis; foliis maturis coriaceissimis, nitentibus, oblongis vel late lanceolatis, obliquis, apice obtuso; alabastris ca. 9 capitulo, sessilibus, pedunclo breve, angulatissimis sed post anthesin ovoideis; antheris reniformibus; fructibus hemisphæricis ad 1 cm. diametro in capitulis, compressis, capsula 4-loculare, apicibus distincte exsertis.

A low branching shrub or stunted tree, almost Mallee-like and under twelve feet in height, and with stems about two inches in diameter. Covered with stellate hairs when young. Bark scaly-fibrous or fibrous, flattish, tough—a Stringybark.

Juvenile leaves very scabrous, abundantly provided with stellate hairs in the earliest stage, cordate to orbicular, often emarginate, never lanceolate in the young state. Often 2 cm. × 2 cm. with intermediate sizes up to 4 cm. × 4 cm. (They remind one irresistibly of *Angophora cordifolia*, and when small as well as young, of *Correa speciosa*.)

Mature leaves remarkably coriaceous and oblong to broadly lanceolate, with a blunt point, oblique, lustrous or shiny, as if varnished. Up to 1 dm. long and say 3·5 cm. broad. Oblique and coarse in the intermediate stage with a mucro.

Buds about nine in the head, small, very angular through compression, becoming ovoid or scarcely angular on anthesis, sessile on a short peduncle or none. Anthers renantherous, but not typically so.

Fruits hemispherical, up to 1 cm. in diameter, in heads, compressed, sometimes so much so that they are almost syncarpous, with a shiny dark red rim, capsule 4-celled with the tips distinctly exsert.

The type is from Middle Harbour, Port Jackson, 25th May, 1897. Julius Henry Camfield, for many years Overseer of the Garden Palace Grounds, Botanic Gardens, Sydney, who died 26th November, 1916. He was not only an excellent gardener, but a competent botanist, and I have much pleasure in dedicating this interesting species to his memory.

Range.

On exposed situations on sandstone tops, only known at present between Broken Bay and George's River, a few miles north and south of Port Jackson, New South Wales. There is little doubt that careful search will greatly extend the range. Following are specific localities:—

About half a mile south of the 17 mile post on the Galston Road from Hornsby (W. F. Blakely). The west side of Berowra Creek, Hornsby, or about one and a half miles from the 17 mile post above.

Eight to nine feet high, in low Honeysuckle *(Banksia)* Scrub, Willoughby (A. G. Hamilton). Near the Suspension Bridge, Willoughby (J. L. Boorman). "Looks like *E. capitellata*. From very stunted trees (very likely saplings from old stumps) only a few feet high. Note the sucker leaves." On the high ground of Middle Harbour (J. H. Camfield, 25th May, 1897). Mosman (W. M. Carne).

The following are south of Port Jackson:—

Woronora River at Heathcote (J.H.M. and J. L. Boorman).

A dwarf form, eight feet high, Waterfall (R. H. Cambage No. 4169).

Affinity.

With *E. capitellata*, Sm., with which it has long been confused. *E. capitellata* is a tree, sometimes a large tree, and the organs are all larger, while there is an absence, or almost absence, of stellate hairs in the young shoots. E. *Camfieldi* is a Mallee, forming a dense undergrowth, from three to about twelve feet high. *E. capitellata* appears to be absent from the Hornsby district, where the new species is not rare. The juvenile leaves (suckers) of *E. Camfieldi* are smaller, more orbicular to cordate, scabrous with a persistent stellate tomentum, apparently always present around the base of the adult plants, forming thickets, similar to the low stunted forms of *Angophora cordifolia*. They are never lanceolate like those of *E. capitellata*. The new species has buds smaller than those of *E. capitellata* and less attenuate, usually ovoid; in some specimens they are almost round and devoid of angles. The common peduncle is shorter than in *E. capitellata* and quadrangular to nearly terete. The peduncle of *E. capitellata* is very often more compressed in the early bud. The fruits are smaller than those of *E. capitellata*, but otherwise very similar.

The juvenile foliage shown in figures 4a and 4b, Plate 37, Part VIII of my "Critical Revision of the Genus Eucalyptus," (under *E. capitellata*) and also figure B, Plate 106, Part XXVIII of my "Forest Flora of New South Wales," belong to *E. Camfieldi*.

It is the form (b) for the most part, of p. 493 of this Journal, Vol. LII (1918).

2. E. DE BEUZEVILLEI n. sp.

Arbor amplaplusve minusve glauca; cortice læve, lamellis longissimis decidua, trunci basi aspero-lamellosa, ligno pallido fere albo, gummi venis; foliis fragrantibus, foliis junioribus orbicularibus ad cordatis, venis secondariis patentibus vel sursum curvatis; foliis maturis lanceolatis, crassis, venis secondariis basi patentibus postquam longitudinalibus; alabastris angularibus fere alatis, operculo conoideo calycis tubo ca. dimidio æquilongo; fructibus polygonalibus, angularibus, piriformibus vel subglobosis, capsula depressa, sessile vel brevissime pedunculata.

A tree of medium or large size, up to 60 feet high, a "White Gum," more or less glaucous, the young branchlets glandular. Bark smooth, but with usually more or less rough-flaky bark at the butt. Where the rough bark is present it usually ascends the trunk about five to six feet; the deciduous or smooth portion in long strips, not ribbons, some of the pieces being thirty feet long. Timber pale-coloured, almost white, with gum (kino) veins, with a general resemblance to that of *E. coriacea.* Foliage fragrant.

Juvenile leaves almost orbicular to cordate, thin, shortly petiolate, secondary veins spreading or curved upwards, no distinct intramarginal vein. Some leaves measured are 9 cm. long by 7 cm. broad.

Mature leaves lanceolate, slightly falcate, with a short blunt point, thick, slightly shining, the secondary veins spreading at the base, thence longitudinal and parallel to the midrib. An average leaf is about 13 cm. long and about 4 cm. in greatest width. There are leaves intermediate in shape, thickness and venation between the juvenile and mature leaves.

Buds remarkably angular by compression, the angles almost winged, peduncles about 1 cm. long, convex to flattened, expanded, especially at the top, pedicels absent or very short, the conoid operculum about half the length of the calyx-tube. Filaments cream-coloured, anthers renantherous.

Fruits polygonal and most of them angled, the angles or ribs persisting until maturity, pear-shaped to sub-globose, sessile or very shortly stalked, walls thick; capsule sunk, 3 or 4-celled.

Type from Jounama Peaks, N.S.W., Wilfrid Alexander Watt de Beuzeville, Assistant Forester, Forestry Commission, December 1919.

Range.

So far it has only been found on peaks in the Mount Kosciusko district of New South Wales. "Near the summit of Mount Jounama, at an altitude of 5,400 feet almost. Jounama is one of what is known as the Bogong Peaks in the parish of Jounama, County of Buccleuch, about thirty miles south of Tumut. There is a belt of these trees about five or six miles long by about half a mile wide along the top of the Jounama Peaks. Its lowest level would be between 4500 and 5000 feet. The tree is one of the largest in the district. The buds mature in a few weeks, and the fruits set immediately; in other words, it flowers and fruits in the same year."—(de Beuzeville). [A consequence of the severity of the climate during the greater part of the year.]

Affinities.

1. With *E. coriacea* A. Cunn., var. *alpina*. It differs in being a much larger and, as a rule, a freer growing plant. "Have never seen a form like it before. Tree much like the ordinary *E. coriacea* except for it being much more spreading and gnarled, though this might be accounted for by its exposed position at a high altitude." (de Beuzeville). It has large, mostly oblique leaves, and large angular buds. The fruits are also two or three times as large as those of var. *alpina* and usually with two or three faint angules, and a more convex rim.

Its affinity with the Tasmanian *E. coccifera* Hook. f., is more remote.

2. With *E. gigantea* Hook. f. The affinity lies in the shape of the juvenile leaves (suckers) and more distantly in the fruits. The foliage of both species is fragrant, with the same kind of odour, but *E. gigantea* is a rough barked species, while *E. de Beuzevillei* is a Gum.

3. With *E. tetragona* F.v.M. There is similarity in the polygonal, often quadrangular fruits, which requires a word of caution in case fruits are the only material available.

3. E. EREMOPHILA n. sp.

Frutex vel arbor mediocris, cortice læve, squamosa, ramulis glaucescentibus; foliis junioribus angusto-lanceolatis vel lanceolatis; foliis maturis lineari-lanceolatis ad lanceolatis, coriaceis, nitentibus, venis secondariis tenuibus sed remotiusculis, non pennivenis; pedunculis elongatis, applanatis, pedicellis fere teretibus ca. 5 mm. longis, calycis tubo oblongo vel cylindroideo, turbinato, ca. 5 mm. longo; operculo cornuto calycis tubo ca. quinquies æquilongo, diametro distincte minore; filamentis antherisque Cornutis similibus; fructibus cylindroideis vel sphæricis, calycis tubo crasso, capsulæ apice applanato fere margini æquante, fructu truncato.

A shrub or medium-sized tree, with smooth scaly bark. Branchlets glaucescent.

Juvenile leaves (suckers) not available in the earliest stage, but probably narrow. Those of the seedlings are narrow-lanceolate to lanceolate.

Mature leaves linear-lanceolate to lanceolate, coriaceous, shiny, not glaucescent, the secondary veins fine but rather distant and, at all events in the intermediate stage, spreading and roughly parallel, not feather-veined.

Peduncles elongate, flattened, pedicels nearly terete, distinct, about 5 mm. long.

Calyx-tube oblong or cylindroid turbinate, about 5 mm. long.

Operculum sometimes coloured (reddish), straight or horn-shaped, up to 5 times as long as the calyx-tube and much less in diameter. Filaments yellowish, sometimes crimson, angular, glandular, and with anthers as in the Cornutæ.

Fruits cylindroid to spherical; top of the capsule nearly flush with the rim, giving the fruit, when not fully ripe, a characteristically truncate, flattish appearance. When the fruit is ripe its mouth becomes rounded and somewhat contracted.

Synonym.

E. occidentalis Endlicher, var. *eremophila* Diels, in Engler's Jahrb. xxxv, 442, 1905. See also my C.R., Part xxxvi, p. 147. Figured at Plate 149, figures 7 – 11 of the same work.

The relations of *E. occidentalis* Endl. var. *grandiflora* Maiden (Part xxxvi, "Critical Revision," p. 149, and figures 1 and 2, Plate 150) to *E. eremophila* remain a matter for further consideration.

Range.

It is confined to Western Australia so far as we know at present, but it is quite possible that it may occur in western South Australia. This is a dry country form, and its range may be stated as bounded by Watheroo on the Midland Railway, to 140 miles east of Kalgoorlie, and north of Esperance and back again to the vicinity of the Great Southern Railway. It probably has a very extensive range in country of low rainfall.

"Shrub four metres high, flowers yellow, calyptra (opercula) reddish." Near Coolgardie (Dr. L. Diels, No. 5237). Coolgardie, or rather, Boorabbin (E. Pritzel, No. 917). I have also received it from Coolgardie (L. C. Webster). The type comes from Coolgardie. Other localities are quoted, *op. cit.*, p. 148.

Affinities.

It is a member of the Cornutæ.

1. With *E. occidentalis* Endl. It is sharply separated from this species in its narrow juvenile foliage, that of *E. occidentalis* being broad. Those of the former are shiny, with more numerous oil dots. Buds usually longer, hence with longer filaments; staminal disc broader. The fruit of *E. occidentalis* is campanulate, while that of *E. eremophila* is cylindroid or inclining to hemispherical.

2. With *E. platypus* Hook. Here I invite attention to the similarities and dissimilarities I have brought forward at pages 151 and 152 of Part XXXVI of my "Critical Revision."

EARLY DRAWINGS OF AN ABORIGINAL CEREMONIAL GROUND.

By R. H. CAMBAGE and HENRY SELKIRK.

With Three Text Figures.

[*Read before the Royal Society of N.S. Wales, August 4, 1920.*]

WHAT has been regarded as the earliest plan of an aboriginal Bora or other Ceremonial Ground appears in J. Henderson's "Observations on the Colonies of New South Wales and Van Diemen's Land," published in 1832.[1] The sketches in "An Account of the English Colony in New South Wales" by David Collins (1804), portray various stages of the initiation ceremony without giving a definite layout of the ground. The rough drawings described in the present paper, however, are of earlier date than Henderson's, having been made by Surveyor General John Oxley at Moreton Bay in October 1824, and have remained in obscurity for 96 years. (Field Books 216 and 217, Lands Department).[2] These drawings were made in pencil and the decipherable portions were recently inked in for the purpose of preserving this interesting ethnological record, but some of the notes are too indistinct to be deciphered.

Oxley made these drawings during an expedition to Moreton Bay in 1824 in the cutter "Mermaid." He made three visits to Moreton Bay, the first on his return journey from Port Curtis at the end of November 1823, when the Brisbane River was explored; the second in September and October, 1824, when an extensive marine survey of the bay was carried out; and the third in November and December of the same year, when he was accompanied by His Excellency Sir Thomas Brisbane.

[1] See reference by R. H. Mathews, these Proceedings, Vol. XXVIII, 102, (1894). [2] Now in Mitchell Libraay.

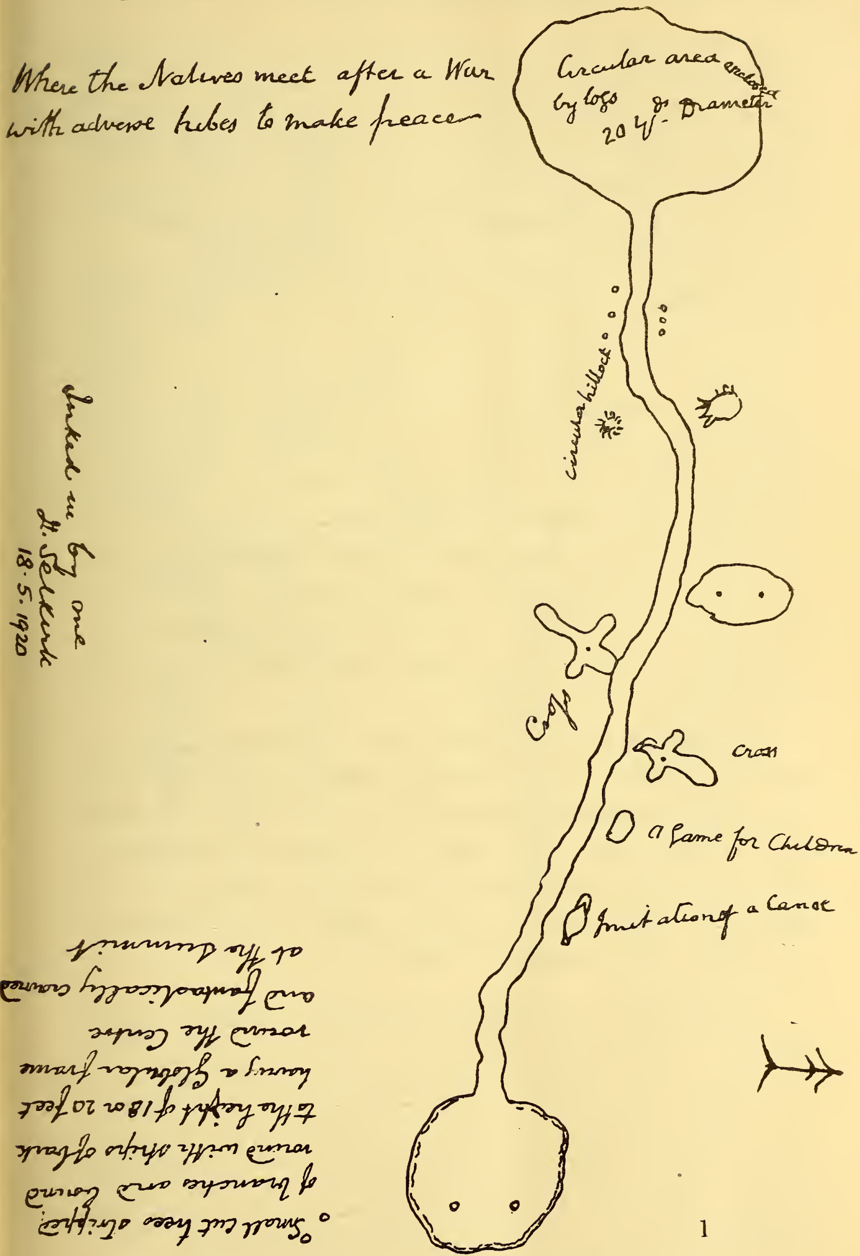


Fig. 1. *Aboriginal Ceremonial Ground, Moreton Bay.*

The drawings depict two circular areas enclosed by logs, and connected by a somewhat sinuous passage about seventy yards long, one area at least being about twenty yards in diameter (Figure 1). The purpose of these enclosures is made clear by the following note:—"Where the Natives meet after a war with adverse tribes, to make peace."

In Barron Field's Geographical Memoirs of New South Wales (1825), reference is made (p. 70) to a circular pit, about forty feet in diameter, being the scene of combat witnessed by John Finnegan in 1823 between two native women of different tribes, and also between two men at Moreton Bay, while Thomas Pamphlet (*Ibid.*, p. 78), when speaking of an encounter brought about by one native wishing to take satisfaction of another who had wounded him sometime previously, stated that "the spot appointed for the combat was a small ring, about twenty-five feet in diameter, about three feet deep, and surrounded by a palisade of sticks." The combat was witnessed by about 500 men, women and children.[1]

The rings depicted by Oxley, however, which were not used for combat, but for making peace, do not appear to have been constructed as pits, as the two dots or small inner circles within the smaller ring appear to represent standing trees which were "fantastically crowned at the summit." The drawings shown, Figure 2, are evidently intended as diagrams giving details.

[1] Finnegan and Pamphlet, together with Richard Parsons and John Thompson, left Sydney on the 21st March, 1823, in an open boat to bring cedar from the Five Islands (Illawarra). The boat being driven out to sea by a gale of wind, they suffered inconceivable hardships, being twenty-one days without water, during which time Thompson died. The others, on the 16th April, landed on an island which they believed to be south of Jervis Bay, but was really Moreton Island, from which they gained the mainland, discovered the Brisbane River, and, except Parsons, were found by Oxley when he arrived in Moreton Bay on the 29th November, 1823. Finnegan and Pamphlet were living with the natives near Bribie Island, but Parsons had gone north, as he thought in the direction of Sydney, and was not heard of after. (Field's New South Wales, p. 89.)

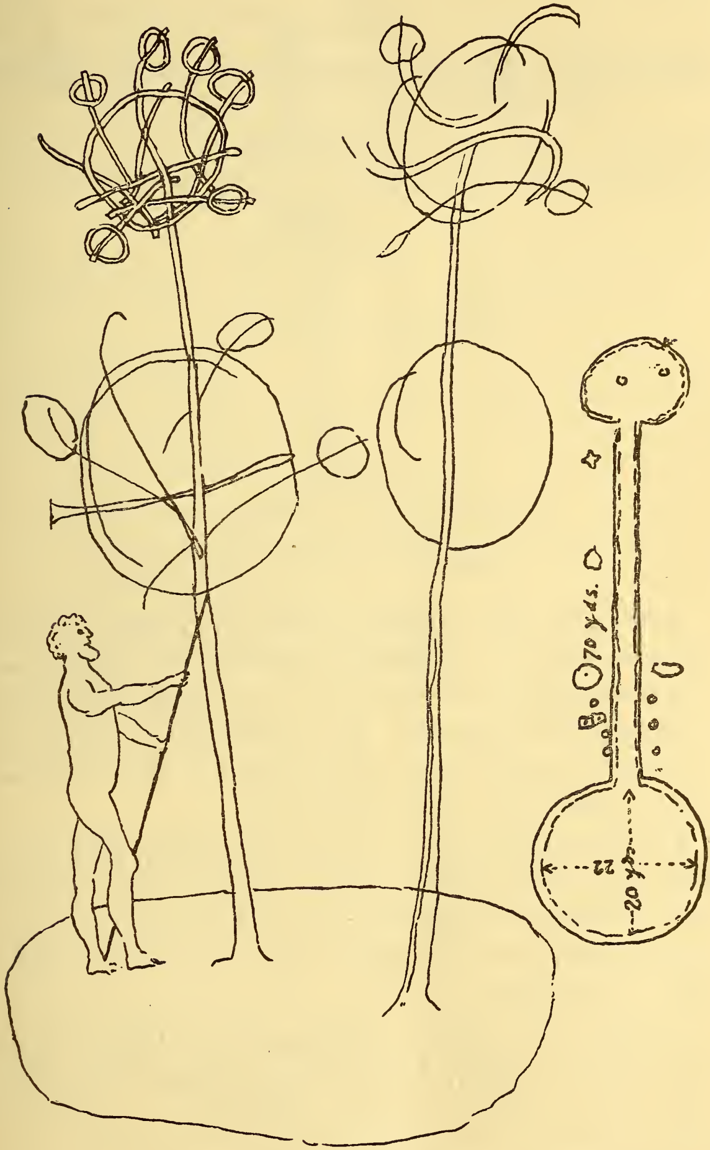


Fig. 2. *Diagrams giving details of figures in figure 1.*

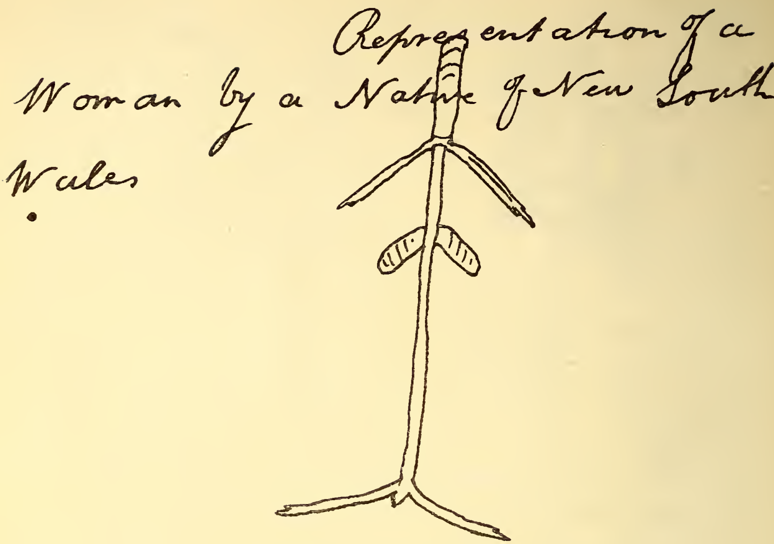


Fig. 3. *Native's Representation of a Woman.*

This Ceremonial Ground is similar in design to a Bora Ground, where the initiation ceremony was carried out, but from Oxley's note it appears to have been used on the occasion of peacemaking. The representations along the sides of the passage are usually formed of earth and turf, or the design may be cut in the ground.

Oxley mentions under date 29th November, 1823, (F.B. 202), that a Sydney native named Bowen, who was with him, understood something of what the Moreton Bay natives said, and on the same date he records seeing a native burial place.

We desire to record our thanks to Mr. A. J. Hare, Under Secretary for Lands, for permission to make use of the information contained in Oxley's fieldnotes.

A GEOLOGICAL RECONNAISSANCE OF THE STIRLING RANGES OF WESTERN AUSTRALIA.

By W. G. WOOLNOUGH, D.Sc., F.G.S.

Lately Professor of Geology, University of Western Australia.

With Plate VI.

[*Read before the Royal Society of N. S. Wales, August 4, 1920.*

TABLE OF CONTENTS.

Introduction.

In spite of their comparative accessibility and their very striking appearance the Stirling Ranges have not received very much attention from geologists. No traces of economic deposits have been encountered. The soil is of the poorest description, water supply is almost non-existent and prickly scrub is extraordinarily dense. Hence there is no settlement in the Ranges, and there is nothing to warrant official geological examination.

My thanks are due to the late H. P. Woodward, Esq., Acting Government Geologist of Western Australia in the early part of 1914, for allowing me the use of a certain

amount of departmental outfit to enable me to carry out the investigation whose results are described in this paper.

Main Geographical Features of the Area.

The Stirling Ranges form a unique feature in the geology of Western Australia. The Ranges proper extend from a point some two miles east of Cranbrook on the Great Southern Railway in a general east-south-easterly direction for 44 miles, and terminate with extraordinary abruptness just to the east of Ellen Peak (about Lat. 34° 20′ S. Long. 118° 19′ E.) They lie 42 miles north of Albany.

The mountains rise abruptly from level plains, mostly 'sand plains,' which, with an average altitude of about 900 feet above sea-level, stretch far and wide in almost every direction. To the north, as far as the eye can reach, even from the highest summits, these plains continue without interruption. To the west, at a distance of seven miles west-south-west from Cranbrook, there is an isolated sugar-loaf hill, Warriup Hill, which, though separated both geographically and geologically from the main mass of the Stirlings, is, nevertheless an outlier of the peculiar formation which builds up the main range.

Seventeen miles to the south, and facing the Stirlings across the broad sand plain through which flows the Kalgan River, lie the Porongrups, a range roughly parallel to, and nearly as rugged as their northern neighbours, but absolutely distinct in geological structure. Like the Stirlings, the Porongrups lie chiefly to the east of the Great Southern Railway, but Mount Barker and one or two other outlying minor summits of the range extend westwards beyond the line. There is, however, no considerable extent of high land in this direction. From the high peaks at the western end of the Stirling Range can be distinguished a number of very distant summits lying in the region of the Lower

Frankland River. These, however, can scarcely be regarded as belonging to the same physiographic unit as the Stirling Range. Much more closely related, though still very distant to the east-south-east and south, are a series of sub-parallel but isolated ranges and hill groups. The most northerly of these includes the Mount Barren Ranges south-west of Ravensthorpe. These lie somewhat to the north of the axis of the Stirling Range. To the east of the Porongrups lie the highlands of Cape Riche. Still further south are the highlands of the Albany—Mount Gardiner Mount Many Peak group.

Fig. 1. General locality map showing the relation of the Stirling Range to the Porongrups and to the Frankland-Gordon and Pallinup River Systems.

These various hill groups are, as above mentioned, roughly parallel, and they indicate the existence of a very well defined tectonic axis running in a general east and west direction. Traces of this same axis are abundant in the South West Division of the State, in spite of the strong dominance of the more recent and much better defined meridional axis. I venture to suggest the name "Stirling Axis" for the former structure line and "Darling Axis" for the latter.

To the north of the Stirling Range the plain above mentioned is simply crowded with salt lakes of all shapes and sizes. From the high peaks of the range they can be counted literally by the score, their white and glistening surfaces being in marked contrast to the sombre dwarfed vegetation of the sand plain. The zone over which these extend is approximately twenty miles wide from east to west.

On the southern side of the range, and between it and the Kalgan River, there stretches a line of salt lakes, quite distinct in many ways from those to the north. The depressions in this system occur singly, and instead of being distributed promiscuously as appears to be the case with their northern brethren, they are arranged in a roughly linear fashion and sweep round the eastern extremity of the range in a curve leading to the Pallinup River.

Description of the Range.

The range is not a continuous crest throughout its entire extent. At the eastern end the hills do form a continuous and almost impenetrable rampart from which rise a number of imposing summits. To the west of Coyanarup, however, the continuous hill feature becomes much lower, and, throughout the western half of the area, the continuity of the highlands is very much broken up. Numerous lofty peaks rise irregularly and abruptly from a comparatively level surface, and deep "bays" of plain country penetrate far into the heart of the range. Several broad "passes," whose floors rise very little above the level of the "sand plain," traverse the range completely, and afford a very easy passage across the mountain area.

Towards the east the range is fairly narrow from north to south. The southern escarpment is a most striking feature, running in almost a straight line bearing about west-south-west, that is, obliquely to the general axis of the range, and cutting it off to a point at its eastern extremity. There are practically no foot hills along this portion of the southern face, which, from Ellen Peak to Bluff Knoll and the unnamed peak which I have called "Wedge" on the map, rises precipitously from the plains. The highest points lie in this eastern section of the range, and, for Western Australia, their altitudes are very considerable. Bluff Knoll reaches 3690 feet and Ellen Peak 3420 feet,[1] while Pyungoorup and Coyanarup are very little, if at all lower.

The northern face of the eastern group conforms to the general trend of the range, that is about west-north-west. It is mostly precipitous, though not perhaps quite as bold as is the southern scarp. Only one of the main peaks, namely Pyungoorup possesses any very considerable foot-hills, though there is a zone of extremely rugged country right along the face. Pyungoorup, however, has a long buttress in the form of a major spur running for several miles into the plains in a north-westerly direction.

The depression west of Coyanarup, while low as compared with the ridge to the eastwards, is, nevertheless, a complete barrier between the plains on the northern and southern sides, respectively, of the range. The first of the "passes" lies to the west of Yungermere, between that

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[1] Lands Department Lithograph, No. 445/80.

peak and Warrungup. From the southern plains a wide "bay" sweeps inwards to the foot of Toolbrunup, the culminating peak of the western group, and this bay is met by another from the north extending between Yungermere and Warrungup. So completely is the range severed by this pass that the highest point reached by the road is only 200 feet above the plains on either side, and the gradients throughout are extremely gradual.[1] Another complete pass runs to the west of the towering mass of Toolbrunup, and emerges near the 30 mile post on the road along the northern flank of the mountains. This is spoken of locally as "Toll's Pass." A wide bay of lowland runs in a south-easterly direction from Yetemerup Spring (twenty-three miles from Cranbrook on the northern road) into Toll's Pass at a point south-west of Toolbrunup. A similar bay of lowland extends in a north-westerly direction from the southern plains towards the Abbey, the two bays being separated by a considerable ridge.

Of the peaks in the western section of the range only one, Toolbrunup, approaches the altitude of the summits of the eastern mass. This magnificent peak reaches 3341 feet, and, rising as it does in solitary grandeur from the almost level plains at its feet, it is one of the most conspicuous and characteristic features of the entire range. In this western section of the chain the isolation of the principal summits, and the extremely abrupt transition from plains to mountains accentuate the differences of level, and the peaks make the most of their height. After Toolbrunup, Warrungup with a height of 2768 feet, Mondurup a great hog-backed ridge rising to 2831 feet, Magog, Barnett, and Donelly are the most striking individual peaks of the western section.

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[1] On the Lands Department Map No. 445/80, this is called simply "The Pass," but local residents claim that this is a mistake. The pass should be called Chester's Pass, while the route so named on the lithograph should be Hassell's Pass.

The Work of Previous Observers.

A bibliography is not attempted here, as it is obtainable in Bulletin No. 61 of the Western Australian Geological Survey, p. 203. A summary of previously published observations is given by Maitland[1] and by Jutson.[2] The Stirling Range is also referred to by David.[3]

The principal points to be noted in these descriptions are:

A Palæozoic age has been assumed for the rocks of the area though no fossils have ever been found.

The metamorphic rocks to the north and south are regarded as older than the sediments of the mountains themselves.

On the northern side of the range deposits of brown coal have been proved by boring.

Gregory refers to the Stirling Range as the western end of the southern scarp of the plateau, but, as Jutson points out, the range is in no sense a scarp. Actually the scarp is much further south, beyond the Porongrups.

Maitland suggests that the Stirling Range is tectonically connected with the Collie senkungsfeld to the west.

David shows the rocks of the Stirling Range as occupying a trough fault in the older metamorphic series and is inclined to follow Maitland in connecting them structurally with Collie.

Jutson, after reviewing the various possible explanations of the structure, rejects as improbable either trough faulting or the formation of a horst, and suggests that the hills are due simply to erosion and are of the nature of a monadnock.

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[1] Maitland, A. Gibb.—Address on some problems of Western Australian Geology. Pres. Address to the Roy. Soc. W.A., 11th July, 1916, Perth, 1917.

[2] Jutson, J. T.—An outline of the physiographical geology (physiography) of Western Australia. Bull. Geol. Survey, W.A., No. 61, p. 158.

[3] David, T. W. E.—Geology Section, Federal Handbook on Australia. British Association for the Advancement of Science 1914, p. 260.

The views of the last two authors are merely of the nature of suggestions as neither has had the opportunity of examining the area personally.

Jutson and Simpson[1] have called the Tertiary Marine Beds of Albany, the "Plantagenet Series." These beds are recognizable in the area under consideration and occur abundantly on the Kalgan River. Patches of them can be seen right up to the foot of the Stirling Range itself.

Geology of the Stirling Ranges (Lithology).

Geologically the mountains are of extreme interest and importance. The great bulk of the south-western portion of Western Australia is composed of crystalline rocks; granites in great variety, gneiss, greenstone, (including chiefly quartz-dolerite and epidiorite), and acid and basic crystalline schists. Comparatively few areas of unaltered or little altered sediments occur.

The mountains are built up of a series of undoubted sediments amongst which quartzite and slaty shale predominate. No limestones are known and conglomerates are extremely rare. The base of the formation is nowhere exposed, the contacts with the crystalline formation being either igneous or faulted. For the most part the sediments lie in horizontal or very gently dipping layers, but, locally, steep dips are exhibited and sharp folds and overfolds are not wanting. Evidence will be adduced to indicate that heavy normal faulting and subordinate overthrusting have occurred. The portion of the formation which is exposed is certainly not less than 3000 feet.

The quartzites and slates alternate very regularly throughout the entire series, though there is a slight preponderance of the former at lower levels and of the latter at higher

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[1] Jutson, J. T. and Simpson, E. S.—Notes on the geology and physiography of Albany. Proc. Roy. Soc. W.A., Vol. II, 1915-16, pp. 45—58.

levels. The predominant colour is purplish or liver coloured, though greys and blues are also quite common. For the most part the quartzites are fine in texture and extremely tough, and show very little trace of metamorphism. The slates in many places approximate to the condition of shales, so little are they altered. Very seldom is secondary cleavage, transverse to the original bedding, developed; but minute examination usually shows a very fine puckering, and an incipient development of mica which is sufficient to distinguish the rock as a slate rather than a shale. Over the greater part of the area this characteristic of very slight alteration is to be observed. Locally, however, a much greater degree of recrystallisation has occurred, and, in places, the rocks are intensely metamorphosed. This is very notably the case along the southern margin of the eastern section of the ranges. As above noted this margin runs in a strikingly rectilinear manner from near the mountain indicated as "The Wedge" to Ellen Peak and Andrew Hill at the eastern extremity of the range; and, throughout its entire extent, presents a very steep face towards the southern plains. This fact alone indicates the probability of the occurrence of a fault plane, and other evidence in favour of this supposition will be adduced below. At the Wedge the most intense alteration seen by me occurs. The liver coloured quartzites of the rest of the range are represented by thorough quartz schists, while the interbedded slates have been converted into corrugated mica schists. At Ellen Peak the degree of alteration is less, but, even here, is sufficiently intense to have converted the slate into phyllite with wavy structure and silvery lustre. Here, the finer textured beds predominate though they are interbedded with quartzite which has not been altered, as at the Wedge, into quartz schist. The whole series at this point is, however, very much veined with white quartz mostly in sheets under an inch in thickness.

In Bluff Knoll the quartzites are beautifully ripple-marked and show current bedding. The latter structure dips almost due east. The quartzite beds here are very little altered, but the finer sediments are almost completely recrystallised. The quartzites are somewhat in excess of the phyllites. As in Ellen Peak, there is much quartz veining. Amongst the foothills to the west of Coyanarup the same characteristics are encountered. The veining of the rocks with white quartz is even more pronounced than it is on top of Bluff Knoll. In Yungermere we have the same association of quartzites and phyllites. The former are very little altered, and are current bedded and ripple marked. The latter are silky and minutely puckered. In the cliff just below the summit of this peak, the alternation of coarse and fine beds is very rapid so that the structure becomes very thinly laminated. The quartzites are very strongly jointed, and, where they occur in massive beds as they do towards the western foot of the mountain, it becomes extremely difficult to distinguish between this structure and the dip of the beds. The amount of quartz injection here, though still considerable, is less than that noted further east.

In the hill about a mile S.S.E. of Moingup Spring in 'The Pass' the same general features are encountered, though the quartzites preponderate. Current-bedding with a south easterly dip is distinguishable, and the quartz veinlets are quite saccharoidal, instead of being vitreous as they usually are. In the upper portions of Warrungup the rocks are mainly much puckered phyllites, sandy in places, with bands of strongly current-bedded quartzites up to 18 inches in thickness. Quartz veining is still a notable feature, though it is less abundantly developed than in the rocks further to the east.

In the lower slopes of Mount Hassell, fine, hard, purple quartzite predominates. In the upper portions of this conical hill, phyllitic layers become more pronounced, but, throughout, the quartzites are very considerably in excess. Current-bedding is very pronounced and ripple marking is exquisitely developed. These ripples are all of the asymmetrical type,[1] with small amplitude (about half an inch). In numerous instances the small intermediate ridges mentioned by Kindle are beautifully shown. Such ripple marks undoubtedly indicate the action of strong currents in very shallow water. At the western end of Princess Royal Harbour, Albany, ripple marks in fine sand formed by waves with a wave length of about three feet and an amplitude of about six inches, and in water not more than from four to six inches deep, appeared exactly similar to those in question.

The phyllites interbedded with these ripple marked quartzites rarely exceed four inches in thickness. They are much more slaty in character than those described above from the eastern peaks. They are smooth and not puckered, and, although shiny and lustrous on the bedding planes, do not show nearly so much development of mica as do those of Ellen's Peak, etc. The beds of phyllite are often considerably ruptured, and, near the summit, there is a band of quartzite through which are scattered, irregularly and not very abundantly, rounded and angular fragments of phyllite. This structure recalls very strongly the occurrence of disrupted shaly blocks in the Hawkesbury Sandstone of New South Wales, and, in conjunction with the marked development of false bedding and ripple marks, suggests that the Stirling Range Beds, like the Hawkesbury Sandstones are estuarine in origin. The rocks of the

[1] Kindle, E. M.—A comparison of the Cambrian and Ordovician ripple marks found at Ottawa Canada. Journal of Geology, Vol. XXII, 1914, p. 703 - 713.

magnificent peak of Toolbrunup are very similar to those just described. Here again quartzites are considerably more abundant than phyllites. Ripple marking and false bedding are very pronounced. To the south-east of the main peak, and on the opposite side of the gorge the dip of the current beds is south 29° east at 24°.

Near the 26 mile post on the northern road there is a mass of pink vitreous quartzite differing very much in appearance from the normal quartzites of the range. This outcrop lies at the extreme northerly limit of the foothills and just on the edge of the plains. In its isolated position its relationships are not very clear. In general appearance, however, it is somewhat similar to one of the rocks at the Slate Quarry (to be described later), which occur under such conditions as to leave no doubt as to their formation as a result of contact metamorphism of the Stirling Range quartzite by the granite. While the evidence is not at all conclusive, the occurrence in question suggests the possibility of an igneous contact at the 26 mile post.

Amongst the rocks which form the very rugged summit of Talyuberlup phyllite and quartzite occur in about equal proportions. The former are very wavy and even the quartzites are gently undulating. While ripple marks can be traced in the latter rocks, they are by no means so pronounced as in some of the outcrops further to the east. False bedding, however, is just as well defined, the laminæ dipping south 18° west at 35°, a direction very markedly different from the general trend of the inclination in other cases. The rocks are very much injected by lenses of quartz, mostly of very small size, very few of which exceed three feet in length. In the foothills immediately to the south the rocks appear to be mostly phyllitic with only occasional quartzite bands. The southern summit of Mount Magog is composed chiefly of quartzite which is perfectly ripple marked.

The great hog-backed ridge of Mondurup is built up chiefly of quartzite which is strongly ripple marked and false bedded. There has been very considerable disturbance of stratification in this area, and one reading of the inclination of the current laminæ about half way up the slope gave a dip of 42° to the south east. The strong probability is that this does not represent, in amount at all events, the angle of repose of the unconsolidated sediment.

The Cranbrook road traverses the extreme northern foothills of the range for the greater part of its length, and consequently runs chiefly over the sediments of the range or their products of weathering. At four and a half miles from Cranbrook, however, the sedimentary series is left, and thenceforth the road passes over eruptive rocks. The nature of the junction at this point was not determined by me, but probably this locality would yield valuable information as a result of careful investigation.

From Tenterden for a distance of five and a half miles due east along the Lunt Road, plentiful exposures of normal granites and greenstones are encountered. The contact of these with the sedimentary rocks of the range is very clearly defined in the immediate neighbourhood of the Slate Quarry on Loc. 2772. At the time of my visit the country had been swept clean by an immense bush fire, so that a very satisfactory section was exposed. The actual contact is at a point an eighth of a mile west of the quarry. It is sharply defined and trends north 33° west. At the immediate point of contact the granite is intensely acid, and passes into the slates in the form of vein-quartz loaded with partially to almost completely digested and assimilated fragments of jasper. The contact is a transgressive one. As above mentioned, to the west of the slate quarry, slates are in juxtaposition with the plutonic rock, further to the south-east quartzites stand in a similar relationship, and have suffered induration. At a distance of about twenty yards from the contact the slates have been converted into a thoroughly recrystallised hornstone, a type of alteration completely distinct from the regional metamorphism into phyllites which occurs to such a large extent in the eastern section of the range. In the slate quarry, two hundred yards from the contact, the rocks are lustrous purple slates with a very perfect cleavage striking 23° west of north, and therefore nearly parallel to the general trend of the junction line. This cleavage stands vertically; cross joints dip north 28° west at 50°. At a point ten chains south-west of the quarry a tongue of quartz-porphyry intrudes the quartzite. There is thus no shadow of doubt as to the relative ages of, at all events some of the granites, and the Stirling Range Series.

Considering the great frequency of basic dykes through the gneissic granite in the areas surrounding the Stirling Ranges, the scarcity of such dykes cutting the sediments is conspicuous. Throughout the length and breadth of the range only one basic dyke was definitely located. There is one of very considerable magnitude (about 18 feet wide), which crosses the ridge of Toolbrunup immediately to the west of the highest summit and gives rise to the depression which separates this peak from the western summit. The steep talus slope which forms the best means of access to the summit is composed to a notable extent of material from this dyke. While the presence of the eruptive rock can be traced from a distance on both slopes of Toolbrunup by reason of the brighter colour of the vegetation growing on it, no indication of its continuation was noted on the plains either to the north or the south. The rock of this dyke is rather coarse grained ophitic quartz-dolerite in which a good deal of the pyroxene has been altered to fibrous green uralite. It is therefore of a type which is extremely wide spread in Western Australia.

On the eastern side of the summit of Ellen Peak is a deep narrow grassy cleft about twelve feet wide, which cuts through the rocks of the summit with the precision of a knife edge. It bears 70° east of north. No eruptive rock was seen, and the structure may be due to the widening of a joint fissure. Its general appearance, however, is very strongly suggestive of the cavity left by complete weathering of a basic dyke though no "white trap" was noticed. In the summit of Bluff Knoll there is a somewhat similar cleft bearing 10° west of north, which is suggestive of a dyke fissure. Here again, however, no trace of eruptive rock was encountered. While, then, it is clearly evident that the granite of Tenterden is younger than the Stirling Range Beds, it would appear that the gneissic granites and their associated basic dykes are, with few exceptions, older.

Summary of Lithological Characters.

The sediments are quartzites and slates with a slight tendency for the former to predominate towards the base and for the latter to be in excess at higher levels. The sediments are not intensely altered for the most part: the quartzites have suffered scarcely at all, while the slates have been more profoundly metamorphosed. The extreme is reached in "The Wedge" where quartz-schists and mica-schists are developed. In general, alteration is greater in the southern and eastern areas. In the former section most of the slates have been converted into wavy phyllites and considerable quartz injection has occurred. No trace of fossils has been detected in spite of repeated and assiduous search. At the western end the sediments are intruded by granite, and at Toolbunup one considerable dyke of quartz-dolerite was noted.

Occurrence of Laterite.—That ubiquitous formation in Western Australia, "laterite," is very scantily developed in the area under consideration. The Darling Peneplain is practically completely covered with this material at an average level of 800 to 1000 feet above sea level. The peneplain surface in the neighbourhood of Mount Barker (829 feet) is no exception to the rule, and the same feature is carried almost to the Kalgan River on the road to the ranges. On the sand plain to the south-west, south and east of the highlands patches of laterite are left uncovered at intervals, and evidently the normal peneplain conditions extend over these areas.

Immediately on entering the Ranges the laterite is lost and we traverse the outcrops of the Stirling Range Series. At almost the highest point of each of the "passes," however, laterite again puts in an appearance, and spreads out in sheets to the flanks of the hills on either side. On the slopes of Yungermere on the east, and of Warrungup on the west of "The Pass" the altitude of the laterite is about 1250 feet above sea level (aneroid). In Hassell's Pass approximately the same relation exists but the altitude was not determined. This difference in level is very suggestive of a slight, though decided, "post-plateau" movement.

Structural Features.

Woodward[1] describes the ranges as being folded into a series of anticlines and synclines at the western end, while at the eastern end the rocks are nearly horizontal. The most striking feature of the geological structure of the area is the almost horizontal bedding which prevails throughout the entire series. For the most part the rocks are bent into extremely gentle folds. In these the dips are readily discernible when the great precipitous faces are observed from a little distance, but are so small that the inclination of the bedding planes is so masked by the

[1] Woodward, H. P.—Annual General Report of the Government Geologist for the year 1890, Perth, By Authority 1891.

slight irregularities of the surface as not to be measurable by clinometer on the rock exposures themselves. Determinations of dip are obtainable with certainty only on the slopes and summits of the peaks where extensive rock outcrops occur in situ. On the foothills and lowlands the rocks are so much broken and covered by angular rubble that it is extremely difficult, and often impossible, to determine with certainty whether what is apparently a dip surface is a true dip, current bedding, jointing or local superficial disturbance. The extreme density of the scrub is also a factor which renders the measurement of a continuous geological section impossible in the course of a reconnaissance like the present investigation.

While the general horizontality of the stratification is so outstanding a feature, there are, nevertheless, abundant and very striking exceptions to the general rule. Where dips were measured with certainty they are indicated on the map. Broadly, there is a very decided tendency for southerly dips on the northern side of the range and for northerly ones on the southern side, so that the structure, as a whole, is markedly synclinal.

In Ellen Peak the stratification is practically horizontal. In the peaks of the five summits of Isongerup the same structure is exhibited. In Pyungoorup there is a general southerly dip of about 10°. Bluff Knoll and Coyanarup are seen from a little distance to possess a gentle synclinal structure. At closer quarters this apparent regularity is found to be subject to local disturbances. In the magnificent precipice on the northern side of the range at Coyanarup the dip of the ripple marked quartzite is south 30° east at 25°, and, in the lower parts of the cliff, the bedding is highly contorted, with a strong suggestion of overfolding towards the north. In the low gap in the crest of the range near by the ripple marked surfaces are horizontal.

In the small but very conspicuous hill shown on the map herewith as "West Knoll," the dip is south 15° east at 35°, and the shape of the hill is very plainly influenced by its structure, since there is a steep scarp towards the north and a long dip slope towards the south. This dip slope falls in a gentle curve towards the axis of the range and then rises equally gradually towards the summit of "The Wedge." This hill is almost the mirror image of West Knoll possessing a precipitous scarp on the south and a dip slope on the north. Curiously enough these two very conspicuous hills, which show the synclinal structure of the range in a very striking manner are not indicated on the Lands Department lithograph (No. 445). On the summit of the Wedge the dip of the quartz schists is north 10° east at 49°. A little further to the south-west, on the lower slopes, the dip is about vertical, if not actually slightly overturned and inclined to the south at a very high angle. In the western foothills of this peak, a dip of south 10° east at 28° was recorded in very much metamorphosed rocks. The arrangement of the main beds of quartz schist as seen in the western profile of the Wedge is very strongly suggestive of the existence of a small normal fault throwing in a southerly direction. It is obvious then that the structure of this very remarkable hill calls for much more detailed investigation than I was able to give it.

Close to the junction of the two roads immediately south of the entrance to The Pass, and just where the last outcrops of quartzite are seen near the beginning of the sand plain, the sediments appear to have a very persistent strike in a direction north 70° east, with a nearly vertical dip. As above noted, dip readings on the lowlands are very uncertain and unsatisfactory. In this case, however, the position, line of strike and apparent dip all conform so closely with the structure of The Wedge and with the remarkable south-eastern escarpment of the range that the measurement is worthy of more attention than would otherwise be the case. Taking all these facts into consideration there seems to be a very strong probability of the escarpment in question being due to a heavy fault throwing northwards, that is, inwards towards the range. In the hill about a mile and a half south of Moingup Spring the highly jointed ripple marked quartzites dip at very gentle angles to the south-south-east. This fact is very definitely established by the relationship of outcrop to contour, though, on superficial observation, one would be inclined to determine the dip as being steep towards the south-east. It is probable in this case that the apparent north-east to south-west strike is due to local alteration of the quartzite by secondary silicification along a joint plane running in that direction.

In the lower slopes of Yungermere the dip of the quartzite bands is south 30° east at from 30° to 35°. Higher up in the overhanging cliff just below the summit it is south 40° east at 47°. This local abnormality of dip does not seem to conform with any others in the vicinity, and is probably due to a fault or sharp flexure running transversely through the range. It is worthy of note that this ridge is the eastern boundary of The Pass, and, though it is suggested below that The Pass is an erosion feature, it is quite likely that the erosion has been influenced by this structural line of weakness.

Just below the eastern summit of Warrungup the beds show a dip of south 30° east at 5°. The dip is slightly irregular and rolling, but is everywhere very small in amount. Several remarkable structural features are exhibited in the fine cliff sections of this peak. In one place, very clearly defined contemporaneous erosion of one of the thin quartzite beds is shown. This is illustrated to scale in fig. 2.

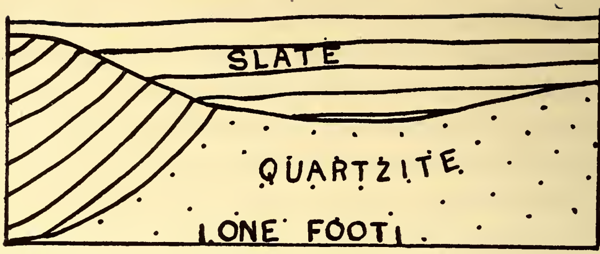

Fig. 2. Sketch (to scale) showing contemporaneous erosion: near the summit of Warrungup.

In another place the beds are very much step-faulted. The phyllites have given way by regular rock flowage, with development of a decided cleavage, but the thin quartzite layers have fractured more sharply and show evidence of distinct, though minute, overthrust faulting. Such an occurrence is illustrated in fig. 3.

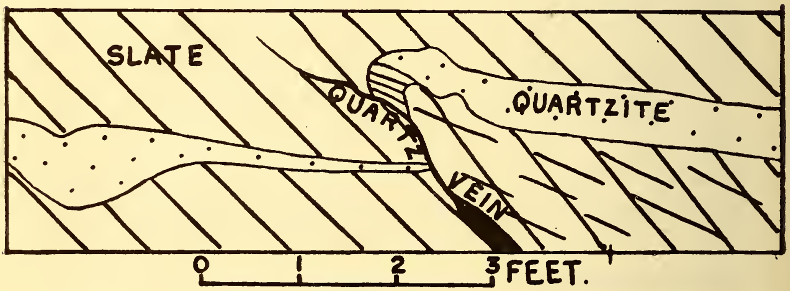

Fig. 3. Sketch (to scale) showing overthrusting and injection by quartz: near the summit of Warrungup.

In another place a more extensive movement has developed incipient crush conglomerate, the thin quartzite layers being shattered into fragments, which, more or less rounded by attrition, are embedded in a ground mass of crumpled phyllite. This zone is about twenty yards wide, and, like the small fault of fig. 3, shows evidence of a powerful overthrusting force from south to north. In some instances the slip-faulting produces a pseudo-ripple-marking on the rock surfaces. This, however, is easily distinguishable from true ripple-marking which is also extensively developed in the same beds. Sometimes cases may be found where the primary and secondary irregularities are shown in a single specimen, producing a decidedly complicated structure.

Mount Hassell shows fine rock exposures at its summit. Some of these exhibit perhaps the most beautifully preserved ripple marks in the district. On the spot their dip is inappreciable, but from Toolbrunup a general east-north-easterly inclination can be detected. On the lower slopes suggestions of steep and irregular dips are probably to be explained as due to jointing, induration or slip, though they may be connected with the disturbance which produced the steep dips in Yungermere.

In the "cock's-comb" ridge of Toolbrunup there is a decided synclinal structure; though the dips are all very slight there is an inclination towards the central peak from each side. Towards the end of the south-western ridge there is a good deal of contortion and dips of 45° towards the central ridge are to be observed. There is probably a fault hereabouts. In the long spur south of Toolbrunup and separated from it by a deep gorge, dips, which may be those of false bedded layers, tend south 20° east at 24°. At the summit of this ridge where it joins the transverse spur which connects it with main mountain, the dip of the ripple marked surface, and therefore undoubtedly the true dip, is north 17° east at 44°. One hundred yards to the north-west the dip is north 39° west at 69°, less than a quarter of a mile away towards the south, the inclination is about south south-east and amounts to not more than 8°. There is therefore a very decided plane of disturbance at this point, the axis of which is roughly parallel to the disturbance forming the south-east scarp of the range. It is practically certain that the disturbance is a fault throwing to the north, but no data are to hand to determine the magnitude of the displacement. From the summit of the ridge the zone of disturbance can be traced very clearly down the western slopes of Toolbrunup into the depths of Toll's Pass separating that peak from Talyuberlup and Magog. In the rocky summit of Talyuberlup the beds are decidedly wavy in structure. Just below the culminating cliff a dip of south 8° west at 12° was recorded, while on the summit itself, the dip is in the same general direction but extremely gentle. From the summit a most interesting field for investigation can be seen immediately to the south. I was unable to visit it, but could detect the presence of a considerable disturbance in the hill immediately south-west of Talyuberlup, where there appears to be a very sharp anticline. The north-western beds dip in that direction at approximately 40°, while on the other limb of the fold the dip is south-easterly at about 30°. The structure must be merely local or else must have a steep pitch towards the south-west, as the rocks in the next ridge to the south do not appear to be affected. The view obtained by me was not altogether satisfactory, as it was raining at the time, and there is just a possibility that what I took to be an anticline was really the intersection of a bed, dipping steeply towards the north-east, with the convex contours of the hill, but I strongly favour the first alternative. It is worthy of note that this disturbed area is very nearly on the line of strike of the fault plane postulated to the south of Toolbrunup.

In the cave under the summit of Talyuberlup considerable disturbance, in the nature of sheet faulting of the beds, can be seen. This has given rise to overthrusts of the quartzite layers from west to east to the extent of about three feet, and has caused a cleavage in the phyllites dipping east at 27°. On the southern flank of Magog the dip of the ripple marked quartzite is east 30° south at 15°. In the southern peak of the twin summits the inclination is in the same direction, but with angles up to 30°. The rapid steepening of the dip at this point suggests either a very sharp anticline or more probably another line of fault transverse to the axis of the range. If this exists, it is probable that the low depression west of Magog, and The Pass have both been determined by transverse lines of weakness.

In the summit portion of Peak Barnett the beds appear to dip a little west of north at about 20° (estimated from a distance). The low north-western outliers of the range, near which the road passes, all seem to have slight scarps towards the north with long gentle dip slopes towards the south.

In the neighbourhood of Mondurup there is an area of very considerable disturbance. About half way between Redgum Spring and the mountain the ripple marked quartzite dips south 19° west at 19°. On the western slope of Mondurup itself the dip is south 35° east at 17°. About half way up the slope there is a very conspicuous outcrop in which the dip is due south at 44°. Still higher up tremendous contortion of the quartzite is to be noted. In the western summit of the ridge, where the heavy quartzite beds are exquisitely ripple marked, the dip is south 17° west at 48°. In the saddle slightly to the south-east of this summit there is a local twist giving rise to a strike trending north 72° east with a vertical dip. On the whole then, the rocks of this mountain exhibit moderately steep inclination in a general southerly direction. The main axis of the great hog-back which forms the mountain bears south 37 degrees east, so that the structures do not conform at all closely to the mountain axis, and, in some cases, cut almost perpendicularly across it. In a strongly wedge-shaped foot-hill to the south-south-west of the trigonometrical station, a precipitous scarp to the north and a rather steep dip slope to the south indicate that the southerly dip persists beyond the limits of the main ridge. The continuation of the same structure can be seen in a high peak to the south-east of Mondurup. In Ross Peak the summit rocks, which are beautifully ripple marked, dip north 5° west at 12°, which structure is reflected in the precipitous southern face and gently sloping northern side of the peak. As seen from Ross Peak, the rocks in Peak Donelly appear to have very much the same inclination, but Peak Donelly is by no means a rocky summit. At the Slate Quarry the cleaved slates dip north 49° west at 17°. At a point so close to the intrusive contact, however, it is quite probable that the dip has suffered considerable local variation.

Summary of Structural Features.

It is obvious that the data obtained concerning dips, etc., are far too scattered and scanty to determine in any detail the structure of the Stirling Ranges. Several important features are nevertheless outstanding. In the first place the strong predominance of nearly horizontal stratification is most remarkable. I have noted the most important departures from horizontality actually observed in my journey, and their recapitulation above may lead to an erroneous idea as to the amount of contortion present. Where no statements are made, it may be assumed that the beds are essentially level. *Such a mass of level bedded sediments, consisting of alternate layers of hard, jointed quartzites, and of relatively soft slates and phyllites, constitutes an almost ideally weak structure from the point* *of view of denudational forces*, an aspect which will be treated later.

Transversely the Range is essentially a broad syncline. On the south-eastern escarpment there is almost certainly evidence of heavy faulting, and there is almost equally strong probability of a similar fault on the northern border, so that the area may be described as a trough-faulted syncline. In at least one instance, namely west of Toolbrunup, there is evidence of a fault line well within the range, in the same general direction as the faults above postulated.

In the western section of the range the structures noted from Mondurup to Ross Peak indicate an anticline rather than a syncline. Transverse faults, or folds, or both, are suggested by the structures of Yungermere and Magog respectively.

In several places the results of compression are clearly defined, and similar phenomena may be inferred with some certainty elsewhere. The overthrust faulting from south to north, with formation of crush conglomerate, on Warrungup, and the easterly directed overthrusts on Talyuberlup are the most definite cases.

Age of the Stirling Range Series.

When examined superficially and compared with geological features in Eastern Australia, the dominance of horizontal stratification and apparently insignificant metamorphism strongly suggest that the beds are not very ancient, certainly not older than Palæozoic. When, however, the area is more closely studied it is found that very considerable disturbances of stratification have occurred, including overthrusting and formation of crush conglomerates, and that the rocks are much more profoundly altered than one would at first suppose. In fact, considering the general horizontality of the strata, the amount of recrystallization of the finer sediments is really remarkable. A very careful search for fossils has not, so far, revealed any trace of organic remains. Many estuarine deposits are singularly barren of fossils, as, for instance, the Hawkesbury Series of New South Wales, so that the absence of such remains cannot be taken as certain proof of great age. The absence of fossils is nevertheless remarkable if the beds are as recent as Palæozoic. It has been shown above that granite has intruded the Stirling Range Series at the western end of the area, so that the granite is very definitely the younger formation. So far as the author has been able to ascertain by reference to the literature, and from personal enquiries and investigations, there is no record, within the western half of Australia, of injection of granites into formations whose age can be referred with certainty to any portion of the Lower Palæozoic. Pre-Cambrian granites occur over enormous areas and are injected very freely into the later members of the Pre-Cambrian sedimentary formations, for instance into the Barossian Series of the Mount Lofty Range of South Australia, the schistose rocks of Yorke's Peninsula, the metalliferous slates and schists of the Northern Territory, and the Warrawoona and Mosquito Creek Series of northern Western Australia. On the other hand in the Lower Cambrian Katherine River Series of the Northern Territory, the Lower Cambrian beds of the Kimberly Division of Western Australia, and the Nullagine Series of the Pilbara Goldfield of Western Australia granitic intrusions are conspicuous by their absence. The age of the Nullagine Series is undetermined through lack of fossil evidence, but there is strong presumption that it is not later than Devonian nor older than Cambrian, so that, so far as it goes, the evidence is concordant.

With considerable hesitation I therefore suggest, as a tentative generalisation, the probability of the Pre-Cambrian age of all the granites in Australia west of a line joining Adelaide to Cloncurry.

If this suggestion can be verified it is obvious that the Stirling Range Series must belong to some part, probably the later portion, of the Pre-Cambrian. While I am prepared to admit that the evidence from my suggested generalisation is by no means conclusive, I consider that the lithological character of the sediments, and the absence of fossils are presumptive evidence in favour of great antiquity of the beds. In connection with the lithological features the fact must be borne in mind that south-western Western Australia is an immense granite "shield," and that it appears to have suffered no orogenic disturbance since extremely early geological times. The nearest Palæozoic sediments to the Stirling Ranges, namely the Permo-Carboniferous coal-measures of Collie and of the Irwin River, and the associated marine beds in the latter area, are largely unconsolidated sands and clays. The contrast between them and the homotaxial beds of Eastern Australia is most striking. While a comparison between the crystalline schists of South Australia and the Stirling Range Series no doubt suggests the comparative youthfulness of the latter, a comparison with the rocks of the Collie Coal Measures leads to exactly the opposite conclusion. In my opinion the latter comparison is much the more logical of the two, since it is obvious that Post Cambrian orogenic movements on a grand scale have affected the South Australian area.

A very strong lithological resemblance exists between the rocks of the Stirling Range and the Roper River Beds and Mount McMinn Beds of the Northern Territory.[1] The reddish or purplish colour of the beds (suggesting aridity

[1] Woolnough, W. G. Report on the Geology of the Northern Territory. Bulletin of the Northern Territory, No. 4, (1913).

of climate) the textures of the sediments, the prevalence and character of ripple marks and the degree of folding are similar in the two cases. The accounts given by Maitland[1] in his Presidential Address to the Royal Society of Western Australia, and in various publications of the Geological Survey of Western Australia suggest very forcibly that the Nullagine Formation of this State is to be correlated with the Katherine and Roper River Beds of the Northern Territory.

While lithological resemblance in widely separated areas is very misleading, the possibility of a correlation of the Stirling Range Series with the two formations above mentioned must be considered.

Physiography.

The general geographical features of the Stirling Range and of the surrounding area described above call for more detailed consideration. The courses of the streams which take their rise to the north of the range are highly interesting. To the north-east the Pallinup or Salt River runs in a general south-easterly direction from a point not far from Gnowangerup, on the Ongerup branch railway line. It runs into the Southern Ocean near Bremer Bay. The major tributaries of this stream all enter the left bank, and only a few minor creeks appear to fall into the stream from the other side. It appears as though the major tributaries just referred to must originally have been the main streams of the district, and at one time these streams probably flowed in a general southerly direction into the Southern Ocean east of Albany. The main stream of the Pallinup is certainly of much later origin, and has beheaded and captured the pre-existing water courses. While the

[1] Maitland, A. Gibb. Address on some problems of Western Australian Geology. Pres. Add. to the Roy. Soc. of W.A., 11th July, 1916, Perth, 1917, p. 23.

Pallinup River does not run strictly parallel with the general axis of the Stirling Range, it is extremely probable that the river course was brought into existence as a result of the faulting which produced the range itself, and that the river is therefore of the nature of a diverted stream, and not as supposed by Jutson,[1] due to purely erosional forces.

Much more definite and instructive is the case of the Gordon-Frankland River System. The Gordon rises just west of Broome Hill and runs southwards about parallel to the Great Southern Railway to within a couple of miles of Cranbrook. Here it suddenly turns off at right angles and flows to the west-north-west in which direction it continues for 25 miles (direct measurement) until it reaches the valley of the Frankland River into which it falls at right angles. The cause of the deflection is the influence of the axis of elevation of the Stirling Range. The higher peaks of the range extend only to the railway line, and the country to the west is not perceptibly uplifted. It consists of the normal crystalline rocks of the area, with the one exception of Warriup Hill about 10 miles west of Cranbrook. This isolated sugarloaf consists[2] of an outlier of the Stirling Range Beds, and is built up of the same purplish ripple-marked quartzites as the main range. In spite of the comparatively insignificant altitude of the country, the elevation in this area has been of such a character, and has taken place at such a rate as to cause the complete deflection of the drainage. On the northern bank of the Gordon, in its east and west portion heavy aggradation has taken place, a feature which is conspicuously absent on the southern side.[3] Both Pallinup and Gordon Rivers are therefore diverted streams.

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[1] Jutson, J. T. Bulletin Geological Survey of Western Australia, No. 61. p. 160.

[2] Fide M. Aurousseau (private communication).

[3] Fide W. K. Weller, (private communication).

Between these main streams the country to the north of the Stirling Range forms an area of internal drainage. Its characteristics and the extraordinary abundance of salt lakes have been described above. The intersection of the range itself by broad valleys has also been mentioned. Taking these two facts together, the origin of the entire structure may be understood. The following probably represents fairly accurately the sequence of events.

Originally there flowed across the low-lying peneplain from north to south a number of subparallel streams, each entering the Southern Ocean, which extended far north of its present limits, by an independent mouth. Uplift of the Stirling Range commenced, and proceeded so slowly at first as to permit the streams to keep their channels not only cut to base-level, but fairly mature as well. Under such conditions laterite was formed over the lowlands, including the valleys through the range. After the latter had attained almost its full altitude above the plains, a sudden sharp movement completed the differential elevation and the streams were cut off and "beheaded."[1]

It is extremely probable that the climate of the whole of Australia was undergoing a gradual desiccation while these changes were in progress. Be that as it may, it is certain that the rainfall of the area was no longer sufficient to enable the smaller streams to emulate their more powerful neighbours the Gordon and Pallinup, and "turn the flanks" of the range.

It is worthy of note that the area thickly covered by salt lakes extends as far east as The Pass; that is, the salt lake area faces that portion of the range which is traversed by deep valleys. East of Warrungup the salt lakes cease to be conspicuous, and, coincidently, the highlands of the range become continuous. In all probability there was an

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[1] Vide suggestion of faulting of laterlite level.

interval here between the original stream valleys. Possibly there was a low divide running in a north and south direction and separating the smaller streams from the valley of the Pallinup. At what period in the history above outlined the uplift of the peneplain occurred is by no means certain. It seems clear that it was after the trenching of the range by the streams and it is likely that the sudden beheading of them may have been brought about during the major period of uplift of the plateau.

The relation of the Porongrups to the earth movements above postulated has not been examined. It is worthy of note however, that, like the Stirlings, these mountains present continuous summits in their eastern portion, and isolated hills separated by broad valleys in the western portion. This strongly suggests that, though entirely distinct in every detail of geological structure, the two parallel mountain ranges have had a very similar physiographic history. If the above outline is correct in its main features, the beheaded remnants of what were formerly much more extensive river systems are to be recognised in such streams as the King, Kalgan and Hay.

The Kalgan River calls for some description. Its upper valley lies between the Stirling and Porongrup Ranges and the river flows in a general east-south-easterly direction until, rounding the eastern flank of the Porongrups, it turns southwards and falls into Oyster Harbour near Albany. On the above described physiographic hypothesis the upper portion has been brought into existence at a comparatively recent date. Within the broad valley part, of which is occupied by the Upper Kalgan, are a number of lakes, some of which at all events are moderately permanent. At first sight their linear arrangement suggests that they represent the remnants of a stream which formerly flowed round the eastern end of the Stirling Range and emptied into the

Pallinup. While this is a possible explanation, it seems more probable that the lakes represent the expiring efforts of a number of small creeks, heading in the Stirling Range, to extend across the sand plain and reach the Kalgan or the Pallinup. Originally they may have been successful, but as the climate has become progressively drier, their waters have failed to extend beyond the limits of the foot-hills. This latter explanation is very strongly suggested by the character of the gully crossing the old road south of Sandalwood Station, which contains the quite considerable creek rising on the northern side of Ellen Peak.

Earth Movement.

While the sketch of the physiography may explain some of the later earth movements of the region, the complete history of these movements is undoubtedly highly complicated. It is obvious from the structure of the range that it must be regarded as a well defined narrow senkungsfeld bounded on the north and south by faults, and as such it is indicated in the handbook prepared for the Australasian Meeting of the British Association for the Advancement of Science in 1914. The preservation of the sedimentary series in such a narrow zone could have been accomplished in no other way.

The present altitude of the sedimentary series above the plain is, however, more difficult to account for. Differential erosion seems quite inadequate as an explanation. The alternation of brittle, highly-jointed quartzites, and of relatively soft slaty beds in almost horizontal layers yields a structure which is almost ideally weak. It seems inconceivable that such a structure could have withstood the agents of denudation so much better than the massive granites and gneisses, ribbed with greenstones, which form the plains, as to have produced mountains over 2000 feet high by simple differential erosion. The presence of the

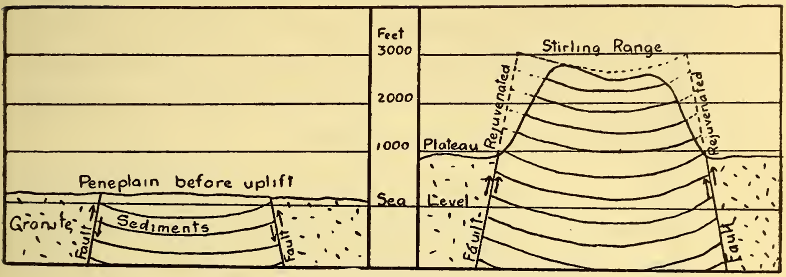


Fig. 4. Fig. 5.

Figures 4 and 5 indicate, diagrammatically, the tectonic history of the Stirling Range. Before peneplanation the sediments had dropped into a "senkungsfeld." This was bounded by reversed faults, since overthrusting was contemporaneous with quartz injection, and therefore, probably, Pre-Cambrian.

During the uplift of the peneplain, and its conversion into a plateau, the formations on *both* sides of the fault *moved upwards.* The sedimentary series, however, underwent greater uplift; so that the granite areas are *relatively depressed.* In this way the faults, originally *reversed* become *normal* after rejuvenation.

Compression and overthrusting are characteristic of late Pre-Cambrian time, while tension and normal faulting were associated with Cainozoic epeirogenic movements.

Porongrups is also opposed to such an explanation, and the peculiarities of river development indicate that something more than passive resistance to erosion must be postulated. It seems probable, then, that the fault planes which originally let down the substance area at some very distant geological epoch, and so preserved the weak sedimentary masses in the trough, became planes of weakness again in more recent times, and, when the plateau area of Western Australia commenced that long series of upward movements which culminated in the development of the Darling Plateau, the Stirling Ranges and the Porongrups were thrust upwards faster than the rest of the area, and, what was formerly a senkungsfeld has now become a horst.

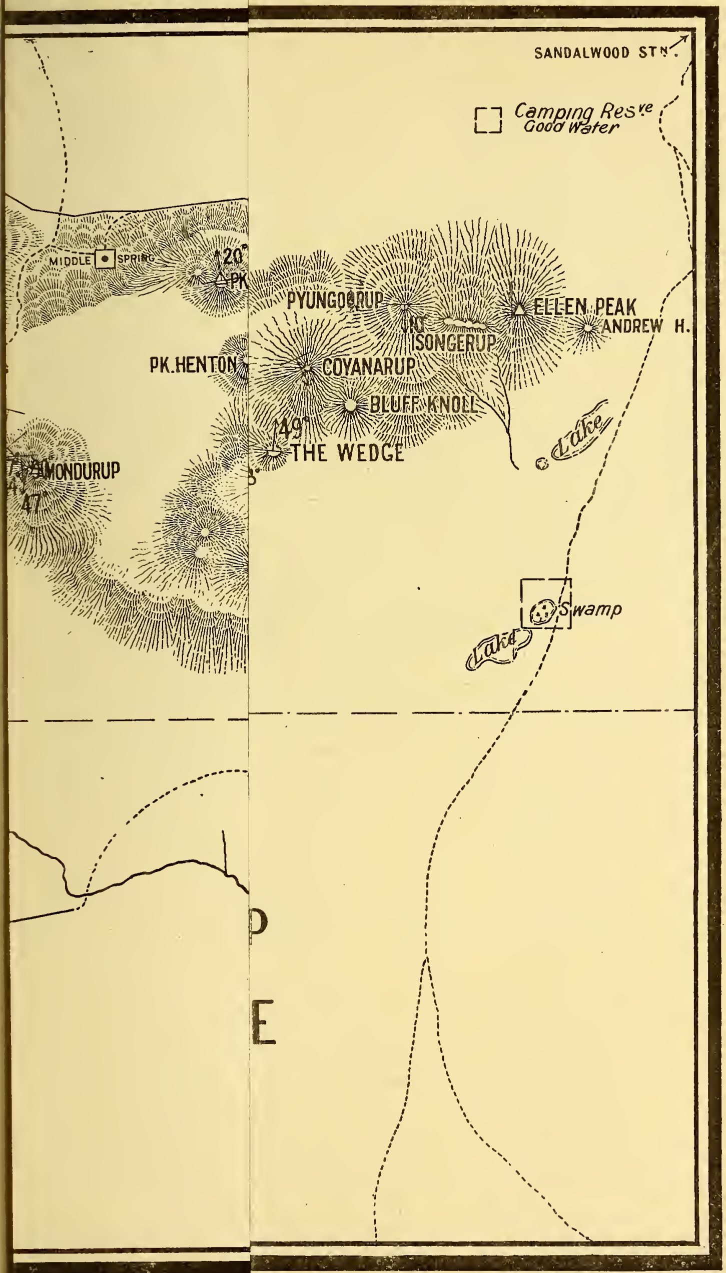
The abrupt termination of both Stirlings and Porongrups on the east indicates that the zone of movement has been limited in that direction by a fault which originally had a downthrow to the west, but which has since taken its part in the relative uplift of both ranges.

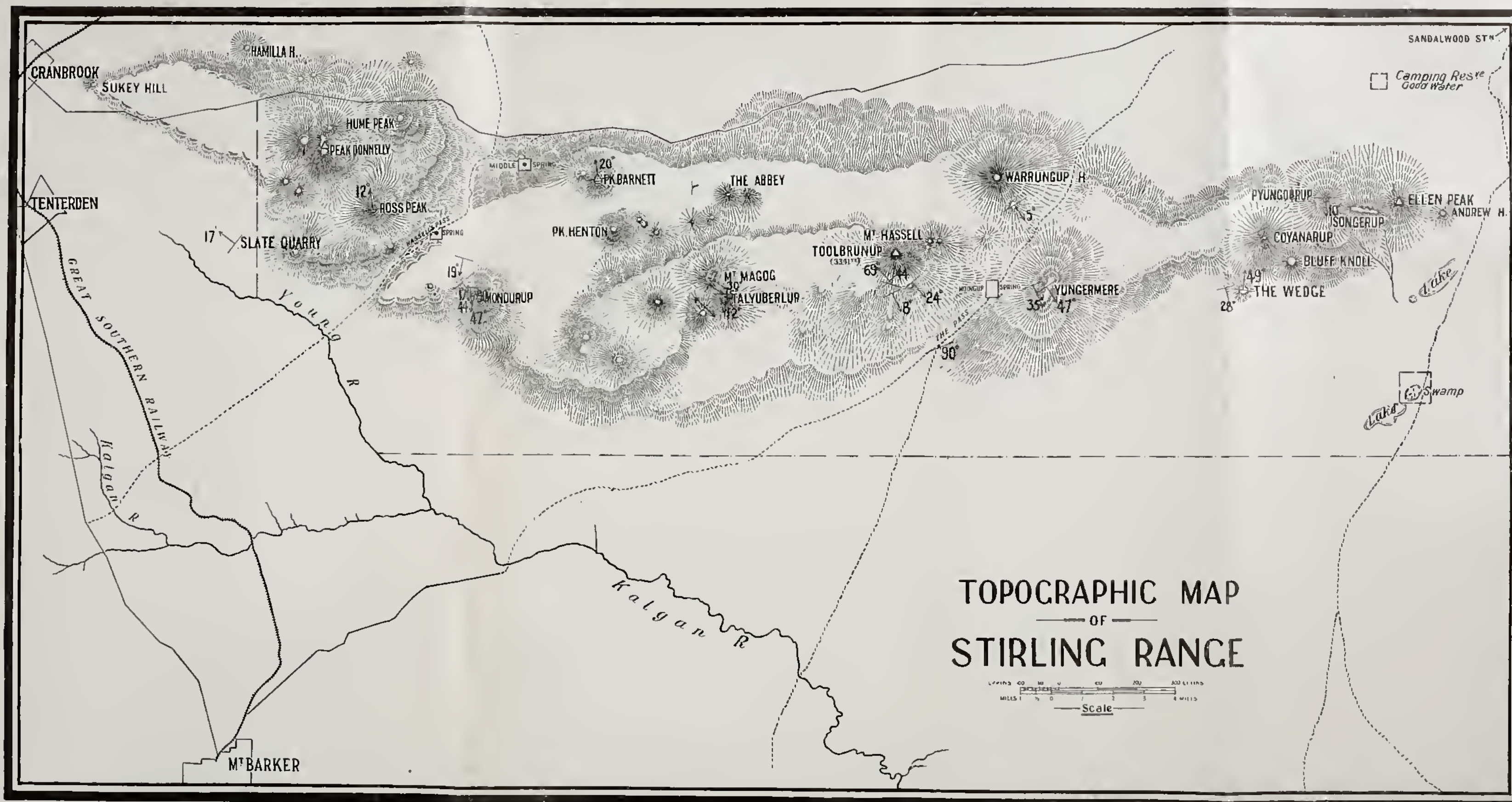
Summary of Conclusions.

The Stirling Ranges consist of a mass of ripple-marked and current bedded quartzites alternating with fine-grained slates possessing for the most part almost horizontal stratification. Locally, very considerable crumpling, sometimes associated with overthrusting has occurred. On the north, south and east the Stirling Range Series is probably faulted heavily, and comes into contact with older gneissic granites and greenstones. On the west the contact is an igneous one, the granites being more recent than the sediments. For this reason it is believed that the age of the sedimentary series may be Pre-Cambrian.

While the sediments must have been preserved from denudation in a senkungsfeld, it is probable that the latest differential movement has resulted in the uplift of the sediments. In this movement extensive rearrangement of drainage systems has occurred. The Pallinup and Gordon rivers are explained as diverted streams, while an area of internal drainage has been formed to the north of the Stirling Ranges. The great "passes" through the range are regarded as "air gaps" produced by stream erosion during the penultimate period of the earth movement.

Plate VI.


SANDALWOOD STN.
Camping Resve
Good Water
MIDDLE
SPRING
20°
PK
PYUNGOORUP
ELLEN PEAK
ANDREW H.
ISONGERUP
PK.HENTON
COYANARUP
BLUFF KNOLL
Lake
49°
THE WEDGE
MONDURUP
47°
Swamp
Lake
P
E


TOPOGRAPHIC MAP
OF
STIRLING RANGE
Scale
CRANBROOK
SUKEY HILL
HAMILLA H.
HUME PEAK
PEAK DONNELLY
ROSS PEAK
TENTERDEN
SLATE QUARRY
GREAT SOUTHERN RAILWAY
Young R
Kalgan R
MIDDLE SPRING
PK. BARNETT
THE ABBEY
PK. HENTON
MONDURUP
Mt MAGOG
TALYUBERLUP
Mt HASSELL
TOOLBRUNUP
WARRUNGUP H.
YUNGERMERE
THE PASS
PYUNGORUP
ISONGERUP
ELLEN PEAK
ANDREW H.
COYANARUP
BLUFF KNOLL
THE WEDGE
SANDALWOOD STN
Camping Reste Good Water
Lake
Swamp
Mt BARKER

THE VOLCANIC NECK AT THE BASIN, NEPEAN RIVER.

By G. D. OSBORNE,

Deas-Thomson Scholar in Geology (1919) University of Sydney.

(Communicated by Professor T. W. Edgeworth David.)

With Plate VII.

[Read before the Royal Society of N.S. Wales, September 1, 1920.]

CONTENTS.

Part I. General.

"The Basin" is the name given to the locality at the junction of the Warragamba and Nepean Rivers, twelve miles south of Penrith. In this area there occurs a volcanic neck which in the following pages, will be designated the "Basin" neck. Similar in general features to many of the Post-Triassic pipes in the Sydney-Blue Mountain district, this neck has been known to Sydney geologists for many years. On the "Geological Sketch Map of the Country in the Vicinity of Sydney," issued by Mr. Pittman in 1904, it is shown, but incompletely as regards extent. This portion of the map, was taken from a sketch map by Mr. R. N. Dart, B.E., who, visiting the neck in 1903, was only able, at the time, to map portion of it.[1]

The Basin neck has been referred to several times in geological literature, namely, by Benson,[2] Mawson and Taylor,[3] and Woolnough.[4] Also the record of a chemical analysis of a diallage rock from the Basin, made by Mr. J. C. H. Mingaye, is given in a Mines Department publication.[5]

The chief interest attaching to the Basin neck is the occurrence of xenoliths, mostly of igneous rock. These are included in both breccia and basalt, chiefly in the latter. In the basalt only cognate xenoliths occur.

This and similar occurrences in New South Wales of basic and ultrabasic xenoliths in generally less basic igneous rocks are matters of more than passing petrographical interest. Some have been treated in more or less detail by Profs. David and Benson, Mr. Sussmilch and others.[6]

As far as we know all our examples of Tertiary ultrabasic rocks occur as xenoliths. The mass of picrite within the dolerite in Jellore Creek, Mittagong, seems from the details given in the paper by Taylor and Mawson[7] to be an example,

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[1] Verbal communication from Mr. Dart.

[2] (*a*) Journ. Roy. Soc. N.S.W., Vol. 44, p. 548. (*b*) P.L.S., N.S.W., 1914, p. 452-3.

[3] Journ. Roy. Soc. N.S.W., Vol. 37, p. 349.

[4] "N. S. Wales Historical, Physiographical and Economics," p. 92.

[5] Ann. Rept. Mines Dept., N.S.W., 1908, p. 174.

[6] For detail of references see Benson, Proc. Roy. Soc. N.S.W., Vol. 44, pp. 496, 548.

[7] Journ. Roy. Soc. N.S.W., 1903, p. 326, and fig. 8.

on a large scale, of the result of the intratelluric differentiation, which is evidenced at Dundas and elsewhere.

The present paper is based on observations made in 1919, and is intended mainly as a contribution to our petrographical knowledge of these interesting occurrences in the Sydney district.

It is very probable that a more complete suite of inclusions exists than is described below, as the outcrop of the dyke containing the xenoliths is very small and decomposed.

General Geology.

A geological sketch map of the neck and the surrounding country is given in fig. 1. The neck presents an elongated shape in plan, being about one and three-quarter miles long, and about twelve chains in mean width. The maximum width does not exceed thirty chains. The general trend of the vent is E. 18° N.

At its surface outcrop it is intrusive almost entirely into Hawkesbury sandstone. The definite relations of the igneous rock to the surrounding sediments at the eastern end of the neck are somewhat obscured by the recent alluvium of the Nepean and also by the fact that the soils derived from the breccia, the Wianamatta shales and the river alluvium are similar in appearance, but the neck probably breaks through the Wianamatta shales. The filling of the neck is composed almost wholly of a dark greenish breccia, and within this there are blocks which, though termed "inclusions," are identical with certain fragments in the fine-grained matrix, and thus have distinction in size only. On the other hand both foreign and cognate fragments occur within the breccia.

Examples of the former comprise blocks of quartzite ranging in size up to several feet in diameter. Judged by their general felspathic residuum they are probably meta-

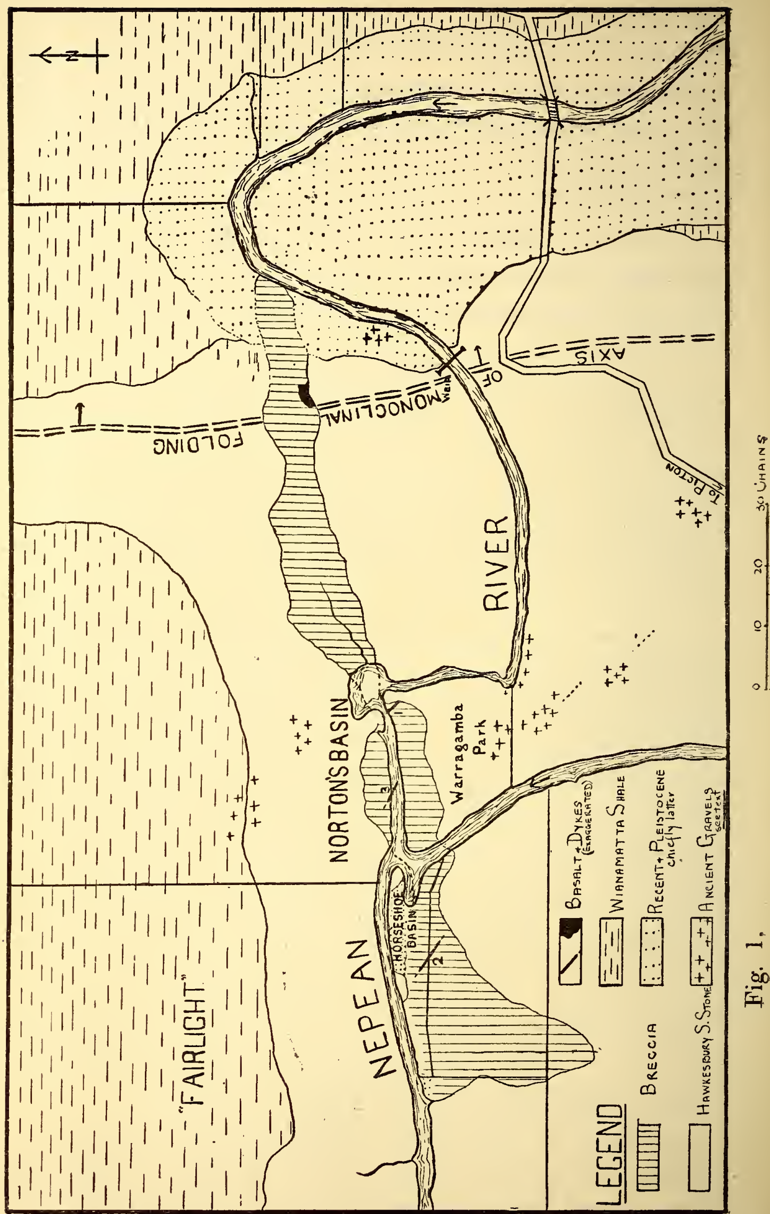
"FAIRLIGHT"
NEPEAN
RIVER
NORTON'S BASIN
HORSESHOE BASIN
Warragamba Park
FOLDING
MONOCLINAL
OF
AXIS
Weir
To Picton
LEGEND
Breccia
Hawkesbury S. Stone
Basalt + Dykes (exaggerated)
Wianamatta Shale
Recent + Pleistocene chiefly latter
Ancient Gravels see text
0 10 20 30 Chains

Fig. 1.

morphosed Hawkesbury sandstone. In some of the less altered sandstone fragments examples of "injection breccia" have been observed: along the bedding planes the breccia has been forced giving a characteristic appearance.

The foreign and cognate inclusions comprise peridotites, rhyolitic rocks, granitic representatives and a calcareous sedimentary rock of decided Mesozoic facies. These types will be described in Part II. Another interesting occurrence in the breccia is that of a large mass of coal-like material, which appears to be the cindered remains of a tree-trunk. Similar occurrences at Hornsby are invariably associated with aragonite and silica. At the Basin smoky calcite is associated with this coaly material.

The breccia has been intruded by at least three dykes and an irregular mass of basalt. These are shown diagrammatically on the map (Fig. 1).

The dykes are numbered on the map, and their respective features are tabulated below:—

Dyke.	Strike.	Dip.		Width.	Rock Inclusions.
		Amount.	Direction.		
No. 1	S. $42\frac{1}{2}$° E.	71°	W. $42\frac{1}{2}$° S.	2 ft.	abundant.
No. 2	E. $33\frac{1}{2}$° S.	80° (?)	S. $33\frac{1}{2}$° W.	5 ft. 6 in.	absent.
No. 3	E. $26\frac{1}{2}$° S.	Indeterminate.		1 ft. 4 in	absent.

Dyke No. 1 has sent out an offshoot intruding the adjacent breccia in a joint plane parallel to the parent dyke. It has also produced a sympathetic set of joints in the breccia parallel to itself.

Relation of the neck to the tectonics of the area.—From the map it will be seen that the vent breaks through the Hawkesbury rocks close to and even at the axis of the monoclinal fold. The sandstone is dipping at 32° in a general easterly direction at the eastern end of the neck.

One of the striking facts which the geologist realises, when investigating the post-Mesozoic history of the Sydney area (part of a larger geological unit), is the genetic relationship existing between the Glenbrook fold, with its accompanying geosynclinal development, and the Tertiary vulcanicity of the area.

The volcanic neck at the Basin, in common with many other necks in the district, was one of the manifestations of this volcanic activity which followed or perhaps in part accompanied the epeirogenic movements.

The elongated nature of the vent was mentioned in the early portion of the paper, and a careful consideration of the facts observed leads the writer to conclude that the east-west orientation of the vent has in general been determined by the existence of a dominant fissure which formed a weak structure and along which explosive action was concentrated.

Such fissures do exist in folded regions, running at right angles to the fold axes, and along them in areas where the folding has been intense dislocation and faulting often occur. In most cases there is a transverse drag between the two portions of the folded block with the production of horizontal slickensides. Suess[1] has described such movements in detail.

In the case in question, the monoclinal folding, due to differential epeirogenic uplift, has been gentle and the zone of fissuring represents the expression of only the initial stages of the development which is exhibited in more intensely folded regions. That the postulated fissure crosses the fold is shown by the occurrence of breccia to the east of the monoclinal flexure.

Another contributing factor in the location of the vent has been the probable existence of a zone of weakness

[1] Suess, "Das Anlitz der Erde," Sollas, Trans. Vol. I, pp. 115–118.

lying to the west of Norton's Basin, trending meridionally and representing the southward continuation[1] of the senkungsfeld structure which exists west of Kurrajong. The location of the Springwood, Euroka Creek, and Mountain Lagoon[2] volcanic necks also points to a local genetic connection with some such zone of weakness.

Speaking of the intimate relation between the epeirogeny and the vulcanicity mentioned above, Dr. Jensen says, "The extrusion (and intrusion, G.D.O.) of basalt, may be here, as elsewhere, a phase, function or effect of a senkungsfeld formation."[3] To the author the last suggestion seems the correct one.

Physiography.

(a) *Local.*—The purely local physiographic detail can be described in a few words. The neck has been considerably eroded leaving a large area of excavation, accomplished mostly by the Nepean River. This stream flows within the neck for about half a mile of its course, and part of its northern bank is formed by a precipitous scarp which represents approximately the junction of sandstone and breccia.

Norton's Basin is a deep pool of water, with an average depth of fifty feet, and has been produced by the scooping action of the Nepean on the soft breccia.

(b) *Regional.*—Briefly a few points may be mentioned with regard to the relation of the position of the neck to broader problems of physiography in the surrounding district. On the heights adjacent to the Basin fairly extensive

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[1] A preliminary examination by the writer of the section from Emu Plains to the Basin resulted in the observation of westerly dips on the sandstone over a considerable distance, suggesting a continuance of the western limb of the Glenbrook anticline.

[2] Prof. David, Ann. Add. Roy. Soc. N.S.W., 1896, p. 59.

[3] Journ. Roy. Soc. N.S.W., Vol. XLI, 1911, p. 257.

deposits of river gravel occur. Here it might be noted that the deposits on the southern side of the Basin extend some distance to the south. (On the map these gravels are only indicated, with no suggestion of extent.) Further other river gravels occur near the Wallacia Bridge, quite close to the Nepean, but comprising rocks which are not found in the present drainage area of this river.

The curious bends taken by the Nepean River from the Wallacia Bridge to its confluence with the Warragamba are suggestive of river capture and the present junction of the two rivers is within the Basin neck. These facts make it clear that the Basin neck, composed of comparatively soft material, has, on account of its location, formed an important unit in the latest stages of the evolution of the Nepean-Warragamba river systems during the Cainozoic Era.

Part II. Petrology.

1. *The Breccia.*—The agglomerate has a fairly uniform grainsize of about ·3 mm. Dark in colour, it weathers to a greenish-grey. Under the microscope it is seen to consist of quartz and acid plagioclase grains, and fragments of sandstone and chert. These constituents are cemented together by a base in which chloritic and kaolinic material preponderate. Calcite as small veins and irregular secondary masses also occurs throughout the rock. Only one small fragment of basaltic nature was noted in the slides of the breccia. This was similar to the "trachytic" basalt of Hornsby.

2. *Inclusions within the Breccia.* (a) *Calcareous Clastic Rocks.*—The occurrence of these was mentioned in Part I. In some parts of the neck they are numerous. Microscopic investigation reveals a suite of rocks with variable grain-size, the chief constituents being fragments of lava, chert, grains of quartz, plagioclase, chlorite and an indeterminate

brown material. The cementing material is distinctly calcareous. The quartz shows sharp extinction on the whole, but some has been strained. The felspar is acid oligoclase. The fragments of lava comprise basalt and andesite, the latter sometimes glassy. The basalt is hyalopilitic in fabric and much chloritised. The indeterminate brown individuals seem to suggest ostracod remains but Mr. W.S. Dun expressed the opinion, on looking through the slides, that the material was not of organic origin. Some examples of the rocks under description are extremely fine grained and others very arenaceous in character. Although there is a considerable divergence in some properties, they can be conveniently grouped together. The question of the origin of these numerous inclusions cannot be definitely answered, but there is a similarity between some of the slides and sections of certain horizons in the Narrabeen beds. Those inclusions at the Basin which contain fragments of lava, as described above, suggest redistributed tuffs. Other slides strongly resemble sections kindly lent by Mr. W. L. Havard of an upper horizon of the Wianamatta stage which is associated with the calcareous rocks of this age at Picton and elsewhere. It is possible that the inclusions in question are derived from the Narrabeen stage or represent remnants of a roof of upper Wianamatta rocks, an obvious extension of those calcareous horizons which covers considerable areas in the County of Cumberland.[1] If the latter is in part or wholly correct, then the instance is recalled of the preservation in the vent at Arran Island of blocks of Triassic and Cretaceous strata, the sole surviving relics of a former series now completely eroded away.

(b) *Rhyolitic Rocks.*—This type of inclusion is rare. One specimen was found by the author and a slide of a similar inclusion from the Basin was kindly lent by Mr. G. W. Card.

[1] The writer is indebted to Mr. Havard for information as to the extent of these rocks.

Petrographically the former specimen is very felsitic with a little flow structure and a few phenocrysts of quartz. The Survey collection slide is of greater interest. Microscopically it consists of quartz and felspar in a cryptocrystalline groundmass which is fluidal in places. This criterion coupled with its tuffaceous nature is significant as regards origin. Many small devitrified cuspate bodies and examples of spherulitic aggregates are present.

The quartz phenocrysts are clear and free from strain effects. Partial corrosion has occurred in some cases. A few of the felspar grains have properties suggestive of anorthoclase, but the grains in question are very altered, and hence the point is in doubt, Intergrowth of quartz and felspar occurs in one or two very small patches in the base. Radial chlorite is also present. As a whole the rock appears very similar to some of the Pokolbin and Currabubula types. It is strongly suggestive of the New South Wales Carboniferous facies. If derived from a Carboniferous terrane thousands of feet below, a possible southward extension of the Kuttung Series as far as Sydney is indicated.

(c) *Ultrabasic Plutonic Rocks.*—Xenoliths of these rocks are less numerous in the breccia than in the basalt. However the types in both are identical and a detailed description of the specimens in the basalt is given below. The types recognised in the breccia are harzburgite and lherzolite.

(d) *Granitic Rocks.*—A short description of a granite inclusion found at the Basin is given by Prof. Benson.[1] A similar inclusion has been examined by the present writer, and a comparison of the two slides shows that they are almost identical. In hand specimen the rock in the writer's collection shows a gneissic appearance, and while generally

[1] Proc. Linn. Soc., N.S.W., 1914, p. 453.

under the microscope this structure is due to the orientation of the constituents, still there is a suggestion of granoblastic structure. This point was noted by Prof. Benson also. The rock may therefore have been derived from a mass in which metamorphism had not progressed very far. The occurrence of granitic rocks in these Tertiary necks is very interesting, in that, as it is improbable that they are derived fragments, they must have been brought from a great depth. Recently Mr. H. Yates, B.Sc., has shown the writer an inclusion of granitic nature from the Hornsby vent, and the possible occurrence of granite in the Mount Gilead neck is to be noted.[1]

3. *Occurrence of Basalt.*—Other than the three dykes there is an irregular outcrop of basalt near the eastern end of the neck, (see map). It is almost identical in petrological features with the rock in dyke No. 2, slight textural differences being observed.

The Dyke Rocks.—The general structural features of the dykes are given in a tabular statement in Part I. They are all decomposed and unfit for chemical analysis.

(a) *Dyke No. 2.*—In hand specimen this dyke rock is somewhat amygdaloidal but the body of the rock is extremely dense and compact. Microscopically it appears as a very fine grained groundmass in which are set altered phenocrysts. The phenocrysts are all decomposed and the criteria of form and nature of pseudomorph are the only guides to their original nature. Some of the individuals have been olivine showing the characteristic macropinacoidal sections, and poorly developed cross-sections of augite can be made out. Calcite and possibly dolomitic material have taken the place of most of the phenocrysts, although some altered olivine shows pseudomorphism by

[1] M. Morrison, Rec. Geol. Surv. N.S.W., Vol. VII, 1904, p. 19.

calcite, serpentine and quartz in association. In many cases carbonates have probably replaced original hydrous magnesium silicate pseudomorphs after olivine.

The base of the rock presents some unique characteristics. Magnetite is abundant and exists as idiomorphic and sub-idiomorphic octahedra and also as minute needles. The latter are often arranged in radiating groups or in parallel lines. Many of the needles stand perpendicular to the phenocrysts, which were evidently floating about in the magma just prior to complete freezing. At other times the magnetite grains have wrapped round the phenocrysts in coronal fashion.

The rest of the base consists of small brown prismatic augites of the second generation and of felspar laths. The augites are fresh and free from iron inclusions. Some grains are simply twinned. The felspar is altered to sericite and chlorite. A careful search failed to reveal the presence of felspathoids or of melilite. The rock is holocrystalline and exhibits glomero-porphyritic structure in places.

(b) *Dyke No. 3.*—This rock is considerably decomposed and is evidently coarser in grainsize than the other dyke rocks. The field presented in the microscope is 60% rhombohedral carbonate, but careful examination reveals evidence of the former presence of olivine, augite and felspar. There is a distinct tendency to ophitic fabric. It is clear that the rock was originally an olivine dolerite or olivine basalt.

(c) *Dyke No. 1.*—This is the most important of the three dykes, in that it is the matrix of the interesting xenoliths. In hand specimen it has a slaggy appearance and is characterised by a large number of small joints.

The dyke rock, a basalt, varies mineralogically from point to point. Whether this difference has been contributed to by assimulation of xenolithic material or not, is hard to say. There are however textural changes which are certainly due to the proximity of inclusions. One phase of the basalt consists of small well formed prisms of purple augite which exhibit characteristic transverse cracking and occasional simple-twinning. A little lath-shaped plagioclase felspar ($Ab_1 An_1$), with albite twinning, and subordinate ilmenite complete the mineral constitution. In appearance this rock resembles the so-called "aphanitic dolerites" of Antarctica.[1]

A more normal phase of the basalt consists essentially of laths of basic labradorite, crystals of green augite and iron ore with a little interstitial glass. A few grains of olivine are also present. This olivine belongs to the rock proper, but other extraneous olivine crystals are seen in the slide. These latter are altered and invariably possess a tiny border of diopside crystals.

The arrangement of the constituents of the basalt gives rise to a pseudo-variolitic texture. The rock probably cooled rapidly.

4. *Inclusions in Dyke No. 1.*—This section of the petrology has been studied in most detail and it is proposed to consider the rocks in types, the general description of each type being based on the examination of a number of examples. The rocks will be treated in the following order: Gabbros, Hypersthene Gabbros (Norites), Troctolites, Harzburgites, Lherzolites, Dunites, Pyroxenites and other miscellaneous types.

(a) *Gabbros.*—True gabbros have rarely been met with at the Basin. Most of the gabbroic rocks are hypersthene-bearing, thus being noritic in character. However, one gabbro has been examined, the component minerals being felspar, augite, magnetite and apatite. The augite shows

[1] W. N. Benson, British Antarctic Expedition 1907-9, Geol. II, p. 153.

twinning and inclusion of schiller plates, and in common with the felspar it is noticeably fresh. The felspar exhibits pericline twinning very well, and has the composition of basic labradorite.

(b) *Hypersthene Gabbros grading into Norites.*—These rocks are very abundant in the suite of inclusions. The component minerals comprise plagioclase 42%, augite (sometimes diallagic) 38%, hypersthene 14%, and ilmenite 4%, with decomposition products 2%.

The structure is gabbroic and the grainsize coarse and even. Some of the felspar plates exceed 3 mm. in diameter. The order of consolidation has been made out as follows:—Iron ore, if primary, early, followed by augite, which was then quickly succeeded by hypersthene. Some of the augite has been corroded by the still molten felspathic magma, but no corrosion of the rhombic pyroxene is seen, indicating that felspar and hypersthene commenced to crystallise with but little interval between them.

The felspar is twinned after the albite and pericline laws, the characteristic wedged-shaped segments in the twinning of gabbroid felspars being seen. The reading for extinction angles measured on the trace of the (001) cleavage in sections parallel to (010) is -24°, indicating an average composition of $Ab_2\ An_3$. The boundaries between some of the felspar plates are very ragged and produce very irregular intergranular spaces, in which secondary material has developed. Similar material fills many of the cracks which traverse the mineral. This secondary product has a high birefringence and is probably sericite. There is also some chlorite. Augite varies in degree of development and many small grains are included in the felspar. Pleochroism to a very slight degree is noticed, indicating the existence of a little titanic acid in the pyroxene. The maximum extinction measured is $Z \wedge c = 44^{\circ}$. Schiller enclosures abound in some sections and their development in any one grain is capricious, suggesting a possibility of primary nature.[1] Interaction with the residual magma has been mentioned. Between felspar and pyroxene there seems to be chlorite. Alteration to chlorite is very frequent, showing that the augite is aluminous. The possibility of the derivation of large masses of iron oxides from the augite has been noticed.

The orthorhombic pyroxene is definitely hypersthene, fairly rich in iron. It is pretty abundant and is strongly trichroic with the following scheme:—*X*, pale reddish-purple; *Y*, reddish-yellow; *Z*, greyish-green.

Perhaps the most important feature of this mineral generally is the development of the so-called schiller plates. Although some crystals have an absence of schillerisation still the great majority show this phenomenon to different degrees. In particular in one crystal which is figured in Plate VII, fig. 2, these schiller plates are seen to be developed parallel to three planes. However, the dominant schiller effect is that parallel to (100) with the minor effect in the plane parallel to (010).

In the augite the schillerisation is confined in most cases to planes parallel to the orthopinacoid, with examples at times of development in clinopinacoidal planes.

The question of the origin of schiller structures is a fascinating one. Prof. Judd[2] discussed it at some length, and insisted on the secondary nature of the phenomenon, attributing it to deep-seated conditions. He averred that the degree to which this property is developed in rock minerals is in general a function of the depth from the surface. Essentially Judd's concept, therefore, was that

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[1] *Cf.* Harker, "Tertiary Igneous Rocks of Skye," p. 109.

[1] Q.J.G.S., 1886, p. 382.

of pressure and resulting solution and deposition. Harker,[1] however, in connection with his work on the British Tertiary terranes, disagreed with Judd's view, and hinted at the structure being a primary one. Judd would certainly extend the idea of schillerisation to wide limits, thereby dealing with changes in felspars and olivines. Zirkel,[2] too, mentions the process in connection with the mineral olivine.

Without discussing the matter definitely, the opinion may be stated that the occurrence of these inclusions in the Basin rocks is indicative probably of separation from solid solution in the host rather than of infiltration and solvent action. This would not accord with Judd's view, but would postulate a secondary nature, in that the separation of the inclusions took place after the actual crystallisation of the host. This tentative conclusion is based on the examination of the schillerised minerals, *with special reference* to their association, to the changes in adjacent felspars, and to the occurrence of the rocks containing them.

This mode of origin of the dark plates is therefore surely analogous to the secondary perthitisation of alkali-felspar, the albitic element often originally held up in potash-felspars corresponding to the metallic oxides which existed in solid solution in the pyroxene. It would appear that the pyroxene individuals have been, with reference to the metallic constituent, in a labile condition, but while the dominant factor regulating the spontaneous separation of the dark inclusions has been that of decreasing temperature, still in the present study the possibility of pressure aiding in a small way in their development has been recognised.

One rock which is included in this group is of the nature of a hyperite, containing both monoclinic and orthorhombic pyroxenes and much olivine together with a little primary

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[1] Harker, "Tertiary Igneous Rocks of Skye," p. 109.

[2] Zeitschr. der deutsch. Gesell. (1871) p. 189.

ilmenite and felspar of the composition of labradorite, determined by reading the angle between the pericline twinning striation and the trace of the basal cleavage on sections parallel to (010).

The olivine is altered to the reddish mineral iddingsite, and the felspars are sericitised in places. This rock is interesting in being a linking type between hypersthene gabbro, normal gabbro and olivine gabbro.

(c) *Troctolites.*—One of the most interesting features of the work on the Basin material, is the recognition of the presence of the olivine-felspar rock, troctolite, among the inclusions. As far as the writer knows, this is the first time troctolite has been recorded in New South Wales, and although the occurrence is not as an individual rock mass, still it has been deemed of sufficient importance to merit an analysis.

In hand specimens the troctolites show the typical spotted appearance produced by the uniform grainsize of the light felspar and dark olivine, characteristic of the Forellenstein of von Lasaulx. A typical portion of the field as seen under the microscope, is shown in Fig. 1, Plate VII. Microscopically the rock is seen to consist of olivine in corroded grains, augite, felspar, a little ilmenite and a granophyric intergrowth of pyroxene and green spinel. The general features of the crystallisation are similar to those of many British Tertiary ultrabasic rocks. Olivine evidently commenced to crystallise before felspar, as the former is sensibly corroded; there is no trace of eutectic (not graphic) consolidation, and although the proportions of the constituents are as follows:—felspar 60%, olivine 30%, augite 7%, spinel 1%, ilmenite 2%, still olivine has crystallised first and yet could not originally have been in excess. This, therefore, is evidently another example to be explained on the hypothesis which Vogt has assumed, that the presence in the magma of pyroxene (here augite), which has one ion in common with olivine, has "accelerated" the freezing of the latter mineral. This suggested explanation of an apparent anomaly on the theory that rock magmas behave as chemical solutions, has been used by Harker in the interpretation of certain features of the ultrabasic rocks of Rum.[1] The augite crystallised soon after the olivine and before the felspar, but the augite-pleonaste system was a late product of solidification, being subsequent to the adjacent felspar.[2]

The felspar is subidiomorphic with stoutish habit, exhibiting albite and pericline twinning. Strain is expressed by undulose extinction and peripheral shattering. The alteration in cracks and irregular patches has given rise to sericite, chlorite and calcite. The extinction angle in sections parallel to the brachypinacoid give, in different slides, values ranging to bytownite of about the composition $Ab_{29}An_{71}$. These determinations are in general substantiated by the results of the analysis.

Olivine occurs in rounded grains, and in places is completely pseudomorphed by iddingsite and bowlingite. Secondary carbonates are also present. The augite is fairly fresh and of a pale greyish-green colour. It is generally concentrated locally and shows incipient alteration to chlorite.

Granophyric intergrowth of pyroxene and pleonaste is present, showing the same general features as the similar occurrence at Dundas. An example is figured in Plate VII, fig. 6. Dr. Benson[3] accounted in one way for the intergrowth, by postulating the solution of felspar of a partially solidified gabbroic magma by a peridotitic magma on

[1] Harker, "Natural History of Igneous Rocks," pp. 170, 171, 205.

[2] Benson, Journ. Roy. Soc. N.S.W., 1910, p. 519, *et seq.*

[3] Benson, *loc. cit.*, p. 521.

admixture of the two, with the production of a syntectic melt, which crystallised as pyroxene and pleonaste granophyrically intergrown. In connection with the Basin rocks it must be remembered that felspar crystallised late.

Below is placed a chemical analysis of a troctolite from the Basin (A) and with it (B) an analysis of a troctolite from Coverack.

	(A)	(B)
SiO_2	46·71	45·73
Al_2O_3	24·08	22·10
Fe_2O_3	·51	·71
FeO	4·99	3·51
MgO	2·12	11·46
CaO	10·01	9·26
Na_2O	2·51	2·54
K_2O	·10	·34
TiO_2	·26	—
H_2O+	1·22	4·38 (H₂O+ and H₂O−)
H_2O-	·69	
MnO −	·27	—
	100·47	100·03

Norms.

	(A)	(B)
Orthoclase	·56	1·67
Albite	20·96	17·13
Nepheline	—	2·13
Anorthite	49·76	48·09
Corundum	1·63	—
Diopside	—	7·07
Hypersthene	6·12	—
Olivine	18·00	18·36
Ilmenite	·61	—
Magnetite	·70	·93
Water	1·91	4·38
	100·25	99·76

Classification for both rocks ÷II. 5. 4. 5.

Magmatic Name—Hessose.

(A) Troctolite from the Basin. Analyst, G.D.O.

(B) Troctolite from Coverack, Cornwall.[1] Analyst, F. T. S. Houghton.

It will be seen that these rocks are very similar in chemical composition. The Basin rock is more felspathic and the Coverack rock more olivinic. The calculation of the plagioclase felspars gives the following results, assuming that in the case of (B) there is available silica to form the polysilicate albite with the disappearance of nepheline:

[1] (a) Geol. Mag., 1879, p. 504. (b) Q.J.G.S., p. 906.

(A)	Albite 29·64%	Anorthite 70·56%
(B)	„ 30·88%	„ 69·12%

The actual composition of the felspar would be slightly different from that given at (A), in that a little lime must be allotted to pyroxene, with the necessary deduction of small amounts of lime and alumina from the anorthite molecule. However, allowing for such a change the composition of the felspar as determined optically, corresponds closely to the value obtained from the analysis.

(d) *Harzburgites.*—This type of peridotite is by far the most abundant. Its average mineralogical composition, based on rough estimates of the proportions of the minerals in the slides, is approximately as follows:—olivine 70%, enstatite 18%, diopside 8%, and spinel (picotite) 4%.

In the following accounts of peridotites the brown spinel will be referred to as picotite. It is not possible to say definitely whether the spinel is picotite or chromite, but the percentage of chromium sesquioxide in two analyses of the Basin rocks is evidently too low to admit of the existence of chromite.

The harzburgites are coarsely crystalline and variable in grainsize. The component minerals are very much altered. Particular attention has been paid to the significance of the decomposition products of olivine, as regards their relation to the conditions of formation. Thus, as Professor Benson[1] has clearly explained, the alteration of olivine to serpentine and to bowlingite represents a dual set of conditions, the production of serpentine being effected at great depths, and the changes to bowlingite and iddingsite being wrought by katamorphic agencies.

In the harzburgites complete pseudomorphs of olivine by bowlingite do occur as well as mesh-serpentine replace-

[1] "Origin of Serpentine," Am. Journ. Sci., December 1918, p. 693.

ments. Secondary iron ore in a fine state of division is also present; this is often in the minute veins of carbonate which transverse the grains in all directions. Associated with the bowlingite there is a certain amount of what is probably opal. The serpentine is often fibrous, forming veins in which the fibres stand perpendicular to the vein-walls.

The rhombic pyroxene is considerably altered, the chief alteration product being a reddish platy mineral, which is probably iddingsite; bastite is also developed. Associated with the bastite is a mineral which almost pseudomorphs the bastite, and has pleochroism with Z = c, brownish-red, and X = a, yellowish-green. This is thought to be the orthorhombic amphibole anthophyllite. One other decomposition product of obscure derivation, but possibly after enstatite, is a colourless mineral with a high birefringence. This has the appearance of talc or tremolite. The latter might be supposed to have originated by pressure[1] under deep-seated conditions, evidence of which is to be seen in the occurrence of serpentine, or the mineral may be colourless anthophyllite, as in some of the Cornwall ultrabasic rocks. The strong birefringence and the absence of pleochroism suggest either talc or tremolite, but the actual determination is a matter of difficulty.

The diopside is very fresh and contains a few schiller inclusions.

Picotite has crystallised in the main during the early stages of solidification, but one very remarkable occurrence of graphic intergrowth of augite and picotite occurs. (See Plate VII, fig. 4). This particular type of structure has not been encountered by the writer in his research into literature on ultrabasic rocks.

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[1] *Cf.* Flett and Hill, "The Geology of the Lizard and Meneage," p. 65.

(e) *Lherzolites.*—The lherzolites contain less olivine than the harzburgites, and diopside dominates over enstatite. While many features are to be found in this group similar to those investigated in the last group, still one of the most singular changes of olivine occurs in a lherzolite.

While bowlingite and serpentine occur with no striking features, a number of grains of olivine show a composite pseudomorph, so to speak. This consists of bowlingite, with bright interference colours, forming fibrous patches or segments partitioning off the olivine grains, serpentine which is sometimes developed at the periphery of the grains or in cracks, and opal with characteristic low D.R.; the opal is always associated with a puzzling brown decomposition product of irregular shape. This material is opaque with dark brown to black colour, and in places grades off insensibly into the bowlingite. It preserves the original cracks of the olivine, and in reflected light shows no metallic lustre, and only the merest indications of the common hydrated iron oxides. That it is an altered iron oxide which originally separated anhydrous out in large measure after the manner of alteration of olivines described by Judd and Zirkel, is the only explanation forthcoming at present. This view is strengthened by the existence of opal which is often associated with residual iron oxides in olivine. A figure of this manner of alteration is given in Plate VII, fig. 5.

In contrast to the olivine enstatite is almost unaltered. The (110) cleavage is very well marked and schiller plates are absent, although the rest of the rock expresses the various vicissitudes through which it has passed, comprising the subjection to pressure and conditions in plutonic regions and also circumstances favouring the infiltration of solutions in the zone of weathering. Thin bands of fibrous carbonate cross the crystals and a little talc[1] is developed

[1] *Cf.* Rosenbusch, 'Mikroskopische Physiographie,' Band I, II, p. 180.

along some of the more pronounced cleavage planes. Among these and other peridotitic rocks the crystallisation of free picotite has been studied carefully, and it is found that no constant period of solidification is indicated.

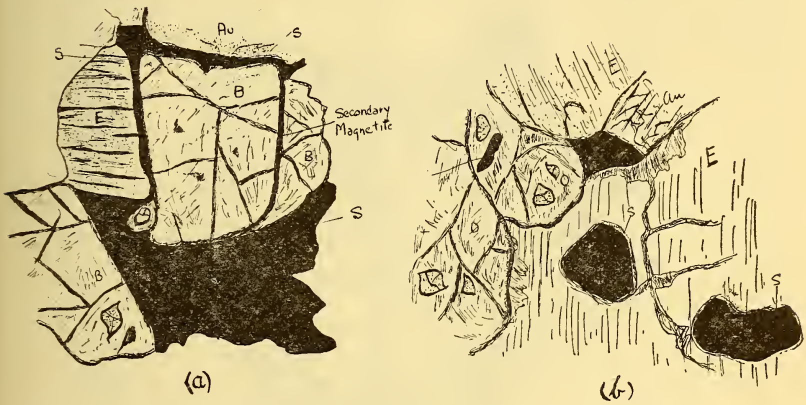

Fig. 2. *Crystallisation of Spinel in Peridotites.*

(*a*) Late Crystallisation. S picotite, E enstatite, B bowlingite pseudomorphs after olivine, Au augite.

(*b*) Early Crystallisation of picotite S, in association with E enstatite, Au augite and O altered olivine.

Fig. 2 (*a*) shows the evidence for referring the formation of spinel to a period late in the crystallisation history of the rock. There as elsewhere it is found filling intergranular spaces and enclosing olivine. However, in many cases picotite has undoubtedly crystallised first, as shown in figure 2 (*b*). Often, too, corrosion of the spinel is seen and a pretty example occurs of a small reaction rim between picotite and enstatite which is unmistakably composed of serpentine, a result which is hard to explain chemically.

The peridotites contain excellent examples of cracks developed in unaltered minerals, particularly pyroxene, by pressure exerted upon them by the expansion of adjacent olivine grains, as a result of alteration to bowlingite and serpentine; one such example, in a rock allied to wehrlite, is figured in text fig. 3. Such structures are common in altered ultrabasic rocks.[1]

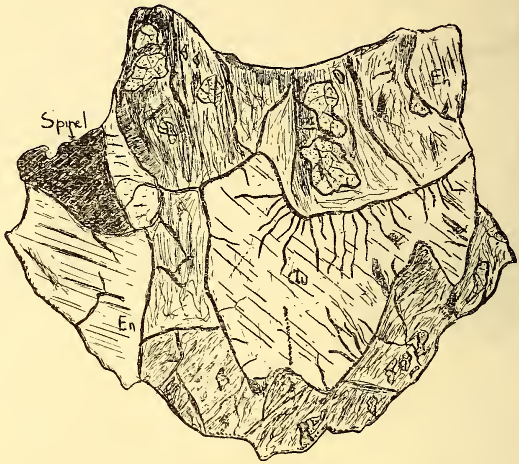

Fig. 3. *Augite in Lherzolite, showing cracks produced by the expansion consequent upon the change of olivine to serpentine.*

(f) *Dunites.*—Dunites are comparatively rare and show no special features. They contain up to 80% of olivine, with very subordinate amounts of enstatite and augite, and always some picotite of early crystallisation. The structure in the slices examined is equigranular.[2] The alteration of the olivine is mainly to serpentine, and in such cases has been effected in the anamorphic zone.

A tolerably fresh specimen was analysed with the following result (A): beside it is placed an analysis of a dunite from Dundas.[3]

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[1] *Cf.* Harker, "Petrology for Students," p. 90; Teall, British Petrography, Plate viii, fig. 2; Twelvetrees and Pettard, Roy. Soc. Tasmania, 1897, p. 28,

[2] *Cf.* Iddings, "Igneous Rocks," Vol. I, p. 195, Vol. II, p. 321.

[3] W. N. Benson, Journ. Roy. Soc. N.S.W., 1910, p. 582,

	A	B	Norms.	A	B
SiO_2	41·20	39·13	Anorthite	6·39	—
Al_2O_3	2·85	3·48	Olivine	59·89	72·14
Fe_2O_3	1·67	1·83	Enstatite	23·80	16·02
FeO	7·23	7·58	Corundum	·41	3·48
MgO	38·04	42·15	Magnetite	2·32	2·60
CaO	1·29	·07	Ilmenite	—	·30
NaO	trace	—	Chromite	·31	·30
K_2O	absent	—	Water	3·51	2·88
TiO_2	trace	·16	CO_2	3·40	3·05
CO_2	3·40	3·05			
H_2O+	2·65	2·80		100·09	100·77
H_2O-	·92	·80			
NiCoO	·45	·04			
MnO	·26	·21			
Cr_2O_3	·21	·20			
	100·17	100·75			

(A) Dunite from the Basin ; Analyst G. D. Osborne.

(B) Dunite from Dundas ; Analyst W. N. Benson.

The correspondence of the two rocks is very evident and is of course to be expected. The Dundas rock is slightly more basic.

In the case of (A) lime is higher than in (B), and owing to the presence of CO_2, most of the lime in the rock must be in the form of calcite, though some of the lime is probably in the pyroxene molecule.

The strict calculation of lime as anorthite uses up some alumina which together with the remainder, given normatively as corundum, is expressed mineralogically by the augite and possibly picotite.

(g) *Pyroxenites.*—No rocks of this type were found by the author but the following is an analysis by Mr. Mingaye[1] of a diallage rock from the Basin :—

SiO_2	...	50·36	TiO_2	...	trace
Al_2O_3	...	2·46	CO_2 ...	...	4·41
Fe_2O_3	...	4·26	Cr_2O_3	...	·04
FeO ...	...	4·41	NiCoO	...	·31
MgO	...	20·76	MnO	...	·29
CaO ...	...	6·25	BaO ...	...	·02
Na_2O	...	·51			
K_2O ...	...	·09			100·45
H_2O-	...	2·21			
H_2O+	...	4·07			

(h) *Other rock types within the Basalt.*—Under this heading it is desired to mention briefly the nature of three sections of rock material, which contain some most unusual characteristics in their mineral content. Two sections were cut from a small inclusion which was associated with gabbro and lherzolite in a closely packed portion of the dyke. Under the microscope both sections show very similar features. Fortunately in one slide the junction of the inclusion and its host, the basalt, is presented. The rock consists essentially of two minerals quartz and another colourless mineral, whose characters, if not anomalous, suggest something fairly rare as a rock constituent. The structure is allotriomorphic granular and the second mineral has included the quartz. However, the quartz does not appear to be normal. The appearance is rather that of recrystallised quartz in most cases, yet its inclusion in the second mineral appears more or less ordinary.

The second mineral shows a fine felted or fibrous appearance similar to many secondary silicates after olivine. Against these fibres the extinction is practically parallel.

[1] Ann. Rept. Mines Dept. N.S.W., 1908, p. 174.

Some sections, evidently basal, are completely isotropic and the mineral is uniaxial with negative character. The refractive index is lower than that of Canada balsam. It has not been possible yet to examine the mineral separately and determine ω and ϵ, but the D.R. measured on a section ·039 mm. thick was calculated at ·0045. Sometimes, an apparently homogeneous grain, will, under crossed nicols, exhibit a division into an isotropic central portion and a number of surrounding feebly doubly-refracting areas.[1]

If the above characters are themselves not abnormal, then the data given suggest some such mineral as apophyllite or chabazite. The occurrence, however, is not that of crystals lining cavities or cracks as one might expect in the case of such minerals.

The mineral in question alters to irregular masses which grade almost imperceptibly into the fresh mineral, these resultant masses showing high birefringence. The effect of pressure on this assemblage of minerals has been to produce a large number of parallel fissures into which secondary solutions have found their way, and now the quartz shows a perfect network filled with a strongly birefringent material which has also a high index of refraction. Many of the quartz fragments have been detached and lie embedded in the basalt. Whether selective assimilation was the only factor in effecting this separation is hard to say. There is often developed between the separated crystals of quartz and the compact rock inclusion a vein of bowlingite with its distinctive characteristics.

The third section is made up almost entirely of the unknown mineral, which is idiomorphic towards some irregular, more or less rounded areas, now much confused and stained, but suggesting broken down pseudomorphs

[1] *Cf.*, Iddings, "Rock Minerals," p. 287.

after some ferromagnesian mineral. The structure of the main mass of colourless mineral is typically subidiomorphic granular under crossed nicols, the junctions between adjacent grains being extremely difficult to discern in ordinary polarised light.

It is intended to investigate this mineral further, with possibly the application of micro-chemical or staining tests. At present the actual identity is left as a matter of doubt.

To conclude this section the occurrence of xenocrysts of quartz and olivine in the basalt should be noted. The quartz is clearly foreign in nature. It is sometimes very shattered and cracked, at other times more compact. Sometimes it has the appearance of having been recrystallised. Invariably surrounding the quartz xenocrysts there is a border of tiny diopside crystals.[1] The olivine, which is often decomposed, is of cognate nature, having been derived either from the breaking down of peridotites or by original fractional crystallisation from the ultrabasic magma.

5. *Relations between Host and Inclusions.*—In the Dundas papers by Prof. David, Watt, and Smeeth[2] and Prof. Benson,[3] attention was drawn to the assimilation effect by the basalt on the xenoliths and its bearing of their rounded form. The former point was also mentioned by Benson in his Gerringong notes.[4]

The Basin inclusions are often well rounded, an effect due in part to magmatic corrosion. Some specimens of basalt with inclusions simulate the appearance of a conglomerate.

The mutual relations of the basalt and inclusions are well shown in some of the slides, and descriptions follow.

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[1] *Cf.* Lacroix, " Enclaves des Roches Volcaniques," p. 19, fig. 1.

[2] Prof. David, Watt, and Smeeth, Journ. Roy. Soc. N.S.W., 1893, p. 401.

[3] W. N. Benson, Journ. Roy. Soc, N.S.W., 1910, p. 542.

[4] P.L.S., N.S.W., 1914, p. 447.

The expression of a change in the nature of host by absorption of xenolithic material is twofold: (*a*) textural and (*b*) mineralogical. The first is conditioned by physical, and the second by both physical and chemical circumstances. Nothing appreciable along the lines of (*b*) has been effected like the results observed in the Skye rocks, where the chemical compositions of the host and inclusions are antithetical. The mild effect of a basaltic magma on basic inclusions as at Dundas and the Basin, and the profound alteration of acid fragments in a similar magma, agree with the view, expressed by Harker, that between magma and xenoliths of like composition, there is a general chemical equilibrium.[1]

It is taken here that the inclusions at the Basin, with the exception of such fragments as quartz, etc., are fragments cognate with the environing basalt, and are the expression of a phase which differentiated under plutonic conditions. Subsequent transport to higher levels has caused rounding of many of the fragments through corrosion and corrasion.[2] From microscopic examination it appears that certain processes went on in deeper regions, altering the fragments before they were carried up to their present position.

The absorption of the magma here, as at Dundas, has been selective, felspar succumbing much more readily than augite.

The basalt has penetrated intergranular spaces in the xenoliths and especially in those of gabbroic types, showing that the whole of the inclusions were well heated to allow such fine strings of basic material to penetrate so far. Plate VII, fig. 6 shows the manner in which augite is freed by the gradual absorption of felspar. An interesting feature observed was that of a felspar grain adjacent to the magma

[1] A. Harker, "Tertiary Igneous Rocks of Skye," p. 354.

[2] "Origin of Dike Inclusions, Journ. of Geol., 1915, p. 169.

which was partly assimilated in such a way as to produce a flask-shaped area, the neck of the "flask" being the entrance through which the basalt made its way and the body of the flask representing partially dissolved anorthite. Crystallisation of the host prevented the complete solution of the felspar, and the molten material in the "flask" solidified as felspathic basalt. The forces of crystallisation probably de-oriented the undissolved felspar a little, with the result that a broad pericline twin striation which was originally continuous across the "flask" area now shows a marked deviation.

6. *Comparison with the Dundas Rocks.*—In the preceding pages the general geological and petrological features have been described in some detail. It is proposed here, briefly, to refer to the Dundas rocks by way of comparison. Through the kindness of Prof. Benson the author has been able to examine personally, his slides of the Dundas and Gerringong inclusions. As one might expect the Basin rocks are essentially similar to those at Dundas. Among the points of distinction between the two sets, we must note the absence of troctolites at Dundas. The felspars of the gabbros at this locality show effects of alteration akin to schillerisation, in Judd's sense, and secondary twin lamellation, which are not met with at the Basin.

The crystallisation of the spinel picotite in the ultrabasic rocks has been different in some of the rocks considered in this paper.

The rock analyses show that in the dunites the ratio of the bases to each other and to silica, and the content of the alkalies, lime and the accessory metallic oxides, are fairly constant at both localities. Nickel oxide is perhaps an exception being ·41% and ·30% respectively in two of the basin rocks, such values being much higher than those in the Dundas rocks. At both localities it would appear that certain changes in the differentiates went on in the intratelluric stage of the crystallisation of the basaltic magma, and ceased on completion of the activity, which is expressed by the basalt plugs and dykes, after the consolidation of which, changes in the minerals of the inclusions took place, which are referable to katamorphic agencies.

The granophyric intergrowth between pleonaste and monoclinic pyroxene is characteristic of both localities and occurs in gabbroic rocks which are olivine-bearing. The intergrowth of augite and picotite is peculiar to the Basin.

Part III. Summary and Acknowledgements.

At the Basin, Nepean River, there occurs a volcanic neck which evidences at least two stages in its past activity. The first epoch was one of explosive violence when a fine-grained breccia consisting mainly of fragments of sedimentary rock was formed. Three dykes and an irregular plug of basalt, which intrude this breccia, form the second phase of vulcanicity. The formation of the neck, with the production of a long narrow vent, has been due to explosive action concentrated upon a weak fissure structure, lying more or less perpendicular to the Eastern Cordillera. There is a genetic relation between the igneous activity and the earth movements of late Tertiary times.

The Basin neck has formed an important unit in the physiographic evolution of the Nepean-Warragamba system during Cainozoic times.

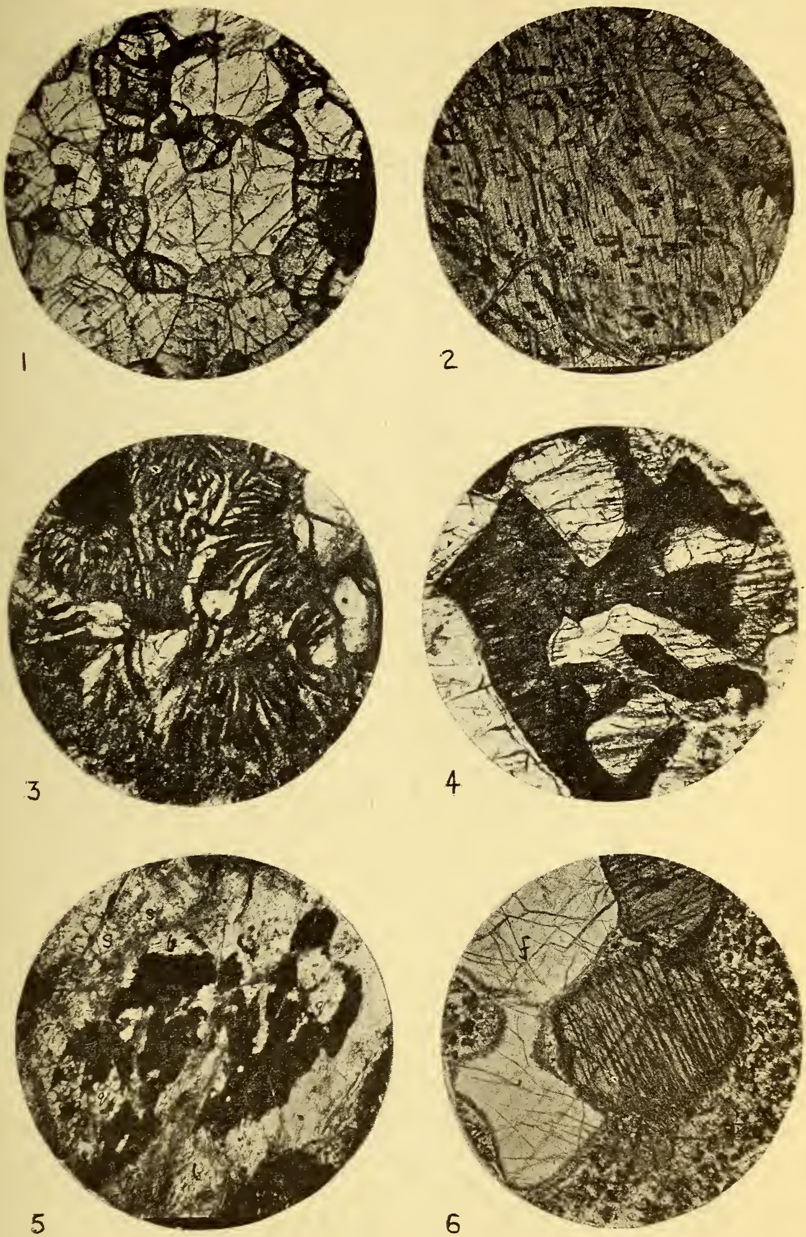
The breccia consists of fragments of quartz, plagioclase, chert, quartzite cemented by chloritic and kaolinic material. It is hard to say whether the two dykes and plug of basalt, which do not contain xenoliths, on the one hand, and the inclusion-bearing dyke on the other hand, were contemporaneous or not, because the former may contain inclusions at lower depths, and also since a similar association is to be seen in the South Coast area. Certainly under the microscope there is a big textural difference, but chemical comparison is difficult owing to the decomposed state of the rocks.

The inclusions in dyke No. 1 have been interpreted on precisely the same lines as those laid down by Dr. Benson for Dundas. These rock types vary from norites right through with decreasing acidity to dunites, including the rock troctolite, recorded in this State for the first time. The rare association is found of pleonaste and augite in olivine-bearing gabbroid rocks, and also a unique intergrowth of augite and picotite in a harzburgite. The differentiation which produced the phases, later torn up into fragments and carried to higher levels, may have some features directly explicable on Bowen's theory of differentiation by sinking of crystals. The ultrabasic rock types very probably represent a phase, derived by differentiation in an intercrustal reservoir from a magma, which itself was a differentiation product from an alkaline magma.

Amongst the inclusions not cognate in nature, there are examples of gneissic? granite derived from an ancient terrane, and rhyolitic rocks possibly referable to the Carboniferous Volcanics (Kuttung Series) which may probably extend underground as far south as the Basin. A third type is of a certain fragmental calcareous rock which may have been part of an upper Mesozoic unit.

Veining the igneous rocks at the Basin there occur satin spar, quartz, calcite and aragonite.

Acknowledgements.—In conclusion the writer wishes to thank those who have helped in matters connected with the preparation of this paper. To Professor David he is indebted for advice on many points, and for constant sympathetic interest. He has profited by discussions with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Dr. L. A. Cotton and Prof. W. N. Benson on various points, and through the kindness of the latter was able to examine his slides of the Dundas rocks.

To Mr. G. W. Card, A.R.S.M., F.G.S., he acknowledges many kindnesses, and the opportunity of examining material belonging to the Geological Survey. And in particular to Mr. W. R. Browne, B.Sc., for help in petrographical difficulties, and for advice generally, his best thanks are due. Finally he wishes to express gratitude to Mr. W. E. Baines, J.P., a resident of the Basin district, for much kindness extended to him during his visits to the Basin area.

Explanation of Plate VII.

Fig. 1. Troctolite, showing relations between felspar and olivine, the latter exhibiting initial alteration. Polarised light × 15.

Fig. 2. Crystal of Hypersthene in norite showing the development of "Schiller" inclusions parallel to three planes. Polarised light × 22.

Fig. 3. Granophyric intergrowth between green spinel and augite in troctolite. Ordinary light × 86 (high power).

Fig. 4. Graphic intergrowth of picotite and pyroxene in harzburgite. Ordinary light × 31.

Fig. 5. Common mode of decomposition after olivine in lherzolite, the products comprising bowlingite = *b*, serpentine = *s*, quartz (chalcedonic?) = *q*, and an indeterminate brown substance, the last two being always directly associated. Polarised light × 22.

Fig. 6. Section across junction of a gabbroid xenolith and its host (basalt) showing the manner in which felspar is more readily assimilated than pyroxene by the enclosing magma. Polarised light × 22.

ACACIA SEEDLINGS, PART VI.

By R. H. CAMBAGE, F.L.S.

[With Plates VIII - X.]

[*Read before the Royal Society of N. S. Wales, September 1, 1920.*]

SYNOPSIS:

Vitality of Seeds in Sea-Water.

Seeds of *Acacia melanoxylon* and *A. penninervis* var. *falciformis* from Jenolan Caves germinated when planted after having been immersed in sea-water for 1,192 days or 3¼ years.

Transport of Seeds by Water.

When discussing the possible transport of seeds in Part I,[1] it was mentioned that a pod of *Acacia Farnesiana*, when placed in sea-water, sank in a few days, but that Dr. H. B. Guppy had known pods to float for four or five weeks. Recently a cluster of four fresh pods which had only just ripened was placed in sea-water and floated for ten weeks and then sank. The cluster was then taken out and divided into four, when two pods sank, but two again floated, one for a further thirteen days, or eighty three days in all, and the other for a further nineteen days or eighty nine days in all.

[1] This Journal, Vol. XLIX, 93, (1915).

The likelihood of the wide distribution of this species having been assisted by the transport of seed-pods by ocean currents, though not proved, is much strengthened by the result of this experiment.

Twin Stems.

Several seeds of *Acacia asparagoides* from Medlow, and *A. vomeriformis* from Mount Victoria, produced twin stems which became two separate plants. This feature has previously been recorded in the case of *A. juniperina* (Part I, 93).

Sequence in the Development of Leaves.

In Part V, (p. 144), it was pointed out that of 104 species examined, 92 commenced with one simply pinnate leaf, while 12 had an opposite pair. The following three may now be added to those which produce only one pinnate leaf, and this brings the number to 95:—*A. argentea* Maiden, *A. Hamiltoniana* Maiden, and *A. vomeriformis* A. Cunn.

Number of Pinnæ on One Leaf.

In addition to the records already furnished (Part V, p. 145), relating to the number of pinnæ on one leaf of a phyllodineous Acacia, the following are now added—*A. rigens*, *A. cultriformis* and *A. Hamiltoniana*, all of which may have two pairs. *A. rubida* may have seven pairs.

Tripinnate Leaves.

In Part III (p. 393), reference is made to tripinnate and apparent tripinnate leaves. The latter, which are not uncommon, consist of three pinnæ at the end of the leaf, but with the excurrent point or terminal seta[1] still present,

[1] I have decided to adopt the term "terminal seta" as being more expressive than "excurrent point" for the prolongation of the leaf axis, and this feature may be seen practically on every pinnate leaf of Acacia seedlings. See a paper by J. J. Fletcher, M.A., B.Sc., "On the correct Interpretation of the so-called Phyllodes of the Australian Phyllodineous Acacias." Proc. Linn. Soc. N.S. Wales, Vol. XLV, 24, (1920).

thus showing that the central pinna is not a true prolongation of the leaf axis. In such cases the internode between the terminal pair of pinnæ and the third or lowest pinna is remarkably short, and one pinna, the fellow to the lowest, has not developed. What may perhaps be regarded as a strictly tripinnate leaf, however, has recently been found on a seedling of *Acacia rigens*, where the central pinna of a No. 3 leaf appears to be a prolongation of the main leaf axis, and no trace of the terminal seta can be seen. At the same time the central pinna is not a straight prolongation of the common petiole, but bends to the right. The common petiole does not taper gradually into the petiole of the central pinna, but becomes suddenly reduced in size at the point of contact, the thickness of the former being quite double that of the latter, and the leaf looks very like an apparent but not a true tripinnate leaf. (This Journal, LI, 393).

A second type of tripinnate leaf was noticed as the second leaf of *A. stenophylla*. (See Plate X, No. 8.) In this instance the basal pair of leaflets appear to have developed into a pair of pinnæ; what might have been the midrib of the leaflet in each case became transformed into the rachis of a pinna, thus making the leaf tripinnate, the central pinna having four pairs of leaflets.

A similar feature is shown in Part V, fig. 3, (This Journ. Vol. LIII, 145), where the basal leaflets on a leaf of a seedling of *A. podalyricæfolia* are shown to have developed as a pair of pinnæ; the remainder of the leaf, however, consists of a single pair of leaflets only. An exactly similar occurrence to the last has been noted on a third leaf of *A. difformis*. The first or simply pinnate leaf of a seedling of *A. floribunda* commonly has two pairs of leaflets, but in one instance one of the basal leaflets developed as a complete pinna with two pairs of leaflets. This is the only case I have seen of a divided leaflet on a first leaf.

These examples suggest the idea that the first pair of pinnæ of a bipinnate leaf correspond with the basal rather than the apical pair of leaflets of the first or simply pinnate leaf.

Glands, Nectaries or Vents.

The small processes known as glands, nectaries or vents which occur on the upper edge of many mature Acacia leaves have been observed also on those of seedlings.[1] In connection with phyllodineous Acacias it is found that glands may sometimes occur on the first or simply pinnate leaf, and on all or most of the bipinnate leaves of certain species, but are absent from other species. They may occur on the bipinnate leaves but be absent from the simply pinnate leaf.

Bentham has divided the phyllodineous Acacias into eight Series, (B. Fl., 303), as follows:—Alatæ, Continuæ, Pungentes, Calamiformes, Brunioideæ, Uninerves, Plurinerves, Julifloræ. So far as the present investigations have gone, glands have not been noticed on seedlings of Series 1 to 3, and faint ones have been only rarely seen on Series 4 and 5, but they are most plentiful on seedlings of No. 6, Uninerves, and are chiefly on leaves of the Racemosæ section of that Series. They may also occur on the bipinnate leaves of Nos. 7 and 8, but are not nearly so large or definite as those on leaves of the Uninerves. This distribution agrees very well with that noticed by other writers on the adult foliage.

Glands have been noticed on the first or pinnate leaf, as well as on all or most of the bipinnate leaves of *Acacia accola*, *A. Bancrofti*, *A. linifolia*, *A. penninervis* var. *falciformis*, *A. podalyriæfolia*, and *A. Westoni* Maiden (in MS.).

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[1] See "The distribution of leaf glands in some Victorian Acacias," by A. D. Hardy, F.L.S., Vict. Nat. XXIX, 26. Also "Observations on the function of Acacia leaf glands," by Reginald Kelly, *Ib.*, XXX, 121. Also "Notes on Acacia," by J. H. Maiden, F.R.S., this Journ., XLIX, 465.

They may occur on all the bipinnate leaves of *A. binervata*, *A. fimbriata*, *A. flavescens*, *A. implexa*, *A. longifolia*, *A. Mabellæ*, *A. neriifolia*, *A. obtusata*, *A. penninervis*, *A. pycnantha*, and *A. rubida*.

Glands have been noted on the second and subsequent bipinnate leaves of *A. aulacocarpa*, *A. conferta*, *A. cultriformis*, *A. crassiuscula*, *A. cyclopis*. *A. elongata*, *A. juncifolia* (very faint), *A. prominens*, and *A. venulosa* Benth.[1]

They have been seen on the third bipinnate leaves of *A. difformis*, and on the third and upwards of *A. Hamiltoniana* and *A. myrtifolia;* on the fourth and upwards of *A. buxifolia*, *A. melanoxylon* (faint), and *A. rigens* (faint); on the sixth and upwards of *A. Chalkeri* and *A. pravissima*.

It is highly probable that further investigation will somewhat modify the above statement of results, as there is variation in different individuals of the same species.

In cases where *A. rubida* has four, five or six pairs of pinnæ, glands are usually on the petiole and at the base of the terminal pair of pinnæ, or sometimes, in the latter case, at the bases of the fifth and sixth pairs as well as on the petiole. When there are seven pairs of pinnæ a gland is on the petiole, and others may be at the bases of the last three pairs of pinnæ.

Where *A. neriifolia* has three pairs of pinnæ one gland is on the petiole and the others at the bases of the second and third pairs of pinnæ.

Where *A. accola* has three or four pairs of pinnæ the glands are on the petiole and at the bases of the last or last two pairs of pinnæ.

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[1] This species has been previously referred to in these papers as *A. lanigera*.

Many of these glands, especially those which occur on leaves of seedlings of the Uninerves section, secrete a honey-like substance, chiefly during the spring and summer months, on which insects, especially ants, evidently feed; two species which commonly visit them have been kindly identified by Mr. W. W. Froggatt as *Iridomyrmex rufoniger* and *Ectatomma metallicum.*

In addition to the honey-like matter, the glands on young phyllodes of advanced seedlings of *A. Westoni*, *A. penninervis*, and to a slight extent of *A. pycnantha*, often exude a white substance which looks to be somewhat of the texture of cream, and although these white spots are scarcely 1 mm. in diameter, they may be seen distinctly on the first two species from distances up to five yards from the plant.

Flowering Seedlings.

In Part V, (p. 146), several examples were quoted of Acacia seedlings having flowered while growing in pots, and the following, which are growing in 4, 5 or 6-inch pots, are now added to the list:—*A. amblygona*, *A. asparagoides* (one dwarf plant eleven months old and four inches high bore two flowers), *A. continua* (fairly freely at 21 months old), *A. Howittii*, *A. juniperina* (sparsely at 17 months), *A. lineata*, *A. obtusata* and *A. verticillata.* A plant of *A. venulosa* four years old, and grown in a four inch pot, flowered for the second time.

Fertile Seeds from Pot Plants.

Many seeds ripened on a young plant of *Acacia crassiuscula*, grown in a six-inch pot, and, of thirteen planted, twelve germinated readily.

Description of Seedlings.

PUNGENTES—(Plurinerves).

ACACIA TRINERVATA Sieb. Seeds from Springwood. (Plate VIII, Numbers 1 to 3).

Seeds chocolate-brown, oblong, 3·5 to 4·5 mm. long, 1·5 to 2 mm. broad, 1 mm. thick.

Hypocotyl terete, reddish-brown above soil, 1 to 4·5 cm. long, up to 1·2 mm. thick at base, ·5 mm. at apex, much constricted above the soil, glabrous.

Cotyledons sessile, sagittate, oblong, apex rounded, 5 mm. long, 1·5 to 2 mm. broad, upperside reddish-green, underside reddish-brown with raised centre line, becoming revolute and almost cylindrical in a few days.

Stem terete, slightly striated, brownish-green, hispid. First internode ·5 mm.; second ·5 to 4 mm.; third 1 mm. to 1·6 cm.; fourth to sixth 2 mm. to 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 4 mm., green, glabrous or faintly pilose; leaflets four to five pairs, oblong-acuminate, the terminal pair sometimes obovate, mucronate, 4 to 7 mm. long, 1 to 1·5 mm. broad, the terminal pair broader, upperside green, underside paler to reddish-green, midrib fairly distinct; rachis 6 to 9 mm., green, glabrous or faintly pilose, terminal seta present.

No. 2. Abruptly bipinnate, petiole 7 to 8 mm., pilose; leaflets four to seven pairs, oblong-acuminate, mucronate, about 4 mm. long, 1 mm. broad; rachis 7 to 8 mm., pilose, with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 6 mm. to 1 cm., hirsute; leaflets five to eight pairs, 4 to 5 mm. long, 1 mm. broad, mucronate; rachis 7 mm. to 1·1 cm., hirsute.

Nos. 5 to 12. Abruptly bipinnate, all may have two pairs of pinnæ, common petiole 7 mm. to 1·5 cm., terete, with one or sometimes two nerves showing on underside, hispid, terminal seta 1·5 mm.; leaflets seven to eleven pairs on the terminal pair of pinnæ, similar to those on Nos. 3 and 4; rachis 7 mm. to 1·6 cm., hirsute. Stipules flat acuminate scales about 1 mm. long.

Nos. 13 to 16. Some of these may be phyllodes, or all may be bipinnate with three or four pairs of pinnæ, petiole slightly dilated, with a strong midrib and a finer nerve below, sometimes with a faint one above, the common petiole 1 to 2·5 cm., hispid to pubescent; leaflets up to twelve pairs.

Nos. 17 to 25. Usually linear pungent pointed phyllodes, 2 to 2·5 cm. long, 1 to 1·5 mm. broad, usually with three nerves, the centre one most prominent and the upper one sometimes rather obscure, glabrous.

This species is very prone to develop axillary twice pinnate leaves or axillary branches, at first with bipinnate leaves and later with phyllodes.

UNINERVES—(Brevifoliæ).

ACACIA FLEXIFOLIA A. Cunn. Seeds from Temora, (Right Rev. J. W. Dwyer, per J. H. Maiden) and Wyalong. Plate IX, Numbers 1 and 2.

Seeds dark brown, oblong, 5 mm. long, 1·5 to 2 mm. broad, 1 mm. thick.

Hypocotyl terete, reddish-green to red, 1 to 2·5 cm. long, 1 to 1·3 mm. thick at base, up to 1 mm. at apex, glabrous.

Cotyledons sessile, slightly auricled, oblong, apex rounded, 6 mm. long, 2 mm. broad, upperside dark green, underside pale green, sometimes pinkish towards apex, becoming revolute, often remaining until after several phyllodes appear.

Stem at first slightly angular, becoming terete, hoary. First internode ·5 mm.; second 1 mm. to 1·7 cm.; third 3 mm. to 2·5 cm.; fourth and fifth 3 to 8 mm.; sixth 2 mm. to 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole 4 to 7 mm., green, glabrous; leaflets two pairs, obliquely oblong to sometimes obovate, 3 to 7 mm. long, 1 to 2 mm. broad, upper and undersides pale green, midrib distinct; rachis 2 to 4 mm., green, glabrous, with terminal seta.

No. 2. Abruptly bipinnate, petiole 7 mm. to 1·5 cm., terete or slightly dilated, faintly pilose, green, with terminal seta; leaflets one to two and a half pairs, often unequally pinnate, 1 to 3 mm. long, ·5 to 2 mm. broad, slightly mucronate; rachis 3 to 5 mm. with terminal seta; stipules minute flat acuminate scales.

No. 3. This may be a phyllode, or bipinnate, petiole 1·3 to 1·5 cm. long, up to 1 mm. broad, midrib below the centre of lamina; leaflets one to two pairs, usually smaller than those of No. 2; in one case only one pinna appeared but the terminal seta was present.

Nos. 4 to 10. Linear phyllodes, from about 1·3 to 2 cm. long, 1 to 2 mm. broad, narrowed at the base, obtuse, with the apex often curved outwards and downwards, more so than in later phyllodes, slightly mucronate, with sometimes a minute gland showing in a depressed portion of the upper margin near the base, midrib above the centre of the lamina which is unusual in early phyllodes. (See under *A. falcata*, Part II, 151). Bentham mentions that on mature plants the prominent nerve is very near the lower margin.[1]

This is the fourth seedling described in this series where the No. 3 leaf has been reduced to a phyllode, the previous ones being *A. excelsa*, *A. alata*, and *A. aspera*.

UNINERVES—(Angustifoliæ),

ACACIA SENTIS F.v.M. Seeds from Broken Hill (E. C. Andrews). Plate VIII, Numbers 4 to 6.

Seeds brown, with paler horse-shoe areole on each side, oval, 5 mm. long, 4 mm. broad, 2 mm. thick.

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[1] B. Fl., Vol. II, 356,

Hypocotyl terete, creamy to brownish, up to 1·5 cm. long, 2 to 3 mm. thick at base, 1 to 1·3 mm. at apex.

Cotyledons sessile, auricled, oval-oblong to obovate, 6 to 7 mm. long, 4 to 5 mm. broad, upperside yellowish, becoming green, underside yellowish, becoming pale green, yellowish-green or reddish-brown, with raised centre line or longitudinally wrinkled.

Stem terete, pubescent. First internode ·5 mm.; second about 1 mm.; third to sixth 1 to 4 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 7 mm., green, glabrous; leaflets three to five pairs, oblong-acuminate, terminal pair sometimes obovate, up to 7 mm. long, 1 to 3 mm. broad; rachis 5 mm. to 1·4 cm., green, glabrous, with terminal seta.

No. 2. Abruptly bipinnate, petiole 4 to 6 mm., glabrous or slightly pilose, with terminal seta; leaflets two to four pairs, oblong-oval to oblong-acuminate, 2 mm. long, 1 mm. broad; rachis 3 to 8 mm., glabrous.

Nos. 3 to 7. Abruptly bipinnate, petiole 4 to 9 mm., pilose, sometimes slightly dilated, with midrib along lower margin; leaflets two to four pairs; rachis 4 to 7 mm.; stipules short spines.

Nos. 8 to 20. Abruptly bipinnate, petiole 5 mm. to 1 cm. long, sometimes dilated to 3 mm. broad, midrib below centre of lamina, hirsute, with terminal seta; leaflets three to four pairs; rachis 4 to 9 mm.; stipules up to 5 mm.

Nos. 21 to 30. These may be phyllodes, or abruptly bipinnate, petiole up to 1·6 cm, long, 5 mm. broad, hirsute; leaflets three to five pairs; stipules up to 6 mm., sometimes hirsute.

Nos. 31 to 40. Usually phyllodes, up to 2 cm. long, 5 to 7 mm. broad, with numerous lateral veins, pilose or glabrous, margins sometimes nerve-like, mucronate, no glands seen.

In some cases ten or fifteen phyllodes may be succeeded by several bipinnate leaves.

Among the branchlets collected from trees of this species at Boomara, near Cloncurry, North Queensland, no stipules were noticed.

As showing the variability in the presence of stipules it may be mentioned that of seven seedlings one year old of a species of Gleditschia, all grown from seeds obtained from one pod, five showed no sign of stipules, one had two pairs, and another three pairs.

UNINERVES—(Racemosæ).

ACACIA ACCOLA Maiden and Betche. Seeds from Wahroonga (J. H. Maiden, cultivated). Plate X, Numbers 1 to 3.

Seeds black, obovate to oval, with flange-like rim, 6 to 8 mm. long, 4 to 5 mm. broad, 3 mm. thick.

Hypocotyl terete, brownish-red, 1·8 to 6 cm. long, 1·3 to 2·5 mm. thick at base, ·5 to 1 mm. at apex, glabrous.

Cotyledons sessile, sagittate, obovate-oblong, 9 mm. to 1 cm. long, 5 mm. broad, upperside brown to puce, sometimes red, underside convex, with a few slightly raised lines near base, puce to red, becoming cylindrical and soon falling.

Stem terete, brownish-red, glabrous. First internode ·5 mm.; second 2 mm. to 2·2 cm.; third 1·5 to 3 cm.; fourth 1·3 to 2·7 cm.; fifth up to 3 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 6 mm., usually with gland, red, glabrous; leaflets seven to nine pairs, oblong-acuminate, the terminal pair often obovate, 6 mm. to 1·3 cm. long, 1·5 to 3 mm. broad, upperside greenish-red to red, becoming green, underside red, often becoming pale green with reddish margins; rachis 9 mm. to 2·5 cm., green, glabrous, with terminal seta.

No. 2. Abruptly bipinnate, petiole 8 mm. to 2 cm., gland on upper margin, glabrous, with terminal seta; leaflets four to seven pairs, oblong-acuminate, 2 to 8 mm. long, ·5 to 2 mm. broad, underside reddish-green to pale green with red margins; rachis 9 mm. to 2·3 cm.

Nos. 3 to 5. Abruptly bipinnate, petiole terete, 1·2 to 2·6 cm., gland on upper margin, glabrous; leaflets six to thirteen pairs; rachis 1·5 to 4 cm.

Nos. 6 to 11. Abruptly bipinnate, with usually two or three pairs of pinnæ, common petiole 2·5 to 6 cm., slightly dilated, one to three glands; leaflets twelve to seventeen pairs; rachis 3·5 to 5·7 cm.

Nos. 12 to 20. Usually abruptly bipinnate with three or four pairs of pinnæ, common petiole 4·6 to 6·3 cm. long, 1 to 2 mm. broad, glands two or three; leaflets eleven to eighteen pairs, the latter number being on a No. 14 leaf; rachis 3·2 to 5·5 cm.

Nos. 21 to 30. These may all be abruptly bipinnate and similar to No. 20, or they may be linear phyllodes about 8 to 11 cm. long, 2 to 3 mm. broad, with distinct midrib, and one to three glands on upper margin.

Seedlings of this species two or three feet high may retain many bipinnate leaves, and individuals vary in regard to the number of bipinnate leaves they may have before the advent of phyllodes.

For the disposition of glands on the common petioles see under Glands etc. (supra).

Uninerves—(Racemosæ).

Acacia Hamiltoniana Maiden.[1] Seeds from Leura, New South Wales. (A. A. Hamilton and R. H. Cambage). Plate IX, Numbers 3 to 5.

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[1] This Journal, Vol. LIII, 199, (1919).

Seeds black, oval, 4 mm. long, 3 – 3·5 mm. broad, 2 mm. thick.

Hypocotyl terete, spreading into flange at base, pale below soil, green to reddish above, 8 mm. to 3 cm. long, 2 to 2·5 mm. thick at base, 1 mm. thick at apex, glabrous.

Cotyledons sessile, sagittate, oblong-oval to obovate, 5 to 6 mm. long, 3·5 to 4 mm. broad, upperside brownish-green to reddish-green, underside brown to brownish-red.

Stem at first angular, becoming terete, reddish-brown, glabrous. First internode ·5 mm.; second to fourth ·5 to 1 mm.; fifth to eighth 1 to 3 mm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 6 mm., green to reddish-green, glabrous; leaflets three to four pairs, oblong-acuminate, the terminal pair sometimes obovate, usually mucronate, 3 to 5 mm. long, 1·5 to 2 mm. broad, the terminal pair sometimes 3 mm. broad, upperside green, underside pale green with midrib distinct; rachis 6 mm. to 1 cm., green, glabrous, with terminal seta.

No. 2. Abruptly bipinnate, petiole 4 to 7 mm., glabrous, with terminal seta; leaflets four to six pairs, oblong-acuminate, up to 4 mm. long, 1 to 2 mm. broad, upperside green, underside sometimes reddish-green; rachis 6 mm. to 1 cm. glabrous.

This leaf may sometimes have two pairs of pinnæ.

Nos. 3 to 6. Abruptly bipinnate, petiole terete, from 5 mm. in No. 3, to 2·1 cm. in Nos. 5 and 6, sometimes with a faint gland on Nos. 4 to 6, glabrous; leaflets four to ten pairs; rachis 7 mm. to 2·4 cm.; stipules flat acuminate scales up to 1 mm. long.

Nos. 7 to 9. The latter is sometimes a phyllode, or all may be abruptly bipinnate, petiole from 1 to 3·4 cm., Nos. 8 and 9 usually slightly dilated but rarely up to 1 mm. broad, midrib towards lower margin, faint gland on upper margin, glabrous; leaflets six to ten pairs; rachis 1·5 to 2·5 cm.

Nos. 10 to 20. Linear-lanceolate one-nerved phyllodes with nerve-like margins, from about 1·3 to 2·7 cm. long, 2 to 4 mm. broad, narrowed towards the base, mucronate, usually with small marginal gland, glabrous.

This seedling is quite different from that of *A. obtusata* (Part IV, 424, 1918), a species with which it has affinities, and in most cases the petioles of the last two bipinnate leaves are longer than any of the first twenty phyllodes.

Plurinerves—(Triangulares).

Acacia amblygona A. Cunn. Seeds from Tottenham, New South Wales. Plate IX, Numbers 6 to 8.

Seeds black, obliquely oval to obovate, 3·5 to 4 mm. long, 2 to 2·5 mm. broad, 1·5 mm. thick.

Hypocotyl terete, greenish to reddish-brown and red, 1·5 to 2 cm. long, about 1·5 mm. thick at base, about 7 mm. at apex.

Cotyledons sessile, auricled, oblong to oblong-oval, 4 to 5 mm. long, 2 to 2·5 mm. broad, upperside reddish-green, underside reddish-brown with perhaps two or three raised lines, sometimes with warty surface, remaining erect and falling in two or three days, or earlier than those of any other species yet examined.

Stem terete, hirsute to tomentose. First internode ·5 mm.; second 1 mm.; third 1 to 2 mm.; fourth and fifth 2 to 4 mm.; sixth to eighth 3 to 5 mm.

Leaves—Nos. 1 and 2. Abruptly pinnate, forming an opposite pair, petiole, about 3 to 4 mm.; leaflets two pairs, oblong-acuminate, 3 to 6 mm. long, 1·5 to 2 mm. broad, venation obscure, upperside green, underside pale green to reddish; rachis 2 to 3 mm., green, glabrous, with terminal seta; stipules acuminate scales 1 mm. long.

No. 3. Abruptly bipinnate, petiole 6 mm. to 1·3 cm., glabrous to pilose, with terminal seta; leaflets two to three pairs, oblong-acuminate to obovate, often mucronate, 2 to 6 mm. long, 1·5 to 3 mm. broad; rachis 3 to 8 mm., glabrous; stipules 1·5 mm.

Nos. 4 to 6. Abruptly bipinnate, petiole terete, 1 to 2·1 cm., pilose; leaflets three to four pairs; rachis 6 mm. to 1 cm.; stipules 2 mm., pointed.

Nos. 7 to 9. Abruptly bipinnate, petiole 1·2 to 2 cm., No. 9 sometimes slightly dilated, with midrib along lower margin, pilose to hirsute; leaflets three to five pairs; rachis 7 mm. to 1·3 cm.; stipules 2 mm.

No. 10. This may be a phyllode or abruptly bipinnate similar to No. 9, terminal seta 1 mm.

Nos. 11 to 20. Phyllodes from obliquely oval-lanceolate to almost triangular in the later ones, much shorter than the petioles of most of the bipinnate leaves, hirsute, midrib not far from lower margin and terminating in a sharp spine, two or three finer nerves above.

Plurinerves—(Microneuræ).

Acacia stenophylla A. Cunn. River Cooba of the Lachlan River near Euabalong, Eumong of western districts of New South Wales, Goodlay of the Natives around Garah near Moree (A. W. Bucknell). Seeds from Winton (E. G. Davies), and Geera (Howard C. Cullen), both near Central Queensland. Pate X, Numbers 4 to 8.

Seeds brown, flat, oblong-oval, 6 to 7 mm. long, 4·5 to 5 mm. broad, 1·3 to 2 mm. thick.

Hypocotyl terete, pale green, 2·5 to 6·2 cm. long, 1·4 to 2·5 mm. at base, 1 to 1·5 mm. at apex, spreading into a flange at the root.

Cotyledons sessile, auricled, oval-oblong, 9 mm. to 1·2 cm. long, 5 to 6 mm. broad, upperside at first yellowish-green, becoming rich green, underside creamy to pale green.

Stem terete, green, glabrous. First internode 1 to 6 mm.; second 2 to 9 mm.; third to sixth 8 mm. to 1·8 cm.

Leaves—No. 1. Abruptly pinnate, petiole 4 mm. to 1·2 cm., pale green, glabrous; leaflets four to six pairs, oblong to ovate-oblong, 5 mm. to 1 cm. long, 2 to 3·7 mm. broad, upperside green, underside pale green; rachis 8 mm. to 2·5 cm., with terminal seta.

No. 2. Usually abruptly bipinnate, petiole 5 mm. to 1·4 cm., glabrous, with terminal seta; leaflets two to four pairs, oblong-acuminate, about 5 mm. long, 1·5 to 2·5 mm. broad, midrib distinct; rachis 8 mm. to 1·7 cm.; stipules minute.

In one case No. 2 was abruptly pinnate with four pairs of leaflets. In another case the leaf was strictly tripinnate, the basal pair of leaflets having developed as a pair of pinnæ, while the terminal pinna had four pairs of leaflets. (Plate X, fig. 8).

Nos. 3 to 8. Abruptly bipinnate, petiole 1 to 2·8 cm., becoming slightly dilated, with a strong nerve near the lower margin, glabrous; leaflets four to seven pairs; rachis 7 mm. to 2·4 cm.

Nos. 9 to 15. These may be linear phyllodes, or abruptly bipinnate, petiole 2·2 to 4·4 cm., dilated from 1 to 2 mm., with distinct midrib; leaflets four to six pairs; rachis 1·3 to 2·2 cm.

Nos. 16 to 38. These may be linear phyllodes, or abruptly bipinnate, petiole 3·1 to 8·2 cm.; leaflets three to eight pairs. In the early phyllodes the midrib is so distinct as to make the leaf appear to be uninerved, though by close inspection a finer vein may be seen on each side of the central one.

No. 20 may be 10 cm. long and 3 mm. broad.

EXPLANATION OF PLATES.

Plate VIII.

Acacia trinervata Sieb.

1. Cotyledons and pinnate leaf. Springwood.
2. Pinnate leaf, bipinnate leaves and pungent pointed phyllodes.
3. Pod and seeds.

Acacia sentis F.v.M.

4. Cotyledons, with pinnate leaf showing. Broken Hill, (E. C. Andrews).
5. Pinnate leaf, bipinnate leaves, phyllodes and stipules.
6. Pod and seeds.

Plate IX.

Acacia flexifolia A. Cunn.

1. Cotyledons, pinnate leaf, bipinnate leaf and phyllodes. Wyalong.
2. Pod and seeds.

Acacia Hamiltoniana Maiden.

3. Cotyledons and tip of pinnate leaf. Leura.
4. Pinnate leaf, bipinnate leaves and phyllodes.
5. Pod and seeds.

Acacia amblygona A. Cunn.

6. Cotyledons and tips of pinnate leaves. Tottenham.
7. Pinnate leaves, bipinnate leaves, phyllodes and stipules.
8. Pods and seeds.

Plate X.

Acacia accola Maiden and Betche.

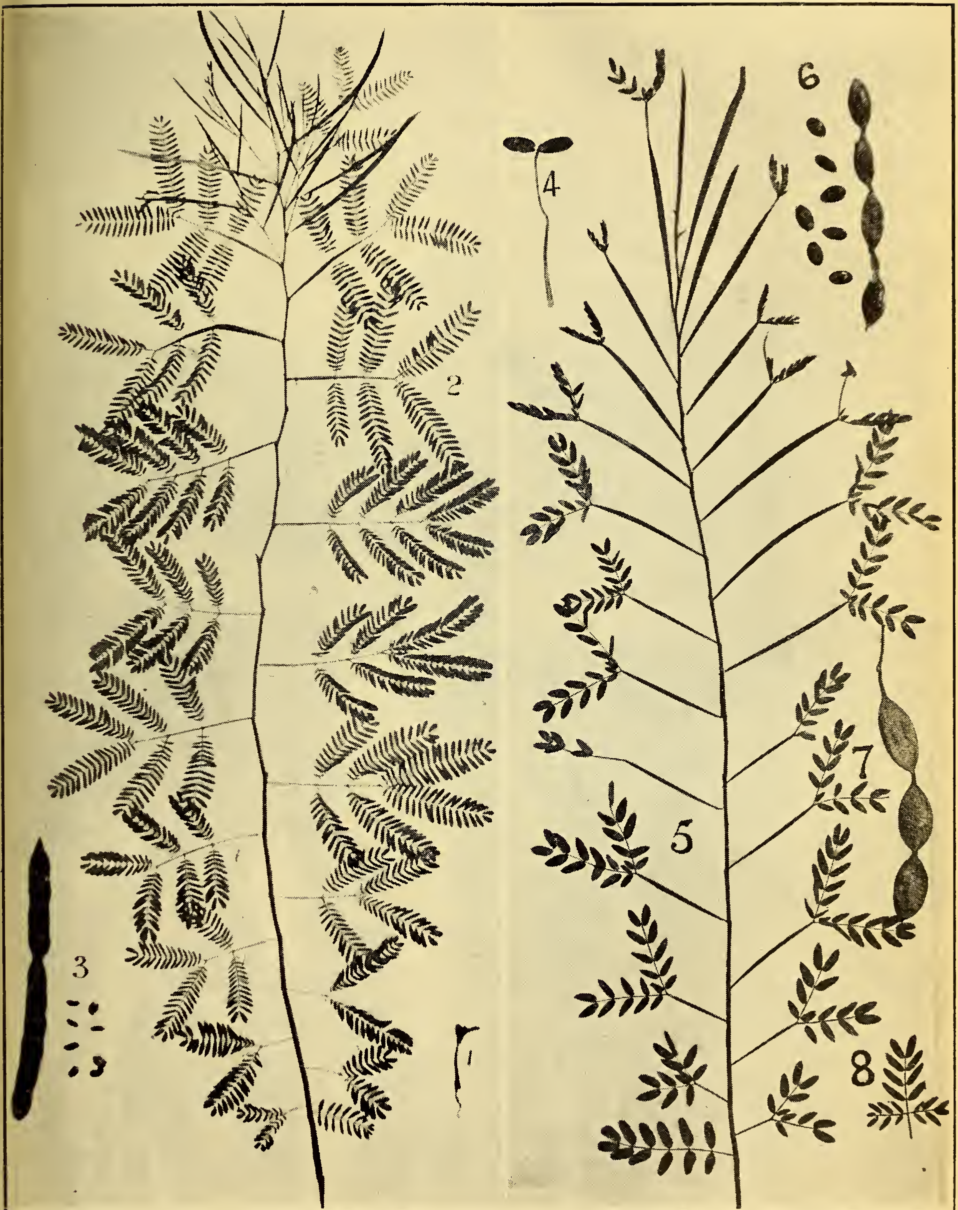
1. Cotyledons and tip of pinnate leaf. Wahroonga.
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

Acacia stenophylla A. Cunn.

4. Cotyledons. Winton, Queensland, (E. G. Davies).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Pod and seeds. Geera, Queensland, (H. C. Cullen).
7. Pod. Garah near Moree, (A. W. Bucknell).
8. Tripinnate leaf. Winton.

Acacia trinervata (1 – 3); *Acacia sentis* (4 – 6).
Four-fifths Natural Size.

Acacia flexifolia (1 and 2); *A. Hamiltoniana* (3 – 5); *A. amblygona* (6 – 8).
Four-fifths Natural Size.



Acacia accola (1 – 3)
Two-sevenths Natural Size.

Acacia stenophylla (4 – 8).
One-half Natural Size.

ON A BOX-TREE FROM NEW SOUTH WALES AND QUEENSLAND.

By J. H. MAIDEN, I.S.O., F.R.S., F.L.S.

[*Read before the Royal Society of N.S. Wales, September 1, 1920.*]

EUCALYPTUS PILLIGAENSIS n. sp.

Arbor mediocris, cortice cana *E. hemiphloiæ* simile et in trunco ramisque persistente; ligno brunneo, fibris tortuosis; foliis junioribus lineari-lanceolatis ca 10 cm. longis et 1·25 cm. latis, utrinque obscuris, venis distinctis sed praeter costam non conspicuis, vena peripherica a margine paullo remota, venis patentibus; foliis maturis angusto-lanceolatis ca 10 cm. longis, 2·5 cm. latis, nitentibus vel obscuro-nitentibus utrinque, venis junioribus foliis similibus; alabastris non angularibus, operculo conico, calyce in pedicillum angustato; antheris *E. odoratæ* similibus, stigma paullo dilata; fructibus parvis conoideis ad subcylindraceis ca 3 mm. longis in pedicellum paullo longiorem angustatis, pedunculo ca 9 mm.; margine distincta valvis plerumque 4, valde immersis.

A medium sized tree.

Bark—Whitish-grey like that of *E. hemiphloia*, and persistent as in that species, on the trunk and main branches.

Timber—Brown coloured and interlocked.

Juvenile leaves—Linear-lanceolate, say 10 cm. (4 inches) long and say 1·25 cm. ($\frac{1}{4}$ inch) broad, dull on both sides, venation distinct though not conspicuous, except as regards the midrib. Intramarginal vein a little distant from the edge, venation spreading.

Mature leaves—Narrow lanceolate, say 10 cm. (4 inches) long and up to say 2·5 cm. ($\frac{1}{2}$ inch) broad, shining or dull-shining (egg-shell lustre) on both sides; venation as in juvenile leaves.

Buds—Not angular, with conical operculum, the calyx tapering into the pedicel.

Flowers—Anthers very similar to those of *E. odorata;* the stigma slightly dilated.

Fruits—Small, conoid to subcylindrical, say 3 mm. ($\frac{1}{8}$ inch) long, tapering to a pedicel rather exceeding that length, into a common peduncle of 9 mm. ($\frac{3}{8}$ inch); rim distinct, valves usually 4, well sunk.

This tree has received both attention and neglect, because it has been by some looked upon as included in *E. Woollsiana* R. T. Baker. As I have now no hesitation in saying that it is not included in *E. Woollsiana* (compare Mr. Baker's figures of that species), and as I am of opinion that it has not been formally described as a species, I offer it as new. Inasmuch as it is so common in the Pilliga Scrub, New South Wales, that the district may be looked upon as a focus of it, the specific name chosen may be useful.

Illustrations.—See Part XI, plate 51, figures 27 – 30 of my "Critical Revision of the Genus Eucalyptus." See also my "Forest Flora of New South Wales," Part XLI, plate 152, figures B and C, for much larger and better figures. These were all drawn from a specimen collected by me at Narrabri, N.S.W., in November 1899, and form the type. A photo. block of saplings at Gilgandra, N.S.W. (R. H. Cambage) was backed by specimens referable to this new species. All the figures were labelled *E. odorata* var. *Woollsiana.*

Synonym.

E. odorata Behr and Schlecht., var. *Woollsiana* Maiden, as described at p. 32, Part XI of my "Critical Revision."

Range.

So far as I know, this species is confined to New South Wales and Queensland, but we have much to learn in regard to its range in these, and possibly in other States. It is represented by the following specimens in the National Herbarium, Sydney. The localities quoted are all in the northern half of New South Wales, extending just into Queensland, the two quoted from that State marching with the northern New South Wales localities.

New South Wales.—Mount Boppy (J. L. Boorman, August 1903). Four and a half miles from Coolabah Railway Station on the way to the old Experiment Farm (J. L. Boorman and J.H.M.). "Mallee Box," Moondana, Parish Flinders, Nymagee district (Forest Guard E. F. Rogers).

Gilgandra (R. H. Cambage, No. 1135, with photo. of a clump of saplings, already quoted). Large shrub or small tree. Dubbo-Gilgandra road, 18 miles from Dubbo (W. Forsyth, No. 2). "Narrow-leaved Box," Coonamble (E. Taylor).

Castlereagh River (Revd. Dr. Woolls), (labelled *E. largiflorens* by Mueller). "Narrow-leaved Box." On the plains near Baradine (W. Forsyth, No. 5).

Very common in the Pilliga Scrub, as the following specimens will show:—

Box, slaty smooth bark on branches. F. Reserve 1263, Ph. Leard, Co. Nandewar; 45 feet high, girth 54 inches (Forest Guard M. H. Simon).

"Narrow-leaved Box." Bark greyish in colour and rough on trunk, smooth on limbs and of darkish colour. Height 60 feet, diameter 3 to 4 feet. Wee Waa (Forest Guard T. W. Taylor, No. 14).

"White Box," near Old Wongan Station, Dubbo Creek area (Dr. H. I. Jensen, No. 56).

"Gum-topped White Box," Cuttabri (J. L. Boorman, Dr. H. I. Jensen, Nos. 2, 19).

"Narrowed-leaved Box." A tree of 60 feet, fairly straight Ph. Kenebri, Co. White, Pilliga (E. H. F. Swain, No.40). A Box, girth 7 feet, Pilliga (E.H.F.Swain, No.29).

Narrabri, November 1899 (J.H.M.). The narrow suckered tree defined by me as *E. odorata* var. *Woollsiana*. Type of *E. Pilligaensis*.

"A Box growing on flats, black soil plains, by side of river, medium-sized trees." Narrabri West (J.L. Boorman). "Narrow-leaved Box. Bark whitish-grey, like that of *E. hemiphloia*, and persistent as in that species, on the trunk and main branches. I also saw it growing in the Forbes district." Narrabri (Henry Deane). (I have not seen the Forbes specimens.—J.H.M.).

"Narrow-leaved Box." Moree (W. S. Campbell). In flower only, and at one time considered by me to be *E. odorata.*

"Apple," Bingara (E. H. F. Swain, No. 11). "Mallee Box," Yagobie, between Gwydir and MacIntyre Rivers (E. H. F. Swain, No. 8).

Dark flaky bark. Denman, the most southerly locality known, at all events in the coastal districts (W. Heron, No. 24).

Queensland.—A medium sized tree known locally as "Mallee Box," Inglewood, viâ Warwick (J. L. Boorman).

"Ribbon Box." Same growth, size and bark as Gum-topped Box (*E. hemiphloia*), but leaves narrow, and fruit very small. Very abundant. Wyaga, Goondiwindi district (C. T. White, No. 26).

Affinities.

It is known as "Narrow-leaved Box" and best deserves this name of all the Boxes. This, combined with the remarkably small fruit, readily separates it from such species. From *E. Woollsiana* R. T. Baker, *E. odorata* Behr. and Schlecht., *E. hemiphloia* F.v.M. var. *microcarpa*, *E. conica* Maiden, all Boxes, like it, with pale timbers and similar bark, it is distinguished by its very narrow juvenile leaves and usually narrower mature leaves. From *E. bicolor* A. Cunn., which has narrow juvenile leaves, it is sharply separated by the thick, dark bark and red-brown timber.

NOTES ON EUCALYPTUS, No. IX.

(With Descriptions of Three New Species).

By J. H. Maiden, I.S.O., F.R.S., F.L.S.

[*Read before the Royal Society of N. S. Wales, November 3, 1920.*]

Eucalyptus adjuncta n. sp.

Arbor alta, "Grey Gum," ligno atro-rubeo. Foliis maturis petiolatis lanceolatis, rectis vel falcatis, venis secundariis patentibus non prominulis. Alabastris axillaribus, umbellis 3-floris in duobus paribus, pedunculis pedicellisque gracilibus, calycis tubo obconico, operculo rostrato 1 cm. longo. Fructibus hemispherico-conoideis, ca. 1 cm diametro, calycis tubo læve margine distincta, capsulæ valvis valde exsertis.

A tall tree of 70 or 80 feet, with a diameter of 3 or 4 feet (Andrew Murphy); the bark smooth, and somewhat rough in patches, like that of a Grey Gum; timber deep red.

Juvenile leaves. What are known as "suckers" (adventitious shoots) are not available, but a young seedling with leaves of medium width.

Mature leaves small (as far as the material is available),[1] petiolate, lanceolate, straight or falcate, tapering gradually to the apex, without lustre, secondary veins not prominent, spreading, the midrib and marginal vein pink in colour.

Buds axillary, usually in two pairs of three flowered umbels, peduncles slender, 1 cm. long and more, decurved,

[1] The original material was mislaid. When subsequent search was made for the original trees it was found that the group of three had been destroyed in the wideniug of the Line, and others have not yet been found. The belated description is published now, in the hope that other trees may be traced.

pedicels slender, of half that length, calyx-tube smooth, obconical, 5 mm. long, 7 mm. broad, terminating somewhat abruptly in the pedicel; operculum rostrate, 1 cm. long. Anthers long, white, opening in parallel slits, gland at back, versatile.

Fruits hemispherical-conoid, about 1 cm. in diameter, calyx-tube smooth, with distinct, domed rim, the valves of the capsule 3 or 4 and well exsert.

Range.

Close to the bank of a fresh-water creek near the eastern side of the railway line, about three-quarters of a mile from Wyee Railway Station, towards Morrisset. Wyee is 71 miles north of Sydney and 33 miles south of Newcastle, New South Wales.

The species has been temporarily lost, so we must postpone further notes as to its range. It has probably been confused with other Grey Gums in well-watered littoral districts of New South Wales and Queensland.

Affinities.

Its position seems to be between *E. longifolia* Link and Otto and *E. punctata* DC., but to come nearer to the former. The timber seems to be nearer *E. longifolia* in texture and colour, although that of *E. punctata* runs it closely. As regards the bark, while *E. punctata* is consistently a Grey Gum, one may have logs showing that the woolly bark (woolly-butt) of *E. longifolia* almost disappears, showing bark intermediate between a Grey Gum and a Woolly-butt. *E. adjuncta* is a Grey Gum.

1. With *E. longifolia* Link and Otto. For *E. longifolia* see Part xx, plate 86 of my "Critical Revision." There is similarity in the pink veins of the leaves and in the three-flowered umbels and in the timber. There are differences in the larger leaves of *E. longifolia*, in the (as a rule)

smaller flowers, in the absence or almost absence of exsertion of the valves and in the roughness of the bark.

2. With *E. punctata* DC. Originally *E. adjuncta* was sent as "bark and timber not to be distinguished from *E. punctata*." For *E. punctata* see Part xxix, plates 121, 122 of my "Critical Revision," where it will be seen that the peduncles and pedicels are thicker, the flowers are more in the umbel, the buds different in shape, and the fruits different.

EUCALYPTUS NOTABILIS n. sp.

Arbor mediocris pulchra umbrosa, cortice lamelloso-fibrosa "Mahogany" simile, ligno pallido rectis fibris duro. Ramulis quadrangulatis. Foliis juvenilibus lanceolatis, petiolatis, pallidis inferiore pagina, venis secundariis fere parallelibus. Foliis maturis crassis, coriaceis, lanceolatis, rectis vel falcatis, penniveniis. Alabastris ad 9 capitulo, pedunculo lato fere sessile, calycis tubo hemispherico ad hemiellipsoides, angulis duobis prominulis. Fructibus fere hemisphericis, ca 7 mm. diametro angulis vel alis duobus, margine distincta, valvis valde exsertis.

A tree of moderate size, say about 50 feet, with a diameter of 4 to 5 feet. It has rich dark umbrageous foliage, and is a handsome species.

Bark flaky-stringy, or fibrous-flaky in young trees. It is rough to the tips of the branches, and the trunk does not display corrugations of the bark. Timber pale-coloured (of the palest brown when freshly cut), straight grained, a good splitter and possessing a fair degree of tensile strength.

Juvenile leaves. Young branchlets markedly quadrangular, leaves very thin, pale on the underside, punctate, lanceolate, petiolate (say 10 or 11 cm. long, 3 or 4 cm. broad with petioles of 1 cm. and more), secondary veins thin, roughly parallel, rather spreading, making angles of 60 – 80 degrees with the midrib, a few nearly at right angles; intra-marginal vein well removed from the edge.

Mature leaves thick, coriaceous, of egg-shell lustre on the upper, but dull on the lower surface, lanceolate, straight or falcate, tapering into a long apex, petiolate, up to 14 cm. long and more, up to 4 cm. in greatest width, with petioles of 2 cm. Venation inconspicuous, the secondary veins penniveined, nearly as parallel and commonly making scarcely a more acute angle with the midrib than the Corymbosæ; the intramarginal vein not far removed from the edge.

Buds up to nine in the head, on a broad strap shaped peduncle of 1 cm. or less, sessile or on pedicels of ·5 cm., each commonly with a double operculum; calyx-tube hemispherical to hemiellipsoid, with two angles or ribs sometimes so prominent as to be winged; operculum hemispherical to conoid, up to 7 mm. in diameter and sometimes exceeding that of the calyx-tube.

Anthers white, opening in parallel slits, the two cells usually cohering to the tips; versatile; large gland at the back.

Fruits almost hemispherical, about 7 mm. in diameter, often with two or more angles or wings; rim well defined; the calyx-valves three or four, broad at the base, and the tips well exsert.

Type—Glenbrook, Blue Mountains, New South Wales (R. H. Cambage and J.H.M.)

Illustrations—The new species is figured as intermediate between *E. resinifera* and *E. pellita* in C.R., Part xxx, plate 125, figs. 7, 8, 9. We there have a juvenile leaf, mature leaf, buds with hemispherical and conoid opercula, anthers and fruits.

Synonym.

Recorded as the Blue Mountains form of those intermediate between *E. pellita* F.v.M. and *E. resinifera* Sm. See C.R., Part xxx, pp. 216, 217.

Range.

Confined to New South Wales so far as we know at present, and to the vicinity of the lower slopes of the Blue Mountains, but owing to wide-spread confusion with *E. resinifera* we have much to learn of its range. It has only been recorded so far from the Lower Kurrajong and Glenbrook to Faulconbridge.

Following are specific localities:—Lower Kurrajong, one of the lower slopes to the Blue Mountains (J.H.M.). Glenbrook (R. H. Cambage, J.H.M., J. L. Boorman). Lapstone Hill to Springwood (R. H. Cambage and J.H.M.). Springwood (J. L. Boorman). North Springwood (R.H. Cambage and J.H.M.). Faulconbridge (J.H.M.).

Affinities.

1. It is one of the few species, of which *E. gomphocephala* DC. is the most notable, which have an operculum of diameter greater than the calyx-tube, giving it an overhanging appearance.

2. The anthers of *E. notabilis* and *E. canaliculata* are to all intents and purposes alike. Affinity to each other is thus indicated and also that they belong to the same group which includes *E. punctata*, *E. resinifera*, and *E. pellita*.

3. With *E. resinifera* Sm. (and *E. pellita* F.v.M.). The position of *E. notabilis* seems to be nearest to these two species, but closer to the former in some respects. The figures and remarks on this association have already been referred to. The bark is that of a "Mahogany," but the paleness of the timber of *E. notabilis* at once separates it from these two species.

EUCALYPTUS CANALICULATA n. sp.

"Grey Gum" alta, in cortice læve maculis lenticularibus. Ligno pallido, fibris crassis, duro. Foliis juvenilibus petiolatis, lanceolatis, venis tenuibus. Foliis maturis, angusto-lanceolatis, paullo crassis, venis tenuibus fere parallelibus angulum ca. 45° cum costa formantibus. Alabastris magnis, clavatis, umbellis ad 6 capitulo pedunculis applanatis; operculo hemi-ellipsoideo, mucrone breve. Fructibus magnis, conoideo-hemisphericis, pedicello breve applanato, calycis tubo duobus costis prominentibus margine paullo rotundata conspicua.

A tall Grey Gum, whose trunk usually averages scarcely two feet in diameter, but it may attain, exceptionally, twice that size (A. Rudder). It is a tall tree with a diameter of 4 feet, 70 feet to the lowest branches, the whole tree being 90 – 120 feet high (J. L. Boorman, also speaking of a Dungog tree). Bark smooth, but with lenticular patches in places, like that of a Grey Gum (*E. punctata*.

Timber pale coloured, somewhat coarse-fibred, interlocked and tough, resembling that of Spotted Gum (*E. maculata)* a good deal, and also that of Tallow-wood (*E. microcorys)*. The colour of the timber approximates to pale snuff-brown, say Dauthenay, Rep. de Couleurs, Plate 2, shade 303.

Juvenile leaves not seen in the earliest state, but some still opposite are lanceolate to broadly-lanceolate, equally green on both sides, with numerous fine, not prominent, roughly parallel veins, at an angle of about 45° with the midrib. Leaves about 5 or 6 cm. long and about half that width, with petioles of 2 cm.

Mature leaves of medium size, narrow-lanceolate, petiolate, say 1 – 2 dm. long and 2 – 3·5 cm. broad, with petioles say 2 – 3 cm. long, dark green, moderately thick venation almost as in juvenile leaves.

Buds large, clavate, umbels up to 6 in the head on flattened expanding peduncles 2 cm. long and more, the calyx-tubes with one or two opposite sharp ridges, gradually tapering in short but distinct thick pedicels, the operculum hemi-ellipsoid with a short mucrone, each bud with a second deciduous operculum which leaves a sharp commissural edge.

Anthers white, opening in parallel slits, the cells cohering at their edges; versatile, gland at the back.

Fruits large, about 1·7 cm. in greatest width and about the same in depth, including the tips of the capsule. Conoid-hemispherical, the shiny calyx-tube with a short, flattened pedicel, the continuation of the edges of which forms two somewhat sharp ridges. The calyx-tube is surmounted by a slightly domed conspicuous rim of about 3 mm. in width, (which rim morphologically consists of a fusion of the disc and of the staminal ring). This again is surmounted by a pudding-basin rim barely 2 mm. wide. Valves triangular, moderately exsert.

Type—Seven miles from Dungog on the Booral road (Augustus Rudder, J. L. Boorman). The specific name is given in reference to the channelled appearance of the fruit.

Illustrations. See my "Forest Flora of N.S.W.," fig. D, plate 37, Part x (fruits); the same drawing reproduced in my C.R. Part xxix, fig. 1, plate 123. For mature leaf, buds and anther, see figs. 9 a – c, plate 122 of C.R. The specimens "fruit rather globular, but not perfectly ripe," Spit Road, Manly, Port Jackson (J. L. Boorman), figured at fig. 3, plate 123, do not belong to *E. punctata* var. *grandiflora* (*E. canaliculata* n. sp.); they belong to *E. punctata* though rather larger than those of the type.

Synonym.

E. punctata DC., var. *grandiflora* Deane and Maiden, in Proc. Linn. Soc. N.S.W., xxvi, 133 (1901).

Range.

It seems to be confined to New South Wales. "I have only observed the large-fruited Grey Gum in the Counties of Gloucester and Durham. It seems, so far as I have seen, to occupy the intermediate country a little back from the coast to near the eastern slopes of the Dividing Range. I do not think it is very plentiful, but small patches of it are occasionally met with, besides isolated trees, and it often associates more or less with the small-fruited Grey Gum, *E. propinqua*." (The late Augustus Rudder in a letter to the writer, dated 31st August, 1893).

It grows in company with Ironbark *(E. paniculata)* and abundance of *E. saligna*. It is very scarce in the Dungog district (J. L. Boorman).

Affinities.

1. With *E. saligna* Sm. The similarity of these trees is chiefly in their barks, but the differences between them in this respect have been already stated. Mr. Boorman says that, at Dungog, the direction of the branches in *E. canaliculata* is more horizontal and the shape less inclined to be pyramidal as in *E. saligna*. The floral organs and the timber of course sharply separate them. (See Plates 99 and 100, Part xxiii, C.R., for *E. saligna*).

2. With *E. punctata* DC. The new species is nearer *E. punctata* (indeed it has been regarded as a variety of it) than *E. saligna*, but the discovery that *E. canaliculata* n. sp. has a pale timber at once showed that it must be removed from *E. punctata* and other species with red timbers. For drawings of details of *E. punctata*, see C.R., Part xxix, plates 121 and 122, while that of *E. canaliculata* n. sp. are in the same Part (as *E. punctata* var. *grandiflora*) in plates 122 and 123. The anthers of the two species are alike. The outstanding difference shown there is in the smaller size of the buds and fruits of *E. punctata*, their less tendency to vertical angularity, and less marked commissural edges. The juvenile leaves are broader in *E. punctata*.

3. With *E. maculata* Hook. We have undoubted affinities in the smooth, more or less blotched bark, and also in the timber, for both are remarkably alike in external characters. But *E. maculata* (Plate 178, Part xliii) is a well defined member of the Corymbosæ, and the differences are very great, as regards the organs.

ANGOPHORA CLELANDI N. SP.

By J. H. MAIDEN, I.S.O., F.R.S., F.L.S.

[*Read before the Royal Society of N. S. Wales, November 3, 1920.*]

Frutex Mallee similis, cortice aspera, inflorescentia et foliis immaturis ± hispidis. Foliis juvenilibus magnis cordatis ad lato-lanceolatis, amplexicaulibus. Foliis maturis lanceolatis paullo falcatis distincte petiolatis, supra glabris nitentibusque, infra glaucis. Floribus majusculis 3 in umbella, corymbum irregularem terminalem formantibus. Petalis ca 7 mm. diametro. Calycis tubo 6 mm. longo, 7 mm. diametro. Calyce fructifera durissimo, ca 7 mm. lato et æquilongo.

A shrub, mallee-like, or several-stemmed, 3 or 4 feet to 12 feet high, bark rough, thickish, the inflorescence and young foliage more or less hispid.

Juvenile leaves large, cordate to broadly lanceolate, always with the apex blunt, stem clasping (common measurements are 7 cm. broad and long and 9 or 10 cm. long by 4 cm. in greatest breadth).

Mature leaves lanceolate, slightly falcate, mostly obtuse, distinctly petiolate, with some tendency to shortly rounded auricles, about 1 dm. long, and under 3 cm. broad, glabrous and shining above, glaucous but not pubescent underneath.

Flowers of medium size, three in each umbel, forming a rather loose irregular terminal corymb.

Calyx-tube about 6 mm. long and about 7 mm. in diameter.

Petals nearly circular, about 7 mm. in diameter.

Fruiting calyx very hard, about 7 mm. broad at the top, and as much in length.

Range.

It has only been found so far at Kogarah, near Botany Bay, south of Port Jackson (Julius H. Camfield, December 1897), and Northbridge, North Sydney, north of Port Jackson, N.S.W.; (James Williams, November 1915; Dr. J. B. Cleland, December, 1915).

I name it in honour of John Burton Cleland, M.D., now Professor of Pathology in the University of Adelaide, for many years Principal Microbiologist, Sydney, who first prominently drew my attention to this plant.

Affinities.

This species could very easily be (and has been) passed over as a petiolate and more lanceolate leaved form of *A. cordifolia*, or even as a dwarf form of *A. intermedia* DC. It seems to me that its affinities are with these species, but nearer the former. *A. intermedia* and *A. Bakeri* have rough bark, somewhat resembling the Boxes (e.g. *Eucalyptus hemiphloia* F.v.M.). That of *A. cordifolia* is rough-flaky.

In habit *A. Clelandi* is near *A. cordifolia*, but smaller in all its parts, less hispid, the inflorescence less corymbose and with the differences between the juvenile and mature leaves more accentuated.

THE CALCULATION OF REFRACTIVE INDEX IN RANDOM SECTIONS OF MINERALS.

By LEO A. COTTON, M.A., D.Sc., and MARY M. PEART, B.Sc.

[*Read before the Royal Society of N. S. Wales, November 3, 1920.*]

Part I.—Principle of the Method.

By Dr. COTTON.

A relatively simple formula has been established for estimating the double refraction of minerals in random sections, the said formula being

$$\gamma^1 - \alpha^1 = (\gamma - \alpha) \sin \theta \sin \theta^1$$

in which $\gamma^1 - \alpha^1$ is the double refraction sought, $\gamma - \alpha$ is the maximum double refraction of the mineral and θ and θ^1 are the angles which the particular direction of transmission makes with the two optic axes.

Such an equation does not, however, furnish the separate values of γ^1 and α^1. As it is sometimes desirable to obtain these values other methods must be employed.

It is a well known proposition of analytical solid geometry that if the equation of an ellipsoid referred to its principal axes as co-ordinates be

$$\frac{x^2}{\alpha^2} + \frac{y^2}{\beta^2} + \frac{z^2}{\gamma^2} = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

then the major and minor axes r_1 and r_2 of a given central section of the ellipsoid are given by the roots of the equation

$$\frac{1}{r^4} - \frac{1}{r^2}\left(\frac{l^2+m^2}{\gamma^2} + \frac{l^2+n^2}{\beta^2} + \frac{m^2+n^2}{\alpha^2}\right) + \frac{l^2\alpha^2+m^2\beta^2+n^2\gamma^2}{\alpha^2\,\beta^2\,\gamma^2} = 0 \quad \ldots(2)$$

where l, m, and n are the direction cosines of the normal to the plane of the central section.

The roots r_1 and r_2 of equation (2) are given by the theory of equations and may be obtained by solving the two following equations:—

$$\frac{1}{r_1^2 r_2^2} = \frac{l^2 \alpha^2 + m^2 \beta^2 + n^2 \gamma^2}{\alpha^2 \beta^2 \gamma^2} \text{ ....(3)}$$

and

$$\frac{1}{r_1^2} + \frac{1}{r_2^2} + \frac{l^2+m^2}{\gamma^2} + \frac{l^2+n^2}{\beta^2} + \frac{m^2+n^2}{\alpha^2} \text{ .... (4)}$$

Now it is known from the properties of the optical indicatrix that the two refractive indices of a mineral plate are represented in magnitude by the major and minor axes of the central section of the indicatrix which is parallel to the plane of section of the mineral plate.

If therefore, the values α, β, γ are the axes of the indicatrix and l, m, and n are the direction cosines of the normal to the plane of the mineral section, then the refractive indices γ^1 and α^1 of this particular section are given by the values of r_1 and r_2 derived from equations (3) and (4).

Now these formulæ are not nicely adapted for numerical computation and in any case they involve the solution of equations (3) and (4).

As an alternative to this rather tedious method the author proposes the following method which is largely graphical in character.

Let α, β, γ as before be the principal refractive indices of the mineral and therefore the principal axes of the indicatrix.

The equation of the indicatrix is therefore as before

$$\frac{x^2}{\alpha^2} + \frac{y^2}{\beta^2} + \frac{z^2}{\gamma^2} = 1.$$

Let r_1 and r_2 be the refractive indices of a mineral plate the direction cosines of whose normal are l, m, and n.

Then r_1 and r_2 will be the major and minor axes of the central section of the indicatrix parallel to the mineral plate.

Let the direction cosines of r_1 and r_2 be respectively l_1, m_1, n_1, and l_2, m_2, n_2.

Hence the co-ordinates $x_1\ y_1\ z_1$ of the extremity of the diameter r_1 are given by the equations

$$x_1 = r_1 l_1 \qquad y_1 = r_1 m_1 \qquad z_1 = r_1 n_1$$

Since the point $(x_1\ y_1\ z_1)$ lies on the surface of the indicatrix the co-ordinates $x_1\ y_1\ z_1$ must satisfy the equation of the ellipsoid and hence we have

$$\frac{(r_1 l_1)^2}{\alpha^2} + \frac{(r_1 m_1)^2}{\beta^2} + \frac{(r_1 n_1)^2}{\gamma^2} = 1 \text{ ....(5)}$$

which may be expressed in the form

$$\frac{l_1^2}{\alpha^2} + \frac{m_1^2}{\beta^2} + \frac{n_1^2}{\gamma^2} = \frac{1}{r_1^2} \text{..................(6)}$$

Thus when $l_1\ m_1\ n_1$ are known the value r_1 is simply calculated. Similarly from the equation

$$\frac{l_2^2}{\alpha^2} + \frac{m_2^2}{\beta^2} + \frac{n_2^2}{\gamma^2} = \frac{1}{r_2^2} \text{..................(7)}$$

the value r_2 of the second refractive index can be calculated.

The problem therefore, is now resolved into one of finding the direction cosines $l_1\ m_1\ n_1$ and $l_2\ m_2\ n_2$.

These values may be readily obtained by graphical means. The stereographic projection is employed for this purpose. The general method may be illustrated by a particular case.

It was desired to obtain the values for the two refractive indices for a section of labradorite cut parallel to the 010 face. The plane of the stereographic projection is chosen so that it is perpendicular to the direction of section in the mineral plate.

In this case it was possible to take the plane of the stereographic projection so that it was perpendicular to the crystallographic axis *C*. The direction of transmission *C P*, (Fig. 1) therefore lies in the plane of the projection and is perpendicular to the trace of the mineral section *S C T*.

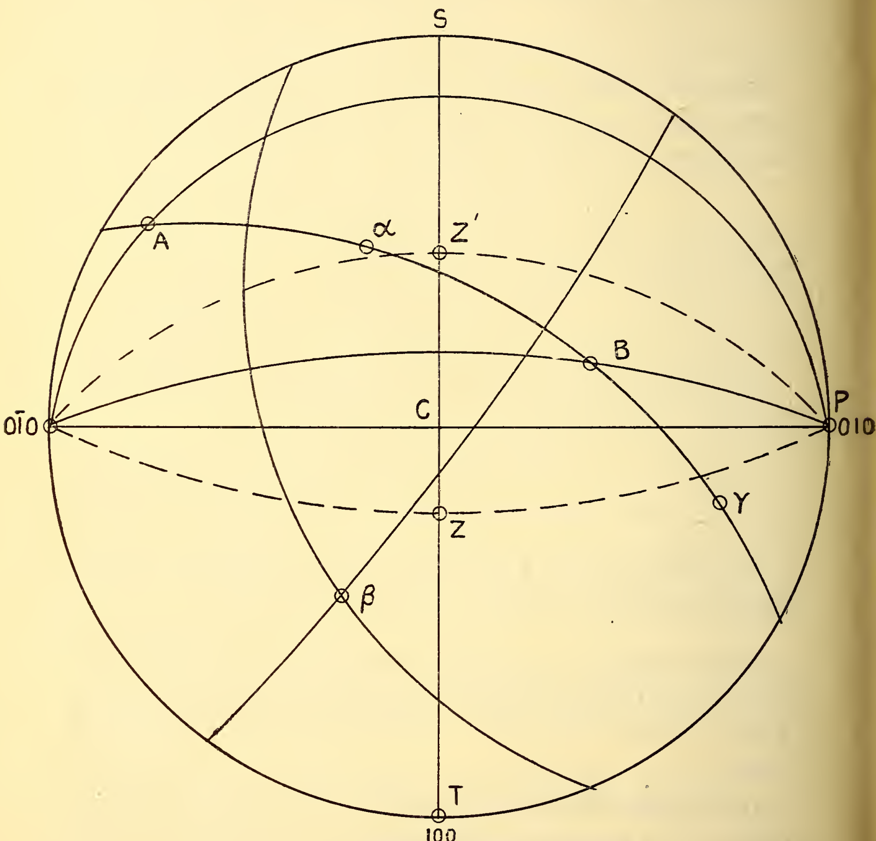


Fig. 1.—*Stereographic Projection showing the method of finding the directions of vibration corresponding to the required refractive indices.*

The data required are given as follows:—

The composition corresponded to Ab_1An_1. The values of the principal refractive indices are known to be

$$\alpha = 1{\cdot}554, \qquad \beta = 1{\cdot}558, \qquad \gamma = 1{\cdot}562.$$

The position of the acute bisectrix corresponding to α and of the optic axial plane are given from text books of mineralogy such as Idding's Rock Minerals.

γ lies in the optic axial plane at 90° from α; and the direction of β is given by the pole of the optic axial plane.

An amount equal to V (where $2V$ is the optic axial angle in the mineral) is marked off on each side of α and in the optic axial plane, so that the two points A and B so obtained represent the optic axes.

Now according to the Biot-Fresnel law the planes of polarisation bisect the angles between the two planes passing through the direction of transmission and each of the optic axes respectively.

If a stereographic net be employed the positions of these planes can be readily determined and hence the planes of polarisation can be drawn. The directions of vibration in the plane of the mineral section are given by the lines of intersection of the planes of polarisation $P\,Z$ and $P\,Z^1$ with the plane of the mineral section $S\,C\,T$. The points Z and Z^1 therefore represent the directions of the vibrations corresponding to the refractive indices r_1 and r_2. They are, therefore, the directions corresponding to those radii of the indicatrix which have for their lengths r_1 and r_2.

Hence if we find the direction cosines of r_1 and r_2 we may substitute these values in equations (6) and (7) and so determine the required refractive indices.

Here again the employment of a stereographic net will enable the angular distance of Z from α, β and γ to be easily determined and the cosines of these angles are the required values of $l_1 m_1 n_1$. Thus r_1 is determined and a similar process will enable r_2 to be also evaluated.

Where one or more of the direction cosines are closely equal to unity the inaccuracies of the actual measurements on the stereographic net may give rise to sensible inaccuracies in the results. In order to obviate this difficulty we have recourse to the relation

$$l_1^2 + m_1^2 + n_1^2 = 1$$

If the sum of $l_1^2 + m_1^2 + n_1^2$ as obtained from the observed values be not equal to 1, the total should be made equal to one by proportional change in the values of l_1^2, m_1^2 and n_1^2, and the corrected values so obtained should be substituted in equation (6) in order to obtain the best value of r_1.

The method described above is simple in principle though it may appear a little elaborate in detail. The author has however, found this method quite simple in its application and with the aid of a stereographic net the calculations may be quickly executed. He has also found that the principles have been easily grasped by his students who have applied this method in their class work. In practice it has proved very much more satisfactory than the purely analytical method.

Part II.—The application of Dr. Cotton's Method of Calculating Refractive Index to the Felspars.

By Miss Mary M. Peart.

With variation in the composition of the plagioclase felspars from albite to anorthite there is a gradual increase in refractive index. The various plagioclases might therefore be discriminated by an accurate determination of the refractive index in some given direction. Curves showing the variation for the maximum and minimum values of the refractive index (α and γ) are given in various text books, *cf.* "Idding's Rock Minerals," but in practice sections containing the α and γ are difficult to obtain.

Dr. Cotton's method, however, affords a means of calculating the refractive index in any random direction. In applying this to the plagioclase felspars the directions selected were those paralled to (010) and (001). Such sections are parallel to the two prominent cleavages and may be readily obtained in practice.

The data required for the construction of the stereograms were obtained from Michel Levy's "Etude sur la Determination des Felspaths," and the values of α, β and γ necessary for the solution of the equation

$$\frac{l^2}{\alpha^2} + \frac{m^2}{\beta^2} + \frac{n^2}{\gamma^2} = \frac{1}{r^2}$$

from Idding's "Rock Minerals." They are here given in tabular form.

The positions of the elements α, β and γ and of the optic axes A and B as well as the crystallographic forms (001), (010) and (100) are thus defined by the values of ϕ and ρ. The values of ϕ are measured in the plane of projection (vide Fig, 1) and the values of ρ are the distances of the elements from the centre of projection. This nomenclature is the same as that conventionally adopted in crystallographic work.

Values for r_1 and r_2 were obtained for both the (010) and (001) sections of each felspar and graphs constructed. These are given in Figs. 2 and 3 respectively.

A series of liquids was then prepared with refractive indices equal to the mean of the values obtained for r_1 and r_2 of the various felspars on the (010) and (001) faces respectively. The liquids used were mixtures of clove oil and momobromo-naphthalene and had the following refractive indices.

1. 1·535	3. 1·542	5. 1·558	7. 1·588
2. 1·540	4. 1·550	6. 1·562	

These were then used to determine the refractive index of small cleavage fragments by the Schroeder van der Kolk method.

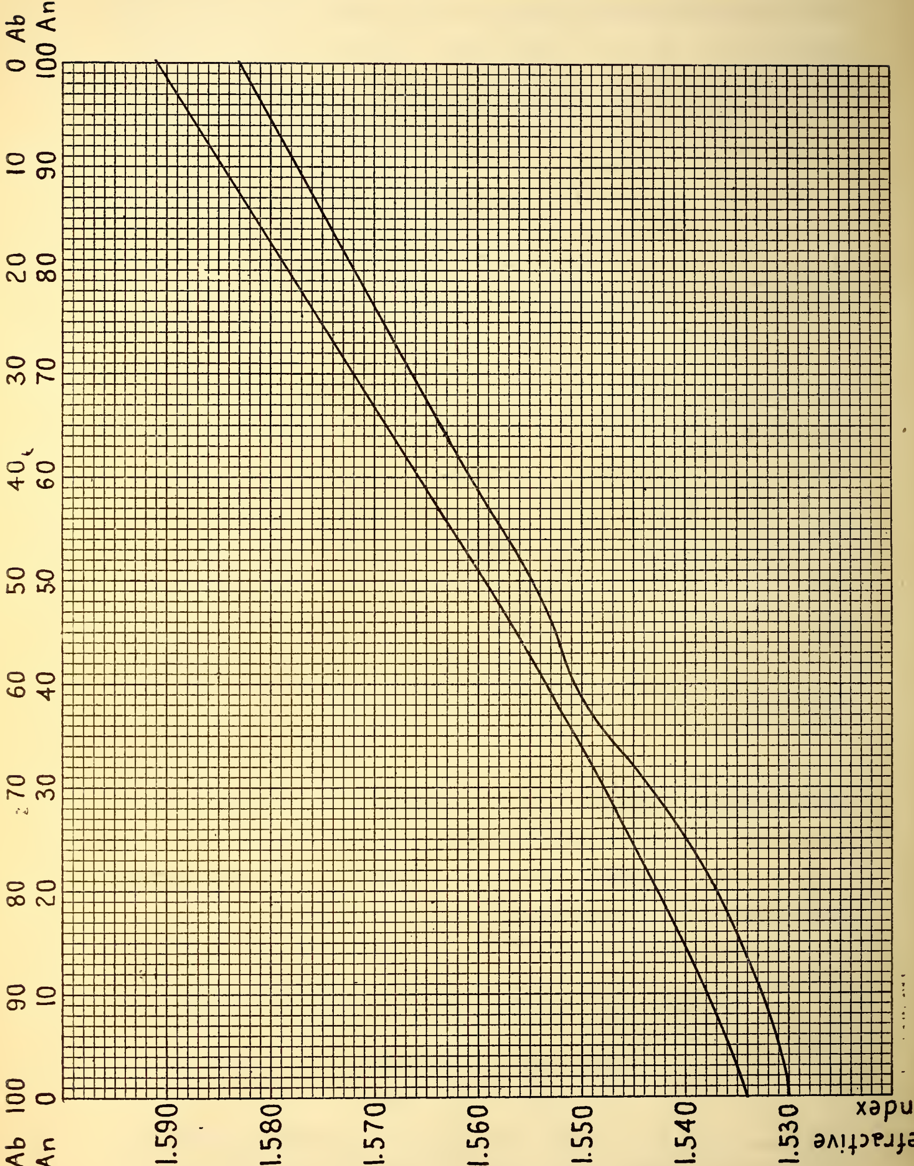


Fig. 2.—*Refractive Indices for sections of the plagioclases taken parallel to the 010 cleavage.*

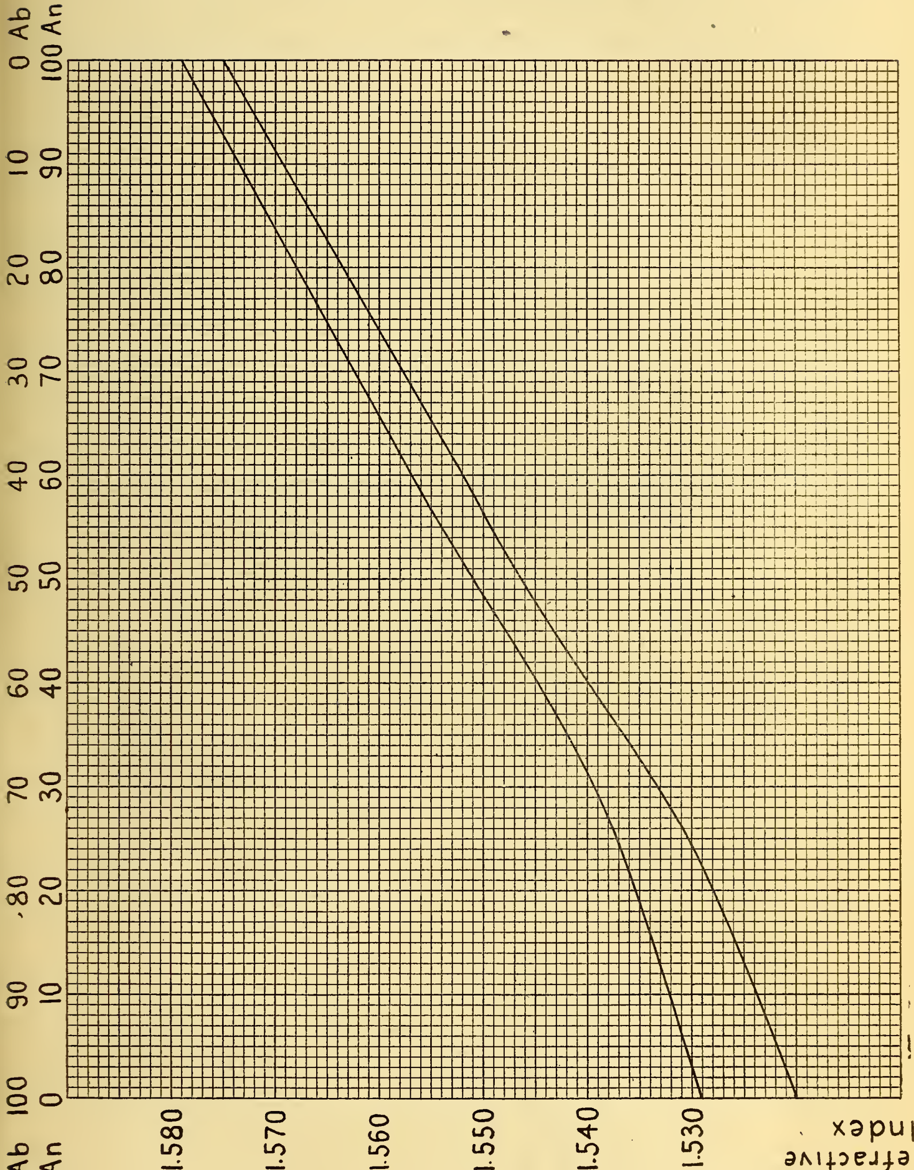


Fig. 3.—*Refractive Indices for sections of the plagioclases taken parallel to the 001 cleavage.*

Table giving data required for the construction of Stereograms.

Felspars.	001		100		010		Optic Axes. A.		Optic Axes. B.		Axes of Indicatrix. α		Axes of Indicatrix. β		Axes of Indicatrix. γ	
	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ
Albite Ab	171°	27°	180°	90°	90°	90°	309°	73°	230°	81°	1°	83°	113°	18°	269°	74°
Oligoclase Ab_4An_1 ...	171	27	180	90	90	90	314	76	47	76	1	70	180	202	70	90
Oligoclase Ab_3An_1 ...	171	27	180	90	90	90	316	75	45	68	0	65	194	26	93	85
Andesine Ab_5An_3 ...	171	26	180	90	90	90	312	78	51	55	355	56	208	38	97	76
Labradorite Ab_1An_1 ...	171	26	180	90	90	90	306	84	67	43	347	47	211	53	102	67
Labradorite Ab_3An_4 ...	171	26	180	90	90	90	305	87	69	27	333	42	213	68	108	58
Anorthite An	171	26	180	90	90	90	298	76	158	8	292	34	29	86	122	55

Values for α, β and γ.

Felspars.	α	β	γ
Albite Ab	1·529	1·533	1·539
Oligoclase Ab_4An_1 ...	1·538	1·543	1·547
Oligoclase Ab_3An_1 ...	1·540	1·544	1·548
Andesine Ab_5An_3 ...	1·548	1·551	1·555
Labradorite Ab_1An_1 ...	1·554	1·558	1·562
Labradorite Ab_3An_4 ...	1·557	1·562	1·566
Anorthite An	1·579	1·558	1·594

In carrying out the work fragments of known felspars were used and the composition estimated from a determination of the refractive index corresponded very closely with the known composition.

Acknowledgements.—The above work was undertaken at the suggestion of Dr. Cotton, and I have to thank him for his assistance in carrying it out.

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THE STETHOSCOPE, WITH A REFERENCE TO A FUNCTION OF THE AURICLE.

By J. A. POLLOCK, D.Sc., F.R.S.

[*Read before the Royal Society of N. S. Wales, December 1, 1920.*]

IF apology were needed for a paper on the physics of a simple apparatus in such constant use as the stethoscope, it might well be based, in the first instance, on the remarkable paucity of references to the instrument in physical literature. The name 'stethoscope' does not occur in the subject index[1] to the Royal Society Catalogue of Scientific Papers, 1800–1900, nor is the appliance mentioned in any standard work on Sound which I have been able to consult. From medical sources[2] it appears that in discussions on the action of the simpler forms of stethoscope attention has been directed to the 'sound conducting' properties of solid rods and columns of air. As a dynamical aspect of the problem is not mentioned, I am led to consider that the explanation which I have to offer may be new.

[1] Vol. 3, Physics, Part 1. [2] See, *e.g.*, Williams, B.M.J., Vol. 2, 1907, p. 6.

Reference will first be made to forms of stethoscope in which the mechanical action is obvious. Types of such instruments are shown in section in figures 1 and 2, about one half natural size.

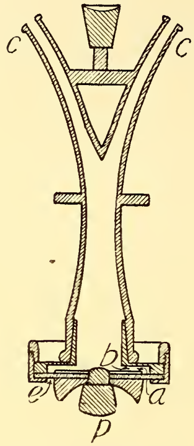

Fig. 1.

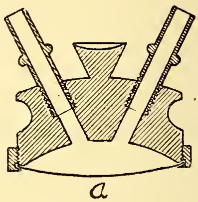

Fig. 2.

In figure 1 *a* is a plate attached to the case of the instrument by a ring of elastic material *e*. Parallel to this is a fixed plate *b*. A layer of air, in communication with the ears through rubber tubes attached to the hollow arms *c*, is thus formed between two plates, the lower one of which is capable of movement relative to the other. When in use the knob *p* is placed on the spot where it is desired to determine the nature of the mechanical movements. In figure 2 *a* is a base of thin flexible material.

Such instruments possess two main features, very familiar to seismologists, a comparatively large mass—the case of the apparatus—and an elastic attachment connecting the mass to the surface which supports it.

The equations of motion appropriate to dynamical systems like these stethoscopes, when subject to vibration, are similar to those discussed with reference to the theory of seismographs in books on seismology. Here an elementary description is all that is needed.

Referring to figure 1, if the surface on which such a stethoscope rests suffers a sudden upward displacement, the plate *a* moves with it and the case of the instrument thus receives an impulse. Owing to the comparatively large mass of the apparatus, the displacement may be completed before the case appreciably alters its position. In virtue, then, of the elasticity of the connecting ring *e* and the inertia of the case, the initial result of a sudden displacement of the surface is a movement of the lower plate relative to the upper one.

Such movements of the lower plate relative to the rest of the instrument create pressure pulses in the air contained in the apparatus which are transmitted through the air enclosed in the rubber tubes to the ears, to be there perceived as sounds.

A similar description is clearly applicable to instruments like that shown in figure 2. To the uninitiated, stethoscopes of this latter class must appear unnecessarily massive.

Simpler forms of instrument have now to be considered. The immediate discussion deals with those types of which the common trumpet or bell shaped binaural stethoscope, not provided with a diaphragm, may be taken as an example.

As I am concerned here merely with the physical action and not at all with the interpretation of the sounds heard, my experiments have been made in connection with the vibrations of the surface of a slate bench, or wooden table, caused by very gently tapping or stroking the surface with the tips of the fingers or, in some cases, by the working of a watch with a smooth movement. With such surfaces, as contrasted with that of the human body, purely local disturbances, occurring, perhaps, within the area of the aperture of the instrument, are wholly avoided.

Types of the forms tested, drawn about one half natural size, are shown in section in figure 3.

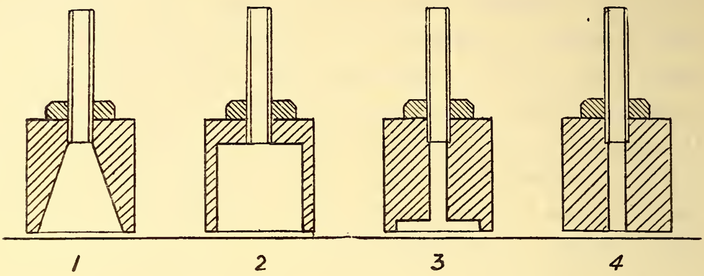

Fig. 3.

The instruments either rested on the table or were held against the surface with the hand, the connection to the ears being through a rubber tube fixed to the projecting pipe. No. 3 gives the loudest sounds, but with respect to performance there is not much to choose between the forms shown; they are all efficient detectors of the surface movements, even No. 4 with a plane undersurface, only broken by the central aperture, gives quite good results. Here, indeed, one meets with a puzzle of long standing. It really seems impossible to make anything with an aperture connected to an ear piece which will not act, in association with the ears, as a detector of small surface vibrations.

As ordinarily used the stethoscopes are lightly held against the surface. The intensity of the sound is a maximum for a certain pressure of contact, but under the conditions of the experiments, all sounds cease if the instruments are pressed hard down on the table.

The air in a stethoscope can be set into appreciable vibration by mere contact of the appliance with a vibrating body if the amplitude of the movement is sufficiently great.

This is usually the case with disturbances caused in wood by the working of a watch. The present discussion is limited to the realm of disturbances of smaller amplitude which do not give rise to sounds if the stethoscopes are pressed hard against the surface.

That the vibration of the surface is not altered by the pressure can be ascertained by using an ordinary old fashioned wooden stethoscope. The intensity of the sound is not affected in this case by the force with which the instrument is pressed against the table.

The observation, with stethoscopes like those in Fig. 2, that when held hard against the surface all sounds cease, indicates the solution of the problem of their action. When resting on the table, or held lightly against it, the instruments evidently float on the film of air between the surfaces usually considered as in contact. This film of air forms an elastic connection between the mass and the surface, and in explanation of the air pulses which actually reach the ears in the case of these simple forms of binaural stethoscope there is nothing to add to the description just given in connection with the obviously mechanical type of instrument shown in figure 1.

The evidence in favour of this explanation is, however, not confined to the fact that the sound ceases when the instruments are pressed against the surface, for before the extinction of the sound occurs, with increasing pressure applied by the hand, the pitch of the sound continuously rises. This effect is a striking one and is to be expected if the mass is supported on a layer of gas. If the gas were enclosed the vibration-frequency would vary as the square root of the gas pressure.

The recognition of the elastic air film as a definite part of these simple appliances completely solves the puzzle previously mentioned, for the 'steady mass' is always present, and the instruments are, in respect to this part of their action, as definitely mechanical as the forms shown in figures 1 and 2.

A large hollow cone, with its wider opening held against the table, the narrow end being connected by a rubber tube to an ear-piece, is a fairly good detector of small surface vibrations. If sounds are heard with this apparatus they do not cease when the instrument is pressed hard against the surface, and the action is that of an ear trumpet.

Thus, as a result of the previous discussion, stethoscopes of the forms examined must be considered, from a physical point of view, as instruments which locally transform minute mechanical movements of solids to corresponding vibrations of the air associated with them. Stethoscopes with conical shaped openings have, in addition, the property of concentrating disturbances already existing in the air as a direct result of the vibrations of the surface, but, with the instruments in ordinary use, any effect due to their shape is wholly negligible in comparison with that of the local mechanical transformation.

The old fashioned stethoscope, consisting of a hollow wooden or ebonite stem with a small conical opening at one end and an ear-plate at the other, still remains to be considered.

Comparative observations, made by placing the ear against a vibrating surface and then against the ear plate of one of these stethoscopes pressed against the surface, show that very small movements are, in this way, as readily detected without the stethoscope as with it. Also in the case of vibrations of small amplitude, the intensity of the sound heard when using these stethoscopes is the same whether the stem of the apparatus is solid or hollow, so very little experimenting is required to prove that the main function of these instruments is to act as a part of the vibrating surface to which the ear may be conveniently applied.

With the experience gained from experimenting with instruments of the types previously described it can hardly be doubted that in connection with the use of the old fashioned form there is some kind of local transformation of vibrations from solid to air. As it is quite certain that the instrument plays no part in any such transformation we are forced to look beyond it.

A feature of the art of the tracker here comes into view and a problem, appropriate to the point which the discussion has reached, suggests itself:—how is it that minute movements of the ground are appreciated by listening with the ear to the surface? The experience of the tracker to which reference is here made is known to everyone in a limited way, and certainly merits consideration. It is familiar from the habit of putting a watch under one's pillow at night.

The matter may be readily investigated. With ground movements only barely detectable the following points are experimentally definite:—

(1) On resting the head on the ground on the cheek bone no sound is heard until the head is turned so that the air between the folds of the auricle is almost wholly imprisoned by the surface of the ground. One can just appreciate that, in this position, the auricle is slightly pressed against the surface.

(2) The intensity of the sound notably increases when the head is further turned so that the air associated with the auricle and ear passage becomes completely enclosed, and the weight of the head is definitely borne either wholly or in part by the auricle.

(3) If while the head rests on the cheek bone, the auricle being free, the air connected with the auricle is imprisoned

by holding a flat surface to the ear, no sound due to the ground vibration is heard. This point is of importance as it means that the sound heard when the head rests on the ear is not due to the air associated with the auricle and ear passage being set into vibration by the mere contact of the head with the vibrating surface.

Such astonishing results are obtained by this method of detecting earth movements with the ear, that clearly a definite physical description is required of the way by which vibrations, of sufficient energy to give rise to the sensation of sound, are created in the air of the ear passage from the minute ground movements.

In view of the last experience just mentioned, to account for the sounds heard with the ear to the ground, alternatives are only possible. Either the auricle acts as an ear trumpet in concentrating disturbances already existing in the air, or there is a local transformation of vibrations from the solid to the air of the ear passage.

The auricle is not, however, fashioned to concentrate to any extent the energy of air vibrations. Further, the matter may be put to the test of experiment, and it is found that conical ear trumpets with apertures even ten times the area of the auricle will not pick up earth disturbances which are strikingly evident when the ear is laid to the ground. The former alternative may, therefore, be dismissed from further consideration.

The maximum sound occurs when the auricle is used wholly or in part as a rest for the head. In such a case the air in the channels between the folds of the auricle, still in communication with the ear passage, becomes enclosed. On one side of this confined air is the surface of the ground, on the other the drum-skin attached to the massive head, while the auricle forms an elastic connection between the head and the ground.

The features so familiar in connection with seismoscopes are here again prominent, and in view of the whole evidence it may be confidently concluded that the head acts as a 'steady mass,' the auricle as the elastic support, and that the mode of transformation of vibrations from solid to air is exactly similar to that involved in the use of the stethoscopes described in the earlier part of the paper. On this view, as the ground rises and falls, the auricle yields before the head, on account of its considerable mass, appreciably moves. Relative to the head the ground acts like the end of a concertina, the expansible sides being represented by the elastic auricle. The movement of the ground, though on a microscopic scale, thus gives rise to condensations and rarifications of the air in the ear passage which, if of sufficient intensity, are perceived as sounds.

It appears, then, as a general result of the discussion, that the acoustic determination of surface vibrations has, in the last resort when the disturbances are very small, a definite dynamical aspect, the detection, in all the instances described, depending on the movements of the surface relative to a 'steady mass' elastically supported. In detecting small movements with the old fashioned stethoscope, or after the manner of the tracker, the mechanism is supplied by the head and ear, the auricle having the very definite function of acting as the elastic connection between the mass and the surface. In other cases, where the air disturbances are led by tubes directly into the ear passages, the mechanical action is recognisable associated with the instruments.

The minuteness of the movements which may be appreciated by this local transformation of vibrations from solids to air, either by instrumental means or by head and ear, is only another tribute to the well known extraordinary sensitiveness of the ear to slight periodic fluctuations of pressure in the air.

From a physical point of view the auricle seems well adapted for the part which it plays in the detection of small earth movements, both with respect to the extent of the air connected with the ear passage which becomes enclosed when the head rests on the ground, and to its capability of being used as a support for the head. It is, perhaps, not improbable that the exercise of the geophonic function of head and ear, certainly common among primitive people, may have been a factor in the development of the auricle in man.

A model, which has to a slight extent the appearance, but, when in use, almost exactly the action of the head and ear when detecting earth movements, may be made by embedding a complete ring of rubber tube in a groove in a wooden disc, the ring being about five centimetres in diameter and projecting a couple of millimetres or so below the surface of the wood. A pipe through a hole in the centre of the disc enables the apparatus to be attached by a rubber tube to an ear piece. When placed on the ground the layer of air within the circumference of the ring is enclosed, and the instrument, with an appropriate mass, gives effects not unlike those obtained with the head and ear.

All appliances of this type, including stethoscopes, have natural periods of vibration, the movements in most cases being only slightly damped. These natural periods give a selective sensitiveness to the instruments, as in all similar cases, and dominant tones to the indications. This matter is of importance when the interpretation of the sounds is in question. I am unable to recognise in my own case a period natural to head and ear

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THE ESSENTIAL OILS OF LEPTOSPERMUM FLAVESCENS VAR. GRANDIFLORUM AND LEPTOSPERMUM ODORATUM.

By A. R. PENFOLD, F.C.S.

[*Read before the Royal Society of N. S. Wales, December 1, 1920.*]

LEPTOSPERMUM FLAVESCENS var. GRANDIFLORUM Bentham.

(LEPTOSPERMUM GRANDIFLORUM Lodd.)

THE botany of this species, is described by Mr. E. Cheel in the present proceedings of this Society. It is a shrub varying from 6 to 10 feet in height, and like *L. odoratum* is found frequenting the beds of creeks and rivers. It was whilst gathering material of *L. odoratum* for oil distillation that the species was met with and consequently leaves were collected for the same purpose.

Only one distillation was made and as the oil did not possess any very special interest from an economic point of view it was not thought worth while collecting further supplies of leaves. The principal constituents are the two sesquiterpenes, aromadendrene and eudesmene, together with a sesquiterpene alcohol unidentified. As these sesquiterpenes of a high lævo rotation occur in quantity in the oil of *L. odoratum*, the chemistry of which is dealt with fully later in the present paper, it was considered advisable on account of this connection to include this species at the same time.

The Essential Oil.

60 lbs. of leaves were collected in the bed of the Nattai River, near Hill Top, N.S.W., and the oil obtained was equal to 0·61%. It was somewhat viscous and so dark in colour that its chemical and physical characters could not

be determined until it had been cleared up by washing with dilute sodium hydroxide solution. By this means phenolic bodies and considerable ferric hydroxide were removed.

Experimental.—The oil was then of a greenish-brown-yellow colour with a pronounced odour of sesquiterpenes and had:—

Specific gravity at 15° C.	0·9324
Optical Rotation	−2·42°
Refractive Index at 20° C.	1·5048
Insoluble in 10 vols. 80% alcohol by weight.	
Ester No. 1½ hours, hot saponification ...	7·2
Ester No. after acetylation:—	
2 hours contact in cold	24·95
1½ hours contact, hot	40·98

50 c.c. of oil were distilled at 10 mm., first drops came over at 99° C. collected three fractions as below:—

Fractions at 10 mm.		Specific gravity 15°C.	Optical Rotation.	Refractive Index at 20° C.
99 − 123° C.	1 c.c.	...	...	...
123 − 132° C.	30 c.c.	0·9217	−2·52°	1·5029
133 − 156° C.	17½c.c.	0·9456	−3·91°	1·5079

Determination of the Sesquiterpenes.

The two large fractions totalling 47½ c.c. were allowed to stand over metallic sodium for several days and then repeatedly fractionated over the same metal at 10 mm. until about equal volumes of the following fractions of constant boiling point were obtained:—

Boiling Point at 10 mm.	Specific Gravity at 15° C.	Optical Rotation.	Refractive Index at 20° C.
123 − 125° C.	0·910	− 6·2°	1·4967
129 − 132° C.	0·921	+ 0·72°	1·5063

Neither of these fractions would form any of the usual sesquiterpene derivatives, but gave the beautiful colour reactions with bromine vapour, halogen and sulphuric acids characteristic of aromadendrene and eudesmene (see below on the essential oil of *Leptospermum odoratum*). The constants given above agree well with those for these two sesquiterpenes. The sesquiterpene alcohol could not be identified, although eudesmol was tested for.

Phenolic Bodies.—Upon examining the alkaline liquor used in clearing the crude oil for examination, a mixture of solid and liquid phenols was obtained equal to about 2·5% on the weight of oil. It distilled at about 170 – 190° C. at 10 mm. and had specific gravity at 15° C. 1·127. Refractive index at 20° C. 1·5405, inactive to light, and gave a characteristic blood red colouration with ferric chloride solution similar to that given by tasmanol.[1]

As the mixture consisted of both liquid and solid phenols, the amount at disposal was too small to permit of separation and identification.

The essential oil of *Leptospermum grandiflorum* consists principally of lævo rotatory aromadendrene, eudesmene (slightly dextro rotatory) and an unidentified sesquiterpene alcohol, and is distinct from the oil of *L. flavescens*, the chemistry of which will be communicated early in 1921.

My thanks are due to Mr. R. T. Baker, Curator of the Technological Museum for making available the facilities of the Institution, to Mr. E. Cheel for his kindness in personally supervising the collection of the material, and Mr. F. Morrison, Assistant Chemist, for assistance in working out the composition of the oil and in helping in the collection of the leaves.

LEPTOSPERMUM ODORATUM Cheel.

This species was described before this Society and given specific rank by Mr. Cheel and a full description of its botany is published.[2]

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[1] Baker and Smith, "Research on the Eucalypts," 2nd Ed., p. 396.

[2] This Journal, Vol. LIII, 122, (1919).

It is a shrub 3 to 5 feet high and is found almost invariably in the beds of creeks and rivers. It is well named by its author on account of the pleasant rose odour detected when the oil glands are ruptured. On account of its habitat great difficulty was experienced in obtaining sufficient leaves for distillation as although the locality selected for obtaining them—the bed of the Nattai River, near Hill Top, N.S.W.—is but 80 miles from Sydney, the rough and mountainous nature of the country and almost entire absence of transport necessitated personal collection. In this connection the writer is much indebted and desires to specially express his thanks and appreciation to Mr. Cheel for his work in supervising the collection of the whole of the leaves which was carried out at his own expense and entailed considerable personal inconvenience. It is due to his enthusiasm and energy that the chemical part of the work was enabled to be undertaken. The leaves distilled therefore are absolutely authentic.

The Essential Oil.

The oil thus obtained from this species was yellow in colour, fairly mobile and possessed a pleasant terpene and rose-like odour, the latter being most pronounced when diffused. The leaves were obtained in every instance from the bed of the Nattai River near Hill Top, N.S.W., and were distilled within a few days after cutting.

Altogether 190 lbs. weight of leaves and branchlets, cut as for commercial distillation, were distilled and gave an average percentage yield of 0·75%. The yield obtained from leaves cut during the months of August and October in different years was 0·9%, whilst those cut in the month of May showed but 0·4%. This figure is slightly on the low side as the woody portion of the plant was present in larger amount than in the other lots.

The eudesmol appears to be present in minimum amount at this time of the year, hence the high lævo rotation and low specific gravity of the May sample, and this was fortunate as it enabled the sesquiterpenes to be the more readily isolated. The principal constituents of the oil so far determined are:—

(1) The dextro rotatory bicyclic sesquiterpene alcohol—eudesmol.

(2 and 3) A mixture of two lævo rotatory sesquiterpenes—eudesmene and aromadendrene.

(4) β pinene.

(5) α pinene.

(6) Butyric and acetic acid esters of unknown alcohol, as well as small amounts of alcohol of citronellol odour (not geraniol or citronellol), also small amount of both a solid and liquid phenol giving bright red colouration with ferric chloride solution. Free acids, aldehydes, ketones, phellandrene or limonene were not detected.

This oil is of considerable scientific interest as it is the first record of the occurrence of the sesquiterpene eudesmene in nature, it having previously been obtained by dehydration of the corresponding sesquiterpene alcohol.

The presence of eudesmol in a Leptospermum has not been noticed before, and its occurrence in quantity in such is not without interest. This sesquiterpene alcohol has only previously been recorded as being present in the oils obtained from the Eucalypts.[1]

Nopinene (β pinene) has not previously been identified as a definite constituent of Australian essential oils. The oil of this Leptospermum is therefore, quite distinctive in character and differs from that of any of its congeners so far described.

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[1] Baker and Smith, "Research on the Eucalypts," 2nd Ed., p. 379.

Experimental.—The 190 lbs. of leaves and branches were collected at different periods and on distillation yielded crude oils which on examination gave the chemical and physical characters shewn in the following table:—

Date.	Percentage yield.	Specific gravity at 15° C	Optical Rotation	Refract. Index at 20° C.	Ester No. Hot 1½ hours sap.	Ester No. Cold 2 hours contact.	Ester Nos. after Acetylation.		Solubility in 80% alcohol by weight.
							Hot.	Cold.	
5/8/1917	0·88%	0·9246	-16·32°	1·4960	7·2	7·2	91·93	33·95	1 vol in 10
15/5/20	0·4%	0·9163	-33 02°	1 4989	5·5	5 6	57·00	21·55	insol in 10
3/10/20	0·9%	0 9280	-19·02°	1·4990	7 2	7 2	87·03	22·60	1 vol. in 10

The saponification No. after acetylation of last distillation is a little lower than the first on account of portion of the eudesmol having been collected separately from the oil by increasing the steam pressure towards the end of distillation. The amount of oil obtained was equal to 0·81% and the crude eudesmol separately obtained = 0·09%.

The crude oils gave the following fractions on distillation:

Sample 5/8/17.

The acids forming the esters were separated by cold saponification and were found to consist principally of butyric acid with a small amount of acetic acid. On then subjecting to distillation 50 c.c. of the ester-free oil the following fractions were obtained:—

Initial boiling point 157° C. at 762 mm.

Boiling Point. ° C.	Percentage	Sp. Gravity at 15° C.	Optical Rotation	Refractive Index at 20° C.
157–161	4	...	...	...
161½–165	14	0·8703	–13·00°	1·4740
165–180	10	...	...	...
180–240	10	...	...	...
240–269	23	0·9293	–24·33°	1·5010
270–280	27	0·9494	–17·20°	1·5095
280–285	9	0·9606	nil	1·5103 (solidified)

Samples 15/5/20 and 3/10/20 were distilled under reduced pressure at 10 mm. 100 c.c. of each taken.

Sample 15/5/20.

Boiling Point.		Percentage.
at 10 mm.	60 – 90° C.	25%
	90 – 123	6
	123 – 140	54
residue allowed to solidify ...	...	15
		100

Sample 3/10/20.

Boiling Point.	Percentage.
60 – 90° C.	15%
90 – 125	4
125 – 145	48
145 – 160	23
residue allowed to solidify	10
	100

These fractions possessed the following constants :—

Sample 15/5/20.	Sp. Gravity at 15° C.	Optical Rotation	Refractive Index at 20°C.
1st fr. 60 – 90°C. at 10 mm.	0·8651	– 20·65°	1·4757
2nd 90 – 123	0·8875	– 36·80°	1·4870
3rd 123 – 140	0·9266	– 47·50°	1·5063
Sample 3/10/20.			
1st fr. 60 – 90°C. at 10 mm.	0·8731	– 11·52°	1·4760
2nd 90 – 125	0·8905	– 22·60°	1·4846
3rd 125 – 145	0·9309	– 34·51°	1·5065
4th 145 – 160	0·9587	– 11·02°	1·5107

Determination of Terpenes.

The fraction boiling at 60 – 90° C. at 10 mm. from sample 15/5/20 was fractionated at 762 mm. and found to consist almost entirely of α and β pinene :—

Boiling Point ° C.	Sp. Gravity at 15° C.	Optical Rotation °	Refractive Index at 20°C.
Small fraction 156 – 159	0·8632	– 8·78	1·4719
Main fraction 160 – 164	0·8651	– 14·50	1·4747
Small fraction 164 – 169	0·8661	– 24·05	1·4751

The portion boiling at 156 – 159° C. gave an excellent yield of nitrosochloride of melting point 104° C., which after careful purification melted and decomposed at 109° C. The other two fractions whose constants agree well with those for β pinene[1] were mixed and 5 c.c. shaken with 12 grms.

[1] Parry's Essential Oils, 2nd Vol. p. 37.

ground pot. permanganate, $2\frac{1}{2}$ grms. caustic soda, 100 grms. ice and 600 c.c. water for several hours; saturated solution with CO_2 gas and steam distilled, then concentrated to about 200 c.c. volume in CO_2 gas and extracted with chloroform several times to remove impurities. On further concentration and cooling the characteristic crystals of sodium nopinate separated. These were pumped off and on addition of dilute H_2SO_4 crystals of the free acid separated. These on purification and recrystallisation from benzene formed beautiful needles melting sharply at 127° C.

The terpenes therefore are α and β pinene.

Alcohol of Rose Odour.

The constituent giving the delicate and characteristic odour of citronellol to the oil was not present in sufficient quantity for identification.

It was found to be concentrated apparently in the sesquiterpene fractions boiling between 123 – 130° C. at 10 mm. from which it was separated by shaking the latter with 50% resorcin solution and subjecting this to steam distillation. Not more than a couple of c.c.'s were obtained in this way. It had a distinct odour of citronellol and refractive index of 1·4854 at 20° C.

It was recovered unchanged after heating on a water bath for several hours with equal weight of phthalic anhydride in benzene solution (proof of it not being geraniol or citronellol). It did not form a phenylurethane.

Determination of the Sesquiterpenes.

These were worked up from Sample 15/5/20, fraction 125 – 140° C. at 10 mm. This was allowed to stand over metallic sodium for a week, and then repeatedly fractionated over this metal at 10 mm. until about equal volumes of the following fractions of constant boiling point were obtained:

Boiling Point at 10 mm.	Specific Gravity at 15° C.	Optical Rotation °	Refractive Index at 20° C.
123 – 126° C.	0·9152	–53·21	1·4975
129 – 132	0·9175	–59·10	1·5078

Both liquids were quite colourless and mobile.

Fraction 123 – 145° C. of Sample 3/10/20 was treated in the same way with similar results except that the optical activity of the fractions was somewhat lower, being –44·02° and –48·44° respectively.

Neither fractions gave any of the well known derivatives for sesquiterpenes, although the nitrosites were apparently formed at low temperature, but were too unstable to be handled at atmospheric temperature. Both the fractions gave the beautiful colour reactions previously described as characteristic of the sesquiterpene aromadendrene,[1] of which two are as follows:—

(*a*) Bromine vapour allowed to fall upon the surface of an acetic acid solution gave a violet crimson colouration changing to indigo blue.

(*b*) A few drops H_2SO_4 added to a solution in acetic anhydride gave a bright green colouration changing to deep blue on standing.

The constants of the two sesquiterpenes separated correspond remarkably well with those now known for aromadendrene and eudesmene respectively, and for purposes of comparison are arranged in tabular form below:—

	Fraction (1)	Fraction (2)	Aromadendrene*	Eudesmene†
Boiling Point at 10 mm.	123 – 126° C.	129 – 132° C.	124 – 125° C	129 – 132° C.
Specific Gravity at 15° C.	0·9152	0·9175	0·922	0·9204
Optical Rotation	– 53·21°	– 59·10°	± 4·7°	$[a]_D$ +49°
Refractive Index at 20° C	1·4975	1·5078	1·4964	1·5074

* Baker and Smith, "Research on Eucalypts," 2nd Ed., p. 417.
† Semmler and Tobias, Ber. 46, 1913, 2026.

[1] Baker and Smith, "Research on the Eucalypts," p. 417.

Although it is very difficult to separate sesquiterpenes in a high state of purity when their boiling points lie at all close, particularly when the quantity available does not exceed 50 c.c., still they appear to have been separated in as pure a condition as is possible.

As both of them gave similar colour reactions with bromine vapour, halogen and other acids, it was considered only reasonable that the eudesmene would do so even if only a trace of aromadendrene were present as the reactions are so delicate.

Eudesmene, however, was prepared by two methods from pure eudesmol, M. Pt. 79—80° C. $[\alpha]_D$ 20° + 31·07° separated from *Eucalyptus Macarthuri*, and it gave similar constants to those given by Semmler and Tobias, (Ber. 46, 1913, 2026) and Semmler and Risse (Ber. 46, 1913, 2303). Both these preparations gave the identical colour reactions as described for aromadendrene, except that bromine vapour, besides giving the characteristic violet-crimson and indigo-blue colouration, showed a fine brownish fluorescence in reflected light much resembling a gold "sol." These colourations therefore are given by both sesquiterpenes and are not distinctive of aromadendrene alone.

The sesquiterpenes present in the oil are therefore lævo rotatory eudesmene and aromadendrene, and it is remarkable that the rotation of the eudesmene so found naturally, together with dextro eudesmol, should be lævo rotatory when that prepared in the laboratory is dextro rotatory.

Determination of the Sesquiterpene Alcohol.

The residue from the crude oils distilled under reduced pressure, as also the fourth fraction from sample 3/10/20 were spread on porous plates for absorption of adhering sesquiterpenes to take place. After about ten days, the hard cakes were dissolved in alcohol, filtered and recrystallised by addition of water. This was repeated until crystals were obtained of fixed melting point after drying upon porous plates. It formed an exceedingly light and bulky white mass of well developed acicular crystals possessing a silky lustre quite characteristic of eudesmol.

The crystals melted at 79 – 80° C. and boiled at 156° C. at 10 mm. Three samples from different distillations after melting on water bath gave the following specific rotations in chloroform solution:—

0·7825 gram.	in	10 c.c. $CHCl_3$	at 20° C.	$[\alpha]_D$ 20°		+31·95
1·3124	,,	10 ,, $CHCl_3$	,,	,,		+31·62
1·5748	,,	10 ,, $CHCl_3$	,,	,,		+32·06

It is therefore identical with the bicyclic sesquiterpene alcohol (eudesmol) present in the Eucalypts and of the same order of specific rotation as that present in *Eucalyptus Macarthuri.*[1] The saponification number of the oil after acetylation is due to this alcohol.

The oil of *Leptosperum odoratum* consists essentially of the following terpenic bodies:—

Dextro rotatory eudesmol	β Pinene
Lævo rotatory eudesmene	α Pinene
Lævo rotatory aromadendrene	

together with small amounts of a rose odour alcohol, with butyric and acetic acid ester, and phenols, one of which is probably identical with tasmanol.

Besides my previously expressed indebtedness to the author of this species (Mr. E. Cheel) I have also to thank Mr. R. T. Baker, F.L.S., Curator of the Technological Museum, for his interest in the work, and for making available the facilities of the Institution, also to Mr. F. Morrison, Assistant Chemist, for able assistance in working out the composition of the oil and for his kindness in helping to collect portion of the material.

Technological Museum, Sydney.

[1] Baker and Smith, "Research on the Eucalypts," 2nd Ed., p. 379.

EUCALYPTUS OIL GLANDS.

By M. B. WELCH, B.Sc.

With Plates XI – XIV.

[*Read before the Royal Society of N. S. Wales, December 1, 1920.*]

THE literature dealing with the Eucalypts is rather extensive, the species of the genus having received, in recent years much attention, particularly at the hands of systematists, technologists and chemists. The anatomy of the various parts has perhaps been least investigated, and so in this paper it is proposed to give the results of some observations of the oil glands, their contents and structure.

At the present time Eucalyptus oils are receiving much attention in the pharmaceutical, perfumery and general industries and the production of this commodity has attained very large proportions. The prominence which this industry has now reached has led me to investigate the oil *in situ* in the gland itself.

The oil glands, as they are usually termed, occur in the leaves of almost every species but in varying number, reaching perhaps a minimum in the Bloodwoods; *e.g.*, *E. terminalis*, where they are practically non-existent, and a maximum in the leaves of some of our Mallees, *e.g.*, *E. polybractea*, *E. costata* and others. They reach a comparatively large size in leaves with a width of less than 0·5 mm. while yet in bud. These glands also occur in the petioles, young stems, calyx, operculum and even in the fruits. In the case of barks, oil is rarely found, but nevertheless exceptions occur in that of *E. Bridgesiana* and *E. Macarthuri*. An examination of the bark of *E. Macarthuri* was made, but though the odour of geranyl acetate was noticeable in the freshly cut surfaces, no clear evidence of the presence of oil glands has yet been found, the bark being in a very friable condition. The yield from the bark of the latter species amounts to 0·12%.

Although the distribution and number of the glands is not of very great taxonomic value, yet, as pointed out in this paper, certain variations do occur and without doubt hold good throughout the distribution of the species. Again it is quite possible to recognise certain differences in their arrangement which would permit of a rough classification into groups, of which some examples are given.

In *E. hæmastoma*, *E. goniocalyx*, *E. phlebophylla*, *E. Moorei*, etc., the glands are often distinctly flattened in a direction at right angles to the leaf surface and occur only in the palisade tissue, which in these species (isobilateral) is directed towards either surface, and do not encroach on the narrow zone of spongy mesophyll between. In the case of *E. intermedia* and *E. corymbosa* for example, the distribution is somewhat different, the major portion of the gland being found in the spongy mesophyll, and is usually narrower towards the epidermis. In *E. piperita*, *E. aggregata*, *E. hemiphloia*, *E. Smithii*, etc., a type of gland is found which extends right across the leaf section. In *E. robusta* and *E. resinifera* the glands are comparatively large and extend well into the mesophyll but are usually directed towards the upper surface. In *E. maculata*, *E. citriodora*, *E. siderophloia* and others the glands are small and directed towards either surface in approximately equal numbers.

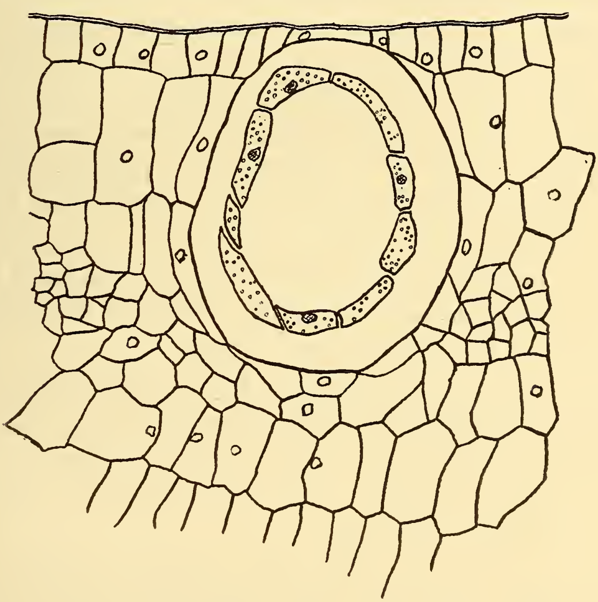
Although in almost every case an oil gland occurs towards the surface of the leaf, the epidermal cells forming the lid of the cavity being usually thinner than elsewhere, this very often does not appear in section. This can be readily understood since the cavity is more or less ovoid and only a section in the median plane will give a complete view of the structure.

In the case of the young leaves of *E. corymbosa*, the oil glands are apparently formed from hypodermal meristematic cells and there appears to be no connection with the outer epidermis. It is in this species that a thin coating of rubber is found enveloping the young leaves, and this may possibly be the explanation, as it is apparent that at this stage of development at any rate, no purpose would be served by the gland discharging at the surface.

The deep-seated glands are characteristic of petioles, *e.g.*, *E. Luehmanniana*, *E. piperita* etc., and also of stems as shown in *E. Luehmanniana.* It is evident that subsequent cell division in the cortical tissues has occurred, thus removing the glands further from the surface in the older petioles and stems. In the very young structures mentioned the glands approached the surface. It is interesting to note that in the petioles of *E. piperita* the deep-seated oil-glands still contained oil, although no means of direct communication with the surface was found.

A cross section of the leaf of any of the well known oil yielding species shows a number of these oil glands, or secretory cavities, in which the essential oil peculiar to the species is found. In section the gland varies in shape from an ellipse with the longer axis either at right angles or even parallel to the leaf surface, to an ovate or circular shape, but perhaps the most common form is that of ovate with the apex directed towards the upper or lower epidermis.

According to Briosi (Anat. Foglie *E. globulus)*, working on *E. globulus* alone, the first stages in the development of the gland are caused by segmentation of an epidermal and a hypodermal cell. The early stages in the formation of the glands, (*E. Smithii* being selected for the purpose) can best be studied in a section of a leaf bud. The gland is then represented by a mass of thin walled parenchymatous cells with dense granular contents. Due partly to increase in size of the leaf, and consequently of the oil gland, the adnate mass of cells separates, forming a hollow ball. Further increase in size causes a breaking away of the central body from the interior walls of the enlarged gland, and disintegration occurs in the innermost cell tissues. Finally the gland is usually seen to be lined with the remains of collapsed cells, evidently caused by the



Highly magnified median section of an oil gland in an intermediate stage of development. The separation of the interior cell mass (in section) from the wall of the cavity is quite pronounced. An extremely thin lid cell is seen at the top of the gland. The groups of small cells on either side of the gland indicate vascular bundles. *Eucalyptus Smithii* R. T. Baker. × 400.

enlarged cavity encroaching on the surrounding parenchyma. It would thus appear that the oil in this case is the outcome of the alteration of the already present cell contents.

There are three methods by which secretory cavities can be formed, namely:—

(1) lysigenous *i.e.*, breaking down of the secretory cells.

(2) schizogenous *i.e.*, separating apart of the secretory cells.

(3) schizolysigenous *i.e.*, a combination of the first two.

Although Haberlandt, (Plant Anatomy, p. 516), and others state that the secretory cavities in the Myrtaceæ are characterised by the schizogenous mode of formation, the evidence of the Eucalypts seems rather to indicate the third method, *i.e.*, schizolysigenous, as far as this genus is concerned. It might be mentioned in passing, that the early gland development in some of the Rutaceæ (which Order Haberlandt (*l.c.*, 516), places in the lysigenous group) shows an apparently identical structure to that found in the early stages of *E. Smithii*. De Bary regarded the Myrtaceous gland as being lysigenous in origin.

Again, according to Haberlandt (*l.c.*, 517), the secretory tissues of a schizogenous gland generally consist of a single layer of glandular cells, which are almost always readily distinguishable from the cells of the adjoining tissues in their form and contents.

Solereder, (Syst. Anat.) does not regard the presence of an epithelium lining the fully developed cavity as being conclusive proof of a schizogenous origin. In the Eucalypts so far examined, (over fifty species) an epithelial layer is not a conspicuous feature.

The discharging mechanism of the gland is also important. Porsch, working on *E. globulus* and *E. pulverulenta* found a cover of a single pair of cells with the outer and inner walls very thin, and the septum between them S shaped and irregularly thickened and pitted. The double celled lid of the gland may perhaps be characteristic of the Eucalypts, but the most striking feature is its want of definition, in this respect differing from the Rutaceæ. In most cases it is not an easy matter to decide which are the "lid cells" and which are typical epidermal structures, an example being *E. piperita*. So far there has been no occasion to consider an S shaped septum as typical, the division between the indefinite "lid cells" being usually straight or slightly curved.

Turning now to the oil in the gland, it would seem that the idea of the oil being present as a single drop, as usually shown in text books, was not altogether justified. The contents as seen are usually contracted in places from the side of the gland, and in some cases the contents are so sparse as to merely form a fringe round the interior of the cavity.

In a number of leaves examined the gland contents appeared to have a fine granular appearance, though in some cases small droplets were also seen. These granules on treatment with alcohol of various strengths coalesced, finally disappearing when the alcohol became sufficiently strong to cause solution of the oil; apparently indicating the presence of an emulsion. As one would expect the percentage of alcohol necessary for complete solution varies in the different species, from 50% in the case of *E. australiana*, *E. Luehmanniana*, etc., to 95% in *E. aggregata*, *E. oleosa* and others.

No matter what metabolic changes give rise to the oil, it is evident that in the first place it must be in an extremely fine state of division, analogous to the formation of a chemical precipitate. The presence of a protective colloid e.g., *a protein body*, would tend to inhibit coalescence of these minute droplets, and this apparently is what occurs. An artificial emulsion of Eucalyptus oil was prepared and stabilised by the addition of a protective body, the magnitude of the particles of the disperse phase being approximately of the same order as those in the oil gland. The addition of dilute alcohol caused a breaking up of the emulsion, in some respects a parallel case to that mentioned above.

The following is a summary of the results obtained by treating, with different strengths of alcohol, sections of the leaves of several of the species:—

E. AUSTRALIANA.

In the majority of cases the cavity was not completely filled, but showed contraction from the sides, or even large bubbles. The addition of 35% alcohol caused the latter to burst and consequent contraction ensued. 50% alcohol sometimes caused the contracted mass to again rupture, when it lined the wall of the gland. Total disappearance occurred in 50 – 70% alcohol.

E. GLOBULUS.

Contents minutely granular, little change occurring up to 80% when small droplets formed. In 90% contraction occurred and the mass became darker in colour, finally going into complete solution in 95%.

E. OLEOSA.

Contents with dark coloured granules and small droplets, the latter running together with 35%. Contraction occurred in 50% and the granules increased in number on standing, but cleared again with additional 50%. In 70% the structure became more densely granular, forming droplets in 85% with slow contraction, and finally disappearing in 95%.

Some glands showed marked contraction with 35%; others did not until 85 – 90% was reached, though the contents varied in granularity, especially under 85%.

E. LONGICORNIS.

Slight contraction occurred in 35%, but little effect up to 85% when contents became densely granular, the whole breaking up in 95%.

E. AGGREGATA.

Some glands showed yellowish contents stretching irregularly across the cavity, some were completely filled, others again contained cellular tissue packed with globules. 30% caused an increase in granularity, which continued up to 70 – 80% when coalescence to form droplets took place. Gradual clearing and contraction occurred in 90% with total disappearance in 95%. In some glands 80% was sufficient for complete solution of the contents.

E. LUEHMANNIANA.

A number of the glands showed no contents, others were completely or partially filled. In a number of cases "bursting" of the contents occurred in 30%. Final solution occurred usually in 50 – 60%.

E. CORIACEA.

Distinct cellular divisions were seen in some glands though the majority were without contents or were irregularly lined with dark substance, (the former case is evidently due to the gland not being in median section). Glands containing cellular tissue in which were dense granules showed clearing up to 60% when only a few globules were left. Those with a fringing of dark material behaved in a similar manner. A few glands were observed with the cavity completely filled with a matrix, but "bursting" usually occurs in 30%, leaving a small residue finally soluble in 70% alcohol.

The observations given are sufficient to indicate the great variability in the behaviour of the oil in the glands under the different species. Variation also occurs even in the one species, for example in the final solubility, thus seeming to indicate differences, within limits, of the oil product.

There are still several interesting and unsolved points awaiting investigation, and these I hope to deal with in a later paper.

In conclusion I wish to record my indebtedness to Mr. R. T. Baker, F.L.S., Curator, Technological Museum, for the great assistance he has given me at all times in collecting the data for this paper.

EXPLANATION OF PLATES.

Plate XI.

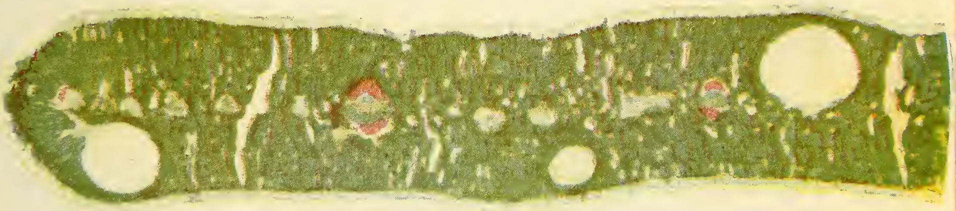
Eucalyptus Moorei Maiden and Cambage.

Cross section of a portion of a mature leaf near the edge. The oil glands are in this species situated towards either epidermis and are confined to the two palisade zones, never extending across the narrow intermediate spongy tissue. The glands are commonly flattened in a direction parallel to the leaf surface. Three prominent bicollateral vascular bundles are indicated by the red stained tissue. × 55.

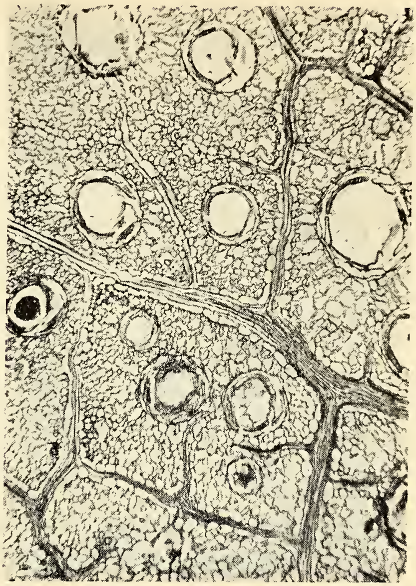
Plate XII.

Eucalyptus Smithii R. T. Baker.

a. Horizontal section of a young leaf below the epidermis, showing arrangement of the oil glands in the leaf tissue. The glands are in various stages of development, and the separation from the interior wall of the cavity of the cells containing the oil in very minute globules, is seen. × 60.

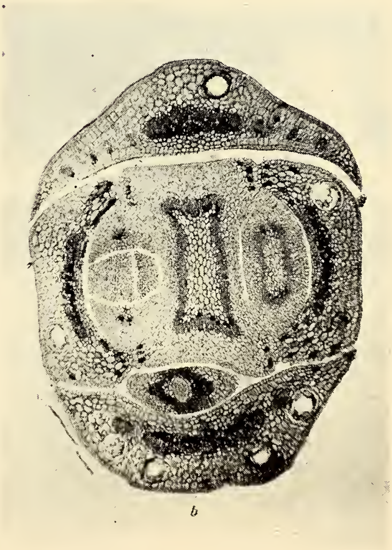


Eucalyptus Moorei. × 55.



a

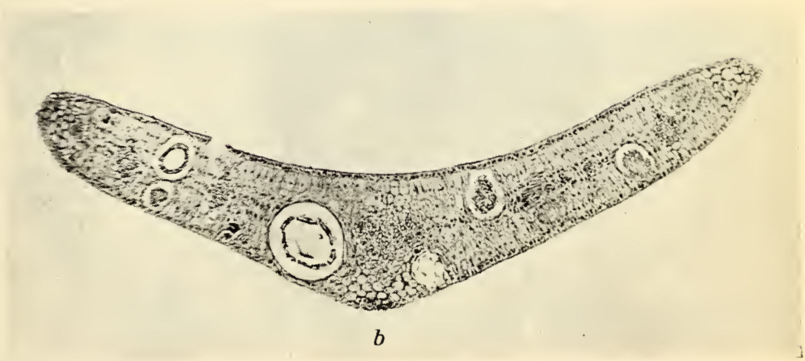
Eucalyptus Smithii. × 60.



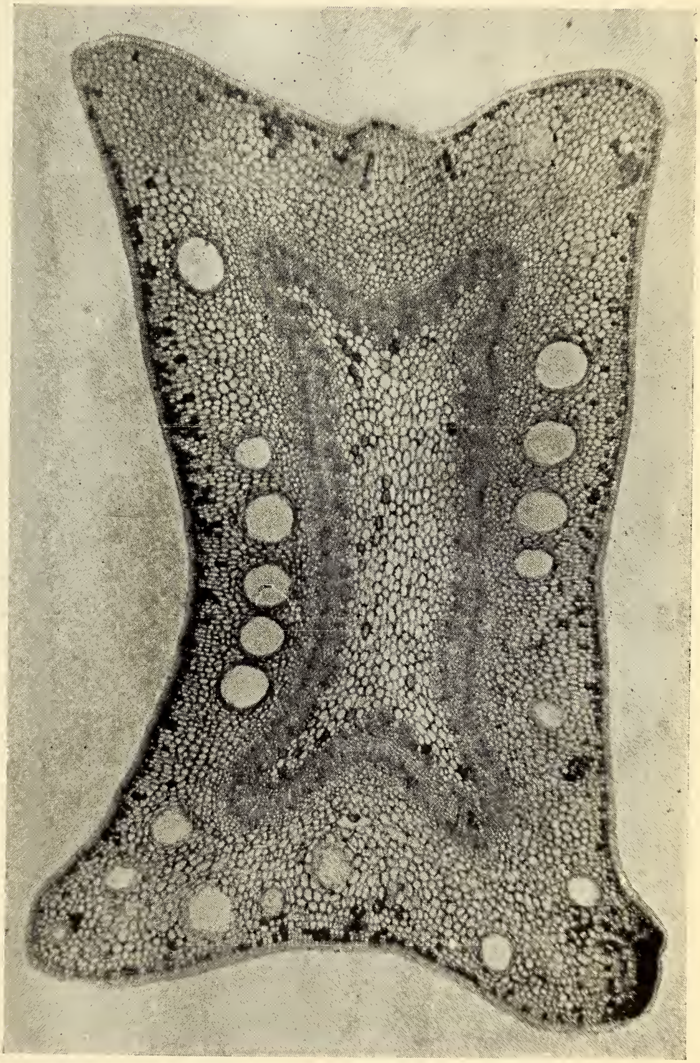
b

Eucalyptus Smithii. × 55.

Eucalyptus Smithii. × 110.



Eucalyptus Smithii. × 65.



Eucalyptus Luehmanniana. × 40.

Eucalyptus Smithii R. T. Baker.

b. Transverse section of a leaf bud, including the young stem, showing oil glands in various stages of the leaf development. × 55.

Plate XIII.

Eucalyptus Smithii R. T. Baker.

a. Cross section of a very young leaf illustrating how important a feature the oil glands are at this stage in its development since such a large amount of space is taken up by them. × 110.

Eucalyptus Smithii R. T. Baker.

b. Transverse section of a young leaf at a somewhat later stage than the preceding figure, the largest cavity represents a comparatively late stage in the development of the gland. The glands are here, as is usual, directed towards either surface. × 65.

Plate XIV.

Eucalyptus Luehmanniana F.v.M.

Transverse section of a young stem showing the deep-seated nature of the oil glands. This is evidently brought about by growth of the stem due to the phellogen. × 40.

Technological Museum, Sydney.

THE TEMPERATURE OF THE VAPOUR ARISING FROM BOILING SALINE SOLUTIONS.

By George Harker, D.Sc.

[*Read before the Royal Society of N. S. Wales, December 1, 1920.*]

The temperature of the vapour arising from a boiling solution has been the subject of much dispute, and even now different opinions appear to be held. Some think that the temperature is substantially the same as that of the solution, others that it is the same as that of the vapour from pure water boiling under the same pressure.

Sakurai in his paper "Determination of the Temperature of Steam arising from Boiling Salt Solutions,"[1] has given a brief historical summary of the views held and the experimental work carried out up to that time. From this it appears that Faraday was the first in 1822 to publish a paper bearing on the question. He found that when the bulb of a thermometer was sprinkled over with a salt and then introduced into steam coming from boiling water, the thermometer showed a higher temperature than 100°. From these experiments Faraday concluded that since a salt solution was heated up to its boiling point by the action of steam at 100° (a fact which was evidently known at that time) the steam generated from a boiling salt solution had only the temperature of 100°. Gay-Lussac on theoretical grounds disagreed with this view as he considered that the vapour must have the same temperature as the liquid with which it is in contact. Faraday then published another paper in which he stated that he had proved Gay-Lussac's assertion to be correct, but that in order to do so he had

[1] Journ. Chem. Soc., 1892, 61, 495.

to use a double-walled vessel which contained the boiling solution not only between the walls but above them, and that he had to heat the thermometer previously to a temperature higher than the solution. Sakurai criticises these experiments adversely, pointing out that as the walls were of highly conducting material, the steam would be heated by them. In fact he says, it can be shown that by keeping the walls of a vessel at 110° the steam issuing from boiling water itself indicates a temperature almost equal to the walls. Rudberg in 1835 published the results of a long series of observations from which he concluded that the temperature of the vapour arising from boiling salt solutions was exactly the same as that from the pure solvent, *i.e.*, 100° under ordinary pressure. Since his time many papers have been published, some holding one view and some another.

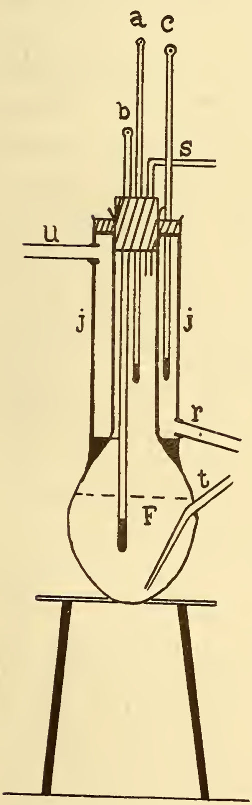


Fig. 1.

In the experiments carried out by Sakurai the solution was boiled in a flask *F* (see Fig. 1) the walls of which, above the level of the solution, were enclosed in a glass cylinder *J J*, so as to form a jacket. This jacket was filled with hot vapour at a slightly lower temperature than the solution, so as to reduce to a minimum radiation losses from the vapour arising from the boiling solution. The vapour was derived by boiling a liquid in a separate flask. It entered the jacket by the tube *u* and passed out by *r* into a condenser. Steam from a separate flask could be blown into the solution through the tube *t*, while the vapour issuing from the boiling solution passed away from the flask through the tube *s*. The corrected thermometers *a*, *b*, and *c* gave the temperatures of the vapour from the boiling solution, the solution itself, and the vapour in the jacket respectively.

The results obtained in a typical experiment are shown below:—

Temperature of the Steam.	Solution.	Amyl alcohol vapour.	Difference in Temperature.	
(I)	(II)	(III)	(II) – (I)	(I) – (III)
127·5	128·3	126·5	0·8	1·0
128·1	128·5	126·8	0·4	1·3
128·6	128·9	127·2	0·3	1·4
129·1	129·2	127·8	0·1	1·3
129·4	129·5	128·1	0·1	1·3
129·7	129·8	128·5	0·0	1·3

In this experiment a strong solution of calcium chloride was employed and amyl alcohol containing a little of the lower alcohols was used for the jacket. The time occupied was about twenty minutes.

From the results of his experiments, Sakurai concluded that he had proved beyond any reasonable doubt that the temperature of the vapour escaping from a boiling salt solution is exactly the same as that of the solution. But although his experiments were carefully conducted the results do not seem to have met with general acceptance; probably owing to the doubt as to whether the vapour arising from the solution did not gain heat from the surrounding jacket. Apparently the temperature of the jacket was always below that of the vapour of the solution (compare cols. (I) and (III) in the above Table), but, on looking into the matter more closely, it is clear that the temperature of the inner wall of the jacket must have been higher than the temperature registered by the thermometor *c*. Although the leading tubes *u* and *t* were lagged to prevent condensation the jacket itself was not lagged. There must have been very considerable condensation and reduction of temperature on the outer wall of the jacket, in fact the conditions were those of air condensation of the vapour. The temperature shown by the thermometer *c* would depend, under these circumstances, upon its position relatively to the inner and outer walls of the jacket, and there could easily be a considerable difference in the temperature of these walls with a vapour at 130° and the outer wall unlagged. The thermometer in the diagram is shown midway between the two walls, so that it is quite possible that the temperature of the inner wall of the jacket was considerably higher than that shown by the thermometer *c*, and that consequently heat may have been supplied by the jacket although the thermometer *c* was lower than *a*. Another drawback to Sakurai's experiments is that the vapour for the jacket was not obtained by boiling a pure liquid. Either acetic acid diluted with water, or amyl alcohol containing a little of the lower alcohols, was used. This was unfortunate, because the temperature of this vapour must have risen gradually as the liquid was distilled.

Although this rise is shown in the experiments quoted, there is no data to indicate how much the temperature of the thermometer *c* was lower than the temperature of the vapour as it left the flask from which it was distilled. In the case of the amyl alcohol it can be assumed, from the fact that it contained a little of the lower alcohols, that it was derived from fusel oil. The main constituent of amyl alcohol from this source, viz. isobutyl carbinol, boils at 131·4°. It is also known that amyl alcohol from fusel oil distils principally between 128° – 132°, so that looking at the above experiment it appears likely, in confirmation of what has already been said, that the thermometer *c* was showing a lower temperature than the temperature of the entering vapour. This of course leaves a doubt as to whether the vapour from the solution was not deriving heat from the jacket, and whether if the experiment had been continued, the temperature of the vapour would not have risen higher than the solution itself, showing definitely that the vapour was being superheated by the jacket.

Seeing that the main point at issue is whether the temperature of the vapour from a boiling solution is or is not higher than the vapour from the boiling pure solvent, it does not seem necessary to prove that the temperature of the vapour is identically the same as that of the boiling solution. If a substantial difference between the temperature of the vapour arising from a boiling solution and from the boiling pure solvent can be established, the main purpose of the enquiry will be achieved.

It is claimed that the experiments now to be described establish this difference in a simple but direct manner. They have been conducted with the view of eliminating any possibility of raising the temperature of the vapour by heat from an outside source, and, while the observed temperature of the vapour has been much below that of the boiling solution, it has been substantially higher than 100°, the temperature of the vapour from the boiling pure solvent water. From the manner in which the experiments were conducted, and owing to the care taken not to add heat, loss of heat from the vapour after leaving the boiling solution was unavoidable, yet in spite of this loss the vapour still showed a temperature much higher than 100°.

The experiments were carried out in a hypsometer kindly lent by Professor Pollock from the Department of Physics of the University. As will be seen from the diagram (Fig.

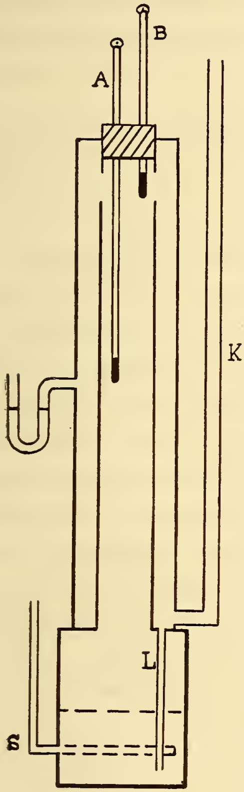


Fig. 2.

2) the vapour arising from the boiling solution passed up the central column, and then down the outside space before entering the condenser tube K, to the top of which a glass condenser was attached. The condensed water was led by a tube L back to the bottom of the hypsometer and thus kept the solution at constant concentration. A brass coil S was inserted in the bottom of the hypsometer in order that steam could be blown in if required. The addition of steam of course altered the concentration. Two thermometers were inserted into the centre column of vapour. The bulb of one A, was just halfway down the column, and was about ten inches above the level of the boiling solution, the other B, was nearer the cork and opposite the passage into the outer space. In the above arrangement the inner column of vapour arising from the boiling solution is jacketed by the vapour outside, which is of course at a lower temperature, so that although radiation losses are minimised, a certain loss of heat from the inner vapour to the outer must take place. There is, therefore, no possibility of the vapour in the outer jacket supplying heat to that in the centre column. Superheating of the vapour in the jacket was effectually prevented by placing the hypsometer on a large piece of asbestos cardboard, provided with a small hole in the centre through which the flame of the bunsen burner impinged on the bottom of the hypsometer. There is still the possibility that heat may have been con-

ducted from the boiling solution to the metal surrounding it, and so to the metal cylinder separating the inner column of vapour from the outer.

However, the presence of water running continuously from the condenser ensured that the bottom portion of the jacket contained saturated water vapour at a temperature certainly not higher than 100°. The presence of even a trace of water on the walls of the inner column always prevented the thermometer *A* from rising above the temperature of the vapour of the pure solvent. In the early stages of the boiling of the solution the thermometer *A* usually remained quite stationary for ten minutes or more, at the temperature of the vapour of the pure solvent, although the solution was boiling vigorously all the time. It would then rise showing that all trace of water had disappeared from the walls of the centre column. It is, therefore, certain that the presence of water in the lower portion of the jacket effectually prevented conduction of heat from the solution through the metal walls of the jacket. The thermometers used were corrected in the hypsometer in the usual way by boiling distilled water. The results of a typical experiment follow. The solution

Time.	Thermometer *A*. ° C.	Thermometer *B*. ° C.	Remarks.
10·35		...	Started.
10·39		...	Solution boiled.
10·43	99·9	...	
10·48	99·9	99·0	
10·50	101·0	99·2	
11·0	104·5	100·4	
11·6	105·5	100·4	
11·14	105·3	101·0	
11·20	106·0	103·2	
11·26	106·0	103·8	

employed in this case was made by dissolving 220 grams of anhydrous calcium chloride in 400 grams of water and boiled normally at 115° C.

A maximum difference of 6·1° C. was obtained. A barometric reading confirmed 99·9° C. as the boiling point of the pure solvent.

In his paper Sakurai mentions that he obtained a very much greater elevation of temperature in the vapour arising from the boiling solution, when he passed steam into the flask owing to the fact that there was a greater volume of vapour arising from the solution, and consequently less relative loss of heat by radiation. Steam was admitted in some experiments but made very little difference to the temperature of the vapour. It was thought of interest, however, to see what would result on boiling the solution by steam alone in the absence of the bunsen flame. The figures obtained in such an experiment are given below, and it is to be understood that the operations in the fourth column were carried out immediately following the taking of the readings placed opposite them. The solution used was more dilute than in the previous experiment and boiled at 110·4° C.

Time.	Thermometer *A.* ° C.	Thermometer *B.* ° C.	Remarks.
1·30	103·2	100·2	
1·34	103·2	100·2	Steam admitted.
1·35	103·6	101·0	
1·37	103·5	102·0	Removed flame also condenser
1·39	103·1	101·6	
1·42	102·8	101·6	Steam shut off, flame and condenser replaced
1·44	102·4	101·2	
1·51	102·7	101·6	

The admission of steam only raised the temperature from 103·2° to 103·6°. It immediately began to fall owing to dilution of the solution. The bunsen flame was then removed, and with it the condenser, in order to prevent too rapid dilution of the solution. The vapour arising from the solution still remained well above the temperature of 100° C. Its temperature gradually fell but that this was due to the dilution of the solution was proved by shutting off the steam, replacing the condenser, and boiling again by the bunsen flame. In a few minutes the thermometers *A* and *B* showed the same readings as were obtained just before the steam was shut off. This experiment was of interest, because it showed that the bunsen flame was not causing superheating.

The results obtained prove that the vapour arising from a boiling solution has a higher temperature than the vapour from the boiling pure solvent. Since in these experiments the vapour was cooled after it left the solution, there can be little room for doubt but that it leaves the solution at the same temperature as the boiling solution itself. It is therefore steam in an unsaturated condition.

NOTES ON TWO ACACIAS.

By J. H. Maiden, I.S.O., F.R.S., F.L.S.

[*Read before the Royal Society of N. S. Wales, December 1, 1920.*]

1. A form or race of *A. pycnantha* Benth.; or a new species, for which the name of *A. Westoni* is proposed.

I desire to invite attention to an Acacia which I have had under attention for several years, and which I believe has certain characters which sufficiently distinguish it from *A. pycnantha* Benth., but examination of the leaves (mature phyllodia) and floral organs on which descriptions of species are usually based, fails to disclose differences of sufficient importance for the ordinary detailed description. It is in regard to other characters, which I shall bring forward, that the necessity (in my view) for naming this Acacia has arisen.

The following is an unpublished translation of the original description of *A. pycnantha* Benth., in Hooker's London Journ. Bot. i, 351 (1842).

"Very glabrous, shining, branchlets terete, phyllodes elongate-falcate, obtuse or somewhat acute, gradually narrowed at the base into a petiole, coriaceous, marginate with a rather large gland removed from the base, racemes flexuose pleiocephalous, shorter than the phyllode, heads very dense, more than 70-flowered, calyx a little shorter than the corolla, ovary hispidulous. Affinity is *A. leiophylla*, easily to be distinguished by flowers often almost 100 in the head, corollas shortly prominent out of the ciliate calyx. Interior of New South Wales, Mitchell."

I have never seen the type. Bentham, who describes his own species more fully in B.Fl. ii, 365, neither mentions the type, nor New South Wales. He quotes Victoria comprehensively, and there seems but little doubt that what he meant in 1842 as New South Wales referred to Victoria before the separation, and Mitchell's route through Victoria in 1836 would enable the modern botanist to pick up a very close approximation to the type.

Habitat—The habitat of *A. Westoni* is the northern and western slopes of Mount Jerrabomberra, near Queanbeyan and within the Federal Territory, vide plan (not reproduced). The altitude is 1950 to 2400 feet above sea level. The area of distribution is approximately 2000 acres. The nature of the soil is sandstone of very fine texture at the higher levels, on the lower levels the soil is of the nature of a clay-loam formed in large measure from an overlying fractured shale.

Size—Twelve of the largest at three feet from the ground gave an average girth of 24·396 inches. Six of these were above twenty-five inches and six below. Their height is twelve to fifteen feet. A few of the best specimens are fully eighteen feet. The best specimens are invariably found on the lower levels. The great mass of trees are upon the higher portions of the mount. This no doubt is in great measure due to the fact that here the country is unimproved, whereas upon the lower places grazing has been in full swing for many years.

The other trees observed in the area are *Acacia dealbata*, *A. diffusa* (?), *A. rubida*, *A. decurrens* var. *mollissima*. Of the above, *A. diffusa* (?) is by far the most numerous. The other species are represented by a few specimens only. Also *Eucalyptus macrorrhyncha*, *E. polyanthemos*, *E. melliodora*, *E. tereticornis* (?), *E. Stuartiana* and *E. maculosa*. Of these *E. macrorrhyncha* is the predominating species.

A sample of the bark has been analysed with the following result:—

Moisture...	...	...	...	12·0%
Extractive matter		...	...	38·6%
Soluble solids	...	...	...	35·4%
Non-tannins	...	...	...	13·8%
Tannins ...	...	...	...	21·6%

The bark was analysed according to the current methods adopted by the American Leather Chemists' Association—vide Journal, Vol. XI, November 1916. (Sgd) W. Percy Wilkinson, Commonwealth Analyst, 18th April, 1918.

Seedlings—Because of the affinity of this species to *A. pycnantha*, I appealed to Mr. R. H. Cambage, who is doing such admirable work on Acacia seedlings, to compare them. He favours me with the following reports (he has referred to it at p. 149 of the present volume).

1. "The seedlings of the Jerrabomberra Wattle (Queanbeyan) are now 6 or 8 inches high. . . Neither do they appear to be *A. pycnantha*, though the phyllodes somewhat resemble them. The internodes of *A. pycnantha* are remarkably short, while those of this new (?) species are definitely long." (18th October, 1918).

2. "I regard *Acacia pycnantha* and the Jerrabomberra Wattle as separate species. The internodes of the seedlings of the Wattle (*A. Westoni*) are longer than those of *A. pycnantha*, and although the gland is not a truly specific character it is very helpful in this case, for while the latter appears to have only one, and that near the base, the new Wattle may have three glands along the upper margin of the phyllode," (30th June, 1919).

3. "In "Acacia Seedlings" Part VI (this Journal, Vol. LIV, p. 149), I mention, when writing about glands on seedling leaves, that glands may occur on the first or simply pinnate leaf of *A. Westoni*, but I have not seen them on the first leaves of *A. pycnantha*." (18th October, 1920).

Mr. C. J. Weston, Afforestation Officer at Canberra, whose name I desire to identify with this interesting plant, writes under date 6th October, 1920, "The exasperating thing about this beautiful Acacia is that we cannot keep it alive through an ordinary winter, either in the nurseries or their immediate surroundings, owing to its susceptibility to frost. The same thing holds good in the case of the South Australian form of *Acacia pycnantha*.

"Here we have a tree growing and flowering profusely on the N. and N.W. slopes of Mount Jerrabomberra, but when we take it to the nurseries, distant some eight miles and approximately 200 to 250 feet lower in altitude, it proves a dismal failure. Thousands of seedlings have been raised, but the story every winter has, so far, been the same. No doubt many will yet prove hardy in sheltered situations."

At the same time we require further observations. When I was in the Federal Territory in July 1919, I made some imperfect notes in regard to young plants. "*A. Westoni* has a greater resistance to cold, *A. pycnantha* only exceptionally standing in the district. *A. pycnantha* is not a third of the size of *A. Westoni* in the same time in the nursery."

I have brought under notice an interesting matter in regard to the amount of variation permissible in a species, and realize that the last word is not yet said on the subject.

2. Acacia granitica n. sp.

Frutex patens, deinde erectus, glaber. Phyllodiis linearibus ad 2 dm. longis, 3 mm. latis, basi glandula, crassiusculis, nervis numerosis tenuibus parallelibus. Spicis sessilibus geminis ovatis vel sub-cylindraceis, 15 mm. longis, 7 mm. latis. Calyce hemispherico sinuato-dentato corallam minus dimidio æquante, brevibus pilis sparse tectis. Ovario dense piloso. Leguminibus ad 1 dm. longis, 5 mm. latis, paullo moniliformibus. Seminibus elongatoovoideis, longitudinaliter dispositis, funiculo in arillum irregularem expansum terminante

A spreading shrub growing in fissures of granite rock, but it may assume an erect habit and become 10 feet high. Glabrous, branchlets at first acutely angular, but soon terete. Phyllodia linear, slightly falcate, shortly acuminate, up to 2 dm. long, 3 mm. broad, slightly narrowed towards the base, a small gland at the base; rather thick, with numerous fine parallel nerves, three being most prominent. Spikes sessile or very shortly pedunculate, in pairs, ovate or sub-cylindrical, 15 mm. long, 7 mm. broad. Flowers mostly 5-merous. Calyx hemispherical, sinuate-toothed, not half as long as the corolla, well-besprinkled with short hairs. Petals besprinkled with hairs over the upper third. Ovarium densely hairy. Pods up to 1 dm. long, 5 mm. broad, slightly moniliform. Seeds elongate-ovoid, longitudinally arranged, brownish-black, shiny, with a well defined areola; funicle at first thread-like and after several folds terminating in an irregular expanded arillus.

Synonym.

Acacia doratoxylon A. Cunn., var. *ovata* Maiden and Betche in Proc. Linn. Soc. N.S.W., xxx, p. 362 (1905).

Range.

On the New England table-land, both in New South Wales and Queensland. Also on the Darling Downs, Queensland. Apparently always on granite.

New South Wales.—Howell, near Tingha, on granite rocks, capping the tops of many hills, growing in dense masses along the fissures of the rocks, forming in many places almost the only vegetation of the bare rocks. (J.H.M. and J. L. Boorman, 1904). Mr. Boorman, visiting Howell in 1914, said "Usually low spreading on exposed granite rocks, but some are more upright, up to 6 – 10 feet high in better conditions. A fairly common plant in the granite country of New England."

Bismuth, near Deepwater (A. McNutt). Wallangarra, Queensland border (J. L. Boorman).

Queensland.—Stanthorpe (J. L. Boorman). Stanthorpe, as *A. doratoxylon* var. (?) (F. M. Bailey through C. T. White).

Crow's Nest, a little north-east of Toowoomba, on granite, common (Dr. F. Hamilton Kenny, through C. T. White).

Affinity.

1. With *A. doratoxylon* A. Cunn.; and particularly with var. *angustifolia* Maiden, this Journ. LIII, p. 217.

It differs in its habit, smaller size; in the short, sessile spikes, which are axillary and not racemose; in the hairy ovarium.

NOTES ON LEPTOSPERMUM FLAVESCENS Sm., var. GRANDIFLORUM Benth.

By Edwin Cheel.

Read before the Royal Society of N. S. Wales, December 1, 1920.

In defining this from the normal species *L. flavescens*, Bentham[1] gives the following description:—"Leaves rather large. Flowers larger than in any other variety." The habitat given is Parramatta (Woolls), Blue Mountains (A. Cunningham), and Tasmania (C. Stuart).

It is of special interest to note that *L. grandiflorum* Lodd. Bot. Cab. tab. 514 (1821) together with *L. nobile* F.v.M. and *L. virgatum* Schau., are quoted as synonyms.

When we refer to Loddige's work for particulars as to where his material came from, we find the following are given, viz., "A very fine species, a native of Van Dieman's Land; it grows to about two feet in height, the branches are angular, and the leaves, which are obscurely 3-nerved have a twist at their insertion, which causes them to stand edge-ways. The flowers are an inch in diameter, are membranaceous, and being placed one between each petal, add much to the beauty of the flower; the style and germen were wanting in some of the flowers of our plant."

It might be gathered from the above remarks that the original material from which the drawing was made came from Tasmania, but although the illustration somewhat resembles some of the forms of what we regard as the var. *grandiflorum*, it is not possible to give a decisive determination, especially as we have no specimens of either typical

[1] Fl. Aust. iii, p. 105 (1866).

L. flavescens or the var. *grandiflorum* from a Tasmanian locality in the National Herbarium which includes a fairly complete collection made by Hooker, Gunn, and others in Tasmania.

We have an abundance of herbarium specimens of what may be regarded as var. *grandiflorum* Benth. in the National Herbarium, which are usually found in the beds of creeks, from the following localities:—Kangaroo Creek, National Park, J. H. Camfield, December, 1898; Helensburgh, J. H. Camfield, January 1899; Jervis Bay, J. H. Maiden (in fruit) July, 1899; Macquarie Fields, A. A. Hamilton, December, 1912; Nepean River, E. Cheel, December, 1919; Menangle, A. A. Hamilton (in fruit) April 1912; Douglas Park, A. A. Hamilton, December, 1915; Bargo River viâ Hill Top, E. Cheel, December, 1911; Mittagong to Jellore, E. Cheel, March 1916; Nattai River, E. Cheel, November, 1911; Robertson (top of Macquarie Pass) J. H. Maiden, November, 1905 and Fitzroy Falls to Nowra, E. Cheel, June 1919.

In examining this material, either in the field or in the herbarium there is no difficulty in separating it from the typical forms of *L. flavescens* Sm., but there is some superficial resemblance to *L. citratum* Chal. Cheel and Penf., and to another form which seems to belong to *L. Petersoni* Bail. When critically examined, there is no difficulty in separating it from *L. citratum*, but it remains to be seen if *L. Petersoni* of Bailey and the var. *grandiflorum* of Bentham are really distinct.

It is of special interest to note that *L. grandiflorum* Lodd., is upheld as a distinct species in Walper's Rep. Bot. System Tom. ii, p. 168 (1843), and that two other synonyms are quoted, namely, *L. brevifolium* Wendl. fil. in Otto et Dietr. Allgem. Gartenzig, i, 186, and *L. obtusum* Lodd. Cat. ex G. Don in Lond. Hort. Brit. 195, with the following description:—"Foll. obovatis spathulatisve emarginatis v. apice rotundatis, 3-basi 5-nerviis punctatis glabris; calycib. glabris, dentib. membranaceis coloratis deciduis." The two latter synonyms are not mentioned by Bentham, but according to Index Kewensis *L. obtusum* is = to *L. flavescens*, whilst *L. brevifolium* is = to *L. buxifolium* Wendl. (Non Dehr.), which is = to *L. flavescens.*

From the description given in Walper *l.c.*, it would appear that *L. grandiflorum* of Lodd is very closely allied to *L. emarginatum* Wendl. (*L. obovatum* Sweet), especially as the two species are placed in section Spathulata under subsection Emarginata.

It is rather difficult to say at present what *L. grandiflorum* of Loddiges really is, and until we are able to clear the matter up, as to whether the species is to be found in Tasmania it will be advisable to refer the specimens from the above mentioned localities, to the var. *grandiflorum* of Bentham, notwithstanding the fact that I regard them abundantly distinct from *L. flavescens* and worthy of specific rank.

Mr. A. R. Penfold has procured a quantity of leaves from plants growing in the bed of the Nattai River via Hill Top, also some material of the typical *L. flavescens* from the neighbourhood of Hill Top for distillation, and I feel there will be no difficulty in proving these to belong to two distinct species.

ABSTRACT OF PROCEEDINGS

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OF THE

Royal Society of New South Wales.

MAY 5TH, 1920.

The Annual Meeting, being the four hundred and twelfth General Monthly Meeting of the Society, was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Dr. R. Greig-Smith, Acting-President in the Chair.

Fifty-four members and five visitors were present.

The minutes of the General Monthly Meeting of the 3rd December, 1919, were read and confirmed.

The certificates of thirteen candidates for admission as ordinary members were read: four for the second and nine for the first time.

Messrs. A. A. Hamilton and G. I. Hudson were appointed Scrutineers, and Mr. C. A. Sussmilch deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society, Frederick Cooke, Eustace William Ferguson, William John Kirchner and Arthur Hamilton Tebbutt.

The Annual Financial Statement for the year ended 31st March, 1920, was submitted to members, and on the motion of Professor Chapman, seconded by Mr. R. T. Baker, was unanimously adopted :—

GENERAL ACCOUNT.

Receipts.	£	s.	d.	£	s.	d.
To Balance, Cash on hand and at Bank, 1st April, 1919				16	2	5
,, Subscriptions—						
Annual				601	13	0
,, Rents—						
Offices	312	5	0			
Hall and Library	88	10	0			
				400	15	0
,, Sundry Receipts				27	17	10
,, Government Subsidy for 1919				399	19	10
,, Clarke Memorial Fund—						
Amounts received to date				50	0	0
				£1496	8	1

Payments.	£	s.	d.	£	s.	d.
By Salaries and Wages—						
Office Salary and Accountancy Fees ...	191	15	0			
Assistant Librarian	48	0	0			
Caretaker	164	19	9			
				404	14	9
,, Printing, Stationery, Advertising, Stamps, etc.—						
Stamps and Telegrams	51	18	2			
Office Sundries, Stationery etc.	8	8	4			
Advertising	14	9	0			
Printing	94	2	6			
				168	18	0
,, Rates, Taxes and Services—						
Electric Light	27	11	10			
Gas	9	9	9			
Insurance	23	11	0			
Rates	161	0	0			
Telephone	10	0	1			
				231	12	8
,, Printing and Publishing Society's Volume—						
Printing, etc....	322	5	0			
Bookbinding	56	16	9			
				379	1	9
,, Library—						
Books and Periodicals				88	6	10
,, Sundry Expenses—						
Repairs...	31	14	3			
Lantern Operator (Rent of Lantern) ...	9	7	6			
Bank Charges...	2	10	4			
Sundries	34	15	4			
				78	7	5
Carried forward				1351	1	3

PAYMENTS—*continued.*	£	s.	d.	£	s.	d.
Brought forward				1351	1	3
By Building and Investment Fund—						
Interest on Mortgage				126	10	0
,, Balance—						
Credit Balance at Union Bank of Australia	17	15	1			
Cash on Hand	1	1	7			
				18	16	8
				£1496	8	1

Compiled from the books and accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

HENRY G. CHAPMAN, M.D., *Honorary Treasurer.*

W. PERCIVAL MINELL, F.C.P.A.,

SYDNEY, 7TH APRIL, 1920. *Auditor.*

BUILDING INVESTMENT LOAN FUND.

BALANCE SHEET AS AT 31ST MARCH, 1920.

LIABILITIES.	£	s.	d.
Loan on Mortgage—			
Amount due to the Australasian Association Advancement of Science	2300	0	0
	£2300	0	0

ASSETS.	£	s.	d.	£	s.	d.
Cash, Government Savings Bank				179	0	0
Commonwealth War Loan				200	0	0
Balance as at 31st March, 1919	1935	15	0			
Less: Interest received during the year ..	14	15	0			
				1921	0	0
				£2300	0	0

STATEMENT OF RECEIPTS AND PAYMENTS, 31ST MARCH, 1920.

RECEIPTS.	£	s.	d.	£	s.	d.
To Balance, 31st March, 1919, Government Savings Bank				264	5	0
,, Interest—Commonwealth War Loan... ...	4	15	0			
Government Savings Bank	10	0	0			
				14	15	0
,, Amount received from General Fund... ...				126	10	0
				£405	10	0

Payments.	£ s. d.
By Interest paid to the Australasian Association Advancement of Science	126 10 0
,, Commonwealth Peace Loan	100 0 0
,, Balance, Government Savings Bank	179 0 0
	£405 10 0

Bookbinding Fund, 31st March, 1920.

Liabilities.	£ s d.
Accumulation to 31st March, 1918	87 10 0
Assets.	
War Saving Certificate	87 10 0

CLARKE MEMORIAL FUND.

Balance Sheet, 31st March, 1920.

Liabilities.	£ s. d.	£ s. d.
Accumulation Fund—		
Balance as at 31st March, 1919		702 7 10
Additions during the year—		
Interest Savings Bank of N.S.W. ...	1 1 0	
,, Government Savings Bank ...	0 2 2	
,, Commonwealth Savings Bank	0 15 7	
,, Commonwealth War Loan ...	32 10 0	
		34 8 9
		£736 16 7

Assets.	£ s. d.	£ s. d.
Commonwealth War Loan...		600 0 0
Cash Savings Bank of N.S.W.	29 9 1	
,, Commonwealth Savings Bank	27 15 1	
,, Government Savings Bank	29 12 5	
		86 16 7
Loan to General Account		50 0 0
		£736 16 7

Statement of Receipts and Payments, 31st March, 1920.

Receipts.	£ s. d.	£ s. d.
To Balance 31st March, 1919.		
Savings Bank of N.S.W.	28 8 1	
Government Savings Bank...	47 0 3	
Commonwealth Savings Bank	26 19 6	
		102 7 10
Carried forward		102 7 10

	£	s.	d.	£	s.	d.
Brought forward				102	7	10
To Interest to date—						
Savings Bank of N.S.W.	1	1	0			
Government Savings Bank...	0	2	2			
Commonwealth Savings Bank	0	15	7			
War Loan	32	10	0			
				34	8	9
				£136	16	7

PAYMENTS.	£	s.	d.	£	s.	d.
By Loan to General Fund				50	0	0
,, Balance at date—						
Savings Bank of N.S.W.	29	9	1			
Commonwealth Savings Bank	27	15	1			
Government Savings Bank	29	12	5			
				86	16	7
				£136	16	7

On the motion of Mr. W. Poole seconded by Mr. R. W. Challinor, Mr. W. P. Minell was duly elected Auditor for the current year.

The Annual Report of the Council (see pp. 25 – 36) was read, and on the motion of Mr. R. H. Cambage, was adopted. In addition the following particulars are recorded:—

During the Society's year there have been eight monthly meetings and nine ordinary and one special Council meeting.

A Clarke Memorial Lecture entitled "Geology at the Western Front," was delivered by Professor T. W. Edgeworth David, C.M.G., D.S.O., F.R.S., on August 21st, 1919.

Four Popular Science Lectures were given, namely:—

July 17—"The Romance of Silver-lead in Australia," by Mr. W. M. Poole, B.E., A. M. Inst. C.E.

September 18—"Science in Breadmaking," by Professor H. G. Chapman, M.D.

October 16—"The Causes of Earthquakes," by Mr. L. A. Cotton, M.A., B.Sc.

November 20—"Temperature: Its Control and Measurement," by Mr. W. M. Hamlet, F.I.C., F.C.S.

Owing to the illness of Professor S. J. Johnston, the lecture which stood in his name for June 19th, "On the Ectoparasites of Man," was not delivered.

On October 7th, 1919, a dinner was given by the Society at the Burlington, 324 George Street, to those members who had returned from active service at the front, and we were honoured by the company of His Excellency the Governor General Sir Ronald Craufurd Munro Ferguson.

The Acting-President announced that the following Popular Science Lectures would be delivered this Session:

June 17th—"The Ectoparasites of Man," by Professor S. J. Johntson, B.A., D.Sc.

July 15th—"The Romance of Broken Hill," by Mr. E. C. Andrews, B.A., F.G.S.

August 19th—"Bovine Tuberculosis and the Necessity for its Repression," by Professor J. D. Stewart, B.V.Sc., M.R.C.V.S.

September 16th—"Einstein's Theory of Space and Time," by Mr. E. M. Wellish, M.A.

It was announced that the following members had died during the recess:—Mr. R. Etheridge, Mr. Edward Noyes and Sir Thomas Anderson Stuart.

Letters were read from Mr. N. Etheridge, Mrs. Noyes and Lady Anderson Stuart expressing thanks for the Society's sympathy in their recent bereavements.

In pursuance of a previous notice of motion, Mr. A. B. Hector moved:—"That the time is now opportune to consider the advisability of obtaining for the Royal Society of New South Wales, more commodious and up-to-date premises, so as to have ample room for the proper housing of the library, and more room and better facilities for the social intercourse of its members."

This was seconded by Mr. A. D. Ollé and supported by the following members:—Messrs. W. Poole, T. H. Houghton, W. Welch, R. W. Challinor, Dr. G. Harker, Professor H. G. Chapman, Dr. R. K. Murphy, Judge Docker and Professor T. W. E. David.

The motion was carried unanimously.

The following donations were laid upon the table:—227 parts, 31 volumes and 16 reports.

At the request of the Council, Mr. J. H. Maiden, I.S.O., F.R.S., delivered a lecturette, illustrated by means of lantern slides, on the Landing of Captain Cook and Sir Joseph Banks in Australia, with special reference to the action of the first scientific Society in Australia, the Philosophical Society of Australasia, in placing a brass tablet at Kurnell in honour of these illustrious scientific explorers.

As more than the necessary number of members of Council had been nominated, a ballot was taken, after which the Acting-President declared the following gentlemen to be officers and Council for the coming year:—

President:

J. NANGLE, F.R.A.S.

Vice-Presidents:

T. H. HOUGHTON, M. INST. C.E.
J. H. MAIDEN, I.S.O., F.R.S., F.L.S.
W. S. DUN.
Prof. T. W. EDGEWORTH DAVID, C.M.G., D.S.O., F.R.S.

Hon. Treasurer:

Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries:

R. H. CAMBAGE, F.L.S.
J. A. POLLOCK, D.Sc., F.R.S.

Members of Council:

C. ANDERSON, M.A., D.Sc.
E. C. ANDREWS, B.A., F.G.S.
R. GREIG-SMITH, D.Sc.
CHARLES HEDLEY, F.L.S.
F. H. QUAIFE, M.A., M.D.
Prof. J. READ, M.A., PH.D., B.Sc.
H. G. SMITH, F.C.S.
C. A. SUSSMILCH, F.G.S.
J. VICARS, M.E.
Prof. W. H. WARREN, LL.D., WH.Sc.

The Acting-President then installed Mr. James Nangle, F.R.A.S., as President for the ensuing year, and the latter expressed his appreciation of the honour conferred upon him.

On the motion of Professor H. G. Chapman, a cordial vote of thanks was passed to Dr. R. Greig-Smith, both for his services as Acting-President since December 1919, and for his efforts to further the best interests of the Society.

JUNE 2ND, 1920.

The four hundred and thirteenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. James Nangle, President, in the Chair.

Thirty-two members and nine visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of eleven candidates for admission as ordinary members were read: nine for the second, and two for the first time.

Messrs. A. J. Sach and W. Welch were appointed Scrutineers, and Mr. E. C. Andrews deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—Edgar Harold Booth, Hon. Sir Joseph Carruthers, Herbert Henry Hinds, Edward William Hulle, James Campbell McDowall, Robert Jackson Noble, Arthur Ramon Penfold, Marcus Baldwin Welch, and Edward Montague Wellish.

The President announced that it had been decided to present an address of loyalty and welcome to His Royal Highness the Prince of Wales on the occasion of the visit of His Royal Highness to Sydney. The following is a copy of the Address:—

To His Royal Highness, Edward Albert Christian George Andrew Patrick David, Prince of Wales, Earl of Chester in the Peerage of England, Duke of Rothesay, Earl of Carrick and Baron of Renfrew in the Peerage of Scotland, Lord of the Isles and Great Steward of Scotland, K.G., P.C., G.M.M.G., G,M.B.E., M.C.

May it please Your Royal Highness—

We, the Members of the Royal Society of New South Wales, a daughter society of the illustrious mother society, which has so long enjoyed the privilege of Royal patronage, desire to approach Your Royal Highness with our most respectful and cordial greetings on the occasion of this the first visit of Your Royal Highness to Australia.

This visit, momentous in the History of our Commonwealth, will assuredly make for that advancement of knowledge for which our Society exists, and which is so essential to human progress, and will ever be memorable for strengthening the sympathy, loyalty and affection between the Motherland and this country.

We further desire to express the hope that this visit to Australia will hold for Your Royal Highness many pleasant memories, and we tender to you our earnest wishes for your health and happiness now and always.

Signed on behalf and in the name of the Royal Society of New South Wales.

(Signed) James Nangle,
President, 1920.

It was announced that the Society would hold a conversazione early in September, provided portion of the University building would be available for use on that date.

The following donations were laid upon the table:—92 parts, 2 volumes, and 4 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Action of Cupric Chloride on Organo-metallic Derivatives of Magnesium," by E. E. Turner, M.A., M.Sc., A.I.C. This paper was read by Professor J. Read in the absence of Mr. Turner.

2. "On the manufacture of Thymol, Menthone and Menthol from Eucalyptus Oils," by H. G. Smith, F.C.S., and A. R. Penfold, F.C.S. Remarks were made by Professor Read, Mr. A. B. Hector and Dr. R. Greig-Smith.

3. "A new species of Queensland Ironbark," by R. H. Cambage, F.L.S. Remarks were made by Mr. R. T. Baker.

The President tendered a cordial welcome to Dr. A. P. Newton, Rhodes Professor of Imperial History in the University of London.

EXHIBITS:

1. Mr. E. C. Andrews exhibited a facetted, ice-scratched boulder weighing about 120 lbs. found by Mr. L. J. Jones and himself in Permo-Carboniferous formation about five miles north-west of Gulgong, being the first glacial boulder recorded from this locality.

2. Mr. A. A. Hamilton exhibited from the National Herbarium, examples of the contorted "Teasel" *Dipsacus sylvestris torsus* grown by Professor De Vries in the Botanic Gardens at Amsterdam, which formed part of the evidence advanced in favour of his theory of mutation. "Species and Varieties: their origin by Mutation. Hugo De Vries, p. 402."

   A flower-head (capitulem) of the "Fuller's Teasel," used by woollen cloth manufacturers to give a "nap" to fabrics.

JULY 7TH, 1920.

The four hundred and fourteenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. T. H. Houghton, Vice-President. in the Chair.

Thirty-five members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of six candidates for admission as ordinary members were read: two for the second and four for the first time.

Messrs. A. E. Stephen and H. V. Bettley-Cooke were appointed Scrutineers, and Mr. C. Hedley deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—Ernest Thomas Fisk and William Horace Paine.

A letter was read from the Secretary to His Royal Highness the Prince of Wales in reference to the address of loyalty and welcome recently presented by this Society, and the Secretary stated that His Royal Highness much appreciated the splendid work done by the Royal Society and sent all its members his best wishes.

THE FOLLOWING PAPERS WERE READ:

1. "On *Aprophyllum Hallense*, gen. et sp. nov. and *Lithostrotion* from neighbourhood of Bingara, N.S.W.," by Stanley Smith, M.A., D.Sc, F.G.S., (communicated by Prof. W. N. Benson, D.Sc., F.G.S.). Remarks were made by Mr. Maiden.

2. "Descriptions of three new species of Eucalyptus," by J. H. Maiden, I.S.O., F.R.S. Remarks were made by Mr. Hector.

EXHIBITS:

1. Mr. R. H. Cambage exhibited two small dead branches of *Eucalyptus coriacea* from the tree line at 6,500 feet on Kosciusko, which showed the dominating effect of the westerly aspect, the western sides of the branches being worn smooth and white while the eastern sides still retained the bark.

2. Mr. E. C. Andrews exhibited some pebbles from Mount Drysdale, near Cobar, which had been elongated by earth pressure.

3. Mr. A. B. Hector exhibited a coloured diagram, and spoke of analogies existing among various physical phenomena.

Mr. R. W. Challinor made reference to certain trees of *Platanus orientalis* near the Sydney Railway Station which were retaining their leaves on the side next to the electric light, while on the opposite side the leaves had all fallen.

Remarks were made by Messrs. A. A. Hamilton, R. H. Cambage, E. N. Ward and J. H. Maiden.

AUGUST 4TH, 1920.

The four hundred and fifteenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. James Nangle, President, in the Chair.

Thirty-eight members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of seven candidates for admission as ordinary members were read: four for the second and three for the first time.

Messrs. G. Hooper and G. I. Hudson were appointed Scrutineers, and Dr. R. Greig-Smith deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—Sydney Joseph Gilbert, Albert Sherbourne Le Souef, Cecil William Mann and John Sulman.

Professor A. Liversidge wrote from London thanking members of the Society for their message of greeting sent by them when assembled at the Annual Dinner.

The following donations were laid upon the table:—268 parts, 10 volumes, and 11 reports.

THE FOLLOWING PAPERS WERE READ:

1. "A Geological Reconnaissance of the Stirling Ranges of Western Australia," by W. G. Woolnough, D.Sc., F.G.S. This paper was read by Professor T. W. E. David in the absence of Dr. Woolnough.

2. "Early Drawings of an Aboriginal Ceremonial Ground," by R. H. Cambage F.L.S. and Henry Selkirk. Remarks were made by Messrs. J. H. Maiden, D. Carment, and G. H. Halligan.

EXHIBITS:

1. Mr. A. B. Hector exhibited some crystal formations of metallic bismuth and carborundum.

2. Mr. R. H. Cambage exhibited a specimen of fungus found by Mr. R. G. Wilson growing in a gold mine at Salida in Sumatra, and which had been identified by Mr. E. Cheel as probably a form of *Fomes lucidus* Fr.

SEPTEMBER 1st, 1920.

The four hundred and sixteenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. James Nangle, President, in the Chair.

Forty-two members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of four candidates for admission as ordinary members were read: three for the second and one for the first time.

Messrs. A. D. Ollé and A. B. Hector were appointed Scrutineers, and Mr. H. G. Smith deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—Albert John Fortescue, John Gower Stephens and Harvey Sutton.

The following donations were laid upon the table:—108 parts, 1 volume, and 3 reports.

THE FOLLOWING PAPERS WERE READ:

1. "The Volcanic Neck at the Basin, Nepean River," by G. D. Osborne, B.Sc., (communicated by Prof. T. W. E. David, C.M.G., D.S.O., F.R.S.). Remarks were made by Mr. W. R. Browne and Professor David.

2. "Acacia Seedlings, Part VI, by R. H. Cambage, F.L.S. Remarks were made by Messrs. T. I. Wallas, A. B. Hector and R. W. Challinor.

3. "On a Box Tree from New South Wales and Queensland," by J. H. Maiden, I.S.O., F.R.S.

EXHIBITS:

1. Mr. R. T. Baker exhibited some timber specimens showing traumatic growth. Remarks were made by Messrs. J. H. Maiden, H. G. Smith and R. H. Cambage.

2. Mr. A. A. Hamilton exhibited a series of timbers from the National Herbarium, Botanic Gardens, representing various phases of traumatism (*a*) Callus over a shot wound in the 'Red Pine,' *Callitris calcarata*, Wyalong, F. W. Wakefield, 8/1918; (*b*) Repair of an axe-cut in Eucalyptus sp. Nambucca Heads, E. G. Beale, 3/1917; (c) Strangling of a young tree of *Pinus radiata (insignis)* by a neglected stake tie.

3. Mr. J. H. Maiden exhibited specimens and drawings of the new species of Eucalyptus described in his paper. Also a number of Eucalypts collected by Allan Cunningham in Oxley's First Expedition to the Interior in 1817 which are of scientific and historical interest.

4. Mr. T. I. Wallas exhibited portion of a sweet pea plant, and briefly discussed the question of assimilation of nitrogen by plants.

5. The President exhibited a photograph showing the character of the star images on a photograph taken at Sobral on May 29th, 1919, during the total eclipse of the sun.

OCTOBER 6TH, 1920.

The four hundred and seventeenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. James Nangle, President in the Chair.

Forty-eight members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of four candidates for admission as ordinary members were read: one for the second and three for the first time.

Messrs. A. J. Sach and G. Hooper were appointed Scrutineers, and Mr. J. Vicars deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—Reginald George Downing.

The President announced the deaths of Mr. B. J. Smart and Rev. W. W. Watts.

The following donations were laid upon the table:—25 volumes and 73 parts.

A letter was read from Mrs. B. J. Smart expressing thanks for the Society's sympathy in her recent bereavement.

Short addresses were given on the Pan-Pacific Scientific Congress held at Honolulu during August, 1920 :—

Mr. C. A. Sussmilch, the delegate deputed to represent the Royal Society, explained to members that this first Congress had for its object the co-ordination of our existing knowledge of the Pacific region, so as to make the best preparation for an early and comprehensive study of the resources of that region, including Anthropology, Agriculture, Coral Reefs, Plant and Animal Distribution, Geodesy, Geography, Isostasy, Geology, Oceanography, Vulcanography, Seismology and related subjects.

Mr. C. Hedley gave a brief account of the remarkable flora and fauna of the Hawaiian group, illustrated with lantern slides. In the opinion of Mr. Hedley, the peculiarities of the distribution of the plants and animals connoted a former land connection of this island group with continental masses, or at least with islands now far distant to the south. The connection had been necessarily in the nature of continuous land bridges, but may have consisted of land forms rising above the sea in some directions, and being submerged simultaneously at others.

Mr. E. C. Andrews showed lantern slides illustrating the physiography of the Hawaiian group. He dwelt on the interesting fact that volcanic action appears to have been a marked feature over the whole group at a recent period, but it appears also as time progressed to have passed gradually from the north-west to the south-east group where active volcanoes now only occur..

Dr. L. A. Cotton, with the aid of lantern slides dwelt briefly on the wonders of the active volcanoes at Kilauea, and described interesting observations of Dr. T. A. Jaggar, Junr. and others at the volcano at Kilauea.

EXHIBITS:

1. Mr. A. B. Hector briefly referred to certain analogies between sound and light in connection with the movements of approaching and receding bodies.

2. J. L. Somerville, B.Sc., and W. G. Woolnough, D.Sc., furnished the following note on a brilliant display of marine phosphorescence which was seen at Pittwater, Broken Bay.

"On the evening of 6th September, 1920, we spent some time in watching, from Newport Jetty, a somewhat exceptionally brilliant display of marine phosphorescence at Pittwater. The time was 8·45 p.m. and the night was intensely dark, phenomenally still and oppressively silent. The whole surface of the bay was sparkling with pin-points of phosphorescent light, reminding one of a spinthariscope.

When a stone or clod of earth was thrown into the water there was the usual splash of pale phosphorescence, the comet-like effect of the brilliantly illuminated sinking object, followed by a 'tail' of ghostly light, and the phosphorescent air bubbles rising through the water as they became detached from the missile. If several stones were thrown into the water in succession the response became progressively weakened; in other words the phosphorescence exhibited a decided fatigue effect.

The fact which was unique in our experience of such phenomena was that it was accompanied by an infinitesimal, though distinctly audible crackling sound, somewhat resembling that of an electrical discharge, or the boiling of a very viscous liquid. Our attention being drawn to the fact we examined the matter critically, and were able definitely to connect the appearance of each flash in the confined space under the jetty with an individual minute explosion.

The whole phenomenon was suggestive of explosive spontaneous oxidation of some unstable chemical substance.

The meteorological conditions were so remarkably favourable that the occurrence seemed worthy of record.

Up to this point we are positive as to the accuracy of our observations, and we publish them with confidence. One of us, (W.G.W.) imagined that a very faint and elusive pungent odour could be detected. As this idea may have been subjective, or as the smell, if present, may have arisen from anything in the vicinity, from mud-flats to motor launches, we do not put this observation forward with any confidence."

NOVEMBER 3RD, 1920.

The four hundred and eighteenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. James Nangle, President, in the Chair.

Twenty-seven members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of nine candidates for admission as ordinary members were read: three for the second and six for the first time.

Messrs. A. J. Sach and A. A. Hamilton were appointed Scrutineers, and Mr. E. C. Andrews deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—Eldred George Bishop, Jiri Victor Danes, and Anthony Hordern.

The following donations were laid upon the table:— volumes, 117 parts, and 6 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on Eucalyptus No. IX, with descriptions of three new species," by J. H. Maiden, I.S.O., F.R.S.

2. "On a new Angophora," by J. H. Maiden, I.S.O., F.R.S. Remarks were made by Mr. R. T. Baker.

8. "The calculation of refractive index in random sections of minerals," by L. A. Cotton, M.A., D.Sc., and Miss Mary M. Peart, B.Sc.

EXHIBITS:

Mr. E. Cheel exhibited a fine series of fresh specimens of "Bottlebrush" *(Callistemon)* representing 16 distinct species and three varieties or colour forms, as well as two species undescribed, taken from cultivated plants in the Botanic Gardens by kind permission of the Director (Mr. J. H. Maiden) supplemented with a few from his private garden at Ashfield. Also fresh specimens of the true *Swainsona galegifolia* cultivated at Ashfield from seeds collected near Wombeyan Caves in December last, which are identical with the figure in Bot. Mag. tab. 792, together with the variety *coronilifolia* and var. *alba*, from the Botanic Gardens.

DECEMBER 1st, 1920.

The four hundred and nineteenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. James Nangle, President, in the Chair.

Forty-eight members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of twelve candidates for admission as ordinary members were read: six for the second and six for the first time.

Messrs. E. Cheel and R. W. Challinor were appointed Scrutineers, and Professor J. Read deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—George Brabason Carleton, James Elliott Furneaux Mann, John James Richardson, Basil Sawyer, Rupert Boswood Scammell, and Harry Williams.

The following donations were laid upon the table:—5 volumes, 175 parts and 2 reports.

THE FOLLOWING PAPERS WERE READ:

1. "The Stethoscope, with a reference to a function of the Auricle," by J. A. Pollock, D.Sc., F.R.S. Remarks were made by Rev. E. F. Pigot.

2. "The Essential Oils of *Leptospermum flavescens* var. *grandiflorum* and *Leptospermum odoratum*," by A. R. Penfold, F.C.S. Remarks were made by Messrs. H. G. Smith and R. W. Challinor.

3. "Eucalyptus Oil Glands," by M. B. Welch, B.Sc., A.I.C. Remarks were made by Messrs. R. T. Baker and J. H. Maiden.

4. "Temperature of the vapour arising from boiling saline solutions," by G. Harker, D.Sc. Remarks were made by Professor Pollock, Drs. Greig-Smith and Walkom.

5. "Notes on two Acacias," by J. H. Maiden, I.S.O., F.R.S.

6. "Notes on *Leptospermum flavescens* var. *grandiflorum*," by E. Cheel.

EXHIBITS:

Mr. R. C. Simpson showed a lantern slide of photographed diffraction bands.

* * *

Summary of lecture, September 16th, 1920, entitled

"Einstein's Theory of Space and Time."

By E. M. Wellish.

According to the undulatory theory, light consists of vibrations in a medium commonly known as the 'æther of space'; this medium transmits electrical and optical disturbances through it with the velocity of 186,000 miles per second. Bradley's experiments on the aberration of light prove that the æther outside matter is at rest. Michelson and Morley attempted in 1887, by a refined optical experiment to measure the æther drift, *i.e.* the velocity with which the earth moves through the æther. The result of the experiment was entirely negative, the most careful observations failing to bring out this æther drift.

Lorentz and Fitzgerald accounted for the negative result by assuming that the dimensions of a moving body contract slightly in the direction of motion, but this explanation was not satisfactory, as it led to other difficulties of a serious nature.

In 1905 Einstein, a Swiss, now Research Professor at Berlin, investigated the logical consequences of the hypothesis that it is utterly impossible to bring out experimentally motion with respect to the æther, the only possible motion being that of matter with respect to matter. In his earlier or restricted theory he confines his considerations to the case when the body (usually the earth) is moving uniformly in a straight line. He shows that all observers must agree in assigning the same velocity to a beam of light, even though the observers may be in very rapid motion with respect to one another. The standards of length and time employed by the observers must therefore alter according to their state of motion. Einstein gave the exact relations according to which these standards would alter with the motion. Among other results he showed that two observers in relative motion could record a definite event as occurring at slightly different positions in space and at slightly different times.

Minkowski used the relations of Einstein and showed that if time be added as a fourth dimension to space the two observers would record the event alike in this four-dimensional world. Space and time are thus, as it were, ideas introduced by the observers, the only reality being a blend of the two; various observers resolve the real world differently into space and time, just as the vertical direction differs for people who live in different latitudes.

Einstein subsequently generalised his theory so as to apply to all types of motion. He showed that it is impossible to distinguish between a permanent field of force such as gravitation and a certain peculiar type of motion; in fact, by choosing suitable axes of reference gravity can be disregarded, just as the traveller inside the projective described by Jules Verne regarded the contained bodies as being without weight.

By making use of this equivalence and by using the conception of a four-dimensional world Einstein succeeded in expressing the law of gravitation as a relation between space, time and mass. From this relation he deduced that space and time in the vicinity of matter are slightly distorted so that the ordinary propositions of Euclid are no longer strictly valid. The space in the vicinity of matter has many points of resemblance to the space imaged in a slightly convex mirror. In particular a ray of light which moves in a straight line when distant from matter is slightly bent when passing near a large mass such as the Sun. Einstein calculated the deflection to be expected and his prediction was verified by the published results of the British Astronomical Expedition to Brazil in connection with the solar eclipse, 29 May, 1919; this deflection was twice that calculated on the Newtonian view that light consists of corpuscles or minute bodies.

There will be an Astronomical Expedition to Australia to observe the solar eclipse occurring in September, 1922, and it is confidently expected that further valuable information will be obtained.

GEOLOGICAL SECTION.

ABSTRACT OF THE PROCEEDINGS

OF THE

GEOLOGICAL SECTION.

Monthly Meeting, 12th May, 1920.

Mr. R. H. Cambage in the Chair.

Eight members and two visitors were present.

Professor David and Mr. W. R. Browne were elected Chairman and Honorary Secretary respectively.

EXHIBITS:

1. From the Mining Museum:—(*a*) Etched slice of the Yenberrie meteorite, an octahedral iron; (*b*) a bismuth-silver-gold sulphide (perhaps a new mineral species) from Kangiara, near Yass; (*c*) amblygonite from Lady Don Mine, Euriowie; (*d*) Baryto-celestite, Trangie; (*e*) Diatomite with fossil fish remains, Bugaldi.

2. From the Australian Museum:—(*a*) Stilbite from Garawilla, near Gunnedah, a superb specimen presented by Mrs. Hubert Kelly; (*b*) colourless garnet (grossularite) and vesuvianite from near Bowling Alley Point.

3. By Mr. W. R. Browne:—(*a*) Varve rock from the tillite of Pre-Cambrian age (?) at Campbell's Creek, Poolamacca; (*b*) contorted pegmatite vein in granulite, Broken Hill; (*c*) Pyrites pseudomorphed by limonite in schist, near Mount Gipps Railway Station, Broken Hill district.

Father Pigot discussed recent earth movements in the Pacific, especially that which occurred early in February and was particularly marked in the region south of New Britain, in the neighbourhood of the deep trough discovered and surveyed by the German exploring ship "Planet."

Dr. Cotton pointed out that a study of the time and direction of the New Britain earthquake lends support to the view that earthquakes are precipitated by tidal stresses.

Monthly Meeting, 9th June, 1920.

Professor David in the Chair.

Sixteen members and seven visitors were present.

EXHIBITS:

1. From the Mining Museum:—(*a*) a curiously-carved tuffaceous stone from New Guinea (collected by Mr. MacDonnell); (*b*) model of a gold nugget recently found at Mudgee; (c) travertine from Belubula Caves; (*d*) copper sulphate from Mount Hope Mine, formed by the decomposition of copper pyrites; (*e*) auriferous mispickel from Hill End; (*f*) a polished section of the Yenberrie meteorite exhibiting octahedrite markings.

2. From the Australian Museum:—(*a*) crystal of beryl embedded in native bismuth from Torrington; (*b*) quartz crystals fractured and re-cemented by secondary silica, from Goodwin's Cut, Kingsgate.

3. By Dr. Walkom:—A fossil from the Newcastle Coal-measures, possibly an equisitaceous stem.

4. By Messrs. Andrews and L. J. Jones:—Ice-scratched quartzite boulder from three chains above Beryl Bridge, Reedy Creek, Gulgong district. This was found in steeply dipping Permo-Carboniferous strata, and indicates a new area for Permo-Carboniferous glacial beds.

5. By Judge Docker:—an enlarged photograph of a mass of ironstone having the appearance of a petrified log, from Wentworth Falls.

PAPER:

The Chairman gave an account, illustrated by diagrams, of some interesting geological features revealed during the construction of the tunnel under Parramatta River between Long Nose Point and Greenwich. The bed of the old river is found to be at a depth of about 165 feet below present high water mark, indicating a fall of about 10 feet per mile between this point and the railway bridge at Meadowbank. What appears to be a slight fault occurs in the tunnel and has caused much trouble. The nature and significance of the deposits revealed by trial bores at intervals across the river were discussed.

Messrs. Rankin, Halligan and Melville commented on various points raised in the address.

Monthly Meeting, 14th July, 1920.

Professor David in the Chair.

Fifteen members and four visitors were present.

It was resolved that the time of meeting be 7·45 p.m. in future instead of 8 p.m.

EXHIBITS:

1. From the Mining Museum:—(*a*) two meteorites, from Warialda and Barraba respectively, which with the Bingara meteorite probably represent one fall; (*b*) amygdales in basalt, filled with opal, from Tintenbar opal field, Ballina.

2. From the Australian Museum:—Hexagonal calcite from Garabaldi Mine, near Lionsville.

PAPER:

Dr. Woolnough addressed the meeting on "The Coal Fields of West Australia and the Associated Rocks," dealing in interesting fashion with the stratigraphical, lithological and tectonic features of the Collie Coalfield ; brief reference was also made to the coal measures of the Irwin River district.

Discussion of the address was postponed to a special meeting.

Special Meeting, 21st July, 1920.

Professor David in the Chair.

Ten members and one visitor were present.

The business of the meeting was the postponed discussion of Dr. Woolnough's paper on the West Australian Coal Fields. Dr. Woolnough exhibited a revised section across the Irwin River area, and gave a vertical section of the stratigraphical succession. His remarks were illustrated by a fine suite of rock specimens and fossils.

A discussion followed in which most of those present participated.

Monthly Meeting, 11th August, 1920.

Professor David in the Chair.

Eight members and eight visitors were present.

EXHIBITS:

1. By Mr. Watkin Brown:—A collection of minerals from the Royal Ontario Museum, including fine specimens of sodalite, pink vesuvianite, oligoclase, pyroxene (crystal $6\frac{1}{4}$ inches long), pseudo-hexagonal phlogopite, smaltite and associated minerals, argentite, allemontite, skutterudite, breithauptite and spencerite.

2. By Mr. L. L. Waterhouse for Mr. A. Combe:—A series of photographs of the Grampian Mountains, Victoria, illustrating various geological structures.

3. By Mr. L. L. Waterhouse:—A specimen of pigottite from Redruth, Cornwall, recently presented to the University by Mr. F. Danvers Power.

DISCUSSION:

The business was the discussion of Dr. Woolnough's paper on "A Geological Reconnaissance of the Stirling Ranges of West Australia" recently read before the Society. In this paper the theory is put forward that the range is due to an elevation of the softer rocks composing it above the level of the surrounding hard gneissic granites and greenstones.

This view was supported by Professor David, and contributions to the discussion were made by Mr. Somerville and Judge Docker.

Monthly Meeting, 8th September, 1920.

Professor David in the Chair.

Five members and two visitors were present.

EXHIBITS:

1. From the Mining Museum:—A collection of fulgurites from Port Macquarie, collected by Mr. T. Dick.

2. By Professor David:—Volcanic breccia from the Old Man Valley, Hornsby, containing plant stems.

3. By Mr. W. R. Browne:—Specimens and photographs illustrating arid weathering in the Broken Hill district.

PAPER:

A short paper on "The Conditions of formation of Arkose deposits, and their Geological Significance," was given by Mr. W. R. Browne, and was discussed by most of those present.

Monthly Meeting, 13th October, 1920.

Dr. C. Anderson in the Chair.

Nine members and three visitors were present.

EXHIBITS:

From the Mining Museum:—(*a*) Specimens of "Pélé's hair" and of gropy lava from Kilauea; (*b*) pyrites from Mount Stewart Mine, Leadville.

PAPER:

Mr. E. C. Andrews contributed a paper on "The Framework of the Pacific," emphasising its essential structural unity, while at the same time recognising the instability of the western as contrasted with the stability of the eastern portions. Instability is indicated by the varying heights to which the coral reefs have been raised in many of the coral islands of the western Pacific. The eastern portion is remarkably clear of islands, and in the case of the Hawaiian Group, at all events, the botanical evidence is against the theory of a former connection with the mainland.

The subsequent discussion was participated in by Professor Cotton, Messrs. Osborne and Browne, Father Pigot and the Chairman.

Monthly Meeting, 10th November, 1920.

Professor Sir Edgeworth David in the Chair.

Eleven members and three visitors were present.

EXHIBITS:

1. Mr. E. C. Andrews exhibited and explained a 40-chain geological map of portion of the Barrier Ranges, indicating the principal tectonic features of the region, and in particular a great fault with a horizontal displacement of about seven miles.

2. Dr. Walkom exhibited specimens of scale-leaves of *Glossopteris*, from the Dawson River and Stanwell, Queensland.

PAPER:

Professor Cotton read a paper on "Polar Wanderings and their Geological Corollaries." The possibility of migrations of the terrestrial pole was denied, after investigation, by physicists and mathematicians, but their calculations involved certain fundamental assumptions as to the constitution of the earth's interior which are now known to be erroneous. A migration of the pole would have certain effects, as, for example, in regard to the zonal distribution of forms of life, etc.

Discussion was postponed until the next monthly meeting.

Professor Heim, of the University of Zurich, was introduced by the Chairman, and gave some interesting notes on the latest views as to the folding of the Swiss Alps, illustrating his remarks by diagrams showing the very complex nature of the overfolding.

Monthly Meeting, 8th December, 1920.

Professor Sir Edgeworth David in the Chair.

Fourteen members and two visitors were present.

EXHIBITS:

1. By Dr. Walkom:—*Vertebraria* from Dawson River, Queensland.

2. From Australian Museum:—Axinite with associated epidote and (?) albite, from Bingara, collected by Mr. D. Porter.

3. From the Mining Museum:—(*a*) amosite, an amphibole asbestos from the Transvaal; (*b*) veins of chrysotile associated with dolomite from the Clarence River.

4. By Mr. W. S. Dun:—A number of excellently preserved Permo-Carboniferous fossils collected by Mr. Varney Parkes from the neighbourhood of Ulladulla.

5. By Mr. Sussmilch:—*Noegerrathiopsis* from Stanford Merthyr Colliery, a large specimen exhibiting a number of leaves radially arranged and apparently joined on to one stem.

A discussion on Professor Cotton's note on Polar Wanderings was initiated by Mr. E. C. Andrews, Mr. Dun, Professor Benson, Dr. Walkom, and the Chairman also participating.

A brief synopsis of Dr. H. I. Jensen's "Note on probable Late Cretaceous Glaciation in the Mount Hutton District, Queensland," was given by Mr. Andrews.

SECTION OF AGRICULTURE.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF AGRICULTURE.

Monthly Meeting, 10th May, 1920.

Sir Joseph Carruthers in the Chair.

A report was received from Mr. P. Hindmarsh, M.A., giving details of the progress of the experiments carried out on "The Inheritance of Fecundity in Fowls."

The following officers were elected for the ensuing year: *Chairman*, Sir Joseph Carruthers, K.C.M.G.; *Vice-Chairmen*; Messrs. A. E. Stephen, H. W. Potts, and F. B. Guthrie, *Hon. Sec.*, Mr. E. Breakwell. *Committee*, Doctors R. D. Greig-Smith and S. Dodd, Messrs. E. Cheel, E. N. Ward, A. A. Hamilton, P. Hindmarsh, A. Spencer Watts, A. D. Ollé, and A. J. Sach.

Mr. A. E. Stephen referred to the progress of the Section during the past year, and stated that very interesting lectures on all manner of agricultural subjects had been given.

Mr. Stephen also delivered an address on factors to be considered in choosing a farm.

Monthly Meeting, 14th June, 1920.

Mr. A. E. Stephen in the Chair.

Correspondence was received from the Commonwealth Institute of Science and Industry, through the Hon. Secretary of the Royal Society, intimating that action had already been taken with regard to the economic nomenclature of plants, and suggesting that a committee be formed in New South Wales to deal with marketable timbers. The following committee was appointed:—Messrs. Maiden, Baker, Ward, Cheel, A. A. Hamilton, and Hon. Secretary.

Mr. E. Breakwell exhibited various types of Sweet Sorghums displaying a considerable amount of variation in each type. The history of each variable form was traced.

Mr. E. Cheel exhibited an extremely well developed leaf of Spineless Cactus, and also the fruits of ordinary Moreton Bay Fig with their chemical analysis by Mr. A. R. Penfold. The analysis showed that the figs possessed high nutritive qualities.

Sir Joseph Carruthers delivered a lecture on the Reorganisation of Agriculture. He emphasised the fact that the farming industry in Australia had not been properly organised and had been forced to sell its products at too low a rate. He pointed out that the principal factors necessary for reorganisation were:—(*a*) Systematic Soil Survey; (*b*) Appointment of district agricultural agents to advise farmers; (*c*) Co-operative Farmers' Societies; (*d*) Better seed production and more specialisation in a few of the best wheats; (*e*) Rural Finance.

An excursion to the Homebush Abattoirs took place on 24th June.

Monthly Meeting, 12th July, 1920.

Sir Joseph Carruthers in the Chair.

Dr. S. Dodd read an original and most instructive paper on Tick Paralysis. Dr. Dodd pointed out that the usual symptoms of tick paralysis were well known and were usually ascribed to the "Scrub Tick." There were, however, several species of scrub ticks, and his investigations had fixed the identity of a certain species responsible for a particular form of paralysis. He had also established the period of incubation elapsing between the attack by the tick and the development of paralysis. He had proved that a single tick of the species *Ixodes holocyclus* was sufficient to set up a train of symptoms closely resembling intoxication, and often resulting in death. The popular idea that symptoms of paralysis appeared in a day or so after infestation was incorrect, as it took 5 – 7 days for the symptoms to manifest themselves. The question as to whether the condition was due to a living organism or virus, or to a toxin or venom, had not been determined.

Monthly Meeting, 9th August, 1920.

Sir Joseph Carruthers in the Chair.

A discussion took place on "Stud Seed Production." Sir Joseph Carruthers, Mr. W. Birks, and Hon. Secretary, pointed out the valuable work done in this connection in Canada, Sweden and Denmark. In both Sweden and Canada there existed Seed Companies who procured the foundation stocks of the best seed from the Agricultural Departments and extended the sowing of such seed on a large commercial scale. The New South Wales Agricultural Department had commenced to induce farmers to take up the matter of stud-seed production.

Mr. J. W. Matthews delivered a lecture on "Wool Production." He pointed out that with improved methods of breeding in 1918-19 with 25,000,000 less sheep there were 70,000,000 ℔s. more wool produced than in 1891. He demonstrated that, although closer settlement should be encouraged, merino breeding which required large areas, should be safeguarded. The Border Leicester × Merino had proved the best cross for mixed-farming areas.

Monthly Meeting, 13th September, 1920.

Sir Joseph Carruthers in the Chair.

A conference of the principal agricultural bodies in Sydney was held to devise means for stimulating agriculture in this State. The Chairman, Hon. W. F. Dunn, Minister of Agriculture, Mr. A. E. Wearne, M.L.A., and Messrs. Trethowan and Black, M.L.C., Professor Stewart and Doctors Clubb and Mary Booth spoke on the matter. It was unanimously agreed that proposals, formulated by the chairman, were necessary for the further development of agriculture.

A successful excursion was held on 25th September to the stud-farms of Sir Samuel and Mr. Anthony Hordern at Bowral.

Monthly Meeting, 11th October, 1920.

Sir Joseph Carruthers in the Chair.

The Section expressed to the Chairman of the Select Parliamentary Agricultural Commission its appreciation of the valuable investigations which were being conducted.

Mr. W. H. Paine contributed a paper on Agricultural By-products and Pests, illustrated by exhibits. The lecturer pointed out that by-products of the vegetable oil industry, originally discarded, were now being widely utilised for stock food. The gluten of maize was also now in general use, although its proper application was little understood. Oat hulls, brewer's grains, and distillery wastes should be a standard article of food. He had obtained extracts from oil seed residues, which were similar in appearance and taste to meat extracts, to which also their analyses were closely allied. Original work had also been done in converting soup waters into stock foods. Finally Prickly Pear had been made to produce a meal which was relished by poultry, although for dairy stock there would probably have to be an admixture of molasses.

Monthly Meeting, 8th November, 1920.

Sir Joseph Carruthers in the Chair.

Mr. W. S. Campbell delivered a lecture on the Origin of Wheat. One of the leading features of the lecture was the reference to the remarkable knowledge possessed by the Greeks and Romans concerning the selection of definite varieties for particular soils and climates. Special attention was paid as far back as 370 B.C. to the testing of the strength of wheats. In Pliny's time, 1850 years ago, the absorption test for the strength of flour was in use. Careful attention was also paid to keeping the varieties pure, even more so than at present. Hybridising wheat was first carried out in 1795-96, by Knight in England. Mr. Campbell showed several pot-grown specimens of Emmer, Macaroni, Federation, Marquis, and other wheats. He referred to the possibility and scope of crossing wild wheat with a native grass like Mitchell grass.

Monthly Meeting, 12th December, 1920.

Sir Joseph Carruthers in the Chair.

Mr. A. E. Stephen quoted results obtained by Mr. E. Breakwell in co-operation with the Chilian Nitrate Committee, on the fertilising of grasses with complete manure and with superphosphate and sulphate of potash, excluding nitrate of soda. In all cases, except one, a considerable increase in yield was obtained with the complete manure, sometimes over 100 per cent. The native grasses, except *Andropogon sp.* responded particularly well.

Mr. E. Cheel showed exhibits of various kinds of Castor Oil plants. He said that the Indian variety had proved on analysis by Mr. Penfold, to be superior to Eureka, the variety usually grown in Queensland. He also discussed the possibilities of mint growing.

Mr. G. Hamblin exhibited several forms of interesting fungus diseases.

Mr. A. A. Hamilton contributed a note on the acrid principles of *Phytolacca* and other drugs.

SECTION OF INDUSTRY.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF INDUSTRY.

Monthly Meeting, 26th May, 1920.

Mr. W. T. Willington, O.B.E., in the Chair.

Mr. Thos. McMahon gave a lecture upon "The Industries of the South Pacific Islands," illustrated by a number of lantern slides depicting the industries and the inhabitants of the islands.

Monthly Meeting, 30th June, 1920.

Mr. W. T. Willington, O.B.E., in the Chair.

Mr. A. Worsfold gave a lecture upon "Some War Inventions and their Making," illustrated by means of diagrams and models.

The following sectional Officers were elected for the current session:—Chairman, Mr. E. T. Fisk; Hon. Secretary, Dr. R. Greig-Smith; Committee, Messrs. A. B. Hector and W. T. Willington, O.B.E. (Past Chairmen), J. E. Bishop, F. A. Coombs, W. W. L'Estrange, W. Poole, B.E., B. J. Smart, B.Sc., A. E. Stephen and H. J. Sullivan.

Monthly Meeting, 21st July, 1920.

Mr. E. T. Fisk in the Chair.

The Chairman gave a lecture upon "Recent Advances in Wireless," and illustrated his remarks by means of lantern slides and experimental exhibits. The structure and use of the triode valve was emphasised.

Monthly Meeting, 18th August, 1920.

Mr. E. T. Fisk in the Chair.

Mr. A. J. Perier gave a lecture upon "Micro-cinematography," in which he described the use of the ultramicroscope, and by means of the bioscope showed a number of films of scientific interest.

Monthly Meeting, 15th September, 1920.

Mr. A. B. Hector in the Chair.

Mr. S. J. McAuliffe gave a lecture upon "Modern Coal Carbonisation," illustrated by means of lantern slides.

Special Meeting, 8th October, 1920.

Dr. R. Greig-Smith in the Chair.

Mr. A. B. Hector gave a lecture upon "Colour Music and its Industrial Application," which he illustrated by means of diagrams and exhibits.

Monthly Meeting, 20th October, 1920.

Mr. E. T. Fisk in the Chair.

Mr. J. C. McDowall, B.Sc., gave a lecture upon "Brasses and Bronzes," which he illustrated by means of lantern slides and exhibits.

Monthly Meeting, 17th November, 1920.

Mr. W. T. Willington, O.B.E., in the Chair.

Mr. W. van der Velden gave a lecture upon "Colour Photography, its Principles and Practice," which he illustrated by means of lantern slides and by exhibits. Mr. H. J. Thompkins contributed a series of slides taken by the Paget process.

Monthly Meeting, 15th December, 1920.

Mr. E. T. Fisk in the Chair.

Mr. R. Vicars gave an address upon "The Woollen Industry," and illustrated his remarks by means of exhibits.

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