JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1919.

VOL. LIII.

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THE HONORARY SECRETARIES.

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

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1919.

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THE ROYAL SOCIETY OF NEW SOUTH WALES SYDNEY FOUN. 1821. INC. 1881

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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 172, etc., for *nigripilosus*, read *nigripilosa*.

Page 173, line 13, read *A. Prainii*.

Page 206, line 6, for *A. eremea* n. sp., substitute the name *A. cana* n. sp., the name *eremea* having been pre-occupied by C. R. P. Andrews in *Journ. W. A. Nat. Hist. Soc.* (May 1904), p. 40.

PUBLICATIONS.

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

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Vol.	I	Transactions of the Royal Society, N.S.W.,	1867, pp. 83,	,,
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C. A. SUSSMILCH, F.G.S.
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.
1916		Allen, William John, "Oriel," The Boulevard, Strathfield.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ltd., Cement Works, Granville.
1905	P 2	Anderson, Charles, M.A., D.Sc. *Edin.*, 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., 'La Chateau,' Spofforth-st., Cremorne.
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., ASSOC. 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, The University of Otago, Dunedin, N.Z.

Elected		
1919		Bettley-Cooke, Hubert Vernon, 304 Kent-street.
1916		Birrell, Septimus, "Florella," Dunslaffnace-st., Hurlstone Park.
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.*, No. 4 A. G. Hospital, Randwick.
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, Wentworth Court, Elizabeth-street.
1917		Bond, Robert Henry, 'Tiro-Tiro,' Middleton-street, Stanmore.
1910		Bradley, Clement Henry Burton, M.B., Ch.M., D.P.H., 'Mebra,' 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.
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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; p.r. "Waipara," Neich Parade, Burwood.
1914		Broad, Edmund F., 'Cobbam,' Woolwich Road, Hunter's Hill.
1913	P 1	Browne, William Rowan, B.Sc., Lecturer and Demontrator in Geology in the University of Sydney.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Aberdour,' Daniel-street, Granville.
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, 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 14	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.
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., Beecroft Road, Beecroft.

Elected		
1917		Carpenter, Frederick Wm., M.A., Senior Science Master, Sydney Grammar School, College-street.
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 Pharmacology in the University of Sydney. *Hon. Treasurer.*
1913	P 9	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.) *Vice-President.*
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. INST. C.E., Water and Sewerage Board, North Sydney.
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.
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.
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 2	Cotton, Leo Arthur, M.A., D.Sc., Lecturer and Demonstrator in 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.
1875		Dangar, Fred. H., c/o W. G. Deuchar, 12 and 14 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, 'Longheath,' Little Bookham, Surrey, England.
1910	P 1	Darnell-Smith, George Percy, D.Sc., F.I.C., F.C.S., Department of Agriculture, Sydney.
1886	P 22	David, T. W. Edgeworth, 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.)
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.

Elected		
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., Analyst, Department of Public Health, Sydney.
1908	P 4	Dun, William S., Palæontologist, Department of Mines, Sydney. *Vice-President.* (President 1918.)
1919		Earp, George Frederick, 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, 68½ Pitt-st.; p.r. 26 Bayswater-rd., Darlinghurst.
1909	P 4	Fawsitt, Charles Edward, D.Sc, Ph.D., Professor of Chemistry in the University of Sydney. *President.*
1881		Fiaschi, Thos., M.D., M.Ch. *Pisa*, 'Beanbah,' 235 Macquarie-st.
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.
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., c/o Dr. R. I. Furber, 'Sunnyside,' Stanmore Road, Stanmore.
1917		Galbraith, Augustus Wm., C.E., City Engineer, Perth, W.A.
1918		Gallagher, James Laurence, B.A. *Syd.*, Unwin's Bridge Road, Marrickville.
1919		Garlick, John, Under Secretary, Local Government Department; p.r. 'Currawang,' Doll's Point, Sandringham.
1918	P 2	Gillies, C. D., M.Sc., Assistant Lecturer in Biology in the University of Queensland, Brisbane.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.

Elected		
1916		Granger, James Darnell, Ph. D., 338 Mitchell Road, Alexandria.
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.) *Vice-President.*
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., 'Riversleigh,' 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.
1909		Hammond, Walter L., B.Sc., Public High School, Newcastle.
1916	P 1	Hamilton. Arthur Andrew, Botanical Assistant, Botanic Gardens, Sydney.
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).
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 2	Harker, George, D.Sc., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1919		Harrison, Launcelot, B Sc., *Syd.*, B.A. *Cantab.*, Lecturer and Demonstrator in Zoology in the University, Sydney.
1913	P 1	Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1918		Hassan, Alex. Richard Roby, c/o W. Anglios & 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.
1891	P 3	Hedley, Charles, F.L.S., Assistant Curator, Australian Museum, Sydney. (President 1914.)
1899		Henderson, James, F.R.F.S., 'Wahnfried,' Drummoyne.
1916		Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.
1919		Henriques, Frederick Lester, 56 Clarence-street.

Elected.		
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., 'Linden Park,' Revesby, viâ Bankstown.
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.
1919		Horsfall, William Nichols, M.B., B.S. *Melb.*, Surgeon Commander Royal Navy, p.r. 'Barrymore,' Morton-st. N. 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., 'Gudvangen,' Arden-street, Coogee.
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.
1905	P 8	Jensen, Harold Ingemann, D.Sc., Treasury Chambers, George-street, Brisbane.
1917		Jenkins, Richard Ford, Engineer for Boring, Irrigation Commission, 6 Union-street, Mosman.
1918		Johns, Morgan Jones, M.A.M.E., Mount Morgan Co., Mount Morgan, Queensland.
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.
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		Kesteven, Hereward Leighton, D.Sc., M.D., Ch.M., Anzac Parade, Maroubra.
1901		Kidd, Hector, M. INST. C.E., M. I. MECH. E., Cremorne Road, Cremorne.
1896		King, Kelso, 120 Pitt-street.
1919		Kirk, Robert Newby, 25 O'Connell-street.

Elected		
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; p.r. 'Normanhurst,' Denmark-st., Kew, Victoria. (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.
1916		L'Estrange, Walter William, 55 Albert Road, Homebush.
1906		Lee, Alfred. 'Glen Roona,' Penkivil-street, Bondi.
1909		Leverrier, Frank, B.A., B.Sc., K.C., 182 Phillip-street.
1883		Lingen, J. T., M.A. *Cantab.*, 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.
1919		McGeachie, Duncan, The Caledonian Collieries, Newcastle, N. S. Wales.
1919		McGlynn, William Henry, 'Cohoes,' 350 Military Rd., Mosman
1906		McIntosh, Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., ASSOC. M. INST. C.E., Geelong Waterworks and Sewerage Trusts Office, Geelong, Victoria.
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; p.r. Flat 14, Kelburn Hall, Elizabeth Bay Road, Elizabeth Bay.
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., P. N. Russell Lecturer in Electrical Engineering in the University of Sydney.

Elected		
1883	P 37	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.)
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1897		Marden, John, M.A., LL.D., Principal, Presbyterian Ladies' College, Croydon, Sydney.
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.
1903		Meggitt, Loxley, 12 Teakle-street, Summer Hill.
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., c/o Dalgety's Ltd., London.
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, F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; p.r. 'St. Elmo,' Tupper-street, Marrickville.
1917		Nash, Norman C., 'Ruanora,' Lucas Road, Burwood,
1891		‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
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, 'Gilbulla,' Menangle.
1919		Oram, Hector, 'Oramston,' Central-street, Crows Nest, 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.

Elected
1880 Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1901 Peake, Algernon, M. INST. C.E., L.S., Prospect Rd., Summer Hill.
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.
1919 Poate. Hugh Raymond Guy, M.B., Ch. M. *Syd.*, F.R.C.S. *Eng.*,
L.R.C.P. *Lond.*, 225 Macquarie-street.
1881 Poate, Frederick, F.R.A.S., L.S., 'Clanfield,' 50 Penkivil-street,
Bondi.
1887 P 11 Pollock, J. A., D.Sc., F.R.S., Corr. Memb. Roy. Soc. Tasmania; Roy.
Soc. Queensland; Professor of Physics in the University
1917 of Sydney. *Hon. Secretary.*
Poole, William, B.E., A.M. INST. C.E., L.S., 906 Culwulla Cham-
1896 bers, Castlereagh-street.
Pope, Roland James, B.A., *Syd.*, M.D., C.M., F.R.C.S., *Edin.*,
1910 183 Macquarie-street.
Potts, Henry William, F.L.S., F.C.S., Principal, Hawkesbury
1918 Agricultural College, Richmond, N.S.W.
1919 Powell, John, 170-2 Palmer-street.
1918 Pratten, Herbert E., Senator, Jamieson-street.
Priestley, Henry, B.Sc., M.D., Ch. M., Acting Professor of Phy-
1914 siology in the University of Sydney.
Purdy, John Smith, D.S.O., M.D., C.M. *Aberd.*, D.P.H. *Camb.*, Metro-
1893 politan Medical Officer of Health, Town Hall, Sydney.
Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 193 Macquarie-street.

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, Blackfriars.
1916 P 1 Read, John, M.A., Ph.D., B.Sc., Professor of Organic Chemistry
in the University of Sydney.
1914 Rhodes, Thomas, Werris Creek.
1909 Reid, David, 'Holmsdale,' Pymble.
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.,
City Bank Chambers, Pitt-street, Sydney.

Elected		
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.
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.
1912		Smart, Bertram James, B.Sc., Public Works Department, Sydney.
1893	P 55	Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney. (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.
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.
1913		Stewart, Alex. Hay, B.E., Metallurgist, Technical College, Sydney.
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.
1919		Sutherland, George Fife, A.R.C.Sc., *Lond.*, Lecturer in Mechanical Engineering, in the University of Sydney.
1918		Sundstrom, Carl Gustaf, 6 Arcadia Road, Glebe Point.
1901	P 8	Süssmilch, C. A., F.G.S., Technical College, Newcastle, N.S.W.
1912		Swain, E. H. F., Director, Forestry Department, Brisbane.
1919		Swain, Herbert John, B.A. *Cantab.*, B.Sc., B.E. *Syd.*, Technical College, Ultimo.

Elected

1917 Tate, Herbert, Bridge Road, Stanmore.

1915 P 1 Taylor, Harold B., B.Sc., Kenneth-street, Longueville.

1905 Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.

1893 ‡Taylor, James, B.Sc, A.R.S.M. 'Cartref,' Brierly-st., Mosman.

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., 'Kuranda,' Mount Errington. Hornsby, N.S.W.

1879 Trebeck, P. C., Orange, N.S.W.

1900 Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st.

1919 P 1 Turner, Eustace Ebenezer, B.A. *Cantab.*, M.Sc. *Lond.*, A.I.C., Lecturer and Demonslrator 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., Assistant Professor of Physics in the University of Sydney.

1919 Waley, Robert George Kinloch, 63 Pitt-street.

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.

1910 Walker, Charles, 'Lynwood,' Terry Road, Ryde.

1910 Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.

1919 Walkom, Arthur Bache, D.Sc., Linnean Hall, 23 Ithaca Road Elizabeth Bay.

1917 Wallas, Thomas Irwin, 175 Macquarie-street.

1891 P 2 Walsh, Henry Deane, B.A.I. *Dub.*, M. INST. C.E., 'Fermagh,' Leura, N.S.W. (President 1909.)

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.

Elected		
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1918		Ward, Edward Naunton, Superintendent of the Botanic Gardens, Sydney.
1916		Warden, Robert Alexander, President, Government Savings Bank, N.S.W., Moore-street, 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.
1915	P 5	Watts, Rev. W. Walter, F.L.S., 'The Manse,' Wycheproof, Victoria.
1910	P 1	Wearne, Richard Arthur, B.A., Principal, Central Technical College, Brisbane.
1907		Welch, William, F.R.G.S., 'Roto-iti,' Boyle-street, Mosman.
1881		‡Wesley, W. H., London.
1918		White, Edmond Aunger, M.A.I.M.E., c/o Electrolytic Refining and Smelting Co of Australia Ltd., Port Kembla, N.S.W.
1909		White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's 'Kooringa,' Robinson-street, Chatswood.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D. *Dub.*
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 Sydney.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 7	Woolnough, Walter George, D.Sc., F.G.S., Professor of Geology in the University of Western Australia, Perth.
1916		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry, Department of Agriculture, The University, Sydney.
1917		Wright, George, c/o Farmer & Company, Pitt-street.
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.

Elected

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.)

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.

1894 Spencer, Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., 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, Cavendish Professor of Experimental Physics in the University of Cambridge, Trinity College, Cambridge, England.

* Retains the rights of ordinary membership. Elected 1872.

Obituary 1919-20.

Clarke Medalist.

1912 Twelvetrees, W. H.

Ordinary Members.

1879 Etheridge, Robert.
1893 Noyes, Edward.
1875 O'Reilly, W. W. J.
1883 Stuart, Sir Thomas P. Anderson.
1897 Webb, Frederick William.
1908 Willis, Charles Savill.

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.

Awarded

1878 *Professor Sir Richard Owen, K.C.B., F.R.S.

1879 *George Bentham, C.M.G., F.R.S.

1880 *Professor Thos. Huxley, F.R.S.

1881 *Professor F. M'Coy, F.R.S., F.G.S.

1882 *Professor James Dwight Dana, LL.D.

1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.

1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.

1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

1886 *Professor L. G. De Koninck, M.D.

1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.

1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.

1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.

1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.

1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc. D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.

1893 *Professor Ralph Tate, F.L.S., F.G.S.

1895 Robert Logan Jack, F.G.S., F.R.G.S., late Government Geologist, Brisbane, Queensland.

1895 *Robert Etheridge, Jnr.

1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.

1900 *Sir John Murray, K.C.B., LL.D., Sc. D., F.R.S.

1901 *Edward John Eyre.

1902 *F. Manson Bailey, C.M.G.. F.L.S.

1903 *Alfred William Howitt, D.Sc., F.G.S.

1907 Walter Howchin, F.G.S., University of Adelaide.

1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.

1912 *W. H. Twelvetrees, F.G.S.

1914 A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History) London.

1915 Professor W. A. Haswell, M.A., D.Sc., F.R.S., The University, Sydney.

1917 Professor T. W. E. David, C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., The University, Sydney.

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

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

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

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

The Society's Bronze Medal and £25.

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

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

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

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

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

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

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

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

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

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

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

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

PRESIDENTIAL ADDRESS.

By W. S. Dun.

With Diagram.

[*Delivered to the Royal Society of N. S. Wales, May 7, 1919.*]

My four predecessors in the Presidential Chair have had to address you under the shadow of the world's greatest calamity, and though the cloud has lifted, the beams of peace are still struggling to pierce the gloom. During the calm to which we look forward, our Society will endeavour to maintain its reputation, and assist both the State and the Empire in the stimulation of industry by the aid of scientific research. Co-ordination of control and resources is necessary, and the numerous problems surrounding these questions will require the most careful thought and investigation—matters which will appeal to all our members.

I have the privilege of welcoming to-night two of our most esteemed members, whose names are more than household words to us and Australian science, Lt. Colonel Professor David, C.M.G., D.S.O., F.R.S., and Major Professor Pollock, D.Sc., F.R.S., who for three years have given their advice and services to the Allies, and we are thankful to say, in spite of war risks, wounds and privations, have returned to their homes, we trust to work for many years in their respective fields of knowledge. I speak with feeling on this occasion; since Professor David has for the past thirty years been my instructor and close personal friend and advisor, and while all have been anxious to welcome him home, I think no one has a greater right than I have. The Society will gain a Councillor of the ripest experience;

it is not necessary to say more. Major Professor Pollock was a fellow student who has achieved the highest honours, proving himself a worthy successor to our former member, his teacher, Sir Richard Threlfall. His useful years of service as our Honorary Secretary will be renewed; our veteran adviser, Mr. J. Maiden, I.S.O., F.R.S., retiring from the office. I may be allowed to remind you, though it is not necessary, that Mr. Maiden has now been an office-bearer for 29 years, including two years as president, two as vice-president, 22 years as Honorary Secretary. He has been our guide and philosopher, and during the past year has added an invaluable gift to our archives—the history of our Society, which can with justice claim to have occupied a most prominent position in the encouragement of scientific research in the State. Though losing him as one of our Secretaries, he remains a Councillor whose wealth of information will guide us. The relief from his administrative duties will add to his opportunities to complete his life's work—the monographs on the Forest Flora of New South Wales, and his Critical Revision of the genus Eucalyptus, a world recognised compendium, and fitting supplement to Bentham's and von Mueller's labours, and the Census of the Flora of New South Wales.

During the year the functions of the Society have been most satisfactorily performed, eight meetings were held, nineteen papers were read, the attendance of members was satisfactory, and the discussions in many of the subjects dealt with of great interest.

As a result of energy of the Sectional Secretaries the interest taken in past years has been maintained, and has led not only to more ample discussion than is possible at general meetings of the Society but has resulted in the introduction of new members.

Popular Science lectures were delivered:—"The Planet Mars," by Mr. James Nangle, F.R.A.S.; "Some Modern

Phases of Agriculture," by Mr. H. W. Potts, F.L.S., F.C.S.; "Radium," by Mr. S. Radcliff, F.C.S. These lectures were appreciated by satisfactory audiences.

Members were honoured by the visit of Professor R. J. A. Berry M.D., of the University of Melbourne, who delivered the Clarke Memorial Lecture on "Brain-growth, Education and Social Inefficiency.

During the year eighteen new ordinary members were elected, and one honorary member. There were two resignations.

It is gratifying to know that several of our members have been honoured during the past year, Dr. James Adam Dick (Colonel A.A.M.C.), and Mr. James Fraser, Chief Commissioner for Railways, having had conferred on them the Companionship of St. Michael and St. George, the same order being received by Colonel Frank Marshall and by our honorary member Dr. C. J. Martin. Mr. John Russell French has received the Knight Commandership of the British Empire; Dr. Archibald Lang Maclean (Captain, A.A.M.C.) has been awarded the Military Cross, and Mr. William T. Willington, the Order of the British Empire.

During the year I, as your representative, attended a meeting of the Board of Visitors of the Observatory.

The success of the Society is largely due to the constant attention of your Honorary Secretaries Mr. R. H. Cambage, F.L.S., and Mr. J. H. Maiden, I.S.O., F.R.S., and of the Honorary Treasurer, Professor H. G. Chapman, M.D., and all members appreciate their unsparing care of the Society's interests.

There are now 307 members on the roll; unfortunately we have lost by death and resignation 14 members, and 16 names have been removed from the rolls. Nineteen new members have been elected. The losses by death are:—

Joseph Brooks, L.S., F.R.A.S., F.R.G.S., was elected a member of the Society in 1878. He was born at Stockport, England, in 1847, arriving in Adelaide at the age of nine, and was educated at St. Peter's College. In 1877 he was appointed to the Survey Staff of the Lands Department of this State, and for many years was in charge of various trigonometrical surveys, being particularly interested in astronomical work. The observations made by the late Mr. J. Brooks in connection with the Trigonometrical Survey of N.S.W., extended over twenty-five years, during which period he observed at some 250 stations of the survey. The reduction of these observations has shown that they are of a very high order of precision, and take rank with those made in connection with the best triangulation carried out in other countries. Mr. Brooks' work on the survey also embraced astronomical observations for the determination of latitude and azimuth at a number of selected stations. He likewise determined, by transmission of electro-telegraphic signals, the differences of longitude between Sydney Observatory and some thirty stations distributed over the State, at which stations the latitude was also observed astronomically. These stations formed the basis for construction of reliable maps of the State in advance of the triangulation to which some of them have since been connected. Mr. Brooks also took a large share in the observations for the triangulation of the cities of Sydney, Newcastle, and Bathurst. He was a born observer with considerable mechanical ability, which enabled him to use his instruments to the best advantage.

Sir William Crookes, Kt., O.M., LL.D., D.Sc., F.R.S., a former President of the Royal Society of London, died on April 4th, 1919. By his death this Society loses from its list of Honorary Members one of the most famous names, for it is given to few, as it was to him, to make, in new directions, discoveries of striking importance in both physics and chemistry. Born in 1832, and as a young man appointed assistant to Hofmann the chemist, his scientific career extended over a period of seventy years. During the whole of this long life his activity as a scientific investigator was extraordinary. The isolation of a new metal, thallium, in 1861, early brought him fame. For twelve years he investigated the properties of the new element, finally determining the atomic mass with great accuracy. To increase the precision of the results in this research, the materials were weighed in a partial vacuum. Even then the determinations showed slight irregularities. Following up the residual discrepancies with painstaking persistence like the genius he was, Crookes was rewarded by the discovery of 'a repulsion resulting from radiation.' The explanation of the novel phenomena in gases at low pressure here disentangled by Crookes is associated with some famous names and is appreciated by few, but an exquisite piece of apparatus invented by Crookes to show the repulsion, known as the 'Crookes' radiometer' or 'light mill,' is so common as to be seen on hawker's trays in Sydney. The idea of investigating the electric discharge in gases perhaps naturally presented itself at this time to Crookes, now specially expert in the technique connected with experiments at low pressure. A result of these wonderful researches is the series of 'Crookes' tubes,' so well known to every student of electricity, with which Crookes found and demonstrated the properties of the cathode rays. Many years later it was with one of these Crookes' tubes that Rontgen made his sensational discovery. Crookes was, as a chemist, equally famous. In 1857 he found the selenocyanides. Following his discovery that under the bombardment of the cathode rays a large number of substances emit phosphorescent light, he elaborated a new method of spectroscopic analysis. In his hands the method has given valuable results, the outcome of a very lengthy series of researches chiefly on the rare earths. Of his more recent work, in connection with radio-activity he first effected the separation of the product resulting from the disintegration of uranium, calling it uranium X, and discovered in 1903 that a zinc sulphide target phosphoresces under the influence of a bombardment of α particles. The effect is seen in the 'Spintharoscope' which Crookes invented for the purpose, and through the agency of this fascinating little instrument the phenomenon is well known. This discovery has important applications in connection with radio-active determinations.

Much of Crookes' work dealt with practical matters. In 1859 he started the "Chemical News" which he edited until the end of his life, and he published many papers and books on technical subjects covering a wide range. For some years he devoted much attention to the study of the origin and properties of diamonds. He was given unique opportunities to visit De Beers' mines, and to examine the famous blue clay. Several papers and a most interesting book record the results of his investigations of these precious stones. In 1914 he completed a comprehensive study of the effects of adding various metallic oxides to the constituents of glass in a search for glasses for spectacles which, though transparent in the ordinary sense, would be opaque to the rays which have been found injurious to the eyes of workers exposed to furnace glare. The result is a table giving the composition and appropriate use of nineteen glasses which are valuable, out of more than 300 kinds investigated. To many workers glasses made to these prescriptions will prove an inestimable boon. Sir William Crookes during his life time received many honours. He served as President of several Societies, including the Chemical Society, the British Association, and the Institution of Electrical Engineers. He was President of the Royal Society from 1913 to 1915, and was one of the few scientists on whom the Order of Merit has been conferred. By the Royal Society he was awarded the Royal, the Davy and the Copley Medals, and by the French Academy of Sciences, a gold medal and prize of 6,000 francs.

Sir JAMES READING FAIRFAX was born at Leamington, Warwickshire on October 17th, 1834, and was the second son of the late Hon. John Fairfax, M.L.C. He was a member of this Society for fifty-one years, having joined in 1868, and at the time of his death, 28th March, 1919, was the oldest member on the roll. He was senior proprietor of the *Sydney Morning Herald* and the *Sydney Mail.* Sir James was knighted in 1898 at which time he was president of the Young Men's Christian Association in Sydney. He was one of the founders of the Royal Prince Alfred Hospital and was actively associated with its management almost continuously up to the time of his death. He always took a lively interest in the welfare of the poor and neglected children of the city and suburbs, and at the time of his death was chairman of the Sydney Ragged Schools Committee. He also took a deep interest in the welfare of sailors of the Royal Navy who were stationed in these waters, and was a trustee of the Royal Naval House. Throughout his life Sir James was a lover of art, and in addition to being one of the founders of the National Art Gallery he was Vice-President, and later President of that Institution. For many years he took a keen interest in aquatic sport, and for a number of years was commodore of the Royal Sydney Yacht Squadron. Sir James was for a long period of his life prominently associated with movements for the benefit of mankind, and as a journalist he was conspicuous in doing so much to preserve the best traditions of the press.

Sir PHILIP SYDNEY JONES, at the time of his death on 18th September, 1918, was the oldest member of the Society, having been elected in 1867. He was born in Sydney in 1836, and his life was full of usefulness. Few Australians have rendered such valuable service to medical science, education and philanthropy. He received his early education in Mr. Cape's well-known school, Mr. T. S. Dodd's school, and Mr. Henry Cary's academy at Darling Point, whence he proceeded to the University College, London. He obtained the medals for anatomy and medicine, conferred only upon distinguished students, and graduated with honours in 1859, taking the degree of Bachelor of Medicine. In 1860 he obtained the degree of Doctor of Medicine, and in 1861 became Fellow of the Royal College of Surgeons, England. Sir Philip filled the offices of house surgeon and house physician, together with that of resident medical officer at University College Hospital, London, and obtained the gold medal given by Dr. Fellowes to the most proficient student in clinical knowledge for the year. After returning to Sydney, Sir Philip was for twelve years honorary surgeon to the Sydney Hospital, then called the Sydney Infirmary, and in 1876 he gave up general practice and devoted himself to consulting work, and was regarded as the leading physician of the time. In order to keep abreast of development in medical science he visited Europe on several occasions. He was the pioneer in this State of the open-air treatment for consumption, and had much to do with establishing the Queen Victoria Homes at Thirlmere and Wentworth Falls. He was a member of the Senate of the Sydney University from 1887 till the time of his death, and for two years occupied the Vice-Chancellor's chair. He was one of the originators, and later an honorary physician of the Royal Prince Alfred Hospital, and also a member of the Board of Management of the National Museum, as well as of a number of other associations—scientific, educational and religious. For some time he was president of the New South Wales Medical Board. In 1905 he was created a

Knight Bachelor. Throughout his life Sir Philip commanded the affection, respect and esteem of all who came in contact with him, and was always a power for good.

Robert Hamilton Mathews, who died at Parramatta on the 22nd May, 1918, had been a member of the Society for forty-three years, having joined in 1875. During this period he contributed twenty-eight papers, chiefly on matters relating to the Australian Aborigines, on which subject he was an acknowledged authority. The most of his information was obtained by personal interviews with the natives themselves. By profession, Mr. Mathews was a Licensed Surveyor, and, in the 'Seventies,' carried out many surveys for the Mines Department, especially during the boom days of the tin mining on northern New England. He was employed for a long time by the Lands Department, both in this State and in Queensland, and it was while carrying out his surveying duties in remote country districts that much of his information concerning the aborigines was obtained. Mr. Mathews held many medals and diplomas from the principal anthropological and ethnological societies of the world, including the silver medal (Prix Godard) of the Anthropological Society of France, and the bronze medal of the Royal Society of New South Wales, for papers on aboriginal rock paintings and carvings. He was a magistrate for the States of Queensland, South Australia, and New South Wales for close on twenty years, and the author of the handbook, "Magisterial Inquiries," which ran into several editions.

Charles Henry Myles, who died on 11th May, 1918, was one of the oldest members of the Society, having been elected in 1876. His life was rather in the commercial than the scientific world, and he was a director of various business institutions. In maintaining his membership for forty-two years his object was to support science which he realised was of so much importance to the nation's progress.

HUGH PATERSON, who died on 22nd August, 1918, at the age of sixty, had been a member of this Society for forty years having been elected in 1878. For many years he carried on a successful dental practice in Sydney, and was one of tho founders of the Odontological Society of New South Wales. He was a supporter of science from a firm belief in its value.

PERCIVAL PEDLEY, elected a member in 1877, was a well known Sydney dentist, practising for many years in Macquarie Street, and took a keen interest in natural science in its broadest aspects. For many years he was a prominent worker in connection with the Microscopical Section of the Society. He was a member of the Council of the Linnean Society for many years. He took a great interest in aquatic sport; and during the latter part of his life lived at Lord Howe Island for several months each year. He died on the 2nd of June, 1918.

T. F. G. POCKLEY, a member since 1879, for many years an officer of the Commercial Banking Company, died on the 16th August, 1918. He was closely associated with the development of banking matters during the expansion of interests connected with the gold rush, both in this State and Queensland.

The Rev. THOMAS ROSEBY, M.A., LL.D., F.R.A.S., was born in Sydney on 8th April, 1844, and died on the 16th December, 1918. He joined this Society in 1913. Dr. Roseby was educated at the Sydney University. He held, successively, three University scholarships, was gold medallist in logic and mental science in 1868, and took the degrees of M.A. in 1871, and LL.B. and LL.D. in 1873. He became, in 1867, the first minister of Petersham Congregational Church; in 1872 he went to New Zealand and took charge of the

Dunedin Congregational Church. After fourteen years' work in Dunedin he went to Ballarat, where he laboured from 1885 until 1888, when he became Congregational minister at Marrickville, and he retired from the active ministry in 1911. Dr. Roseby was widely known as an astronomer. He took up the study of the science early in his career, and wrote numerous articles and some books in connection with it. His principal work was the computation and publication in 1895 of "Elliptical Elements of Gale's Comet." No elliptical comet elements had previously been computed in Australia since Rumker's computations in 1822 and 1825. He was elected a Fellow of the Royal Astronomical Society, and was president of the New South Wales branch of the British Astronomical Association in 1901 and 1902. From 1913 till 1916 he was chairman of the Australasian Congregational Union. He was chairman of the New South Wales Congregational Union in 1891 and 1903, and delegate from New South Wales to the International Congregational Conference in London in 1891, and was first president of the New South Wales Evangelical Council in 1900.

JOHN McGARVIE SMITH was born at Paddington in 1844, and died at Woollahra on 6th September, 1918. He had been a member of this Society for forty-four years, having joined in 1874, and was known as a practical scientist. At the age of thirteen McGarvie Smith was obliged to seek his own livelihood, and learned the trade of a watchmaker and jeweller. He took up photography, which led to an interest in chemistry. At the age of twenty-three he began to attend classes at the Sydney University in practical chemistry under Professor Liversidge, and theory under Professor John Smith, at the same time attending to his private business. As a metallurgist he rendered valuable help in solving problems on mining fields, including

Sunny Corner, Broken Hill, and Mount Morgan. For many years he worked at the problem of finding a vaccine which would enable persons to be inoculated against snake-bite, and in connection with his experiments he got together 500 Australian snakes and periodically extracted their venom. His greatest achievement was his successful treatment of the disease known as anthrax among cattle and sheep, and he presented the State Government with the formula for the preparation of a vaccine, and also endowed a new institute for the purpose of manufacturing and distributing the vaccine by a board controlling this McGarvie Smith Institute. He married the widow of Daniel Henry Deniehy a well-known Australian Orator, but she predeceased him by many years.

Horace Taylor, J.P., was elected a member of this Society in 1906, and died on the 10th February, 1919. He was connected with a city business firm for thirty years, but also took a great interest in the dental profession, and was secretary to a committee of dentists formed in the early nineties to prepare a Dental Bill, which later became law, when Mr. Taylor was appointed Registrar of the Dental Board constituted by the Government to administer the Act. He occupied the position of Registrar for about eighteen years.

II. The Development of the Mineral Industry of the State.

One of the most important post war problems that has to be met is connected with the mineral industry, affecting both the producer and the manufacturer, and the closely associated employment of labour. The war has stimulated the production of certain metals, reviving the industry and enhancing the value of the product, and the cessation of hostilities will, at any rate, greatly diminish the immediate demand for the finished product. This will entail increased investigation by the State, both as regards the capabilities of our mining industry, the possibility of the opening of new fields, and the conduct of research in connection with the treatment of the more complex ores which up to the present have baffled exploitation on a commercial basis.

The great question of by-products offers a large field for experimentation in Australia, more especially as regards our coal industry. The gas and coke industries alone afford scope for investigation which would yield invaluable results. This would necessitate the establishment of State and private laboratories which could be used to supplement the labours of the Bureau of Science and Industry. This is a work which will appeal to the members of this Society, and will meet with the support of the Section of Industry.

The Department of Mines has directed its energies during the past year to the examination of mining fields in greater detail, with a view to attracting attention to new possibilities in the legitimate employment of capital. Mr. E. C. Andrews, Geological Surveyor, has kindly supplied me with the following notes of certain branches of this work, dealing more particularly with his geological survey of the Barrier Ranges Silver-Lead Field and the Copper bearing areas.

1. *Broken Hill District.*—The district is being surveyed geologically by the Department of Mines. The main results of the geological survey of the district may be expected to be made known at the end of the present year. The Barrier Ranges, within which are distributed the mines of Broken Hill, consist of a very large land block which has been forced above the low-lying plain associated with it. This block is about 100 miles in length and is tilted in the form of a skillion roof, the abrupt face of the block having a western aspect and running through Corona, Willangra, Mundi Mundi, Umberumberka, and near the Umberumberka Mine. The eastern and southern aspects show a surface

which dips very gradually under the plain. The mines are contained within a sedimentary and igneous complex which shows the effect of variable regional metamorphism.

The trend of the main Broken Hill Lode sympathises in the main with that of the associated country rocks, and along this portion of the area the greatest rock alterations appear to have taken place. Thus the sediments appear to have been sands and clays with a high proportion of felspar, which in the neigbourhood of Broken Hill, the Pinnacles and Round Hill lodes, have been altered, in many places to sillimanite schist, whereas the sediments appear as sandstones, mica schists, and allied types well away from these lodes.

Gneisses of variable types, but closely related to each other, occupy much of the area near the main lodes, but they are conspicuously absent at a distance from the central area. Amphibolites and pegmatites are extremely common in the Broken Hill district, the types of the central area being different, in some measure, from the types lying to the east and west. All these intrusive rocks are in the form of sills or laccolites. A subordinate amount of basic igneous material occurs in the form of cross dykes of later age than the amphibolites. The amphibolite sills themselves are later than the gneissic rocks. The Broken Hill lodes were formed within the core of an old mountain range long since denuded to a plain.

Near the main lodes well marked zones of crushing occur. Cross-zones of crushing occur also as well as the main zones following the strike of the country rocks. Both types of crush zones contain pegmatite and quartz intrusions. The main crush zones appear to lie along the trend of strike faults, but these have not been determined satisfactorily at present. One of the large cross faults, however, has been worked out by Mr. W. R. Browne of the

Geological Department, at the Sydney University, from petrographical data. This fault has a surface displacement exceeding 1,000 feet. It is expected that the geological survey of the area will result in the location of several important "strike" faults within the Pinnacles-Broken Hill-Round Hill area. These faults have an important relation to the Broken Hill ore bodies.

About fifty miles to the north-west of Broken Hill the rock outcrops are suggestive of silicified sandstones and shales, and with these are associated an abundance of ironstained nodules of flinty appearance with masses of compacted sand and with abundant traces of opalised wood. It is reported that similar occurrences are to be seen closer to Broken Hill to the north-west. By analogy with the appearance of the rocks in the White Cliffs district these sediments appear to belong to the Cretaceous period. The present surface is that of a plain of denudation with outliers of Cretaceous sediment.

2. *Cobar District.*—Just as Broken Hill is the great centre of the lead-zinc-silver production, so the Cobar district has been the great centre of the copper industry of the State. The rocks in which the copper occur are not so old as those containing the lead, silver and zinc of Broken Hill; nevertheless, they appear to be Lower Palæozoic in age. Each lies within a low plateau or shield of old rocks having a trend somewhat north and south, the Cobar rocks west of north, and the Broken Hill types east of north. The two districts are separated by the wide area of the Darling River alluvium. The lodes of Cobar appear to lie within subparallel and overlapping crush zones from Mount Hope one hundred miles south, to the C. S. A. Mines, seven miles north-north-west of Cobar.

The commercial ore bodies occur as lenses within these crush zones, and the known bodies are only payable at present under high prices for copper. Unless fresh bodies are forthcoming to take the places of the depleted deposits or unless scientific skill be brought to bear upon the treatment of the complex ores remaining, the district will become little more than a group of subarid pastoral areas. It would be important to make experiments with the complex mixture of copper pyrites, iron pyrites, galena and zinc blende at the C. S. A., to see whether it has any commercial importance as regards copper, lead, zinc, silver, sulphur and flux for smelting. This deposit is supposed to exceed a quarter of a million tons in amount, and is at present lying idle awaiting research work. While yet the richer copper ore known to be of commercial value is being won, it would be important to undertake the research work. The sulphur is needed for superphosphates, the cinders from the roasting of the iron pyrites after separation from the lead and zinc would be useful as a flux in smelting, if arsenic, antimony and bismuth are present only in negligible amount.

Other mines calling for intelligent study are the siliceous gold ores of the Occidental, Cobar Gold and Peak Mines. The Peak ores appear to be replacements along zones of crush and along folded sediments. No complete conception appears as yet to have been gained as to the relation of the gold relationship to the complex movements of folding and faulting associated with it. Attention to this area within the near future would appeal to the function of the trained geologist and the metallurgist rather than of the old time prospector. The outcrops located by the prospector have been worked, the field may now be examined for zones of decided crush, and such zones, if found, may be prospected with drilling apparatus. The research student would follow the geologist.

3. *New England.*—The margins of the country rock alongside of the more sandy types of granite within New

South Wales have been favourite prospecting localities by miners in the search for tin. Later, when wolfram became valuable, these granite margins or the country rock alongside were found to hold most of this tin associate. Molybdenite and bismuth also were found to occur in commercial quantity in pipes or in tortuous channels, somewhat like bent cylinders. These deposits were found almost wholly *within* the granitic margins and not in the country alongside. Moreover, these granites differed from the tin and wolfram granites in that they were less sandy, and, as a rule, were much coarser in the texture of the base. These granites, however, are intimately related to the associated granite types, and the various types merge into each other in places. The prospector thus becomes perplexed in his quest for minerals and loses one granite within another.

During the past year the report—Mineral Resources, No. 25—The Limestone Deposits of New South Wales, by J. E. Carne, Government Geologist, and L. J. Jones, Assistant Geological Surveyor, has been issued. The work is most complete and conforms with the scope outlined in the Presidential Address for 1917. The importance of the industry is evidenced by the following figures:—

(*a*) Amount and value of cement produced in New South Wales, 1917, 112,850 tons, value £347,381.

(*b*) Lime, 1917, 26,090 tons, the value on truck varying, according to locality, from £1 10s. to £1 14s. 6d. per ton.

(c) Marble. Many of our marbles are of a highly ornamental character and will prove to be of considerable architectural value.

Mineral Resources No. 27. The Hill End and Tambaroora Goldfield report has been prepared by Mr. L. F. Harper, Geological Surveyor, and will doubtless lead to the revival of mining in this historic field, which since 1851 has yielded some fifty tons of gold.

The financial value of the industry to the State is shown by the following totals, 1918; £14,419,352. Total to end of 1918, £300,526,555. Of this grand total the Coal Industry accounts for £92,721,420, and this proportion will increase with the further development of manufacturing concerns and the direction of attention to the preparation of by-products.

Among the principal items of purely scientific interest that have been published during the past year, and which will be of direct concern to geologists of this State may be mentioned:—"The completion of Dr. Walkom's series of memoirs on the Lower Mesozoic Flora of Queensland," published in Bulletins 367, 384, and 389 of the Queensland Geological Survey. In this valuable work the author has brought to modern standards the pioneer work of McCoy, Morris, Feistmantel, Tenison-Woods, Etheridge, Shirley, and others. He has had the opportunity, and has availed himself fully of examining the large collections of the Queensland Geological Survey and those deposited in the Museum of the University of Brisbane. This work is of particular interest to New South Wales, in that the palæontological classification that he has adopted for the Ipswich, Walloon, Bundamba, and Burrum Series, will have to be adopted as a standard for the classification of our fresh water Mesozoic periods. The general succession in Queensland is comparable to, though not complying with those accepted in this State. As was pointed out in the Federal Handbook we have in New South Wales, as evidenced by the strata passed through in the Sydney Harbour Colliery Mine, a direct succession from Permo-Carboniferous to Mesozoic *Thinnfeldia* beds which must be regarded as being of Triassic age. In the Sydney section we have a series of strata analogous to the barren sandstone and conglomerates of the Clarence Coal Basin, which in that region were succeeded by sandstone and shales containing *Alethopteris* and *Tæniopteris Daintreei.* These beds must be regarded as the equivalents of the Walloon Series of Queensland, and possibly also of the upper members of the Ipswich formation. To this later series we can safely assign a Jurassic age, and the general appearance of the flora is of the cosmopolitan type. This is confirmatory, to a great extent, of the opinions that have been expressed from time to time, that in the central portion of Eastern Australia there is a direct sequence in sedimentation from Permo-Carboniferous to Cretaceous time. This condition has led to the mingling of faunas and floras which undoubtedly has confused stratigraphers, not only in Australia, but in Europe. It will be remembered that in the discussion of Daintree's paper already referred to in the criticism of the list of fossils published by Etheridge, it was considered by the leading geologists of England that his Cretaceous fossils had been hopelessly mixed, as the assemblage showed analogies to forms that in Europe might occur individually in Jurassic, Oolite, Kimmeridgian, Gault, or Chalk.

This is also borne out by the case of the fossil fish occurring in the Wianamatta shales of St. Peters, near Sydney, which Smith Woodward regarded as coming from two separate horizons of Carboniferous or Permian and Triassic respectively. These points lead to the establishment of the fact that in this region the European standard of palæontological classification cannot be followed.

Further support of this is brought forward by Chilton's description of crustacian remains from the Wianamatta. These forms of Anaspids show close resemblance to the Carboniferous type of Europe and America, furnishing another instance of the survival in Australia of Palæozoic forms into the Mesozoic.

The life of the two main divisions of the Queensland Cretaceous we now know to be practically the same, notwithstanding the unconformability, at any rate, so far as the fossils from the only localities in the Desert Sandstone known to yield them permits us to form an opinion, viz., Maryborough on the East coast, Battle Camp, near Cooktown, also in the eastern division of Queensland, and Croydon in the Gulf country.[1]

In New South Wales the two main divisions have been recognised, but the work of the Geological Survey in the Cretaceous area, has not, from unavoidable causes, so far been of that detailed character as to permit a delimitation to the same extent as in Queensland, except in the neighbourhood of the White Cliffs Opal-field, westward to the boundary of the colony, and north-westward beyond the Paroo River, where recent explorations by Mr. E. F. Pittman have revealed a much greater extent of the Upper Cretaceous than was at first believed to exist.[2] The first notification of beds answering in position to Daintree's Desert Sandstone Series, in New South Wales, was, I believe, made by Mr. H. Y. L. Brown,[3] and a reference of the White Cliffs beds to the same subdivision by Mr. William Anderson,[4] subsequently confirmed by J. B. Jaquet.[5]

Mr. E. F. Pittman in describing the Upper Cretaceous rocks of New South Wales, says:—

"*The Upper Cretaceous Rocks.*—After the close of the Lower Cretaceous period there must have been a still further subsidence of the floor of the basin, for the desert sandstones, which are of marine origin are distributed over a much wider area than the

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[1] Geol. and Pal., Q'land., etc., 1892, pp. 531, 554.

[2] Ann. Report Dept. Mines and Agric. for 1894 (1895), p. 110; Records Geol. Survey N. S. Wales, 1895, IV, pt. 4, p. 143.

[3] Report on the Albert Gold Field (N.S. Wales Parl. Papers), 1881. p. 3.

[4] Records Geol. Survey N.S. Wales, 1892, III, pt. 1, p. 29.

[5] Ann. Report Dept. Mines and Agric. for 1892 (1893), p. 140.

earlier Mesozoic rocks. In New South Wales they occur as far south as Bidura, near Balranald, and they have been recognised in many other places outside the limits of the Artesian basin. They have, however, suffered to an enormous extent from denudation, and are generally seen as small hills, forming isolated outliers of what was once a continuous far-reaching deposit.

"The desert sandstones are well represented in the neighbourhood of Mount Oxley, Milparinka, Mount Poole, Mount Stuart, and the Gray ranges to the north of the latter. There are two typical varieties of rock to be seen in these localities. One is a soft grayish white sandstone, passing in places into a coarse grit, while the other is an intensely hard but brittle porcelainised rock, which has the appearance of having originally been a porous grit, but which has been indurated by having all the interstices between the sand grains filled with secondary silica, which gives it a very opaline appearance when examined under a lens. One of the peculiarities of this rock is the manner in which it breaks up on the hill tops. The intense heat of the sun in summer raises the rock to a high temperature, and when this is followed by the sudden cooling effect of a thunderstorm, the large blocks of stone exfoliate and break up rapidly; it is consequently somewhat rare to see an outcrop of solid beds—the summits of the hills being covered with a rough shingle, which is so characteristic of Sturt's Stony Desert, in the neighbourhood of Milparinka and Mount Poole. This rock rings like porcelain when struck, and breaks with a conchoidal fracture. There seems to be very little doubt that it was originally identical with the softer variety of sandstone, and that the metamorphism has been caused by the action of thermal springs which deposited silica between the sand grains.

"The desert sandstone occurs in this district in isolated ranges or hills, which, as a rule, have steep escarpments. The beds are generally horizontal or dip at a low angle, and are traversed by vertical joints. Near the top of the series there is a bed of conglomerate, a few inches thick, consisting of pebbles of an infinite variety of colour, and owing to the breaking up of this conglomerate by weathering, the lower ground is, in many places, strewn with highly polished pebbles of banded agate, chalcedony, jasper, carnelian, pink and white quartz, etc. The extremely high polish which these stones exhibit may possibly be due to the action of the wind and sand.

"Occasionally highly ferruginous beds of desert sandstone are met with, to the disintegration of which the red sandy soil, which covers large areas of the plains, is probably due. Intercalated with the Desert Sandstones there are frequently seen beds of soft white rock which has very much the appearance of kaolin; and which is often mistaken for the latter; it consists, however, of nearly pure silica in an extremely fine state. It has been carefully examined under the microscope; but it has not been found to contain any organisms. Precious opal is found in rock of this character at White Cliffs in the Wilcannia District."

Several Desert Sandstone localities have been found to be fossiliferous, the only one, however, known in detail, is the White Cliffs Opal-field.

One of the problems which has exercised the minds of Australian geologists for many years and has led to many misstatements and misinterpretations by European writers has been the question of the succession and stratigraphical relation of the beds succeeding the palæozoic formations of Eastern and Western Australia.

In 1873 Richard Daintree, then Government Geologist of Southern Queensland, made the first detailed report on the geology and mineral resources of Queensland. In this classical work, he not only constructed a stratigraphical table of the sedimentary formations, and dealt in detail with the volcanic and plutonic rocks, more especially as concerning their intimate relation to economic minerals, but also in his sketches, showed the keen appreciation of the relation of geological formations to erosion and physiographic features. Daintree's work may be regarded as a memoir of the broadest scientific value, foreshadowing, though not perhaps, recording much of the work which has been evolved during the last twenty-five years of more detailed research.

I draw attention more particularly to Daintree's labours because it constitutes the keystone of the monumental work which was performed by Robert Logan Jack and Robert Etheridge, Jnr, "The Geology and Palæontology of Queensland, 1892," and has since been added to, and we trust will continue to be, by the labours of the Geological Survey of Queensland.

Daintree was helped by Robert Etheridge, Senior, and William Carruthers in the examination of the animal and vegetable fossils respectively. These authors were satisfied with classifying the fossiliferous beds above the Palæozoic beds as of Mesozoic age. This was certainly a correct general observation, but when we consider that the sequence of fresh water and marine sedimentation represents a thickness of from 3,500 to 4,500 feet, it must be realised that there is room for the assumption that notice of the time limit of sedimentation must be taken into account.

Certainly Daintree appreciated the fact that the fresh water beds now known as the Ipswich Coal Measures were the lowest in the Series. He also realised the fact that what he termed the Cretaceous was divisible into two series, or as we term them now, formations, the Lower or "Rolling Downs," and an Upper or "Desert Sandstone." This was a most natural subdivision to be adopted by a pioneer, who not only was hampered by the lack of communication, but also was influenced by the absence of adequate maps. In many cases the geologists of that time had to determine their positions by their own astronomical observations, and we find now that Daintree's classification while a natural one, cannot be regarded as strictly a logical one. Daintree's region of observation of the Cretaceous in Queensland was confined mainly to the eastern half of the State. His definition of the Upper Cretaceous was based on the assumption that the upper bed or beds of the system were composed usually of coarse sandstone which weathered out into flat-topped hills or mesas. We will see later that this is not invariably nor even frequently the case, the most notable exceptions being the Upper Cretaceous beds of Rockhampton, which were so carefully collected from by W. Smith, R. L. Jack, and T. W. Edgeworth David, and which have since been shown by the work of Professor Richards, Mr. Dunstan, Government Geologist of Queensland, and Dr. Walkom to be really referable to the lower beds of the Cretaceous succession.

The hitherto considered Desert Sandstone beds of the White Cliffs Opal Field afford little evidence in favour of their separation from the Rolling Downs. The point which has been lost sight of in the adoption of the terminology is the fact that the lithological characters of the older (lower) marine sediments are due to the drainage areas which fed the Cretaceous mediterranean sea.

The lower series which were deposited in a gradually sinking area extending from Carpentaria through North-western New South Wales to Lake Eyre were derived mainly from the denudation of the Coastal Ranges composed of Gympie mudstones, star cherts and shales, and in the more northern areas of the limestones, calcareous shales and slates of the Burdekin and Fanning River series. This is sufficient to account for the fact that the major proportion of the sediments of the lower strata of our Cretaceous is composed of fine grained shales, calcareous shales, and impure limestones, and an extremely small proportion of strictly arenaceous beds. Occasionally there are cases in which more siliceous beds occur low down in the series. These are simply local occurrences, and are due to proximity to shore lines bounded by the friable Ipswich and Bundamba Sandstones. This constitutes the at one time famous Blythesdale Braystone, considered to be the intake region of our Cretaceous Artesian water supply, though it has been shown that, at any rate in the more southern districts,

Map of Australia showing extent of Cretaceous Mediterranean Sea.

the Blythesdale Braystone is actually a calcareous sandstone, the surface porosity of which is due to the leaching action of terrestrial waters and is only superficial, the dense rock being met with at depths of from twenty to fifty feet.

Towards the close of the Cretaceous era, there was, as happened in Europe and in America, and in fact as in all cases of inlocked estuarine or marine areas of oceanic and drainage deposition associated with a stable isostatic condition of the general region, a gradual shoaling, a recession of the sea, and a reduction in the area of denudation, leading to the condition of reduction of stream to base level.

The concluding stages of Cretaceous sedimentation at any rate in Northern Queensland are represented by a series of coarse sandstones, grits and fine conglomerates. These are frequently red-coloured and show examples of cross bedding. This appears to be clear evidence that they represent the last stages of the elevation of this area of land, the rapid shoaling of the sea and the assumption of estuarine conditions and its associated faunal changes and gradual extinction of the marine fauna.

It may be seen by a study of the fossils, that the variation in fauna between the lower and the upper members of this unbroken series of sediments, can be accounted for adequately by the alteration of shore conditions, and by the probable alteration during the later period of the composition of the water. The term "Desert Sandstone" has been much misapplied. As used by Daintree in the first case, it was a correct phrase as expressing the upper members of a great system, but when we find that Tate in the Journal of the Horn Expedition, has described sandstones and quartzites containing Dicotyledonous leaves of Tertiary Age, and Eocene and Miocene, as that of Desert

Sandstone, and in the Northern Territory we have shown on the maps of H. Y. L. Brown and Tate, areas of Desert Sandstone which in reality are now known to be of Lower Palæozoic sandstones and quartzites, we can realise how there has been confusion between physiographic character and geological terminology. These will serve as a few general remarks on the question as affecting Eastern Australia, but this is local only. The point of the greatest scientific significance is the relation between the faunas of the Western Cretaceous Mediterranean region and those of the Eurasian province.

It was pointed out in the Federal Handbook of the British Association for the Advancement of Science in 1914, that the Eastern and Western Mesozoic marine faunas as a whole have no species in common, excepting of genera of extremely inconstant form.

It has been pointed out by David, Woolnough, and other writers, that the difference between the marine faunas of the Permo-Carboniferous system in Eastern and Western Australia necessitates the presence of a more or less complete land barrier during late Palæozoic time, preventing the mingling of the respective faunas and resulting in the isolation in the East of an endemic, and what may be termed a specific Permo-Carboniferous life assemblage, as compared with a contemporaneous Western fauna, which is a direct result of a southern migration of the typical Eurasian Permo-Carboniferous assemblage, which evidences, to a great extent, a mingling of Carboniferous and Permian types. This question has already been discussed in the Federal Handbook previously mentioned, and the Asiatic Russian and American aspects have been summarised by Schuchert in the American Journal of Science for 1906.

It is one of the interesting points in our continental geology that this barrier was maintained through Mesozoic time. We find that the Western and Northern Territory Cretaceous faunas have a general Asiatic and European facies. We also find that the same general character and affinities persist through the Malay Archipelago, Timor, New Guinea, New Caledonia, and New Zealand, whereas, on the other hand, our Eastern Australian Cretaceous fauna, on analysis, is seen to be unique. The only genera in common being those types which may be regarded as cosmopolitan forms, associated with which are many strictly local genera and species.

ON SOME AUSTRALIAN FRESHWATER COPEPODA AND OSTRACODA.

By MARGUERITE HENRY, B.Sc.

Communicated by Professor S. J. JOHNSTON.

With Plates I and II.

[*Read before the Royal Society of N. S. Wales, July 2, 1919.*]

Introduction.

The present paper is a continuation of the work on Freshwater Crustacea begun in the paper "On Some Australian Cladocera," published in the Proceedings of the Royal Society of N.S.W., Vol. LII.

The work has been done under the ægis of the Commonwealth Advisory Council of Science and Industry as work arising out of an investigation of the transmission of worm-nodules in cattle by a Special Committee appointed for that purpose. The work was begun at Kendall on the North Coast and continued at the Zoological Laboratory of Sydney University.

Material Investigated.

The material was mainly obtained from freshwater ponds and creeks in the vicinity of Kendall, and from a pond in the University grounds. Collections were also made at Waterfall, on the Lett River, Blue Mountains, Botany and Dorrigo. One or more tubes of preserved material were received from each of the following places: Byron Bay, Casino, Bangalow, Orange, Cumbalum, and Corowa. Two of the new species here described were found at Kendall, one at Cumbalum and one at Botany.

Methods Employed.

In the case of Crustacea obtained at Kendall, Botany and the University, the specimens were examined alive and drawn with the aid of a camera lucida. Others were fixed and preserved in glycerine alcohol. The smaller, more delicate forms were mounted unstained in glycerine jelly, the larger forms were stained with borax carmine, cleared and mounted in Canada balsam.

I have to thank Miss Somerville, B.Sc., for collecting and preserving Crustacea, and Professor S. J. Johnston for his advice and assistance in the preparation of the paper.

COPEPODA.

Division CALANOIDA.

Family CENTROPAGIDÆ.

Boeckella minuta, Sars.
Gladioferens brevicornis, sp.n.
Gladioferens spinosus, sp. n.

Family DIAPTOMIDÆ.

Diaptomus orientalis, Brady.

Division CYCLOPOIDA.

Family CYCLOPIDÆ.

Cyclops australis, King.
Mesocyclops obsoletus, Koch.
Pachycyclops annulicornis, Koch.
Leptocyclops agilis, Koch.
Leptocyclops viridis, sp. n.
Platycyclops phaleratus, Koch.

OSTRACODA.

Division PODOCOPA.

Family CYPRIDIDÆ.

Cypretta globulus, Sars.
Cypretta viridis, Thomson.
Stenocypris malcolmsonii, Brady.
Cyprinotus dentato-marginatus, Baird.
Cyprinotus fuscus, sp. n.
Ilyodromus varrovillius, King.

COPEPODA.

Division CALANOIDA.

Family CENTROPAGIDÆ.

Genus BOECKELLA, De Guerne and Richard.

BOECKELLA MINUTA, Sars.

This species was first described by Sars in "Freshwater Entomostraca from the neighbourhood of Sydney."[20] He again gave a description of it in "Freshwater Copepoda from Victoria."[27]

This form was found in abundance in a pond in the University grounds in June and July. It was also found at Kendall in June and at Corowa in March.

Sars recorded it from Botany Bay, the Waterloo Swamps and from Heidelberg near Melbourne.

Genus GLADIOFERENS n. g.

Cephalothorax consisting of six segments, last segment rather short with the lateral parts only slightly expanded, rounded. Abdomen *consisting of four segments in the female*, five in the male. Caudal rami long and slender. Antennules in the female consisting of twenty-five segments; right antennule in the male geniculate. Antennæ, with the outer ramus about the same length as the inner, composed of six segments. Oral parts of normal structure. Natatory legs biramus, each ramus consisting of three segments; basal segment of each leg of the fourth pair in the female *bearing a long curved sword-like spine on the inner edge*. Fifth legs in the female similar, each with a curved process on the inner edge of the middle segment of the outer ramus. Fifth legs in the male dissimilar, outer ramus usually three segmented, terminal segment of the outer ramus of the right leg armed with one long spine, that of the left leg armed with several short spines. Ovisac present, situated on the ventral surface.

This genus is nearly allied to *Boeckella*, De Guerne and Richard, with which it agrees in the structure of the oral parts, the natatory legs and the fifth pair of legs in the female. It differs, however, in the number of abdominal segments in the female; the length of the caudal rami; the presence of a long spine on the basal segment of the fourth leg in the female and the structure of the last pair of legs in the male.

Gladioferens spinosus, sp. n.

(Plate I, figs. 1 – 7.)

The average length of the female, not including the caudal rami, is 1·3 mm.

The general form of the body is moderately robust, with the two chief divisions sharply marked off from each other. Seen dorsally, the cephalothorax is of oval form, with the greatest width a little behind the middle; it tapers more anteriorly than posteriorly. The head is narrowly rounded in front, and projects below in a fairly well marked rostral prominence. The last thoracic segment is rather short and has the lateral parts slightly expanded into two rounded lobes; each lobe bears a spine and sometimes one or two smaller spines in addition.

The abdomen is long and slender, composed of four segments. The genital segment widens posteriorly and is expanded into two small rounded lobes; there is also a slight rounded projection on each side at about the middle; a group of bristles is present on each of these four projections. The prominence on the ventral surface of this segment is not very protuberant. The second segment is short and somewhat rounded; the third is longer than the second and is rectangular; the fourth is about the same length as the second. The caudal rami are very long and slender, equalling the length of the last two segments combined. They are divergent and bear hairs on their inner and outer edges; those on the inner edges being the longer. The outer edge on each side has a ledge to which one of the caudal setæ is attached; the remaining four setæ issue close together from the truncated end of each ramus. They are all about the same length.

The antennules are composed of twenty-five segments, some of the proximal ones being very small. When reflexed they extend about as far as the middle of the genital segment.

The antennæ (fig. 4) are biramus, the outer branch, composed of six segments, is about the same length as the inner.

The mandibles are strongly built; the masticatory part is expanded and bears eight somewhat rounded denticles; the outermost of these is the largest, and is separated from the others by a sinus.

The maxillæ and anterior maxillipedes are of normal structure.

The posterior maxillipedes (fig. 5) are long and slender, the four distal segments are small and bear numerous setæ.

The first four pairs of natatory legs are long and slender, each ramus consisting of three segments; the inner rami are shorter than the outer. In addition to the setæ, the outer ramus of each leg bears a denticulated spine on the outer edge of each segment, the third segment also bears two terminal spines, one of which is very long and coarsely denticulated. The basal segment of each leg of the fourth pair (fig. 2), bears a long curved spine on the inner edge, which reaches as far as the end of the middle segment of the inner ramus. The fifth pair of legs (fig. 3) is slightly shorter; the outer ramus is armed like the preceding ones, but bears in addition a long curved spine on the inner edge of the middle segment.

The ovisac is rounded, and is situated on the ventral surface.

The male is smaller than the female, the abdomen is very slender, and consists of five segments. The right antennule (fig. 6) is modified, being swollen and hinged. It may be divided into three sections; the first consists of nine segments, some of which are very small, the last three bear sensory appendages; the second section is swollen and consists of six segments; the terminal part is curved and consists of two long segments.

The natatory legs are armed as in the female, but the spine on the basal segment of the fourth pair is not present.

The fifth pair of legs (fig. 7) are strongly built, the right being the longer. In both legs the inner and outer rami are composed of three segments. In the right leg, the terminal segment of the outer ramus is small and bears one long spine; the second and third segments each bear a denticulated spine on the outer edge; the inner edge of the third segment is produced into a short pointed projection. The inner ramus is smaller, it bears only setæ on the terminal segment. The left leg is shorter, its outer ramus is very stout. Each segment of the outer ramus bears a denticulated spine on the outer edge, while the third segment bears two terminal spines as well; the inner ramus is smaller; its third segment bears a short spine.

Specific Characters.—Female. Body moderately robust with the anterior division oval in form, narrower in front than behind. Lateral parts of the last thoracic segment slightly expanded, rounded, each bearing one or more small spines; abdomen consisting of four segments. Genital segment widening posteriorly. Caudal rami very long, with hairs on the inner and outer edges. Caudal setæ of equal length. Antennules reaching as far as the middle of the genital segment, consisting of twenty-five segments. Natatory legs with both rami composed of three segments; outer rami with long coarsely denticulate terminal spines; fourth pair, each with a long curved spine on the basal segment. Last pair of legs smaller, outer ramus armed in the same manner as in the other legs, but also possessing a curved spine on the inner edge of the middle segment. Ovisac present, ventral in position. Length 1·3 mm.

Male smaller than the female. Right antennule bearing three sensory processes, middle section moderately swollen. Last pair of legs powerful; both rami three segmented. Right leg with a curved terminal spine on the outer ramus; second and third segments with denticulated spines; third segment produced into a projection on the inner edge; inner ramus bearing setæ. Left leg short and stout; outer ramus with three short spines on the third segment, and one on each of the other two; inner ramus armed with one short spine. Length 1·0 mm.

Collected at Kendall and Waterfall in May and June. Type specimen in the Australian Museum, No. ♀ P 4336, ♂ P 4337.

Gladioferens brevicornis, sp. n.

(Plate II, figs. 10–12.)

The average length of the adult female is about 1 mm. The general form of the body is rather slender with the anterior division oval in shape, tapering in front and behind. The greatest width occurs about the middle. The head is narrowly rounded and has a very small rostral prominence. The last pedigerous segment is small, hardly expanded at all, the lateral parts being rounded off and tipped with a bristle.

The abdomen is slender and composed of four segments. The genital segment is rounded, widening posteriorly; the second segment is short and somewhat rounded; the third is longer and narrower; the fourth is about as long as the second.

The caudal rami are fairly long, and only slightly divergent. The outer edge of each ramus has a little ledge from which the outermost seta springs; the two middle setæ of the terminal four are longer than the inner and outer ones.

The antennules are not very long, only extending, when reflexed, to the end of the cephalothorax. They are composed of about twenty-five segments, some of the proximal ones being very small. The oral parts are similar to those of the preceding species.

The first four pairs of legs have both rami composed of three segments. The spines on the terminal segments of the outer rami are long and coarsely denticulated. The fourth pair of legs bears a curved denticulated spine on the inner edge of the basal segment as well as the usual bristle. The fifth pair of legs is armed as in the preceding species; the curved process of the middle segment of the outer ramus is large and coarsely denticulated. The inner ramus reaches beyond the middle segment of the outer. The rounded ovisac is situated on the ventral surface.

The male is slightly smaller than the female and has a slender abdomen composed of five segments.

The right antennule bears three or four sensory processes and several short spiny projections; it is more swollen than that of the preceding species.

The fifth pair of legs are short and very stout. The right leg (fig. 11) is longer, and bears a curved spine on the terminal segment of the outer ramus, the two other segments each bear a spine on the outer edge; the inner ramus consists of two segments, the terminal one bears a spine. The outer ramus of the left leg (fig. 12) is composed of two large segments; the broad expanded terminal one bears four short spines and a longer denticulated spine on the outer edge; the second segment bears a denticulated spine; the inner ramus consists of a single segment bearing four short spines.

This species is smaller than the preceding one; the main points of difference are as follows. The antennules, although consisting of the same number of segments are comparatively shorter; the right one in the male is more swollen.

The caudal setæ are of different lengths instead of being equal.

The spine on the basal segment of the fourth leg in the female bears a row of denticles instead of being smooth. The fifth pair of legs in the male differs in the number of segments in the rami and in the armature.

Specific Characters.—Female. Body slender with the cephalothorax oval in shape, narrowed in front and behind; lateral parts of the last pedigerous segment rounded. Abdomen composed of four segments, of which the genital segment is the largest. Antennule composed of twenty-five segments, only reaching as far as the base of the cephalothorax. Fourth pair of legs each with a long denticulated spine on the basal segment. Last pair of legs with the curved process of the outer ramus large and coarsely denticulated, inner ramus reaching beyond the middle segment of the outer ramus.

Male smaller than the female, abdomen slender, composed of five segments. Right antennule bearing three or four sensory processes, swollen. Last pair of legs short and stout; right leg with a terminal spine on the tri-articulate outer ramus, one lateral spine on each of the other segments, inner ramus small, composed of one segment bearing a terminal spine; outer ramus of the left leg with two broad segments, terminal segment bearing four short spines and a longer lateral spine; inner ramus small, one segmented, bearing four short spines.

Collected at Cumbalum in January. Type specimen in the Australian Museum, No. P 4338.

Family DIAPTOMIDÆ.

Genus DIATOMUS, Westwood.

DIATOMUS ORIENTALIS, Brady.

This species was first described by Brady in "Notes on Entomostraca collected in Ceylon," Linn. Soc. Jour. Zool., Vol. XIX. A more detailed description with good figures was given by Sars in "On some Freshwater Ostracoda and Copepoda raised from Dried Australian Mud."(17)

Both males and females of this species were collected at Casino in January.

Brady recorded this form from Ceylon, and Sars from Rockhampton, Queensland.

Division CYCLOPOIDA.

Family CYCLOPIDÆ.

Genus CYCLOPS, Muller.

CYCLOPS AUSTRALIS, King.

This form was first described by King in his paper "On Australian Entomostracans."(14) It was later described by Sars in "Freshwater Entomostraca from the neighbourhood of Sydney"(20) and figured in "Freshwater Copepoda from Victoria."(27)

This large species was collected at Kendall and at Corowa in March, and at Byron Bay in January.

Sars recorded it from the Waterloo Swamps, Centennial Park and Bourke Street, Sydney.

Genus MESOCYCLOPS, Sars.

MESOCYCLOPS OBSOLETUS, Koch.

Syn. *Cyclops leuckarti*, Claus, *C. simplex*, Poggenpol, *C. scourfieldi*, Brady.

This form was first described by Koch in "Deutchlands Crustaceen, Myriapoden und Arachniden," Heft 21, Tab. 5.(15)

Sars gives a description and good figures in the "Crustacea of Norway."(31)

This species was found in abundance at Kendall in both summer and winter. It was also collected at Waterfall in July.

This form has been recorded from Europe, Asia, Africa and North and South America. Sars gave the following Australian localities, Centennial Park, Bourke Street and the Waterloo Swamps, Sydney, and St. Arnaud, Victoria.

Genus PACHYCYCLOPS, Sars.

PACHYCYCLOPS ANNULICORNIS, Koch.

Syn. *Cyclops quadricornis albidus*, Jurine, *C. tenuicornis* Claus, *C. albidus*, Schmeil, *C. gyrinus*, Forbes.

This species was first described by Koch in "Deutschlands Crustaceen," Heft. 21, Tab. 6.(15)

It is described and figured in detail by Sars in the "Crustacea of Norway."(31)

This form was collected at Kendall in both winter and summer months, and at Waterfall in July.

This species has been recorded from Europe, Northern Asia, Central Africa, North and South America and Hawaii. Sars recorded it from the Centennial Park, Sydney, and St. Arnaud, Victoria.

Genus LEPTOCYCLOPS, Sars.

LEPTOCYCLOPS AGILIS, Koch.

Syn. *Cyclops serrulatus*, Fischer, *C. varius* var. *brachyura*, Lilljeborg.

Koch first described this species in Deutschlands Crustaceen, Myriopoden und Arachniden,(15) Heft 21, Tab. 3.

A more detailed description is given by Sars in the "Crustacea of Norway."(31)

This very common form was collected at Kendall and Orange in December, the Lett River in September, at a pond in the University Grounds in July, and at Byron Bay, Bangalow and Dorrigo in January.

This species has been recorded from Europe, Asia, Algeria, The Azores and North America. In Australia it has been recorded from Centennial Park and the Waterloo Swamps, Sydney.

LEPTOCYCLOPS VIRIDIS, sp. n.
(Plate II, figs. 8, 9).

This is a very small form; the length of the adult female only attains 0·61 mm.

The cephalothorax is moderately slender and oval in outline; the greatest width occurs about the middle. The abdomen is slender and composed of four segments; the genital segment is not dilated and is equal in length to the next two segments combined. The caudal rami are somewhat divergent, slightly longer than the last segment. The inner of the two middle apical setæ is twice as long as the outer; the seta of the inner corner is small, shorter than that of the outer.

The antennules are long and slender, reaching, when reflexed, almost to the end of the cephalothorax. They are composed of twelve segments, the third and sixth of which are very small, the last six are slender and elongated. The rudimentary palp of the mandible bears two long feathered setæ and a bristle.

The anterior maxillipedes have the subdivision of the first basal segment indistinct. The posterior maxillipedes have stout curved setæ on the proximal segment.

The natatory legs are well developed with tri-articulate rami. The first pair is the smallest, and has the second basal joint produced at the inner corner and provided with a spine. The apical spines of the fourth pair are particularly long. The last pair (fig. 9) is very small, it consists of a simple lamella armed inside with a denticulate spine and outside and at the tip with a slender seta. Ovisacs oval in shape and greyish-brown in colour.

The male is smaller than the female and possesses very much swollen and curved antennules.

The colour of males and females is dark green with light orange antennules and antennæ and orange markings on the abdomen.

This species somewhat resembles *Cyclops prasinus*, Fischer. The antennules, however, are straight and lack the hinge of *C. prasinus;* the lateral caudal seta is situated close to the end of the ramus instead of in the middle; the colouring is distinctly green and orange instead of indigo blue.

Specific Characters.—Female with a moderately slender body, cephalothorax oval. Genital segment equal in length to the next two segments combined. Caudal rami divergent, slightly longer than the last segment. Inner middle apical seta twice as long as the outer. Antennules composed of twelve segments, reaching when reflexed, to the base of the cephalothorax. Natatory legs all tri-articulate. Fifth pair of legs consisting of a lamella with a spine and two setæ. Ovisacs oval, slightly divergent.

Collected at Kendall during both winter and summer months. Type specimen in the Australian Museum No. P 4339.

Genus PLATYCYCLOPS, Sars.

PLATYCYCLOPS PHALERATUS, Koch.

Syn. *Cyclops canthocarpoides*, Fischer, *C. lascivus*, Poggenpol.

This form was first described by Koch in " Deutschlands Crustaceen, Myriapoden und Arachniden[15] in Heft 21, tab 9. It is described and figured by Sars in the "Crustacea of Norway,[31] and by Marsh in "North American Species of Cyclops."[16]

This species was found in abundance at Kendall during the winter and summer months; it was also collected from a pond in the University grounds in July.

This form has been recorded from Europe, Turkestan, North America, Egypt and Java. Sars found this species in a collection made at the Centennial Park, Sydney.

Platycyclops fimbriatus, Fischer.

Syn. *Cyclops crassicornis*, Sars.

Fischer first described this species in his "Beiträge zur Kentniss der Cyclopiden," Bull. Soc. Imp. Moscou, 1853.

It is described and figured by Sars in the "Crustacea of Norway,"(31)

A few specimens of this small species were collected at Kendall in December.

Platycyclops fimbriatus has been recorded from various parts of Europe and from North America.

OSTRACODA.

Division PODOCOPA.

Family CYPRIDIDÆ.

Genus CYPRETTA, Vavra.

Cypretta globulus, Sars.

Sars first described this form in his paper "On some Freshwater Ostracoda and Copepoda raised from Dried Australian Mud,"(17) under the name of *Cypridopsis globulus*. This species, however, does not belong to the genus *Cypridopsis* for the caudal rami are normally developed. Sars in his paper on the "Ostracoda from Tanganyika"(28) refers this and the allied Australian species to the genus *Cypretta*, Vavra.

This form was fairly numerous at Kendall in both summer and winter months.

Sars recorded it from Rockhampton, Queensland.

CYPRETTA VIRIDIS, Thomson.

This form was first described by Thomson in "On the New Zealand Entomostraca" as *Cypris viridis.*[35] It was later more fully described by Sars in "Freshwater Entomostraca of New Zealand"[18] as *Cypridopsis viridis.*

A few specimens of this species were collected at Botany in July.

Thomson recorded this form from Dunedin, and Sars from Kaitaia, New Zealand, and Bourke Street, Sydney.

Genus STENOCYPRIS, Sars.

STENOCYPRIS MALCOLMSONII, Brady.

This form was first described by Brady in "Notes on Entomostraca collected by Mr. Haly in Ceylon," Linn. Soc. Jour. Zool., Vol. XIX, as *Cypris malcolmsonii.* A more detailed description with good figures was given by Sars in his paper "On Some Freshwater Ostracoda and Copepoda raised from Dried Australian Mud."[17] Two well preserved specimens of this species were obtained at Casino in January. Brady recorded this species from Nagpur in India, and from Ceylon.

Sars found it in collections made at Gracemere and Crescent Lagoons near Rockhampton, Queensland.

Genus CYPRINOTUS, Brady.

CYPRINOTUS DENTATO-MARGINATUS, Baird.

This form was first described by Baird as *Cypris dentato-marginatus* in "Description of some new recent Entomostraca from Nagpur collected by the Rev. S. Hislope," Proc. Zool. Soc., London 1859. Sars gave a very full description with good figures in "On some Freshwater Ostracoda and Copepoda raised from Dried Australian Mud."[17]

This form was present in abundance in a collection made at Botany in July.

This species was collected at Nagpur in India, and in Australia from the Gracemere and Crescent Lagoons near Rockhampton.

CYPRINOTUS FUSCUS, sp. n.

(Plate II, figs. 13, 14).

The carapace of the adult female attains a length of 2 mm. so that this form grows to a larger size than the other Australian species.

Viewed laterally, the carapace exhibits a wide oval shape, with the greatest height 1·3 mm. occurring about the middle. The anterior extremity is obliquely rounded and somewhat narrower than the posterior. The dorsal margin forms a bold, fairly regular curve; the ventral margin is slightly convex and joins the anterior and posterior extremities without any intervening angle. Seen from above the carapace is rather tumid; the anterior extremity is more pointed than the posterior. The valves are unequal, the left one slightly overlaps the right at both ends, but dorsally and ventrally it is surpassed by fairly large projections of the right valve. The ventral edge of the left valve has a very slight ventral sinus, but the projection of the right gives a convex appearance to the lateral view of the carapace. The left valve has a smooth edge throughout, but the right one, as in all other species belonging to the genus, has a series of small tubercles inside the anterior and posterior extremities. These give the edge a minutely crenulated appearance.

The surface of the carapace is smooth and polished; it is marked with the usual scattered pits. There are only a few hairs, and these are confined to the extremities.

The carapace is an orange-brown colour with darker brown markings. In the living animal the dark greenish intestine and orange coloured ova can be seen through the carapace. The structure of the oral parts is that characteristic of the genus.

The anterior leg (fig. 15) has a long, curved, denticulated terminal spine.

The caudal rami (fig. 14) are of moderate length; they taper slightly distally, and are armed with two unequal claws and two bristles; both the claws are finely denticulated for the outer two-thirds of their length; the larger exceeds half the length of the ramus.

This species most nearly resembles *Cyprinotus dahli*, Sars, described by Sars in his paper "On Some West-Australian Entomostraca."(32) It differs from this smaller form in its general shape, and in having a ventral as well as a dorsal projection of the right valve. It also differs in the fine denticulation of the caudal claws.

Specific Characters.—Carapace, seen laterally, oval in form, greatest height occurring about the middle; dorsal margin boldly arched, ventral slightly convex; anterior extremity obliquely rounded. Seen from above rather tumid, anterior extremity narrower than the posterior. Valves of unequal size, the left one slightly overlapping the right at the extremities, but overlapped by projections of the right valve, both dorsally and ventrally. Surface of the carapace smooth, sparsely hairy at the extremities. Oral parts normal. Caudal rami tapering slightly distally, terminal claws denticulated, outer claw exceeding half the length of the ramus. Colour orange-brown, marked with darker brown. Length 2 mm.

Collected at Botany in July. Type specimen in the Australian Museum, No. P 4341.

Genus ILYODROMUS, Sars.

ILYODROMUS VARROVILLIUS, King.

King first described this species in "On Australian Entomostracans"(14) as *Cypris varrovillia.* Sars gave a description with good figures in "Freshwater Entomostraca of New Zealand."(18) This form was very abundant at Kendall in both summer and winter months.

King found this species at Varroville, near Sydney, and Sars in Lagoons in the neighbourhood of Dunedin, and in ditches at Kaitaia, North Island, New Zealand.

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Explanation of Plates.

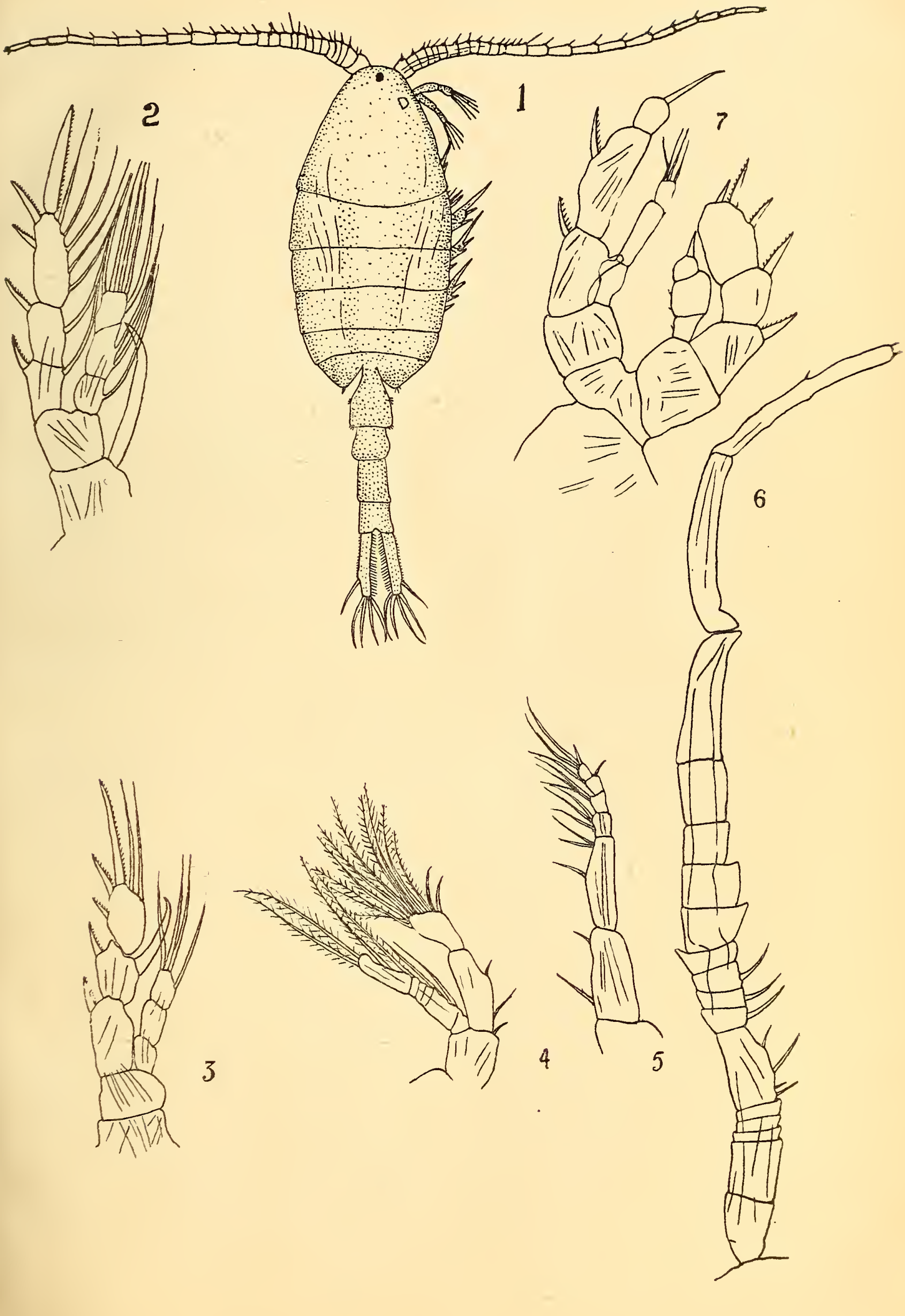
The drawings which were made by Mr. F. W. Atkins, of the Technical High School, Sydney, were all done with the help of the camera lucida.

Plate I, *Gladioferens spinosus.*

Fig. 1. Whole mount.
,, 2. Leg of the fourth pair, female.
,, 3. Leg of the fifth pair, female.
,, 4. Antenna.
,, 5. Posterior maxillipede.
,, 6. Right antennule, male.
,, 7. Fifth pair of legs, male.

Plate II.

Fig. 8. *Leptocyclops viridis.*
,, 9. Fifth leg of *L. viridis.*
,, 10. *Gladioferens brevicornis.*
,, 11. Right leg of the fifth pair, male of *G. brevicornis.*
,, 12. Left leg of the fifth pair, male of *G. brevicornis.*
,, 13. *Cyprinotus fuscus.*
,, 14. Caudal ramus of *C. fuscus.*
,, 15. Anterior leg of *C. fuscus.*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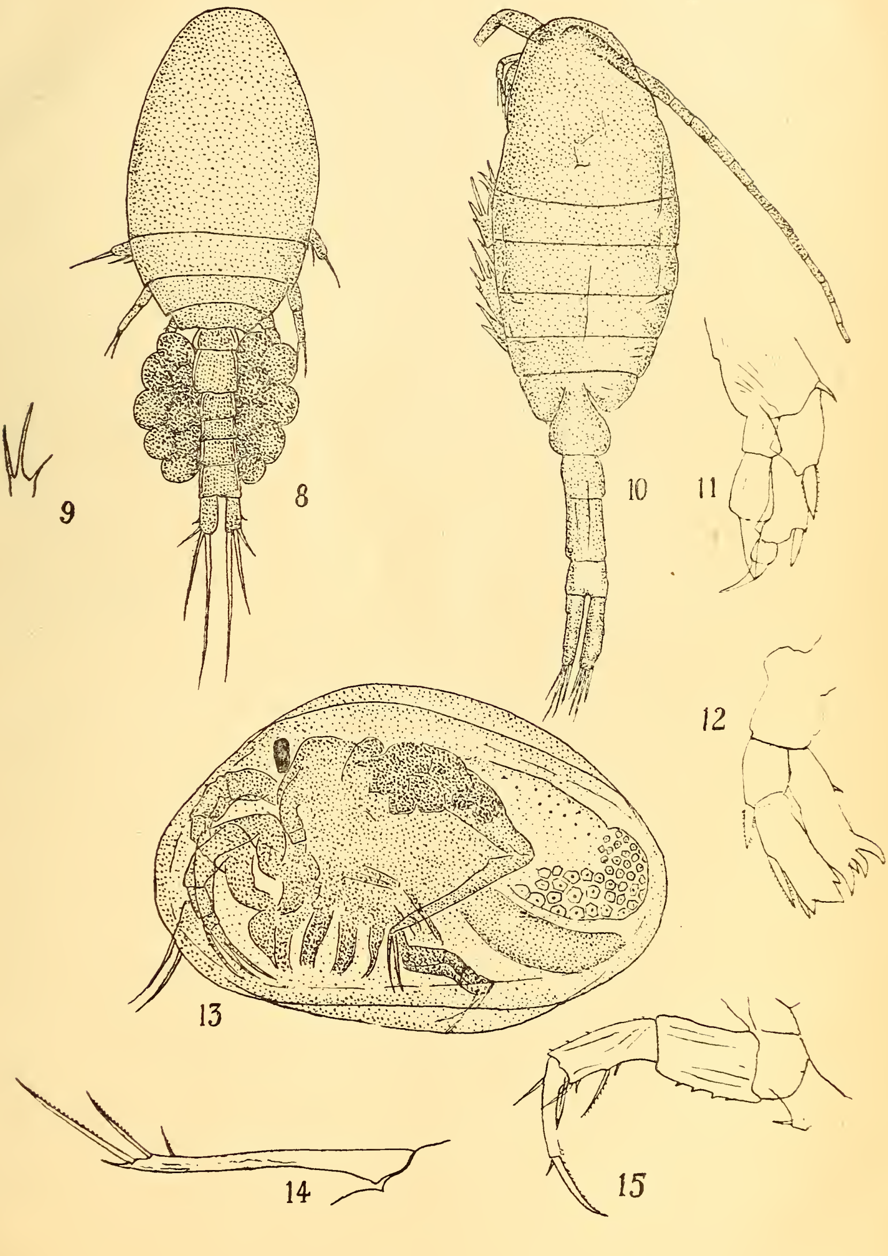
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SOME NOTES ON *NEUROSORIA PTEROIDES* (R.Br.) Mett.

By W. WALTER WATTS, F.L.S.

With Plates III and IV.

[*Read before the Royal Society of N.S. Wales, July 2, 1919.*]

UNDER the name, *Acrostichum pteroides*, Robert Brown[1] published a brief description of a noteworthy fern from tropical Queensland, the scientific classification of which has not, to this day, been satisfactorily established. K. Domin[2] says, of this fern, that it needs to be investigated anew in ample material, seeing that the data regarding the structure of the sorus are contradictory. Pending the finding of such new material, the following notes will, the writer believes, help to elucidate the problem, and, at the same time, place on record the results of earlier research.

At the outset, he begs to acknowledge his indebtedness to the Government Botanist of Queensland, Mr. Cyril T. White, for placing at his disposal the material in the Queensland Herbarium; to Mr. E. E. Pescott, F.L.S., and Mr. C. C. Brittlebank, of the Science Branch of the Victorian Department of Agriculture, to the former for the excellent photograph of the fern (Plate III), and to the latter for the painstaking drawings of the nerve-structure, the sporangia, etc. (Plate IV); and, finally, to Miss Lilian S. Gibbs, F.L.S., of London, who was kind enough to copy out and send to him the whole of the valuable matter published by M. Kuhn,[3] in 1869.

[1] "Prodromus," p. 145 (1810).

[2] "Pteridophyta," p. 147 (1913).

[3] "Botanische Zeitung," Vol. XXVII, pp. 437 ff.

Robert Brown's original description of this fern *(loc. cit.)* was as follows:—

"frondibus bipinnatis glabris, pinnulis linearibus margine reflexis."

This description, slight though it be, accurately enough covers the external characters of the fronds; and the specific name *pteroides*, marks the *Pteris*-like appearance of the pinnules. But, as pointed out by Kuhn *(loc. cit.)*, the distinguished author was in error in assigning the plant to the genus *Acrostichum.* The mistake was easily made, seeing that the sporangia, when ripe, apparently cover the whole of the under side of the pinnules; but while, in *Acrostichum*, the sporangia arise from the parenchyma lying between the nerves, in Brown's plant they spring from the nerves themselves.

Desvaux[1] assigned the plant to his genus, *Phorolobus*, a genus related to *Pteris*, but not recognised in Christensen's "Index Filicum." Hooker[2] kept it in *Acrostichum (§Leptochilus?).* Hooker and Baker,[3] say, of Brown's plant, "*Acrostichum pteroides* R. Br., from tropical Australia, has an ebeneous naked stem 1′ long, and distant lomarioid fertile pinnæ, the lower ones again sparingly pinnate, but the barren frond is not known." There is a brief reference, later in the "Synopsis,"[4] to Kuhn's new genus, *Neurosoria*, "as having the sori confined to the nerves," but no opinion is expressed regarding the validity of the genus. Moore[5] conjectured that the plant in question belonged either to *Gymnopteris* or *Cheilanthes.*

Kuhn *(loc. cit.)* reviews these facts, and adds that Mettenius wrote, "in his Mss.,"

"Vidi specimen fertile in herb. Desvauxii. Sori in decursu nervorum evoluti, nec parenchyma nervis interjectum intrantes

[1] Prodrome, p. 291 (1827). [2] Species Fil. V, p. 279.
[3] Synopsis Fil., p. 424. [4] *Ibid.*, p. 524. [5] Index Fil., p. 13 (1857).

ansam præbuerunt, speciem ad huc incomplete notam ab *Acrostichaceis* removere."

Kuhn further states, that he himself had had in his possession an original specimen of Robert Brown's, but that, as in the case of the material in the Herbaria of Hooker and Desvaux, the rhizome was wanting. At that time, he had believed that the plant should be assigned to the genus *Allosorus* [a genus, equally with *Phorolobus* (vide supra), unrecognised in Christensen's "Index."] But more recently he had received for determination a small collection of ferns from Lizard Island, on the north-east coast of tropical Australia [Lizard Island is just above Cooktown], in which numerous specimens of this plant were included; and the result of his examination of the material had been the confirmation of Mettenius' opinion, that the species constituted a new genus.

Seeing that the "Botanische Zeitung" is difficult of access in Australia, Kuhn's description of the new genus *(loc. cit.)* may be advantageously reproduced in full:—

NEUROSORIA Mett. nov. gen.

Rhizoma repens abbreviatum paleis membranaceis lineari-lanceolatis in setam acuminatam cellula terminali globosa oleo repleta terminatis, ferrugineis, mox rigidis infuscatis; fasciculi rhizomatis 3 sphærici; folia rigide membranacea, multifaria, conformia, sterilia minora, fertilia majora; petiolus basi dense paleis lineari-lanceolatis, minutis obsitus, supra et in costis segmentorum laxe paleaceus; sterilium petiolus 1″ – 2″ longus, leviter canaliculatus; lamina ovato-lanceolata 1″ – 2″ longa, bipinnatisecta, nervi infra anadrome supra catadrome disposita; segmenta primaria petiolulata, secundaria sessilia, integerrima, lineari-lanceolata; fertilium petiolus 3″ – 7″ longus, leviter sulcatus, gracilis cum rhachi ebeneus; lamina 3″ – 6″ longa, ovato-lanceolata bipinnatisecta; segmenta primaeia alterna inferiora pinnatisecta, longe petiolulata petiolulo ad 6‴ imposita, 1″ – 2″ longa, superiora sessilia, pinnata 1″ – 1½″ longa; segmenta secundaria ½″ – 1″ longa, ½ – 1‴ lata, sessilia, linearia, margine attenuato vix revoluto; costa tenera, proëminens; nervi distantes medio laminæ furcati, apice vix incrassati; sori more *Allosori*, nervorum ramos occupantes, basis ima nervorum sterilis, annulus verticalis incompletus basin sporangii non attingens; paraphyses nullæ; sporæ magnæ, pyramidatæ, globosæ.

The main points of this description must be considered in order.

1. The form of the vascular structure of the rhizome will be referred to in connection with the question of the classification of the genus *Neurosoria*.

2. The "conformity" of the sterile and the fertile leaves, the former being simply smaller than the latter, appears to depend entirely upon Kuhn's data, which Bentham[1] quotes, while saying that he had not seen the barren fronds. Bailey[2] follows Bentham. Personally, the writer has not found a single sterile frond among the specimens he has examined from the Queensland and the Victorian Herbaria. In one case, some very small leaves were, at first, taken to be sterile, but they proved, on closer examination, to be fertile, like the larger ones. Kuhn, however, seems to have seen sterile leaves, and his testimony ("sterilia et fertilia conformia") must be accepted, unless new material should compel a revision of his conclusion.

3. The evidence regarding the leaf-margin is somewhat confusing. Robert Brown's original description was "pinnulis . . . margine reflexis." Bentham's description (*loc. cit.*) is, "a very narrow margin recurved over the young sori." Bailey (*loc. cit.*) says "margin recurved over the sori." But Kuhn, as will be seen above, says "margine attenuato vix revoluto," and later in differentiating *Neuro-*

[1] Flora Austr., vii, p. 780. [2] Fern World of Anstr., p. 74, (1881).

soria from *Allosorus*, he says, of the former, "margo segmentorum vix revolutus," and, of the latter, "margo segmentorum ultimorum fertilium manifeste revolutus." The contradiction is perhaps more apparent than real. As distinguished from the ferns formerly assigned to *Allosorus* (now included in *Pellœa*, *Cryptogramma*, etc.), in which the indusium-like margin is widely bent back over the sori, the margin of *Neurosoria* may be regarded as, comparatively, "vix revolutus"; but Brown's original description (*vide supra*) cannot be ignored, nor the testimony of Bentham and Bailey. Judging from the material I have seen, the facts are as follows:—

(*a*) When specimens are dry, the opposite edges of a pinnule bend under to such an extent that, often, they nearly, sometimes quite, touch one another, almost completely hiding the sori. Moreover, when moistened, the pinnules are flattened out with difficulty.

(*b*) In addition to this bending back of the opposite edges of the pinnules, there is often visible a narrow recurving of the attenuated margin. It does not at all approach the strong, indusium-like, recurved margin of *Pellœa*, but the modified recurved margin is certainly present; and Bentham's "a very narrow margin recurved over the young sori," must be accepted. For the removal of any remaining doubt, it is much to be desired that living plants should be examined.

(*c*) A point overlooked by Kuhn must be noted. The attenuated margin is crenulated, as will be seen from Plate IV *a*, *d*; but the crenulations do not exhibit any regularity in structure, nor do they appear to stand in any definite relation to the ends of the nerve-branches.

4. The nerve-structure is of great importance in this fern. First of all, Kuhn's "costa tenera, proëminens" accurately describes one of the striking features of the

pinnules. The main nerve in each pinnule, while not robust (Kuhn's "tenera" may be accepted), projects very distinctly and prominently from the surface of the frond, being in this respect very similar to the costa of *Hypolepis tenuifolia*. The structure of the side-nerves is of much interest. These branch off from the main nerve at a very acute angle, and then ramify dichotomously, the branches curving towards the margin of the pinnule (see Plate IV *a*, *d*). The nerve-ends are free, and are more or less thickened and dentate. Kuhn's "apice vix incrassati" hardly does justice to the case (see Plate IV *b*).

5. The sorus now demands attention. This is the point at which, in Domin's opinion *(vide supra)*, the data are contradictory. The figures drawn by Mr. Brittlebank show the sorus-structure accurately. The sporangia spring from the sides of the upper nerve-branches, and lie more or less on the surface of the lamina. There are no sporangia on the lowest parts of the nerve-branches (*cf.* Kuhn's "basis ima nervorum sterilis"), Plate IV *c* shows also that Kuhn's description of the annulus as "vertical and incomplete, not reaching the base of the sporangium" is quite correct.

We are now in a position to consider the proper place of this interesting plant in Fern-Classification.

1. That it is not an *Achrostichum* is already quite clear.

2. Kuhn associates it closely with the supposed genus *Allosorus*, of which *Cryptogramma crispa* (R.Br.) may be taken as typical. The similarity of the sorus-structure is certainly striking, and raises the question whether the name *Neurosoria*, is sufficiently distinctive; but the nerve-structure is quite different in *Cryptogramma crispa* and *Neurosoria pteroides*, being, in the former, simply pinnate, not dichotomously branched, and the nerve-ends not being free, but joined together submarginally, the lines of junction, as well as the upper nerve-branches bearing sporangia. All

the evidence points to the *Cheilanthinæ* as the section of the *Pterideæ* to which *Neurosoria* belongs, and to *Cheilanthes* and *Hypolepis* as its nearest relations. That is to say, that *Neurosoria* must find a place among the *Cheilanthinæ* with thickened nerve-ends. For, to return once more to a point already touched upon, there can be no longer any doubt as to the nerve-ends of *Neurosoria* being thickened (see Plate IV*b*); indeed Kuhn himself, while describing the nerve-ends as "vix incrassati," yet, when he comes to the comparison of *Neurosoria* with *Allosorus*, says, of the latter, nerve-ends "non incrassati," and, of the former, nerve-ends "paullulum incrassati."

3. The testimony derivable from the structure of the vascular bundles of the rhizome, while used by Kuhn to distinguish *Neurosoria* from *Allosorus*, with its one horseshoe-shaped fascicle, may perhaps be disregarded for the purposes of this paper. The writer has no specimen of the rhizome of *Neurosoria*, but what he takes to be a structure corresponding to the "fasciculi 3 sphærici" of Kuhn's description of the new genus is found in the rhizome of *Cheilanthes tenuifolia* Sw.

4. A fern that has a striking superficial resemblance to *Neurosoria pteroides*, and might easily be mistaken for it, is Brown's *Cheilanthes caudata*, which Domin *(op. cit.)* makes a subspecies of his amplified and emended *Ch. tenuifolia* (Sw.); but close examination shows this plant to be a true *Cheilanthes* with submarginal confluent sori, and a distinct indusium, though this latter, unlike most spp. of *Cheilanthes*, is practically continuous, as in *Pteris*. It comes from Tropical Queensland, and like *Neurosoria*, is very rare.

As the result of these considerations, the writer ventures to suggest that the following scheme, based partly on that of Diels in the "Pflanzenfamilien," indicates the place of *Neurosoria* in fern classification.

Cheilanthinæ.

Sori occupying the upper ends of the nerves, sometimes laterally confluent, sometimes extending backwards down the upper branches of the nerves; the leaf-margins mostly reflexed and often modified; stipes often black-polished.

i. Leaves uniform.
  A. Nerve-ends scarcely thickened.
    Pellæa, *Doryopteris*, *Notholæna*, etc.
  B. Nerve-ends thickened.
    a. Sori on the nerve-ends.
      1. More or less laterally confluent: *Cheilanthes*
      2. Solitary at the base of a leaf-sinus: *Hypolepis*
    b. Sori occupying the whole of the upper nerve-branches: *Neurosoria*
ii. Leaves, or segments of leaves dimorphous: *Plagiogyria*

Summary of References.

Acrostichum pteroides R. Br., Prodromus, p. 145 (1810); F. v. Mueller, Fragmenta Phyt., v, p. 139 (1866), Second Census, p. 234 (1889); Bentham, Fl. Austr. vii, p. 780 (1878); Bailey, Fern World of Australia, p. 74 (1881), Synops. Q. Fl., p. 723 (1883), Catal. Q. Pl., p. 60 (1890), Lithograms Q. Ferns, t. 188 (1892), Q. Fl., p. 1994 (1902).

Phorolobus pteroides Desvaux, Prodrome, p. 291 (1827).

Neurosoria pteroides Mettenius—Kuhn, Bot. Zeit., xxvii, pp. 437 ff. (1869); Christensen, Index Fil. (1906); Domin, Pteridophyta, p. 147 (1913).

Explanation of Plates.

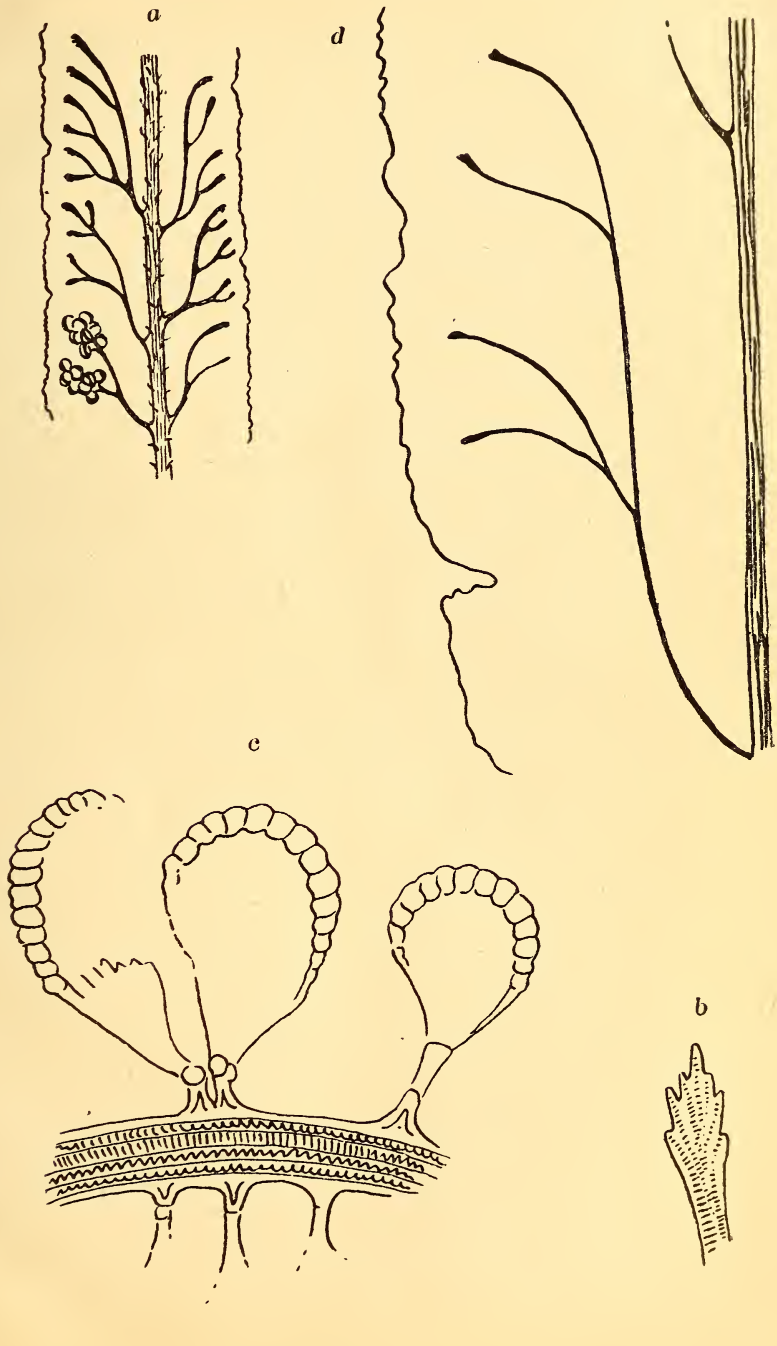
Plate III.—Photographs by E. E. Pescott, f.l.s.

a. Complete plant from Queensland Herbarium, natural size.
b. Two fronds with parts of stipites, natural size.
c. Rhizome with bases of stipites, natural size.

Plate IV.—Microscopic drawings, *a* by Miss Phyllis Clarke; *b* to *d* by C. C. Brittlebank.

a. Section of pinnule (underside).
b. End of a nerve, magnified cir. 100 times.


c
b
a


a
d
c
b

c. Sporangia *in situ* on nerve, magnified cir. 120 times.

d. Section of lamina showing nerve structure and crenulated margin, magnified.

In addition to the acknowledgements made at the beginning of this paper, the author begs to thank Miss Phyllis Clarke for preparing the figures for the plates, and for drawing fig. "a" (Plate IV) from his rough copy. Unfortunately some cross-markings on the nerve were mistaken by the artist for short hairs; the nerve is quite smooth.

NOTES ON EUCALYPTUS, No. VII.

(WITH DESCRIPTIONS OF FOUR NEW SPECIES.)

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

[*Read before the Royal Society of N.S. Wales, July 2, 1919.*]

Proposed New Species.

1. *E. transcontinentalis.*
2. *E. Jutsoni.*
3. *E. Hillii.*
4. *E. approximans.*

Notes on Described Species.

1. *E. Bakeri* Maiden.
2. *E. Gillii* Maiden, var. *petiolaris* var. nov.
3. *E. macrocarpa* Hook.
4. *E. marginata* Sm., var. *Staerii* Maiden.
5. *E. melanophloia* F.v.M. Heteroblastic and hybrid forms.
6. *E. Morrisii* R. T. Baker.
7. *E. nitens* Maiden.
8. *E. quadrangulata* Deane and Maiden.
9. *E. sepulcralis* F.v.M.
10. *E. Todtiana* F.v.M.

1. E. TRANSCONTINENTALIS n. sp.

Arbor glauca mediocris Mallee similis, Morrel vel Blackbutt nominata; cortice læve, trunci basi lamellis crassis nigris; ligno rubro duro; foliis teneribus sessilibus vel fere sessilibus, lato-lanceolatis, vel fere ovatis; foliis maturis petiolatis, lanceolatis, acuminatis, plerumque circiter 10 cm. longis et 2 cm. latis, vena peripherica a margine distincte remota; pedunculis teretibus vel subangularibus 3 – 9 flores plusve minusve pedicellatos ferentibus; alabastris operculis elongatis (subconstrictis præcipue siccantibus) calycis tubo circiter bis æquilongis; filamentis subflavis; fructibus urceolatis vel sub-globosis, circiter 8 mm. diametro, valvorum apicibus subulatis exsertis.

Looked upon by bushmen as the glaucous or Eastern Goldfields form of the "Morrel" *(E. longicornis)*. Shares the name "Blackbutt" with other Western Australian trees. A medium-sized tree, say one foot in diameter (but it may be much smaller, like a Mallee), a White Gum with blotched bark and more or less short flaky ribbons on the trunk, with a little of the roughness at the butt. Colour of timber rich reddish-brown and very tough. A felled tree shows long tough splinters.

Juvenile leaves glaucous, sessile or very nearly so, broadly lanceolate to nearly ovate, say 4 cm. broad by 6 cm. long, secondary veins irregularly pinnate, intramarginal vein distinctly removed from the edge.

Mature leaves glaucous, petiolate, lanceolate, acuminate, commonly about 10 cm. (4 inches) long, and about 2 cm. at greatest width, covered with fine dots, secondary veins not very distinct, pinnate, making an angle of about 45° with the distinct midrib, intramarginal vein distinctly removed from the edge.

Peduncles terete or slightly angular, each with three to nine more or less pedicellate flowers.

Buds with elongated opercula about twice as long as the calyx-tube, and which are somewhat constricted, particularly on drying. The calyx-tube sometimes of a lesser diameter than the base of the operculum, particularly on drying.

Flowers with yellowish filaments, the stamens inflected in the bud, anthers broad, thick, white, the slits slightly oblique.

Fruits urceolate to sub-globose, about 8 mm. in diameter, truncate, a little contracted at the orifice, the rim flat or concave, the capsule sunk, but the slender points of the valves protruding.

The type is from Kalgoorlie, W.A., (J. H. Maiden, September 1909), and is in the National Herbarium of New South Wales. It is abundantly figured at Part xv, plate 66, C.R. The type is shown at figures 8 a – d.

Synonyms.

1. *E. uncinata* Turcz. var. *rostrata* Benth.
2. *E. oleosa* F.v.M. var. *glauca* Maiden.

1. See B. Fl. iii, 216. In C.R., xiv, 144, I have referred to Drummond's fifth coll. No. 186, which Bentham calls *E. uncinata* Turcz., var. *rostrata* Benth. A plant with an acuminate or rostrate operculum (though differently shaped) is figured at 14 a – c, plate 62, but it is not the same as Drummond's plant. It is a form of *E. uncinata.*

2. In Journ. W.A. Nat. Hist. Soc., iii, 171 (1911). See also C.R., part xv, p. 167.

Range.

We have so long been accustomed to find this species under *E. oleosa*, that it will be some time before its range is understood. It has a very wide range in the drier parts of the continent. Thus it is widely diffused in Western Australia, South Australia and the Northern Territory, and is found, probably not widely, in the Mallee country of Victoria. Many of the New South Wales localities, hitherto attributed to *E. oleosa* belong to this new species.

Western Australia.—In C.R., xv, p. 172, will be found a large number of localities, enumerated under *E. oleosa* var. *glauca*, but which belong to this species. All the specimens referred to under page 169 of Part xv (as *E. oleosa*), from the words "at page 124," to the end of the page (169), and coming from the Murchison district, belong to *E. transcontinentalis.*

Northern Territory.—241a, thirty-five miles north-west of Meyer's Hill, 2nd June, 1911. Broadish leaves and fruit. One small specimen. 117, Hugh River, 21st March, 1911. Stunted scrub on stony ridges. Stem covered with long flakes of smooth bark. New bark brown colour. Both specimens have leaves broader than the type, especially No. 241a, and hence show a transition to *E. Gillii* Maiden. Collected by G. F. Hill. (In Ewart and Davies' "Flora of the Northern Territory," p. 305).

Gosse's Range, Central Australia. (Revs. Schwarz and Schulze ex. herb. Melb.), under *E. oleosa* in Part xv, p. 171).

South Australia.—The following specimens referred to under page 170 of Part xv (as *E. oleosa*), belong to *E. transcontinentalis.* Port Lincoln (in part), Murray Scrub, Murray Bridge, Tintinarra, Flinders Range, also near Quorn, Mount Remarkable and Crystal Brook, Roseworthy, Venus Harbour, Water Mallee (Ooldea).

Victoria.—In the localities for *E. oleosa*, enumerated in Part xv, p. 171, it is associated at Nyaah and Bumbang with *E. transcontinentalis.* This is in the Mallee or north-west part of the State, which should be further searched for this species.

New South Wales.—The following localities for *E. oleosa*, enumerated at Part xv, p. 171, belong to *E. transcontinentalis.* Lower Lachlan River, Coolabah and Girilambone, Cobar and Wittagoona, Mount Boppy (the last interspersed with *E. oleosa*).

To these may be added a number of specimens from Mr. W. D. Campbell, L.S., from localities in the Narrandera district. The same gentleman forwarded *E. oleosa* from the same localities.

"A small tree of 12—30 feet. It is usually a mallee, with numerous stems issuing from a common stock, each stem being pretty uniform in size and height. It has rather a large or long leaf, making it appear conspicuous amongst the other Mallees. Known locally as "Large Mallee." Grows in gravelly places. Bark long-fibrous, breaking away in long flakes, leaving the inner bark of a pale yellow glaucous colour. Tips of branches pale deep brown." Cobar (J. L. Boorman, May, 1918).

Affinities.

1 and 2. *E. oleosa* F.v.M and *E. longicornis* F.v.M. Its closest relations are with these two species.

3. With *E. falcata* Turcz., and particularly var. *ecostata* Maiden.

If we turn to Plate 68, Part xv, C.R., we shall find undoubted relations between the two species. The juvenile leaves of *E. falcata* are more glaucous, broader, less acuminate and more petiolate. The calyx tube is more ribbed (even in var. *ecostata*), the fruits more ribbed, more pear-shaped, and more constricted at the mouth.

4. With *E. Gillii* Maiden var. *petiolaris* Maiden.

See Plate 67, figures 3a, 3b, and 4a, 4b, with Plate 66, figures 8a—d (*E. transcontinentalis*). Both forms are glaucous, but their mature leaves (and indeed their juvenile leaves) are very different. Their buds are not very dissimilar. The fruits of *E. transcontinentalis* are more urceolate and with more protruded valves.

2. E. Jutsoni sp. nov.

Frutex parvus ramulosus circiter 6 – 8′ altus, trunco tenue. Ramulorum apicibus planis mox teretibus. Foliis maturis brevissime petiolatis, angusto-linearibus, 7·5 – 9 cm. longis, crassis, duris venis inconspicuis. Pedunculis brevissimis vel absentibus 2 – 4 floris; calycis tubo conoideo operculo acuminato conoideo æquilongo. Antheris *E. angustissimae* similibus. Flores non vidimus.

"A small thin-stemmed, branching-from-the-root-gum, about 6 to 8 feet high on the average. White flowers, yellow pointed buds. Ants very numerous on the bark." (J. T. Jutson). Branchlets flattened at the tips, but soon becoming terete.

Juvenile leaves not seen.

Mature leaves very shortly petiolate, narrow linear, acuminate, slightly twisted, 7·5 – 9 cm. (say 3 – 3½ inches) long, wiry, thickish and tough, the veins inconspicuous, often channelled at the inconspicuous midrib.

Peduncles axillary, very short or absent, flattened, each with two to four flowers.

Buds sessile or tapering into a short, flattened, pedicel-like process, the calyx-tube conoid, and of the same length as the acuminate conical operculum.

Flowers.—Stamens inflected in the bud, anthers renantheroid (*i.e.*, somewhat resembling the Renantheræ), and apparently similar to those of *E. angustissima.* Style long, the stigma scarcely thickened, the ovary conical.

Fruits not seen.

Type from Comet Vale, W.A. (John Thomas Jutson, No. 216. Formerly Geological Surveyor on the staff of the Geological Survey of Western Australia).

Range.

It is only known from Comet Vale, a township on the railway line 63 miles north of Kalgoorlie,

Affinities.

1. With *E. angustissima* F.v.M. Its closest affinity appears to be with the imperfectly known *E. angustissima.* See C.R., Part xix, with Plate 84.

E. Jutsoni appears to be a coarser plant than *E. angustissima*, and its conoid or tip-cat buds are quite different in shape to those of fig. 7a, which has very short, though distinct, non-tapering pedicels. Fruits of 8 b as depicted could not result from the flowers of *E. Jutsoni*. The anthers of the two species may not be dissimilar, but I have not seen ripe ones of *E. angustissima*. After the most careful consideration I am quite satisfied that, although the two species present some points of resemblance, they are distinct.

2. With *E. oleosa* F.v.M. var. *angustifolia* Maiden. This is a narrow leaved form of the species, figured at fig. 17, Plate 65 (the type), with other specimens referred to this form, viz., fig. 18, Plate 65, and fig. 1, Plate 66, with figs. 2 and 3, Plate 66, perhaps belonging to it.

The type of var. *angustifolia* = *E. socialis* F.v.M. and it differs from *E. Jutsoni* in the broader, more distinctly veined leaves, and in the number of flowers in the head. Incidentally it may be pointed out that the buds figured at fig. 1 b, Plate 66, display great similarity to those of typical *E. angustissima* (fig. 6a, Plate 84).

3. E. Hillii n. sp.

Arbor mediocris, cortice tenere squamosa, ramis lævibus, ligno duro rubro-brunneo. Foliis primariis longe petiolatis, magnis, irregulariter orbicularibus, apice rotundato vel obtuso, glabris crassis, venis fere pinnatis, margine undulato. Foliis maturis similibus sed minoribus. Inflorescentia racemosa, floribus paucis plerumque 4 in umbella, pedunculis longis, teretibus. Calycis tubo piro simile formato, circa ·5 cm. diametro in pedicellum 1 cm. angustato. Operculo hæmispherico vel conico calycis tubo æquilongo. Antheris longis longitudinaliter aperientibus. Fructus non vidimus.

A broad-leaved tree of medium size, the bark somewhat tessellated or soft scaly, the branches smooth. Timber rich reddish-brown, " hard."

Juvenile leaves with very long petioles, irregularly orbicular, the base flat or slightly tapering into the petiole, the apex rounded or blunt, the venation pinnately spreading; glabrous, thick and leathery, the margin undulate, large, say 14 cm. broad by 12 long (5½ by 4¾ inches).

Mature leaves very similar to the juvenile ones, but smaller, with some tendency to becoming broadly-lanceolate, with the secondary veins making a smaller angle with the midrib.

Buds few in an umbel, usually four, the umbels forming a racemose inflorescence. The long peduncles terete or slightly flattened. The calyx-tube pear-shaped, about ·5 cm. in diameter, tapering into a pedicel of 1 cm. The operculum hemispherical with a slight umbo or conical, of about the same length as the calyx-tube.

Anthers long, opening in parallel slits, gland at top, filament at base with affinity to the semi-terminal ones. Style conspicuous, the stigma not exceeding it in width.

Fruit not seen.

Type from Bathurst Island (Gerald F. Hill, No. 468).

Range.

I have only received it from Bathurst Island, (which is to the immediate west of Melville Island, and with it forms a huge island off the Northern Territory, north of Darwin).

It grows in somewhat heavy soil, in rather flat localities (presumably subject to floods) and associated with *E. papuana*, *E. terminalis* and an occasional No. 464. (*E. latifolia* F.v.M.) (G. F. Hill).

A photograph of a moderately dense forest, taken by Mr. Hill, shows the distinct outlines of a tree of this species about forty feet high, with a diameter of about two feet. There is, partly in the foreground, a tree of the same species, perhaps fifty feet high.

Affinities.

1. With *E. oligantha* Schauer. Its closest affinity appears to be with this species, but *E. oligantha* has paler foliage, urceolate calyx-tube, which does not continuously taper into the pedicel, much shorter filaments, and capitate stigmas. The anthers of the two species are similar, but not identical. *E. oligantha* is described as shrubby (but later it may prove to attain tree size), but we know nothing of its bark and timber. The fruits of neither species are known.

2. With *E. Spenceriana* Maiden. As a rule this species has thin, graceful, lanceolate leaves, but occasionally it has coarser foliage, *e.g.* the Stapleton, Northern Territory plant shown at fig. 4, Plate 156, C.R. But even in that tree, which presents a good deal of similarity to a tree of *E. Hillii*, the foliage is not broad as a whole. Also, the bark of *E. Spenceriana* is not tessellated; it is a Box. The fruit of *E. Spenceriana* is small and of papery or angophoroid texture, which that of *E. Hillii* can never be.

3. With *E. alba* Reinw. A large leaved, long petiolate species suggesting a similarity to *E. alba*. For that species Plates 105–7, C.R., may be referred to. But *E. alba* differs in buds and anthers, and in developing into lanceolate leaved forms.

E. APPROXIMANS n. sp.

Frutex Mallee similis 4–10′ altus magna multitudine crescens. Foliis teneribus lineari-lanceolatis, foliis maturis lineari-lanceolatis rectis vel leniter falcatis, acuminatis 7·5 cm.–1 dm. longis, 6–7 mm. latis, crassis, nitentibus, costa media sola conspicua, marginibus uniformiter glandulosis, glandulis oleosis dense punctatis. Pedunculis circiter ·5 cm. longis, 4–8 flores breve pedicellatos ferentibus. Alabastris clavatis, operculo hemispherico-conoideo calycis tubo dimidio æquilongo. Antheris reniformibus. Fructibus cylindroideis circiter 5 mm. diametro, capsula valde emersa.

"A Mallee-like plant of 4 – 10 feet growing in masses. Much resembles *E. stricta* of the Blue Mountains in its mode of growth. Stems dark grey, with patches of lighter bark. Becomes ribbony at certain periods. Generally one inch in diameter and never more than two." (J. L. Boorman).

Juvenile leaves (seen almost but not quite opposite), linear-lanceolate, very similar to the mature leaves, the stems glandular.

Mature leaves linear-lanceolate straight, or slightly falcate, acuminate, and often with a hooked point, 7·5 cm. to 1 dm. (say 3 to 4 inches) long, and 6 – 7 mm. broad, thick and shining, the midrib alone visible, the margins uniformly glandular, giving them almost the appearance of being serrulate. Uniformly and copiously dotted with oil-glands on the upper surface, the more prominent of which become black points as age proceeds.

Peduncles about ·5 cm. long, slightly angular or terete, each with 4 to 8 shortly pedicellate flowers.

Buds clavate, calyx-tube about 3 mm. in diameter, operculum hemispherical-conoid, about half the length of the calyx-tube. Stamens inflected in the bud, filaments nearly white, anthers reniform.

Fruits cylindroid or ovoid-oblong, truncate, not contracted at the orifice, about 5 mm. in diameter, the rim narrow and sloping inwards, the capsule deeply sunk.

Type Barren Mountain (Henry Deane), in National Herbarium, Sydney.

Range.

Confined to the north-eastern part of New South Wales so far as we know at present. "From the summit of the Barren Mountain, on the range dividing the Bellinger and Clarence Rivers, 45 miles from the coast, and 4,500 feet above the sea." (Henry Deane, 1901). "Grows facing a northerly aspect. This mountain is in the Dorrigo and Guy Fawkes district." (J. L. Boorman, 1913).

Affinities.

With *E. stricta* Sieb. and *E. apiculata* Baker and Smith.

Its closest relations are with these two species, but their fruits are always urceolate or ovoid, and not cylindroid or ovoid-oblong. The leaves are broader than those of *E. apiculata* and resemble those of *E. stricta* a good deal, but those of the new species are more copiously dotted and possess the appearance of an almost serrulate margin.

The new species is referred to in C.R., ix, 283, under *E. stricta*. The specimen from Blackheath referred to as "B" (Maiden and Cambage) has prominent spreading, usually well-defined venation, with the fruits inclined to be barrel-shaped. This puzzling form is still under investigation for it has affinities with other Renantheræ.

E. approximans is a member of a trio (the other two members being *E. stricta* and *E. apiculata*) that are not easy to separate. Thus the two latter can only be separated by a convention (width of suckers, a variable, like all other characters, see C.R., Part ix). The same thing may be said (perhaps quoting other characters) of other geminate species. But it seems to me that, in the important matter of fruits, those of *E. stricta* and *E. apiculata* are always urceolate, or approximate thereto. In specimen "B" the primary shape appears always to be that of a barrel, while in *E. approximans* the shape is always cylindroid. I have raised seedlings of "B," *E. apiculata*, (*E. stricta* may be omitted, as less close to *E. approximans* than *E. apiculata*) and *E. approximans*. Those of "B" are for the most part with stem-clasping leaves, and have no close affinity to the last; those of *E. apiculata* and *E. approximans* present certain differences that are difficult to make clear without illustrations.

I have already shown how close the species is to the *E. stricta* series, but although I have examined the relationship over and over again since I received the plant in 1901. I have never distributed it, as after every careful inquiry I felt that I could not place it under a described species, and therefore now describe it.

Notes on Described Species.

1. E. Bakeri Maiden, this Journal, xlvii, 87 (1913).

It was recorded at p. 235 (*h*) of the same volume as *E. oleosa*, but this is a mistake. This plant is *E. Bakeri* and it is new for Queensland. I record the following additional specimens:—

1. "Willowy Eucalypt" Warialda, N.S.W. (W. A. W. de Beuzeville, No. 3).

2. "Tree-like Mallee," 28 feet high and 5 inches in diameter, wood brown, bark grey, up to six feet, then yellowish. Ticketty Well, locality of type. (Forest Guard A. Julius, Nos. 17 and 19). The leaves of these specimens are broader than those of the type.

The record of *E. Bakeri* from Jericho, Queensland, extends its range considerably to the north, and it is hoped that specimens from localities intermediate between those stated will be forthcoming.

2. E. Gillii Maiden. See C.R. xv, 177.

It seems to me that besides the typical form (from Umberatana, Flinders Range, South Australia), with sessile leaves, usually nearly orbicular, but occasionally lanceolate, (Mount Lyndhurst, S.A., fig. 6, Plate 67), we have a petiolate form, with broadly lanceolate leaves, which it would be a convenience to constitute a variety, and which I accordingly do, under the name *petiolaris*. At the same time, it is quite possible that we may find, on further investigation, that both forms may occur on the same plant. The varietal name will then become unnecessary, but it is a useful provisional name until we know more of *E. Gillii*.

The normal form of *E. Gillii* is restricted to South Australia (Flinders Range and farther north), and the Broken Hill district of New South Wales, so far as we know at present. As regards the latter State, the following is an additional definite locality. Height thirty feet. In bases of rocky valleys in wild rocky hills. Mundi Mundi Trig. Station, Broken Hill district. (E. C. Andrews).

Var. *petiolaris* var. nov.

A shrub or small tree apparently in all characters similar to that of typical *E. Gillii* except that the leaves are petiolate (with petioles of about 1 cm.), and broadly lanceolate in shape. The type from Wirrabarra, S.A. (Walter Gill); see figs. 4a, 4b, Plate 67, C.R.

Range.—This form is restricted to South Australia, so far as we know at present, and includes *E. socialis* F.v.M. var. *laurifolia* F.v.M. (See C.R., Part xxv, p. 177, and figs. 3a, 3b, Plate 67). The original came from "Pine forest near Gawler Town (Behr.)" The modern Gawler is on the North Railway line, about 25 miles north of Adelaide. I have identical specimens from considerably further north, viz. Laura, and Wirrabara Forest (W. Gill), which are east of Port Pirie, and approach the Flinders Range. Mount Lynhhurst (Max Koch, No. 113). In the Flinders Range district.

Affinities.—1. *E. transcontinentalis* Maiden. It possesses some resemblance to this species, from which it differs in leaves, those of var. *petiolaris* being shorter and broader, with buds less rostrate, and with fruits more spherical and less urceolate. Both plants are glaucous.

2. *E. oleosa* F.v.M. In foliage it presents some resemblance to *E. turbinata* F.v.M. and Behr., (C.R., xxv, 178, and fig. 9, Plate 65), which is an aberrant form of *E. oleosa* F.v.M. The buds at once separate it from *E. Gillii* var. *petiolaris*.

3. E. MACROCARPA Hook. See this Journ. LII, 506.

Mr. C. E. Lane Poole, Conservator of Forests in Western Australia, says this beautiful species is known as "Mottlecar" by the aborigines of the Bolgart district, W.A. Mr. W. F. Blakely has collected from the Botanic Gardens, Sydney, suckers in which the alternate leaves are $1\frac{1}{2}$ inches apart on the shoots. In other words, the broadly lanceolate leaves which are very shortly petiolate to stem-clasping, have the petioles $1\frac{1}{2}$ inches apart.

4. E. MARGINATA Sm. var. STAERII Maiden.
See this Journ. xlvii, 230.

Dr. F. Stoward, under No. 111, April, May, 1917, sends this form with the following note, "Stunted Black-butt, tree 30 – 35 feet, up to two feet in diameter. Grows in the Albany and Denmark districts in large and sandy flats, and is of a stunted nature."

Mr. C. E. Lane Poole points out the similarity of the fruits to those of *E. Todtiana*, but the anthers and the timbers sharply separate the two species. The relation of this proposed variety to the normal form (the Jarrah, *E. marginata*) is worthy of local enquiry.

5. The E. MELANOPHLOIA F.v.M., complex.
See this Journ. xlvii, 233.

Following are two interesting forms:—

A. "Growing about thirty chains from the bank of the Gwydir River, away from the flooded area, on a small red soil ridge, with Silver-leaf Ironbark *(E. melanophloia)*. Coolabah *(E. microtheca)* is growing in the next paddock about twenty chains away, but the trees in the immediate neighbourhood are Silver-leaf Ironbark and a few Poplar Box-trees *(E. populifolia)*. One Ironbark tree is growing within a few feet of the tree under observation. The tree under observation has black bark, but not rough and corrugated like an Ironbark." Ph. Moree, Co. Courallie, on Mr. Solling's freehold. (W. M. Brennan, Forest Guard).

The above is *E. melanophloia* F.v.M. (lanceolate or heteroblastic leaved form). See C.R., xii, 71. I would also invite attention to the specimens from Warialda referred to in this Journ, XLVII, 233, which displays a good deal of affinity to Mr. Solling's specimen, with the difference that the Warialda specimens are more glaucous. They emphasise the lesson that *E. melanophloia* is more variable than previously supposed.

B. " Bark white like a White Box *(E. hemiphloia* var. *albens)*, but the foliage is like Silver-leaf Ironbark, *(E. melanophloia)*. All the surrounding trees are Silver-leaf Ironbark. This is the first tree of its kind I have noticed in this division." Parish Yagobie, Co. Burnett. (W. M. Brennan). Again reporting on this tree, Mr. Brennan says, "Grows on a red ridge, well away from the river, and the only Coolabah *(E. microtheca)* tree I know of is about five miles away; this tree is somewhat similar in foliage to the tree in Mr. Solling's paddock (See A), but the bark is very different, being white like the White Box bark."

Mr. District Forester Gordon Burrow has visited this tree and confirms Mr. Brennan's observations. Excellent specimens are before me.

It is a question as to the affinity of this tree to *E. melanophloia* or to *E. microtheca*. Its foliage is like *E. melanophloia*. I think its affinity is with *E. melanophloia*, but the timber is *pale*. I think we have a *melanophloia* hybrid, and as I am actively collecting data and materials in regard to Eucalyptus hybrids, I draw attention to what appears to be an interesting one.

Following is a Northern Territory form of *E. melanophloia*. The Wandi Ironbark. Fruits small, almost sessile, leaves short, lanceolate to broadly lanceolate, pedicellate. 30 – 40 feet high, spreading, giving good shade. Trunk and branches have rough bark. Trunk up to two feet in diameter. (H. I. Jensen, No. 372). " Belt about one mile wide, between three and four miles west of Wandi. As far as known this tree occurs nowhere else in this part of the Territory." This is a definite locality.

6. E. MORRISI R. T. Baker.

Mount Patawurlie, near Moolooloo, S.A. (E. H. Ising, 3/10/18, through J. M. Black). The first record of the species in South Australia. Some smaller fruits of this specimen show a remarkable resemblance to some belonging to *E. dealbata* A. Cunn.

The round buds resemble those of Captain Baudin's Expedition 1802, provisionally referred to *E. accedens* at C.R.

7. E. NITENS Maiden. See C.R., xix, p. 272., also this Journal, LI, 455.

"A fine large gum up to 150 feet, with a symmetrical barrel of three or four feet diameter. Rough bark about one third of the way up, and then peeling in ribbons. Timber comparatively heavy in relation to associated timbers, cuts of a deep pink, concentric rings clearly marked and rather narrow. Buds very noticeable on account of their reddish colour. A noticeable feature is that this tree forms a kind of ring round *E. fraxinoides* area and then merges into the *E. fastigata* forest."

Elevation about 4000 feet. Tallaganda State Forest, via Queanbeyan (W. A. W. de Beuzeville). This is a useful locality of an important forest tree whose range is imperfectly known. The Nundle reference quoted in this Journal LI, 455, for *E. nitens* is erroneous, the tree proving to be *E. quadrangulata* Maiden.

8. E. QUADRANGULATA Deane and Maiden. See C.R., xxiv, p. 76.

The record for *E. nitens* as Nundle in this Journ. LI, 455, is wrong, *E. quadrangulata* being the tree in question, and it is requested that the note be transferred to that species, whose range it extends still further northward from the Scone district. The affinity of the two species (see under Affinities XXIV, p. 77) is also emphasised.

9. E. SEPULCRALIS F.v.M., "Weeping Gum."
See C.R., VIII, 244.

One is gradually accumulating information in regard to this very rare and very interesting W.A. species. The type (See Eucalyptographia) came from "near the Thomas (River, Campbell Taylor)," a small stream which has disappeared from most maps, even official ones. It flows into the sea a few miles to the north-west of Cape Arid. Taylor's Station, however, remains on the maps. I have received valuable information both from Mr. W. C. Grasby and from Mr. F. W. Wakefield. Mr. J. Wellstead sent me seeds from Eyre's Range, ten miles north of Hopetoun.

I pointed out in Part viii, C.R., p. 244, how little is known of the affinities of this species. The seedlings raised in the Botanic Gardens show that its closest relation is *E. buprestium* F.v.M., and that both species present considerable affinity to the Corymbosæ. They have huge cotyledon leaves.

10. E. TODTIANA F.v.M. (Eucalyptographia).

Mr. C. E. Lane Poole in his Report on the W. A. Forest Department, ending 31st December 1917, calls it "Prickly Bark." He writes to me, "It is a good burner, but it is disregarded by the housewife for fire-wood on account of its many prickles. Often called Coastal Blackbutt." A reference to this phenomenon will be found under *E. Considenіana* Maiden, this Journ. LI, 448, and I invite attention to a subject concerning which we have but few records.

VOLUME CHANGES IN THE PROCESS OF SOLUTION.

By George Joseph Burrows, B.Sc.

(Communicated by Prof. C. E. Fawsitt.)

[*Read before the Royal Society of N. S. Wales, August 6, 1919.*]

A considerable amount of work has been recorded on the changes in volume which take place in the formation of solutions. When a solid is dissolved in a liquid, or when two liquids are mixed, the volume of the resultant solution is found in most cases to differ from the sum of the original volumes of the constituents. We cannot state how far this is due to a change in the volume of the solute and how far to the solvent. For the sake of convenience it is customary to assume that the volume of the solvent is unaltered by the process of solution, and to attribute any change in the volume of the system to the solute. In this way the volume of a solute in a solution may be determined.

Thus if A represents the weight in grams of solute dissolved in 100 grams of solvent,

d_0 = the density of the pure solvent,

d_1 = the density of the solution,

and v_s = the specific solution volume of the solute,

$$\text{then, } v_s = \left(\frac{100 + A}{d_1} - \frac{100}{d_0}\right) \div A \ldots\ldots\ldots\ldots\ldots \text{(I)}$$

or if ϕ = the molecular solution volume of the solute,

$$\text{then, } \phi = \frac{M + g}{d_1} - \frac{g}{d_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(II)}$$

where g = the weight in grams of solvent containing the molecular weight (M) in grams of solute.

By employing the above formulæ Tyer[1] and Dawson[2] have shown that the specific (or molecular) solution volume

[1] J.C.S., (1910) 97, 2620. [2] *Ibid.*, 1896.

of a solute varies slightly in different solvents, the order of variation in most cases being the same as that of the compressibility of the solvent. In cases where the process of solution is accompanied by no change in the molecular complexity of both solute and solvent the specific solution volume is found to be practically independent of concentration. In aqueous or alcoholic solutions, however, it has been repeatedly shown that the specific volume of the solute varies with its concentration. The results recorded in the present paper were obtained chiefly from experiments with solutions in water or alcohol, or in mixtures of these solvents. All the reagents used in this investigation were purified by suitable means, and their final purity determined by physical methods, *e.g.*, density, melting point or boiling point. The solutions were all prepared by weighing both solute and solvent. The density of the solvent or solution was determined by means of a pyknometer of capacity about 22 cc. Before adjusting the volume of the liquid in the pyknometer it was allowed to remain suspended for about an hour in a thermostat, the temperature of which was maintained constant to 0·05° C. All weighings were reduced to vacuo.

Aqueous Solutions.

In the following tables, A represents the concentration of solute in grams per 100 grams of solvent, d_0 the density of the pure solvent, d_1 the density of the solution, v_s the specific solution volume of the solute (Equation I), and ϕ the molecular solution volume of the solute (Equation II). The temperature is stated in each case.

Table I.

Potassium chloride in water (d_0 = ·997073). Temp. 25° C.

A	d_1	v_s	ϕ
·1637	·998117	·361	26·92
·4221	·999775	·358	26·71

Table I.—*Continued.*

A	d_1	v_s	ϕ
1·1491	1·004265	·371	27·65
2·1030	1·010137	·373	27·84
5·2017	1·028575	·382	28·48
8·2830	1·046080	·389	29·00
11·6167	1·064402	·393	29·35
20·0902	1·107547	·405	30·21
26·7036	1·138501	·412	30·72

Table II.

Mercuric chloride in water. Temp. 25° C.

A	d_1	v_s	ϕ
·2981	·999468	·194	52·74
·3593	·999983	·188	50·92
·8301	1·003829	·183	49·63
1·8639	1·012268	·180	48·84
3·0954	1·022273	·180	48·68
3·9302	1·029027	·179	48·64
5·4144	1·040988	·179	48·60

Table III.

Saccharamide in water. Temp. 25° C.

A	d_1	v_s
·09474	·997521	·527
·38925	·998861	·540

Table IV.

Succinic acid in water. Temp 25° C.

A	d_1	v_s	ϕ
0·9192	·999803	·702	82·90
2·3348	1·003930	·703	82·95
3·5546	1·007314	·706	83·33
3·8726	1·008090	·709	83·69

Table V.

Succinamide in water. Temp. 25° C.

A	d_1	v_s	ϕ
·1730	·997450	·783	91·00
·2229	·997607	·761	88·46
·3547	·997892	·770	89·42

Table VI.

Tricarballylamide in water. Temp. 25° C.

A	d_t	v_s	ϕ
·1853	·997611	·710	123·0
·3235	·997984	·719	124·5
·4729	·998462	·706	122·3
·5916	·998757	·715	124·0
1·3564	1·000989	·710	122·9
1·9499	1·002696	·709	122·8
2·2798	1·003636	·709	122·8

Table VII.

Carbamide in water. Temp. 25° C.

A	d_1	v_s	ϕ
2·6329	1·003912	·737	44·27
5·0484	1·009800	·738	44·36
7·3010	1·015198	·740	44·47
14·4848	1·030884	·743	44·66
33·0611	1·064318	·748	44·96
53·8893	1·093286	·751	45·14

Table VIII.

Carbamide in water. Temp. 30° C.

A	d_1	v_s	ϕ
2·3290	1·001575	·744	44·72
9·0567	1·017457	·745	44·76
15·4282	1·030922	·747	44·88

Table IX.

Acetamide in water. Temp. 30° C.

A	d_1	v_s	ϕ
4·5875	·998254	·945	55·84
7·5278	·999892	·944	55·76
10·1471	1·001300	·943	55·72
16·7179	1·004590	·942	55·66

The specific volume of liquid acetamide[1] at 30° C. is ·956.

[1] Meldrum and Turner, J.C.S., 1908, 93, 876.

Table X.

Propionamide in water. Temp. 30° C.

A	d_1	v_s	ϕ
1·8533	·996096	·981	71·72
3·9972	·996593	·980	71·65

The specific volume of liquid propionamide[1] at 30° C. is 1·000.

Table XI.

Sucrose in water. Temp. 30° C.

A	d_1	v_s	ϕ
2·7695	1·006078	·619	211·9
4·5190	1·012373	·621	212·6
8·2459	1·025524	·621	212·6

The specific volume of liquid sucrose at 30° C. is ·661.[2]

It will be noticed from the foregoing tables that the value of v_s or of ϕ varies with the concentration in nearly every case. The effect of concentration is most marked in the case of electrolytes; thus in the case of potassium chloride the value of v_s increases by 14 per cent. from A = ·16, to A = 27. But even in the case of non electrolytes, such as carbamide, the specific solution volume is not constant but increases with concentration. In the case of mercuric chloride and of acetamide, the solution volume decreases with concentration.

The above results are similar to those obtained by various authors for other solutes in aqueous solution. In general it has been found that the solution volume increases with the concentration of the solute, the effect being most marked in the case of strong electrolytes. This variation of v_s with A in the case of aqueous solutions (and of solutions in other solvents containing hydroxyl group) has been attributed chiefly to two causes:

(*a*) the formation of hydrates (or solvates)

(*b*) in the case of electrolytes to the variation in the degree of dissociation of the solute.

[1] Meldrum and Turner, [2] Schwers, J.C.S., 1911, 99, 1478.

There is a considerable amount of evidence now available indicating the existence of solvates in solution. Furthermore Tyer[1] has shown that in certain cases *e.g.*, calcium chloride in ethyl alcohol, in which there is little doubt that the calcium chloride exists in solution as $CaCl_2, 4C_2H_5OH$, increasing concentration is accompanied by a marked increase in the specific solution volume of the solute, due to a decrease in the degree of solvation with increasing concentration of solute. These results would indicate that the variation of v_s with concentration observed in aqueous solutions even in the case of non-electrolytes is due also, in part at least, to the formation of solvates.

The solution volumes of many strong electrolytes in water have been determined by various authors, and their results show that the specific volume increases with concentration. In certain cases, *e.g.*, magnesium sulphate, if the value of A be sufficiently reduced v_s may even become negative, indicating that the volume of the solution is less than that of the water used. The effect of concentration varies considerably with different electrolytes, being far more marked for instance in the case of sodium chloride than with magnesium sulphate. This decrease of v_s with dilution has been attributed to the effect of increasing dissociation of the solute. The observed decrease in v_s cannot be attributed entirely to a decrease in the actual specific volume of the solute. The fact that in certain cases a negative value is obtained for v_s indicates that in these cases the water is appreciably contracted in the process of solution. As Tyer has already pointed out, it is quite probable that in aqueous solutions of electrolytes, the ions of the solute cause a condensation in the volume of the water molecules. But there is apparently no proportionality between the degree of dissociation of an electrolyte and its specific solution volume.

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[1] J.C.S., 1911, 99, 871.

In discussing the variation of the specific solution volume with concentration of solutes in aqueous or alcoholic solutions, one other factor has been constantly overlooked. The formulæ (Equations I and II) from which the solution volume of a solute is calculated, must give rise to regular variations of v_s or ϕ with A, in all cases where the volume of the solvent is altered by the process of solution. In the above equations, if the solvent contracts during the process of solution, this contraction is attributed wholly to the solute. Thus in the equation:

$$v_s = \frac{\frac{100 + A}{d_1} - \frac{100}{d_0}}{A} \quad \text{........................(I)}$$

the term $\frac{100}{d_0}$ is taken to represent the volume of 100 grams of water in all solutions, no matter what the concentration of the solute may be. These formulæ are strictly applicable only in the investigation of solutions of the same solute in different solvents. Thus if solutions of a certain solute in two different solvents be prepared, and the solution volume of the solute in each be calculated, the relative values of v_s or ϕ, may in these cases be taken to represent the relative volume changes in the system solute-solvent. Results obtained in this way afford us information as to the relative order of volume changes produced by dissolving a certain solute in different solvents. But the formulæ are not applicable to the study of the effect of different concentrations of a solute in a particular solvent. It is quite illogical to assume that the volume of one constituent of a solution is unaltered over a wide range of concentrations and then to attempt to explain the variations in the volume of the other constituents, deduced by means of this assumption. Let us consider for example, two solutions of a certain solute in water, in both of which A is small, but in one case much greater than in the other. Furthermore, we will assume that the process of solution causes a contraction in the volume of the water, and also that although the actual volume of the latter in both cases is less than $\frac{100}{d_0}$ it is sensibly the same in both solutions.

In calculating the specific solution volumes of these solutions according to Equation I, it follows that in both cases v_s would be less than the actual volume occupied by one gram of the solute in the solution, and furthermore, the error so obtained would decrease with increasing values of A. Even in a case where the actual specific volume of the solute was constant and independent of its concentration, the values found for v_s would increase with A. We cannot infer, therefore, that because the values of v_s are found to vary in a definite direction with concentration, the actual specific volume of the solute varies in this direction, or indeed that there is any variation at all. This particular point can be well illustrated by considering a solution formed by mixing two liquids, *e.g.*, formamide and water, in which the formamide is considered the solute and the water the solvent. The formamide used in these experiments was purified by the method of Röhler,[1] by standing over anhydrous sodium sulphate from which it was distilled under reduced pressure. The density of the pure amide at 25° C. was 1·13126. The densities of the solutions were determined both at 20° C. and 25° C. and the specific solution volume of the formamide in water calculated in the usual way. In addition, the contraction per cc. of the original volume was determined by subtracting the volume of the solution from the sum of the volumes of the constituents, and dividing this difference by the original volume of the constituents. Thus if x represents the volume of formamide, y the volume of water, and z the resulting volume of the solution, then the specific contraction $\triangle_v$ is given by:

[1] Zeit. f. Electrochem., 16, 420.

$$\triangle_v = \frac{(x + y) - z}{(x + y)}$$

Table XII.—Formamide in water.

Per cent conc. of Formamide.	A	Temp. 20° C.			Temp. 25° C.		
		d_1	v_s	$\triangle_v$	d_1	v_s	$\triangle_v$
0·73	0·7332	0·999321	·8515	·000212	·998136	·8561	·000203
1·70	1·7251	1·000858	·8467	·000576	·999558	·8559	·000475
4·10	4·2770	1·004545	·8482	·00134	1·003115	·8556	·00116
14·73	17·274	1·020458	·8536	·00405	1·018488	·8598	·00362
25·70	34·584	1·036469	·8580	·00601	1·03397	·8637	·00537
37·11	59·016	1·05254	·8625	·00705	1·04963	·8676	·00632
46·52	86·976	1·06541	·8660	·00722	1·06226	·8706	·00655
59·05	144·229	1·08216	·8702	·00663	1·07859	·8746	·00594
66·86	201·709	...	...	...	1·08874	·8766	·00532
75·94	315·699	1·10408	·8753	·00446	1·10020	·8792	·00401
88·27	752·19	1·11979	·8786	·00206	1·11580	·8820	·00191
94·82	1831·6	1·12846	·8799	·000859	1·12427	·8833	·000745
97·48	3863·1	1·13204	·8803	·000394	1·12783	·8837	·000347
99·77	42160·0	1·13507	·8807	...	1·13090	·8840	...
100·00	...	1·13552	·8807	...	1·13126	·8840	...

It will be seen from the above table, that whereas the value of v_s increases with concentration for solutions containing more than one per cent formamide, the actual specific contraction of the system also increases up to 44 per cent. formamide and then decreases (Fig. 1). Between these concentrations therefore, the values of v_s would lead to the inference that the specific volume of the system increased with concentration, whereas the reverse is really the case.

Similar conclusions can be drawn from results obtained by mixing ethyl alcohol with water, and considering the solution as one of alcohol in water. The results obtained in this case are given in the following table.

Table XIII.

Ethyl alcohol in water. Temp. 30° C.

Per cent. alcohol.	A	d_1	v_s	$\triangle_v$
0	—	—	—	—
25·44	34·1123	·955387	1·1708	·02602
30·47	43·8186	·946572	1·1754	·02952
36·62	57·7890	·934695	1·1832	·03231
47·11	89·0805	·912305	1·1992	·0339
58·89	143·232	·885436	1·2167	·03233
100·00	...	...	1·2808	...

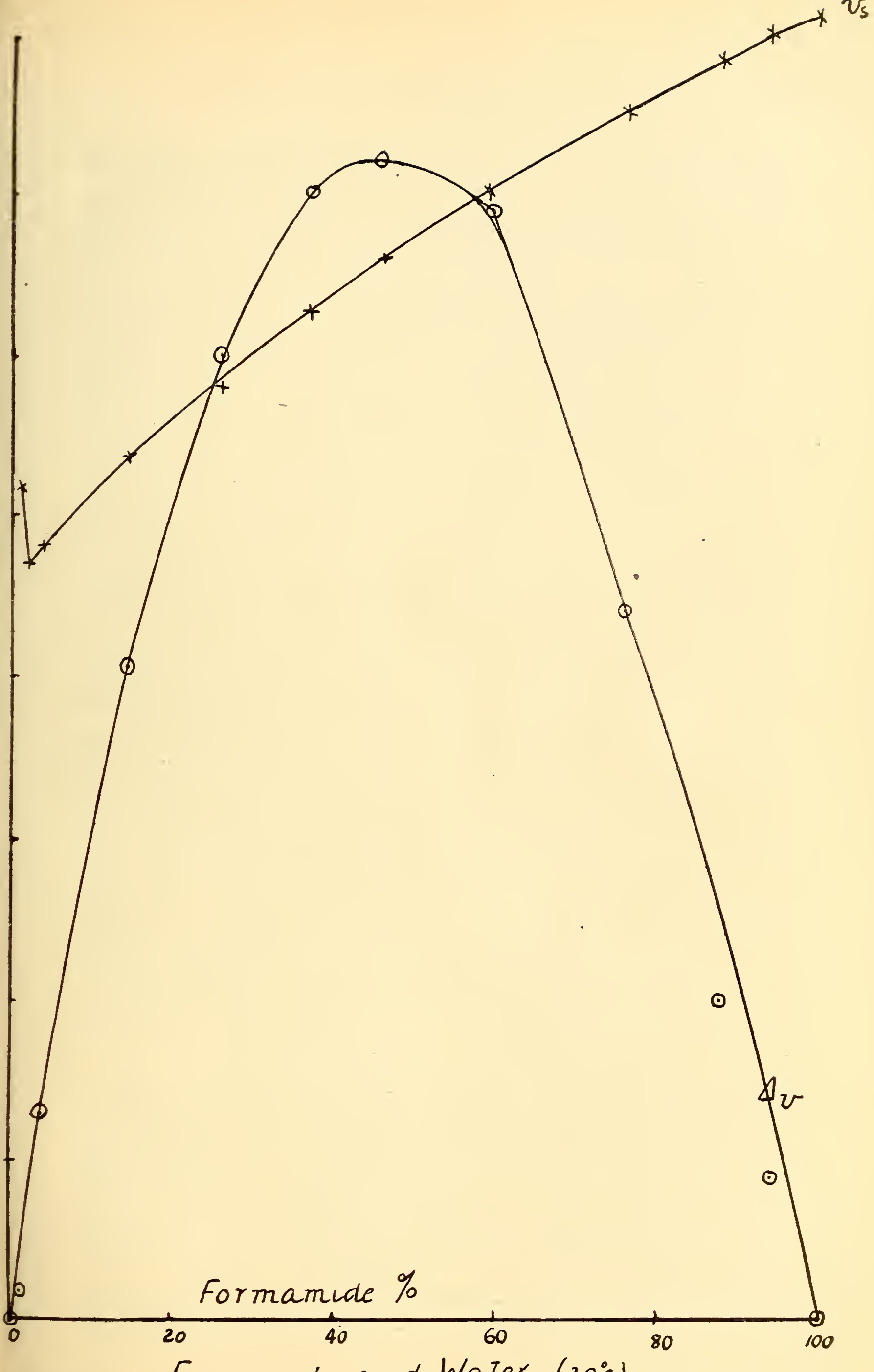

Fig. 1. Formamide and Water (20°c)

Here the value of v_s increases regularly with concentration, whilst the specific contraction also increases up to 47·1 per cent. and then decreases. In these two cases the variation of v_s with A cannot be interpreted as indicating an increase in the specific volume of the system with increasing concentration of the solute. It follows, therefore, that a comparison of v_s with A is likely to lead to incorrect conclusions. Thus in the examples given above, since the specific volume of the solvent is considered constant throughout the series ($= \frac{1}{d_0}$) and v_s is found to increase with A one would naturally conclude that the specific volume of the system as a whole increased with concentration of the solute, whereas we know that up to a certain concentration in each case it decreases.

There is no reason to doubt that the same is also true for solutions of solids in water. In the case of sucrose solutions at least, similar results have been obtained. Thus in Table XI, the values under v_s are constant within the limits of experimental error, and yet by measuring the actual contractions in the formation of aqueous sucrose solutions, Schwers[1] has shown that the specific volume of the system as a whole decreases with increasing concentration up to 70 per cent. sucrose. These results show that the application of Equations I or II in considering the effect of the concentration of the solute on its solution volume is apt to lead to erroneous conclusions.

From an exhaustive study of the molecular solution volumes of homologous series, Traube[2] found that certain values could be assigned to the solution volumes of the different atoms. The "molecular volume" is equal to the sum of the atomic volumes together with the "molecular

[1] J.C.S., 1911, 99, 1478.

[2] Zeit. anorg. Chem. 1895, 8, 338 Ber., 1895, 28, 2728, 2924, Ber., 1896, 29, 1023; Ber., 1897, 30, 265

co-volume" which represents the additional volume occupied by the molecule by virtue of its vibrations. The molecular solution volume ${}_sV_m$ may therefore be expressed by

$$ {}_sV_m = \Sigma\, n\, V_a + \triangle $$

where $\Sigma\, n\, V_a$ is the sum of the atomic volumes and $\triangle$ the molecular solution co-volume, which Traube found to be approximately constant for all classes of compounds, the mean value at 15° C. being 12·4 ccs. Thus the following values were obtained for atomic volumes at 15° C.:—C = 9·9 H = 3·1, O(OH of COOH) = 0·4, O(OH) = 2·3, O(CO) = 5·5, N = 1·5, $\triangle$ = 12·4.

In the following table the values under ϕ are those determined experimentally (Tables IV – XII), and those under ${}_sV_m$ are the values calculated from the atomic volumes at 15° C. (Traube).

Table XIV.

	ϕ	${}_sV_m$ (15° C.)
Formamide (25° C.) $HCONH_2$	38·9	38·6
Acetamide (30° C.) CH_3CONH_2	55·8	54·7
Propionamide (30° C.) $C_2H_5CONH_2$	71·7	70·8
Carbamide (25° C.) $CO\langle{}^{NH_2}_{NH_2}$	44·4	43·2
Succinamide (25° C.) $(CH_2CONH_2)_2$	89·4	90·8
Succinic acid (25° C.) $(CH_2COOH)_2$	83·0	82·4
Tricarballylamide (25° C.)	124·0	126·9

The agreement between the experimental and calculated values is satisfactory; the difference between the values is no doubt due to the increase in value of $\triangle$ with temperature.

Solutions in ethyl alcohol.

The specific and molecular solution volumes of several amides in alcoholic solution were determined at 30° C. The results obtained are given in the following table.

Table XV.

Solvent—Ethyl alcohol (d_0 = ·780777). Temp. 30° C.

A	d_1	v_s	ϕ
(*a*) Formamide.			
1·8454	·785604	·846	38·14
6·1292	·796280	·849	38·25
18·5815	·823708	·855	38·52
(*b*) Acetamide.			
4·3441	·789723	·932	55·07
7·0327	·794941	·933	55·15
9·6461	·799847	·934	55·16
(*c*) Propionamide.			
3·2024	·786515	·980	71·62
7·5389	·793896	·979	71·55
11·4767	·799920	·983	71·86
(*d*) Butyramide.			
2·6969	·785056	1·015	88·41
5·9635	·789912	1·018	88·65
(*e*) Capronamide.			
2·2745	·783658	1·069	123·10
3·4050	·785038	1·069	123·17

The values of v_s for any particular solute are fairly constant and independent of concentration. If we subtract the molecular volume of one amide from the next higher homologue in the series, the difference in volume corresponding to an addition of CH_2 to the molecule can be calculated. These results are given below.

Table XVI.

Amide.	ϕ	$\Delta\phi$
$HCONH_2$	38·3	...
CH_3CONH_2	55·1	16·8
$C_2H_5CONH_2$	71·7	16·6
$C_3H_7CONH_2$	88·5	16·8
$C_4H_9CONH_2$	...	...
$C_5H_{11}CONH_2$	123·1	2 × 17·3
	Mean	17·0

It will be noticed that $\triangle_\phi$ is approximately constant up to butyramide, but between this member and the next there is a considerable increase in volume difference. This variation for higher members of an homologous series is common to most physical properties.

Mixed Solvents.

Determinations were also made of the solution volumes of different solutes in solvents prepared by mixing two liquids. Weighed quantities of the liquids were mixed and the density of the mixture determined with a pyknometer in the usual way. A weighed quantity of the solute was then dissolved in a weighed quantity of the mixture, and the density of this solution determined, and the specific solution volume of the solute calculated in the usual way. In the following table are given the solution volumes of benzophenone in various solvents at 30° C.

Table XVII.

Solute—Benzophenone. Temp. 30 C.

A	d_1	v_s
(*a*) Solvent—Benzene (d_0 = ·868327).		
1·5067	·871189	·897
4·2746	·876398	·893
12·4329	·890517	·892
(*b*) Solvent—Acetone (d_0 = ·781169).		
3·6851	·790169	·870
7·5410	·798813	·872
11·9758	·808462	·873
(*c*) Solvent—Ethyl alcohol (d_0 = ·780897).		
7·7015	·798935	·876
11·8189	·807776	·877
(*d*) Solvent—Benzene-Acetone, Acetone = 50·72% (weight) d_0 = ·822244.		
5·8368	·835038	·878
12·9402	·848865	·883
(*e*) Solvent—Alcohol-Acetone, Acetone = 56·36% (weight) d_0 = ·781568.		
10·1467	·804867	·877
13·2029	·811255	·878

For the sake of comparison the specific volume of the pure solute in the liquid state was also determined. Benzophenone is solid at the ordinary temperature, having a melting point of 48°·5 C. If, however, liquid benzophenone be allowed to cool without shaking, it is possible to keep it liquid for a considerable time below 30° C. The volume of the liquid benzophenone was determined by carefully filling a five cc. pyknometer with the molten material, from which air had been removed as completely as possible by means of a suction pump, and then cooling carefully in the thermostat and adjusting the volume in the usual way. With a little care the liquid could be kept without crystallising till after the adjustment, and the volume accurately determined. One determination gave for the density of liquid benzophenone, $d_{30} = 1·10231$ whence $v = 9072$. A duplicate experiment gave $v = ·9070$.

It will be seen from Table XVII that the specific solution volume is less in any of the solvents than the specific volume of the liquid solute, indicating that the process of solution is accompanied by contraction in each of these cases. The specific volume is greater in benzene than in either acetone or alcohol. This is in agreement with the results obtained by Tyrer *(loc.cit.)* for other solutes in these solvents. The values of v_s for solutions in the benzene-acetone mixture are intermediate between the values obtained in the pure solvents. In the case of the acetone-alcohol solutions, the values of v_s are almost identical with those for solutions in pure alcohol. In the preparation of both of these "mixed solvents" there is practically no change in volume. Thus in the preparation of the benzene-acetone mixture, 145·3922 cc. of benzene at 30° C. were mixed with 166·3833 cc. of acetone at 30° C., and the final volume was 311·5620 cc. at 30° C. The total contraction was only 0·2135 cc. which corresponds to a specific contraction per cc. of the original volume of Δ_v = ·000685 cc. Similarly for acetone-alcohol, Δ_v = ·000842. These results point to the conclusion that in mixtures of organic liquids such as the above, in the preparation of which there is practically no change in volume, the specific solution volume of a solute lies between its values in the simple solvents. It will be seen from the following tables that this is not the case with solutions in water-alcohol mixtures. In Table XVIII are given the specific solution volumes of mercuric chloride in water, ethyl alcohol, and in a mixture of alcohol and water, at 30° C.

Table XVIII.

Mercuric chloride.

A	d_1	v_s
(*a*) In water (d_0 = ·997062).		
2·1396	1·013096	·180
3·6307	1·025072	·182
(*b*) In ethyl alcohol (d_0 = ·780897).		
7·2830	·830233	·160
13·2739	·870108	·160
22·9652	·933074	·162
(*c*) In water-alcohol (d_0 = ·941605). Alcohol = 33·17 per cent. (weight).		
2·8875	·963672	·196
6·1069	·987959	·196
7·0298	·994844	·197

The solvent used in this case was prepared by mixing 88·1129 cc. of water with 55·7538 cc. of alcohol. The resulting volume was 139·4110 cc., which corresponds to a contraction of 4·4557 cc. or ·03097 cc. per cc. of the original volume. This contraction is about fifty times as great as that observed in the case of benzene-alcohol or benzene-acetone.

It will be noticed in the preceding table that the value of v_s is greater in the mixture than in either of the simple solvents. This was found to be the case with all solutes whose specific volumes were determined in water-alcohol mixtures, several examples are given in the following tables. The specific contraction Δ_v observed in the preparation of the different mixtures used as solvents is stated in each case. The percentages of alcohol given are by weight.

Table XIX.

Solute—Carbamide. Temp 25° C.

(*a*) In water (d_0 = ·997073.

A	d_1	v_s
2·6329	1·003912	·737
5·0484	1·009800	·738
7·3010	1·015198	·740
14·4848	1·030884	·743

(*b*) In ethyl alcohol (d_0 = ·785211).

2·4796	·794191	·677
2·8160	·795421	·678
3·5211	·797950	·676
5·4320	·804559	·679

(*c*) In water-alcohol (24·41 per cent. alcohol).

d_0 = ·959875 Δ_v = ·0255 cc.

2·3307	·965917	·756
5·4357	·973611	·757
11·8262	·988369	·758

(*d*) In water-alcohol (35·70 per cent. alcohol).

d_0 = ·940129 Δ_v = ·0326 cc.

1·9700	·945452	·754
3·5158	·949373	·759
6·8602	·957711	·760
9·8484	·964845	·760
13·5561	·973289	·760

(*e*) In water-alcohol (44·17 per cent. alcohol).

d_0 = ·922752 Δ_v = ·0345 cc.

A	d_1	v_s
3·3277	·931880	·754
6·7110	·940644	·756
9·8411	·948375	·757
15·7980	·962235	·758

(*f*) In water-alcohol (66·13 per cent. alcohol).

d_0 = ·872753 Δ_v = ·0305 cc.

2·7611	·881119	·741
5·3457	·888744	·740
6·4242	·891689	·743
10·7088	·903470	·743

(*g*) In water-alcohol (75·50 per cent. alcohol).

d_0 = ·850251 Δ_v = ·0258 cc.

3·5510	·861364	·734
5·6643	·867714	·735
6·9366	·871478	·734
9·9906	·880130	·737

If the values of v_s in Table XIX be compared for the same concentration of solute, the variation of the specific solution volume with the composition of the solvent is more clearly shown. The values of v_s for $A = 6$ are given below, together with the specific contraction observed in the preparation of each of the solvents.

Table XX.

Alcohol per cent. in solvent.	Δ_v	v_s
0	...	·739
24·44	·0255	·757
35·70	·0326	·759
44·17	·0345	·755
66·13	·0305	·742
75·50	·0258	·735
100·00	...	·680

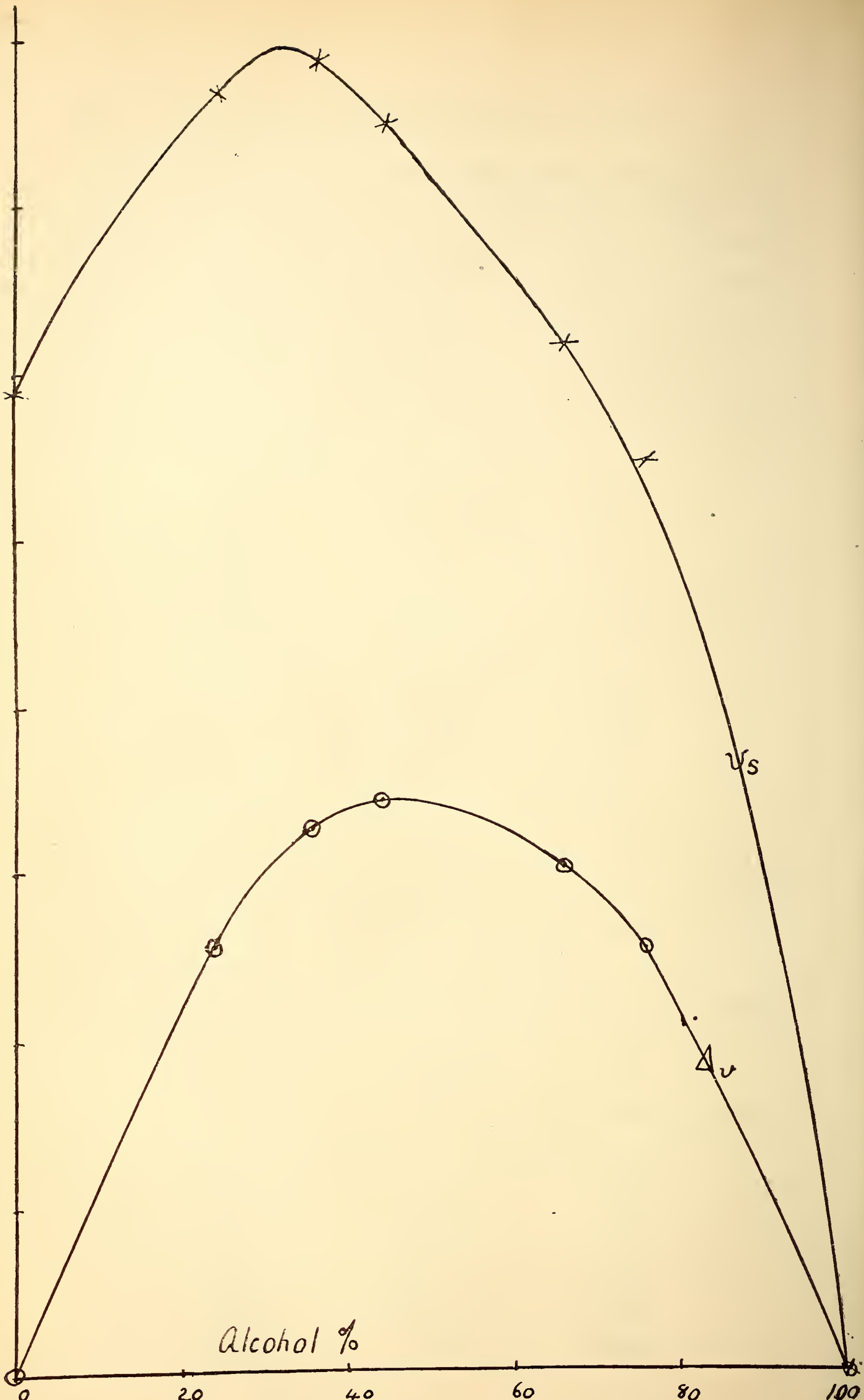

Fig. 2. Carbamide in Water-Alcohol Mixtures.

If the values of v_s be plotted against the composition of the solvent, a maximum value is found for a solution containing 32 per cent. alcohol (Fig. 2). The maximum value of Δ_v corresponds to about 44 per cent. alcohol. A similar series of results was obtained for solutions of carbamide at 30° C.

Table XXI.

Solute—Carbamide. Temp. 30° C.

(*a*) In water (d_0 = ·995677).

A	d_1	v_s
2·3290	1·001575	·744
9·0567	1·017457	·745
15·4282	1·030922	·747

(*b*) In ethyl alcohol (d_0 = ·780777).

2·3698	·789391	·677
4·3264	·796280	·679

(*c*) In water-alcohol (25·44 per cent. alcohol).
d_0 = ·955387 Δ_v = ·0260 cc.

4·0276	·965613	·760
11·5191	·983142	·761

(*d*) In water-alcohol (30·47 per cent. alcohol).
d_0 = ·946572 Δ_v = ·0295 cc.

4·3638	·957766	·761
9·3135	·969667	·761

(*e*) In water-alcohol (36·62 per cent. alcohol).
d_0 = ·934695 Δ_v = ·0323 cc.

3·2901	·943409	·760
6·4193	·951311	·760
13·0705	·966975	·761

(*f*) In water alcohol (47·11 per cent. alcohol).
d_0 = ·912305 Δ_v = ·0339 cc.

4·5592	·924928	·752
7·7650	·933190	·756

(*g*) In water-alcohol (58·89 per cent. alcohol).
d_0 = ·885436 Δ_v = ·0323 cc.

5·2383	·900608	·747
13·2060	·921661	·749

If the values of v_s be compared for the concentration $A = 4$ the results are seen to vary in the same manner as those in Table XX.

Table XXII.

Alcohol per cent. in solvent.	Δ_v	v_s
0	...	·744
25·44	·0260	·760
30·47	·0295	·761
36·62	·0323	·760
47·11	·0339	·752
58·89	·0323	·747
100·00	...	·679

Results obtained with other solutes are given in the following tables.

Table XXIII.

Solute—Formamide. Temp. 30° C.

(*a*) In ethyl alcohol (d_0 = ·780777).

A	d_1	v_s
1·8454	·785604	·847
6·1292	·796280	·849
18·5815	·823708	·855

(*b*) In water-alcohol (44 per cent. alcohol) d_0 = ·918665.

1·7433	·921389	·901
3·2160	·923652	·900
4·0509	·924849	·902

The corresponding determinations in aqueous solutions at 30° C. were not made since a complete series of values had already been obtained at both 20° and 25° C. The values of v_s for concentrations corresponding to the above are here given for these temperatures, and the values for 30° calculated by assuming that the difference in solution volume for 5° C. is the same between 30° and 25° as it is between 25° and 20° C.

(*c*) In water.

A	v_s 20° C.	v_s 25° C.	v_s 30° C.
1·7251	·847	·856	·865
4·2770	·848	·856	·865
17·2736	·854	·860	·866

The specific volume of liquid formamide at 30° C. was found to be ·88776, so that whereas the process of solution in either water or alcohol is accompanied by contraction, when dissolved in the mixture there is an increase in the volume of the system.

Table XXIV.

Solute—Acetamide. Temp. 30° C.

A	d_1	v_s
(*a*) In water.		
4·5875	·998254	·945
7·5278	·999892	·944
10·1471	1·001300	·943
16·7179	1·004590	·942
(*b*) In ethyl alcohol.		
4·3441	·789723	·932
7·0327	·794941	·933
9·6461	·799847	·934
(*c*) In water-alcohol (25·44 per cent. alcohol).		
5·3795	·959944	·949
13·2547	·965848	·950
(*d*) In water-alcohol (36·62 per cent. alcohol).		
5·2768	·939815	·954
10·9203	·944726	·954
(*e*) In water-alcohol (47·11 per cent. alcohol).		
4·5536	·917524	·953
9·5581	·922779	·954
16·2709	·929080	·955
(*f*) In water-alcohol (58·89 per cent. alcohol).		
4·8831	·892021	·950
12·1520	·900599	·954

The specific volume of liquid acetamide, extrapolated for a temperature of 30° is ·956 (Meldrum and Turner),[1] and the values of v_s in solutions containing 36·62 and 47·11 per cent. alcohol are almost identical with this.

[1] J.C.S., 1908, 93, 876.

Table XXV.

Solute—Propionamide. Temp. 30° C.

A	d_1	v_s
(*a*) In water.		
1·8533	·996096	·981
3·9972	·996593	·980
(*b*) In ethyl alcohol.		
3·2024	·786515	·980
7·5389	·793896	·979
11·4767	·799920	·983
(*c*) In water-alcohol (47·11 per cent. alcohol).		
4·9714	·916309	·995

The specific volume of liquid propionamide for this temperature is a 1·000.

Table XXVI.

Solute—Sucrose. Temp. 30° C.

A	d_1	v_s
(*a*) In water.		
2·7695	1·006078	·619
4·5190	1·012373	·621
8·2459	1 025524	·621
(*b*) In water-alcohol (25·44 per cent. alcohol).		
5·9306	·977454	·625
9·5612	·990192	·625
(*c*) In water-alcohol (30·47 per cent. alcohol).		
5·1754	·966014	·624
8·5266	·977847	·626
(*d*) In water-alcohol (36·62 per cent. alcohol).		
6·8290	·960193	·625
8·9480	·967624	·627
(*e*) In water alcohol (47·11 per cent. alcohol).		
4·8789	·930920	·625
10·9941	·952719	·627
(*f*) In water-alcohol (58·89 per cent. alcohol).		
4·6037	·903305	·622
9·9049	·922626	·624

It will be seen from the above results that in every case considered, the specific solution volume of a solute is greater in a water-alcohol mixture than in either water or alcohol, and not intermediate between its value in the simple liquids. In the case of formamide as solute the specific solution volume is actually greater than the specific volume of the pure liquid, although the solution volume in either water or alcohol is considerably less. In the examples where the solution volume has been determined in a series of water-alcohol mixtures, a more or less definite maximum has been found, but the position of the maximum varies with the solute. The maximum solution volume of carbamide is found in a solution containing about 32 per cent. of alcohol both at 25° and 30° C., but in the case of both acetamide and sucrose, the mixture corresponding to the maximum contains over 40 per cent. of alcohol.

Maxima or minima have been recorded for several physical properties of alcohol-water mixtures, but the position of such maxima are by no means constant. These abrupt changes in the physical properties of mixtures have been interpreted by various authors as indicating combination between the alcohol and water with the formation of more or less stable "solvates." If this be so, the results obtained for solution volumes of solutes in such mixtures indicate in addition, the existence in the solution of solvates between the solute and either water or alcohol or both. The formation of a solvate results in a change in the specific volume, the magnitude of which will vary with the particular solvate in question. Combination between the alcohol and water molecules results in a contraction in volume, which varies with the composition of the mixture and also the temperature. If in such a mixture we dissolve a solute, which also forms a solvate with water (or alcohol) the original equilibrium of the system will be altered, and a further volume change result. This second change may be in the same direction as the first or it may be in the opposite direction, depending on the relative magnitudes of the specific contraction accompanying the formation of solvate in each case.

In order to explain the results obtained in this work we would therefore have to consider that the formation of solvates is characteristic of all the substances that have been used as solutes. It is considered that the results obtained in this research can be explained by assuming that the observed volume changes result from a rearrangement of the molecules in the system.

From a consideration of the specific solution volumes of organic solutes in organic solvents Tyrer *(loc. cit.)* concluded "that a connection exists between the compressibility of a solvent, and the volume which a solute, when dissolved in it, takes up." In the case of solutions in water alcohol mixtures there is undoubtedly some connection between the specific contraction that has already taken place in the preparation of the mixture and the specific volume of a solute in this mixture.

The contraction which results from the mixing of water and alcohol is due to a condensation in the volume of the system resulting from a rearrangement of the molecules in such a way as to permit of closer packing. For any two liquids (*e.g.*, alcohol and water) this condensation will tend towards a maximum corresponding to a certain mixture at any particular temperature. The effect of dissolving a solute in such a mixture will depend on the relative size of the molecule of solute, and the amount of condensation that has already taken place in the preparation of the solvent. In the case of the pure solvents (water or alcohol) the addition of solute will cause a rearrangement of molecules in the system resulting in a relatively large decrease in total volume. In the case of a mixture of alcohol and water which is already condensed, the addition of the solute would be expected to have a smaller effect. The observed value of v^s would therefore be greater in such a mixture than in either of the simple solvents.

It follows from the results given above that the maximum solution volume of a solute is not always found in the mixture which has undergone the maximum contraction in its preparation. Thus in the case of carbamide, the maximum solution volume occurs in a 32 per cent. alcohol mixture, whereas the maximum specific contraction (between water and alcohol) takes place when the mixture contains about 44 per cent. alcohol. The position of the observed maximum contraction depends on the relative volumes of the different molecules concerned.

NOTE ON ORGANO-METALLIC DERIVATIVES OF CHROMIUM, TUNGSTEN AND IRON.

By George Macdonald Bennett, M.A., M.Sc., and Eustace Ebenezer Turner, B.A., M.Sc.

(Communicated by Prof. J. Read).

[*Read before the Royal Society of N.S. Wales, August 6, 1919.*]

It has been shown[1] that anhydrous chromic chloride reacts with aryl-magnesium halides to give compounds which, on decomposing with mineral acids, are quantitatively converted into the respective di-aryl hydrocarbons. The nature of the intermediate compounds, usually (as in the case of the product from phenyl magnesium bromide) orange-red in colour, has not yet been determined, owing to the difficulty of isolating pure substances from the reaction-mixtures, but in view of some experiments (carried out in 1914) on the interaction of phenyl magnesium bromide and anhydrous ferric chloride, the view is now expressed that in the case, both of chromic and ferric chlorides, organo-metallic derivatives are formed, these being decomposed in presence of mineral acid, so that in the preliminary experiments their formation escaped observation.

Of the two series of organo-metallic compounds, the iron compounds are apparently the more stable. The chromium intermediate compound (phenyl) on treatment with mineral acid, is at once converted into diphenyl, whereas the iron compound is partly so decomposed, the major portion remaining in the ethereal solution. Thus in one experiment, a Grignard reagent prepared from 37·5 grams of bromobenzene, 4·6 grams of magnesium and 50 ccs. of ether was

[1] Trans. Chem. Soc., 1914, 105, 1057.

divided into two equal portions. The first was at once decomposed with water and acid and gave 0·6 grams of diphenyl. The second was treated with 5 grams of ferric chloride and gave 4 grams of diphenyl, so that evidently the majority of the initially-formed iron organo-compound remained in the ethereal solution as such.

An attempt was made to isolate an iron organo-compound: the reaction mixture from phenyl magnesium bromide and ferric chloride in ether was treated with water and dilute sulphuric acid and the ethereal solution separated, dried, filtered and evaporated. The dark coloured solid residue so obtained was freed from diphenyl by extraction with light petroleum, when an ochre-coloured solid was obtained. This was washed with water, dried, dissolved in benzene and precipitated by the addition of light petroleum. A greenish solid resulted, which contained iron, was soluble in benzene and depressed the melting point of diphenyl.

Oddo, who has investigated the subject from a different point of view[1] apparently failed to isolate a solid phenylated iron compound, although his conclusions are in substantial agreement with those now put forward.

In the interaction of tungsten chlorides with Grignard reagents, organo-metallic compounds seem to be produced as unstable intermediate products, all attempts to isolate them, however, having at present met with no success.

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[1] Gazz. chim. ital., 1914, 44, ii, 268.

VOCABULARY OF ONE HUNDRED AND FIFTY-FOUR WORDS OF THE YUCKABURRA DIALECT,

SPOKEN BY THE MUNKEEBURRA, SOUTH KENNEDY DISTRICT, CAPE RIVER, QUEENSLAND.

By J. P. BEUZEVILLE.

(Communicated by W. A. W. BEUZEVILLE.)

[*Read before the Royal Society of N. S. Wales, September 3, 1919.*]

NOTE.—The following vocabulary was gathered by my father, the late Jame Paroissien Beuzeville, when he was living in the Cape River District of Queensland. The date of collection was about 1860.—W.A.W.B.

Family.

Aboriginal man	Murri
Aboriginal woman	Wongho
Child (either sex)	Cundu
Girl (maiden)	Oolbo
Woman (young married)	Munkino
Father	Yaboo
Mother	Yungana
Husband	Goongul
Wife	Pigoona
Elder brother	Kuthana
Younger brother	Waboo
Mother-in-law	Mungaroo
Aunt	Tabina
Son-in-law	Wamida

The Human Body.

Hair	Cutha
Eye	Dilli
Nose	Ninde
Teeth	Ear

Beard	Ungun or Yarrine
Throat	Bood
Breast (woman's)	Ammon
Milk	Ammona
Elbow	Munga
Hand	Mullah
Right-hand-side	Billimbah
Left-hand-side	Warrambah
Liver	Yarkory
Thigh	Tia
Foot	Deena
Blood	Cooma
Bone	Pulbum
Fat	Tommi
Skin	Pidgee

Reptiles, Birds, etc.

Snake (generic name)	Moonda
Death Adder	Munnum
Black Snake	Boothoo
Brown Snake	Yabbeya
Carpet Snake	Carbool
Brown Snake (speckled belly, very savage)	Cooleroo
Brown Snake, black head	Goyo Gurra
Green Tree snake	Warrowa
Water snake (black)	Ammondora
Red speckled snake, small	Toombledoomble
Goana	Tuckine
Sleeping Lizard	Bungara
Ant (green)	Moondoon
Bandicoot	Uigella
Bee	Whogan
Bird (small)	Devilla
Bustard	Burkum
Turkey (scrub)	Coocabean

Cockatoo (white)	Thiroon
Fish (generic name)	Goyo
Black Perch	Binim
Trout	Goorba
Eel	Wokkul
Turtle (freshwater)	Konghari
Crow	Waohan
Black duck	Coobeiy
Whistling duck	Dimiju
Wood duck	Ougwhoi
Black Shag (Snake Bird)	Gurren Gurren
Native Dog	Wunte
Eagle	Goorithella
Emu	Goondooloo
Native Companion	Goolderoo
Meat Hawk	Peiju
Pelican	Bullen
Hawk (Pigeon)	Kurgine
Quail	Boonduloo
Pigeon (Squatter)	Marmitta
Laughing Jackass	Kookaburra
Frog	Goonghgul
Bullfrog	Toomoobra
Jewfish	Goonghala
Kangaroo (grey)	Wooar
Kangaroo Rat	Wiver
Wallaroo (old man)	Kargool
Wallaroo (female)	Culberoo
Paddymelon	Toomba
Rock Wallaby	Goonyooloo
Leech	Doonum
Opossum (male)	Tungaroo
Sheep	Munkey
Flying Squirrel	Mungaroo

Pheasant	Boan Boan
Swallow	Bullen Bullen
Feathers	Boona

Miscellaneous.

Sound heard at a distance, Curra, as for instance, "Ia Walloogo Curra Coobarool," I hear the sound of his tomahawk in the Gidyah tree.

Where	Yungadee
Flood	Wirran
Fear	Bunga
Frightened	Bungine
Enough	Punda
Pull Away	Booria
That will do	Unoo
Alas (in sorrow)	Pegooroo
Alas (in pity)	Yakii
Wonderful	Yakie
Close up	Yarro
Longway	Cowrie
Honey	Carba
I go to catch fish	Ia Goyogo
Flower	Munga
Fruit (wild currant sweet)	Boorum
Possum cloak	Combo
Waterlily root (used for food)	Dooey or Cooney
Waterlily seed (used for bread)	Pundy
Yam	Coothia
Smoke	Tugar
Tail	Boongha
Tree	Tular
To Lie (untruth)	Mootheroo
You are a liar	Iuder Mootherooburra
Wind	Ebara
Yard (enclosure)	Warra Warra
Grass	Mooloo or Bogan

Stinking	Kija
Dead	Goonga
Laugh	Yie
Cry	Barry
White Clay	Bunbera
Grey Clay	Binga
Red Ochre	Nameroo
Quick	Wokker
Be off	Mungha Mungha
Be off instantly	Mungha Winga
One	Wijin
Two	Bullaroo
Three	Golbera
Four or many	Moorga
Bite	Curraburra
Rob (steal)	Morella
Fishingline	Minke
Climb	Yakka
Coo-ee	Kongul
Cut	Kunginego
Mulga tree	Boonaroo
Gidyah tree	Coobarool
Gum tree	Dandaloo
Box tree (swamp)	Bokkara
Angry	Coolee
Ashes	Boan
Tomahawk (stone)	Polgo
Knife	Kurrinjine
Bark	Goga
Belt (woman's)	Womby
Boomerang	Wonghul
Spear (jagged)	Moorja
Spear (grasstree)	Culga
Throwing stick	Tamulla
Shield	Coolmurry
Heavy two hand club	Bullen Bullen
Lighter jagged head club	Dimy Dimy
Light stick for killing wallaby	Miroo

NOTES ON EUCALYPTUS, No. VIII.

(WITH DESCRIPTIONS OF TWO NEW WESTERN AUSTRALIAN SPECIES.)

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

[Read before the Royal Society of N. S. Wales, September 3, 1919.]

E. LANE-POOLEI n. sp.

Arbor mediocris, White Gum vocata; cortice crassa, pulvere alba tecta; ligno hepatico; foliis primariis lanceolatis vel lato-lanceolatis, ca 6 cm. longis 3 cm. latis, venis secondariis fere parallelis; foliis maturis breve petiolatis, lanceolatis, acuminatis subfalcatis, ca. 10 vel 11 cm. longis, 2 cm. latis, venis inconspicuis; pedunculis teretibus, ca. 1·5 cm. longis, plerumque 4 - 6 floris, pedicellis teretibus 1 cm. longis; calycis tubo ca. 1 cm. diametro, fere hemispherico; operculo crassissimo, hemispherico; antheris grandis fissuris parallelis late dehiscentibus; fructibus hemisphericis, ca. 1 cm. diametro, margine lato, leniter convexo, valvis distincte exsertis.

A medium sized tree known as "White Gum," and carrying a thick bark covered with a white powder. Sapwood pale-coloured and thick, the timber interlocked, and rich reddish-brown in colour, drying, in the course of years, to a deep purplish-brown.

Juvenile leaves shortly petiolate, lanceolate to broadly-lanceolate, about 6 cm. long by 3 cm. broad, of the same colour on both sides, the secondary veins moderately spreading, and tending to be parallel to each other. A vein more prominent than the other secondary veins, roughly following the outline of the leaf, but at a considerable distance from the margin, and giving the leaf a tripli-nerved appearance.

Mature leaves shortly petiolate, lanceolate, acuminate, slightly falcate, not large, usually about 10 or 11 cm. long, and up to 2 cm. broad, venation inconspicuous, the fine veins roughly parallel and making an angle of about 45° with the midrib, intramarginal vein hardly removed from the edge.

Peduncles axillary or lateral, terete, about 1·5 cm. long, bearing usually 4 to 6 moderately large flowers on terete pedicels up to 1 cm. long. Buds shiny.

Calyx-tube nearly hemispherical, about 1 cm. in diameter, with two slightly raised ridges separated by 180°; tapering rather abruptly into the pedicel.

Operculum very thick, hemispherical or terminating in a slight but sharp point when nearly ripe. When less ripe, slightly broader than the calyx-tube and without a point.

Stamens about 9 mm. long, inflected in the bud, anthers large, opening widely in parallel slits. Gland long, faintly visible at the back. Filament at the base. The anthers belong to the Platyantheræ group.

Disc broadish, oblique, forming a prominent ring round the ovary, of which the obtusely conical centre protrudes slightly above the disc at the time of flowering.

Fruit hemispherical, about 1 cm. in diameter, the rim broad, slightly convex, the capsule not sunk, the valves conspicuously exsert.

Type from Beenup, W.A. (C. E. Lane-Poole, No. 465).

Named in honour of Charles E. Lane-Poole, Conservator of Forests of Western Australia, who collected this species, and who has done much to promote the study of this genus in his State.

Range.

It is confined to Western Australia, and, so far as is known at present, to a strip of coast-land, more or less ascending the Darling Range, in the south-western portion of the State, on the Perth-Bunbury Railway Line, between Kelmscott 16, and Waroona, 70 miles south of Perth.

"Very clean White Gum, Kelmscott, foot of Darling Range, 16 miles south of Perth." (Dr. J. B. Cleland, No. 4), figured at fig. 4a and 4b of Plate 74 of my "Critical Revision of the Genus Eucalyptus."

"White Gum," 40 feet high, 12 inches in diameter, near Beenup, S. W. Railway, on the Perth to Bunbury road, 24 miles south of Perth (C. E. Lane-Poole, No. 8, November 1918, fruits only; No. 465, July 1919, complete material).

"A White Gum, sandy scrub land, Serpentine River, W.A." In herb. Melb. and variously attributed by Mueller (on the label) to *E. uncinata* and to *E. micranthera*.[1] It is a very old specimen, and is figured at fig. 8a, 8b, 8c of Plate 74 (C.R.). This and the following three localities are practically identical.

"Salmon White Gum or Powder Bark Wandoo. Height to about 40 feet, to 3 feet in diameter." Near Keysbrook, (39 miles south of Perth), near the Belgobin School on the Perth-Bunbury road. (Mr. Schock, through C. E. Lane-Poole, under the same number 8, as given to some Beenup specimens).

Tree of 40 feet, 3 feet in diameter. Keysbrook, Perth-Bunbury road, (Mr. Schock, per Dr. F. W. Stoward No. 1).

"Salmon Gum or Powder Bark Wandoo," half a mile south of Serpentine River on Perth-Bunbury road. (Mr. Schock, per F. W. Stoward, No. 90).

Sent as "Wandoo," Waroona, January 1903 (Forester J. J. Fitzgerald). Waroona is 70 miles south of Perth, and I could only obtain buds. Referred to at p. 224, Part xvii, C.R.

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[1] This is the specimen referred to at C.R., Part xx, bottom of page 308, under *E. micranthera*. There is, however, very little affinity between the two species.

Affinities.

1. With *E. redunca* Schauer. That officers of the Forest Department of Western Australia should, quite independently, in 1903 and 1918, speak of this as a Wandoo, shows that the general appearance of the tree, its bark and timber, must bear more than a superficial resemblance to the true Wandoo (*E. redunca*). But comparison of the figures 4 and 8, Plate 74 (C.R.), which partly depict *E. Lane-Poolei*, and Plate 140 which shows *E. redunca*, shows that the two species are botanically very dissimilar.

2. With *E. accedens* W. V. Fitzgerald. Mr. Schock, the Collector of the Forest Department of Western Australia, calls *E. Lane-Poolei* "Powder-bark Wandoo." Both species are White Gums with white powdery barks, and the timbers have some external resemblance. The sylvicultural conditions of the two trees require to be worked out. As to the use of the term "Powder-bark," Part xxxiv, p. 101, C.R., may be referred to. If we turn to Plate 142, of the same Part, and compare it with figures 4 and 8 of Plate 74, which in part depict *E. Lane-Poolei*, it will be seen that the two species have no close botanical affinity.

3. With *E. Oldfieldii* F.v.M. The affinity of this species is with *E. Oldfieldii* F.v.M., which included *E. Drummondii* Benth., a species which in Part xvii, C.R., I erroneously followed Mueller in suppressing. I have shown, in Part xli, how these two species differ. The affinity of *E. Lane-Poolei* is with *E. Drummondii* rather than with *E. Oldfieldii sensu strictu*. *E. Oldfieldii* is a Mallee with fruits in threes, while *E. Lane-Poolei* is a tree of considerable size, with fruits up to six in the head. The buds and leaves, both juvenile and mature, are very different.

4. With *E. Drummondii* Benth. This species, of which but little is known in the field, is described from the York district as "a small tree of about twenty feet, with trunk

and branches smooth, whitish-buff, with a few brown semi-detached scales of dead bark." Additional field-notes are very desirable, but it would appear that *E. Lane-Poolei* is a different tree, and a Powder-bark.

Comparison however with figures 3, 5, 6, 7, 9, 10 of Plate 74 *(E. Drummondii)*, together with a good specimen of the type of this species, is sufficient to show that it and *E. Lane-Poolei* (figures 4 and 8 of Plate 74) are sufficiently different. The leaves of *E. Drummondii* are commonly, perhaps preponderatingly ovate-lanceolate, the buds more ovoid; with the opercula longer than the calyx-tube; the fruits are smaller and very different.

5. With *E. Campaspe* S. le M. Moore. It is interesting to note a resemblance in the very thick, hemispherical operculum of *E. Campaspe*, but the anthers are different, and so are the fruits and other characters. But one so frequently receives, particularly from distant places, botanical specimens which are quite fragmentary, and a hint which may put one on one's guard may be useful.

6. With *E. oleosa* F.v.M. In its anthers it belongs to the Platyantheræ, which includes *E. oleosa* and its allies. The species are, however, very different in many other respects, but endeavour will be made to discuss these relationships when the seedlings of all the species are brought into comparison.

E. EWARTIANA n. sp.

Frutex Mallee similis, 20′ altus, multis caulibus 3″ diametro; cortice decidua peculiariter striatis; foliis primariis crassiusculis, late ovato-lanceolatis vel fere orbicularibus, 7 cm. latis, 10 cm. longis; foliis maturis petiolatis, lanceolatis, 5–7·5 cm. longis, 1·5 – 2·25 cm. latis, petiolo 1–1·5 cm. longo, crassis, venis patentibus; pedunculis teretibus 2 cm. longis, 2 – 7 flores breve pedicellatos umbella gerentibus; alabastris clavatis, operculo hemispherico, ca. 8 mm. diametro, calycis tubo angustioribus; antheris, forma irregulare paralleliter aperientibus, filamentis brevibus; fructibus conoideo-globosis, ca. 12 mm. diametro, margine latissimo, truncato, conoideo; capsula non depressa, valvis leniter exsertis.

Many-stemmed, 10 – 15 or 20 feet high. Somewhat Mallee-like in habit. The stems three inches in diameter and the timber tough and pale. The bark is peculiar, falling off in narrow, longitudinal pieces, giving it a striped appearance, which, if not unique, is certainly rare in Eucalyptus. Wood hard, the centre deep reddish-brown.

Juvenile leaves (described from Kunnunoppin No. 146) with petiole of 1 cm., broadly ovate-lanceolate to nearly orbicular, 7 cm. broad by 10 cm. long, very thick, venation spreading.

Mature leaves lanceolate, 5 – 7·5 cm., say two to three inches long, and 1·5 – 2·25 cm., say three-quarters to one inch broad, with a petiole of half to three-quarters of an inch (say 1 – 1·5 cm.) long. Dull yellowish-green on both sides, thick, venation spreading, the secondary veins not very prominent and meeting the midrib at about an angle of 45°; the intramarginal vein distinctly removed from the edge.

Peduncles terete, long (say 2 cm.), each supporting an umbel of 2 – 7 flowers on short but distinct terete pedicels.

Buds clavate, very yellow, with hemispherical operculum, about 8 mm. in diameter, and no mucro. The operculum less in diameter than the calyx-tube, and affording an excellent example of "egg-in-egg-cup," *i.e.* showing the place at the commisural rim of a deciduous additional operculum.

Anthers most irregular in shape and opening in parallel slits. The gland sometimes seen on the top and sometimes at the base. The filament attached nearly half-way up at the back of the anther. It is included in the Macrantheræ. Filaments very short, the stigmas not dilated.

Disc forming a broad conical truncate band around the ovary, which becomes less truncate as the fruit develops. In its early stages it resembles a hat with a depressed crown.

Fruits conoid-globose, about 12 mm. in diameter, the rim very broad, truncate-conoid, at length almost conical, the capsule not depressed, the valves slightly exsert.

Named in honour of Alfred J. Ewart, D.Sc., Professor of Botany and Vegetable Physiology in the University of Melbourne, well known for his researches on the Australian flora.

Type, Pindar, W.A. (J.H.M., October 1909).

Range.

This is a species of dry country, mainly recorded, so far, from Western Australia, but, by the Elder Expedition, found first in South Australia and subsequently in the Western State.

Western Australia.—"Many-stemmed, 10 – 15 or 20 feet. Tough wood. Peculiar bark, falling off in narrow longitudinal pieces, giving it a striped appearance. The indurated stems are three inches in diameter. Several clumps seen. Very yellow buds, with hemispherical operculum, and absolutely no mucro. Operculum, which is distinctly smaller than the calyx, affording one of the best examples I remember of the 'egg-in-egg-cup' bud. Leaves greenish yellow, dull coloured. The material I have is figured at 11, Plate 74." The above statement will be found at p. 225, Part xvii, C.R. (66¼ mile post, Pindar, Murchison Line J. H. M. Oct. 1909).

"Bark decorticating from one foot from the ground. Mallee, branching from the ground to a height of fifteen feet and up to six inches in diameter. The bark at base grey, rough, decorticating in rolled up grey strips leaving the stem, which is red in colour, with a peculiar streaked appearance. On rubbing, the loose pieces of bark come off easily, leaving the stem more or less smooth." Near Government Tank, Westonia. This is six miles north of Carrabin, a railway station 195 miles east of Perth. (C. E. Lane-Poole, Nos. 220, 463).

Shrub 5 – 8 feet, several stems springing from base, 2 – 3″ diameter, bark smooth above, inclined to be rough at base. Open flowers and young fruits. On ironstone gravel on high land. Best specimens always near the summit, Kunnunoppin district (Dr. F. Stoward, No. 144).

"Shrubby Mallee, 8 – 10 feet. Sucker leaves, flowers, mature fruits and bark. Found on ironstone ridge, Kunnunoppin district" (Dr. F, Stoward, No. 146). The bark precisely similar to that of the Pindar specimens but the leaves of this specimen are broader than those of the type.

"*Eucalyptus Oldfieldii*, Mountain form." Mount Cooper, Cavenagh Range, R. Helms, 31st July, 1891. "A dwarf state at 2,500 feet elevation." This locality is in Western Australia, and the Camp. No. 31, Long. 128°.

South Australia.—"*Eucalyptus Oldfieldii*," Elder Expl. Exped., R. Helms, 15 feet high, 12/6/91. The Expedition was then in the vicinity of Yeeluginna Hill, in South Australia, say in lat. 27° 20″ S., long. 131° 70″ E.

Affinities.

1. With *E. Oldfieldii* F.v.M. There has been great confusion between *E. Oldfieldii* and *E. Drummondii*, and the present species, like *E. Lane-Poolei*, has been carved out of the aggregate. The affinity of *E. Lane-Poolei* inclines to *E. Drummondii* and so does the present species in general characters, but both *E. Ewartiana* and *E. Oldfieldii* are dry-country Mallees. Mueller and Tate looked upon the Elder Expedition specimens as a mountain form of *E. Oldfieldii*. Both species have fruits with broad rims, though the sculpture is not the same in both. The fruits of *E.*

Ewartiana are smaller, more numerous, have long peduncles and are distinctly pedicellate. The operculum is very different to that of *E. Oldfieldii;* it is hemispherical and shows a contraction with the calyx tube which is not observable in *E. Oldfieldii.* The two species also differ in other characters.

2. With *E. Drummondii* Benth. Compare fig. 11, Plate 74 (*E. Ewartiana*), with figs. 3, 5, 6, 7, 9, 10 of the same Plate (*E. Drummondii*). The buds of *E. Drummondii* are more ovoid than those of *E. Ewartiana;* the former have much longer and slender pedicels. The shape of the fruit is different in the two species, that of *E. Drummondii* having a more convex rim, with the tips of the valves more exsert. The mature leaves of *E. Drummondii* are usually more or less ovate-lanceolate, a character not observed in those of *E. Ewartiana.* The juvenile leaves of *E. Ewartiana* are remarkably coriaceous, and so broadly lanceolate as to be almost orbicular.

3. With *E. Lane-Poolei* n. sp. *E. Lane-Poolei* is a moderately large White Gum, found in coastal situations; *E. Ewartiana* is a Mallee frequenting regions of low rainfall. The foliage of the former is thin, lanceolate to narrow lanceolate, that of the latter much broader and thicker, with the juvenile foliage remarkably coriaceous and so broad as to be almost orbicular, and considerably larger than that of *E. Lane-Poolei.* While the texture of the operculum of *E. Ewartiana* is thinnish, that of *E. Lane-Poolei* is remarkably thick, while comparison of the figures on Plate 74, viz., 4 (*E. Lane-Poolei*) and 11 (*E. Ewartiana*) shows that they are widely different.

4. With *E. accedens* W. V. Fitzgerald. In the size, paleness and extreme coriaceousness, I know only one species whose juvenile leaves resemble those of *E. Ewartiana*, and that is *E. accedens.* See fig. 8, Plate 141, C.R. But in almost every other character the two species diverge.

A NOTE ON A RELATION BETWEEN THE THERMAL CONDUCTIVITY AND THE VISCOSITY OF GASES.

By J. A. POLLOCK, F.R.S.

[*Read before the Royal Society of N. S. Wales, September 3, 1919.*]

IN a recent number of the Proceedings of the Royal Society of London, Hercus and Laby[1] publish the details of an accurate redetermination of the thermal conductivity of air. Combining their result with those of eleven other experimenters, they give as the most probable value of the conductivity at 0° C., $k = 5{\cdot}22 \times 10^{-5}$.

In 1913 Eucken[2] gave the results of a series of measurements of the thermal conductivities of a number of gases relative to that of air, the determinations being reduced to absolute measure by considering the conductivity of air as $5{\cdot}66 \times 10^{-5}$. As shown by Hercus and Laby, the new determination of this latter constant is at once useful, as it enables Eucken's absolute values to be put on a more accurate basis.

After reviewing the whole evidence, Hercus and Laby have collected for the various gases the most probable values of the following constants:—k, the thermal conductivity, C_p, the specific heat at constant pressure, γ, the ratio of the specific heats, and η, the viscosity, and with these results have calculated the values of f given by the equation,

$$f = \frac{\gamma k_0}{\eta_0 C_p} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

As the value of f depends on the atomicity of the molecule, attempts have been made to find a relation between f and γ. Jeans[3] has suggested the formula, $f = (9\gamma - 5)/4$.

[1] Hercus and Laby, Proc. Roy. Soc., A, 95, p. 190, 1919.

[2] Eucken, Phys. Zeit., 14, p. 324, 1913.

[3] Jeans, The Dynamical Theory of Gases, 2nd ed., p. 317, 1916.

The values calculated by this equation agree very well with the values obtained from equation (1) if Eucken's original results for the conductivities are used. When, however, the conductivity of air is taken as $5{\cdot}22 \times 10^{-5}$ instead of $5{\cdot}66 \times 10^{-5}$, the expression is no longer accurate, and Hercus and Laby suggest, on empirical grounds, another linear form,

$$f = 2{\cdot}816\,\gamma - 2{\cdot}2 \quad\ldots\ldots\ldots\ldots(2)$$

which gives numbers closely agreeing, in the majority of cases, with the results they obtain from equation (1).

I had previously mentioned[1] that the values of f, calculated by equation (1) with Eucken's original numbers for the conductivities, are approximately represented by an equation of the form, $f = a\,(\gamma - 1)/\gamma$, where a is a constant. I have now found a value of a appropriate to the new values of f, and the expression becomes

$$f = \frac{6{\cdot}15\,(\gamma - 1)}{\gamma} \quad\ldots\ldots\ldots\ldots (3)$$

In Table I the values of f obtained from equations (2) and (3) are compared with those given by the defining equation (1). An inspection of the differences, $1-2$ and $1-3$ in the fifth and sixth columns of the table, shows, that although the differences $1 - 3$ are on the whole smaller, there is little to choose between the two expressions, but equation (3) has an advantage in that it indicates for perfect gases a simple approximate relation between the conductivity and the viscosity which may be put in the form

$$\frac{m\,\gamma\,k_0}{\eta_0} = 2a$$

where m is the molecular mass and a the constant of equation (3). How this relation fares in the case of actual gases may be seen by an inspection of the calculated values of $2a$ given in the last column of the table.

[1] Pollock, Jour. and Proc.. Roy Soc. N.S.W., XLIX, p. 249, 1915. I now learn that Hercus and Laby's paper was set down to be read before the meeting of the British Association in Australia in 1914, but owing to pressure of other business was not reached. The paper was, therefore, completed for publication before my previous note was written.

Table I.

Gas.	f	f (empirical)		Differences.		$\frac{m\gamma k_o}{\eta_o}$
	$\frac{\gamma k_o}{\eta_o c_p}$	$2{\cdot}816\gamma-2{\cdot}2$	$\frac{6{\cdot}15\,(\gamma-1)}{\gamma}$			
	1	2	3	1 – 2	1 – 3	
He	2·31	2·49	2·46	– ·18	– ·15	11·6
A	2·47	2·49	2·46	– ·02	+ ·01	12·2
Ne	...	2·42	2·40	...	...	12·0
H_2	1·76	1·74	1·75	+ ·02	+ ·01	11·9
N_2	1·76	1·75	1·76	+ ·01	·00	12·1
O_2	1·79	1·75	1·76	+ ·04	+ ·03	12·5
Air	1·76	1·75	1·76	+ ·01	·00	12·3
NO	1·73	1·73	1·75	·00	– ·02	11·9
CO	1·72	1·76	1·77	– ·04	– ·05	11·8
Cl_2	1·50	1·58	1·56	– ·08	– ·06	12·8
CO_2	1·45	1·46	1·42	– ·01	+ ·03	13·0
N_2O	1·47	1·51	1·48	– ·04	– ·01	14·2
H_2S	1·34	1·51	1·48	– ·17	– ·14	10·9
SO_2	1·35	1·34	1·26	+ ·01	+ ·09	12·0
CS_2	1·25	1·29	1·18	– ·04	+ ·07	15·2
NH_3	1·23	1·48	1·44	– ·25	– ·21	11·0
C_2H_2	...	1·35	1·27	...	...	14·1
CH_4	1·45	1·51	1·48	– ·06	– ·03	13·7
C_2H_4	1·27	1·32	1·23	– ·05	+ ·04	14·3
C_2H_6	...	1·24	1·11	...	...	16·8

In Table II. I give the values of $m\,k_o/\eta_o$.

Table II.

Gas.	$\frac{mk_o}{\eta_o}$	Gas.	$\frac{mk_o}{\eta_o}$
He	6·95	CO_2	10·02
A	7·31	N_2O	10·78
Ne	7·29	H_2S	8·28
		SO_2	9·57
H_2	8·52	CS_2	12·25
N_2	8·60		
O_2	8·89	NH_3	8·44
Air	8·74	C_2H_2	11·19
NO	8·52	CH_4	10·44
CO	8·43	C_3H_4	11·44
Cl_2	9·55	C_2H_6	13·79

In Table III the values of the constants are given which have been used in the calculation of the results shown in Tables I and II. These values have been copied from Hercus and Laby's paper with the exception of a few additional entries which have been made from sources mentioned in the footnotes.

Table III.

Gas.	m	$k_0 \times 10^5$	C_p	γ	$\eta_0 \times 10^4$
He	4	32·7 2(*a*)	1·255 2	1·667 (*b*)	1·883 5
A	40	3·85 2	0·123 1	1·667 1	2·108 3
Ne	20	10·87 (*c*)	...	1·642 (*f*)	2·981 (*e*)
H_2	2	36·3 9	3·407 5	1·399 4	0·852 12
N_2	28	5·14 3	0·244 4	1·401 3	1·673 5
O_2	32	5·35 4	0·218 4	1·401 4	1·925 6
Air	29	5·22 14	0 239 7	1·402 18	1·733 31
NO	30	4·93 2	0·231 1	1·397 1	1·737 2
CO	28	5·05 3	0·246 2	1·405 2	1·677 3
Cl_2	71	1·69 1	0·120 2	1·341 3	1·256 2
CO_2	44	3·25 10	0·2015 6	1·300 13	1·428 12
N_2O	44	3·34 3	0·220 2	1·317 2	1·364 3
H_2S	34	2·81 1	0·2389 3	1·317 3	1·154 1
SO_2	64	1·80 1	0·1527 2	1·258 3	1·204 2
CS_2	76	1·49 (*d*)	0·160 (*f*)	1·239 (*f*)	0·924 (*d*)
NH_3	17	4·71 3	0·531 2	1·306 3	0·949 3
C_2H_2	26	4·06 (*d*)	...	1·26 (*f*)	0·943 (*d*)
CH_4	16	6·76 3	0·592 2	1·316 3	1·036 2
C_2H_4	28	3·84 3	0·404 2	1·250 4	0·940 4
C_2H_6	30	3·93 (*d*)	...	1·22 (*f*)	0·855 (*d*)

"(*a*) The number given after each constant is the number of values of which it is the mean. (*b*) The theoretical value is used in preference to the one observed value 1·63 of Behn and Geiger." (*c*) Weber, see Sci. Abs. 313, 1919. (*d*) Eucken, *loc. cit.* (*e*) Rankine, Phil. Mag. 21, p. 45, 1911. (*f*) Kaye and Laby's Tables, 2nd ed. All other values from Hercus and Laby, *loc. cit.*

THREE NEW SPECIES OF *LEPTOSPERMUM*.

By Edwin Cheel.

[*Read before the Royal Society of N.S. Wales, September 3, 1919.*]

Section FABRICIA.

Leptospermum Mjöbergii sp. nov.

Ramulis hirsutis. Foliis lanceolatis, acutis, ad 1 cm. longis vel rarius longioribus plus minusve pubescentibus obscure tri-vel quinque-nervosis, punctiformibus glandulis numerosis. Floribus axillaribus plerumque solitariis bracteo unico sub calice. Calicio-tubo brevi-pedicellato, tomentoso, sepalis ovatis et parum pubescentibus demum glabris, coriceis, caduceis. Petalis oblongis, pallido-albis, vix calicis tubo longioribus. Staminibus numerosis. Stilo simplice. Ovario pubescente, sex vel rarius septem locularibus.

Habit of plant not stated by the collector, but apparently of a small slender shrubby growth. The specimen has several buds and fully developed flowers, and almost matured fruits which may be described as follows:—

Branchlets hirsute. Leaves acutely lanceolate, minutely pubescent, faintly or more or less obscurely 3 to 5-nerved, with numerous oil glands easily seen with a pocket lens.

Flowers—Axillary, shortly pedicellate, supported at the base with a bracteole half as long as the calyx-tube. Calyx-tube as well as the sepals minutely pubescent, at length glabrous, the lobes falling off at an early stage, Petals oblong, whitish or pallid, scarcely exceeding the calyx-lobe. Style simple, stigma scarcely enlarged. Stamens numerous. Ovarium pubescent or hirsute, 6 or rarely 7-celled; the valves more or less prominent owing to the depressions. Seeds few in each cell, distinctly winged.

The nearest affinity of this species seems to be with *Leptospermum fabricia*, but the smaller and much thinner or more flexible leaves, hairy branches, and also the smaller and different shaped fruits clearly separate this as a distinct species.

Habitat: Coleman River, North Queensland. Dr. E. Mjöberg, September, 1913.

Section EULEPTOSPERMUM.

LEPTOSPERMUM EPACRIDIOIDEUM sp. nov.

Frutex parvus, ramis strictis rigidis. Foliis oblongis, sub-cordatis vel obovatis, sessilibus, confertis, crassis, nitidis, $2\frac{1}{2}-3$ mm. longis, $1\frac{1}{2}$ mm. latis. Floribus albis vel nonnuquam roseis coloribus, ad apices in ramis lateralibus insitis. Bracteis tribus vel rarius duobus, scariosis et plus minus nitidis. Calicis tubo glabro, sepalis paene tubo æquantibus. Petalis sub-orbicularibus, laminis brevoribus. Stilo ad 3 mm. longo, stigmate capitato. Ovario glabro, quinque loculari. Fructibus sessilibus.

Small somewhat erect rigid shrubs. Leaves oblong or somewhat cordate at the base, sessile, thick and shiny, more or less crowded and occasionally somewhat appressed to the branchlets as in many Epacridacean plants. Flowers solitary on the tips of the lateral branchlets. Bracts 3, or rarely less, somewhat scarious and shining. Calyx-tube glabrous, more or less wrinkled when dried, with sub-persistent calyx-lobes nearly as long as the calyx-tube. Petals white or occasionally rosy-pink coloured; suborbicular and with rather short claws. Style 3 mm. long, with a distinct capitate stigma. Ovarium glabrous, 5-celled, the mature fruits sessile.

This species is closely allied to *L. rotundifolium*, but may be distinguished by the smaller leaves which are more or less appressed to the branches, especially on the young terminal branchlets, and are quite sessile and somewhat crowded.

Dr. Rodway states that "The plant is a shrubby one, 2–3 feet high, growing in sandy soil on ridge overlooking the Naval College at Jervis Bay. It is found growing In association with *L. rotundifolium (L. scorparium* var. *rotundifolium)*, each form, however, keeping to its distinct habit, and he could not find any intermediate forms."

The distribution is as follows:—Jervis Bay (H. J. Hauschild, (No. 20) January, 1914); and Nowra and Jervis Bay (Dr. F. A. Rodway, February and March, 1916).

Leptospermum odoratum sp. nov.

Frutex ad 3 – 5 ped altus, plus minus erectis, ramulis juvenilibus plus minus angulatis. Foliis sub-coriaceis, sessilibus, obovato-cuneiformibus, emarginatis, $1\frac{1}{2}$ – 3 cm. longis, 5 mm. latis vel rarius 4 cm. longis, trinervosis, punctiformibus glandulis numerosis valde odoriferis. Floribus pedicellatis 2 – 4 sub-apicibus nonnuquam umbellatis. Bracteis solitariis, ad 4 mm. diam., caduceis. Calicibus glabris, lobis lunatis. Petatis 5, albis orbicularibus, duplo-longioribus sepalis. Ovario glabro, fructibus quinque locularibus,

Shrubs about 3 – 5 feet high, usually of an upright growth, but frequently somewhat decumbent owing to flood-waters, as the plant is invariably found in the beds of creeks or rivers, branchlets more or less angular, especially near the tips. Leaves sessile, oblong to obovate or cuneate, obtuse with a distinct shallow notch at the more or less rounded apex, usually about $1\frac{1}{2}$ to 3 cm. long and 5 mm. broad, or rarely up to 4 cm. long, distinctly 3 to 5 nerved, the intra-marginal nerves more or less obscure, oil-glands numerous but obscure unless held up to the sunlight, when they are then plainly visible under an ordinary lens. Flowers usually in clusters of from 2 to 4 or occasionally 5, chiefly on the tips of branchlets, pedicellate, the pedicels varying from 3 to 5 mm. long, so arranged in many instances that the inflorescence has the appearance of a simple umbel. Bracts solitary, about 4 mm. long, somewhat retuse, deciduous. Bracteoles 2, about 2 mm. long, deciduous. Calyx tube glabrous terminated with 5 minute crescent-shaped sepals which are minutely ciliate and very deciduous. Petals white, orbicular, about twice the size of the sepals. Stamens about 25 – 30. Style 2 mm. long, with a capitate stigma. Ovary glabrous, the valves protruding from the rim of the calyx-tube to about 2 mm., the mature fruits normally five-celled, and reaching a diameter of about 4 – 5 mm.

In the herbarium this species has been mixed up with two or three different species, as for example *L. attenuatum*, *L. flavescens*, and *L. abnorme*. It belongs to the Euleptospermæ group and has affinities with *L. wooroonooran*, but may be distinguished from the latter in the different habit of growth, and the leaves being blunt and notched and more nerves in *L. odoratum*, whereas in *L. wooroonooran* they are pointed and recurved at the apex and only three-nerved, also in the fruits being sessile in the latter and pedicellate in the new species. *L. odoratum* also somewhat resembles *L. amboinense* of Blume, but may easily be distinguished from the latter species in that the flowers and fruiting capsules are in terminal clusters or umbellate, while those of *L. amboinense* are solitary and axillary.

Although the oil glands are very numerous they are scarcely visible to the naked eye, but are easily seen under an ordinary pocket lens, and when bruised between the fingers the oil has a nice pleasant fragrant odour. Mr. A. R. Penfold has this under investigation, and states that the most characteristic constituents are eudesmol and levo-aromadendrene in fairly large quantities.

In the National Herbarium there is a specimen which belongs to this species labelled *Leptospermum abnorme* F.v.M.; B. Brown, Iter Australiense 1802 – 1805, ex Herbarium Royal Botanic Garden, Edinburgh. Other localities are as follows:—Mountains East of Braidwood, no collector or date given, but the writing is in the late Mr. Betche's handwriting and is probably his own collecting; Box Point to Kangaroo River (J. H. Maiden, October 1898); Nepean River near Penrith (J. H. Maiden, September 1906 and A. A. Hamilton, July 1912); Nattai River near Colo viâ Hill Top (E. Cheel, November 1911); Rocky Creek, Hill Top (E. Cheel, January 1912); Nerrigundah (E. Cheel, June 1917); Eden, Twofold Bay (E. Cheel, December 1903).

ON THE HYDROLYSIS OF UREA HYDROCHLORIDE.

By GEORGE JOSEPH BURROWS, B.Sc.

[*Read before the Royal Society of N. S. Wales, October 1, 1919.*]

THE hydrolysis of urea hydrochloride in aqueous solutions has been investigated by Walker[1] and Walker and Wood.[2] These authors found that the salt was hydrolysed by water into urea and free hydrochloric acid, the amount so hydrolysed at any dilution being expressed by the equation

$$K = \frac{h^2}{(1-h)v}$$

where h is the fraction of salt hydrolysed
v is the volume in litres containing 1 gram molecule of the salt (total)
and K is the equilibrium constant.

The results contained in the present paper were obtained during an investigation of the properties of water-alcohol and water-acetone mixtures. In such mixtures the total amount of water present can be decreased considerably without altering the total volume of the solution, and it appeared of interest to see how such a change in the nature of the solution would affect the degree of hydrolytic dissociation of urea hydrochloride. It has been found that in these mixtures the equilibrium between hydrolysed and unhydrolysed urea hydrochloride can also be expressed in terms of Ostwald's dilution law for electrolytic dissociation. Some of the results included in this paper were published in a previous paper on the rate of decomposition of urea in

[1] Zeit. physik. Chem. IV, 319. [2] J.C.S., 1903, 83, 484.

water-alcohol mixtures.[1] The investigation has since been extended, the degree of hydrolysis of urea hydrochloride of different concentrations having been determined in mixtures of water and ethyl alcohol and water and acetone.

I. Ethyl alcohol-water Mixtures.

The method employed for determining the degree of hydrolysis of the hydrochloride was similar to that described by Walker *(loc. cit.)* for aqueous solutions, and is as follows. The rate of inversion of sucrose solution by hydrochloric acid was determined, and then the rate of inversion by hydrochloric acid containing the required amount of urea. By assuming that the rate of inversion of the sucrose is proportional to the concentration of free acid (for any particular solvent), the degree of hydrolysis of the salt is expressed as the ratio of the inversion velocity in the solution containing urea to that in the solution containing no urea. The method adopted in preparing the solutions and in following the course of the reaction was the same as that described in a previous paper on sucrose inversion.[2] All alcohol or acetone percentages given in this paper are by volume.

The rate of inversion was calculated from the usual equation

$$k = \frac{1}{t} \log_{10} \frac{R_0 - R_\infty}{R_t - R_\infty}$$

Where R_0 is the initial rotation
R_∞ is the rotation after complete inversion
R_t is the rotation after an interval of t minutes.

The agreement between the values of k obtained in any experiment was quite satisfactory. The following table contains the result of an experiment with 70 per cent. alcohol as the solvent and is quoted as an example.

---

[1] Burrows and Fawsitt, J.C.S., 1914, 105, 612.

[2] J.C.S., 1914, 105, 1260.

Table I.

10 per cent. sucrose, N/2 hydrochloric acid and M/2 urea in 70 per cent. alcohol. Temperature 25° C.

t	R_t	k
0	58·0	...
30	53·3	·00100
50	50·2	·00102
70	47·5	·00100
100	43·0	·00104
138	37·8	·00106
180	33·4	·00104
210	30·4	·00103
240	27·5	·00103
270	24·8	·00103
288	23·5	·00102
∞	– 12·2	...
		mean ·00103

In Table II are given under k_1 the mean values obtained for the rate of inversion of 10 per cent. sucrose by N/2 hydrochloric acid. Under k_2 the rate of inversion by M/2 urea hydrochloride and under $\frac{k_2}{k_1}$ the ratio for the different water-alcohol mixtures at 25° C.

Table II.

Alcohol % (vol.)	k_1	k_2	$\frac{k_2}{k_1}$
0	·00219	·00143	·653
40	·00192	·00112	·583
50	·00177	·00103	·579
60	·00185	·00101	·543
70	·00200	·00103	·515

The ratio $\frac{k_2}{k_1}$ does not represent the true degree of hydrolysis of the urea hydrochloride. As pointed out by Walker and Wood *(loc. cit.)*, the inversion velocity is influenced by the presence of unhydrolysed salt. The latter affects the degree of dissociation of the free hydrochloric acid and it also has a direct effect on the rate of inversion of the sucrose. To correct for this, Walker and Wood determined the effect on the rate of inversion caused by the addition of an amount of sodium chloride equal to that of the unhydrolysed urea hydrochloride, and assumed that this gave approximately the effect of the unhydrolysed salt on the reaction. In a similar manner the present author has determined the rate of inversion by N/2 (HCl + NaCl) in alcoholic solutions. Thus, a solution in 50 per cent. alcohol which was seminormal with regard to the total chlorine, but contained 57·9 per cent. of this as hydrochloric acid and 42·1 per cent. as sodium chloride, was found to give a mean rate of inversion of sucrose $k = \cdot 00092$. As the corresponding value for the inversion by N/2 hydrochloric acid and M/2 urea was ·00103 the correct degree of hydrolysis is considered to be $\cdot 579 \times \frac{103}{92}$. The correcting factor was determined in a similar way for each of the other solutions.

In Table III are given the values for the degree of hydrolysis (h) corrected in this way.

Table III.

M/2 urea hydrochloride. Temperature 25·0° C.

Alcohol % (vol.)	$\frac{k_2}{k_1}$	factor	h
0	·653	1·059	·691
40	·583	1·100	·647
50	·579	1·120	·648 [·630]
60	·543	1·110	·603
70	·515	1·107	·570

The degree of hydrolysis is seen to decrease with decreasing concentration of water. The value for 50 per cent. alcohol is obviously too high. The value for this solution, obtained by plotting a curve for the other mixtures, is $h =$

·630; this value will be used in the subsequent discussion. Experiments were also performed with solutions containing N/2 hydrochloric acid and M/2 urea at 30° C. It was found that at this temperature the value for h in water was the same as at 25° C., while the value in 70 per cent. alcohol was decreased by about 3 per cent. From the figures in Table III it is possible to calculate the hydrolysis constant for urea hydrochloride in each of these mixtures. If we represent the degree of hydrolysis by h, and the volume in litres which contains 1 gram molecule of urea hydrochloride by v, (which in this case equals 2) then the hydrolysis constant H is given by

$$H = \frac{h^2}{(1-h)v}$$

The values of H are given in Table IV.

Table IV.

Alcohol % (vol.)	h	H
0	·691	·773
40	·647	·593
50	·630	·536
60	·603	·458
70	·570	·378

The value of H in water is a little lower than that given by Walker and Wood (·781). This is due to the small difference between the values of h found by them and the present author.

The degree of hydrolysis of M/10 urea hydrochloride was determined at 40° C. These results are given under h_1 in Table V, together with the values calculated from H under h (calc). In determining h_1 no correction has been applied to the ratio $\frac{k_2}{k_1}$ as it has been considered unnecessary owing to the small effect of the unhydrolysed salt at this comparatively high dilution. The values under h (calc) are calculated from the corresponding values of H (at 25° C.) by substituting in the equation

$$H = \frac{C_A \times C_B}{C_{AB}}$$

where C_A = the concentration of free hydrochloric acid
C_B = the concentration of free urea
C_{AB} = the concentration of unhydrolysed salt

Table V.

Alcohol % (vol.)	k_1	k_2	h_1	h (calc.)
0	·00265	·00241	·906	·897
25	·00255	·00219	·859	·882
50	·00230	·00196	·852	·860
75	·00274	·00219	·800	·805

Experiments with 10 per cent. sucrose and N/2 hydrochloric acid and M/4 urea at 25° C. gave the following results.

Table VI.

Alcohol % (vol.)	k_1	k_2	factor	h_1	h (calc.)
0	·00219	·00172	1·03	·809	·826
25	·00204	·00154	1·05	·793	·811
75	·00208	·00143	1·06	·729	·737

The agreement between the calculated and experimental results justifies the conclusion that in water-alcohol mixtures the effect of dilution may be expressed by the ordinary dilution law. That is, the amount of salt hydrolysed depends on the concentration of the salt expressed in terms of the total volume—it is not simply proportional to the amount of water in the solution.

II. Acetone-water Mixtures.

Similar experiments were carried out with acetone-water mixtures as solvents. In this case the concentration of free acid was determined by its effect in hydrolysing methyl acetate. In determining the degree of hydrolysis of the urea hydrochloride, the rate of hydrolysis of methyl acetate was determined, first in a solution containing hydrochloric acid, and then in a solution containing urea hydrochloride. The rate of hydrolysis of methyl acetate was calculated from the equation

$$k = \frac{1}{t\sqrt{4an+1}} \log \frac{4an + 2nx(\sqrt{4an+1} - 1)}{4an - 2nx(\sqrt{4an+1} + 1)}$$

obtained by integrating $\frac{dx}{dt} = k(a-x) - k_1 x^2$

where k = the rate of hydrolysis

k_1 = the rate of esterification

a = the initial concentration of ester

x = amount of ester hydrolysed in time t (minutes)

$n = \frac{a - \xi}{\xi^2}$

and ξ = amount of ester hydrolysed from the beginning of the reaction up to the equilibrium. The value of x was found by determining the amount of acetic acid in the solution after different intervals of time by titrating a portion with baryta solution.

The values of k found in any experiment were constant to within about 2 per cent. of the mean. An example is given in detail in Table VII for the rate of hydrolysis of 5 per cent. methyl acetate by N/2 hydrochloric acid and M/2 urea in water at 25° C.

Table VII.

t	x	$k \times 10^4$
0	...	...
30	·0600	9·14
60	·1192	9·20
91	·1733	9·09
120	·2250	9·23
150	·2692	9·10
212	·3600	9·19
270	·4275	9·03
332	·4975	9·10
	Mean	9·13

In Table VIII are given the mean results obtained for the rates of hydrolysis of 5 per cent. methyl acetate in acetone-water mixtures at 25° C.

In this table k_1 is the rate of hydrolysis by N/2 hydrochloric acid, and k_2 is the rate of hydrolysis by M/2 urea hydrochloride.

Table VIII.

Acetone % (vol.)	$k_1 \times 10^4$	$k_2 \times 10^4$	$\frac{k_2}{k_1}$
0	13·58	9·13	·672
20	12·28	7·98	·650
40	10·33	6·02	·583
60	7·91	3·91	·494
80	7·51	2·27	·303

As in the case of sucrose inversion the effect of unhydrolysed salt was determined, by finding in each of the above mixtures the rate of hydrolysis by N/2 (HCl + NaCl), the amount of sodium chloride taken in each case being the approximate amount of unhydrolysed urea hydrochloride found above. The ratio of this number to the corresponding value of k_2 is taken as the correcting factor for each solution, and by multiplying $\frac{k_2}{k_1}$ by this factor the value of h, the degree of hydrolysis, is obtained. These results are given in Table IX. Under H are given the values of the hydrolysis constants of urea hydrochloride calculated from the equation $H = \frac{h^2}{(1-h)v}$ where v is the volume in litres containing one gram molecule of urea hydrochloride and in this case equals 2.

Table IX.

Acetone % (vol.)	$\frac{k_2}{k_1}$	factor	h	H
0	·672	1·03	·692	·777
20	·650	1·04	·676	·705
40	·583	1·06	·618	·505
60	·494	1·06	·523	·285
80	·303	1·08	·328	·080

The hydrolysis constant decreases considerably as water is replaced by acetone, the effect being greater than when water is replaced by alcohol. The degree of hydrolysis of M/10 urea hydrochloride at 25° C. was also determined in each of these mixtures. The results are given in Table X. k_1 is the rate of hydrolysis of 2·5 per cent. methyl acetate by N/10 hydrochloric acid. k_2 is the rate of hydrolysis of 2·5 per cent. methyl acetate by M/10 urea hydochloride.

$$h = \frac{k_2}{k_1} = \text{degree of hydrolysis.}$$

On account of the small amount of unhydrolysed urea hydrochloride in these solutions the ratio $\frac{k_2}{k_1}$ has not been corrected as in the more concentrated solutions.

Under h (calc.) are given the values for the degree of hydrolysis of M/10 urea hydrochloride calculated from the hydrolysis constants H, given in Table IX.

Table X.

Acetone % (vol.)	$k_1 \times 10^4$	$k_2 \times 10^4$	h	h (calc.)
0	2·60	2·32	·893	·895
20	2·39	2·10	·879	·885
40	1·90	1·64	·863	·855
60	1·42	1·15	·810	·785
80	1·13	0·725	·642	·580

The agreement between the calculated and experimental values of h is satisfactory in all cases except in the mixture containing 80 per cent. acetone. On account of the small value of h for M/2 urea hydrochloride in this mixture, a small error in this determination would produce a relatively large error in H, and on this account there is more likelihood of a difference between the calculated and experimental values of h for M/10 urea hydrochloride in this solution than in the others.

In the next series of experiments the solvent was kept constant (60 per cent. acetone) and the concentration of the urea hydrochloride varied. In Table XI are given the results for the degree of hydrolysis of urea hydrochloride of various concentrations in this particular mixture at 25°C. The values under h (calc.) were obtained from H = ·345, which in turn was calculated from the value h = ·810 found for M/10 urea hydrochloride.

Table XI.

Concentration of urea hydrochloride	$k_1 \times 10^4$	$k_2 \times 10^4$	$\frac{k_2}{k_1}$	factor	h	h (calc.)
M/2	7·91	3·91	·494	1·06	·523	·554
M/4	3·60	2·39	·664	1·03	·684	·675
M/6	2·38	1·81	·760	1·01	·767	·737
M/8	1·77	1·39	·785	...	·785	·780
M/10	1·42	1·15	·810	...	·810	[·810]
M/16	0·870	0·749	·861	...	·861	·865
M/32	0·438	0·406	·927	...	·927	·925

The agreement between the calculated and experimental values of h is considered satisfactory.

A comparison of the figures given in Tables IV and IX shows that the degree of hydrolysis is not independent of the nature of the substance which replaces the water as solvent. Whereas the value of h in aqueous solution is ·691, in 60 per cent. alcohol it is ·603, and in 60 per cent. acetone only ·523. In the case of alcohol-water mixtures the hydrolysis constant H is (approximately) proportional to the total number of molecules of water + alcohol. This is shown in Table XII, in which w represents the number of gram molecules of water in the solution, and a the number of gram molecules of alcohol.

Table XII.

Alcohol % (vol.)	a	w	$(a+w)$	H	$\frac{H \times 10^2}{w}$	$\frac{H \times 10^2}{w+a}$
0	0	50·0	50·0	·773	1·54	1·54
40	6·25	30·5	36·75	·593	1·94	1·61
50	7·83	25·5	33·33	·536	2·10	1·61
60	9·22	20·0	29·22	·458	2·29	1·57
70	10·75	15·0	25·75	·378	2·52	1·47

In the case of acetone-water mixtures the value of *H* is approximately proportional to the number of molecules of water in the solution, the acetone apparently having no hydrolytic effect.

Table XIII.

Acetone % (vol.)	w	H	$\frac{H \times 10^2}{w}$
0	51·0	·777	1·52
20	41·0	·705	1·76
40	31·0	·505	1·63
60	20·0	·285	1·43
80	9·0	·080	0·89

These results indicate that in the mixtures investigated, whereas the hydrolytic power of alcohol is approximately the same as that of water, acetone appears to have no effect on the degree of hydrolysis of urea hydrochloride.

NOTES ON THE ELASTIC PROPERTIES OF SELENIUM.

By O. U. Vonwiller, B.Sc.

[*Read before the Royal Society of N.S. Wales, October 1, 1919.*]

In 1916 the writer performed some experiments primarily with the object of determining elastic constants of selenium. The investigation was not carried far before it had to be given up, mainly on account of lack of time, but some qualitative results were obtained which appear to be of sufficient interest to be recorded; among these is a light effect not noticed before.

Thin threads of vitreous selenium were prepared by dipping the end of a glass rod into molten selenium and withdrawing it fairly rapidly. It was found that, unless the temperature of the liquid were too high—in which case threads could not be drawn on account of the great fluidity of the substance—long threads were produced without difficulty; these invariably contained numerous inequalities in thickness, but usually it was possible to obtain several pieces 10 centimetres or more in length, of fairly uniform section, the diameter being generally about 0·04 centimetre. These threads seemed to consist wholly of vitreous selenium no trace of the crystalline modification being visible.

In endeavouring to determine Young's modulus, methods of bending were first used; in some cases a thread was supported near its ends and loaded in the middle by means of bent pieces of thin wire placed on a light wire hook hanging at the central point, while in others one end of the thread was held between a pair of metal jaws lined with paper to prevent crushing, and loaded by a metal rider placed near the free end, the depression, on loading, of the centre or end of the thread being measured with the aid of a microscope mounted on a vertical screw.

It was found that the behaviour of the selenium resembled that of such substances as pitch and sealing-wax, the application of a load resulting in an immediate depression, which increased continuously as long as the load was applied; upon removal of the load there was an immediate partial recovery and a further gradual rise lasting for a time, depending on the magnitude and duration of the load, the total recovery never equalling the total depression. Gradual and continuous bending took place without any load other than the weight of the thread itself.

Observations made at various times for a week on one thread, showed that the magnitude of the viscosity effect, that is the continuous movement under the application of a steady load, depended on the illumination. This thread was 9·5 cm. long, about 0·04 cm. in diameter, and was supported on two brass cylinders 0·7 cm. in diameter, placed 8·5 cm. apart, no external load being applied. It was noticed that, while the fall of the central point was continuous, the rate of movement was much less in the night than during the day when the selenium was illuminated by diffused daylight. That this effect was not due directly to temperature changes alone, was shown by darkening the room during the daytime when the rate of fall was found to decrease. At the end of the week the rate of fall was practically the same as at the beginning under like conditions; in this time the originally straight thread had been bent to form an arc, the central point of which was 0·9 cm. below the straight line joining the ends.

Experiments with several other pieces of selenium gave similar results; below are given some of the readings obtained in the case of a short thread of average diameter 0·041 cm., one end of which was fixed while a rider of mass

0·06 gm. was applied near the free end, the distance between rider and support being 5·3 cm. In one trial the depressions of the free end observed at various times after the first application of the load were:

Time.	Depression.
40 seconds	0·1287 cm.
80 ,,	0·1330 ,,
190 ,,	0·1377 ,,
495 ,,	0·1460 ,,

while when the load was removed after being applied for 9 minutes, the recovery was as follows:

Time.	Recovery.
40 seconds	0·1176 cm.
120 ,,	0·1286 ,,
180 ,,	0·1322 ,,
315 ,,	0·1384 ,,

The effect of light upon the continuous fall is shown in Table I, where readings are given for several days during the whole of which the load was applied.

When the load was finally removed after being applied for four days, the usual effects were observed, a rapid initial recovery being followed by a gradual rise, which in this case was still perceptible after 25 minutes.

It is seen that the average fall per minute, given in the fourth column, is invariably much greater for periods of illumination than for those of darkness. When the room was darkened after the selenium had been exposed to light, the rate of fall did not drop suddenly but decreased gradually for several hours, as is seen clearly in the readings of 10th April. A corresponding lag occurs in the increase in rate of fall when the selenium is illuminated after having been in the dark, but this change is established in a much shorter time than the other. It is very likely that the viscosity varies with temperature changes, but it is certain that the changes in the rate of fall, due to illumination, in the cases examined, were much greater than those due to the small variations which took place in temperature.

Table I.

Date. 1916 April	Time.	Reading cm.	Rate of Fall 10^{-6} cm. per min.		Temp. °C.
7th	4·30 p.m.	2·9286			21·4
			129	Dark	
8th	9·10 a.m.	2·7995			21·2
			471	Light	
,,	12·09 p.m.	2·7151			21·2
			59	Dark	
10th	9·30 a.m.	2·5534			20·7
			304	Light	
,,	11·08 a.m.	2·5236			21·2
			264	Light	
,,	1·09 p.m.	2·4917			21·0
			201	Dark	
,,	2·13 p.m.	2·4788			21·0
			145	Dark	
,,	3·40 p.m.	2·4622			21·0
			98	Dark	
,,	4·34 p.m.	2·4609			20·8
			62	Dark	
11th	9·45 a.m.	2·3970			20·5
			167	Light	
,,	10·03 a.m.	2·3940			20·8
			225	Light	
,,	11·11 a.m.	2·3787			20·9
			261	Light	
,,	12·05 p.m.	2·3646			21·0
			163	Dark	
,,	1·10 p.m.	2·3540			21·1
			126	Dark	
,,	2·07 p.m.	2·3468			21·0
			128	Dark	
,,	3·33 p.m.	2·3358			21·2

In the example recorded the intensity of illumination probably varied considerably at different times as diffused daylight was used, so that comparisons may not be made of the various results obtained in the light. At the time these measurements were made a new electric light installation was being erected in the Physical Laboratory, and it was not possible to secure satisfactory artificial illumination of constant intensity for any prolonged period.

Some trials made with threads shortly after their preparation showed that the viscous movement was much greater than with older specimens; for example, a thread held at one end without any load was first examined 15 minutes after being drawn; the free end was observed to fall as follows:

in 10	minutes	0·104 cm.
20	,,	·184 ,,
30	,,	·246 ,,
60	,,	·376 ,,

A fortnight later it was found that in 4½ hours the fall was only 0·058 cm.

Owing to the viscosity effect it was not possible to obtain a satisfactory value of Young's modulus by bending methods but the readings obtained indicated that it was of the order of 3×10^{10} dynes per sq. cm. It seemed probable that more trustworthy results would be obtained by a method of direct extension, and an attempt was made with a thread of vitreous selenium about 22 cm. long and of average diameter 0·0430 cm., the upper end of which was held in a clamp while a light scale pan was attached by thin wires and sealing-wax to the lower end. By means of two microscopes the movements of two points, one near the upper and one near the lower end, were observed upon the application of a load. The movement of the upper point was always very small and was read with the aid of a scale in the eye-piece of the upper microscope while the lower microscope was moved on a vertical screw. With the exception of a few millimetres at each end the whole length of the thread could be shielded from light by a brass cylinder blackened on the inside. A narrow longitudinal slit and radial slits in the closed ends enabled the cylinder to be removed without disturbing the thread or its attachments, so that an exposure to light could be made when desired.

Readings with loads of from 0 to 50 gm. showed that Hooke's law was followed, and that with the load applied for several minutes the reading did not change appreciably. A number of readings made with a load of 50 gm. alternately applied and removed, with the thread in darkness and exposed to light, gave a mean extension of 0·0143 cm. in a length of 20·7 cm., and any difference on illumination was certainly less than the probable error of this extension, about 0·0003 cm. The value of Young's modulus calculated from these observations is $4·89 \times 10^{10}$ dynes per sq. cm., but it must be noted that only one thread was examined in this way so that no great weight should be attached to the numerical result. The mean temperature of these observations was 20°·8 C.

When the load was allowed to remain for a prolonged period it was found that the extension gradually and continuously increased, and observations made when a load of 50 gm. was applied continuously for a week showed that the movement was more rapid when the selenium was illuminated than when it was in darkness. Although the rate of movement was very small and some uncertainty exists as to the coefficient of expansion of the material, the light effect was unmistakeable, and the ratio of movement in darkness to that in light seems to be of the same order as in the earlier experiments. The total increase in length in the week was 0·06 cm.

In order to ascertain whether crystalline selenium possessed similar mechanical properties, endeavours were made to produce threads of the substance in this form. Considerable difficulty was met, but a few satisfactory preparations were made by placing threads of vitreous selenium on a horizontal sheet of mica in a closed heating oven, the temperature of which was slowly raised to about 180° C., the time occupied in the heating being about two hours. Generally after the heating the thread was found to be broken into very short lengths, but several good pieces were obtained. Very great care was needed in handling these preparations as they are extremely fragile and threads were frequently broken before any satisfactory readings were obtained.

As with the vitreous selenium, it was found that the application of a load to the end of a "beam" of crystalline selenium resulted in an immediate elastic depression followed by a gradual fall with continued application of the load; this gradual fall, however, in all cases was much smaller than with vitreous selenium under corresponding conditions. The viscosity effect is much greater shortly after removal of the thread from the heating oven, decreasing for several hours. A few observations were made with threads prepared at different temperatures, ranging from 179° C. to 197° C., but it is impossible to say, from them, how the effects depend on the temperature of preparation.

With crystalline selenium light appears to have no influence on the immediate elastic depression due to loading and it has been impossible to detect any difference, due to change of illumination, in the rate of movement under continued application of a load. However, as the rate of movement was always very small and as the threads broke before a long series of readings could be made, the failure to detect a light effect on the viscosity of crystalline selenium must not be taken as conclusive evidence that it does not exist or even that it is very small.

Summary of Results.

Thin threads of vitreous selenium tested by methods of bending and of direct extension, show mechanical properties similar to those of viscous solids, such as pitch and sealing-wax, the first application of a load causing an immediate elastic strain, while the continued application results in a continually increasing permanent deformation.

Similar effects are observed with crystalline selenium, but the viscosity effect is relatively very much smaller.

In the case of preparations of vitreous selenium the viscosity effect, the gradual movement under continued application of a load, is found to depend upon the illumination, the rate of movement being greater when the selenium is exposed to light than when it is in the dark; the response to change of illumination is not instantaneous, the rate decreasing for several hours, when a change is made from diffused daylight to darkness.

No such light effect has been detected with preparations of crystalline selenium. The observations made on these are, however, less satisfactory than those on threads of vitreous selenium.

With threads both of vitreous and of crystalline selenium the viscous movement is much greater shortly after preparation than a few hours later.

A test by direct extension of a thread of vitreous selenium gives a value for Young's modulus of $4{\cdot}89 \times 10^{10}$ dynes per sq. cm. at $20^{\circ}{\cdot}8$ C.

ACACIA SEEDLINGS, PART V.

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

With Plates V – IX.

[*Read before the Royal Society of N. S. Wales, November 5, 1919.*]

SYNOPSIS :

VITALITY OF SEEDS IN SEA-WATER.
SEQUENCE IN THE DEVELOPMENT OF LEAVES.
NUMBER OF PINNÆ ON ONE LEAF.
DIVIDED LEAFLETS.
FLOWERING SEEDLINGS.
DESCRIPTIONS OF SEEDLINGS.

Vitality of Seeds in Sea-water.

Seeds of *Acacia melanoxylon* and *A. penninervis* var. *falciformis* from Jenolan Caves were planted after having been immersed in sea-water for 889 days, and both germinated readily.

Sequence in the Development of Leaves.

In Part IV, (p. 411), it was pointed out that of 93 species of Acacia seedlings raised 83 had one simply pinnate leaf, and the remaining ten commenced with an opposite pair of pinnate leaves. The following nine additions may now be made to those which produce only one pinnate leaf, and this brings the number up to 92:—

A. asparagoides A. Cunn.
A. rigens A. Cunn.
A. juncifolia Benth.
A. conferta A. Cunn.
A. lineata A. Cunn.
A. Bancrofti Maiden
A. trineura F.v.M.
A. Simmsii A. Cunn.
A. complanata A. Cunn.

A. tetragonophylla F.v.M. and *A. amblygona* A. Cunn. are now added to the list of those which produce an opposite pair of simply pinnate leaves, and this brings the number of such species up to twelve. In the case of the first mentioned plant, however, there have been nearly as many examples with only one pinnate leaf as with an opposite pair, so this species appears to be near the middle of a transition stage.

Number of Pinnæ on One Leaf.

In addition to the records given in Parts III (393) and IV (411) relating to the number of pinnæ on one leaf of a phyllodineous Acacia, the following are now added:—*A. podalyriæfolia* and *A. elongata* may have two pairs, *A. accola* four, *A. implexa* five, and *A. melanoxylon* eight pairs.

Divided Leaflets.

On various species from time to time a pinna may be found having one or more divided leaflets. Portions of the lamina on either or both sides of the midrib, usually of a basal leaflet, may be divided into one or several tiny leaflets, the divisions in the lamina extending to the midrib of the main leaflet. The feature may be seen on leaves of *Acacia aspera* (Fig. 1), *A. Farnesiana* (Fig. 2), *A. Oswaldi*, *A. podalyriæfolia* (Fig. 3), and *A. tetragonophylla.* In one instance, in the case of *A. podalyriæfolia* the basal pair of leaflets on an axillary leaf were transformed into two simply pinnate leaves, the original midrib in each case being substituted by a rachis (Fig. 3).

Fig. 1.
Acacia aspera.
Divided Leaflets ×2.

Fig. 2.
Acacia Farnesiana.
Divided Leaflets. ×2.
Each pinna had seven pairs of leaflets.

Fig. 3.
Acacia podalyriæfolia.
Divided Leaflets. ×2.

Flowering Seedlings.

The following examples are given of Acacia seedlings, which were raised and remained in 5 or 6-inch pots, having flowered:—*A. aspera*, *A. cardiophylla*, *A. crassiuscula*, *A. diffusa*, *A. Flocktoniæ*, *A. lanigera*, *A. linearis*, *A. montana*, *A. polybotrya*, *A. spectabilis*, and *A. stricta*. Most of of the plants were about three years old, but the seedling of *A. diffusa*, which flowered sparsely, was only one year and seven months, and of *A. cardiophylla*, one year and eight months. One seedling of *A. montana*, which grew in a 5-inch pot, was three years old, four feet high, and bore 3000 flowers. The plants which were left in the sun throughout the year flowered best. On a plant of *A. crassiuscula* five feet six inches high, growing in a 6-inch pot, pods ripened at two years and ten months.

Descriptions of Seedlings.

PUNGENTES—(Aphyllæ).

ACACIA COLLETIOIDES A. Cunn. Seeds from Cobar, (Archdeacon F. E. Haviland). (Plate V, Numbers 1 to 3).

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

Hypocotyl terete, reddish-brown, 1·2 to 2·4 cm. long, 1 to 2 mm. thick at base, ·4 to 1 mm. at apex, glabrous,

Cotyledons sessile, sagittate, oblong, apex rounded, 4 to 5 mm. long, 2·2 to 2·5 mm. broad, underside pale yellowish-green, reddish-green to red, with one or two raised longitudinal lines, upperside dark green, glabrous; becoming horizontal in a few days.

Stem terete, greenish-brown, pilose when very young, becoming glabrous. First internode ·5 mm.; second to sixth about 1 mm. each.

Leaves—No. 1. Abruptly pinnate, petiole 4 to 7 mm., brownish-green, glabrous; leaflets two to three pairs, up to

5 mm. long, 2 mm. broad, oblong-acuminate, sometimes mucronate, midrib fairly distinct on underside, upperside green, underside paler; rachis 4 to 8 mm., green, glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 6 mm. to 1·1 cm., green, glabrous, excurrent; leaflets two to four pairs, obliquely oblong to obovate, 2 to 3 mm. long, the basal pair often smaller; rachis 5 to 7 mm., green, sometimes reddish at base, glabrous, excurrent.

Nos. 3 to 5. Abruptly bipinnate, petiole up to 1·6 cm., sometimes pilose; leaflets three to five pairs, margins ciliate; rachis up to 8 mm.; stipules acuminate, about 1 mm. long.

Nos. 6 to 8. These may be phyllodes, or abruptly bipinnate, petiole up to 2 cm., slightly dilated and showing a midrib; leaflets four to five pairs.

Nos. 9 and upwards. Linear pungent-pointed phyllodes, striate, some of the first dozen reaching about 2·5 cm. long.

Pungentes—(Uninerves).

Acacia diffusa Lindl. Seeds from Goulburn and Bathurst. (Plate V, Numbers 4 to 6).

Seeds black, oblong, apex rounded, 4 to 5 mm. long, 2·5 to 3 mm. broad, about 1·5 mm. thick.

Hypocotyl terete, pale pink to reddish, 1 to 2 cm. long, up to 2 mm. thick at base, ·7 to 1 mm. at apex, glabrous.

Cotyledons sessile, auricled, oval-oblong, 6 to 7 mm. long, 3 mm. broad, upperside green, underside pale green to brownish-pink, longitudinally wrinkled, often remaining until after the phyllodes appear.

Stem at first angular and striate where affected by decurrent leaf-stalks, becoming terete, brownish-green. First internode ·5 mm.; second 2 to 3 mm.; third to seventh 2 to 5 mm.

Leaves—No. 1. Abruptly pinnate, petiole 6 to 9 mm., green, glabrous; leaflets three to five pairs, oblong-acuminate, the terminal pair sometimes obovate, mucronate, up to 6 mm. long, 2 to 3 mm. broad, midrib distinct on underside, upperside green, underside paler; rachis 7 mm. to 1 cm., green, glabrous, excurrent; stipules small acuminate scales.

The interval of time between the appearance of the first and second leaves is shorter than that noticed in connection with any other species, and in some cases the second appears so soon after the first as to almost make them resemble an opposite pair.

Nos. 2 and 3. Abruptly bipinnate, petiole 7 mm. to 1·5 cm., usually dilated, with strong nerve along lower margin, glabrous; leaflets two to four pairs, up to about 4 mm. long, 1·5 mm. broad; rachis 3 to 9 mm., glabrous, excurrent; stipules acuminate scales nearly 1 mm. long.

Nos. 4 to 6. These may be phyllodes, or abruptly bipinnate, petiole 1·2 to 2 cm., vertically flattened, midrib prominent; leaflets three to four pairs; rachis 5 to 7 mm.; stipules as in Nos. 2 and 3.

Nos. 7 to 12. Linear pungent-pointed phyllodes up to about 1·5 cm. long, 1 mm. broad, with prominent midrib.

Brunioideæ.

Acacia conferta A. Cunn. Seeds from Eidsvold, Queensland. (Dr. T. L. Bancroft per J. H. Maiden). (Plate V, Numbers 7 and 8).

Seeds black, oblong-oval, about 4·5 mm. long, 2·5 to 3 mm. broad, 1 to 1·5 mm. thick.

Hypocotyl terete, pale coloured, up to 2·2 cm. long, about 1·5 mm. thick at base, ·7 to 1 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 mm. long, 2·5 mm. broad, upperside green, underside brownish-green, sometimes with raised line along centre, soon becoming revolute and cylindrical.

Stem terete, greyish-green to greyish-brown, slightly pubescent. First internode ·5 mm.; second ·5 to 1 mm.; third 1 to 2 mm.; fourth 2 to 4 mm.; fifth and sixth 3 mm. to 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 4 mm., glabrous; leaflets three pairs, rarely four, oblong-acuminate, about 5 mm. long, 1·5 to 2 mm. broad, venation obscure, upperside green, underside paler to reddish-brown, rachis 5 to 6 mm. glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 6 mm. to 1 cm., glabrous, excurrent; leaflets two to four pairs, usually three, oblong-acuminate, the terminal pair often obovate, 4 to 5 mm. long, 1·5 to 2 mm. broad; rachis 6 to 8 mm., green, glabrous, excurrent; stipules flat acuminate scales, about ·7 mm.

Nos. 3 to 5. Abruptly bipinnate, petiole 9 mm. to 1·3 cm., terete, often with small gland about middle, pilose to slightly pubescent; leaflets three to six pairs, in one case No. 5 had seven pairs; rachis 6 mm. to 1·2 cm., glabrous to pilose; stipules 1 mm.

No. 6. This is usually a phyllode, but may be bipinnate and very similar to Nos. 4 and 5.

Nos. 7 to 30. Linear phyllodes about 7 mm. long, with outward curving points, pilose to slightly pubescent, crowded or in a few cases approximately verticillate, the longest internodes on a seedling being those between leaves 4 and 6.

UNINERVES—(Brevifoliæ).

ACACIA LINEATA A. Cunn. Seeds from Wyalong, growing on granite formation. (Plate VI, Numbers 1 to 3).

Seeds greyish-black, oblong, 4 to 5 mm. long, 2 mm. broad, about 1 mm. thick, aureole 3 mm. long.

Hypocotyl terete, pale green, becoming reddish above soil, 9 mm. to 1·5 cm. long, about 1·5 mm. thick at base, 1 mm. at apex, glabrous.

Cotyledons sessile, auricled, oblong, apex rounded, 5 to 6 mm. long, 2·5 mm. broad, upperside green, underside pale brown, with raised centre line.

Stem terete, green, slightly pubescent to tomentose. First internode ·5 mm.; second 1 to 2 mm.; third 2 to 4 mm.; fourth to seventh 3 to 7 mm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 4 mm., green, glabrous; leaflets two to three pairs, oblong-acuminate, the terminal pair sometimes obliquely obovate, 4 to 5 mm. long, 3 to 4 mm. broad, venation obscure, upperside green, underside paler; rachis 3 to 5 mm., green, glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole about 5 mm., slightly channelled above, green, with a few scattered hairs; leaflets three to four pairs, oblong to obliquely obovate, margins ciliate, 3 to 4 mm. long, 2 mm. broad; rachis 6 to 8 mm., glabrous, or with a few scattered hairs, excurrent; stipules reduced to acuminate scales.

Nos. 3 to 5. Abruptly bipinnate, petiole 6 to 9 mm., No. 5 being vertically flattened and with a strong nerve along lower margin, pilose to hispid, excurrent; leaflets three to six pairs, usually smaller than those of No. 2, margins ciliate; rachis 6 to 9 mm., pilose; stipules inconspicuous.

No. 6. Sometimes a phyllode, but may be bipinnate and similar to Nos. 4 and 5.

Nos. 7 to 20. Linear one-nerved phyllodes with slightly incurved point, about 7 mm. long, 1 mm. broad, pilose to hispid, somewhat crowded, the internodes rarely exceeding 2 mm.

UNINERVES—(Racemosæ).

ACACIA FIMBRIATA A. Cunn. Seeds from Glen Innes (J. H. Maiden). (Plate VI, Numbers 4 to 6).

Seeds black, 5 mm. long, 2 to 3 mm. broad, 1·5 to 2 mm. thick.

Hypocotyl terete, pale with pinkish tinge, becoming reddish, 1·3 to 2 cm. long, 1 to 2 mm. thick at base, ·7 to 1 mm. at apex, glabrous.

Cotyledons sessile, auricled, oblong to obovate-oblong, about 6 mm. long, 3 mm. broad, brownish-red on both sides, a few raised lines on underside.

Stem at first slightly angular where affected by decurrent leaf-stalks, green to greenish-brown, pilose. First internode ·5 mm.; second 2 mm. to 1 cm.; third to eighth 2 mm. to 2 cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 4 mm., glabrous; leaflets three to five pairs, oblong-acuminate, sometimes mucronate, up to 8 mm. long, 2 to 3 mm. broad, upperside green, underside reddish to red, venation distinct; rachis 8 mm. to 1 cm., glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 1·5 to 1·7 cm., sometimes with gland on upper edge, pilose, excurrent; leaflets four pairs, the lower ones oblong-acuminate, the terminal pair obovate, mucronate, up to 6 mm. long, 2 to 3 mm. broad, underside reddish to red, venation distinct; rachis 1 to 1·5 cm., glabrous to pilose, excurrent; stipules reduced to scales.

In one case No. 2 appeared as a tripinnate leaf, but the excurrent point of the petiole was present near the central pinna.[1]

Nos. 3 to 6. Abruptly bipinnate, petiole 1 to 2·1 cm., with gland on upper margin, usually just below middle,

[1] See this Journal, LI, 393, (1917).

Nos. 4 to 6 vertically flattened, No. 4 having a strong nerve along lower margin, No. 5 having the nerve slightly removed from the lower margin, No. 6. sometimes dilated to 3 mm. broad with nerve just below centre of lamina, faintly pilose, excurrent; leaflets four to eight pairs, underside reddish to red; rachis 9 mm. to 2·5 cm., glabrous or with a few scattered hairs, stipules small acuminate scales.

Nos. 7 and 8. These may be phyllodes or bipinnate, petiole 1·3 to 1·9 cm., vertically flattened up to 3 mm. broad, with marginal gland below middle, faintly pilose; leaflets seven to eight pairs; rachis 1 to 1·4 cm.

Nos. 9 to 20. Linear-lanceolate phyllodes, mucronate, midrib prominent, from 2 to 2·5 cm. long, 3 to 4 mm. broad, glabrous or with a few scattered hairs, margins nerve-like and sometimes slightly ciliate, one or two glands on upper margin.

Acacia decora Reichb. "Western Silver Wattle." Seeds from Rylstone and Tullamore, New South Wales. (Plate VII, Numbers 1 to 3).

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

Hypocotyl terete, pale pink to brownish-red, 1·2 to 2·4 cm. long, 1·5 to 2 mm. thick at base, ·6 to 1 mm. at apex.

Cotyledons sessile, auricled, oblong to oblong-oval, 5 to 6 mm. long, 3 to 3·5 mm. broad, upperside at first yellowish-green, becoming green, underside from brownish-green to reddish-brown, with raised central line.

Stem terete, brown, glabrous. First internode ·5 mm.; second 1 to 2 mm.; third to fifth 2 to 6 mm.; sixth 2 to 4 mm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 5 mm., brownish-green to brownish-red, glabrous or with a few scattered hairs; leaflets two to three pairs, oblong-acuminate, up to 7 mm. long, 2 mm. broad, the basal pair the longest, venation not distinct, upperside green, sometimes at first reddish, underside brownish-red to red, glabrous; rachis 3 to 7 mm. long, glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 4 to 7 mm., glabrous or faintly pilose; leaflets two to three pairs, the numbers not always equal on each pinna of the same leaf, oblong-acuminate, the terminal pair often obovate, up to about 5 mm. long, 1 to 2·5 mm. broad, underside green to reddish; rachis 6 to 8 mm., excurrent; stipules inconspicuous scales.

Nos. 3 to 6. Of these, Nos. 4 to 6 may be phyllodes, or with No. 3, abruptly bipinnate, petiole 6 mm. to 1·3 cm., all being more or less vertically flattened, Nos. 3 and 4 with a strong nerve along the lower margin, and Nos. 5 and 6 with the midrib below the centre of the lamina, glabrous; leaflets three to four pairs, sometimes two pairs on No. 3, similar to those of No. 2, rachis 6 mm. to 1·2 cm.; stipules flat acuminate scales.

Nos. 7 to 12. Linear-lanceolate phyllodes, up to about 2 cm. long, 2 to 4 mm. broad, mucronate, sometimes with a small gland on upper margin, glabrous or slightly glaucous.

The early phyllodes are more linear than those of *A. buxifolia*, a species with which it has affinities.[1]

ACACIA PODALYRIÆFOLIA A. Cunn. "Queensland Wattle." Seeds from Killara and Epping near Sydney. (Cultivated). (Plate VII, Numbers 4 to 6).

Seeds black, oblong-oval, 6 to 7 mm. long, 3·5 to 4 mm. broad, 1·5 to 2 mm. thick.

Hypocotyl terete, reddish-brown above soil, pale below, 1 to 2·6 cm. long, 2 to 2·4 mm. thick at base, ·7 to 1 mm. at apex, glabrous.

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[1] This Journal, LI, 401, plate xvii, (1917).

Cotyledons sessile, auricled, oblong to ovate-oblong, 6 to 8 mm. long, 3 to 4 mm. broad, upperside brownish-green to yellowish-pink, underside pale green to puce, often with raised line along centre, becoming revolute.

Stem terete, brown, pilose to hirsute. First internode ·5 mm.; second and third 1 to 5 mm.; fourth to sixth 2 to 9 mm.; seventh and eighth 4 mm. to 2 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 7 mm., sometimes with gland near base, green, glabrous or with a few scattered hairs; leaflets five to seven pairs, oblong-acuminate, up to 1·1 cm. long, 1 to 2·7 mm. broad, the terminal pair the smallest, midrib and secondary vein distinct, upperside green, underside paler or sometimes purple; rachis 8 mm. to 1·4 cm., glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 7 mm. to 1·1 cm., often with gland at base on upper margin, pilose, excurrent; leaflets five to eight pairs, oblong-acuminate, up to 1 cm. long, the basal pair the smallest, upperside green, underside paler; rachis 8 mm. to 2 cm., pilose, excurrent; stipules inconspicuous scales.

Nos. 3 to 6. Abruptly bipinnate, petiole 1 to 2·6 cm., usually with gland on upper margin, pilose to hoary, Nos. 4 and 5 vertically flattened, with prominent nerve along or near lower margin; No. 6 may be 2 cm. broad, nearly orbicular, with hirsute margins, midrib much below centre of lamina, leaflets eight to fourteen pairs; rachis 1·4 to 3·4 cm., pilose. No. 5 sometimes has two pairs of pinnæ.

Nos. 7 to 9. These may be phyllodes or bipinnate, petiole up to 2·7 cm. long and 2·5 cm. broad, margins and midrib hispid, usually with gland; leaflets eleven to fourteen pairs.

Nos. 10 to 12. Phyllodes, obovate to almost orbicular, slightly glaucous, mucronate, and otherwise resembling the dilated petioles of Nos. 8 and 9.[1]

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[1] See reference to divided leaflets on this species, *supra*.

PLURINERVES—(Nervosæ).

ACACIA MELANOXYLON R.Br. "Tasmanian Black Wood." Seeds from Jenolan Caves, Robertson, N. S. Wales, (F. A. Hynes), Port Arthur, Tasmania, (C. Hedley), Maleny, Queensland, (Walter Cambage). (Plate VIII, Numbers 1 to 3).

Seeds oval to oblong-oval, 5 to 6 mm. long, 3 mm. broad, 1 to 1·5 mm. thick.

Hypocotyl terete, pale to brownish-red, 1·5 to 2 cm. long, 1 to 2 mm. thick at base, ·5 to 1 mm. at apex, glabrous, except that in one Robertson seedling two roots appeared just below the middle.

Cotyledons sessile, sagittate, oblong to oblong-oval, 5 to 6 mm. long, 2 to 3 mm. broad, upperside green, underside at first yellowish-green, becoming pale green and sometimes tipped with light red, with raised line along centre and sometimes a second shorter one, glabrous.

Stem at first slightly angular, becoming terete, slightly striate with decurrent leaf stalks, pilose to somewhat pubescent. First internode ·5 mm.; second 1 to 5 mm.; third and fourth 2 to 7 mm.; fifth to seventh 5 mm. to 1·4 cm.; eighth to tenth 5 mm. to 4 cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 5 mm., glabrous; leaflets three to five pairs, oblong-acuminate, up to 5 mm. long, 1·5 to 2 mm. broad, midrib and sometimes secondary vein showing under pocket lens, upperside dark green, underside paler, margins often red; rachis 5 to 6 mm. glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 4 to 6 mm., glabrous; leaflets three to five pairs, oblong-acuminate, up to about 4 to 5 mm. long, 1·5 mm. broad; rachis 4 to 7 mm., glabrous, excurrent.

Nos. 3 to 5. Abruptly bipinnate, petiole terete, 4 mm. to 1·5 cm., pilose, No. 5 sometimes having a faint gland;

leaflets from five pairs in No. 3 to sometimes fourteen pairs in No. 5; rachis from 5 mm. in No. 3 to sometimes 4 cm. in No. 5, pilose; stipules pubescent acuminate scales 1 mm. long.

Nos. 6 to 10. Abruptly bipinnate, petiole from 1·2 in No. 6 to 7 cm. in the common petiole of No. 10, pilose, dilated, up to nearly 1 mm. broad, and having a small faint gland in some cases, with a strong nerve along the lower margin, and, in Nos. 9 and 10, often a striated lamina above, No. 6 may often have two pairs of pinnæ while No. 10 may have five pairs; leaflets from ten pairs on No. 6 to sometimes twenty pairs on No. 8, up to 1 cm. long, 2 mm. broad; rachis from 2·2 to 5·5 cm., pilose; stipules as in No. 5.

Nos. 11 to 20. In some cases these may be phyllodes, but usually are bipinnate, having up to eight pairs of pinnæ, with common petioles sometimes 10 cm. long, from 1 mm. to perhaps 1 cm. broad, pilose, and with a very faint gland towards the base. Where the lamina is about 3 mm. broad, the strong nerve is about 1 mm. from the lower margin, while there is a finer nerve towards the upper edge, the nerves often being confluent at both ends. When the lamina is 1 cm. broad both nerves are conspicuous, but the lower is the more prominent, the remainder of the lamina being marked with several finer, longitudinal, anastomosing veins, and sparsely covered with fine hairs.

The phyllodes on a plant several feet high show three nerves, the central, which has been evolved from or corresponds to the strong nerve mentioned in connection with leaves 6 to 10, being the most prominent.

In rich soil and a moist climate a seedling of this species may reach a height of five feet before showing any phyllodes, while it may sometimes develop phyllodes at only a few inches high when grown in a pot.

On seedlings of this species it often happens that while the crown of the plant has only bipinnate leaves, the first phyllodes appear on axillary shoots lower down.

This is the only species of phyllodineous Acacia so far observed which has eight pairs of pinnæ, while only one, *A. rubida*, may grow to a greater height before producing any phyllodes, the latter species sometimes reaching ten feet, and flowering while still in the bipinnate stage.

PLURINERVES—(Nervosæ).

ACACIA CYCLOPIS A. Cunn. Seeds from Middleton Beach, Albany, Western Australia (Prof. W. G. Woolnough). (Plate IX, Numbers 1 to 3).

Seeds black, oval, 5 mm. long, 3 mm. broad, 1·5 mm. thick.

Hypocotyl terete, pale brown to pink, 1·5 to 2·5 cm. long, about 1·5 mm. thick at base, about ·7 mm. at apex.

Cotyledons sessile, auricled, oval to obovate, 7 mm. long, 3·5 mm. broad, upperside dark green, underside brownish-green, with one or two raised lines, becoming revolute.

Stem terete, hoary. First internode ·5 mm.; second 1 mm.; third 6 to 7 mm.; fourth to sixth 8 mm. to 1·7 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 4 mm., reddish-green, glabrous; leaflets four pairs, oblong-acuminate, up to 6 mm. long, 1·5 mm. broad, midrib showing under pocket lens, upperside green, underside reddish-green to red, margins red, glabrous; rachis 7 to 8 mm., green to reddish-green, glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 5 to 7 mm., reddish-green, faintly pilose, excurrent; leaflets three to four pairs, not always equally pinnate, obliquely oval to ovate, the terminal pair often obovate, mucronate, 3 to 4 mm. long, 1·5 to 2·5 mm. broad, upperside green, underside paler, margins red, venation obscure; rachis 5 to 7 mm., green to reddish-green, glabrous; stipules flat, ovate-acuminate, 1 mm. long.

In one case the position usually taken by the second pinna was occupied by a single leaflet.

Nos. 3 and 4. Abruptly bipinnate, petiole 8 mm. to 2·3 cm., vertically dilated in No. 3 to 1 mm. broad, and in No. 4, in convex form on the upper side of a strong nerve, from 2 to 6 mm. broad, pilose to hirsute, with gland in both cases at or below the middle on upper margin, No. 4 may sometimes have a second or upper and finer nerve confluent at both ends with the lower; leaflets five to eight pairs in No. 3, seven to nine pairs in No. 4, oblong-acuminate, mucronate; rachis 6 mm. to 1·2 cm., pilose, excurrent; stipules as in No. 2.

No. 5. This may be a phyllode, or bipinnate, petiole 3 to 3·8 cm., vertically dilated up to 1·1 cm. broad, midrib below the centre, with two or three finer nerves above though not all being confluent with the midrib at the apex, also a finer vein below the midrib but scarcely confluent with it, gland towards the base, the whole petiole being pilose to hispid, particularly along the margins; leaflets up to nine pairs.

Nos. 6 to 8. Phyllodes, similar to the dilated petiole of No. 5, pilose.

Phyllodes on a plant two feet high are glabrous, and the gland is either absent or very inconspicuous. Although the phyllode has about three to five nerves, the central one is the most prominent, and its evolution can be traced, as in similar cases, from the strong nerve which appeared first on the lower edge of the petioles of the bipinnate leaves.

JULIFLORÆ—(Rigidulæ).

ACACIA CHISHOLMI Bailey.[1] Seeds from Prairie, Tropical Queensland, (J. C. Chisholm). (Plate IX, Numbers 4 to 6).

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[1] Queensland Agric. Journ., IV, Part 1.

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

Hypocotyl terete, creamy, becoming brownish-red, up to 2·3 cm. long, about 1·5 mm. thick at base, ·7 to 1 mm. at apex, glabrous. In one case five roots grew at 7 or 8 mm. above the base.

Cotyledons sessile, auricled, oval-oblong, 5 to 6 mm. long, 3 to 3·5 mm. broad, upperside green, underside pale green to brownish-red.

Stem at first angular, becoming terete, pilose to slightly pubescent, viscid towards apex. First internode ·5 mm.; second ·5 to 1 mm.; third ·5 to 3 mm.; fourth 1 to 5 mm.; fifth to eighth 2 to 9 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm., brownish-green, pilose; leaflets two pairs, up to 7 mm. long, 2 to 3 mm. broad, usually obliquely obovate, the basal pair sometimes oblong-acuminate, upperside green, underside paler; rachis 2 to 3 mm., glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 4 mm. to 1 cm., pilose, excurrent; leaflets two to four pairs, often unequally pinnate, usually oblong-acuminate, up to 5 mm. long, 1·5 to 2 mm. broad, mucronate, margins often ciliate; rachis 4 to 7 mm., with a few scattered hairs, excurrent; stipules narrow, about 1 mm. long.

No. 3. Bipinnate, petiole 8 mm. to 1·5 cm., pilose; leaflets two to four pairs; rachis 4 to 6 mm.

Nos. 4 and 5. Bipinnate, petiole 6 mm. to 2·1 cm. in No. 4, 1·5 to 2·5 cm. in No. 5, with a channelled appearance owing to the margins having raised nerves, pilose to hirsute; leaflets three to five pairs, rarely six on No. 4, up to about 3 mm. long, often ·5 mm. broad, oblong-acuminate, mucronate, margins often ciliate; rachis 4 to 8 mm., pilose, excurrent; stipules linear, about 2 mm. long.

Nos. 6 and 7. These may be phyllodes, or bipinnate, petiole 2·4 to 3·6 cm., similar to those of No. 5, dilated to scarcely 1 mm. broad; leaflets one to five pairs, often unequally pinnate; stipules as in No. 5.

Nos. 8 to 12. Linnear phyllodes, viscid to resinous, 2·5 to 4·5 cm. long, 1 mm. broad, with raised nerve-like margins giving the phyllodes a channelled appearance, somewhat pungent pointed.

EXPLANATION OF PLATES.

Plate V.

Acacia colletioides A. Cunn.

1. Cotyledons. Cobar (Archdeacon Haviland).
2. Pinnate leaf, bipinnate leaves, pungent pointed phyllodes, and stipules.
3. Seeds.

Acacia diffusa Lindl.

4. Cotyledons, with pinnate leaf showing near top, and tip of first bipinnate leaf on right near base. Bathurst.
5. Pinnate leaf, bipinnate leaves and pungent pointed phyllodes. Goulburn.
6. Pod and seeds.

Acacia conferta A. Cunn.

7. Cotyledons, with tip of pinnate leaf. Eidsvold, (Dr. T. L. Bancroft).
8. Pinnate leaf, bipinnate leaves and phyllodes.

Plate VI.

Acacia lineata A. Cunn.

1. Cotyledons. Wyalong.
2. One cotyledon, pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

Acacia fimbriata A. Cunn.

4. Cotyledons. Glen Innes (J. H. Maiden).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Seeds.

Acacia colletioides (1 – 3); *A. diffusa* (4 – 6); *A. conferta* (7 and 8).

Natural Size.

Acacia lineata (1 – 3); *A. fimbriata* (4 – 6).

Natural Size.

Acacia decora (1 – 3); *A. podalyriæfolia* (4 – 6).

Five-sixths Natural Size.

Acacia melanoxylon.
About One-third Natural Size.

Acacia cyclopis (1 – 3); *A. Chisholmi* (4 – 6).

Slightly under Natural Size.

Plate VII.

Acacia decora Reichb.

1. Cotyledons, with tip of pinnate leaf showing. Rylstone.
2. Pinnate leaf, bipinnate leaves and phyllodes. Tullamore.
3. Pod and seeds.

Acacia podalyriæfolia A. Cunn.

4. Cotyledons. Killara (Cultivated).
5. Pinnate leaf, bipinnate leaves, phyllodes, and stipules.
6. Seeds.

Plate VIII.

Acacia melanoxylon R. Br.

1. Pod and seeds. Robertson (F. A. Hynes).
2. Cotyledons and pinnate leaf. Port Arthur, Tasmania. (C. Hedley).
3. Pinnate leaf, bipinnate leaves (No. 3 missing), and phyllodes. Jenolan Caves. The seed from which this plant grew was immersed in sea-water for 469 days. (Plant 1 ft. 5 in. high).

Plate IX.

Acacia cyclopis A. Cunn.

1. Cotyledons and pinnate leaf. Albany, Western Australia, (Professor W. G. Woolnough).
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds, with double folded orange-coloured funicle.

Acacia Chisholmi Bailey.

4. Cotyledons, with pinnate leaf. Prairie, Queensland, (J. C. Chisholm).
5. Pinnate leaf, bipinnate leaves, phyllodes, and stipules.
6. Pod and seeds.

THE MISCIBILITY OF LIQUIDS.

By CHARLES E. FAWSITT, and CHRISTIAN H. FISCHER.

[*Read before the Royal Society of N. S. Wales, November 5, 1919.*]

WHEN two liquids are shaken together they may (1) mix perfectly in all proportions with one another, or (2) dissolve partially in one another giving two layers, or (3) not mix at all (appreciably). As examples of these cases we might take

(1) ethyl alcohol and water
(2) ether and water
(3) mercury and water.

It was noticed by Rothmund[1] that the chemical composition had some connection with the mutual miscibilities and he drew up the following list of liquids in order:— Water, lower fatty acids, lower alcohols, lower ketones, lower aldehydes, nitriles, phenols aromatic aldehydes, ether, halogen derivatives of hydrocarbons, carbon disulphide, hydrocarbons.

In such a case, liquids which are close together on the list are miscible, while those furthest apart are the least miscible.

Later, Holmes[2] considered that the molecular volume of the liquid was the determining factor in connection with miscibility. According to Holmes, complete miscibility is possible only when the molecular volumes are rather close numerically.

Holmes' conclusions are based on the supposition that the molecules are spherical. While this premise is very

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[1] Zeit. für physikal. Chemie, 26, 489, (1898).
[2] Trans. Chem. Soc., (1913) 103, 2147.

doubtful, the conclusions are strikingly in accord with the experimental results, and it is astonishing that this valuable work has not hitherto been made more use of by chemists. Holmes arranges liquids in the order of the radii of their respective molecular volumes and this molecular volume list really assumes the importance of a miscibility table.

Holmes' Table.

	Molecular Radius compared with water.		Molecular Radius compared with water.
Water ...	... 1	Aniline ...	... 1·72
Glycerol ...	... 1	n-Butyl alcohol	... 1·72
Formic acid	... 1·28	n-Butyric acid	... 1·72
Methyl alcohol	... 1·31	isobutyl alcohol	... 1·72
Diethyl tartrate	... 1·33	isobutyric acid	... 1·72
Acetic acid	... 1·47	Ethyl acetate	... 1·76
Ethyl alcohol	... 1·48	Ethyl ether	... 1·80
Propionic acid	... 1·60	n-Amyl alcohol	... 1·82
Acetone ...	... 1·60	Methyl iodide	... 1·91
n-Propyl alcohol	... 1·60	Chloroform	... 2·07
Pyridine ...	... 1·64	Ethyl iodide	... 2·08
Nicotine ...	... 1·65	Benzene ...	... 2·14
Phenol ...	... 1·70	Carbon disulphide	... 2·37
		n-Hexane ...	... 2·43
		n-Heptane ...	... 2·53

Dealing first with single (liquids) substances only, the following question arises:—"Would it be possible to take all (single) liquids, and arrange them in order in a table, such that the relative miscibility of any one of them (say *A*) with respect to any other (*B*) could be predicted?" This question can only be fully answered by experiment with all liquids. We have tested a somewhat larger number of liquids than Holmes, and for the liquids examined there seems little doubt that each has a fairly definite place on a list of liquids, such that its behaviour with respect to others can be predicted. When *A* dissolves to any extent in *B*, and *B* in *A*, to form two layers, even a small amount of B dissolved in A will affect the properties of the A layer and in particular the molecular volume of A, so that the position of a liquid in regard to miscibility depends not only on its molecular volume and other properties, but on the way these are altered by introduction of the other liquid with which the miscibility is being examined. At the same time the influence of the solution of small amounts of other substances does not usually seem to be so very disturbing.

The following list contains a considerable number of liquids arranged in order.

It may be taken as a rule that if any one of these, say methyl alcohol No. 7, mixes perfectly with any other, say castor oil, No. 46, then all the liquids between Nos. 7 and 47 will mix perfectly. No. 9 mixes with all liquids up to No. 51, therefore all liquids between these will mix perfectly. It is interesting to note that while Nos. 13 and 15, dichlorhydrine and methyl acetate, are only partially miscible with water (No. 1), and partially miscible with No. 55 (liquid petrolatum) pyridine is miscible with No. 1 and No. 55.

The experiments were carried out at a room temperature of 18° – 22° C. and most of liquids used were Kahlbaum's (pre-war stock).

1 Water
2 Glycerol
3 Glycol
4 Formamide
5 Formic acid
6 Diethyl tartrate
7 Methyl alcohol
8 Acetic acid
9 Ethyl alcohol
10 Acetone
11 Propyl alcohol
12 Propionic acid
13 Dichlorhydrine ($C_3H_6O\,Cl_2$)
14 Pyridine
15 Methyl acetate
16 Methylal
17 Methyl ethyl ketone
18 Diethyl acetal [$C_2H_4(OEt)_2$]
19 Isobutyl alcohol
20 Bromal

21 Ethyl acetate
22 Ethylaceto acetate
23 Ethyl ether
24 Phenylhydrazine
25 Amyl alcohol
26 Aniline
27 Malonic ether
28 Heptylic acid
29 Amyl acetate
30 Octyl alcohol
31 Cineole
32 Caprylic acid
33 Nonylic acid
34 α-Phellandrene
35 Chloroform
36 Benzene (C_6H_6)
37 Methyl iodide
38 Carbon tetrachloride
39 Ethyl iodide
40 Toluene
41 Bromoform
42 Isobutyl nitrate
43 Nitrobenzene
44 Isoamyl nitrate
45 o-Methyl propyl benzene
46 Castor oil
47 Caprylidene (C_8H_{16})
48 Pinene
49 Carbon disulphide
50 Heptane
51 Kerosene (sp. gr. ·8)
52 Teal oil
53 Sperm oil
54 Olive oil
55 Liquid petrolatum (Parke Davis, sp. gr. ·836)

The following facts will be noticed:—

(1) Replacement of hydrogen in liquid hydrocarbons by —OH, COOH, $C_2H_3O_2$, NH_2, brings the position of the liquid nearer to the beginning of the miscibility table.

(2) Replacement of H in a hydrocarbon by CH_3 brings the liquid nearer the end of the table.

(3) Unsaturated hydrocarbons are nearer the beginning of the list than the corresponding saturated hydrocarbons.

(Chemical Department, University of Sydney.)

A NEW METHOD OF MEASURING MOLECULAR WEIGHTS.

J. G. STEPHENS, B.Sc.
John Coutts' Research Scholar.
(Communicated by Prof. C. E. Fawsitt.)

[*Read before the Royal Society of N. S. Wales, November 5, 1919.*]

THE ordinary boiling-point method for the determination of molecular weights depends upon the fact that the vapour pressure of a solution is lower than that of the pure solvent. This same fact may also be employed as the basis of the following method in which the molecular weight of a material is measured by comparison with that of a standard substance. The theory of this method will be understood on reference to Fig. 1, where each of the side tubes of the vessel represented contains a quantity of some liquid. Suppose that a quantity of a (liquid) solvent containing some known solute is introduced into one side of the apparatus whilst a quantity of the liquid containing some other soluble material is added to the other side. There will thus result two solutions which, having in general different concentrations of dissolved units, will accordingly possess different vapour pressures. A steady distillation will therefore occur from the solution of high to the solution of low vapour pressure, and equilibrium will only be reached when the transfer of liquid from one vessel to the other has rendered the vapour pressure of both solutions equal.

Now there is a principle stated by Ostwald that if two systems are in equilibrium one way, they must be in equilibrium in every way. It follows, therefore, that since these two solutions are in equilibrium as regards their vapour pressure they must also be in equilibrium as regards their osmotic pressures. In other words the concentration of dissolved particles is the same in each solution.

Upon this condition we have

$$\frac{n_1}{v_1} = \frac{n_2}{v_2}$$

where v_1 and v_2 denote the volumes of liquid in the vessels A and B and n_1 and n_2 the number of dissolved molecules in these respective solutions. Hence, if m_1 and m_2 are the molecular weights of the two solutes, and w_1 and w_2 the weights of solute added to each side,

$$m_1 = \frac{w_1\, m_2\, v_2}{v_1\, w_2} = \frac{w_1\, m_2\, W_2}{W_1\, w_2}$$

where W_1 and W_2 are the weights of liquid in the vessels A and B. The actual form of the apparatus employed to determine molecular weights on the above principle is represented in the accompanying diagram (Fig. 1). The tubes A and B are ground into the connecting limb C, by which the two solutions are placed in communication. The space above the liquids was exhausted of air in order to secure more rapid distillation from one side to the other. Stirring of the solutions was accomplished by placing glass rods in each of the tubes A and B and then rocking the whole apparatus on a mechanical rocker of special construction.

In order to conduct a molecular weight determination with the above apparatus, all that was necessary was to place a weighed quantity of the substance (solute) in one of the tubes, and a weighed quantity of some other substance of known molecular weight in the other tube. Each of the tubes was then filled about two-thirds full of some liquid solvent, in which both of the substances were soluble. The exact amount of solvent added to either tube is immaterial. After fitting the tubes into the connecting limb,

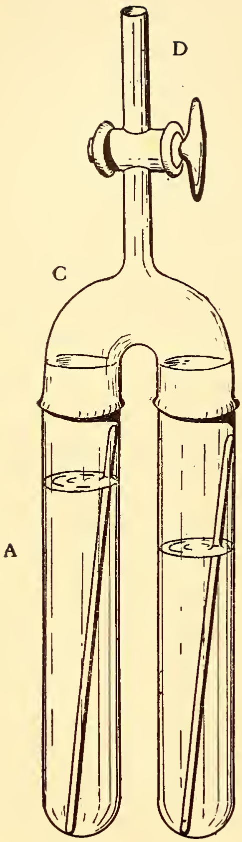

Fig. 1.

the space within the apparatus was evacuated by connecting D to a filter pump. When working the volatile solvents, such as ether, it was found advisable to place some shredded platinum foil in the tubes B and C, to prevent the bumping which would otherwise occur.

As regards the choice of a solvent, volatility is essential for rapid determinations, but the exact state of purity of the solvent does not seem to be of great importance. Both the solutes should be much less volatile than the solvent employed, and must not undergo association in solution.

The whole apparatus was allowed to stand for about forty-eight hours, after which time the tubes A and B were weighed, and the ratio of the weights of liquid in the tubes determined. This procedure was continued until the ratio of liquid in the tubes became constant, when the molecular weight was calculated from the formula developed above.

As an example of the method, the following case is given where benzene was used as the solvent and azobenzene was the substance of known molecular weight:—

Solutes { Weight of unknown substance 1·3586
Weight of azobenzene 1·0343

Weight of benzene in A after 48 hours 8·0512
Weight of benzene in B after 48 hours 16·3907
Molecular weight calculated, (after 48 hours) = 117·0

Weight of benzene in *A* after 90 hours 8·4401
Weight of benzene in *B* after 90 hours 15·9302
Molecular weight calculated, (after 90 hours) = 126·2

Weight of benzene in *A* after 108 hours 8·0202
Weight of benzene in *B* after 108 hours 15·1160
Molecular weight calculated, (after 108 hours) = 126·2

The theoretical molecular weight of the unknown was 128, which suffices to indicate the degree of accuracy which may be obtained by the method.

Using ether as a solvent, however, the same measure of success was not obtained, doubtless owing to the evaporation which occurred in removing the tubes for weighing. The apparatus used with ether was slightly different in form from that described above. It consisted of two small retorts cut off at the neck and connected by a tightly fitting rubber tube. The evacuation was effected by immersing the bulbs in hot water and inserting the stoppers while the ether was still boiling. The rapidity with which the equilibrium condition was approached with this modification of the apparatus suggests that the time necessary for a determination could be considerably diminished by working at temperatures higher than that of the atmosphere.

The results obtained by the method first described may be summarised as follows:—

Solvent.	Substance determined.	Substance for comparison.	Mol. Wt. determined.	Mol Wt. theoretical,
Benzene	Naphthalene	Azobenzene	126·2	128
Benzene	Azobenzene	Benzopenone	181·0	182
Ether	Azobenzene	Diphenylamine	173·7	182
Water	Glucose	Cane-sugar	160·0	180

It will be seen from these figures that the scheme outlined above affords a satisfactory practical method of molecular weight determination. The ease with which measurements may be conducted need not be emphasised. After the work which forms the subject of this paper had been completed, my attention was drawn by Mr. J. W. Hogarth of the University, to papers by Blackman and Barger,[1] in which a somewhat similar method is described. As the principle of Blackman's method is slightly different, however, the present description may not be entirely without value.

In conclusion I wish to express my thanks to Professor C. E. Fawsitt, for much advice and encouragement in the course of the present investigation.

Chemical Laboratory, University of Sydney.

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[1] Trans. Chem. Soc., 1905, 87, 1474.

NOTES ON ACACIA, No. IV, (WITH DESCRIPTIONS OF NEW SPECIES).

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

With Plates X-XVII.

[*Read before the Royal Society of N. S. Wales, December 3, 1919*]

SYNOPSIS:

Pungentes (Uninerves).
nigripilosus n. sp.

Pungentes (Spicatæ).
oxycedrus Sieb.

Calamiformes (Plurinerves).
Helmsiana n. sp.
triptycha F.v.M., and var. *tenuis* n. var.
subflexuosa n. sp.
Sowdeni n. sp.
Havilandi n sp.

Calamiformes (Uninerves).
tenuior n. sp.
Pilligaensis n. sp.

Uninerves (Spinescentes).
oxyclada F.v.M.
spinosissima Benth, (Syn. *A. leptacantha* Pritzel)
ulicina Meissner
ferocior n. sp.
Basedowii n. sp.

Uninerves (Racemosæ).
Hamiltoniana n. sp.
Chalkeri Maiden
Kettlewelliæ Maiden
Clunies-Rossiæ Maiden
brachybotrya Benth.
argyrophylla Hook.
Spilleriana J. E. Brown

Plurinerves (Triangulares).
deltoidea A. Cunn. (Syn. *A. stipulosa* F.v.M.
Luehmanni F.v.M.
Froggattii n. sp.

Plurinerves (Microneura).
eremea n. sp.
Loderi n. sp.

Juliforæ (Stenophyllæ).
Coolgardiensis n. sp.
oncinophylla Lindl. var. *Fauntleroyi* n. var.

Juliforæ (Falcatæ).
doratoxylon A. Cunn. and var. *angustifolia* var. nov.
proxima Maiden
Shirleyi n. sp.
sparsiflora n. sp.
rhodoxylon n. sp.
argentea Maiden
Burrowi n. sp.
oncinocarpa Benth. (Syn. *A. oligoneura* F.v.M.)

Juliforæ (Dimidiatæ).
holosericea A. Cunn, var. *glabrata* Maiden

Bipinnatæ (Pulchellæ).
Mitchelli Benth.

To the bibliography given in this series of papers, this Journ. XLIX, p. 465, add "The secretion of nectar by extra-floral glands in the genus *Acacia* (Wattles)." W. M. Carne in "The Australian Naturalist" (Sydney) April 1913, ii, 198.

Pungentes (Uninerves).

A. NIGRIPILOSUS n. sp.

Frutex parvus. Phyllodiis nitentibus, lineare-subulatis, rigidis, apice acute acumine, planato-angularibus, ad 6 cm. longis, glandula prominente basin versus. Pedunculis minus 5 mm. longis, capitulis breviter oblongis, vel floris in bracteis imbricatis deciduis, scariosis inclusis. Sepalis lobis angustissimis spathulatis, apice paucis pilis, petalora ca. dimidio æquantibus. Petalis pilis subfuscis vel nigrescentibus parte superiore. Ovario glabro. Legumine stipitato, moniliforme, 6 cm. × 5 mm. Seminibus longitudinaliter dispositis, ovatis, funiculo breve, in arillum irregularem carnosum crassatum.

A shrub four feet high, branchlets slightly angular.

Phyllodia shiny, linear-subulate, rather rigid, sharply pointed at the apex, flattish-angular, with a strongly marked central nerve on both sides, and a prominent nerve on each side; up to 6 cm. long (the collector says 2·5 – 7·5 cm.), prominent gland near the base.

Stipules almost aristate, brown, scarious, only seen on the young shoots.

Peduncles solitary or in pairs, under 5 mm. long, bearing each a shortly oblong head of about twenty-one flowers, mostly 5-merous, enclosed in imbricate early deciduous scarious bracts.

Sepals frail, with very narrow spathulate lobes separated almost to the base, early deciduous, and carrying a few hairs at the tips, about half the length of the petals. Petals frail, united about half way up with brownish or blackish hairs on the upper half, and conspicuous also in the bud. Ovary glabrous.

Pod (Kellerberrin specimen) not seen quite ripe, stipitate, moniliform, about 6 cm. long and 5 mm. broad, seeds longitudinally arranged, ovate, a shortish funicle thickened into a somewhat irregularly shaped fleshy aril.

Type. Cowcowing, Western Australia (Max Koch, No. 1030 (in part), August 1904).

Affinities.

1. With *A. Prainii* Maiden, this Journ. LI, 238. These two species are closely allied; the pods and seeds of *A. Prainii* are not available. *A. Prainii* has shorter phyllodes, more rigid and with straight points, longer and more numerous peduncles, and, apparently, an absence of bracts. The petals are quite glabrous in *A. nigripilosus*.

2. With *A. inaequiloba* W. V. Fitzgerald. *A. nigripilosus* was doubtfully referred to *A. inaequiloba*, this Journ. LI, 241. In *A. inaequiloba* the central nerve is less prominent on both sides, and the gland is round, not oblong as in *A. nigripilosus*. In *A. inaequiloba* the gland causes an outward bend of the phyllode when it occurs; not so in *A. nigripilosus*. In *A. inaequiloba* the calyx is irregular in shape, and there is an absence of the hairs which are prominent in *A. nigripilosus*.

3. With *A. triptycha* F.v.M. There is some general similarity between the two species as regards the phyllodes, which are, however, longer and with more numerous though fainter striæ in *A. triptycha*. In *A. triptycha* the striæ can only be seen under a lens, but in *A. nigripilosus* the prominent vein or rib gives the phyllode a quadrangular appearance. The heads of flowers in *A. nigripilosus* are elongated rather than strictly spherical. The two species are also sharply separated by the narrower pods of *A. triptycha*.

A. suaveolens Willd., *A. iteaphylla* F.v.M., *A. Graffiana* F.v.M., and *A. Lindleyi* Meissn., are also species with prominent bracts.

Pungentes (Spicatæ).

A. OXYCEDRUS Sieb.

Mr. A. J. Campbell has sent this plant from the Grampians, Western Victoria, with almost straight phyllodes up to 6 cm. long. Mueller (Pl. Vict.) describes those of the species as $\frac{2}{3} - 1\frac{1}{3}$ inch (say 2 to 3·5 cm.) long. A plant from Gosford N.S.W., shows them 4 cm. long.

Mr. Campbell's plant appears at first sight so different from the Sydney or Blue Mountains form (the type), that I thought we had at least a variety, but, in addition to the increased length of the phyllodes, with the possible exception of more deciduous and less rigid stipules, all the characters appear to agree with the normal form. Mr. Campbell tells me that he saw the species 15 feet high and "base of trunk about a foot through," which is a much greater diameter than I have seen.

Mr. Cambage and I found it a straggling spreading shrub of 4 – 5 feet near Linden, and a bushy shrub 10 feet and very abundant at the old Numantia, close to Linden. The following description of pod and seed from Faulconbridge, a third Blue Mountain locality, was drawn up from perfectly fresh specimens.

Pod almost terete, seeds longitudinally arranged. Valves brown, rims of valves thickened and very marked. Seed intensely shiny black. Funicle filiform, suspending the seed just out of the pod. Arillus white, not clavate, almost cylindrical, on the top of the seed.

Calamiformes (Plurinerves).

A. HELMSIANA n. sp.

Frutex pumilus, breve tomento tecto, gummi exudans. Phyllodiis numerosis, lineari-teretibus 2 nervis immersis, paullo falcatis, apice recurvatis, 1 cm. longis. Pedunculis ca. 8 mm. longis, capitulis parvis globosis ca. 20-floris. Calyce valde lobato, margine ciliato vel granulato, petalis ca. dimidio aequilongo. Petalis glabris praeter apices. Ovario pruinoso. Stylo longissimo. Legumen ac semen non vidimus.

A numerously branched, probably dwarf shrub, largely covered with a very short tomentum, and, particularly the young shoots, exuding a gummy substance.

Phyllodia numerous, linear-terete, with two not very marked sunk nerves, slightly curved, recurved at the point in a slightly rostrate manner, 1 cm. long.

Stipules deciduous and rarely found. They have the similitude of minute thorns, one on each side of the phyllode attachment, and are embedded in a gummy secretion.

Peduncles singly or in pairs, about 8 mm. long, bearing each a small globular head of about twenty flowers mostly 5-merous. Bract capitate. Calyx deeply lobed, attached about half-way up, ciliate or granular at the edges, about half as long as the petals. Petals glabrous except at the tips. Ovary hoary or with fine tomentum. Style very long.

The type is from Camp 42, Elder Expedition (R. Helms).

Range.

We only know it from Western Australia, and from Camps 42 and 54 of the Elder Expedition. These were in the Victoria Desert (R. Helms, No. 12). Labelled *A. Bynoeana* Benth. by Tate. The position of Camp 43, reached on the following day, was Lat. 27° 36′ 10″, and say Long. 126° 40′. Camp 54, 17th September, 1891. Victoria Desert (R. Helms, No. 12). Camp 54 was in Lat. 29° 33′ 25″ and in Long. 124° 30′. Camp 54 is placed in the leader's journal under 18th September, and there is often this discrepancy (easily accounted for) between the numbers of the camps and dates, as entered in the journal and herbarium labels. Evidently they were in botanically very interesting country, as on the 17th Mr. Helms found ten, and on the 18th fifteen plants new to him.

Affinities.

With *A. Bynoeana* Benth. This is its closest affinity, and it is worthy of note that Mr. R. Helms collected both species at Camp 42. The new species has, however, 2-nerved phyllodia in contradistinction to the five nerves of *A. Bynoeana*, longer and quite glabrous peduncles, more deeply divided calyx-lobes, and a hoary ovary. The bracts are spathulate in *A. Bynoeana*.

For some notes on *A. Bynoeana* see my paper in this Journ. XLIX, p. 501 (1915), and that by J. M. Black, Journ. Roy. Soc. S.A., XLII, 45 (1918).

A. Helmsiana is placed in the section Plurinerves of Calamiformes, because of its obvious affinity to *A. Bynoeana*, but it has only two nerves. The sections require revision.

A. TRIPTYCHA F.v.M.

This is briefly and imperfectly described in B.Fl. ii, 337, and instead of stating (on Mueller's behalf) what the type really is, four specimens are quoted, viz.:—(1) Drummond (4th Coll.?) No. 132; (2) 5th Coll. No. 5; (3) Kalgan River, Oldfield; (4) Termination Rock, Maxwell.

Through the kindness of Prof. Ewart I have seen, from Mueller's Herbarium, No. (1). This is not *A. triptycha* and is the same as No. (2) which I received from the British Museum many years ago. It is a new species, which I have named *A. subflexuosa*. No. (3) is *A. triptycha typica*. No. (4) is *A. triptycha* with the phyllodes a little broader than No. 3. He also lent me "Cape Arid, W.A. (John Forrest, 1870)" which is similar to No. 3.

No. 3 is very well figured in Mueller's "Iconography" plate of *A. triptycha*, showing that it satisfied his idea of his own species. The plate, however, shows phyllodia swollen near the tips, doubtless owing to insect action. I have not seen the specimen so drawn, and it is well to note that swellings in *A. triptycha* are quite accidental.

Emphasis should be laid on the fact that the phyllodes of *A. triptycha* are rigid and pungent. It is not correct to say (as in B.Fl. ii, 337), that they are flexuose, but Drummond's (4th) No. 132 and (5th) No. 5, are, and these are *A. subflexuosa* n. sp., as already stated.

The head of flowers in *A. triptycha* may be up to 30. The sepals have the upper portions hairy. The pods are shortly stipitate, 5 – 6 cm. long, and 2 mm. broad, the seeds longitudinally disposed, the valves raised between the seeds, the margins of the valves slightly thickened. Funicle very short and expanded into a narrow arillus obliquely embracing the seed.

Synonym.

A. triptycha F.v.M. var. *pungens* Pritzel, in Engler's Bot. Jahrb., xxxv, 293. In the Stirling district, near the Kalgan River (D. 4596). I have not seen D. 4596, but I collected near the Kalgan River, and my specimens are close to No. 3 (Oldfield) from the same locality, and Pritzel's description of his supposed variety applies to them well.

Range (of the typical form).

It appears to be confined to Western Australia,—in its typical form—between King George's Sound and Esperance Bay.

Typical form.—" Spreading scrub, 3 feet. Sand Plains, Kalgan River " (Oldfield). Co-type. Small pungent shrub, Kalgan Plains (J.H.M.) Esperance Bay (Herb. Melb.)

Mullewa near Geraldton (C. R. P. Andrews, Aug. 1903, through W. V. Fitzgerald, as *A. leptoneura* Benth.). Has long curved tips to the apices which are golden-hairy. This plant, a fragment in flower only, may, in the absence of complete material, be looked upon as a connecting link between *A. triptycha* and *A. leptoneura.*

Var. *tenuis* var. nov.

This is a form readily picked out from normal *triptycha.* The phyllodes are more slender and usually shorter, the young tips golden pubescent, the pistil densely tomentose. The Tammin specimens (J.H.M., Sept. 1909) may be taken as the type.

Range (of the Variety).

In drier country. It has been obtained from the Wongan Hills, 132 miles north of Perth, thence from Cunderdin to Coolgardie along the railway line, thence to Camps 56 and 61 of the Elder Expedition, say 200 miles north east of Coolgardie. Specific localities are Wongan Hills (Dr. A. Morrison). Cunderdin (W. V. Fitzgerald as *A. leptoneura*). Small shrub, Tammin (J.H.M.). Spreading shrub, 2–4 feet, Kellerberrin (W. V. Fitzgerald). Coolgardie (L. C. Webster, 1900).

Shrub of three feet, on sandhills, Camps 56, 59, 61, Victoria Desert. Elder Exploring Expedition 1891 (R. Helms). Camp 56, 19th September, is Lat. 29° 54′ 35″; Camp 59, 22nd September, specimen No. 9; Camp 61, 25th September (Queen Victoria Spring), is Lat. 30° 25′ 38″. I see no reference to this small prickly wattle in the journal, which is not surprising. Mueller and Tate, in their account of the botany of this Expedition (Journ. Roy. Soc. S.A., XVI, 351), refer to this wattle as "*A. triptycha* F.v.M. (?)," showing that they noted its difference from the normal species, but I cannot make up my mind to give it specific rank.

A. SUBFLEXUOSA n. sp.

Frutex paullo pruinosus pubescens. Phyllodiis lineari-subulatis subrigidis, fere teretibus, flexuosis ad 7 cm. longis, tenuiter striatis, ca 6 nervis, apice breve innocuo, obliquo. Stipulis brevibus sublatis, scariosis. Pedunculis ca. 2 mm. longis, hirsutis, capitulis globosis ca 15 floris. Bracteis longis, falcatis. Sepalis angusto-spathulatis, apice ciliatis, petalis plus dimidio aequilongis. Petalis laevibus. Ovario glabro. Legumen ac semina non vidimus.

Doubtless a shrub, branchlets slightly angular, slightly hoary pubescent like the phyllodia.

Phyllodia linear-subulate, rather rigid, nearly terete, flexuose, up to 7 cm. long, finely but clearly striate with about six nerves, with a short, innocuous oblique point, the base terminating in a short, rounded, scarcely decurrent process. Stipules short, broadish, scarious.

Peduncles short (say 2 mm.), hirsute, bearing each a globular head of about 15 flowers mostly 5-merous. Bracts long, falcate.

Sepals narrow-spathulate, divided to the base, fringed with hair at the top, two-thirds as long as the petals. Petals smooth, free. Ovary glabrous.

Pods and seeds not seen.

The type is Drummond's 5th Collection (1849), No. 5. A co-type is Drummond's 4th Coll. (?) No. 132.

Range.

This species occurs in Western Australia, and is only known from Drummond's 5th and (? 4th) collections. His 5th Collection was probably made mainly in the southern part of the State, but it is not possible to speak of a definite locality and the attention of local botanists may be invited to so well marked a species.

Affinity.

With *A. triptycha* F.v.M. It was included with this species by Bentham (B. Fl. ii, 337), as to specimens with "flexuose" phyllodia. The two species can be sharply separated by the absence of that character in *A. triptycha*, and also by the base of the phyllodes, annular and non-decurrent in *A. triptycha*. The flowers are also more numerous in the latter species, being twenty and over.

A. Sowdeni n. sp.

Frutex patens vel arbor parva, phyllodiis junioribus gracilibus argenteis. Phyllodiis linearibus, in apicem longum infirmum terminantibus, 6 – 8 cm. longis, 3 mm. latis, crassis, tenuissime striatis, nervis parallelibus. Nervis primum tomento tectis, deinde distincte definitis. Pedunculis minus 5 mm. longis, hirsutis, capitulis globosis ca. 25-floris. Sepalis spathulatis vel fere linearibus apicibus pilosis, corollæ ca dimidio aequilongis. Petalis laevibus pilis sparse tectis. Ovario hirsuto. Legumine pallide-fusco curvato ca 11 cm. longo, 5 cm. lato, chartaceo, reticulato. Seminibus fuscis, ovoideis longitudinalibus, funiculo longo, semen semi-circumcingente et in arillum brevem terminante.

A somewhat spreading shrub or small tree, consisting of many stems of rather small diameter. Neat in habit and very handsome with its youngish silvery foliage; branchlets at first slightly angular.

Phyllodia linear, slightly curved towards the apex, and terminating in a long weak point, narrowed at the base, 6 – 8 cm. long, 3 mm. wide, thick, very finely striate with parallel nerves only to be seen under a lens. In the younger stages the venation is largely concealed by a close, silvery tomentum, but the mature glabrous phyllodia have the venation sharply defined, if minute, and consisting mainly of a midrib, two parallel veins and thickened margins, with finer intermediate veins. A slightly swollen gland near the base of the phyllode.

Peduncles in pairs or threes under 5 mm. long, and beset with short hairs, each supporting a globular head of about 25 flowers, mostly 5-merous. Bracts oblique-topped.

Sepals spathulate or almost linear, free or slightly connate, glabrous except at the tips which are tufted with hairs, about half as long as the corolla. Petals smooth, free, very sparsely besprinkled with hairs. Ovary hirsute, particularly the upper portion.

Pod pale brown, covered with a fine tomentum, broadish, curved, up to 11 cm. long and more, about 5 mm. broad, chartaceous, reticulate, convex over the seeds.

Seeds brown, ovoid, longitudinally arranged; funicle long, filiform-flattish, crimped, encircling the seed round the longer half, and terminating in a short aril.

This description has been drawn up, as regards habit, phyllodia and fruit, from the Port Augusta specimens (J.H.M.) which I constitute the type. The details of the flower have been described from the Eucla specimen.

This very interesting South Australian species has been named in honour of Sir William James Sowden, of Adelaide, President of the Australian Wattle Day League.

Range.

Its range appears to be confined to South and Western Australia. We know it from the head of Spencer Gulf in South Australia, then roughly following the Transcontinental Railway Line it extends just into Western Australian territory at Eucla. It is one of those species which on its foliage alone has been passed by as something else, and there has been so much confusion in regard to our Acacias that only the trained collector can pick out suitable material to collect and make appropriate notes. And our country is so vast, and the botanical workers so few, that it is but rarely the trained collector passes over our sparsely peopled areas.

South Australia.

Ten to fifteen feet or even twenty feet. Shapely, consisting of many stems, almost like a Mallee. Very handsome, with its silvery somewhat weak foliage. Port Augusta (J.H.M., Jan. 1907).

"Myall." North of Kingoonya, East West Railway to Commonwealth Hill, north east of Ooldea (Dr. H. Basedow, No. 95, April, May, 1917). Some valves and phyllodia.

Western Australia.

Eucla (J. D. Batt, from Dr. F. Stoward, who had received it from the Melbourne Herbarium). In flower and fruit.

Affinities.

1. With *A. papyrocarpa* Benth. The two species recall each other by the size and texture of their chartaceous pods, but the phyllodia of *A. papyrocarpa* are narrower, less flattened and more rigid, while in flower-details, the sepals of *A. papyrocarpa* are less narrow, and shorter in proportion to the corolla. It would seem, however, that *A. papyrocarpa* comes closest to *A. Havilandi.*

2. With *A. pendula* A. Cunn. So far as I have been able to learn, the new species has been looked upon as a Myall or a form of it. This is contributed to by a superficial view of the shape of the phyllodes and their often silvery appearance, and the often pendulous character of the branchlets. But reference to Plate 61, Part 16 of my "Forest Flora of New South Wales" will show that in flower details and in shape of the pods the two species are very different.

3. *A. Cambagei* R. T. Baker. This species is figured by the author at Plate xlii, Proc. Linn. Soc. N.S.W., xxv, (1900), and also by myself at Plate 121, Part 32 of my "Forest Flora of New South Wales." As compared with this species, it is a medium sized tree and is known for its unpleasant smell on the approach of rain. Its phyllodia are silvery, but much broader, and the venation more defined. The flowers are more hairy, and the calyx only about a third the length of the corolla. There are some similarities in pod and seed, but the pods of *A. Cambagei* are straighter and less reticulate.

A. Havilandi n. sp.

Frutex glaber pedes pauci altus. Phyllodiis fragilibus pecuariis edulibus, lineare-subulatis, subrigidis, fere teretibus, rectis circa

4 cm. longis, tenuissime striatis, 8 nerviis vix prominentibus, apice obliquo pungente. Pedunculis tenuissimis, 5 cm. longis, capitulis globosis 25 – 30 floris pallide flavis plerumque 4-meris. Sepalis angustis, fere spathulatis. calyce irregulariter lobato, apice hirsuto, sepalis dimidio aequilongo. Petalis laevibus. Ovario densissime piloso. Legumine lineare, recto vel falcato, ad 7 cm. longo, 2 mm. lato, inter semina valde constricto. Seminibus nigris, longitudinalibus. Funiculo longo pilo simile, in arillum obliquum carinosum dilato.

A glabrous shrub of a few feet high with somewhat brittle foliage, edible by stock; the branchlets scarcely angular. The thin bark roughish.

Phyllodia linear-subulate, rather rigid, nearly terete, straight or nearly so, about 4 cm. long, and very finely striate with up to eight scarcely prominent nerves, with a pungent, oblique point, and a very small gland often 1·5 cm. below it or near the middle of the phyllode.

Peduncles thread-like. 5cm. lông, bearing each a globular head of about 25 – 30 pale-yellowish flowers, mostly 4-merous, but occasionally 5-merous. Bracts variable, boomerang-shaped to quadrangular.

Sepals narrow, nearly spathulate, the calyx irregularly lobed, united to a varying height, hairy at the apex and edges about half as long as the petals. Petals smooth. Ovary densely hairy.

Pod linear, straight or in one curve, up to 7 cm. long, 2 mm. broad, much contracted between the seeds, the valves embossed.

Seeds black, ovate, longitudinally arranged, with a long hair-like funicle, the last fold of which is dilated into an oblique, fleshy aril.

Type, Wong Suey's Paddock, Cobar, N. S. Wales (Rev. Archdeacon Haviland, 1917). Flowers September, fruit November.

Named in honour of Edwin Haviland (1823–1908), for notes and portrait see this Journ. XLII, p. 106, Plate 11; and of his son Archdeacon Francis Ernest Haviland, now of Coonamble, formerly of Cobar, N.S.W. Both have specialised in the fertilisation of Australian plants and have also worked at taxonomy and other branches of botany, and their contributions are mostly to be found in Proc. Linn. Soc. N.S.W. I was for long, in the early eighties, a weekly companion of the father in botanical excursions chiefly in the Port Jackson district, while the son has been a generous contributor to the National Herbarium of New South Wales, and specially brought this species under my notice.

Range.

It has been found over a rather extensive range in the drier parts of New South Wales from the Lachlan to the Pilliga and Angledool (close to the Queensland border). It also extends to the Mallee country of Victoria to the vicinity of Spencer's Gulf in South Australia.

Lachlan district (J. Duff, 1882) (as *A. juncifolia*). Cudgellico viâ Condobolin (G. Horan per E. Cheel). Upper Lachlan River (Rev. J. Milne Curran in Herb. Melb.)

Harvey Range, near Peak Hill (J.H.M., 1898).

Small tree (shrub), 5 or 6 feet high. Leaves fairly brittle. Bark rather rough. Nymagee (R. H. Cambage, 6th June, 1900). So far as I know, Mr. Cambage was the first to draw attention to the brittleness of the phyllodes.

Mount Hope (J. L. Boorman). Height four feet, very bushy; Shuttleton (P. E. Lewis, No. 6). Flowers 4-merous. On Devonian quartzite ridge. Shuttleton (Archdeacon Haviland No. 5),

"I have never seen an Acacia like this before." Wong Suey's garden, Cobar (L. Abraham, Nos. 47 and 141, 1911). Wong Suey's Paddock, Cobar (Archdeacon Haviland, 1917).

Noted under *A. juncifolia* in Proc. Linn. Soc. N.S.W., my error.

"A bush new to me. It is very like Punti (*A. Burkittii*). Mr. R. Mackay of Runnymede says it is edible, and that all stock are fond of it. He calls it Needle-bush." Runnymede Station, between Glenariff and Coolabah (A. W. Mullen L.S., No. 2).

Pilliga Scrub (Dr. J. B. Cleland). Forest Reserve 41288, Pilliga Scrub, vicinity of Goona Creek, Co. of White (Forester T. W. Taylor, No. 57). Merimborough, Pilliga Scrub (E. H. F. Swain, No. 28). Shrub of seven feet, Rocky Creek, Pilliga Scrub (W. A. W. de Beuzeville, No. 3). A tall weak-growing shrub of 6 – 8 feet, having thin stems and a pendulous habit, growing in moist sandy places near the banks of a creek, and at times in the small islands the result of floods. Cuttabri, Pilliga Scrub (J. L. Boorman).

Angledool (Miss Newcomen, in Rev. Dr. Woolls' herbarium).

Victoria.

Gerang (J. Lanyon, through H. B. Williamson).

South Australia.

Mount Livingston (Mr. Langley. Said to have been determined by Prof. Tate as *A. papyrocarpa* Benth.)

Affinities.

1. With *A. rigens* A. Cunn. Its nearest affinity appears to be with this species, but the most obvious differences appear to be as follows:—*A. Havilandi* is a smaller plant, with more brittle phyllodes, which have more numerous, less prominent nerves and paler flowers, and a boomerang-shaped bract and a straight or curved pod, in contradistinction to the capitate one and the smaller twisted or curly pod of *A. rigens*. The flowers and flower-details and seeds are very much alike.

2. With *A. juncifolia* Benth. In this species the phyllodes are up to 17 cm. in length, with a midrib, and with a bend about half an inch from the base, and subtended by a gland. The lobes of the calyx are divided to the base, and their edges are ragged. Ovary smooth and shiny. Very small arillus. There are other differences between this and *A. Havilandi.*

3. With *A. Menzelii* J. M. Black. Its affinities are less close.

Calamiformes (Uninerves).

A. TENUIOR, n. sp.

Frutex probabiliter. Phyllodiis linearibus subulatis paullo planatis 13 – 14 cm longis, costis vel nervis numerosis prominentibus, apice in acumen molle, angustato, breviter villosis. Stipulis brevibus, latis, breviter ac dense villosis. Pedunculis solitariis vel geminis, 1 – 1·5 cm. longis, gracilissimis, villosis, capitulis majusculis globosis 24 – 30 floris, plerumque 5-meris. Sepalis spathulatis, villosis, corollæ dimidium aequantibus. Petalis planis, longitudinis dimidio conjunctis. Ovario dense villoso. Legumen ac semen non vidimus.

Presumably a shrub, with slender branches, almost terete, and well marked by the decurrent lines of the phyllodes.

Phyllodia linear-subulate, somewhat weak, slightly flattened, with numerous (about 8) raised ribs or nerves, 13 or 14 cm. long, the base swollen with annular markings, the apex gradually drawn out into a weak point, the whole sparingly besprinkled with short hairs, but plentifully so towards the base and along the point.

Stipules short, broad, densely covered with short hairs.

Peduncles solitary or two together, 1 – 1·5 cm. long, very slender, and more or less besprinkled with hairs, each bearing a rather large globular head of from 24 to 30 flowers, mostly 5-merous.

Sepals spathulate, free, besprinkled with hairs, half as long as the corolla, the floral-bract simulating a sepal in shape and vestiture. Petals smooth, destitute of a prominent midrib, united for about half their length. Ovary densely hairy. Pod and seed not seen.

The type was collected by Dr. H. Basedow on the "South Australian Govt. North West Expedition," 1903, No. 254, and has been distributed to a limited extent as *Acacia cyperophylla* by the finder. It came from the Musgrave Ranges, Northern Territory, where *A. Basedowi* was also found. I have not seen a second specimen.

Affinities.

1. With *A. prælongata* F.v.M. in Melbourne "Chemist and Druggist," August 1883. This would appear to be its closest affinity, and the species differs from *A. prælongata* in the very much longer glabrous phyllodes of that species, in the fewness of the ribs and in the racemose inflorescence.

2. With *A. Alleniana* Maiden, in Ewart and Davies' "Flora of the Northern Territory," p. 330, with figures. *A. Alleniana* has much longer and fewer-ribbed glabrous phyllodes with numerous conspicuous bracts and with a glabrous ovary.

A. Pilligaensis n. sp.

Frutex glaber Phyllodiis linearo-subulatis, 2 – 2·5 cm. longis paullo planatis, in acumen tenue recurvum angustatis, enerviis vel uninerviis. Stipulis aristatis. Capitulis globosis, solitariis, ca. 20 – 25 floris, pedunculo villoso 5 mm. longo. Calycis lobis brevibus latis truncatis. Petalis laevibus calycem triplo superantibus. Ovario laeve. Legumine at 7 cm. longo, recto vel leniter recurvo, ca. 3 mm. lato, inter semina paullo constricto. Seminibus oblongis, longitudinalibus, in arillum longum clavatum carnosum apice crassatis.

A "shrubby bush," glabrous, the young branchlets angular and glandular-hairy, the phyllodia spreading, or appressed to the stem.

Phyllodia linear subulate, 2 – 2·5 cm. long, slightly flattened, tapering to a fine recurved point, nerveless or with a single nerve. Stipules aristate. Flower-heads globular, about 6 mm. in diameter, solitary, supported in the axil by a peduncle of 5 mm., more or less besprinkled with golden hairs. Flowers 20 – 25 in the head, 5-merous.

Calyx thin and translucent-yellowish, with short, broad, truncate lobes. Petals similar in colour and texture to the calyx, smooth, thrice as long as the calyx. Ovary smooth.

Pod up to 7 cm. long, straight or only slightly curved, about 3 mm. wide, scarcely contracted between the seeds, the valves chartaceous and convex over the seeds. Seeds oblong, longitudinal; funicle bent once or twice, thickened at the end into a long clavate or shortly turbinate fleshy aril.

The type from Ph. Cumbill, Co. Baradine (flower, October 1918). Ph. White, Co. White, 30 miles south of Narrabri (fruit, December 1918). (Forester T. W. Taylor).

Range.

So far, this species has not certainly been found out of New South Wales, though it will probably be found in dry sandy soil in Queensland.

With the exception of the aberrant form from Gulgong (possibly not a correct locality), near Mudgee, perhaps 70 miles south of the Pilliga, most of the specimens come from the Pilliga Scrub. Besides the locality of the type, the National Herbarium, Sydney, has it from the following localities.

Deep sandy soil, Apple tree *(Angophora)* and Pine *(Callitris)* country, Baradine Creek, Pilliga Scrub. (Dr.

H. I. Jensen, No. 78, August, 1911). Also Bohena Creek to Narrabri (Dr. Jensen, August, 1911). On poor lands, Ph. Lloyd, Pilliga; (E. H. F. Swain, No. 38, August, 1913). South-east Pilliga (E. H. F. Swain, No. 21, August 1913). Central Pilliga (E. H. F. Swain, No. 27, September, 1913). Goona Creek, Pilliga Scrub (W. A. W. de Beuzeville, No. 7, July 1915). Pilliga Scrub (Gordon Burrow, No. 22, August 1915). Pilliga Scrub (Dr. J. B. Cleland, October, 1918).

"Three to four feet high, much branched and interlaced like a clump of *A. juniperina.*" Home Rule near Gulgong, (J. L. Boorman, October, 1916). A stronger growing plant than the type and with shorter, broader phyllodes. [Mr. Boorman, on a later visit to Home Rule, was unable to find this plant, so I consider that a doubt attaches to the locality for this species].

In addition to the above, the following three specimens, in bud only, are allied to *A. Pilligaensis*, but what the relations are cannot be stated until flowers, pods and seeds are available. All three appear to be more open in habit than *A. Pilligaensis*, whose branchlets and phyllodes are more appressed.

New South Wales.—1. Ticketty Well, twelve miles N.W. of Wallangra, the latter being forty-five miles N.W. of Inverell (Forest Guard A. Julius). Perhaps this locality is not far from the following.

2. Between the Gwydir and McIntyre Rivers (Co. Burnett), near Warialda (E. H. F. Swain, No. 41, July 1911). Nos. 1 and 2 have the phyllodes narrower and longer. The inflorescence is slightly more glabrous, as also are the young branchlets.

Queensland.—3. "A small shrub of about five feet high, or even seven feet, growing in the desert country around Jericho. The whole plant has much the appearance of the

Port Jackson *A. linifolia* when growing (J. L. Boorman). No. 3 differs from *A. Pilligaensis* in the glabrous or non-hirsute branchlets and peduncles, and in the broader (more spathulate) phyllode. The phyllode of No. 3 is longer than that of Nos. 1 and 2.

Affinities.

1. With *A. uncinella* Benth. Although the phyllodia are described as mostly about 1 inch long, I have seen a specimen collected by Maxwell, and determined by Bentham, with phyllodes of the same length, and remarkably similar in appearance, to those of the type of *A. Pilligaensis*. They are also appressed to the stem as sometimes seen in *A. Pilligaensis*. The structure of the flowers of the two species is, however, very different, the sepals of *A. uncinella* being narrow-spathulate. I have not seen pods.

Only one specimen of *A. uncinella*, the type, is known, and it is very desirable that we should collect it again. Prof. Ewart has lent me the original, and it bears the label "Rocky places, west tributary to Oldfield. One to two feet, low shrubby plant (Maxwell)." Augustus Oldfield was Mueller's collector, but the reference seems to be to a river or creek. Maxwell only collected for Mueller on the south coast of Western Australia.

2. With *A. ericifolia* Benth. The phyllodes of *A. ericifolia* are always shorter and often broader, sometimes almost spathulate, and with less persistent stipules. The calyx has narrow-spathulate lobes; those of *A. Pilligaensis* are short and broad. The pods of *A. ericifolia* are narrow and tend to be circinate.

3. With *A. juncifolia* Benth. *A. Pilligaensis* has probably been distributed a good deal as *A. juncifolia*; certainly some of it has been so named by me. This partly arose from confusion as to what *A. juncifolia* really is; I have tried to set the matter clear in Ewart and Davies'

"Flora of the Northern Territory," pp. 319 and 330. The two species can be readily separated by the comparatively short phyllodes of *A. Pilligaensis*, the fewness of flowers in the head, the short broad calyx in contrast with the narrow spathulate sepals of *A. juncifolia*, and the more enveloping arillus of *A. Pilligaensis.*

Uninerves (Spinescentes).

A. OXYCLADA F.v.M., A. SPINOSISSIMA Benth. (*leptacantha* Pritzel), A. ULICINA Meissner, A. FEROCIOR n. sp.

This is, in my view, the proper sequence of the four species dealt with. Bentham groups *A. oxyclada* in Calamiformes (Uninerves), but I think it is better to put it in the Uninerves.

A. OXYCLADA F.v.M., in B. Fl. ii, 341.

I am indebted to Prof. Ewart for a loan of the type. It comes from the Murchison River, W.A., and only one specimen is known. Oldfield's label (of about 1860) reads:

"Round shrub, three to four feet, rocks south of Oolingarrah, No. 984." The Surveyor-General of Western Australia obligingly informs me that this name was probably a local one, and cannot now be traced.

Evidently Mueller did not agree with Bentham's decision to recognise his own MS. name, for, on examination, it appears that it is figured as the left hand twig in Mueller's Iconography plate of *A. ulicina* Meissn. This is not the first time that Mueller's plates in this work have been shown to be composite, and the difficulty of botanists is increased because no particulars of the origin of the specimens figured are given.

None of the details of the plate belong to *A. oxyclada*, except perhaps No. 1, the tip of the phyllode. The point is in the middle of the phyllode as in *A. oxyclada* (in *A. ulicina* it is oblique turned to the side), but the peculiar and rare central gland at the top (found also in *A. Basedowi*) is not shown.

The material is sparse, and as Bentham saw no flowers his description of the species may be added to and amended as follows:

The phyllodes crowd the short spinescent branches. The gland on the phyllode has already been referred to. The flowers are 5-merous, 7 in the head, each with a very short pedicel. The calyx broad, short, truncate, jagged or with short hairs on the top, about one-third (or less) the length of the free, glabrous petals. Ovary smooth. The valves deeply embossed by the seeds, which are covered, as far as their diameter, with a hood-like arillus.

A. SPINOSISSIMA Benth.
(Syn. *A. leptacantha* Pritzel).

A. spinosissima was described with Drummond's 5th Coll. No. 51 (which is before me) as the type. Mueller forgot the type and labelled a specimen from near Lake Wagin, W.A. (Miss M. Cronin) by that name, which I have called *A. ferocior*. Dr. E. Pritzel, probably misled by this specimen, labelled an identical plant (his 706), *A. spinosissima* also. He then had his D. 3987 on hand, and, having a wrong idea of what *A. spinosissima* is, he looked upon it as new, and described it under the name of *A. leptacantha*. As a matter of fact, his *A. leptacantha* is *A. spinosissima* Benth. and not a new species.

A. leptacantha Pritzel in Engler's Bot. Jahrb., XXXV, 296, (1905).

The author obtained it in the Avon district, which would include York, Cunderdin, and the surrounding country. The author states that it differs from *A. ulicina* in having pungent phyllodes, and in its smaller size and numerous rectangularly spreading branches.

I collected excellent specimens in my 1909 tour of W.A., and my specimens are labelled Perth, but I would like to see this locality confirmed or corrected, as it is quite possible that the locality was confused in the many sendings of my material to Perth.

Mr. Fitzgerald's Cunderdin specimen (see also under *A. ulicina*) was originally labelled by him *A. ulicina*, and I believe that determination to be correct. At the same time an unpublished note of Mr. Fitzgerald says:—"*A. leptacantha* E. Pritzel. Victoria Plains (Diels et Pritzel), Cunderdin (W.V.F.). Of spreading intricate habit, 1 – 2 ft. high; in ferruginous sandy soil." This may refer to the specimen of *A. ulicina* collected by him from Cunderdin, which I have seen, or it may refer to an undoubted specimen of *A. leptacantha* from that locality, which I have not seen. A brief note like this on plants of this habit could refer to either *A. ulicina* or to *A. spinosissima (leptacantha)*.

A. ULICINA Meissn.

This species was described by Meissner in Pl. Preiss. ii, 202, from Drummond's (2nd Coll.) No. 147, which is before me. The only other specimens quoted by Bentham (B. Fl. ii, 345) are two of Oldfield's, and I have a fragment of the South Hutt River one sent to me by Dr. F. W. Stoward, then of W.A., who received it from the Melbourne Herbarium. Its label says "South Hutt. Straggling shrub up to twelve feet, leaves rigid." A second specimen, Bowes River, I obtained from Prof. Ewart. In addition, Diels and Pritzel (Engler's Bot. Jahrb. xxxv, p. 299) quote it from the Irwin district, near the Greenough River (D. 4211), while I have a specimen from Cunderdin (W. V. Fitzgerald, Nov. 1903). These various localities bring us from the vicinity of Northampton (north of Geraldton) to a few miles east of Northam, as the known range of the species. I know no other authentic specimen, and I speak from experience when I say that such pungent shrubs are difficult to collect, and a collector may easily be in a position in which it is practically impossible to secure flowering or fruiting specimens from a porcupiny mass. I am confident that these porcupiny species have a much greater range than is attributed to them.

Mueller figures it in his Iconography, but the left hand top corner plant (including fig. 1) belongs to *A. oxyclada*, while the rest is probably *A. ulicina;* but the general view of the plant and the details are more or less unsatisfactory. In Drummond's specimen the stipules are setaceous throughout, and the buds striate.

A. FEROCIOR n. sp.

Frutex patens *Ulex* similis, ramis brevibus, rigidis, divaricatis in spinas validas terminantibus. Phyllodiis planatis, subulatis, falcatis, ca 1 cm. longis et 1 mm. maxima latitudine, glandula latere dorsale. Pedunculis glabris, 5 mm. longis, capitulis globosis ca 7 floris. Calyce turbinatis, margine ciliato, petalis minus dimidio æquilongo. Petalis glabris. Ovario elongato, glabro. Legumines ac semines non vidi.

A *Ulex*-like spreading shrub with short, stout, rigid, divaricate sulcate-striate branches, terminating in stout pungent thorns.

Phyllodia flattened club-shaped falcate, terminating in an oblique blunt point, about 1 cm. long and 1 mm. in greatest width, distinctly or obscurely one-nerved, gland on the dorsal side, about one-fourth up from the base.

Peduncles glabrous, up to 5 mm. long, bearing each a globular head of about 7 flowers, mostly 5-merous. Bracts incurved circular. Stipules very deciduous, membranous, only present in the very young shoots.

Calyx turbinate, the edge somewhat irregular and ciliate, not half as long as the petals. Petals glabrous. Ovary elongated, glabrous. Pods and seeds not seen.

The type is E. Pritzel, No. 706.

Synonym.

A. spinosissima F.v.M., also Diels and Pritzel, non Benth.

Range.

This species has only been found in Western Australia. Lake Wagin, its northern locality, is a few miles east of Wagin, a railway station on the Great Southern Railway 150 miles from Albany (King George's Sound). Cranbrook is 70 miles from Albany. The Stirling Range is a few miles to the east of Cranbrook.

A fragment given me by Mr. J. G. Luehmann of the Melbourne Herbarium bears the label "*Acacia spinosissima* Bentham" (in Mueller's handwriting), "Bunkin, near Lake Wagin, W.A., Miss M. Cronin, 1890," in his own.

With a spreading habit. In the Stirling district near Cranbrook, in sandy country with Eucalyptus scrub (Diels 4514, Pritzel 706). Diels and Pritzel in Engler's Bot. Jahrb. xxxv, p. 299). The label of Pritzel's No. 706 says, North-west Plantagenet district in scrub on the sides of hills, Stirling Range.

Affinities.

1. With *A. ulicina* Meissn., which seems its closest affinity. Indeed its general appearance reminds one more of *Ulex* than *A. ulicina* does.

Mr. Luehmann, in sending me a piece of the Lake Wagin specimen, added the note "differs from *A. ulicina* in the short truncate calyx as well as in fruit." There is no fruit in my specimen, and I suggest that, through short-sightedness, he may have mistaken a phyllode for it.

The differences between *A. ferocior* and *A. ulicina* appear to be as follows. *A. ulicina* has longer, more subulate phyllodes, those of *A. ferocior* are club-shaped to falcate. *A. ulicina* has 25 flowers in the head, calyx irregularly lobed and more hairy; *A. ferocior* 7 in the head with a truncate calyx.

2. With *A. oxyclada* F.v.M. The two species are very different in habit and phyllodes, but have resemblance in the few (7) flowers in the head, in the morphology of the flowers, including the bracts.

In order to make the statements concerning these three species clear, it is necessary, in addition to the enclosed table, to give some detail drawings. See the Plates.

OXYCLADA.	SPINOSISSIMA (*leptacantha*)	ULICINA.	FEROCIOR.
Branches terminated by fine thorns	"Smaller than *ulicina*, and differs also in its rectangularly spreading branches" of that species. (Pritzel).	Rigid spreading shrub.	A shrub more strongly resembling *Ulex* than does *A. ulicina*.
Phyllodia. Linear, short, hardly striate. Symmetrically mucronate. Terminal gland.	Linear, not striate, obliquely mucronate.	Linear, striate, obliquely mucronate.	Flattened club-shaped, not striate, 1 main nerve, obliquely mucronate, gland a little way up from base.
Flowers. 7 in the head, Petals free, smooth, small calyx with ragged lobed edges. Ovary smooth. *Foliaceous bracts*	20 in the head. Petals smooth, free. Very small calyx with an inflated appearance, ragged edge. Ovary smooth. *No floral bracts found.*	20 in the head. Petals smooth, divided half way down, calyx irregularly lobed, ciliate. Ovary smooth. Large coarse floral bracts.	7 in the head, petals free, 4 or 5. Calyx turbinate with irregular edge, shortly ciliate. Large bract apparently enclosing the flower head. Ovary smooth.
Pods. Moniliform. Seeds globose, ridged and with an arillus covering one side.	Moniliform. Seeds too immature to draw or describe.	Moniliform, with globular seeds with a marked ridge opposite the arillus.	Not seen.

A. Basedowii n. sp.

Probabiliter frutex divaricatus, spinosus, ramulis gracilibus, teretibus in spinam terminantibus. Phyllodiis augusto-spathulatis, obtusis, glandula minuta proxime infra mucronem brevem, pilis brevibus albis tectis, ca. 1 cm. longis, 2 mm. maxima latitudine, obscure 3-nerviis. Stipulis aristatis, pluribus basi phyllodiorum. Pedunculis solitariis vel geminis, 1 cm. longis, capitulis globosis ca. 30 floris. Calyce obtuse lobato, lobis pilis albis dense fimbriatis, corollæ minus dimidium æquante. Petalis sparse villosis. Ovario glabro. Legumen ac semen non vidimus.

Evidently a divaricate thorny shrub, but no particulars available as to size, etc. The few specimens available show slender terete branches, white with a pellicle and sparingly besprinkled with short white hairs, terminating in spines.

Phyllodia narrow-spathulate, obtuse, with a minute gland immediately beneath the short mucro. Closely besprinkled with short white hairs. Not much more than 1 cm. long and about 2 mm. in the widest part, obscurely 3-nerved, with intermediate secondary nerves. Stipules aristate, several at the base of each phyllode.

Peduncles singly or in pairs, about 1 cm. long, each bearing a globular head of about 30 flowers, 5-merous, the buds closely packed.

Calyx obtusely lobed, the lobes densely fringed with white hairs, less than half as long as the corolla. Petals sparingly besprinkled with hairs. Ovary glabrous. Pods and seed not seen.

Type, Musgrave Ranges, Northern Territory (Dr. H. Basedow 1903, No. 70).

Dr. H. Basedow, Musgrave Ranges, Government North West Expedition, 1903, No. 70 (received labelled as *A. erinacea* and a few specimens distributed under that name).

Synonym.—*A. ulicina* Meissn. var. *oxyclada* Mueller and Tate, Herb.

A. Basedowii is identical with a specimen sent to me by Tate from the Adelaide Herbarium labelled "*A. ulicina* var. *oxyclada*, McDonnell Range. W. H. Tietkens, July 6, 1889." There is no record of this plant in Tietkens' Diary in his Journal of the Expedition, nor in the catalogue (furnished by Mueller) of the plants collected, at the end of the Journal.

It is, however, recorded twice in botanical literature, viz.:

1. "Report on Horn Exped. (Botany)" p. 155, March, 1896. Name only, and "West of McDonnell Range (Tietkens)."

2. W.A., Skirmish Hill. Mueller and Tate, "Report on Botany of Elder Expedition." (Trans. Roy. Soc. S.A., XVI, 351, June, 1896).

As I could not find any published record of the variety, I wrote to Professor Ewart of the Melbourne Herbarium, and he informed me that he also cannot trace any.

Affinities.

1. With *A. oxyclada* F.v.M. Both species have narrow phyllodes (those of *A. oxyclada* are the narrower), and each has a short central mucro, close to which is a central circular gland, (apparently not common in the genus), but the phyllodes of *A. oxyclada* are glabrous and those of *A. Basedowii* slightly pubescent. The flowers are very different, the calyx, with very hairy upper portion, being long and conoid, that of *A. oxyclada* being short and very much shorter in comparison with the petals than is *A. Basedowii*. The pod of the latter is unknown.

2. With *A. erinacea* Benth. The phyllodes of the two species are different in shape, those of *A. erinacea* being obovate-oblong or lanceolate, with a very small gland about half way up on the curved margin. The flowers in *A.*

erinacea are fewer, and the calyx very short and scarcely hairy, and about one fourth of the length of the petals, being very much shorter proportionately than those of *A. Basedowii.*

Uninerves (Racemosæ).

A. HAMILTONIANA n. sp.

Frutex erectus dumosus, 5 – 6′ omnino glaber, ramulis angularibus. Phyllodiis lanceolatis, in acumen tenue angustatis, plerumque 4 – 4·5 cm. longis 5 mm. latis, coriaceis, uninerviis, marginibus crassis nervis similibus, venulis inconspicuis, glandula (quum praesente) basin versus. Racemis multis capitulis ca. 20 floris, 5-meris. Sepalis crassis, spathulatis, angularibus, apice et angulis pubescentibus, corollæ dimidium æquantibus. Petalis glabris. Ovario plano. Legumine 8 mm. lato inter semina contracto, valvis marginibus crassatis, seminibus longitudinaliter dispositis. Arillo clavato, funiculo breve.

An erect bushy shrub of 5 or 6 feet, quite glabrous, exhibiting a bluish-green cast when growing, branchlets angular.

Phyllodia lanceolate, straight or a little curved, sometimes tending to be spathulate, terminating in a fine point, the end of the phyllode sometimes bent obliquely, usually $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, rigidly coriaceous, one-nerved, with thickened nerve-like margins, the veinlets inconspicuous, with or without marginal glands, the gland when present being about one-fifth of the way up from the base.

Racemes not exceeding or equalling the phyllodes, with numerous heads of about twenty flowers, all 5-merous.

Sepals thick, spathulate, angled, fringed at the top and along the angles with fine hairs, half as long as the corolla. Petals glabrous. Ovary smooth.

Pod $\frac{1}{4}$ inch broad, the valves with a raised rim along the margin, the pod contracted between the seeds, which are longitudinally arranged.

Seed with a club-shaped aril and a funicle short or as long as the seed, but not encircling it.

Type from Leura, Blue Mountains, N.S.W. (A. A. Hamilton) in National Herbarium of New South Wales. Identical with Sieber's No. 464, which is figured at Plate 181, Part XLVIII of my "Forest Flora of New South Wales."

The history of the species, and a description in English, will be found at Part XLVIII, p. 153 of my "Forest Flora of New South Wales."

Synonyms.—1. *A. crassiuscula* Sieber. This name, however, is barred by reason of the earlier *A. crassiuscula* Wendl. (See my Forest Flora, Part XLVIII, p. 153).

2. *A. obtusata* Sieb. var. *Hamiltoni* Maiden (*loc. cit.*)

Range.

This species is at present only known from the higher parts of the Blue Mountains. N.S.W., viz., from Leura to Clarence Siding, and I invite the attention of observers to extend records of its habitats. There seems no doubt that this rare species is a disappearing one, and that it is displaying a greater tendency to assume the vegetative method of reproduction. It is becoming difficult to get ripe seeds, and people who have it in their ground at Leura find that it largely spreads by underground stems.

Affinities.

It is very closely allied to *A. obtusata* Sieb., figured in my "Forest Flora of New South Wales," Part XLVIII, Plate 177, in flowers.

Mr. R. H. Cambage informs me that the seedlings of *A. Hamiltoniana* have more bipinnate leaves than *A. obtusata*, and that the internodes are shorter. Mr. Cambage has described the seedlings of *A. obtusata* in this Journ., Vol. LII, p. 424 (1918), and will shortly furnish a description of those of *A. Hamiltoniana*.

If Plate 181 *(A. Hamiltoniana)* and Plate 177 *(A. obtusata)* of my "Forest Flora of New South Wales" be compared, it will be seen that the funicle is much shorter and the disposition of the seed more longitudinal in the former species, while the phyllodes of the two species are very different. Those of *A. obtusata* are usually almost spathulate with a prominent marginal gland about a third of the way up from the base, which has the effect of causing a deflection of the margin on the side opposed to the stem. Those of *A. Hamiltoniana* are narrow-lanceolate, almost symmetrical, rigidly coriaceous, acuminate, one-nerved, with thickened nerve-like margins, a gland about one-fifth of the way up from the base.

A. Chalkeri Maiden, this Journ. xlix, p. 482.

Mr. R. H. Cambage gave me flowering specimens (December) from the type locality, showing that they are bright yellow in colour and strongly and sweetly scented. The species was then in full bloom.

A. Kettlewelliæ, this Journ. xlix, p. 484.

Mr. W. A. W. de Beuzeville, Forest Assessor, Forest Department, gives the following useful notes on a little known species:—

"A shrub varying from two feet to fifteen feet high, usually about the former height when growing in thick scrubs and attaining the latter when growing under more or less isolated conditions. Erect in habit, reminding one rather of *Acacia decora* in appearance but more compact. Blooms very freely, in fact produces a more luxuriant crop of blossoms than any other Acacia that I have seen in this locality; greatest diameter I have seen is about three inches. It favours generally rough granite hillsides, on the higher slopes, often to be seen in the deep rough gullies where it seems to attain its greatest height growth growing in company with *Daviesia corymbosa* generally at an elevation of more than

3,000 feet, though I have seen it occasionally at 2,000. It is undoubtedly the most handsome Acacia to be found in these mountains." [He is writing from Batlow, and is speaking of the Batlow Forest Reserve, a new locality.]

A. CLUNIES-ROSSIÆ Maiden, this Journ. XLIX, p. 486.

This has hitherto only been recorded from the Kowmung district, N.S.W., and so a second locality, Cox's River, foot of Mount Solitary, via Wentworth Falls (D. W. C. Shiress) which is a number of miles to the north (it is difficult to measure distances in this broken country) is worthy of record.

(*a*) A. BRACHYBOTRYA Benth. (*b*) A. ARGYROPHYLLA Hook. (*c*) A. SPILLERIANA J. E. Brown.

In Plate 200, Part LIII of my "Forest Flora of New South Wales," these forms are figured. In bringing (*b*) under (*a*) I followed Bentham and Mueller, and in bringing (*c*) under (*a*) I followed Mueller, but I have arrived at the conclusion that they should be kept as distinct species. They seem sufficiently dealt with in the work in question.

Plurinerves (Triangulares).

A. DELTOIDEA A. Cunn.
(Syn. *A. stipulosa* F.v.M.)

In B. Fl. ii, 379, Bentham, speaking of *A. stipulosa*, says "Very near *A. deltoidea*, differing chiefly in the flowers twice as large, and in the proportion of the calyx and corolla." In my experience there are no important differences in the size of the flowers. But a specimen is before me (Fitzroy River, A. Forrest) with a head of flowers twice as large as normal, but they are swollen as the result of insect action. Mueller had not finally made up his mind as to specific differences, for in Fragm. XI, 117, speaking of *A. stipulosa*, he says, "species *A. deltoideæ* ulterius comparanda."

I have long doubted that they were separate species, but there were difficulties because of the scarcity of type material of *A. deltoidea*. I have lately undertaken the examination of certain North Western Australian Acacias collected by Mr. W. V. Fitzgerald, and found a memo by him "*A. stipulosa* not specifically distinct" (from *A. deltoidea*).

Mueller in his "Iconography" figures *A. stipulosa* but does not depict *A. deltoidea*. The flowers depicted are so unsatisfactory, a matter of great importance in Acacia, that the plate has contributed to the uncertainty of the relations of the two species, and I offer drawings which will be more satisfactory than the Iconography plate.

There seems to be nothing in the specimens of the *A. deltoidea-stipulosa* series that shows more than a little variation, hardly amounting to a variety, and I am of opinion that *A. stipulosa* is a synonym of the previously described *A. deltoidea*. In the Edkins Range specimen a glandular angle is almost imperceptible, there being a swelling curve from the gland to the apex. The flowers are 50 – 60 in the head. The pod is rather more than 1 cm. broad and 4 cm. long, with seeds transverse or oblique.

Range.

So far the species is only known from tropical Western Australia. The following localities are in the West Kimberleys. Edkins Range (W. V. Fitzgerald, No. 1421, April 1905). Packhorse Range (W. V. Fitzgerald, No. 999, May 1905). Sunday Island, West Kimberley (W. V. Fitzgerald, November 1906).

Then we have, practically from the same district, King's Sound (All. Hughan, see Fragm. XI, 117); Fitzroy River, which flows into the Sound (A. Forrest, 1879, comm. Dr. F. Stoward); also east of the Oscar Ranges, Humbert River (see Vol. LI, p. 100 of this Journal).

A. Luehmanni F.v.M. in Fragm. xi, 116. Figured in "Iconography."

The Iconography figure is somewhat diagrammatic as regards the flower, and a fresh drawing is submitted. A more important error is that of the ovary, which is shown as glabrous when, as a matter of fact, it is densely hairy. The ovary is not mentioned in the original description, and the figure referred to is probably a slip of the artist. I would point out that the type locality, Liverpool River, is really Northern Territory; the localities given in this Journ. li, 108, belong to North Western Australia as so stated.

A. Froggattii n. sp.

Frutex valde ramosus, glanduloso-pilosus, ramis teretibus. Phyllodiis oblique curvatis, triangulare-ovatis, margine superiore valde curvato, acutis, 6 cm. × 3 cm., 5-nerviis, nervis marginalibus in acumen acutum continuatis. Stipulis aristatis, geminis. Pedunculis plerumque solitariis ca. 1·5 cm. longis, capitulis globosis ca. 25-floris. Calycis parte inferiore poculo simile formato, 5 lobis triangularibus, calyce triente corollam æquante, villoso. Petalis angustis partim villosis. Ovario plano. Leguminibus minus 4 cm. longis ac 5 mm. latis, valvis inter semina leniter levatis, glanduloso-hispidis. Seminibus longitudinalibus, ovoideis, funiculo filiforme in arillum carnosum duabus vel pluribus plicis dilatum.

A much branched, glandular-hirsute shrub, probably of no great height; branches terete.

Phyllodia obliquely curved, somewhat triangular-ovate, the upper margin especially curved; acute, 6 cm. long, by 3 cm. broad, three nerved for the most part, in addition to two marginal nerves which are continued into a sharp point, the upper margin with a small gland near the middle, but without a glandular angle. Stipules aristate, in pairs.

Peduncles usually single, about 1·5 cm. long, bearing each a globular head of about 25 flowers, mostly 5-merous.

Calyx cup-shaped in the lower part, surmounted by five triangular lobes; the calyx about one-third the length of the corolla, hairy. Petals rather narrow, hairy externally as far as the blunt lobes. Stamens very numerous. Ovary smooth.

Pods (but few seen) under 4 cm. long and 5 mm. broad, the valves only slightly raised between the longitudinally arranged seeds, glandular-hispid.

Seeds ovoid, the filiform funicle after two folds dilated into a fleshy aril of two or more folds.

Type. Woollybutt Creek, near Phillip's Range, North West Australia (W. V. Fitzgerald No. 981, May 1905).

Named in honour of Walter Wilson Froggatt, Government Entomologist of New South Wales, in recollection of his collecting tour in this district (Kimberley West). He is President of the New South Wales Branch of the Wattle Day League, and has long taken an interest in the national flower.

Range.

Woollybutt Creek near Phillip's Range (W. V. Fitzgerald, May 1905, No. 981).

Affinities.

1. With *A. deltoidea* A. Cunn. The phyllodia of *A. Froggattii* are dull green, in contrast with the more shiny yellow phyllodia, with shorter hairs and more prominent marginal veins, of *A. deltoidea*. The latter species has laciniate calyx-lobes, an ovary covered with short hairs, and a larger pod whose valves are lobed dorsally.

2. With *A. Luehmanni* F.v.M. The phyllodia of *A. Froggattii* are dull green as contrasted with the more shiny yellow of *A. Luehmanni*. Those of the latter are less hairy, except at the base, broader and more quadrilateral, with the gland in a glandular angle, and with broader stipules. The latter species also has a broader calyx, with shorter

calyx-lobes, which are hairy only at the tips of the lobes, and glabrous petals. Further it has a densely hairy ovary in contradistinction to the glabrous one of *A. Froggattii*, and also a long, narrow, glabrous pod.

Plurinerves (Microneura).

A. EREMEA n. sp.

Frutex erectus vel arbor parva. Phyllodiis pulchris, argenteis, lanceolatis, angustis, 5 – 7 cm. longis, 4 mm. latis, crassis, tenuissime striatis, nervis parallelibus. Pedunculis geminis vel pluribus, ca. 5 mm. longis, pilis aureis tectis, capitulis globosis ca. 30 floris. Sepalis spathulatis, pilis sparse tectis, corollæ minus dimidio æquilongis. Petalis per totum hirsutis, marginibus ciliatis. Ovario hirsuto. Legumine latuisculo, breve tomento tecto, reticulariter venoso, ca. 1 dm longo, 6 mm. lato; seminibus longitudinaliter dispositis. Semina non vidimus.

An erect shrub or small tree with beautiful silvery foliage, the result of a very short tomentum, branchlets at first slightly angular.

Phyllodia straight, or slightly falcate, lanceolate, narrow, tapering to both ends, with a rigid point, 5 – 7 cm. long, 4 mm. broad, thick, very finely striate with parallel nerves only to be seen under a lens. An ill-defined gland at the base.

Peduncles in pairs or more, covered with golden hairs and about 5 mm. long, bearing globular heads of about 30 flowers, mostly 5-merous. Bracts conoid-capitate.

Sepals spathulate, besprinkled with hairs, particularly towards the top, scarcely half as long as the corolla. Petals hairy all over, and ciliate at the edges, free. Ovary hirsute.

Pod of medium width, twisted (?), covered with a very short tomentum and very finely and reticulately veined, about 1 dm. long and 6 mm. broad, the valves moderately convex over the seeds, which are slightly contracted between them; seeds longitudinally arranged.

The type is Milparinka, N.S.W. (C. G. Ivey, September, 1906). In flower, but only one valve of a pod available, and that probably not quite ripe.

The specific name is given in reference to the dryness of the country in which it is found.

Range.

It is a dry country species, and, so far as we know at present, confined to the driest parts of New South Wales and Queensland. At the same time, I rather confidently expect it to be found in north-eastern South Australia or the Northern Territory, nearest to the New South Wales and Queensland localities.

New South Wales.

With the exception of the "Riverina" locality, which is too vague, the species is only recorded from the White Cliffs and Milparinka districts, trans-Darling localities on the route from Wilcannia to the extreme north-west of the State.

Riverina (L[ockhart] Morton). Labelled *A. homalophylla* by Mueller). In unripe curved pods; phyllodes rather broad.

"Nealie." E. P. O'Reilly, Public School, White Cliffs. In flower. "Nilyah," bushy, 14 miles south-west of White Cliffs. Inclined to follow damp courses (J. E. Carne through R. H. Cambage). Foliage only.

"Branches erect. The Nilyah has never been known to flower in this district. I am rather reticent as to whether this is the real Nilyah about here. It is pronounced Nilyah, Nelie and Nelia"(C. G. Ivey, Public School, Milparinka 1905). In flower.

Twelve feet high, branches pendent to the ground. *Acacia pendula*, Evelyn Creek, Sept. 1887 (Mueller's label). (The label of the collector, W. Baeuerlen, reads "Koorningbirry, Sept. 1887, William Baeuerlen, No. 176). The locality is

Lat. 30°, Long. 142° 7, a few miles south of Milparinka. In this specimen the flowers are from 2 to 7 in a node.

Queensland.

"Locally called Boree. Has silvery appearance." Thompson River, Longreach. (R. H. Cambage, No. 3971). In early pod, slightly falcate. Recorded provisionally as *A. homalophylla.*

Affinities.

A. homalophylla A. Cunn. *A. homalophylla* is a medium sized, erect tree, known as Yarran. The phyllodia present considerable external resemblance, except that those of *A. homalophylla* are not silvery. The sepals of that species are truncate-undulate, not spathulate, while the pods (see Plate 189, fig. E of my "Forest Flora of New South Wales") are straight not twisted, and not reticulately veined as in *A. eremea.*

A. lineolata Benth. If flowers are available, the two species can readily be separated, as the heads are almost sessile in *A. lineolata.* The pods of that species remain unknown. The phyllodes of the two species present a good deal of similarity in shape and texture, but those of *A. lineolata* are smaller and more glabrous.

	1 *rigens.*	2 *eremea.*	3 *Loderi.*	4 *Sowdeni.*
	A *Needle-bush* up to 10 or 15 feet. *Green.*	Erect shrub up to 15 feet. *Very silvery.*	A hoary or glaucous dense shrubby tree, up to 20 feet. Wood deep brown; bark flaky-fibrous.	Mallee-like small tree, up to 20 feet. *Very silvery when young.*
Phyllodia	*Filiform,* compressed, nearly terete, rigid. "About three-nerved." Finely striate. 3–4 inches (7·5 – 10 cm.) long, or 2 – 2½ (5-6·5 cm.) (Benth).	Straight, *lanceolate.* Rigid, very finely striate. 5 – 7 cm. long, 4 mm. broad.	Linear, finely striate with parallel nerves, besprinkled with short hairs. 10 or 11 cm. long, 2 mm. broad.	Linear. Moderately rigid. Finely striate with parallel nerves, besprinkled with short hairs when young. 6–8 cm. long, 3 mm. broad.

	1 *rigens.*	2 *eremea.*	3 *Loderi.*	4 *Sowdeni.*
Peduncles	Very short.	In pairs, covered with golden hairs; 5 mm. long.	In pairs, densely hairy.	In pairs or threes. 5 mm. long.
Number in head	Twenty. *More or less viscid.*	*Thirty*	*Thirty-six.*	*Twenty-five.*
Bract	Conoid-capitate	Conoid-capitate.	Fan-shaped at top.	Oblique topped.
Sepals	Spathulate, hairy, but chiefly upper half.	Spathulate, hairy, but chiefly upper half. *More hairy than others.*	Spathulate, hairy, chiefly at top.	Spathulate or almost linear. Hairy at tips.
	About half as long as corolla.	Scarcely half as long as corolla.	Half as long as corolla.	About half as long as corolla.
Petals	Glabrous.	Hairy all over	Smooth.	Very sparsely besprinkled with hairs.
Ovary	Hoary-pubescent.	Hirsute.	Densely hairy.	Hirsute, particularly upper portion.
Pod	Narrow linear, *twisted, 7·5 cm. long; 3 mm. broad.* Slightly contracted between seeds. Puberulous.	Medium width, *twisted into a double curve.* Grey tomentum. *Reticulately veined. 1 dm. long, 6 mm. broad.*	*Markedly moniliform, 8 cm. long, 4 mm. broad.* Glaucous. *Much contracted between seeds.*	*Broadish,* curved, *chartaceous, 11 cm. long, 5 mm. broad. Pale brown, reticulate.*
Seed	Ovate, *black,* longitudinal.	Longitudinally arranged. (Not seen).	*Brownish-black,* ovoid.	*Brown,* ovoid.
Funicle	*Several folds,* turbinate almost cup-shaped aril.		*Pendulous,* with small arillus (like 4), encircling seed for half its length (like 4).	*Pendulous,* etc. (like 3).

A. LODERI n. sp.

Arbor parva, ligno brunneo, cortice lamelloso-fibrosa. Phyllodiis numerosissimis linearibus ca. 10 vel 11 cm. longis, 2 mm. latis, tenuibus, pilis brevibus tectis, tenuissime striatis, nervis parallelibus. Pedunculis dense hirsutis, capitulis densis globosis in racemis, ca 36-floris. Sepalis spathulatis, apice hirsutis, corollæ dimidio æquilongis. Petalis lævibus. Ovario dense hirsuto. Legumine tomento tecto, prominenter moniliforme ca. 8 cm. longo, 4 mm. lato, super semina convexo. Seminibus brunneo-nigrascentibus, ovoideis, funiculo longo, filiforme, pendulo in arillum paullo ampliatum terminante.

A hoary or glaucous, dense shrubby tree, up to about twenty feet high. Wood deep brown, bark flaky-fibrous, and more or less furrowed, branchlets at first slightly angular.

Phyllodia linear, with a fine, hooked point, tapering towards the base, about 10 or 11 cm. long, 2 mm. broad, thick, besprinkled with short hairs, very finely striate with parallel nerves only to be seen under a lens, decurrent. A swollen gland at the base.

Peduncles in pairs or more, densely hairy, bearing dense globular heads of about 36 flowers, mostly 5-merous. In racemes as in *A. homalophylla*. Bracts fan-shaped at the top.

Sepals spathulate, free, hairy chiefly at the top, half as long as the corolla. Petals smooth, free. Ovary densely hairy.

Pod with a fine tomentum, narrow, markedly moniliform, up to 8 cm. long, 4 mm. broad, convex over the seeds and much contracted between them.

Seeds brownish-black, ovoid, with a distinct areole, with a long, thread-like pendulous funicle encircling the seed for half its length, and terminating in a slightly enlarged arillus at the top of the seed.

The type is Yancowinnia, Broken Hill district (A. C. Loder).

Range.

So far as we know at present it is confined to New South Wales, and mainly to the Broken Hill district, but so close to the South Australian border, that it is impossible for it not to occur in the latter State.

Thackaringa, west of Broken Hill, close to South Australian border (J. E. Carne, October 1907). In flower.

"Nelia," Mulculca Creek, twenty miles south-east of Broken Hill. (Assistant Forester Andrew C. Loder, No. 29, same tree as No. 17, January 1906). Phyllodes only, attacked by galls. Also flowers, October 1905.

Kars, some forty miles south-east of Broken Hill (A. C. Loder, January 1907).

"Nelia," Yancowinnia, Broken Hill district (A. C. Loder, November 1905). Flowers, wood and bark.

"Broken Hill Gidgee." Dense shrubby tree, hoary or glaucous. Twenty to twenty-two feet in extreme height. (E. C. Andrews, November 1918). Fruits and late flowers.

Ivanhoe viâ Hay. (K. H. Bennett 1886). In flower only and det. Mueller as *A. rigens*. These specimens accompanied the bark analysed as *A. rigens* in the second edition of my "Wattles and Wattle-barks." The specimens in my possession are not very good, and I invite attention to the district as a probable, not absolutely certain locality for the species.

Affinity.

With *A. Cambagei* R. T. Baker. This is the common "Gidgee," which is figured in Part XXXII of my "Forest Flora of New South Wales." It has odoriferous foliage, the phyllodes broader and the pods very different.

Julifloræ (Stenophyllæ).

A. COOLGARDIENSIS n. sp.

Frutex fere glaber. Phyllodiis subresinosis, lineare subulatis, minute striatis, rigidis, nervis tenuibus parallelibus, acumine breve pungente, 10 – 15 cm. longis. Spicis sessilibus, geminis, ovoideis vel oblongis, 6 vel 7 mm. Floribus 5-meris. Calyce spathulato vel angusto-lobato, apicibus pruinoso, corollæ dimidium æquante. Petalis planis, facile disjungentibus. Legumine stipitato, lineare, terete, inter semina vix constricto, ca. 8 cm. longo. Seminibus longioribus quam latis, longitudinaliter dispositis, funiculo longo, filiforme, arillo lato, oblongo.

An almost glabrous shrub, with scarcely angular branchlets, very soon terete.

Phyllodia slightly resinous or gummy, linear-subulate, rigid, with a short pungent point, 10 – 15 cm. long, terete and minutely striate, with very fine parallel nerves, scarcely visible without a lens, slightly wrinkled and hoary at the base.

Spikes sessile, in pairs, dense, ovoid or oblong, not above 6 or 7 mm. long.

Flowers 5-merous, the floral-bract capitate or spathulate, with a rugose apex.

Calyx spathulate or narrow-lobed, sometimes the sepals less divided to the base, rugose or hoary at the tips, thin, nerved, fully half as long as the corolla. Petals smooth, partly united, but easily separating. Ovary hoary.

Pod shortly stipitate, linear, terete, scarcely contracted between the seeds, smooth, slightly resinous, about 8 cm. long.

Seeds longer than broad, longitudinally placed in the pods, with a long filiform funicle (which suspends the seed when the pod is open), terminating in a broad hemi-ellipsoid to oblong arillus embracing the bottom of the seed.

Type, Coolgardie, Western Australia (1899 – 1900). Description of fruits from Kunonoppin (Dr. F. Stoward, No. 75). I have not seen the specimens, but it is probable that the pods and seeds described by the late Dr. A. Morrison in the "Scottish Botanical Review" for April 1912, p. 99, under the name of *A. aciphylla* Benth. (Kunonoppin, F. E. Victor) belong to *A. Coolgardiensis*.

Range.

It is confined to Western Australia, and, so far as has been ascertained at present, only from the Watheroo Rabbit Fence to the vicinity of Kalgoorlie. The species with filiform, more or less terete, rigid leaves have been confused with each other more or less, and casual travellers and explorers (usually with little botanical knowledge), naturally look upon them as more or less alike, and hence do not frequently collect them. Botanists desire to invite the attention of collectors not so much to bizarre or "obviously different" plants, but rather to plants of a somewhat similar facies. The problem of the botanist is to discriminate those which superficially appear to be alike.

I have it from the following localities:—132 miles and upwards, Watheroo Rabbit Fence (Max Koch, 1338a, Sept. 1905). Kunonoppin (Dr. F. Stoward No. 75).

A tall shrub. Cowcowing (Max Koch No. 1025, Sept. 1904). Received as *A. leptoneura*.

Bruce Rock-Merriden district (Dr. F. Stoward Nos. 8 and 14).

Coolgardie (L. G. Webster) received as *A. aciphylla*, Kurrawang (Dr. J. B. Cleland).

Affinities.

1. With *A. aciphylla* Benth. The type of *A. aciphylla* is Drummond's 4th Coll. No. 14, which I have seen; Mueller has not figured the species in his "Iconography." The outstanding differences between the two species are the thicker, more rigid and decurrent phyllodia, with a different striation, the very shortly lobed turbinate calyx and the "about 1 in. long" (2·5 cm.) pod of *A. aciphylla*. The

present species has been, by some competent Australian botanists, who have not seen the type, referred to *A. aciphylla.*

2. With *A. Burkittii* F.v.M. This is figured in Part LIX of my "Forest Flora of N. S. Wales," and differs from *A. Coolgardiensis* in the phyllodia. In the former species they are ribbed, almost quadrangular, with a weak, tapering point which is very hairy. The fruits of the two species are very different, those of *A. Burkittii* being comparatively broad and moniliform, with a larger, less elongated seed. There are also differences in the flower.

3. With *A. leptoneura* Benth. This species (one of the Calamiformes, sometimes confused with *A. Coolgardiensis*) also has narrow sepals, and is referred to at Vol. LI, p. 261. It differs from *A. Coolgardiensis* in the long, fine phyllodes, and the flattish translucent pods of *A. leptoneura.*

4. With *A. filifolia* Benth. The phyllodia of *A. filifolia* are not terete; they are quadrangular with prominent nerves and some hoariness between them; those of *A. Coolgardiensis* are terete. The calyx of *A. filifolia* is turbinate-truncate and the other details of the flower are different.

A. ONCINOPHYLLA Lindl. var. FAUNTLEROYI n. var.

A tall thin-stemmed shrub, locally called "Fibre-bark Wattle," because of the peculiar way in which the bark peels off in numerous thin, narrow layers of curly bark, useful for stuffing or packing purposes.

The plant is so viscid that it sticks to paper on being pressed, like some other species. The resinous substance gives the plant a delightful turpentinous odour.

The branchlets somewhat angular, the extremities covered with a short white pubescence which is shortly succeeded by a thin flattish, flaky, brownish bark, which later on peels off in curly flakes.

Phyllodia aromatic, covered with short white hairs, linear, straight or slightly curved, with an oblique or hooked point, 10 – 20 cm., 3 – 4 mm. broad, flat, but thick and rigid, with seven or more nerves, the central one usually more prominent, a gland sometimes seen near the base, often concealed by the indument.

Spikes mostly in pairs, with hairy peduncles of 5 or 6 mm., dense, short, about 1·5 cm. long, and under 1 cm. broad. Flowers mostly 5-merous. Bracts spathulate, ciliate on a long slightly curved slender stipes quite as long as the calyx.

Calyx cylindroid, irregularly lobed, the upper portion covered with long hairs, more than half as long as the corolla.

Petals sparingly besprinkled with hairs, particularly in the upper portion; united to the lobes. Ovary enveloped in long white hair.

Pod stipitate, linear, straight or very slightly curved, about 1 dm. long and 5 mm. broad, densely villous with silvery hairs.

Seeds ovate, with an areole of the same outline, obliquely arranged in the pod, with a long suspensory funicle, terminating in a fleshy arillus.

"Grows on the granite in cracks to a fair size, has a pretty way of shredding its bark. I have not seen it off the granite rocks." (C. A. Fauntleroy, Uberin Hill, Dowerin, W.A., in a letter to Mr. W. C. Grasby, "Western Mail," Perth.)

A tree forming a dense thicket. Yarrigin. Flowers only. (Dr. F. Stoward, No. 155).

Affinity.

With *A. oncinophylla* Lindl. (typical form).

This species is so imperfectly known, that I have considered it desirable to describe the variety at length, and to contrast it with its species.

A. oncinophylla.	Var. *Fauntleroyi.*
Phyllodes 3-nerved, one on each side of central nerve. Gland removed from base $\frac{1}{4}''$.	A coarser plant. Phyllodes 5–7 nerved, usually three nerves on each side of central nerve. Gland, when found, at extreme base. Longer and broader.
Petals glabrous, the calyx cleft to the base. Hairy. Large bract. The peduncle to the flower spike is usually very short.	Petals hairy, calyx truncate, irregularly lobed, hairy. Large floral bract differing in shape from *oncinophylla* (typical), (and with more slender stipes). The peduncle to the flower spike is sometimes as long as the spike itself. Spike thicker.
The pod is golden pubescent.	The pod covered with a mat of silver hair, and very much longer; also broader.

Julifloræ (Falcatæ).

A. DORATOXYLON A. Cunn.

This species is figured and described at Part XXXVII of my "Forest Flora of New South Wales. It has become necessary to re-examine material of it contained in the National Herbarium, Sydney. The type came from the vicinity of the Lachlan River, about half way between the modern Cowra and Forbes. The following specimens are very close to the type. I think it convenient to separate some of the material into a variety *angustifolia*. We have, however, intermediate forms, and, on the other hand, I have seen the species (Wyalong) with phyllodes up to 7 mm. broad.

New South Wales.—"Currawang," Bedooba and other stations; common in Lachlan district (J. Duff). Euabalong, Lachlan River (R. H. Cambage). Cobar (Archdeacon F. W. Haviland). Wagga Wagga (J.H.M., T. H. Patterson, No. 201). "Currawang," Wyalong (District Forester Osborne; J. E. Carne, with phyllodes up to 7 mm. broad). Temora (Revd. (now Bishop) J. W. Dwyer, Nos. 130 and 997; No. 654 with phyllodes up to 6 mm. broad). "Currawang," Forbes (Forester H. W. Garling). Gungal near Merriwa (J. L. Boorman).

Queensland.—Trees of 20—30 feet. Inglewood (J. L. Boorman). Near Dalby (Col. Botanist of Queensland).

Var. ANGUSTIFOLIA var. nov.

A shrub eight feet in height with narrow phyllodes of about 2 mm. Eidsvold, Queensland (Dr. T. L. Bancroft, No. 32, with photo.)

In its typical form this is so striking as to puzzle people who know the normal form of *A. doratoxylon.* At the same time, *A. doratoxylon* sometimes produces specimens which have narrow or intermediate phyllodes almost as narrow as those of var. *angustifolia.*

The Jack's Creek, Narrabri, N.S.W., specimen is figured at G, Plate 141 of my "Forest Flora of New South Wales." Following are some localities:

New South Wales.—Bogan Gate (J. L. Boorman). "Currawang," "Boree," Bowan Park, near Cudal (W. F. Blakely). Harvey Range, Peak Hill (J. L. Boorman). Tree of 20—30 feet, Coolabah (J.H.M. and J. L. Boorman). An intermediate form. "Large shrub, growing on sandy loams and poor sand." Parishes of White and Cocaboy, Co. of White, 30—40 miles south of Narrabri, within Pilliga Scrub

(Forest Guard T. W. Taylor). Goona, Pilliga Scrub (W. A. W. de Beuzeville, No. 6). Bohena Creek to Boggabri (Dr. H. I. Jensen). 6 – 10 feet. A very rare plant in the district, growing on the side of Jack's Creek, Narrabri (J. L. Boorman). Warialda (W. A. W. de Beuzeville, Scrub No. 1).

Queensland.—Near Goondiwindi (Dr. John Shirley). Eidsvold (Dr. T. L. Bancroft).

A. PROXIMA Maiden, this Journ. LI, 105.
(Syn. *A. camptoclada* Pritzel).

It is a tropical congener of *A. doratoxylon.* I have not yet seen satisfactory pods, and some differences between the two species have already been gone into (*loc. cit.*) It may be added that *A. proxima* has a shorter calyx, only half the length of the petals, whereas the proportion is one third in *A. doratoxylon.* The ovary is much more densely hairy in *A. proxima.*

Additional localities in North West Australia are Broome, West Kimberley (No. 126), and near junction of Lennard and Barker Rivers (No. 1546). (Both collected by W. V. Fitzgerald).

A. SHIRLEYI n. sp.

Arbor erecta altitudinem 50′ attinens, diametro 1′. Cortice inæquale, sulcata, lamellis fibrosis. Phyllodiis angusto-lanceolatis, falcatis, breviter acuminatis, 12 – 15 cm. longis, 5 mm. – 1 cm. latis, nervis numerosis tenuibus parallelibus, nervo medio prominentiore. Spicis breviter pedunculatis, solitariis vel fasiculatis 5 – 6 cm. longis, angustis, interruptis. Calyce breve, sinuato-dentato, corollæ minus dimidium æquante. Petalis revolutis. Ovario dense piloso. Leguminibus breviter stipitatis, rectis vel fere rectis, 3 – 4 mm. latis, 10 – 11 cm. longis, super seminibus convexis, valvis sublignosis. Seminibus ovoideis. Funiculo bis curvato et in arillum parvum poculo similem expanso.

An erect, medium sized tree, attaining a height of fifty feet with a trunk diameter of one foot. Bark thin, rugged, furrowed, flaky-fibrous, almost stringy. Timber long-grained, splits readily; brown with a tinge of red, and with a pleasing figure.

Glabrous, sometimes with an ashy hue, branchlets at first acutely angular, but soon terete, except for the decurrent processes from the bases of the phyllodes.

Phyllodia narrow-lanceolate, falcate, shortly acuminate, and often with oblique or recurved points, 12 to 15 cm. long, 5 mm. to 1 cm. broad, narrowed towards the base, moderately thick, with numerous fine parallel nerves, the central one more prominent.

Spikes shortly pedunculate, solitary or clustered, 5 – 6 cm. long, narrow, interrupted. Flowers mostly 5-merous.

Calyx shallow, sinuate-toothed, not half as long as the corolla, densely hairy. Petals revolute, with slightly prominent midribs. Ovary densely hairy.

Pods shortly stipitate (stipes under 1 cm.), linear, straight or nearly so, 3 or 4 mm. wide and 10 or 11 cm. long, convex over the seeds, somewhat contracted between them, the valves somewhat thick and woody.

Seeds ovoid, with a small areole, longitudinal, the funicle bent twice and dilated into a small cup-shaped basilar arillus under the seed.

Type from Mount Rose, Eidsvold, Queensland (Dr. T. L. Bancroft, No. 14).

Speaking of the local trees, Dr. Bancroft says—" In a big forest of Lancewood, the average would be nine inches, some twelve or over. The wood is very brittle and splits so readily as not to be of much use as a cabinet wood or for making boxes etc. The saplings are used for outsheds, fowl houses, last well in the ground and are not attacked by white ants. Wood has no smell. Splinters are said to cause bad and painful wounds. I have heard it said that a splinter of Lancewood is as bad as a snake bite. I think that's an exaggeration." Would this be owing to the presence of a saponin?

Named in honour of John Shirley, D.Sc., Principal of the Teachers' College, the University, Brisbane, and a well-known Queensland botanist. He has helped me to get specimens for my Acacia researches.

Range.

This is a native of Queensland and the Northern Territory. It occurs from Eidsvold to the Gulf of Carpentaria. Additional localities will be available as its differences from *A. doratoxylon* become known.

Queensland.—"Considered by me to be Lancewood, but said by some timber-getters not to be true Lancewood, but to be Bastard Lancewood. A fair-sized tree, good timber." Fruits only. Mount Rose, Eidsvold (Dr. T. L. Bancroft, No. 14 of 7th November, 1912). Flowers, March 1918.

"Lancewood," Rockhampton. Fruit only (Engineer-in-Chief for Railways, October, 1906, through C. T. White).

"Lancewood," Gilbert River. Fruit only (E. W. Bick, February 1914, through C. T. White).

Northern Territory.—"Mulga." Fruit only. Track (from Darwin to Katharine) near Bacon Swamp. (Prof. W. Baldwin Spencer, July – August, 1911).

MacDonnell Range (Tietkens' Camp 25 of 9th August, 1889). Flowers only. Distributed by Prof. Tate as *A. doratoxylon*. There is some confusion here. Camp 25 was 11th May at Watson's Range, south of the Macdonnell Range, Long. 131, Lat. 24. (The day before the Expedition had travelled fifteen miles through Desert Oak, Mallee and Mulga). 9th August was spent at Camp 80, where there was a "little Mulga channel." This camp was near the end of the journey, at no great distance from Charlotte Waters.

Affinities.

1. With *A. doratoxylon* A. Cunn. This is the species with which *A. Shirleyi* has long been confused.

A. doratoxylon is a tall shrub or small tree with range from the Lachlan River, N.S.W., to Southern Queensland. I am of opinion that Bentham had mixed material when (at B.Fl., ii, 403) he described *A. doratoxylon; e.g.*, I doubt his Northern Australian specimen (as indeed he does himself), and his Upper Maranoa, Q. (Mitchell) specimen might be re-examined.

A. Shirleyi attains a size far greater than *A. doratoxylon* attains. It is more glaucous than *A. doratoxylon*, the spikes are much longer and the flowers more interrupted, the calyx more shallow, the corolla densely hairy and the petals longer, the ovary densely hairy, the pods broader, flatter, more moniliform and more woody, the seeds broader and smaller, being only about half the length of those of *A. doratoxylon.*

2. With *A. proxima* Maiden. The chief points of difference are as follows. Phyllodes more falcate, gland raised, not depressed circular as in *A. proxima*, and usually more distant from the base. Spikes borne on a very short common peduncle (which is unusual); flowers more distant and the calyces golden pubescent, not hoary as in *A. proxima* and *A. doratoxylon;* rachis glaucous, not resinous. Pods larger, flatter and more woody.

A. SPARSIFLORA n. sp.

Arbor alta erecta, cortice sulcata, trunco 2′ diametro. Ramulis gracilibus, angularibus quum immaturis. Phyllodiis glabris, perviridibus, angusto-lanceolatis, falcatis ad 16 cm. longis, maturis ca. 8 mm. latis, 2 vel 3 venis tenuibus prominentioribus. Spicis interruptis, angustis, pedunculatis, 5 vel 6 cm. longis, rache glabra. Calyce truncato, margine sublobato, pubescente parte superiore petalis minus dimidio æquilongo. Petalis valde recurvatis, ciliatis. Ovario hirsuto. Leguminibus rectis vel paullo curvatis, linearibus, 13 cm. longis, 4 mm. latis, valvularum marginibus pallidis, inter semines constrictis. Seminibus longitudinalibus, elongato-oblongis, funiculo breve pendulo, tenuissimo arillum paullo crassatum formante.

A tall, erect tree, with a hard furrowed bark and a trunk diameter of two feet. Timber brown. Branchlets slender, angular when young, but soon becoming terete.

Phyllodia glabrous, bright green, narrow-lanceolate, falcate, narrowed at both ends, up to 16 cm. long, about 8 mm. broad in mature leaves, coriaceous, with two or three fine nerves rather more prominent than the numerous fine veins between them.

Spikes interrupted, narrow (with peduncles of 5 mm. to 1 cm.) up to 5 or 6 cm. long, solitary or in pairs, rachis glabrous. Flowers bright yellow, mostly 5-merous.

Calyx truncate, with the margin somewhat lobed, pubescent in the upper part, about a third as long at the petals. Petals very recurved; also ciliate. Ovary hirsute, particularly on the upper part.

Pod shortly stipitate, straight or slightly curved, undulate, linear, up to 13 cm. long, 4 mm. broad, valves with slightly thickened, pale-coloured margins, narrowed between the seeds.

Seeds longitudinal, embossing the valves moderately, shining, black, elongate-oblong, without an areole, sometimes slightly ridged, with short pendulous, thread-like, pale-coloured funicle which, after one or two folds, forms a slightly thickened arillus, enveloping the top of the seed.

Type, Dr. T. L. Bancroft's No. 5, Eidsvold, Queensland.

Range.

I only know the type specimen, which came from Eidsvold, a district west of Maryborough. It is there a sturdy tree, and I have no doubt that it will be found in many other parts of Queensland. There has been a good deal of confusion in regard to the Acacias in the series to which the present species belongs, and it is more than likely that it has been recorded under one or more names.

Affinities.

1. With *A. Solandri* Benth. The two species have a good many similarities, *e.g.*, in phyllodes, interrupted spikes, ovary and recurved petals. The trees appear to differ in size, though this is uncertain, but they do differ in the hirsute calyx in *A. sparsiflora*, in the remarkable ciliate margins of the petals, in the straight pods, and also in the seed and funicle.

2. With *A. julifera* Benth. The resemblances to this species are far less close. The phyllodes are very much alike, but in *A. julifera* the spike is dense, the calyx-lobes are spathulate and the pod is coiled.

3. With *A. leptostachya* Benth. This species has very angular branchlets, is "hoary or silvery-white with a very minute pubescence or nearly glabrous." The phyllodes are shorter and straighter, the spikes shorter, the pod moniform, covered with a fine tomentum, but not seen ripe. The two species have, however, certain similarities in the details of the flowers.

4. With *A. linearis* Sims. This is a slender shrub with pale-coloured flowers, whose affinities to the proposed new species are more distant.

A. RHODOXYLON n. sp.

Arbor mediocriter alta, ligno pretioso, cortice nigricante lamellis crispatis. Phyllodiis cineraceis sed glabris, oblongo-falcatis, apice obtuso, ca. 7 vel 8 cm. longis, $1\frac{1}{2}-2$ cm. latis, striatis, venis numerosis tenuissimis, 3 – 5 prominentioribus. Spicis 3 cm. longis, pedunculis 2 cm. rache glabra. Calyce truncato, irregulariter sinuato, dense tomentoso, petalis dimidio æquilongo. Ovario pruinoso. Legumine recto, lineare, 3 – 4 mm. lato ca. 3 cm. longo. Seminibus oblique dispositis, elongato-ovoideis, nigris, funiculo arillum parvum seminis apice mox formante.

A medium sized tree, say 15 metres (say 50 feet) high, with a stem-diameter of 6 – 9 inches. Wood very heavy, more or less interlocked, often ringy and then specially ornamental, colour rich reddish-brown on seasoning, but of a more or less umber-tint when fresh, giving a yellowish cast to the section; obviously a very high class timber. "The most magnificent (timber) of any wattle; has a lovely smell" (Bancroft). May I offer a plea for the conservation of this timber? Bark dark coloured, thin, curly-flaky, like a French fowl.

The foliage ashy-grey but glabrous; the young branchlets moderately angular and sometimes shiny with a gummy exudation.

Phyllodia oblong-falcate, narrowed at both ends, apex blunt, mostly about 7 or 8 cm. long, and about $1\frac{1}{2}$ to 2 cm. broad in the middle, coriaceous, striate with numerous very fine nerves, three to five rather more prominent, all free from the lower margin from the base.

Spikes single on peduncles up to 2 cm., usually 3 cm. long. Rachis glabrous. Flowers moderately closely packed, 5-merous.

Calyx truncate, irregularly sinuate, densely tomentose, about half the length of the petals, floral bract capitate. Petals glabrous, slightly keeled. Ovary hoary or mealy.

A shy fruiter and the pods not seen fully ripe.

Pod shortly stipitate, straight, linear, 3–4 mm. broad and about 3 cm. long, valves smooth or finely granular on the surface, the margins thickened, the thickening sometimes grooved.

Seeds obliquely arranged in the pod, elongate-ovoid, shiny black, funicle soon thickening into a double fold forming a small arillus disposed at the top of the seed.

Type, Dr. T. L. Bancroft, No. 19, Eidsvold, Queensland.

Range.

It appears to be confined to Queensland, and probably extends over a far larger area of that State than is known at present. Specific localities are—

1. Eidsvold, west of Maryborough (Dr. T. L. Bancroft).

2. "Ringy Rosewood" (Bailey's Queensland Hardwoods, No. 139 B), Gladstone. Labelled *A. glaucescens* (?) on poor material. It is interesting that, later on, Dr. Bancroft drew attention to the ornamental "ringy" character of this timber.

3. "Rosewood." "Very like *A. aulacocarpa*, but without pods cannot say." (Note by the late F. M. Bailey). Subsequently named by him *A. glaucescens*. Rockhampton (J. Edgar).

4. Duaringa, 63 miles west of Rockhampton (J. H.M.)

5. Clermont 229 miles west of Rockhampton, (Forest Ranger Gorman). For a view of Nos. 2, 3, 5, I am indebted to Mr. C. T. White, Government Botanist of Queensland.

Affinities.

Its closest relations are *A. Burrowi* n. sp., *A. argentea* Maiden, and *A. glaucescens* Willd., and their differences may be stated in the following table. It has usually been considered to be *A. glaucescens* by Queensland botanists hitherto.

	rhodoxylon.	*argentea.*	*Burrowi.*	*glaucescens.*
	Medium sized tree, erect. Open forests.	*Shrub* of ten feet.	Medium sized tree, erect. Open forests.	Medium sized tree, scrambling. River banks
Timber	Deep reddish-brown, inclined to be ringy.	...	Fissile, deep brown.	Hard inlocked, dark brown.
Bark	Dark, *curly-flaky*, like a French fowl.	...	Thin, furrowed tough-fibrous.	Furrowed.
Phyllodia	Oblong falcate 7 - 8 cm. long, 1½-2 cm. broad. nerves very fine. 3-5 more prominent.	Lanceolate, hoary. 5 - 6·5 cm. long, 1 - 1½ cm. broad. Nerves very fine, 2 or 3 more prominent. *Gland at base.*	Narrow lanceolate to lanceolate, falcate or straight. 4 - 8 cm. long, ·15 to 1 cm. broad. Nerves very fine, 3 rather more prominent.	*Falcate*, glaucous, three prominent nerves.
Spikes	Single. On *peduncles of* 2 cm. 3 cm. long. Rachis resinous, otherwise glabrous.	Mostly in pairs, peduncles under 5 cm. 2 cm. long. Hairy.	Sometimes clustered, upper axils shortly pedunculate. 2-2·5 cm. long.	Peduncles of 1 cm. *large*, 5 *cm. long, broad*, rachis pubescent.
Calyx	Truncate, densely tomentose. half length of petals.	Cup shaped, sinuous ragged edge, less than half length of petals.	Truncate or sinuate-toothed *Pubescent near tips.*	Truncate, shallow, densely tomentose. Quarter length of petals.
Petals	Bract capitate. Petals glabrous, slightly keeled.	Glabrous, recurved.	Bract capitate. Glabrous.	*Bract foliaceous, sessile, hairy.*
Ovary	Hoary or mealy	Hairy.	Hairy.	Hairy.
Pod	3 mm. wide, 3 cm. long (?). Valves with thickened margins, sometimes grooved.	2 - 3 mm, 6 cm. (?). Straight, linear.	2-3 mm. Linear 5-6 cm. Straight linear.	4 mm. wide, 10 *cm. long. Valves hairy.*
Seed	Black, *oblique* in pod. Arillus in double fold, small, at top of seed.	*Brown*, longitudinal in pod. Arillus in double fold, ribbon like, small (?) at top of seed.	Black, longitudinal in pod, Arillus folded on itself several times, forming thickish arillus top of seed.	Black, longitudinal in pod. Arillus in double fold, small, at top of seed.

4. With *A. aulacocarpa* A. Cunn. The present species resembles *A. aulacocarpa* very much in foliage, except that that of the latter species is larger as a rule. It is, however, sometimes difficult to separate the species on that character. The pods of *A. aulacocarpa* are, however, quite different, being coarse and broad. The timbers of the two species are very different.

A. ARGENTEA Maiden, Proc. Roy. Soc. Q., XXX, 41.

I have received this species from Eidsvold, in the Maryborough district, Queensland, which brings its range considerably farther south.

Dr. T. L. Bancroft (No. 33) describes it as a weak shrub, six feet in height. His pods are linear-lanceolate, about 6 cm. long and 2 mm. wide, of a resinous or waxy lustre, the margins of the valves slightly thickened, the valves deeply embossed by the longitudinally arranged seeds, which are pale brown and have no areole. The funicle is filiform and long, and terminates in an arillus which forms a shallow oblique cap on the seed. Also from the Bowen district, Queensland (J. E. Young, through C. T. White).

A. BURROWI n. sp.

Arbor mediocriter alta, cortice tenue, sulcata, ligno fissile, brunneo. Phyllodiis angusto-lanceolatis vel lanceolatis, falcatis vel rectis, 4 – 8 cm. longis, ·15 – 1 cm parte media, coriaceis, striatis, nervis numerosis tenuissimis, 3 prominentioribus. Spicis breviter pedunculatis, 2 – 2·5 cm. longis, floribus dense confertis. Calyce truncato vel sinuato-dentato, loborum apicibus pubescentibus, corollæ ca. dimidium æquantibus. Ovario hirsuto, petalis glabris. Leguminibus linearibus, 5 – 6 cm. longis, 2 – 3 mm. latis, rectis, valvis profunde bullis ornatis, seminibus longitudinaliter dispositis. Seminibus nigris, oblongis funiculo angusto ter vel quater plicato.

A medium-sized tree up to 30 or 40 feet high, with a stem diameter up to a foot. Bark thin, furrowed, tough-fibrous, timber fissile, deep brown, and probably a useful furniture wood. The branchlets angular.

Phyllodia narrow lanceolate to lanceolate, falcate or straight, narrowed at both ends, but tapering more towards the base, mostly 4 to 8 cm. long, ·15 to 1 cm. in the middle, coriaceous, striate with numerous very fine uniform nerves, three rather more prominent, all free from the lower margin from the base.

Spikes shortly pedunculate, often clustered in the upper axils, 2 – 2·5 cm. long, rachis almost glabrous. Flowers rather densely packed, mostly 5-merous. Bract capitate.

Calyx truncate or sinuate-toothed, pubescent near tips of the lobes, about half the length of the corolla. Petals glabrous, each marked with a faint line. Ovary hirsute.

Pods shortly stipitate, linear 5 – 6 cm. long, 2 – 3 mm. wide, straight or nearly straight, valves deeply embossed to receive the seeds, which are longitudinally arranged.

Seeds shiny, black, oblong, with a deep central areole, with a narrow funicle folded on itself several times, forming a thickish arillus slightly enveloping the top of the seed.

Type from the Pilliga, N.S.W. (Gordon Burrow).

Range.

The species is known so far from moderately dry parts of New South Wales and Queensland. It is known from the Bogan district (Nyngan to Coolabah), and it is plentiful in the Pilliga district. In Queensland the typical form is only known from Inglewood.

The slightly anomalous form from Chinchilla, Taroom and Eidsvold brings it more northerly. I have no doubt that search will find many other localities, particularly in Queensland.

New South Wales.

Coolabah and Girilambone (R. W. Peacock). "Small trees of 12 – 20 feet, growing in rough, stony places at the foot-hills near the Railway Station. Much resembles Yarran *(A. homalophylla)* in general appearance." Girilambone (J.H.M. and J. L. Boorman). "Currawang," "A scrub, short leaf, Mallee-like growth, Nyngan," (Forest Guard E. F. Rogers).

Ph. Euligal etc., Co. Baradine (Forest Guard T. W. Taylor No. 77, also No. 34). "Small tree, up to twenty feet, generally grows in dense scrubs; trunks from 1 – 5 inches in diameter and about fifteen feet high. Known in Pilliga as Yarran." (Assistant Forester Gordon Burrow No. 3). "Known in Pilliga as Yarran, though it does not much resemble *A. homalophylla.* It usually grows in dense scrubs, but I have seen trees of from 30 – 40 feet in height and up to 12 inches in diameter." Pilliga District (Forest Guard Simon through Mr. Gordon Burrow, No. 1C). Pilliga Scrub (Dr. J. B. Cleland). "Yarran, on Broom Plain, Coormore Creek, Céntral Pilliga (E. H. F. Swain, No. 28). Yarran or Curracabah, forming dense thickets on ironbark ranges. Central Pilliga (E. H. F. Swain No. 31).

Queensland.

"Tall plants of 12 – 20 feet, fibrous bark, distinctly arboreal in habit." Inglewood, on the South Western Line between Warwick and Goondiwindi (J. L. Boorman).

The following specimens I refer to this species, although they differ somewhat from the type. They have longer phyllodes, the more prominent nerves of which are usually five or six. Only three of the nerves are more prominent than the others in typical *A. Burrowi.*

"Small tree, somewhat resembling Lancewood, Eidsvold (Dr. T. L. Bancroft, with photo., No. 15). Eidsvold is west of Maryborough, and a few miles north of Mundubbera Railway Station. Taroom to Chinchilla (Dr. J. Shirley, Nos. 2 and 3, October, 1917).

The Queensland form displays the following interesting morphological character. The flower falls from the rachis without a calyx; in other words the corolla comes out "clean." This appears to be caused by a fusion of the truncate calyx with the floral bract. This forms a ferruginous honey-comb like membrane (membrana favosus), which surrounds the flowers on the rachis, and separates into irregular pieces, becoming deciduous some time after the flower (corolla) has fallen.

Affinities.

Its closest relations are *A. argentea* and *A. glaucescens*.

1. With *A. argentea* Maiden in Proc. Roy. Soc. Q., xxx, 41. *A. argentea* is a slender shrub up to ten feet high; *A. Burrowi* is a small or medium sized tree; the petals of the former species are reflexed and the calyx completely hairy; the seeds in the former are brown, in the latter black. While the species are undoubtedly different, there may be a good deal of similarity in the phyllodes and also in the pods.

2. With *A. glaucescens* Willd. This is figured at Plate 145, Vol. IV, of my "Forest Flora of New South Wales." The species are allied, but in *A. glaucescens* the phyllodes are, as a general rule, larger and more glaucous, the calyx is smaller in proportion to the petals, both calyx and petals are more hairy, the floral bract is different, the spikes are larger and the valves hairy.

3. With *A. Kempeana* F.v.M. This species is figured in Mueller's "Iconography of Acacias." The phyllodes of the two species are a good deal similar, particularly the bluntly lanceolate Girilambone specimens of *A. Burrowi*, but the calyx in *A. Kempeana* is much smaller in proportion to the petals, the ovarium is smooth, while the broad pod and arrangement of the seeds in *A. Kempeana* are sharply different from those of *A. Burrowi*. In the absence of

pods, the western New South Wales specimens have gone under the name of *A. Kempeana*.

4. With *A. homalophylla* A. Cunn. This species is figured at Plate 133, Part xxxv, of my "Forest Flora of New South Wales." (The pod is wrong, but is corrected at Plate 189, Part L). *A. homalophylla* is the true Yarran, (a name under which *A. Burrowi* sometimes passes); it will be seen that *A. homalophylla* belongs to the Plurinerves, while *A. Burrowi* belongs to the Julifloræ. The two species differ in every important particular.

A. ONCINOCARPA Benth.

In Hook. Lond. Journ. Bot. i, 378 (1842).

(*A. oligoneura* F.v.M. is a synonym).

Following is a translation of the original description of *A. oncinocarpa* :—

"Glabrous, *branchlets* terete, *phyllodes* falcate-oblong or lanceolate, rather obtuse, narrowed at the base, striate-many-nerved, *spikes* elongate, later interrupted, the loose membranous *calyx* half as long again as the *corolla*, *pod* broad-linear, rather straight, uncinate at the apex,[1] narrowed at the base, thick, smooth, glabrous, somewhat woody, obliquely septate inside. *Phyllodes* like *A. loxocarpa* or a little longer. The *rachis* of the fruit-bearing spike about 3 inches long, that of the flower-bearing 1½ – 2 inches long *Flowers* small, 4 – 5 merous finally distinct. *Pod* 4 lines broad. North Coast, Melville Island, *Fraser*, Sims's Island, Cunningham."

Bentham (B.Fl. ii, 409) subsequently gave an amplified description of the species which has an enhanced value because he originally described the species. At the same time, he does not appear to have seen any additional material.

[1] *A Wickhami* Benth. has a somewhat similar pod. See Mueller's "Iconography."

Through the kindness of Dr. A. B. Rendle, F.R.S., of the British Museum, I have:—

(1) a photograph of the sheet of *A. oncinocarpa* in that herbarium, bearing the label—"210. Sims' Island, A. Cunningham, First Voyage of Mermaid, 1818." This was of course Capt. P. P. King, R.N's. Voyage. Accompanying this is part of a phyllode, an opened spike and an unopened one. Sims' Island is a little island 33° 22′ (Northern Territory) say a degree distant from the Liverpool River (see below).

(2) Two phyllodes and a fruit of "No. 236 Melville Is. *Leg.* Fraser." Marked "portion of type." This is Northern Territory, north of Darwin.

Now we come to *A. oligoneura* F.v.M., Journ. Linn. Soc. iii, 139 (1859).

In this Journ. LI, 109, I go fully into the history of this species, heading my enquiry "What is *A. oligoneura* F.v.M.?" I now believe I can answer this question, having compared authentic material of both species. It is a synonym of the older *A. oncinocarpa* Benth. Mueller figured neither species in his "Iconography of Acacias," and I submit drawings which will make the combined species quite clear.

The two localities quoted in B. Fl. ii, 405, for *A. oligoneura* are Victoria River and Macadam Range, Arnhem Land. See also the localities of the type, quoted by me, this Journ. LI, 110. All these are Northern Territory.

The following specimens of *A. oncinocarpa* Benth. have been labelled *A. oligoneura* F.v.M. at different times.

1. "Liverpool River, W.A., B. Gulliver." (Liverpool River is, however, in the Northern Territory, running into the Arafura Sea near 134° E. Long. about intermediate between Darwin and the Gulf of Carpentaria). This was

labelled *A. oligoneura* by Mueller, and Professor Ewart informs me that there are no pods of *A. oligoneura* in the Melbourne Herbarium.

2. Following this specimen, I named "Near Red Lily Lagoon, N.T. (G. F. Hill, No. 132, of 16th April, 1912)" *A. oligoneura* in Ewart and Davies' "Flora of the Northern Territory," p. 343.

3. Granite country, Cullen River (Dr. H. I. Jensen, No. 441 of F. G. Hill).

4. Brock's Creek (E. J. Dunn, 1913).

5. Northern Territory "North of Latitude 15°" (W. S. Campbell, No. 13, September, 1911).

6. Near Darwin (G. F. Hill, No. 437, 20th April, 1916).

7. Point Emery, Darwin (G.F. Hill, 434, 18th July 1916).

8. Edkins Range, West Kimberley (W. V. Fitzgerald, No. 1444, August, 1905).

9. Calder River, West Kimberley (W. V. Fitzgerald, No. 1444).

10. Sunday Island, between King Island and Exmouth Gulf (Dr. H. Basedow, No. 116, May 1916).

Nos. 8—10 are North Western Australia, and so the species occurs in practically the northern margin of our continent and the island off the same.

Juliflorae (Dimidiatae).

A. HOLOSERICEA A. Cunn. var. GLABRATA Maiden in Proc. Roy. Soc. N.S.W., XXX, 48.

This glabrous-glaucous form, originally seen in fruit only (Gilbert River, North Queensland), was collected in flower by Prof. (now Sir) Baldwin Spencer, at Edith Creek, Northern Territory, July—August 1911. All the details of the flower are glabrous.

Bipinnatæ (Pulchellæ).

A. MITCHELLI Benth.

This Victorian species is now to be added to the New South Wales flora, having been collected at Guy Fawkes, about fifty miles from Armidale, on the Grafton road, by J. L. Boorman.

* * *

I desire to offer special thanks to Miss Margaret Flockton, Artist, Botanic Gardens, not only for the drawings of the plates, but also for many other analytical drawings, and also to my Botanical Assistant, Mr. W. F. Blakely, for most valuable critical assistance during the preparation of this paper.

EXPLANATION OF PLATES.

PLATE X.

Acacia nigripilosa n. sp.

1. Phyllode.
2. Base of phyllode.
3. Apex of phyllode.
4. Ovoid head of flowers.
5. Flower.
6. Ovary.
7. Seed and portion of pod.
8. Pod.

From Cowcowing, W.A. (M. Koch No. 1030).
(All variously magnified except 1 and 8).

Acacia tenuior n. sp.

9. Base of phyllode.
10. Apex of phyllode.
11. Portion of phyllode to show ribs.
12. Phyllode.
13. Head of flowers.
14. Individual bud.
15. Flower.
16. Ovary.
17. Bract.

Musgrave Ranges, S.A. (Dr. H. Basedow).
(All variously magnified except 12).

Acacia Helmsiana n. sp.

18. Phyllode and attachment.
19. Head of flowers.
20. Individual flower.
21. Ovary.
22. Bract.

Victoria Desert, W.A., Camp 42 (R. Helms).
(All variously magnified).

Acacia subflexuosa n. sp.

23. Portion of flowering branch (natural size) to show habit.
Drummond's 4th Coll. (?), No. 132.

Plate XI.

Acacia subflexuosa n. sp.

1. Base of phyllode to show attachment.
2. Portion of phyllode showing ribs.
3. Head of buds.
4. Individual flower.
5. Ovary.
6. Bracts.

Drummond's 5th Coll. W.A., No. 5.
(All magnified).

Acacia Sowdeni n. sp.

7. Phyllode.
8. Base of phyllode.
9. Apex of phyllode.
10. Pod and seed.

Port Augusta, S.A. (J.H.M.)
(Nos. 7 and 10 natural size).

Acacia ferocior n. sp.

11. Flowering branch.
12. Phyllode.
13. Individual flower.
14. Ovary.
15. Seed.

Stirling Range, W.A. (E. Pritzel, No. 706).
(All magnified except 11).

Plate XII.

Acacia oxyclada F.v.M.

1. Flowering branch.
2. Tip of phyllode showing terminal gland.
3. Head of buds.
4. Ovary.
5. Bract.
6. Opening bud.
7. Expanded flower.
8. Pod.
9. Seeds.

Murchison River, W.A. (Oldfield, No. 984).
(All magnified except 1 and 8).

Acacia ulicina Meissn.

10. Apex of phyllode.
11. Head of buds showing bracts.
12. Expanded flower.
13. Ovary.
14. Bract.
15. Pod.
16. Seed.

Cunderdin, W.A., (W. V. Fitzgerald).
(All magnified except 15).

Acacia spinosissima Benth.

17. Phyllode.
18. Apex of phyllode.
19. Head of buds showing bracts.
20. Expanded flower.
21. Ovary.
22. Pod.

Perth, W.A. (J.H.M.), but locality requires confirmation.
(All variously magnified except 22).

Plate XIII.

Acacia Basedowi n. sp.

1. Flowering twig.
2. Apex of phyllode showing terminal gland.
3. Bud.
4. Ovary.
5. Expanded flower.
6. Bract.

Musgrave Ranges, S.A. (Dr. H. Basedow).
(All variously magnified except 1).

Acacia deltoidea A. Cunn.

7. Phyllode showing gland and stipules, being portion of type.
8. Phyllode.
9. Phyllode.
10. Head of flowers showing bracts.
11. Bud.
12. Expanded flower.
13. Ovary.
14. Bract.
15. Pods showing seeds horizontally and obliquely arranged.
16. Seed.
17. Seed.

No. 7, from the type received from Herb. Kew. Nos. 8–12, 14–16, from King's Sound, N.W.A. (All. Hughan). Nos. 13 and 17 from Edkins' Range, W.A. (W. V. Fitzgerald, No. 1421). (All variously magnified).

Plate XIV.

Acacia Luehmanni F.v.M.

1. Phyllode showing stipules.
2. Phyllode showing stipules.
3. Head of buds.
4. Individual bud.
5. Expanded flower.
6. Ovary.
7. Bract.

Liverpool River, N.T. (B. Gulliver). Locality of the type. (All variously magnified).

Acacia Froggattii n. sp.

8. Flowering twig.
9. Phyllode with stipules.
10. Head of buds.
11. Individual bud.
12. Expanded flower.
13. Ovary.
14. Bract.
15. Pod.
16. Seed.

Woollybutt Creek near Phillips Range, N. S. Wales, (W. V. Fitzgerald, No. 981). (All variously magnified except 8 and 15).

Plate XV.

Acacia Coolgardiensis n. sp.

1. Apex of phyllode.
2. Head of buds.
3. Expanded flower.
4. Ovary.
5. Bract.
6. Pod and seeds.
7. Seed.

Coolgardie, W.A. (L. C. Webster) except No. 6, which is from Kunonoppin, W.A. (Dr. F. Stoward). (All variously magnified except 6).

Acacia Shirleyi n. sp.

8. Phyllode.
9. Spike of flowers with bract.
10. Expanded flower.
11. Ovary.
12. Bract.
13. Pod.
14. Seed.

Wirra Wirra and Croydon, N.Q. (R. H. Cambage, No. 4106). (All variously magnified except 8, 9 and 13).

Acacia sparsiflora n. sp.

15. Base of phyllode.
16. Spike of flowers.
17. Individual flower.
18. Expanded flower, another view.
19. Ovary.
20. Calyx.

Eidsvold, Q. (Dr. T. L. Bancroft, No. 5). (All variously magnified except No. 16).

Plate XVI.

Acacia sparsiflora n. sp.

1. Phyllode.
2. Phyllode.
3. Pod and seeds.
4. Seed.

Eidsvold, Q. (Dr. T. L. Bancroft, No. 5). (All natural size except 4).

Acacia rhodoxylon n. sp.

5. Phyllode.
6. Phyllode.
7. Flowering spike.
8. Expanded flower.
9. Ovary.
10. Bract.
11. Pod.
12. Seed.

Eidsvold, Q. (Dr. T. L. Bancroft, No. 19). (All natural size except 8, 9, 10, 12).

Plate XVII.

Acacia oncinocarpa Benth.

1. Phyllode.
2. Phyllode.
3. Individual flower.
4. Bract.
5. Pod attached to rachis.
6. Phyllode.
7. Flowering spike.
8. Phyllode.
9. Pod.

Nos. 1 and 2, portion of co-type from Melville Island, N.T. (Fraser). Nos. 3 – 5 from co-type, Sims' Island, N.T. (A. Cunn.) Nos. 6, 8, 9, N.T. north of 15° (W. S. Campbell). No. 7, Darwin, N.T. (G. F. Hill, No. 437). (All natural size except 3, 4 and 9).

DETERMINATION OF THE INCREMENT OF TREES BY STEM ANALYSIS.

I. EUCALYPTUS VIMINALIS Labill.

By W. A. W. de BEUZEVILLE.

[*Read before the Royal Society of N. S. Wales, December 3, 1919.*]

THIS paper is proposed to be the first of a series dealing with the increment of various forest trees of New South Wales. The rate of growth or increment may be ascertained either by systematic measurement of standing trees or by making what is known as a stem analysis of felled trees. Stem analysis can be applied only to those species the timber of which shows well defined rings of growth, and for this reason, unfortunately, is not applicable to many Australian species. Where possible the method should be used, as it enables the forester to obtain valuable data while waiting for the more accurate information secured from the direct measurement of trees. My stem analysis of *E. gigantea* Hook. has already been published by the Forestry Commission, N.S.W. in their Bulletin No. 13.

The specimen of *E. viminalis* selected for analysis was an average tree growing within the Bago State Forest on the southern tableland. The tree carried a good crown occupying a little less than half the total height. It was felled at ground level, and the main stem marked off into seven pieces each of which was cut through the centre. The concentric rings on each section were counted, and the diameters measured, the information being then tabulated, and the calculations made on the assumption that the concentric rings were annual.

Details of the Analysis.

Section	I	taken	at the foot of the tree		showed	66	rings
,,	II	,,	5	feet above ground level	showed	63	,,
,,	III	,,	15	,,	,,	63	,,
,,	IV	,,	25	,,	,,	58	,,
,,	V	,,	35	,,	,,	55	,,
,,	VI	,,	45	,,	,,	50	,,

Section VII taken 55 feet above ground level showed 46 rings
,, VIII ,, 83 ft. 6in. ,, ,, 32 ,,
Top 23 ft. 6 in. long; total height 107 ft.; age 66 years.

Thus at 35 feet from the ground there were only 55 rings as against 66 at the base. This means that the part of the tree above 35 feet had been in existence only 55 years, so that it took 66 − 55 = 11 years for the tree to reach a height of 35 feet. Thus the following table is prepared:—

Height of Section in feet.	Number of rings.	Number of years taken to reach height of Section.
0	66	0
15	63	3
25	58	8
35	55	11
45	50	16
55	46	20
83 ft. 6 in.	32	34
107	0	66

From this table a curve showing the height at different ages is plotted (see Fig. 1).

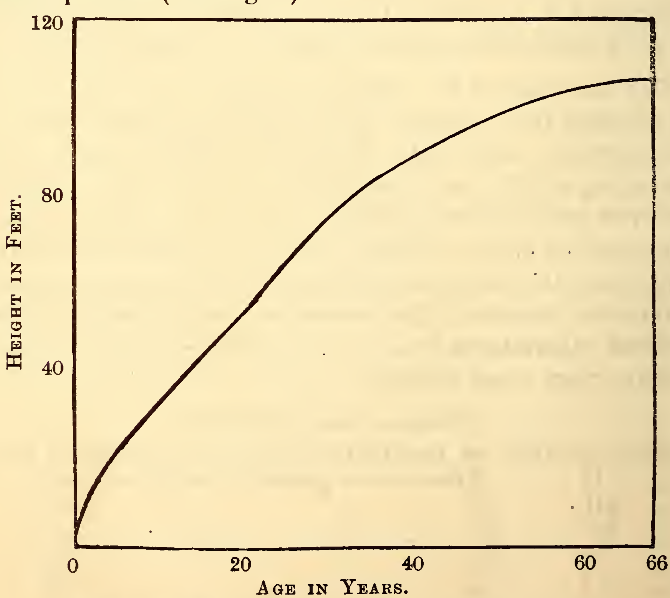
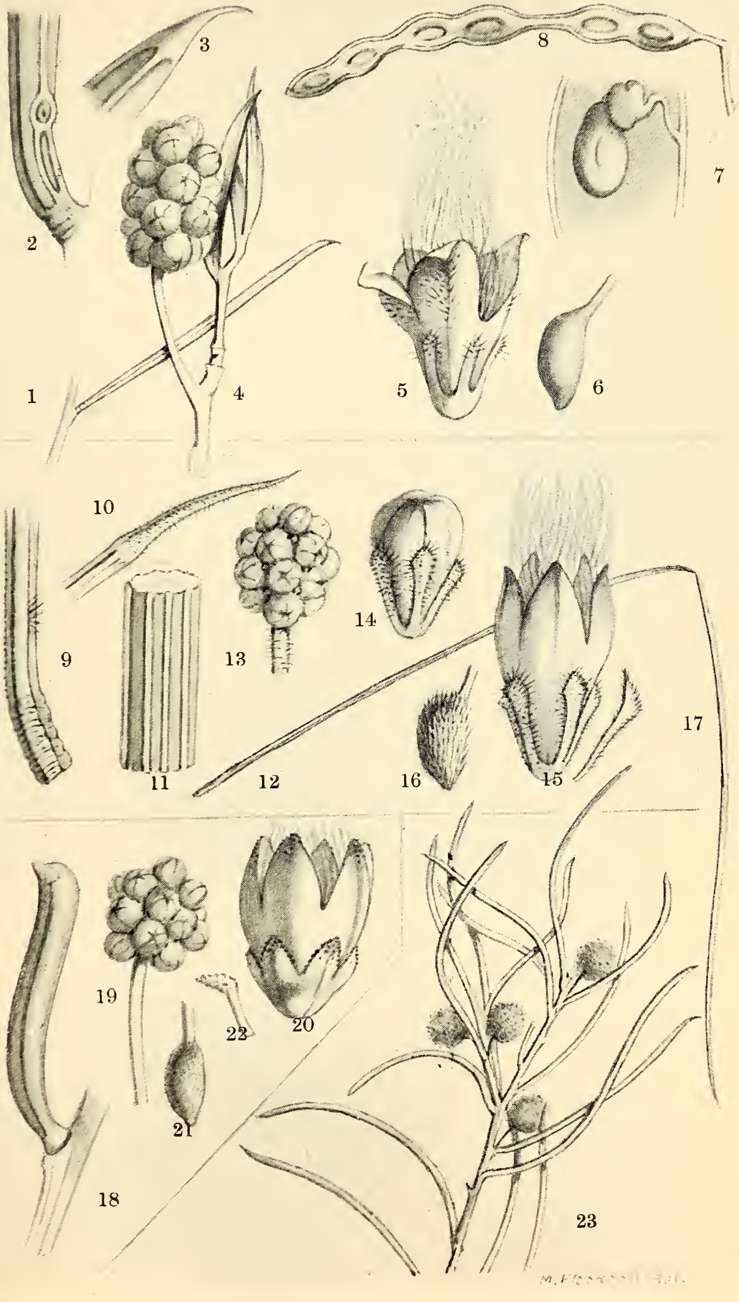
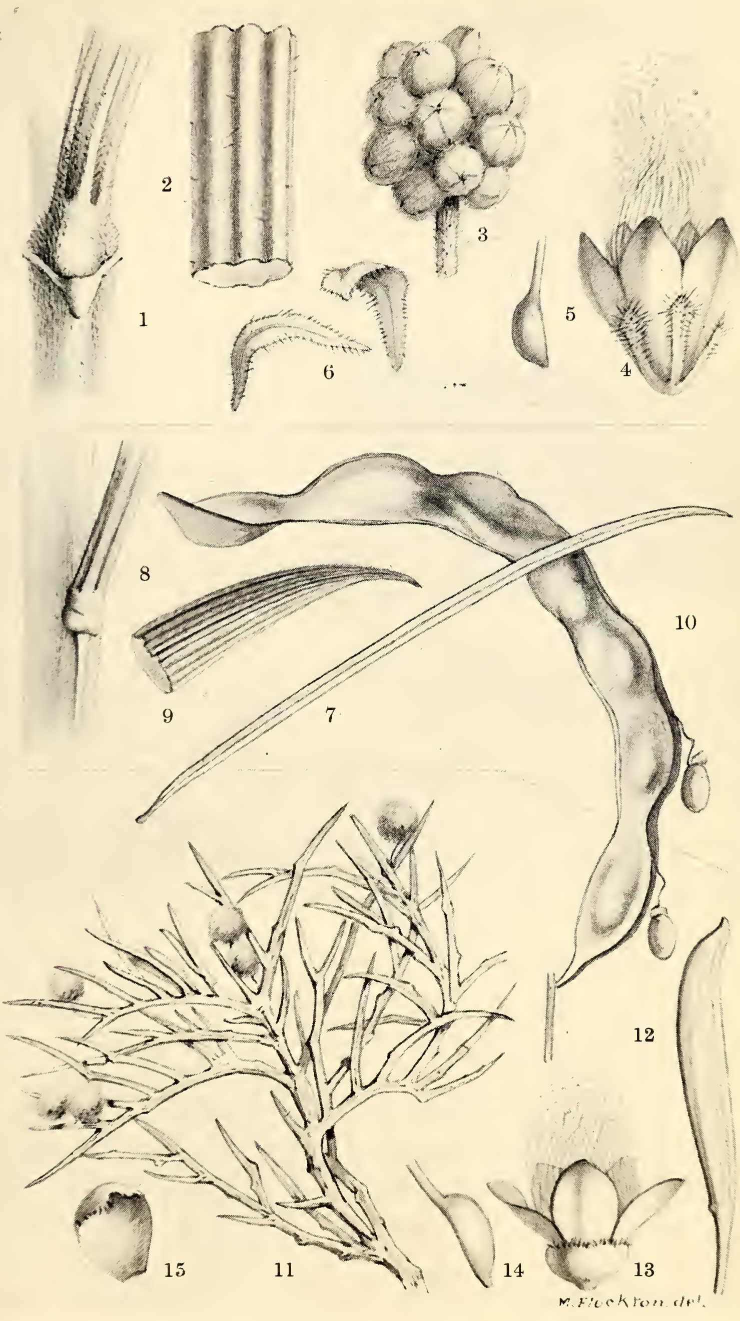


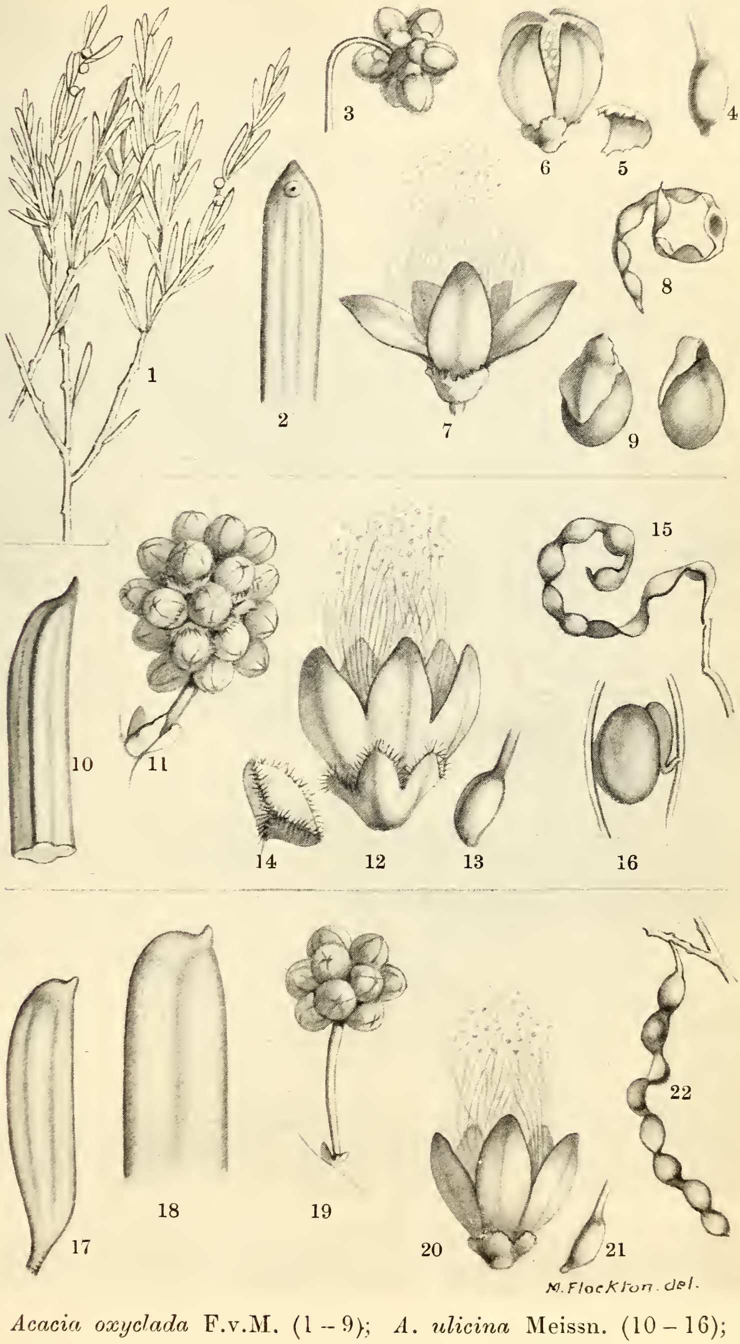
Fig. 1. *Graphic representation of height growth.*



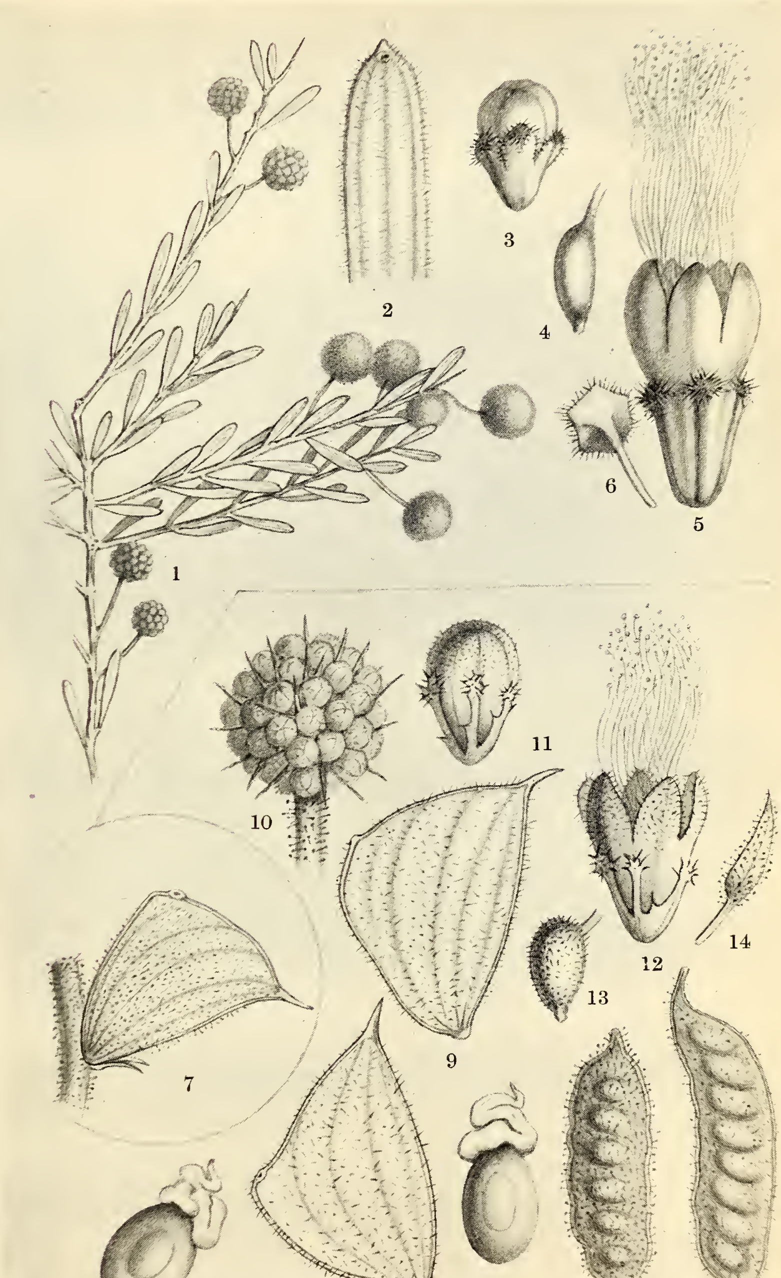
Acacia nigripilosa n. sp. (1 – 8); *A. tenuior* n. sp. (9 – 17); *A. Helmsiana* n. sp. (18 – 22); *A. subflexuosa* n. sp. (23, see next plate.)



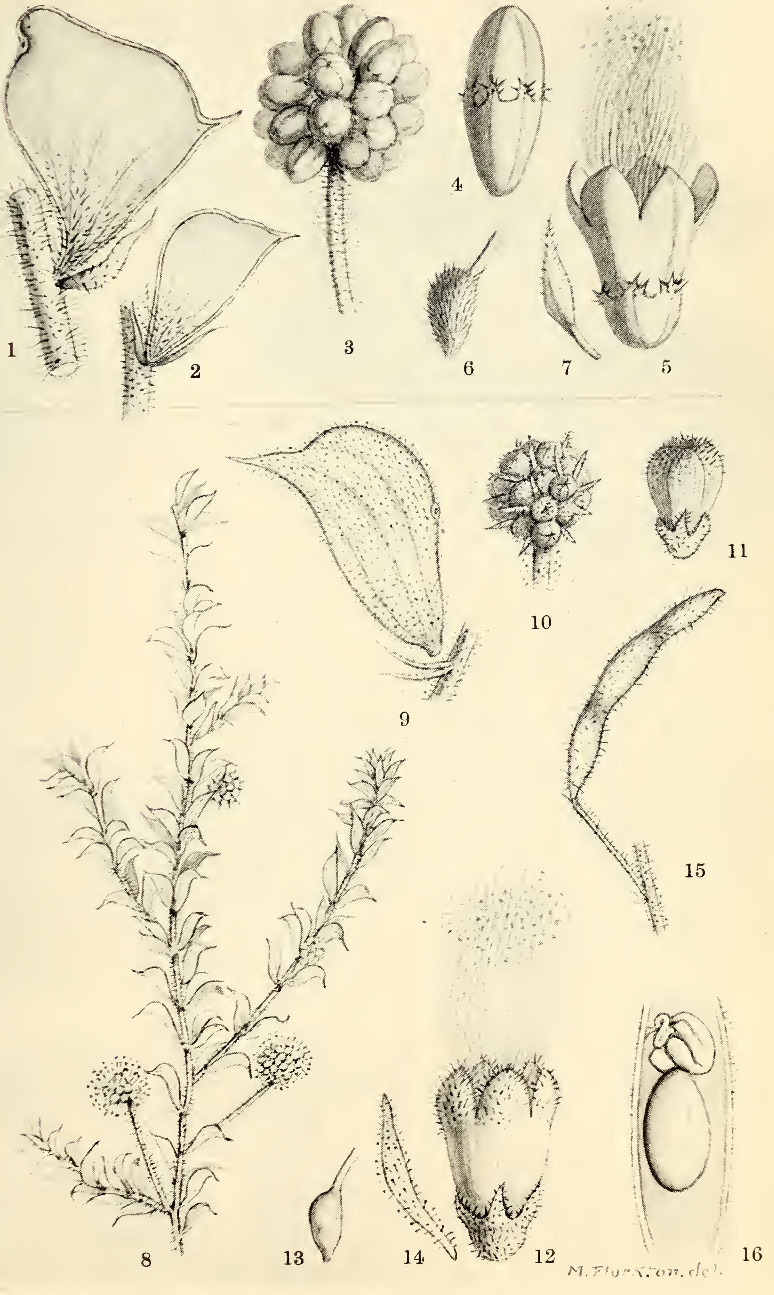
Acacia subflexuosa n. sp. (1 – 6, see preceding plate); *A. Sowdeni* n. sp. (7 – 10); *A. ferocior* n. sp (11 – 15).



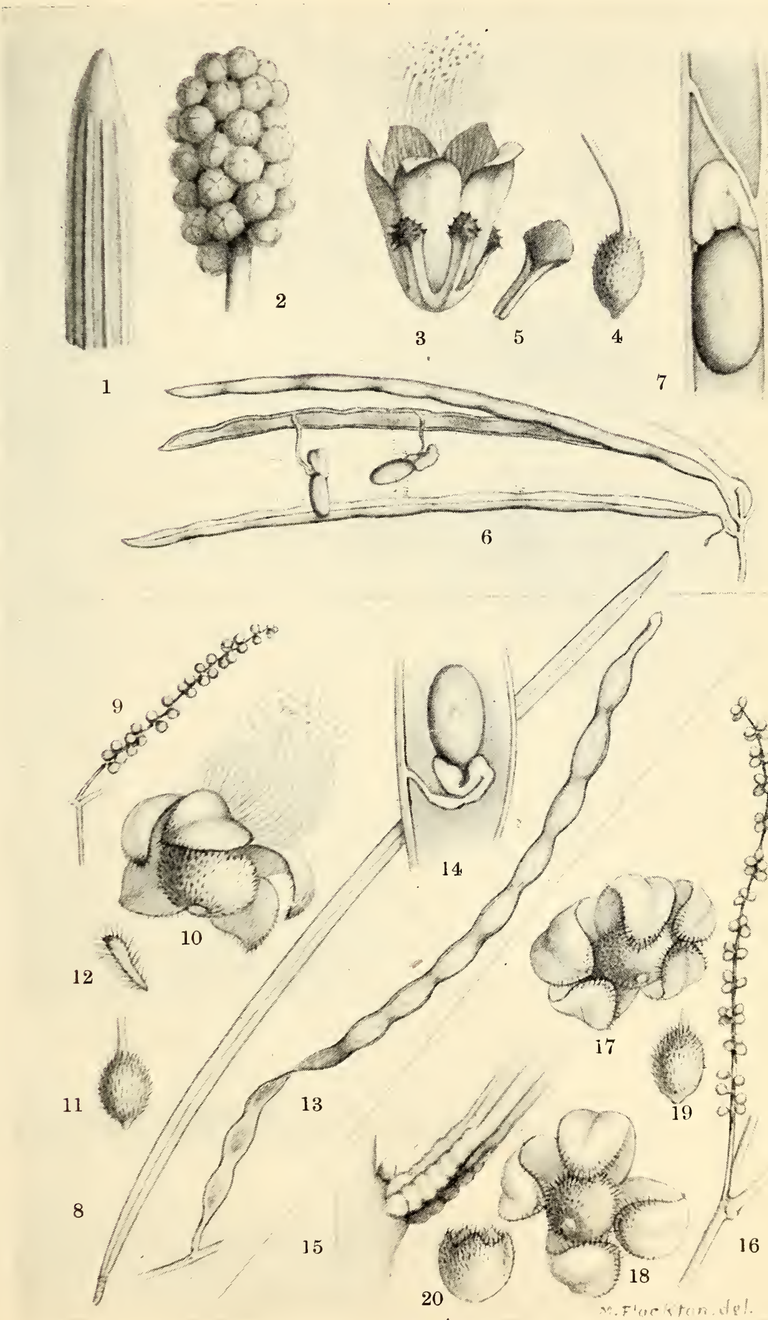
Acacia oxyclada F.v.M. (1 – 9); *A. ulicina* Meissn. (10 – 16); *A. spinosissima* Benth. (17 – 22).



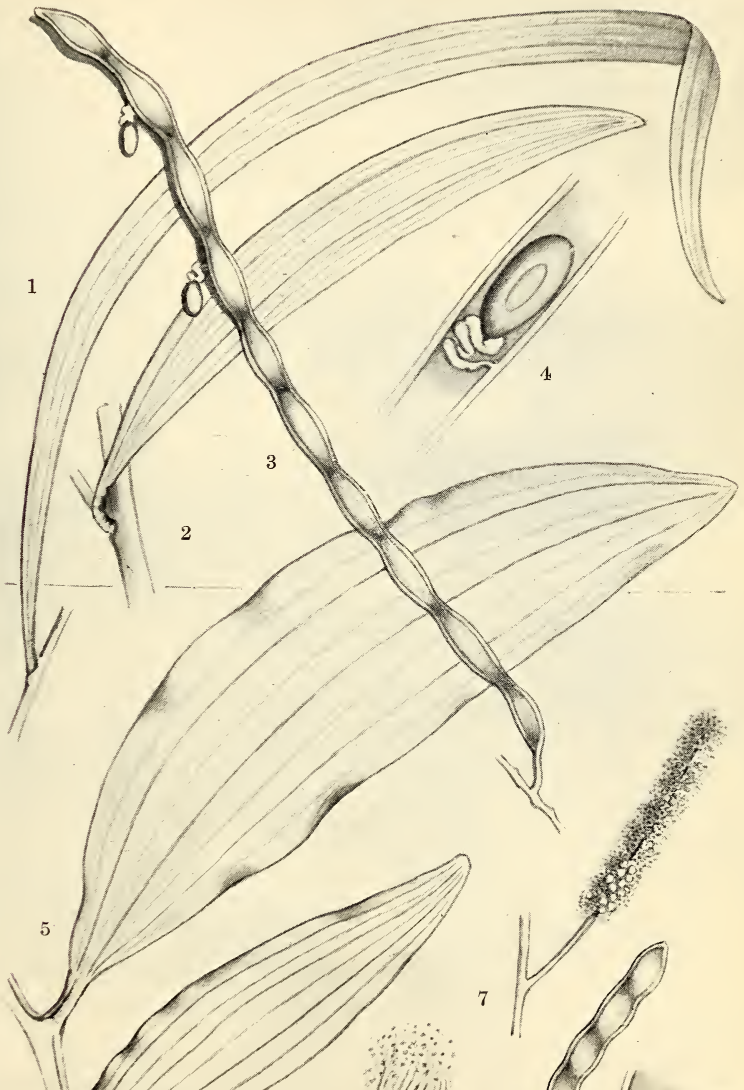
Acacia Basedowi n. sp. (1 - 6); *A deltoidea* A. Cunn. (7 – 17).



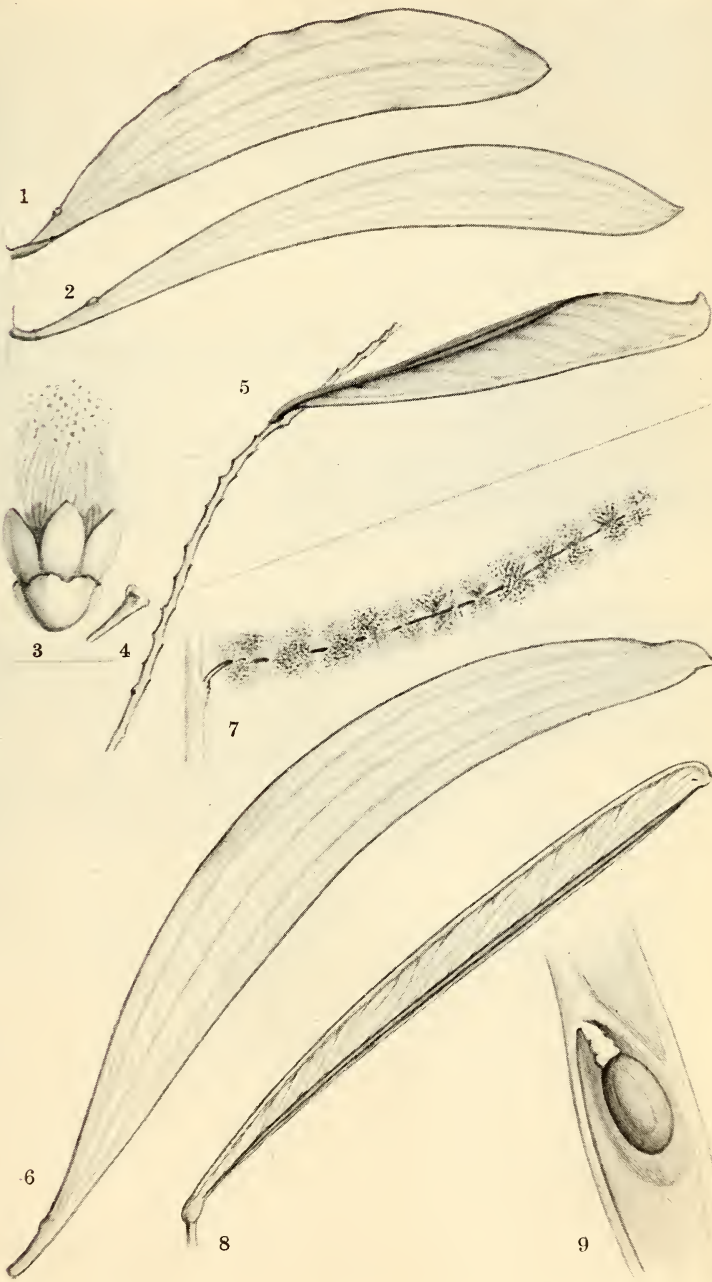
Acacia Luehmanni F.v.V. (1 – 7); *A. Froggattii* n. sp. (8 – 16).



Acacia Coolgardiensis n. sp. (1 – 7); *A. Shirleyi* n. sp. (8 – 14); *A. sparsiflora* n. sp. (15 – 20, see next plate).



Acacia sparsiflora n. sp. (1 – 4, see preceding plate);
Acacia rhodoxylon n. sp. (5 – 12).



Acacia oncinocarpa Benth.

The average radii of the various cross sections and of every tenth ring on each cross section were then measured, and gave the following results:—

Radius of Section I, at foot of tree in inches.			Radius of Section II, at 5 ft. from ground in in.			Radius of Section III, at 15 ft. from ground in in.		
Total over bark,		11·6	Total over bark,		10	Total over bark,		8·9
66	rings	10·7	63	rings	9·1	63	rings	8·3
56	,,	9·9	53	,,	8·3	53	,,	7·7
46	,,	8·7	43	,,	7·0	43	,,	6·6
36	,,	7·2	33	,,	5·5	33	,,	5·1
26	,,	5·2	23	,,	4·1	23	,,	3·6
16	,,	3·3	13	,,	2·9	13	,,	2·2
6	,,	1·6	3	,,	1·0	3	,,	·625

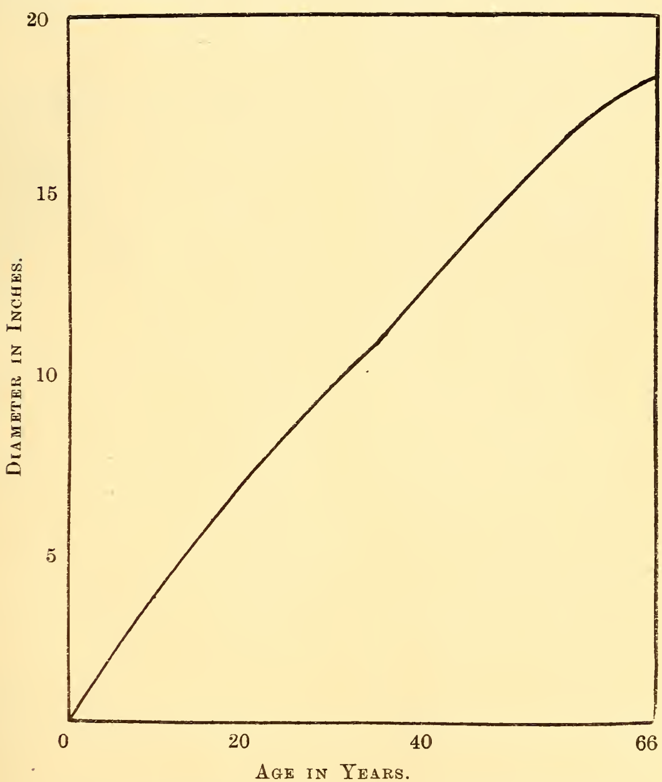


Fig. 2. *Graphic representation of diameter growth.*

Radius of Section IV, at 25 ft. from ground in in.		Radius of Section V, at 35 ft. from ground in in.		Radius of Section VI, at 45 ft. from ground in in.	
Total over bark,	8·2	Total over bark,	7·5	Total over bark,	7·1
58 rings	7·7	55 rings	7·1	50 rings	6·6
48 "	7·2	45 "	6·5	40 "	6
38 "	6·1	35 "	5·6	30 "	5
28 "	4·8	25 "	4·4	20 "	3·7
18 "	3	15 "	2·9	10 "	1·4
8 "	1·4	5 "	·9		

Radius of Section VII, at 55 ft. from ground in in.	
Total over bark,	6·7
46 rings	6·2
36 "	5·5
26 "	4·4
16 "	3·4
6 "	1·8

From the figures for Section II, the relation between diameter and age is shown graphically in Fig. 2.

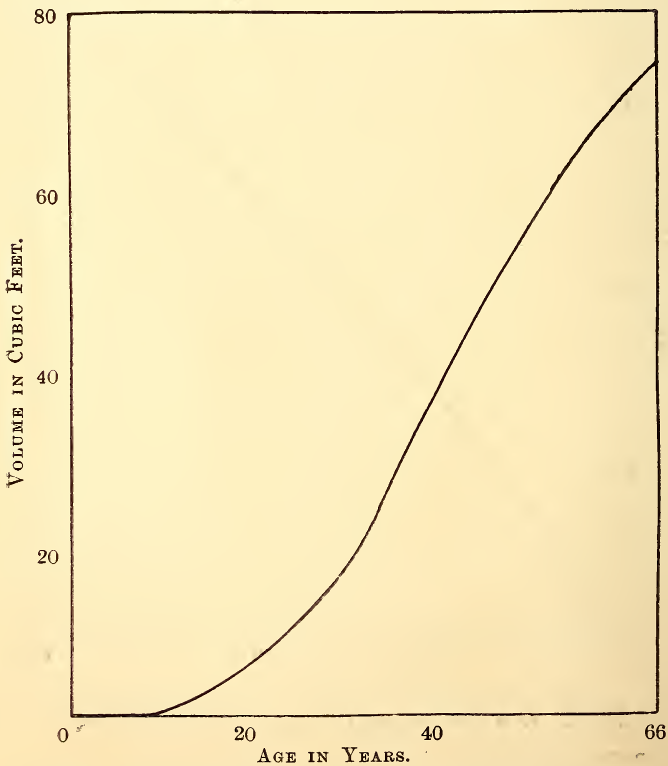


Fig. 3. *Graphic representation of the volume increment.*

The following table gives the volume of the stem of the tree at different ages. As the thickness of bark at former periods cannot be ascertained, the calculations can refer only to the increment of wood, exclusive of bark.

Age, Years.	Total Timber, Cubic feet.	
66	86·50	Whole tree including bark.
66	74·65	Whole tree without bark,
56	62·67	
46	44·93	
36	26·87	
26	11·72	
16	3·34	
6	0·30	
	12·92	Top of tree considered as a cone.

By graphically representing the volume of the wood at the several ages, Fig. 3 is obtained, which with the previous diagrams, gives the following data:—

Age of tree in years.	Height in feet.	Diameter without bark at 5 ft. from ground, in.	Volume without bark, in cubic feet.	Periodic increment for every 10 years, cubic feet.
0	...	...	...	
				1
10	33	3·7	1	
				5
20	55	6·8	6	
				10
30	76	9·6	16	
				19
40	90	12·2	35	
				18
50	100	15	53	
				15
60	106	17·4	68	
				6·6
66	107	18·2	74·6	

Fig. 4 is a graphic representation of the current annual and the mean annual increment of the volume.

The current annual increment rises rapidly after the first youth of the tree is passed and reaches its maximum about the period when the height growth culminates. The mean annual increment keeps below the current annual increment for 62 years.

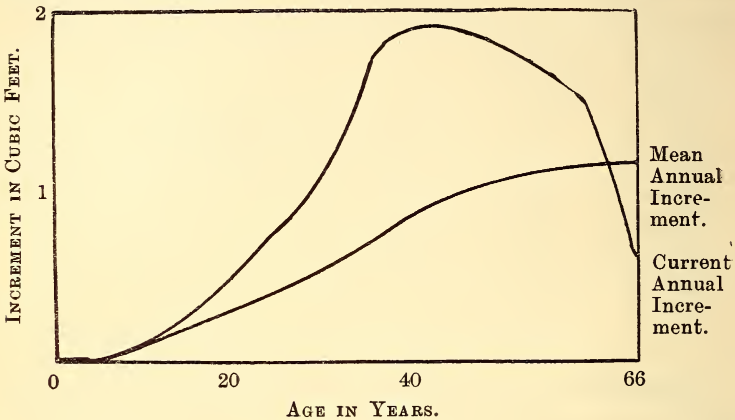


Fig. 4.

As it is more convenient to know the height, and volume for the various diameters, instead of the various ages of the tree, Fig. 5 and Fig. 6 are plotted.

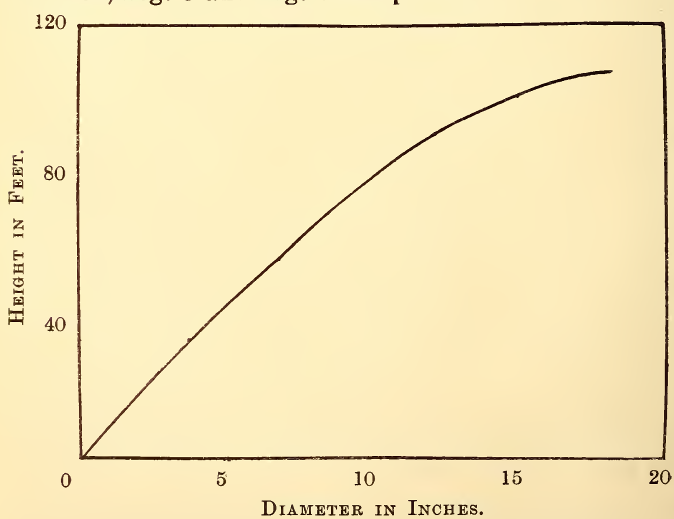


Fig. 5.

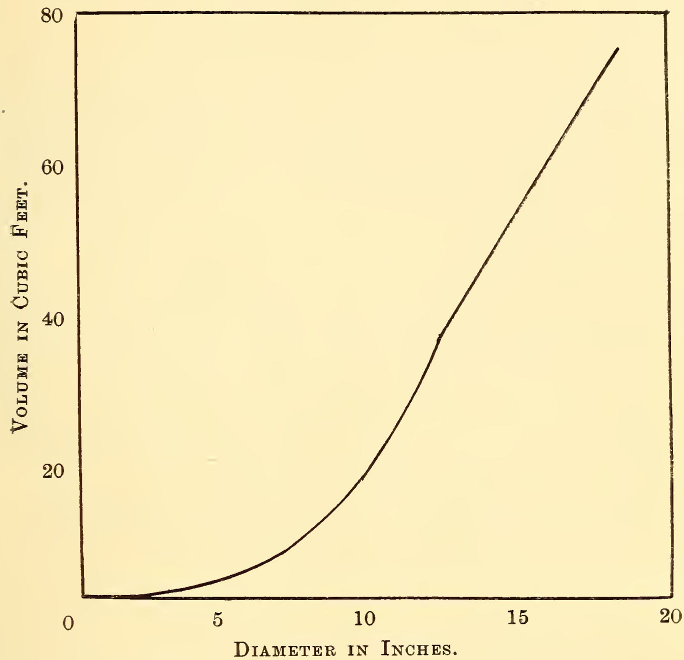


Fig. 6.

Recapitulation.

The stem of the tree had at the age of 66 years:—

A total volume of 86·5 cubic feet.

Of this was Bark 86·5−74·65 11·85 cubic feet equalling 13·7 per cent. of volume. Leaving 74·65 cubic, or 895·8 superficial feet of timber (marketable) in the stem of the tree. Fuel etc. in top of tree excluded.

Total contents of tree, in bark:—

Timber in stem	86·5 cubic feet	
Timber in top	12·92	,,
Total	99·42	,,
	or, 1193·04 superficial feet.	

SEQUENCE, GLACIATION AND CORRELATION OF THE CARBONIFEROUS ROCKS OF THE HUNTER RIVER DISTRICT, NEW SOUTH WALES.

By C. A. SUSSMILCH, F.G.S., F.T.C., and Professor T. W. EDGEWORTH DAVID, C.M.G., D.S.O., F.R.S., Hon. D.Sc., *Oxon.*

With appendices by

A. B. WALKOM, D.Sc., and W. R. BROWNE, B.Sc.

With Plates XVIII – XXXI.

[*Read before the Royal Society of N. S. Wales, December 3, 1919.*]

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(For full description of illustrations see end of paper.)

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Part II.

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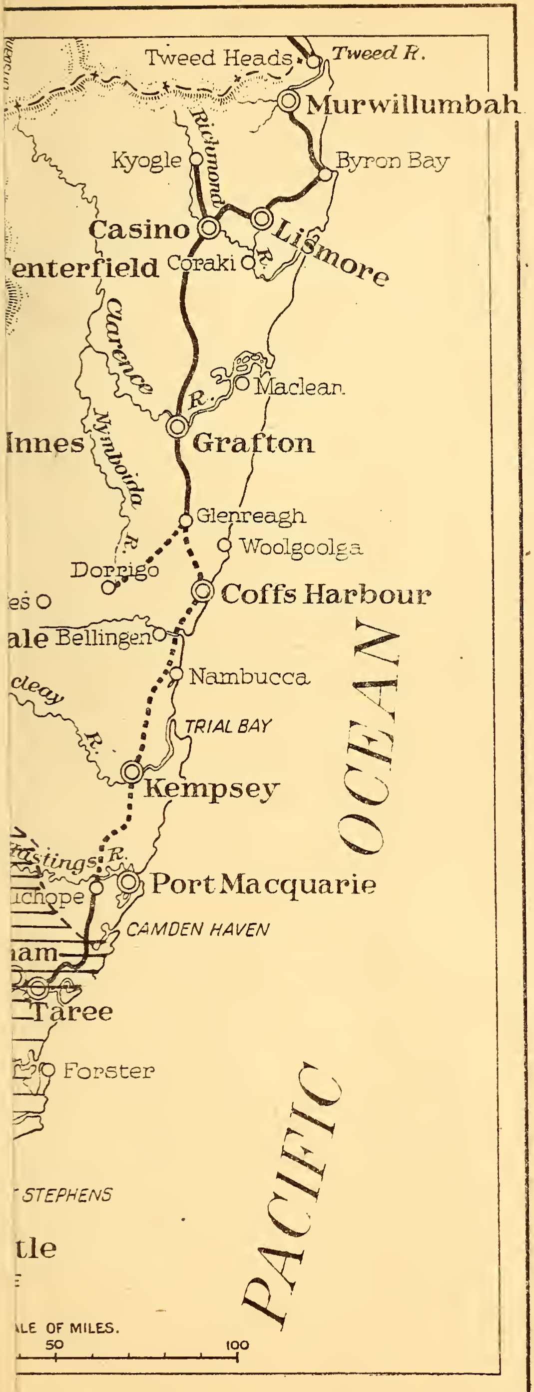
Summary.

PART I.

Introduction.

It has been the practice in the past in New South Wales to include under the term Carboniferous all those strata which occurred between the Devonian formation on the one hand, and the Lower Marine Stage of the so-called Permo-Carboniferous formation on the other hand. There is some reason for thinking that at least part of the so-called Permo-Carboniferous system of this State should be included with the Carboniferous system, but the evidence for and against this view will be discussed fully by Prof. David in Part II, so this matter will not be further debated here, and the term Carboniferous will be used with its old limitations.

The Carboniferous formation of New South Wales occurs only in the north-eastern part of this State. It outcrops on the coast from the Manning River to Port Stephens, and extends westerly thence in a broad belt along the southern margin of the New England Tableland, to the 151st meridian (Plate XVIII); the Carboniferous belt then swings northwards round the western margin of the New England Tableland to the Queensland border. In this present article it is proposed to describe in some detail that part of this Carboniferous belt which occurs immediately north of the Permo-Carboniferous basin of the Lower Hunter River District (the southern part of the County of Gloucester) and particularly that part of the formation which occurs in the lower parts of the valleys of the Paterson and Williams Rivers (see Plate XXXI). Although this district is well-settled and readily accessible, very little detailed geological work has been done in it, probably due to the fact that the deposits of economic value are few and unimportant. The work of previous investigators in other parts of the State will, however, also be drawn upon.



is lined horizontally.

The area occupied by the Carboniferous rocks is lined horizontally.

Previous Observers.

1. A former Government Geologist of New South Wales, C. S. Wilkinson, following the results of extensive trenching done by the late Examiner of Coal-fields, John Mackenzie, and extensive observations by the late Rev. W. B. Clarke, showed a large development of Carboniferous strata on the geological map published by the Mines Department of New South Wales (Mineral Products N. S. Wales, 1887).

2. Professor David in 1893 called the upper part of the Carboniferous rocks the Rhacopteris Series, and the lower the Marine Carboniferous Series (Aust. Assoc. Adv. Sci., 1893).

3. In 1901 Mr. J. B. Jaquet[1] made a detailed examination of the ironstone deposits of Carboniferous age of the Clarence Town District. He described the ironstone deposits and also the limestone deposits in considerable detail and his report is accompanied by an excellent geological map. The other strata are only referred to briefly.

Mr. Jaquet classed the whole of the Carboniferous strata of this district as Upper Carboniferous, including in this term both the marine beds and the fresh-water Rhacopteris-bearing beds. He estimated the Carboniferous strata examined by him to have a thickness of 19,000 feet, and his section did not include either the top or the bottom of the formation. There is, probably, considerable repetition in Mr. Jaquet's section, due to strike faulting, and the inter-stratification of marine and fresh-water beds shown by him is probably also due to the same cause. Mr. Jaquet gives a list of previous observers, and there is no need to repeat that list here.

---

[1] The Iron Ore Deposits of N. S. Wales by J. B. Jaquet, A.R S.M., F.G.S., Memoir No. 2 of Geol. Surv. N. S. Wales, p 62, 1901.

4. In 1907 Professor T. W. E. David[1] in his Monograph of the Hunter River Coal Measures, traversed and mapped the junction of the Permo-Carboniferous and Carboniferous formations of this Lower Hunter District, and made brief reference to the nature of the Carboniferous inliers which occur at Pokolbin and Drake's Hill, south of the Hunter River.

5. In 1911, Messrs. A. B. Walkom and W. R. Browne[2] described in detail, the Carboniferous lava flows of the Pokolbin District; the section described by them belongs to the Kuttung Series, and consists largely of volcanic rocks.

6. In 1913, Prof. W. N. Benson[3] described in some detail the Carboniferous formation as developed in the Barraba-Tamworth District. In this region he subdivided the Carboniferous strata into two divisions as follows:—

The Rocky Creek Conglomerate (including lava flows), thickness 2,000 feet. +

The Burindi Mudstones, thickness 1,500 feet. +

He refers the whole of these strata to the Lower Carboniferous. In this paper he gives a detailed list of the Carboniferous fossils for the district he is describing, and also a list of the fossils for the district now under discussion. This list he has recently revised and he has kindly allowed me to make use of the revised list here.

The Burindi mudstones are described as being fine, dark grey, fissile mudstones with bands of andesitic tuff and occasional coarse-grained breccias, with here and there thin bands of crinoidal limestones and oolitic limestones.

---

[1] The Geology of the Hunter River Coal Measures by Prof. T. W. E. David, B.A., F.R.S., F.G.S., Memoir No. 4, Geol. Surv. N.S.W.

[2] The Geology of the Eruptive and Associated Rocks of Pokolbin, New South Wales, this Journal, 1911, pp. 379–407.

[3] The Geology and Petrology of the Great Serpentine Belt of New South Wales, Part I. by W. N. Benson, B.A., D.Sc., Proc. Linn. Soc. N.S. Wales, Vol. XXXVIII, Part 3, 1913, p. 490.

The Rocky Creek Series is described as consisting of heavy conglomerates containing pebbles of granite, aplite, quartz-porphyry, rhyolite, trachyte, dacite and andesite. The conglomerates are interbedded with flows of rhyolite, trachyte and andesite of a similar character to those of the pebbles in the conglomerate, together with beds of tuff of the same composition passing into tuffaceous and gritty sandstones. Further brief reference to the Carboniferous formation is made by Prof. W. N. Benson in Parts II and III of his Geology of the Great Serpentine Belt.

7. In 1913, A. B. Walkom[1] described briefly the Carboniferous strata which occur in the Glendon Brook District near Singleton.

8. In 1915 M. Aurousseau[2] described the petrology of some of the Carboniferous igneous rocks from Martin's Creek and Eelah.

Acknowledgements.—My thanks are due to three of the geology students of the Newcastle Technical College, viz.: Messrs. V. B. Collins, T. Hynd and A. F. Newman for much help in the field; they accompanied me on many of my field trips and assisted in making the traverses upon which the geological sections are based. My thanks are due to Prof. W. N. Benson for permission to use the list of marine fossils compiled by him, and to Dr. A. B. Walkom for the palæontological note in Appendix I. I have to thank Mr. W. R. Browne and Prof. T. W. E. David for the information regarding the glacial beds of the Lochinvar district and for the geological section of that locality which they have prepared and allowed me to use, and also to thank Mr.

---

[1] Geology of the Permo-Carboniferous System in the Glendon Brook District near Singleton. Proc. Linn. Soc. N. S. Wales, 1913, Vol. xxxviii, Part I, p. 146.

[2] Petrological Notes on Carboniferous Igneous Rocks by M. Aurousseau, B.Sc. Proc. Linn. Soc. N. S. Wales, 1915, Part II, p. 294.

W. R. Browne for his assistance in the petrological part of the work. Finally I have to thank Prof. T. W. E. David for much kindly advice and assistance, both in the field and in writing up the results.

The Subdivisions of the Carboniferous System.

The strata included in the Carboniferous System of this part of New South Wales fall definitely into two subdivisions, *(a)* a lower division of marine origin, and *(b)* an upper division of terrestrial origin (Plate XIX). The lower division contains a marine fossil fauna of undoubted Lower Carboniferous age, and for these beds it is proposed to retain Prof. W. N. Benson's name of the Burindi Series, this series may be looked upon as being the equivalent of the middle Mississippian formation of North America. The upper division includes most of the remaining part of the Carboniferous formation; the strata are of terrestrial origin and are characterised by a fossil flora known as the Rhacopteris Flora. For this series the name Kuttung is proposed, this being the name of an aboriginal tribe which inhabited the region in which these strata are most extensively developed. In the northern hemisphere the Rhacopteris Flora is considered to be of Culm to Middle Carboniferous age, but for the present the Kuttung Series of New South Wales will be considered to occupy the whole of the time period represented by the Middle and much of the Upper Carboniferous formation of the Northern Hemisphere and to be the equivalent of a large part of the Pennsylvanian System of North America.

The following table gives the subdivision proposed for the Carboniferous formation of New South Wales, and gives also the subdivision already in use for the overlying Permo-Carboniferous formation of the same region:—

"Permo-Carboniferous" System probably Permian to about 2000 feet below the Greta Coal Measures. Remainder of deeper strata Uralian (?).

			Max. Thickness, Feet.
	Upper or Newcastle Coal Measures		1400
	Dempsey Series		2000
	Middle or Tomago Coal Measures		800 – 1700
	Upper Marine Series		5000 – 6400
	Lower or Greta Coal Measures		300
	Lower Marine Series		4500
Transition Beds, partly marine			100 (?)
Carboniferous System, (in part).	The Kuttung Series. (Middle and Upper Carboniferous in part.)	Seaham Glacial Beds	1840
		Paterson Rhyolite	300
		Mount Johnstone Beds	1950
		Martins Creek Beds	2200
		Wallarobba Beds	2000-3000
	The Burindi Series. (Lower Carboniferous.)	Hilldale-Dungog Beds (?)	5000

It will be seen that the Carboniferous System has a probable maximum thickness of at least 14000 feet, while the succeeding Permo-Carboniferous System has a thickness of at least 16000 feet, giving a total thickness of Upper Palæozoic strata in this part of N. S. Wales of not less than 30000 feet.

The whole of the Carboniferous formation has been folded into a series of broad anticlines and synclines, which strike from due north to about N. 20° west; these folds pitch to the south, with the result that the Carboniferous strata dip under the Permo-Carboniferous strata in that direction and disappear from view as the Hunter River is approached. The strata have also been intersected by a number of strike faults striking a little west of north; these have produced much duplication of strata and an intimate mixing up of the Lower Carboniferous marine beds with the Middle and Upper Carboniferous terrestrial beds. Denudation has nowhere in the region now under consideration exposed the underlying Devonian strata, consequently the base of the Lower Carboniferous strata is not visible, therefore a complete section of these beds cannot be given. Further to the north, notably in the Gloucester District, junctions between the Devonian and Carboniferous Systems occur; the field work in this northern area is, however, not yet complete, and final results are therefore not available. Sufficient work has been done however to indicate a thickness of at least 5000 feet for the Lower Carboniferous and about 7000 feet for the Middle and Upper Carboniferous in this region.

No angular unconformity exists, so far as the writer's observations have gone, between the Burindi Series and the Kuttung Series, but the change from one to the other is marked by (1) a change from marine to terrestrial conditions of sedimentation (2) a complete palæontological break (3) the presence of an extraordinarily thick bed of conglomerate (the Wallarobba Conglomerate) at the base of the Kuttung series.

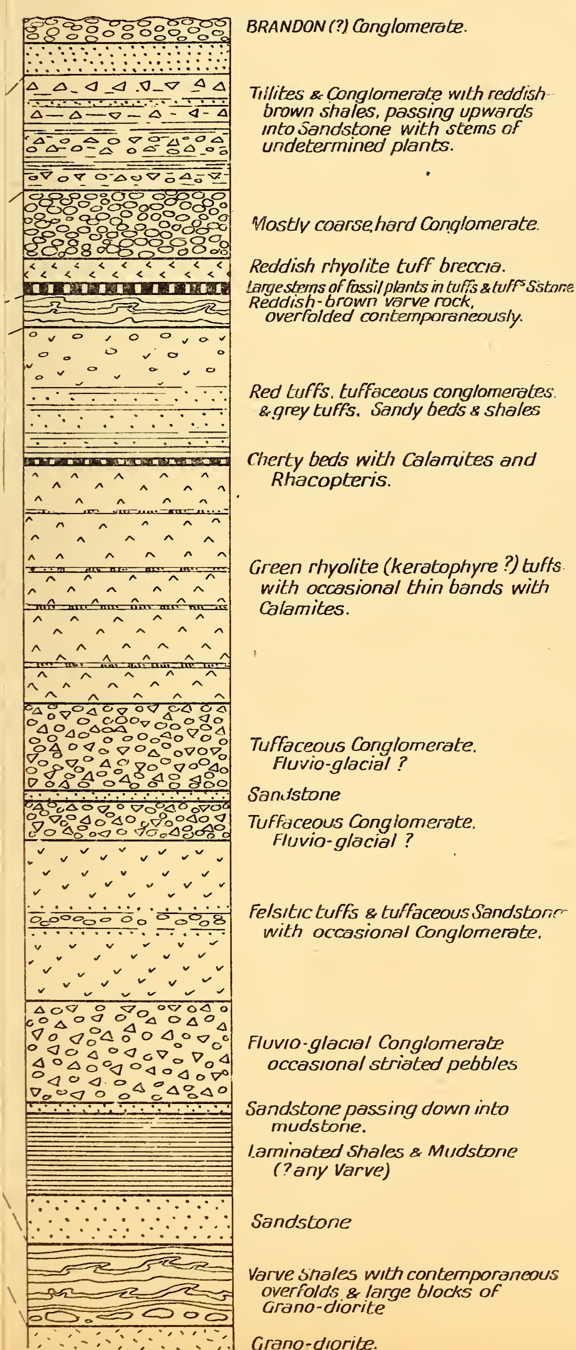
A. The Burindi Series.

The Lower Carboniferous or Burindi Series.—As has already been pointed out a complete section of these strata has not been found in this district; a satisfactory subdivision of this series is further hindered by the extensive strike faulting to which they have been subjected, which has given much repetition of the strata, and in some places so mixed them up with the Kuttung Series that very careful detailed mapping of large areas will be necessary before a detailed section will be possible. The section given in Pl. XIX is only an approximation and is only given for the purpose of indicating the approximate thickness of the series as a whole, the details are not to scale.

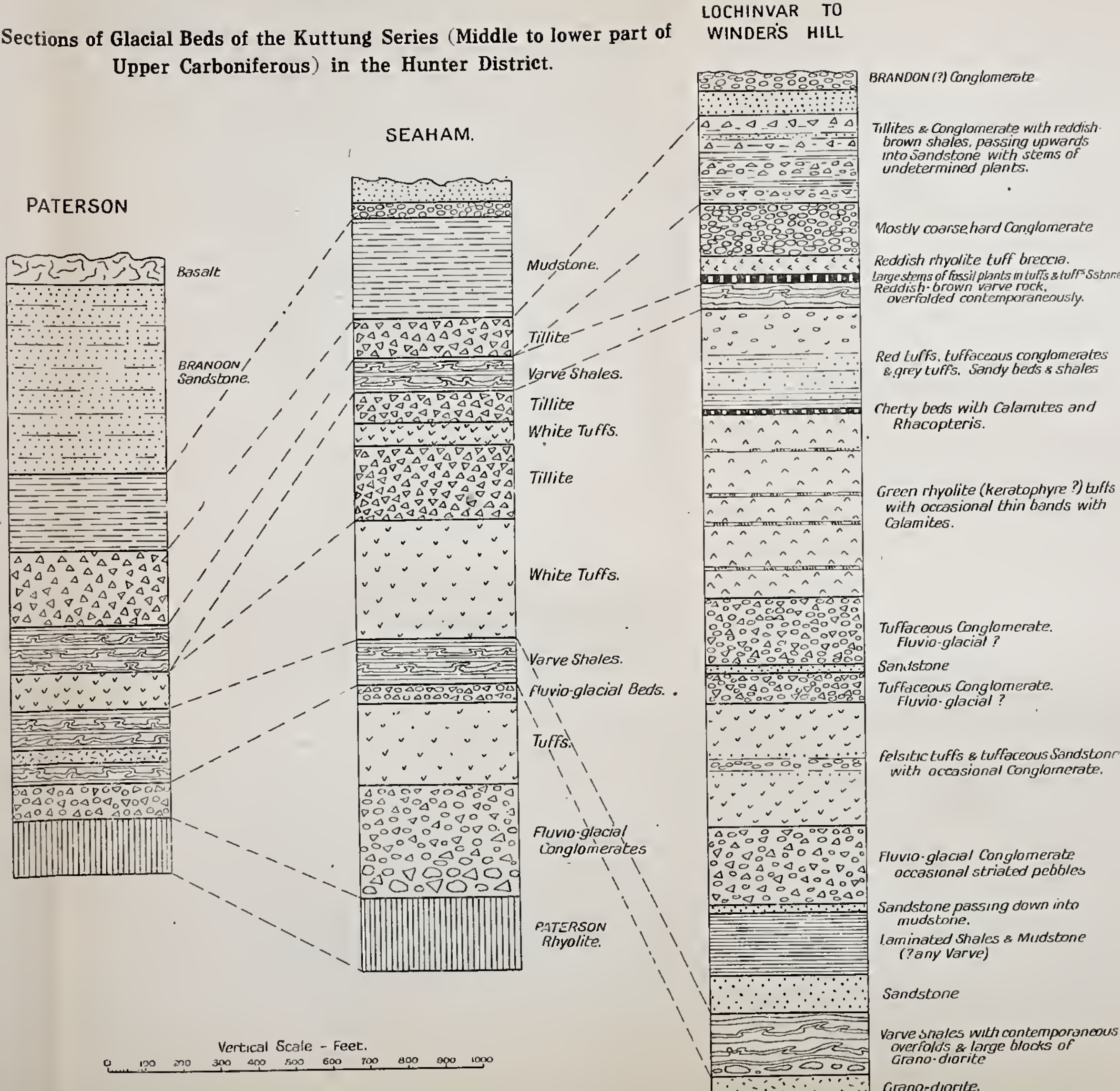
These strata outcrop extensively around the town of Dungog, and excellent sections may be seen in the road and railway cuttings going east from that township; they also outcrop extensively around the village of Hilldale and

Plate XIX.

LOCHINVAR TO WINDER'S HILL



Sections of Glacial Beds of the Kuttung Series (Middle to lower part of Upper Carboniferous) in the Hunter District.



extend northwards from there along the valley of the Allyn River to beyond Eccleston; further good sections occur along the road from Wallarobba to Clarence Town, and from the latter township to Glen William. That part of the Burindi Series exposed in this district will be referred to as the Hilldale-Dungog Beds.

The lower part of the Hilldale-Dungog Beds consists mainly of interstratified mudstone and tuff with some few beds of limestone and occasional beds of conglomerate: towards the top of the series the tuffs increase in relative proportion and several lava flows also occur.

The Hilldale Mudstones.—These are thin bedded strata of greenish-grey colour and quite similar to the Burindi Mudstones described by Prof. W. N. Benson[1] from the Tamworth-Barraba District. Thin beds of tuff are usually interstratified with these mudstones. Marine fossils are fairly plentiful in some of the beds and are listed further on. Fragments of drift wood and small stems of plants also occur in these beds, it being not uncommon to find specimens of Lepidodendron and other fossil plants on the same slab of shale as marine fossils.

The Dungog Limestones.—These appear to be limited to the lower part of the Dungog Beds; they are usually built up of crinoid stems, but oolitic limestones also occur. The individual beds range up to twenty feet or even more in thickness, but do not maintain such thicknesses for any distance, rapidly thinning when followed in the direction of the strike and frequently pinching out entirely, so that they can rarely be traced along the surface for any great distance. These limestones have been described in some detail by J. B. Jaquet and by J. E. Carne,[2] particularly

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[1] Geology of the Great Serpentine Belt.

[2] The Limestone Deposits of N.S. Wales, by J. E. Carne, F.G.S., and L. J. Jones, A.S.T.C., Mineral Resources No. 25, Department of Mines, New South Wales, 1919.

from the point of view of their economic value. The purity of these limestones varies and is usually not of a very high order as the following analyses taken from J. E. Carne's Report on the Limestones of New South Wales will show (the small unimportant constituents are omitted).

Analyses of Limestones

	$CaCO_3$	$MgCO_3$	*Insoluble*
Parish of Lewinsbrook (Dungog Road two miles from Gresford) ...	78·03	2·10	17·32
Parish of Wallarobba (six mile peg Clarence Town-Glen William Rd.)	77·85	3·08	15·20
Parish of Wallarobba ditto	49 28	1·88	43·40
County of Gloucester (two miles from Dungog on Gloucester Road) ...	82·06	1·84	12 0
ditto ditto ...	64·21	1·99	27·05
ditto ditto ...	87·59	0 97	9·10
Parish of Horton, portion 53 ...	90·03	0·48	5·88
ditto ditto ...	72·35	0·75	20 18
ditto portion 18 ...	87·85	1·05	6·90

The impurities consist mainly of tuffaceous material, coarse layers of which can frequently be seen in some of the limestone beds.

The Conglomerates.—The beds of conglomerate range from a foot up to forty feet or even more in thickness. In the smaller beds the pebbles range up to three inches in diameter, but in the larger beds they range up to as much as eighteen inches in diameter. The aggregate thickness of the conglomerate beds in the Lower Carboniferous series is not large, probably not more than 200 feet. The pebbles consist mainly of quartzite, granite and quartz-porphyry. Typical examples of these conglomerates occur on the Wallarobba-Clarence Town Road (Parish of Wallarobba, portions 182, 183), and also in the railway cuttings about four to five miles east of Dungog.

The Hilldale Tuffs.—So far as bulk is concerned these are the most important rocks of the Burindi Series; they are interstratified with the other sedimentary rocks, individual beds ranging from less than an inch up to several hundreds of feet in thickness. Towards the top of the series they become increasingly important and at Hilldale form a very massive bed at the top of the series. When they occur as thin beds interstratified with the mudstones they frequently contain marine fossils and not uncommonly contain fragments of drift-wood. These tuffs are typically fine-grained; under the microscope they are found to consist mainly of angular fragments of quartz and plagioclase with smaller amounts of hornblende and biotite. Small fragments of volcanic rock also occur. They are essentially dacitic tuffs.

The Stony Creek Lava Flows.—Three lava-flows occur in this series on the road from Wallarobba to Clarence Town; whether these are three distinct flows or whether there may be some repetition due to faulting the writer is not yet prepared to say. The first of these flows outcrops on portions 175 and 188 Parish of Wallarobba; the second outcrops in a quarry at the junction of the Wallarobba Road with the road from Clarence Town to Dungog, while the third may be seen crossing the Clarence Town-Glen William Road at portion 13 in the Parish of Uffington. These lavas are aphanitic rocks with abundant small phenocrysts of felspar; in thin slices under the microscope they exhibit phenocrysts of plagioclase, hornblende and more rarely biotite set in a glassy to cryptocrystalline groundmass; an occasional phenocryst of quartz may also occur. The rock is essentially a hornblende-andesite.

Ironstone Beds.—Several beds of a titaniferous magnetite occur in this series; these beds have been mapped in detail by J. B. Jaquet and fully described in his monograph on the iron ore deposits of New South Wales.

The Lower Carboniferous Fossils.—The list of the known marine fossils for this region as compiled by Prof. W. N. Benson, is as follows:—

List of forms recorded from the district around Clarence Town, comprising Dungog, Greenhills, Gresford, Allyn River, Colo Colo, Burragood, Dernvegan, Glen William, Karuah River, Stroud, and Torreyburn.

Cyathaxonia minuta
Zaphrentis (Plerophyllum ?) culleni
,, *(Plerophyllum ?) arundinaceus*
,, *(Plerophyllum ?) georgiana robusta*
Lophophyllum minutum
,, *corniculum*
Cyathophyllum inversum
Aulophyllum davidis
Trachypora sp.
Cladochonus tenuicollis
Syringopora reticulata
,, *ramulosa*
Stenopora sp.
Symbathocrinus ogivalis
Platycrinus sp.
Actinocrinus cf. polydactyla
Periechocrinus ? sp.
Metablastus sp.
Fenestella propinqua
,, *plebeia*
,, *multiporata*
,, *gracilis*
,, *fossula ?*
,, *internata*
Dendricropora hardyi
Penniretepora grandis
Glauconome
Goniocladia laxa
Rhabdomeson ?
Orbiculoidea (Discina) nitida
Crania dubia
Productus cora
,, *semireticulatus*
,, *undatus*
,, *barringtonensis*
,, *aculeatus*
,, *cf. grandicostata*
,, *flemingii*
,, *punctatus*
,, *maximus*
,, *cf. fimbriatus*
,, *scabriculus*
,, *cf. spinulosus*
,, *longispinus*
,, *tenuistriatus*
Strophalosia sp. indt.
Chonetes papilionacea
,, *lagnessiana*
,, *aspinosa*
Orthis striatula
(Schizophoria) resupinata
(Rhipidomella) australis
Leptæna (Strophomena) rhomboidalis var. *analoga*

Orthotetes crenistria
Rhynchonella (Pugnax) pleurodon
Dielasma sacculum var. *hastatnm*
Spirifera triangularis
,, *striata*
Spirifera bisulcata
,, *convoluta*[1]
,, *lata*
,, — cf. *ovalis*
,, *pinguis*
,, *crassa*
Spiriferina cristata (octoplicata)
,, *insculpta*
Reticularia crebristria
,, *lineata*
Syringothyris exsuperans
Actinochonchus phanosulcāta
Athyris cf. *expansa*
Retzia sp.
Sanguinolites tenisoni
,, *undatus*
Leptodomus duplicostatus
Cardiomorpha striatella
Edmondia
Nucula
Paralledon costellata
Arca interupta
,, *subangulata*
Pterinea lata
Conocardium australe
Avicula hardyi
Cardinia
Aviculopecten consimilis
,, *cingendus*
Aviculopecten cf. *knockonensis*
,, *ptychotis*
,, cf. *granosus*
tesselatus
,, *forbesi*
,, *hardyi*
Entolium aviculatum
Allorisma
Pleurophorus
Leiopteria ? australis
Dentalium
,, *proxima*
Gosseletina australis
Yvania konincki
Porcellia Pearsi
Waagenella sp.
Bellerophon sp.
Platyschisma sp.
Euomphalus minimus
,, *cera*
Naticopsis sp.
Macrocheilus filosus
Loxonema acutissima
,, *rugifera ?*
,, *babbindoonesis ?*
,, *diffiicilis*
,, *constricta*
Platyceras angustum
,, *trilobatum*
,, *tenella*
Orthoceras sp.
,, *martinianum*
Phillpsia collinsi
,, *culleni*

[1] This form is perhaps better referred to *S. lata*.

Phillipsia breviceps	*Phillipsia elongata*
,, *stroudensis*	,, *dungogensis*
,, *superba*	*Griffithides convexicaudatus*
,, *waterhousei*	*Brachymetopus strzeleckii*

It will be seen that this marine fauna is a very varied one, the number of genera and species represented being fairly large. The individual fossils are, however, for the most part small in size, particularly when contrasted with the members of the Permo-Carboniferous marine fauna. Corals are comparatively rare in this southern area, but further to the north on the Manning River, near Taree, massive coralline limestones occur. The majority of the species in this fauna belong to the Brachiopoda, and this predominance is even more striking when comparing the numbers of individuals of the different groups, in particular such genera as Spirifer, Productus, Orthis, Strophomena, and Reticularia are exceedingly abundant. Crinoids are abundant in some of the limestones. The Pelecypods and Gasteropods are all small in size and relatively few in number.

The Lower Carboniferous Fossil Plants.—Fossil plants are abundant, being not infrequent in some of the beds containing the marine fossils, they consist of stems of various plants, which are obviously drift material. The most interesting occurrence of fossil plants in this district known to the writer was found by Prof. T. W. E. David and Mr. W. J. Enright on Schaefer's Farm, Portion 181, Parish of Wallarobba; here a thin bed of tuffacous mudstone is crowded with stems of Lepidodendron, Ulodendron, Pitys, etc., some of which have their internal structure perfectly preserved. This bed immediately underlies a thick bed of conglomerate, and this mode of occurrence, as well as the absence of leaves and fronds, suggests that the vegetable material had been carried into the sea during a period of flood. It has not been possible to determine the exact horizon in the Lower Carboniferous Series of this plant-bearing bed, but marine strata occur both above and below it, and it unquestionably belongs to the Lower Carboniferous epoch.

The fossil plants found in the Burindi Beds include the following:—

Lycopods—*Lepidodendron veltheimianum* Feist.
,, sp. (cf. *L. dichotomum* of Europe. or *L. scutatum* of America
Ulodendron
Cyclostigma australe Feist.
Equisetales—*Archæocalamites.*
Coniferales—*Pitys.*

Of these plants Lepidodendron preponderates and apparently grew to a fair size. Pitys grew to quite a large tree, as quite large stumps were found by Prof. T. W. E. David at Hofman's Farm. The absence of fern fronds in this flora is no doubt due to the fact that the plants are found in marine strata and have been drifted probably from considerable distances, conditions which would not be favourable for the preservation of delicate fern fronds.

B. The Kuttung Series.

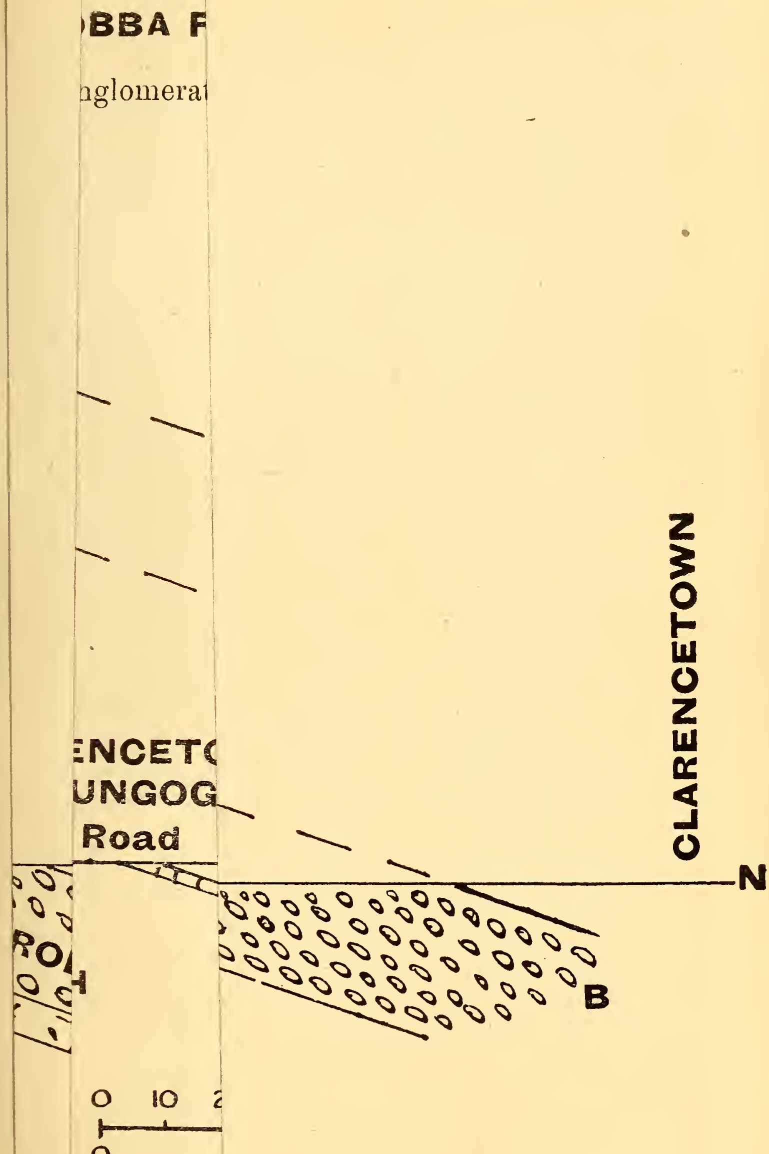
The Wallarobba Conglomerates.—These occur at the base of the Kuttung Series, they follow the Hilldale Tuffs (the topmost beds of the lower series) without any angular unconformity, in fact the tuffs merge upwards gradually into the conglomerates and similar tuffs occur interstratified with the conglomerates themselves.

These conglomerates have an extraordinary development in this district; at Wallarobba they have a thickness, including the interstratified tuffs and tuffaceous sandstones, of about 1300 feet, the bulk of this material being conglomerate, while at Clarence Town the same formation has a thickness of upwards of 2000 feet. The pebbles average two to three inches in diameter, but may exceed this size, individual pebbles ranging up to eighteen inches in diameter being not uncommon. Most of the pebbles are typically waterworn, but some occur which are sub-angular and faceted with some suggestion of having been derived from glacial material; no striated pebbles have, however, yet been obtained from this horizon. A great variety of rocks is represented in this conglomerate, including granites (of various kinds), quartz porphyry, felspar porphyry, quartzite, chert, etc.

Good exposures of this formation may be seen (*a*) in the railway cutting immediately to the east of the Wallarobba Tunnel [Plate XX], (*b*) the road cuttings immediately to the west of Clarence Town on the road from thence to Dungog, (*c*) immediately to the east of the Dungog railway tunnel.

The Tuffaceous Beds.—Towards the top of this formation the conglomerates gradually give place to tuffs, tuffaceous shales and tuffaceous sandstone, with occasional bands of conglomerate, there being a considerable thickness of these tuffaceous beds. At Wallarobba the thickness is about 500 to 550 feet, while at Clarence Town it is probably much greater. These beds possess no features of special interest and gave poor outcrops.

The Martin's Creek Beds.—Although volcanic material occurs more or less throughout the Kuttung Series, this particular part of it consists almost entirely of volcanic material, including both lavas and tuffs. This volcanic belt persists throughout the district extending from the coast at Port Stephens to the Williams River District where it outcrops in the Mount Gilmore Range, it extends thence westward to the Paterson River Valley at Martin's Creek,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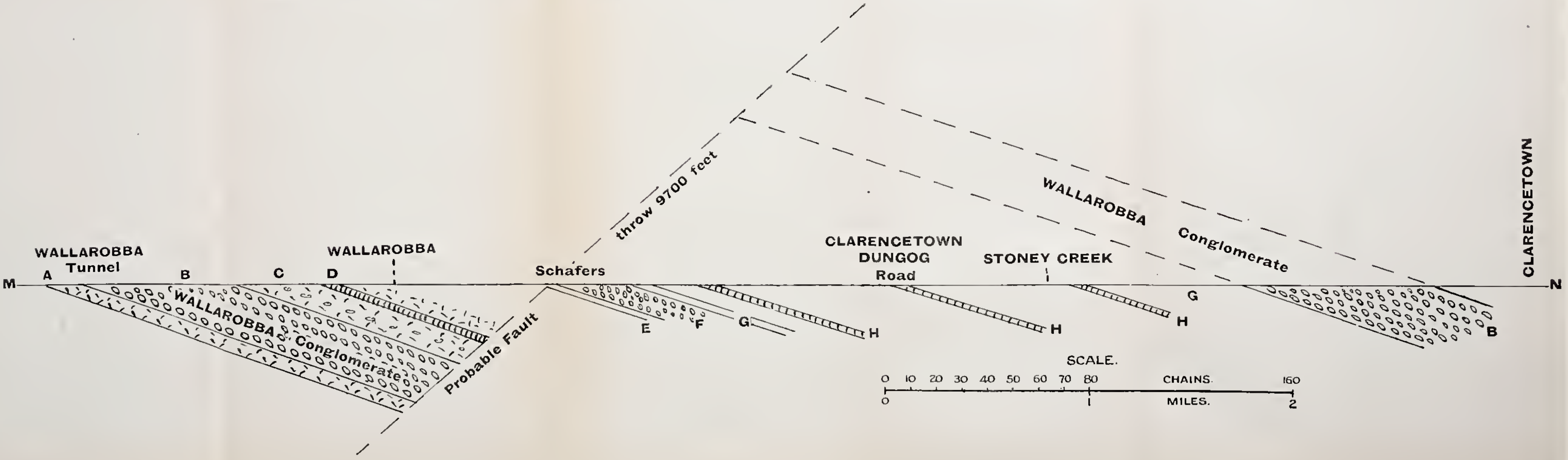
SKETCH SECTION ON LINE M TO N, PLATE XXXI, SHOWING WALLAROBBA FAULT IN THE CARBONIFEROUS ROCKS.

A Tuffs. B Wallarobba Conglomerates. C Tuffs etc. D Martin's Creek Andesite. E Fossil Plants. F Conglomerate. G Tuffaceous Mudstones with Marine Fossils. H Lava Flows.



thence westward to Eelah, from there to Hudson's Peak and Lamb's Valley; the writer's field work has not carried him beyond the latter point. The succession of the lava flows is not everywhere identical as may be seen from the following comparisons:—

Section at Eelah.	Feet	Section at Martin's Creek.	Feet
Tuffs	185	Dacite	200
Biotite dacite	420	Tuffs etc....	100
Pyroxene (?) andesite ...	130	Dacite	200
Augite andesite... ..	185	Conglomerate	100
Hypersthene augite andesitic glass	185	Tuffs and shales... ...	250
		Dacite	50
Pyroxene dacite... ...	225	Tuffs	30
Tuffs	30	Conglomerate	250
Hornblende-biotite-andesite	105	Dacite	100
Biotite rhyolite	80	Conglomerate and tuffs...	400
Tuffs (? altered andesite)	130	Hypersthene, andesitic glass... ...	100 – 200
Hornblende-biotite-andesite	80	Andesitic tuff ...	150 – 200
Tuffs (? altered andesite)	145	Pyroxene-hornblende-andesite ...	150 – 200
Pyroxene andesite ...	370		
Total	2270	Total	2280

Section on the Mount Gilmore Range.

Dacite Flow (? Rhyolite)
Tuffs etc.
Dacite Flow (? Rhyolite)
Tuffs etc.
Dacite (? Rhyolite)
Tuffs etc.
Dacite Flow
Tuffs and conglomerate
Dacite Flow
Tuffs and conglomerate
Hypersthene-andesite glass
Tuffs and conglomerates
Hornblende-andesite

The sections at Eelah and Martin's Creek were measured by the writer and agree closely as to thickness, but do not agree as to the order of extrusion of the lava flows, particularly with regard to the position of the hypersthene-andesite glass. At Martin's Creek and at Mount Gilmore the series of lava flows starts with a normal hornblende andesite, and is followed by a somewhat more basic hypersthene-andesite glass, this in turn being followed by a series of dacites and rhyolites. The names given for the various flows are tentative, and may need revision when chemical analyses are available. Some notes on the igneous rocks of the Kuttung Series are given in Appendix II by Mr. W. R. Browne, B.Sc. The thicknesses of the flows in the Mount Gilmore section are not available.

Excepting at Eelah the general succession of lavas appears to have been from intermediate to acid. The Paterson rhyolite appears much higher in the Kuttung Series and will be referred to later. At Eelah the Martin's Creek horizon is represented by lava-flows and tuffs only, and this was possibly a centre of eruption, but elsewhere interstratified with the lava flows and tuffs are some beds of coarse conglomerate and possibly also some mudstones.

Martin's Creek Andesite.—This is the lowest of the lava flows and owing to its persistent lithological characters throughout the district it forms a useful horizon for mapping purposes. This flow has a thickness which varies from 150 to 300 feet, and is sufficiently resistant to decomposition to give good outcrops. It outcrops on the left bank of the Williams River immediately opposite the township of Clarence Town where it forms the basal flow of the Mount Gilmore volcanic series mapped by Mr. Jaquet; it forms extensive outcrops at Martin's Creek where it is being extensively quarried for railway ballast and road-making purposes; here it forms the base of the Martin's Creek beds; it gives good outcrops at Wallarobba between the railway station and the Wallarobba Tunnel. Good outcrops occur at Eelah (in the Parish of Gresford just north of the Hunter River), and from here it can be traced to Hudson's Peak and Lamb's Valley. This rock is dark blue in colour with abundant small phenocrysts of augite, hornblende and plagioclase with occasional phenocrysts of quartz. Its microscopic characters have already been described by Mr. Aurousseau.[8]

The Hypersthene Andesite Glass.—This is a very wide spread lava flow; at Martin's Creek and the Gilmore Range it is the next flow after the Martin's Creek andesite. It is a pitch-black rock with numerous phenocrysts of plagioclase. Under the microscope it displays a glassy base in which are embedded abundant plagioclase phenocrysts with fairly abundant hypersthene. It varies from 150 to perhaps 400 feet in thickness.

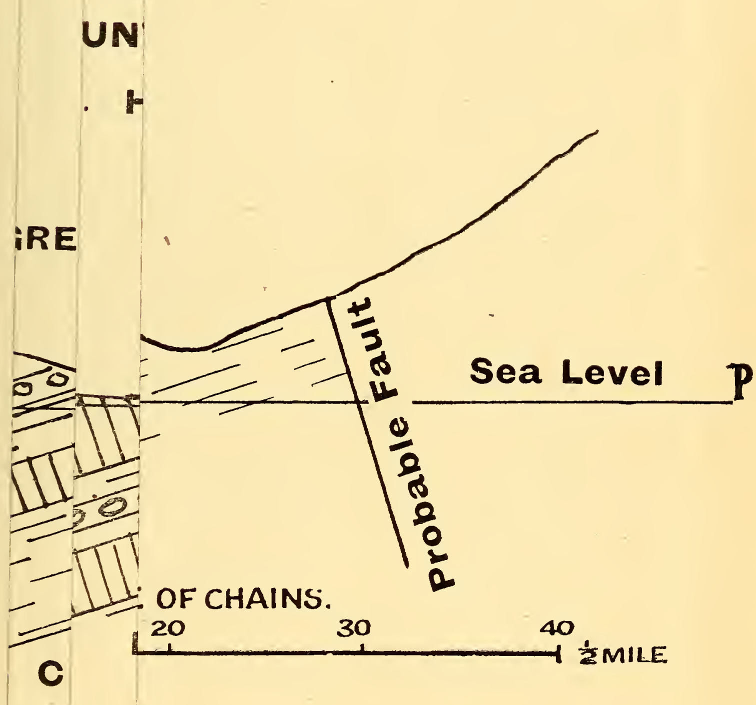
The Dacites.—There are from three to four of these flows, but they are all of somewhat similar character. The unweathered rock has a bluish-grey colour, but the partly weathered rock may be green, red or pure white, phenocrysts may or may not be present, when present they consist of quartz (variable in amount), felspar and biotite, the latter occasionally very abundant. Generally much of the rock consists of volcanic glass which may be more or less devitrified. Although fairly acidic these rocks do not always give good outcrops, and it is difficult to secure specimens that are quite free from decomposition. They frequently contain small fragments of aphanitic igneous rocks which probably represent older rocks which were melted up to form this lava. Some of these rocks upon analysis may prove to be rhyolites, in fact the field evidence suggests that a flow which is a dacite in one locality may merge into a rhyolite not very far away. The possibility of some of these igneous rocks being intrusive sills has not been lost sight of, but the available evidence is all in favour of contemporaneous lava flows, with the possible exception of the hypersthene andesite glass, but nowhere has a good junction of this rock with those above and below it been seen, consequently no very definite opinion can be expressed.

The Tuffs.—These in general are similar in composition to the associated lava flows, for example the tuffs above the Martin's Creek flow are andesitic in character, whereas those associated with the dacites are of a more acidic character. They are typically fine-grained but are in parts fairly coarse-grained giving characteristic volcanic breccias. No large fragments or ejected blocks have been noted in the tuffs proper.

The Conglomerates.—Interstratified with the lava flows are a number of beds of conglomerate, some of which contain very large pebbles. At Martin's Creek the one just above the hypersthene-andesite glass and which outcrops in the railway cutting where the Paterson-Hilldale road crosses the railway line, is a notable example. This bed is crowded with granite pebbles, 12 to 18 inches thick, all well rounded and waterworn. These beds range from 100 to 300 feet in thickness and are very persistent.

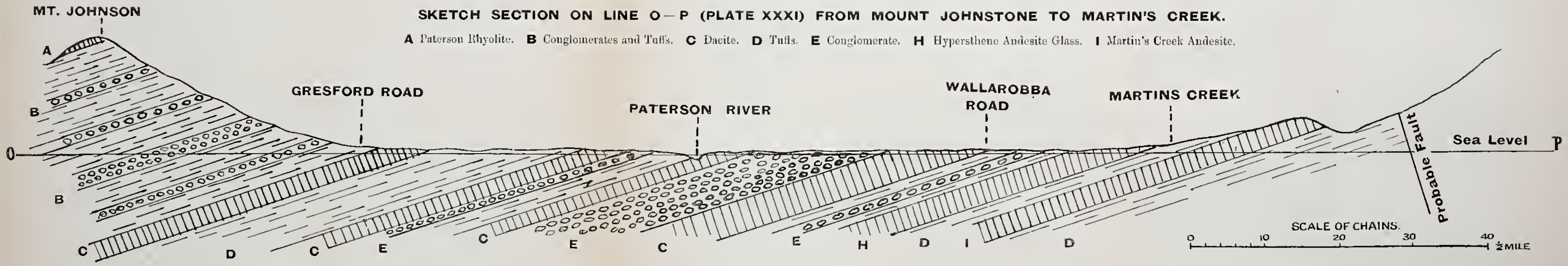
The Mount Johnstone Series.—Following on the Martin's Creek beds there occurs a series of tuffs, tuffaceous sandstones, conglomerates and mudstones, about 2000 feet in thickness, with a final lava flow at the top, viz., the Paterson rhyolite. This series is very largely volcanic in origin and its separation from the Martin's Creek beds is only one of convenience, differing mainly in the absence of actual lava flows. The tuffs are acidic to sub-acidic in character. Beds of conglomerate are frequent, and their aggregate thickness must be considerable. An excellent section of this series may be seen on the eastern side of Mount John-

Plate XXI.



SKETCH SECTION ON LINE O—P (PLATE XXXI) FROM MOUNT JOHNSTONE TO MARTIN'S CREEK.

A Paterson Rhyolite. **B** Conglomerates and Tuffs. **C** Dacite. **D** Tuffs. **E** Conglomerate. **H** Hypersthene Andesite Glass. **I** Martin's Creek Andesite.



stone on the western side of the Paterson River valley, immediately north of the township of Paterson itself, and is shown in Plate XXI. Tuffs preponderate, but interstratified with them are thin beds of shale and in some of these there are present abundant fossil plants. The following is a list of those so far found:—

Equisitales—

Archæo-Calamites radiatus Brong.

Lycopodiales—

Lepidodendron sp. *Cyclostigma.*

Filicales—

Rhacopteris (Aneimites) inequilatera Feist.
,, *intermedia* Feist.
,, *Romeri* Feist.
,, *septentrionalis* Feist.
Archæopteris (? Rhacopteris) Wilkinsoni Feist.
Cardiopteris polymorpha Dun.
Sphenopteris Clarkei Dun.
Rhacophyllum diversiforme Eth. fil.

This flora, in which the genus Rhacopteris predominates, both in variety and number of specimens is known as the Rhacopteris flora and is quite different from that found in the Lower Carboniferous beds of the same district, and referred to on another page. Lepidodendron occurs, but is rare. The correlation of the Burindi and Kuttung floras with Carboniferous floras in other parts of the world is dealt with by Dr. A. B. Walkom in Appendix I. Some thin bands of impure coal are also found in this part of the Kuttung Beds, but they are of no commercial value.

The Paterson Rhyolite.—This flow is one of the most widespread in the district and makes a most useful persistent horizon always occurring at the junction of the Mount Johnstone beds with the overlying glacial beds. It varies from 150 to 300 feet in thickness, and in the hand-specimen displays abundant phenocrysts of quartz and felspar. It is the last of the Kuttung lava flows and is probably the most acidic.

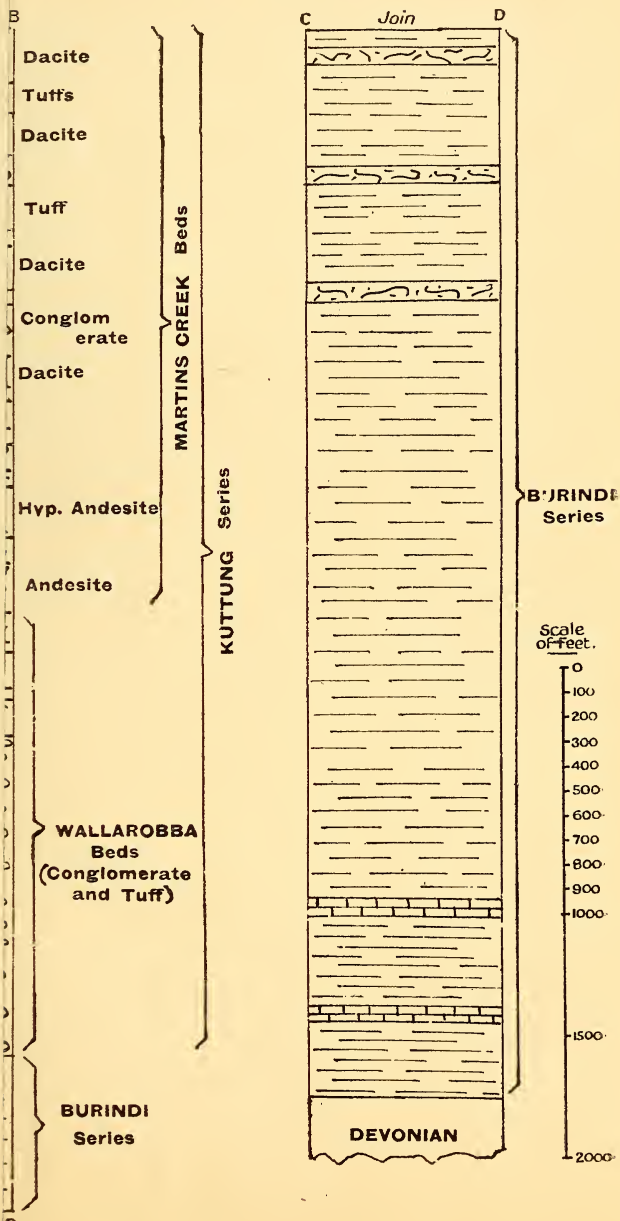
The Seaham Glacial Beds.—This is the most interesting subdivision of the Kuttung Series. These glacial beds, or such parts of them as had previously been observed, have always been considered to belong to the Permo-Carboniferous system. The following are detailed sections of these beds as they occur at Seaham in the Williams River valley and at Paterson in the Paterson River valley; they are also shown in diagrammatic section in Plate XXII.

Section at Seaham.	Feet.
Grey tuffaceous mudstones	264
Tillite Bed (No. 5 Bed) ...	75
Varve Shales	100
Tillite Bed (No. 4 Bed) ...	80
White Tuffs	55
Tillite Bed (No. 3) ...	200
White Tuffs	315
Varve Shales (with contortions)	110
Fluvio-glacial conglomerate (No. 2 Bed)	50
Tuffs (with conglomerates)	220
Fluvio-glacial conglomerate (No. 1 Bed)... ...	270
Total ...	1739

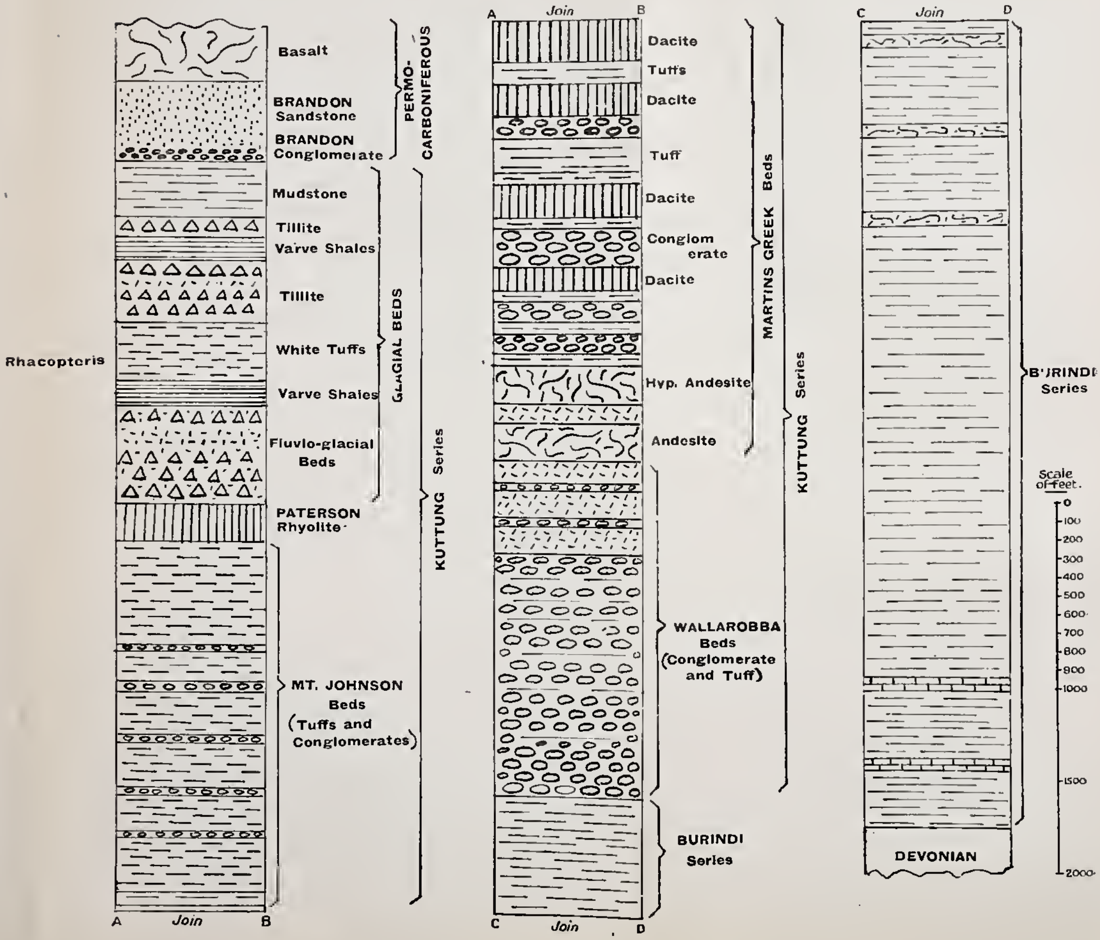
Section at Paterson.	Feet.
Grey tuffaceous mudstones	200
Tillite	230
Varve Shales	120
White Tuffs	100
Varve Shales	100
White Tuffs	35
Fluvio-glacial conglomerate	150
Total ...	935

It will be seen that these beds have their best development at Seaham, and this section will be taken for detailed description.

The Fluvio-glacial Conglomerates and Tillites.—The first bed rests directly upon the Paterson rhyolite not only at Seaham but wherever these glacial beds have been found to occur. At and near its base this glacial conglomerate boniferous rocks of the Hunter District.



Generalised Section of the Middle and Lower Carboniferous rocks of the Hunter District.



Glaciated pebble from Felspar Creek, Seaham (from Kuttung Series), from horizon 9,800 feet below that of the glacial Bolwarra conglomerate of Upper Marine Permo-Carboniferous Series, at Maitland.

(Natural Size.)

contains an abundance of very large boulders; the largest of these consist of a rock identical with the underlying Paterson rhyolite; these rhyolite boulders range up to 12 feet in diameter. Boulders of many other rocks also occur ranging up to several feet in diameter; these include granites (quite a number of varieties) quartz-porphyries, gneiss, amphibolite, quartzite, etc. These rocks must have come from a considerable distance, as no occurrences of similar types are known anywhere in the vicinity. Large boulders are not limited to the base of this bed, but occur throughout; many of these are subangular and faceted, while some show glacial striæ. The groundmass in which the boulders are embedded varies considerably, in some places it is coarse, not unlike a coarse tuff, in other places it consists of exceedingly fine material, like glacial mud. Striated pebbles occur but are not very common, and the only rock of the many which occur which exhibits ice scratches is the quartzite; these besides being scratched are often faceted. This bed outcrops prominently along the road going north from Seaham, particularly at Felspar Creek about one and a half miles north of Seaham. While this bed in parts resembles a true tillite much of it might be compared with the outwash from a glaciated region as the percentage of glaciated pebbles is small, while the groundmass in which the pebbles are embedded, only in places resembles that of a true tillite, it is therefore referred to as a fluvio-glacial conglomerate. (See Plate XXVIII.)

The No. 2 bed is not so characteristic as No. 1, being more like an ordinary conglomerate, but contains some striated pebbles. The No. 3 bed is a true tillite, and outcrops at the turn of the Seaham-Maitland road just south of the township, and is the most typical of the tillites of the district. It consists of consolidated glacial mud showing little or no evidence of stratification, in which are embedded pebbles ranging up to two feet in diameter; in some parts the pebbles are abundant, while in other parts not far away they may be comparatively few and far between. Striated boulders (always quartzites) are fairly abundant in this bed. The same variety of rocks occurs here as are found in the No. 1 bed. The No. 4 and No. 5 tillite beds do not make good outcrops, but are similar to No. 3 in general character.

The Varve Shales.—These resemble in every detail the Pleistocene glacial muds from U.S.A. described by R. W. Sayles[1] and the banded rocks described by the same writer from the Squantum Beds near Boston, U.S.A. A detailed measured section of the lower series of varve shales at Seaham is shown in Fig. 1, and if this section is compared with those given by Sayles in his paper a striking resemblance will be at once apparent. The varve shales at Seaham consist of a regular alternation of relatively coarse and fine layers of material; the coarse layers are yellow to brown in colour, and are coarse enough for the constituent particles to be visible to the unaided eye, the fine layers are grey to white in colour and even under the microscope the material is too fine-grained for identification. The coarser layers frequently exhibit minute false bedding and merge upwards into the finer layer, but the junction between a fine layer with the next coarse layer above is usually quite sharp. There is no doubt in the writer's mind that these alternating layers represent, as Sayles suggests, seasonal deposition of glacial material in a lake, the coarse material representing the summer deposit when the rivers draining from the glaciers were transporting relatively coarse material; the fine layers representing the fine material in suspension in the lake waters which

[1] Seasonal Deposition in Aqueo-Glacial Deposits by Robt. W. Sayles. Memoirs of the Museum of Comparative Zoology at Harvard College, February, 1919.

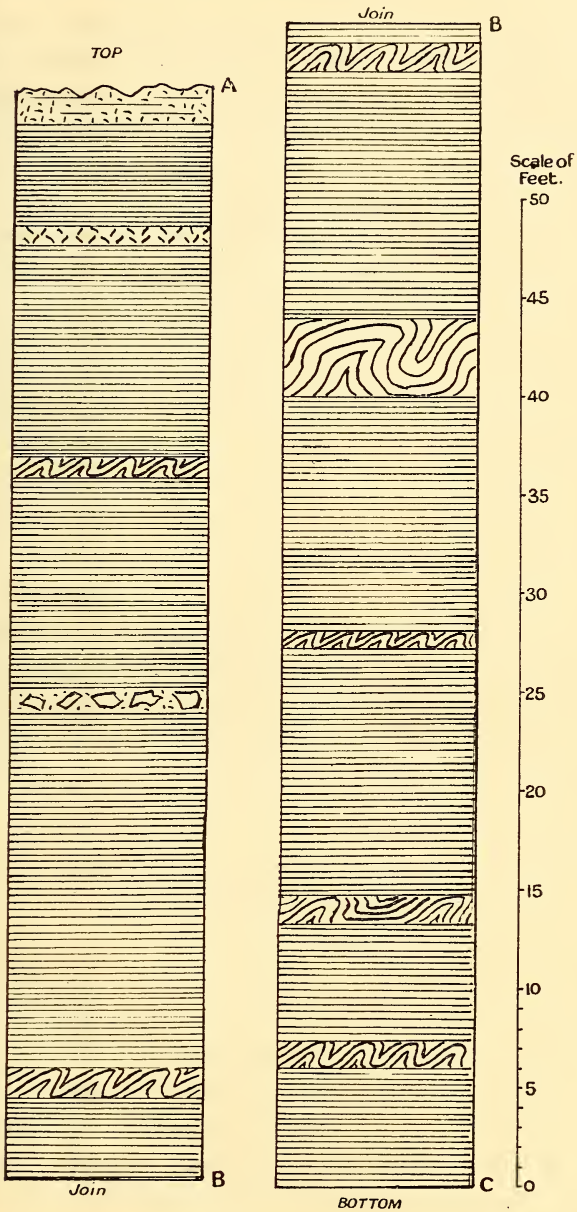
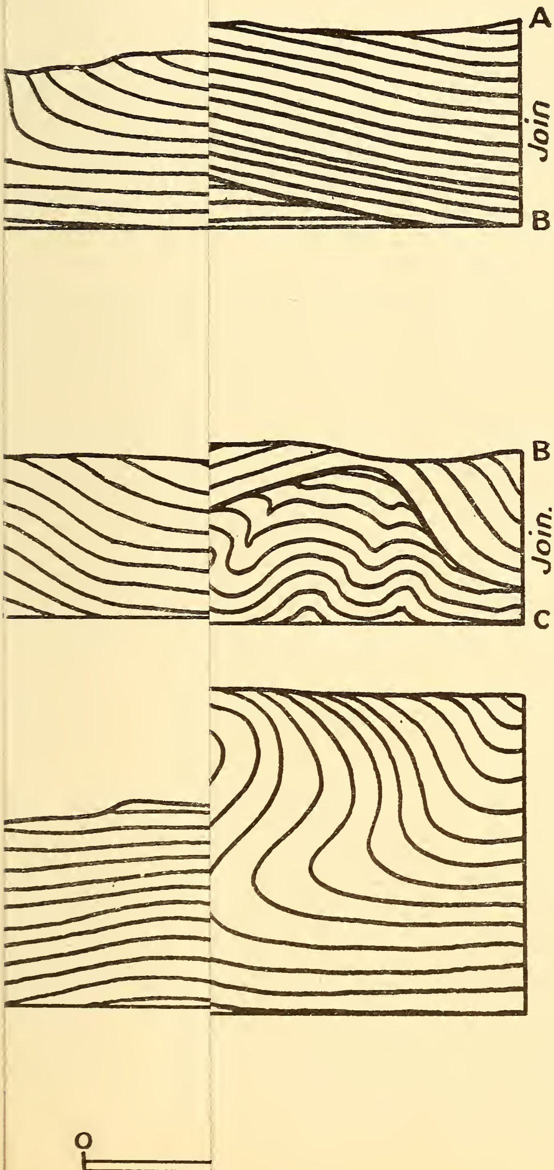


Fig. 1.—*Detailed Section of the Varve Beds at Seaham.*

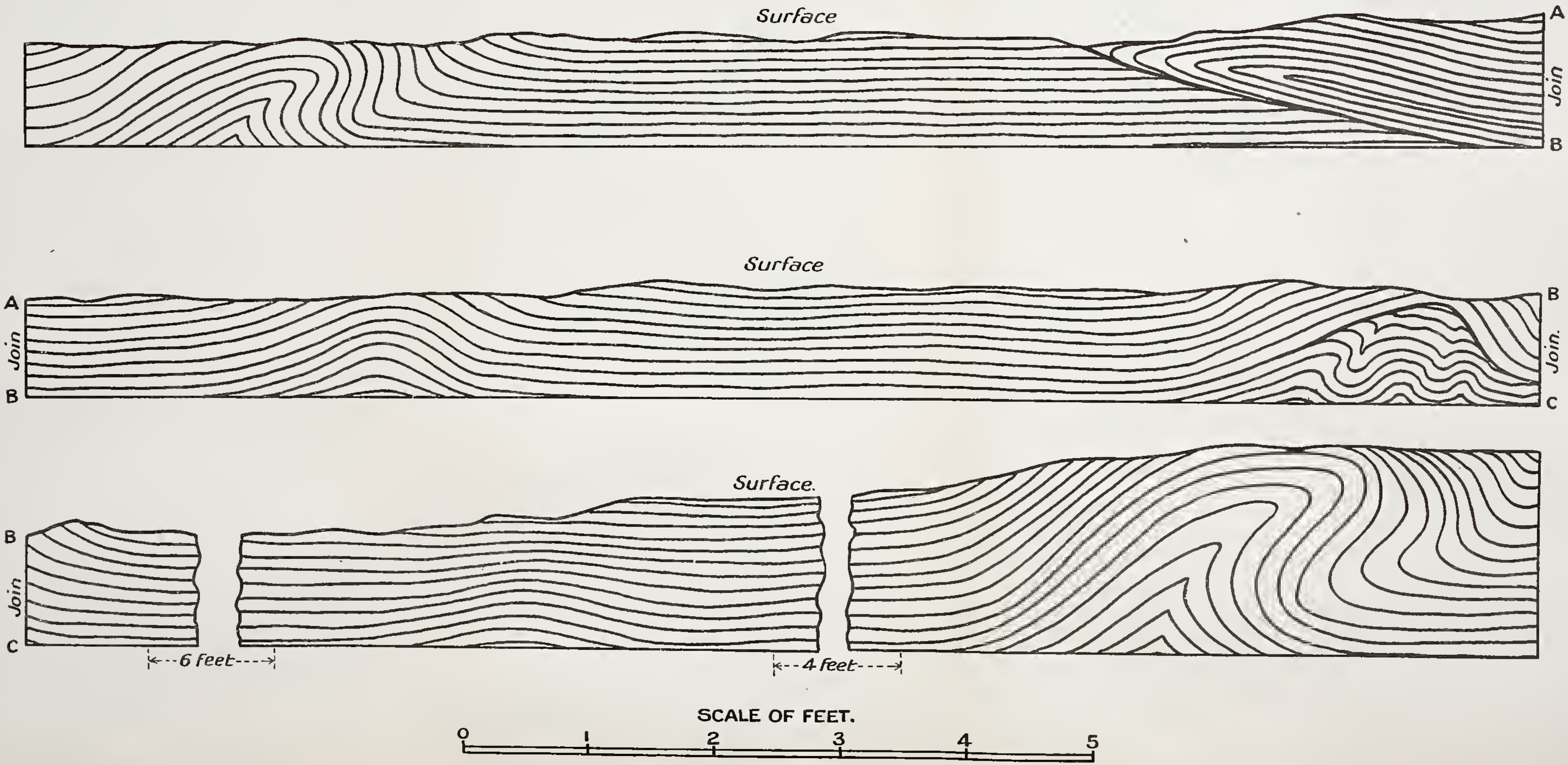
slowly settled down in winter time, while the lake was frozen over and there was no melting of ice on the neighbouring glaciers to bring about the flow of water necessary to transport the coarse material. The thickness of each season's deposit (*i.e.* a pair of layers) is somewhat variable, but averages about two-thirds of an inch, so that the 200 feet of these varve shales which occur at Seaham must have taken about 3,000 years to deposit. Layers from four to six inches thick and consisting of fine material only occur, but are few in number; similarly some thicker layers of coarse material only also occur. Occasional isolated pebbles ranging from half an inch to three inches in diameter are found in these varve shales, and occasionally also a regular 'pocket' of such pebbles is found, the pockets ranging up to several feet in diameter. Such a 'pocket' of pebbles occurring in such exceedingly fine-grained thinly bedded strata must be due to the melting of a small stranded ice-berg dropping its pebbles on the one spot as it melted. The isolated pebbles would be due to the melting of drifting icebergs and the dropping by them of occasional pebbles as they floated over the surface of the lake in which the shales were deposited.

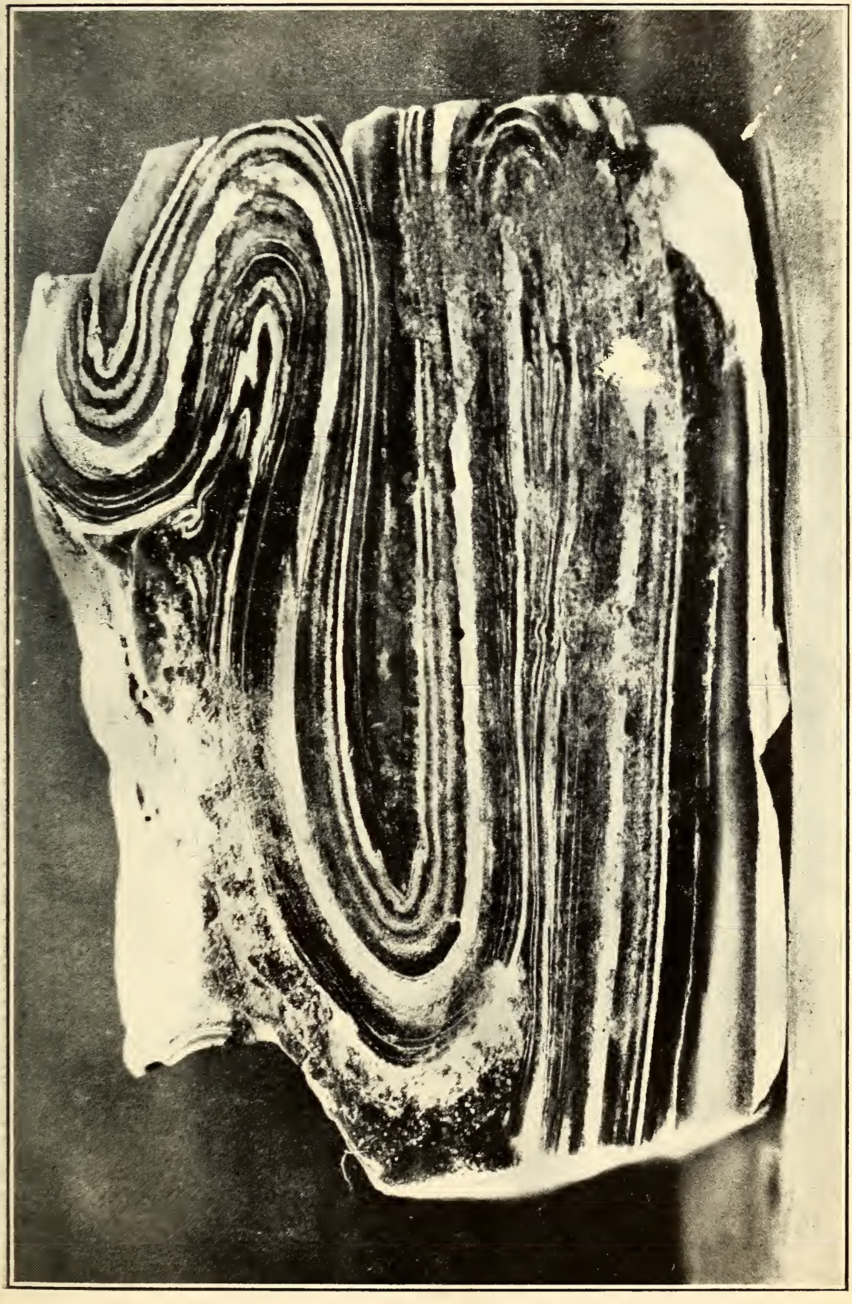
At intervals in the varve shales as shown in fig. 1 there occur layers which are strongly contorted, similar to those described by Sayles from the Squantum Beds. These contorted layers range from a few inches up to four feet in thickness and display in miniature every type of Alpine folding as shown in Plates XXIV, XXVI, and XXVII. A bed which is contorted in one part may fade out into a part which shows no contortion at all, while the contorted layers themselves are interstratified between perfectly regular unfolded layers. The whole evidence suggests that the contortion is contemporaneous and is due to the stranding of floating masses of ice, or perhaps in some cases to the

eous contus Age), Seaham.

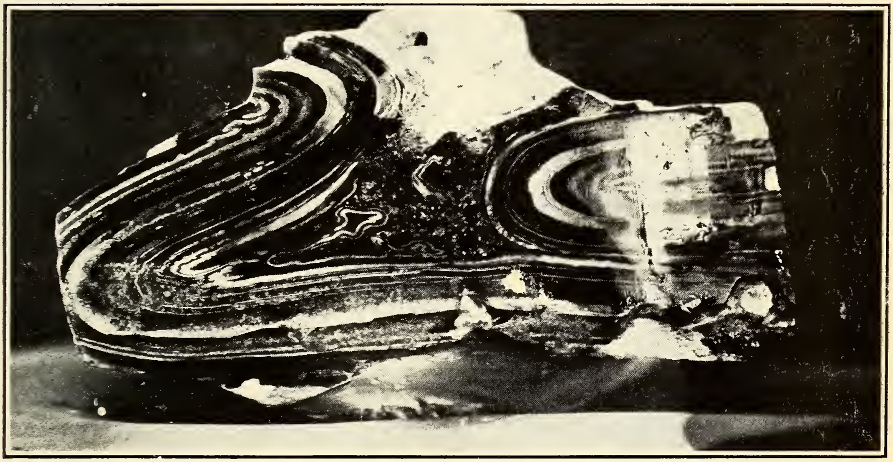


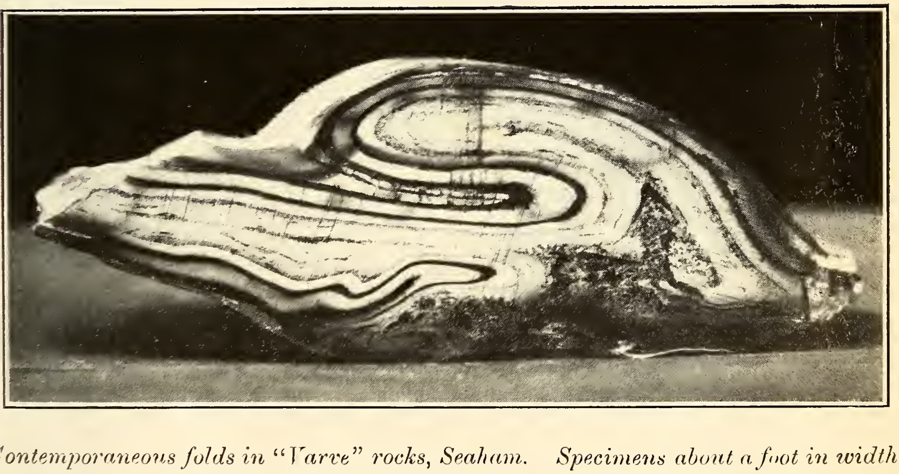
Section showing contemporaneous contortion in the "Varve" Shales (of Middle or Upper Carboniferous Age), Seaham.





Contemporaneously Contorted "Varve" Shales, Seaham. Block about 15 inches wide.





Contemporaneous folds in "Varve" rocks, Seaham. Specimens about a foot in width.

temporary forward movement of the ice front. Delicate, but well-preserved, annelid tracks are found on the bedding planes of some of the varve shales.

Reference to the sections at Paterson and Seaham (Plate XIX) will show that there are two series of these varve shales with an aggregate thickness in each locality of about 200 feet; the thicknesses given are not absolutely accurate as the junctions with the associated strata were not always too clear. These varve shales form a very persistent horizon and have been observed at intervals from the Raymond Terrace Road to Gresford, a distance of over 20 miles. In every place where they have been found they are associated with tillites and always display the same details of character and structure.

The White Tuffs.—These are white to light-yellow coloured rocks, which in the hand specimen look like fine-grained tuffs of an acidic composition, but it is quite possible that they may be deposits of glacial sandy material deposited at times when the conditions were not favourable for the deposition of the varve shales, as they are not unlike the coarser layers of the varve shales. These rocks need further investigation.

The Grey Tuffaceous Mudstones.—These rocks make very poor outcrops and their true nature is difficult to determine; they resemble fairly closely the groundmass of some of the tillites, and apparently contain no fossils. They are included here with the glacial beds, but without any very definite opinion that they are directly of glacial origin.

The Geological Age of the Glacial Beds.—These beds have by previous writers been referred to the Permo-Carboniferous System and placed at the base of the Lower Marine Series. They are here included with the Kuttung Series for the following reasons:—

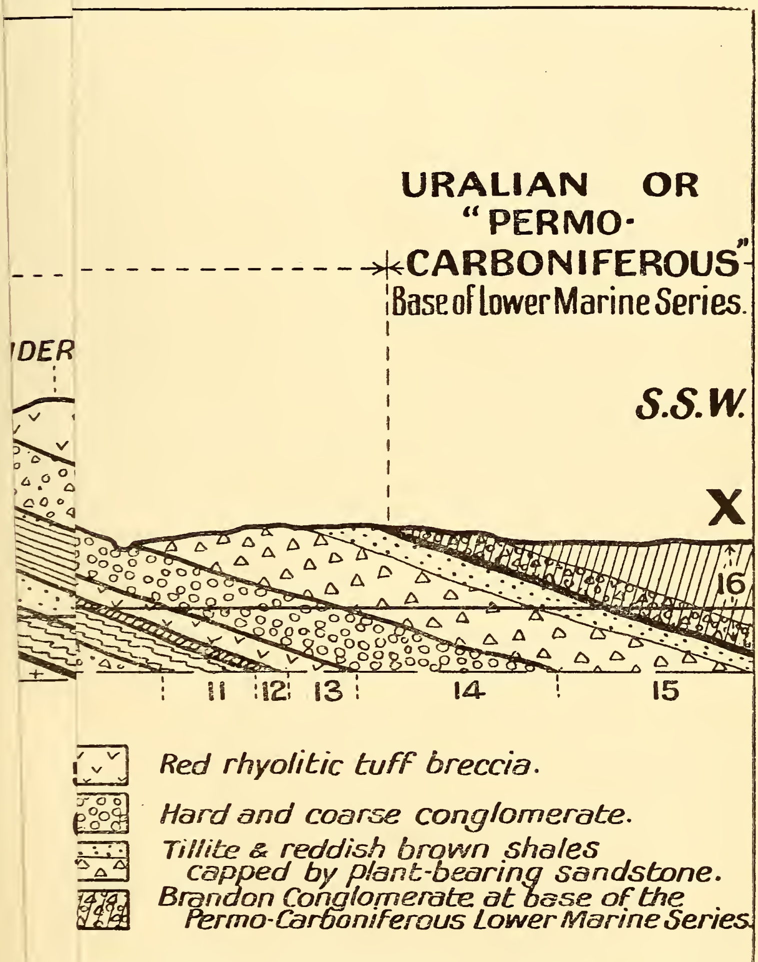
(*a*) They immediately overlie the Kuttung Rhacopteris bearing beds without any angular unconformity, (*b*) like the Kuttung series they were deposited under terrestrial conditions, (*c*) some few fragmentary fossil plant remains have been found in the varve shales, but too poorly preserved for accurate determination, but such as they are they resemble the fossil plants of the Kuttung Series in their method of preservation, and include what appears to be an undoubted pinnule of *Aneimites inequilatera*, (*d*) the lithological characters of some of the beds resemble those of the underlying Rhacopteris Series and are quite unlike anything in the succeeding Permo-Carboniferous strata, (*e*) the climatic and geographical conditions under which they must have been deposited would appear to have been the culminating result of the pronounced crustal uplift which must have been going on throughout the Middle and Upper Carboniferous Epochs in this region, whereas the conditions of the succeeding Permo-Carboniferous were those of a long continued and widespread subsidence.

Since the above was written Mr. W. R. Browne, B.Sc. and Prof. T. W. E. David have examined a section of the glacial beds at Winder's Hill near Lochinvar in which they have found undoubted specimens of *Rhacopteris (Aneimites) inequilatera* occurring in shale beds interstratified with glacial beds. They have measured the following section:—

	Feet.
Tillites and Conglomerate with reddish-brown shales...	300
Coarse Conglomerates	140
Reddish Rhyolite Tuff Breccia...	50
Tuffs and Tuffaceous Sandstones with fossil plant stems	20
Reddish Varve Shales with local contortions	70
Red and Grey Tuffs, Conglomerates, Sandstones, Shales	270
Cherty Shales with Rhacopteris and Calamites	10 – 20
Grey Rhyolite Tuff with occasional thin bands with Calamites	490
Fuvio-Glacial Conglomerates	180

TION.

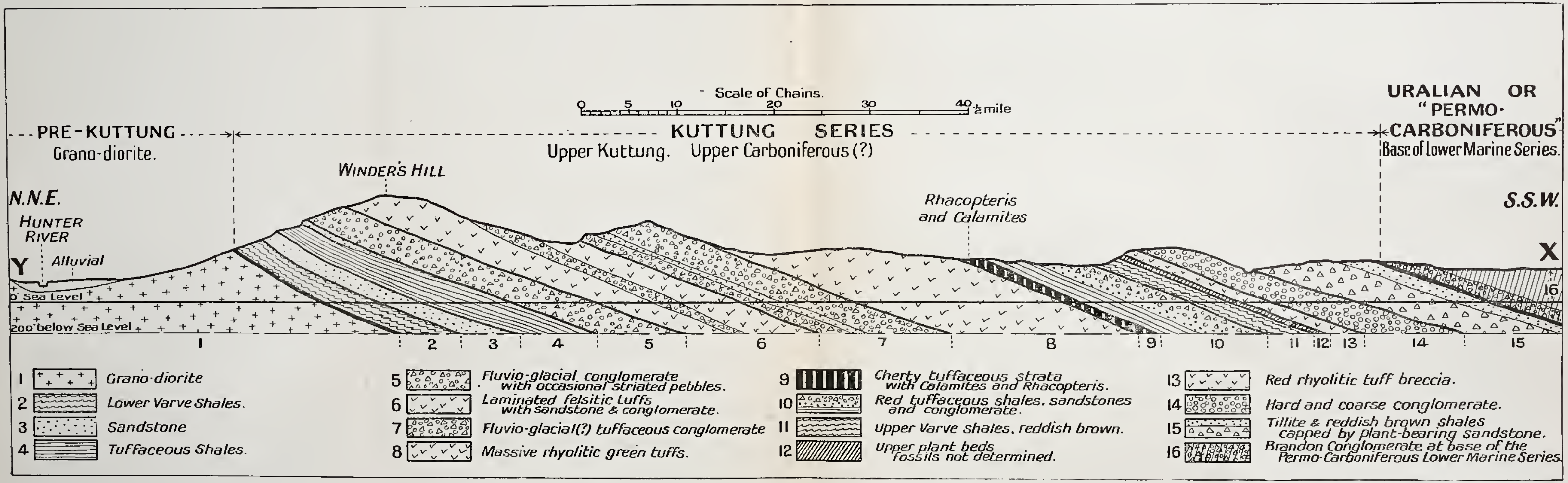
of the re-Rhacopteris floor of Grano-diorite.



–Top of bed 15 is marine to estuarine passage bed.

SECTION, Y — X On Plan, (Chiefly after W. R. Browne, B.Sc.) NORTH OF LOCHINVAR, N.S.W.

Showing glacial conditions in upper part of the "Kuttung" (Middle Carboniferous Series) containing Rhacopteris. The "Varve" rock on left of section rests on a Pre-Rhacopteris floor of Grano-diorite.



NOTE.—*Top of bed 15 is marine to estuarine passage bed.*

	Feet.
Sandstones	20
Fluvio-Glacial Conglomerate	80
Felsitic Tuffs and Tuffaceous Sandstone with some Conglomerates	330
Fluvio-glacial Conglomerates with striated pebbles ...	210
Sandstones and Shales	20
Mudstones	170
Sandstones	100
Varve Shales with contemporaneous contortions and containing some large boulders of grano-diorite...	170
Total	2630

This series of glacial beds is considerably thicker than that which occurs at Seaham and contains a much larger proportion of ordinary sediments. The section, however, is particularly important in that it shows undoubtedly the occurrence of the Rhacopteris flora stratigraphically above some of the glacial beds. This Lochinvar section is shown in Plates XIX and XXIII.

The Geological interval represented by the Kuttung Series.—The topmost beds of the Kuttung Series (the Glacial Beds) are followed in the Lower Hunter District by the Lower Marine Series, the lowest subdivision of the Permo-Carboniferous System, without any apparent angular unconformity. The only fossils so far found in the Kuttung Series, are those listed upon page 258, and these are considered by Dr. A. B. Walkom to be a Middle Carboniferous flora (see Appendix I). This raises the question as to whether there may be a disconformity between the Kuttung Series and the Permo-Carboniferous formation, with a series of Upper Carboniferous strata missing? the field evidence in the area known to the writer does not support such a view.[1] There is, near the base of the Lower Marine Series

[1] My co-author, however, explains in Part II of this paper that he considers such a disconformity exists in places.

a very persistent horizon, consisting of a very thick bed of natrolite basalt, and shown by Professor David in his geological map and section of the Hunter River coalfield. In following the junction of the Carboniferous and Permo-Carboniferous strata from the sea-coast to Paterson, a distance of about 35 miles, the outcrops of this basalt and that of the Kuttung glacial beds always occupy the same relative positions with regard to one another. If a thick series of strata had at one time existed between these two horizons it is hardly likely that it would have been denuded down to exactly the same geological level over such a wide area.

From no other part of the State have any beds yet been found of Carboniferous age occuring above the Kuttung Series and below the Lower Marine Series. It seems improbable therefore that there has been any important removal of strata of Carboniferous age from the top of the Kuttung Series. This being so, and assuming that the Lower Marine Series are retained in the Permo-Carboniferous System, then the Kuttung Series represents the whole of the time interval from the beginning of the Middle Carboniferous Epoch up to the end of the Carboniferous Period. The Neuropteris-Alethopteris flora which characterises the Upper Carboniferous Coal Measures of North America and England does not appear to have found its way into Eastern Australia, and it would appear that the Rhacopteris flora of the Kuttung Series, which is typical of the Middle Carboniferous Epoch only, in the Northern Hemisphere, survived longer in New South Wales, being replaced not by the Neuropteris-Alethopteris flora of Upper Carboniferous time in the Northern Hemisphere, but by the Glossopteris-Gangamopteris flora so typical of the Permo-Carboniferous period in the Southern Hemisphere. Should it however, be decided to transfer some part of the Permo-Carboniferous formation into the Carboniferous Period, then the Kuttung Series would become the Middle Carboniferous Series, and the transferred beds Upper Carboniferous.

Summary of the Carboniferous Period.—The Lower Carboniferous.—The beginning of the Carboniferous Period in New South Wales found the greater part of the State dry land; the exception being a relatively long and narrow belt of epicontinental sea which extended along the southern and western margins of that part of New South Wales now called the New England Tableland. The history of the change from the Devonian Period to the Carboniferous Period will not be dealt with here, as no contacts between these two formations occur in this district, but will be described in a later paper dealing with the Devonian and Carboniferous formations of the Gloucester District. The accompanying map (Plate XVIII), showing the area now occupied by Carboniferous strata, will give some idea of the position and size of the Lower Carboniferous sea, and it will be seen that it completely separated the north-eastern part of New South Wales from the remaining part of the State. This Carboniferous sea extended northwards from New South Wales into Queensland, and similarly cut off the south-eastern part of that State from the remainder.

These portions of New South Wales and Queensland cut off from the remaining parts of Australia during the Carboniferous Period, were parts of a separate land area which existed to the east of the Australian continent at least as far back as the beginning of the Devonian Period, and probably as far back as the beginning of the Palæozoic Era. It is desirable that this land area should have a definite name, and that of Tasmantis is proposed. This land became permanently united to the mainland of Australia towards the close of the Permo-Carboniferous Period. How far to the east of the present shoreline it extended is not known, but the size and positions of the Mesozoic lakes of

Eastern Australia during the Mesozoic Era implies a very considerable extension of the Australian continent over what is now the Tasman Sea during the Mesozoic Era.

That the Carboniferous epicontinental sea was shallow is indicated (*a*) by the marine fauna preserved in the Lower Carboniferous strata, which consists mainly of shallow-water species; (*b*) the presence of occasional beds of conglomerate interstratified with the marine mudstones, and (*c*) the oolitic limestones which occur. Throughout the Lower Carboniferous Epoch, the bed of this sea was undergoing a slow subsidence, which allowed of the deposition of perhaps 5,000 feet of strata. In the lower part of these sediments, the presence of beds of limestone indicates that the sea over some areas was at times sufficiently free of terrigenous sediments to allow of the accumulation of a moderate thickness of calcareous organic material, particularly crinoid stems.

From the adjoining land, stems and twigs of plants were being washed down by rivers, and as these became waterlogged they sank and were preserved in the marine sediments. The abundance of this drift vegetation at some horizons indicates that at times fairly extensive floods took place, an inference supported by the beds of conglomerate which in some cases overlie such deposits.

Volcanic activity accompanied the Lower Carboniferous sedimentation, a considerable proportion of the strata consisting of volcanic ash deposits, and towards the close of the epoch several lava flows were poured out.

At the close of the Lower Carboniferous Epoch, a very pronounced deformative movement affected the crust in this part of New South Wales, particularly that part of it which lay immediately to the south and west of the area of Lower Carboniferous sedimentation, and possibly that part (Tasmantis) which lay to the north-east may also have been similarly affected. The crustal movements do not appear to have folded the Burindi (Lower Carboniferous) sediments, as the strata of the Kuttung Series rest upon them without any angular unconformity, but the movement resulted in the area of Carboniferous sedimentation being elevated above sea-level, thus temporarily uniting Australia and Tasmantis. That these crustal movements were of considerable magnitude is indicated by (*a*) a complete change from marine to terrestrial conditions; (*b*) the complete palæontological break which takes place here; (*c*) the extraordinary deposition of thick coarse conglomerates, which ushers in the Kuttung sedimentation. It is proposed to call this crustal movement the Wallarobba disturbance; probably it was of an epeirogenic type.

The Kuttung Epoch.—The New South Wales area of Carboniferous sedimentation remained under terrestrial conditions throughout the remaining part of the Carboniferous Period, and was probably covered in part, from time to time, by shallow fresh-water lakes. How high this region stood above sea-level during this period, we do not know; but it stood relatively low compared with the land adjoining it to the south-west and north-east. Upon this lowland at the beginning of the Kuttung Epoch an enormous deposition of coarse conglomerates took place, ranging up to 2,000 feet in thickness, while at later intervals throughout the epoch many other beds of conglomerate were deposited, aggregating many hundreds of feet in thickness. These conglomerates must have been deposited under somewhat similar conditions to the Siwalik conglomerates of India, which were deposited along the foot of the rising Himalaya Mountains during the Tertiary Period. The Wallarobba conglomerates of New South Wales are probably the equivalents of the Colorado conglomerates in the western part of the United States and the Pottsville conglomerates in the eastern part of the same country, the latter of which occurs at the base of the Pennsylvanian System, and the former possibly on a similar or higher horizon.

The deposition of the Wallarobba Beds was followed by a period of intense volcanic activity, during which the Martin's Creek series of lavas and tuffs was erupted. This series of volcanic rocks has been traced by the writer from the coast at Port Stephens westwards to Lamb's Valley; while W. R. Browne has noted a similar series at Hudson's Peak, and Dr. A. B. Walkom[1] has noted a similar volcanic series of rocks further to the north-west at Mount Tangorin; and Prof. W. N. Benson[2] has recorded similar volcanic rocks in the Nandewar Ranges. This volcanic series thus extends along a distance of not less than 250 miles. Throughout this distance, the lava flows display a remarkable uniformity of petrological character. During the epoch of the succeeding Mount Johnstone beds, volcanic activity still continued but was somewhat less intense, and is represented mainly by tuffs. Undoubtedly, lakes existed at this time, and in these were deposited the sediments in which the Rhacopteris flora was preserved. That the neighbouring land was still high is indicated by the frequent beds of conglomerate which occur interstratified in this series. That these highlands possibly supported glaciers is indicated by the close lithological resemblance of some of the mudstones deposited at this time with the undoubted glacial muds deposited in the succeeding glacial beds.

The Rhacopteris flora preserved in the Kuttung strata is an entirely new flora as compared with that of the

[1] "Geology of the Permo-Carboniferous System in the Glendon Brook District, near Singleton," by A. B. Walkom, Proc. Linn. Soc. N.S. Wales, Vol. xxxviii, Part 1, 1913.

[2] "Geology of the Great Serpentine Belt," by W. N. Benson, Proc. Linn. Soc. N. S. Wales, Vol. xxxviii, Part 4, 1913.

Burindi epoch; the extinction of the earlier flora was no doubt due to the profound geographical and consequent climatic changes which followed the Wallarobba uplift. The deposition of the Mount Johnstone beds was followed by the pouring out of a fresh lava flow—the Paterson rhyolite.

The climatic changes which followed the Wallarobba uplift now culminated, and there resulted such a refrigeration of the climate as to produce a great glacial epoch. Great glaciers, or possibly even ice-sheets, now covered much of this region, and deposited thick beds of tillite and other glacial material. This tillite includes a good deal of material derived from some of the late Kuttung lava flows, particularly from the Paterson rhyolite, but includes also very much material which must have been derived from very distant sources. It has not been possible yet to identify with certainty the localities from whence this material was derived, it may have come from those parts of the Australian continent which lay to the south and east or it may have come from Tasmantis. No glacial pavements have yet been found in connection with these glacial beds, so there is no evidence available from this source to determine the direction of movement of the ice.

At least three periods of tillite deposition occurred in the Seaham district, and these three periods are separated from one another by two interglacial periods, during which varve shales were deposited in lakes occurring along the margin of an extensive ice-front. The varve beds are known to occur along a distance of not less than 200 miles, and this gives some indication of the great extent of the ice-sheets. The thickness of the varve beds alone represents a period of time of not less than 3,000 years for their deposition.

The close of the Kuttung Epoch is marked by another important crustal movement which ushered in the Permo-

Carboniferous Period. So far no angular unconformity has been found to occur in the Seaham-Paterson region between the Carboniferous strata and the Lower Marine Series (the lowest subdivision of the Permo-Carboniferous System), nevertheless crustal movements are indicated (1) by the fact that the terrestrial deposits of the Middle-Upper Carboniferous Epochs are followed by the marine sediments of the Permo-Carboniferous Period; (2) the appearance of an entirely new flora—the Glossopteris flora; (3) the appearance of an abundant marine fauna, very different from that of the Lower Carboniferous Epoch. This new crustal movement was one of subsidence, which brought about a transgression of the sea over what were probably great highlands during the Carboniferous Period. It is proposed to call this last crustal movement the Hunterian disturbance.

Appendix I.

Note on the correlation of the Fossil Floras of the Carboniferous Rocks, by A. B. Walkom D.Sc.

The Carboniferous strata under discussion in this paper have yielded numerous fossil plants on several horizons. The specimens were some time ago handed over for detailed examination to Professor A. A. Lawson, of the University of Sydney. Owing to the impossibility of his having a preliminary survey completed in time for the results to be made use of by the authors of the present paper, Professor Lawson consented to allow me to make a cursory examination of the material, with the object of expressing an opinion as to the correlation of the beds in which the plants occur with strata in other parts of the world. The suggestion that I should do this came from Professor David, and I have to thank him for the opportunity of examining the material.

It is, of course, obvious that conclusions based on such an examination must be tentative, pending the results of a complete revision and redescription of the whole flora. When the results of such a revision are available it should be possible to give a much more detailed correlation of the strata; for the present, however, it seems possible to indicate the age of the beds in a general way with a fair degree of accuracy.

The plant remains from the Carboniferous strata represent two distinct floras, and there is very little in common between the two. The older flora, occurring in the Burindi Series, is characterised by the preponderance of Lepidodendron, the newer, occurring in the Kuttung Series, by the abundance of Aneimites and Rhacopteris. There is no doubt that there is a certain amount of intermingling of members of the two floras. Lepidodendron certainly persists into the Kuttung Series, for the late John Mackenzie repeatedly recorded the occurrence of Lepidodendron and Otopteris [=Aneimites] together,[1] and there is a specimen in the University of Sydney Collection (No. 991) collected by him, on which *Aneimites ovata* and a Lepidodendroid stem occur together. This came from Sawyer's Point, Port Stephens, the horizon being about 2,000 feet below the top of the Kuttung Series. Stems which have been referred to Cyclostigma also occur in the Kuttung Series (Sugar Loaf Creek, Stroud), and it is to be hoped that careful examination of these may indicate more exactly their botanical affinities.

The flora of the Burindi Series.—The number of species at present known from this Series is small, but many of the specimens are exceptionally well preserved. They include—

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[1] Mines and Mineral Statistics N.S.W., 1875,

Lepidodendron veltheimianum
,, *sp.* (cf. *L. dichotomum* of Europe or *L. scutàtum* of North America.
Ulodendron sp. *Stigmaria sp.*
Pitys sp. *(? Rhacopteris).*

This assemblage of plants, though small, gives a fairly good idea of the age of the beds. The recorded occurrences of *Lepidodendron veltheimianum* both in Europe and America appear to be all in rocks of Lower Carboniferous age. Kidston[1] records it both from the Calciferous sandstone and Carboniferous limestone of Scotland and England, and from the Culm of Silesia; he mentions also its occurrence in the Carboniferous of Brazil. David White[2] refers to its occurrence in the Middle Mississippian of America where it is associated with Rhacopteris, Cardiopteris, Asterocalamites, Sphenopteris, etc. Seward[3] speaks of *L. veltheimianum* as "a species characteristic of Lower Carboniferous strata," and also (p. 128) notes the occurrence of the Ulodendron condition of this species from the Calciferous sandstone of Midlothian.

The specimens of Ulodendron throw no further light on the age of the beds, nor do the examples of Stigmaria which simply represent the underground portions of Lepidodendron.

Some specimens with structure beautifully preserved, show close affinities with species of Pitys *(P. antiqua, P. primæva)* that have been described from the Calciferous sandstone of Berwickshire.[4]

This small flora indicates undoubtedly a Lower Carboniferous Age for the beds in which it occurs. There is, however, hardly sufficient material to determine more exactly

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[1] Proc. R. Phys. Soc. Edinb., XII, pt. 2, 1894, p. 160.
[2] Journ. Geol. XVII, 1909, p. 320.
[3] Fossil Plants. Vol. II, 1910, p. 100.
[4] See Seward, Fossil Plants, III, pp. 285 – 289

the horizon within the Lower Carboniferous represented by these beds.

Flora of the Kuttung Series.—From this series the following plants have been recorded:—

Asterocalamites radiatus Brong.
Lepidodendron sp.
Cyclostigma sp.
Aneimites ovata (McCoy)
Rhacopteris intermedia Feist.
,, *Roemeri* Feist.
Rhacopteris septentrionalis Feist.
,, *Wilkinsoni* (Feist.)
Sphenopteris Clarkei Dun.
Cardiopteris sp.
Rhacophyllum diversiforme Eth.

One of the most striking features of this list is the complete absence of species of the Neuropteris, Pecopteris and Alethopteris groups, all of which become very abundant in typical Middle and Upper Carboniferous floras in various parts of the world. It is possible that future collecting may bring some of these to light, but in view of the fact that the beds in which the plants occur have been known for many years, and that extensive collections have been made from them, it is not probable that any prominent members of the flora have not been collected.

Taken as a whole this assemblage of plants is a rather unsatisfactory one on which to base a correlation. When the whole of the material has been carefully revised, it should be possible to draw more reliable conclusions than at present. Some of the species have at various times been referred to Archæopteris, but in the absence of fertile specimens, it is a matter of considerable difficulty to distinguish between Archæopteris and Rhacopteris. It is therefore wiser for the present to refer all these species to Rhacopteris, and this has been done in the list given above.

The specimens referred to Asterocalamites (= Bornia of some authors, and also Archæocalamites Stur.) are chiefly pith casts in which the ridges on adjacent internodes are opposite. Species of this genus occur commonly in rocks of Devonian and Culm age.

The inclusion of Lepidodendron in this flora is based on the specimen mentioned above, and also on the late John Mackenzie's record of the occurrence of Lepidodendron associated with Otopteris (=Aneimites). It has not been determined specifically.

The determination of the affinities of the species referred to Rhacopteris is a subject which requires considerable study. *R. inœquilatera* has been shown by Dun[1] to be referable to *Aneimites ovata* (McCoy). Whether any of the other species should be referred to this genus is a question for consideration. On the other hand there is the difficulty of defining the limits between Rhacopteris and some types of Sphenopteris *e.g.* Eremopteris.

Aneimites has been recorded from the Devonian of Canada and the Lower Pottsville of the United States. Rhacopteris, as such, has been recorded from both Lower and Middle Carboniferous (Culm and Coal Measures) of Europe, although Seward[2] speaks of it as characteristic of the Culm flora.

As examples showing the difficulties in dealing with this genus we may quote the following:—*Aneimites pottsvillensis* D. White, from the Lower Pottsville Series is a similar form to *R. intermedia; Eremopteris Lincolniana* D. White from the Upper Lykens (Pottsville) is somewhat similar to our *Sphenopteris Clarkei*, while *Eremopteris missouriensis* Lesquereux is a similar type to some of our *R. septentriomalis* and also to *R. Roemeri.*

Cardiopteris appears to be characteristic of Lower Carboniferous strata, but in Asia Minor at least it seems to occur on a higher horizon, viz.:—the equivalent of the lower part of the Westphalian. It must be remembered, however, that the specimens of Cardiopteris from New

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[1] Rec. Geol. Surv. N.S.W., VIII, pt. 2, 1905, p. 157.
[2] Fossil Plants, II, 1910, p. 427.

South Wales are incomplete portions of fronds, and it is not always easy to distinguish in such cases between Cardiopteris and such genera as Neuropteridium. Hence at present these specimens do not help much as regards the age of the beds.

Specimens such as those referred to Rhacophyllum are not at all uncommon in rocks of Carboniferous age, and afford no guide for correlation.

The general facies of this flora, apart from comparisons of individual species, seems to indicate that it is equivalent to floras which are known from the lower portion of the Westphalian (Middle Carboniferous). The horizon of the Kuttung Series then would be approximately that of the Millstone Grit of England, the Ostrau-Waldenburg Basin of Silesia, the Sinork Coal of the Heraclean Basin (Asia Minor) and the Upper Pottsville and Lower Kanawha Series of U.S.A. From the present knowledge of the flora it does not appear possible to say how high up in the Middle Carboniferous the Kuttung Series may be extended.

Appendix II.

Petrological Notes on the Carboniferous Igneous Rocks, by W. R. Browne, B.Sc.

The following notes, which are the result of a brief petrographical study of representative volcanic rocks from the localities whose geology is dealt with in this paper, must be considered incomplete in view of the fact that the rocks are almost all porphyritic, the groundmass being either felsitic or even mostly glassy at times. In such circumstances the true relationships can only be determined when petrographical is supplemented by chemical study, and the present classification and nomenclature must therefore be regarded as tentative and liable to subsequent modification. It should be mentioned also that no great attention has been paid to the occurrence and distribution of minor accessories such as apatite and zircon which are found in certain of the rocks.

Taken as a whole the series, so far as is shown by the mineralogical characteristics, includes a fairly wide range of types. What the field relations and the magmatic relations of all these may be is not known with any great degree of accuracy. The sequence of eruption, as is pointed out elsewhere in this paper, appears on the whole to have been one of decreasing basicity. The cycle of events is usually initiated by the eruption of a hornblende andesite, followed by pyroxene andesites of greater basicity, and these in turn are succeeded by dacites, toscanites and rhyolites.

The Eelah section does not conform to this order of succession, and this and other apparent exceptions, it is suggested, may be due to the overlapping of flows from neighbouring vents, to an actual repetition of the cycle, or perhaps even to certain of the rocks being intrusive, and therefore liable to appear in any stratigraphical relation towards the other rocks of the series.

Only by the very closest of field examination and mapping will these matters possibly be cleared up.

Rhyolites.—For the most part the rhyolitic rocks are of sodic type, some of them, however, containing orthoclase, and passing over by increase of this mineral into more normal sodi-potassic types. The rocks are porphyritic megascopically in quartz and felspar, with biotite in greater or less abundance. The groundmass is usually stony or felsitic in appearance, without visible flow-structure and of buff, pink or pinkish-grey colour. Indeed there is a great similarity between these rhyolites and many of the dacites and toscanites, so that in hand specimens it is often impossible to differentiate them.

The minerals visible microscopically in the rhyolites are as a rule quartz, albite, biotite, and a little ilmenite; sometimes quartz is absent except in the groundmass. The felspar is as a rule much decomposed, but has been generally determined as fairly pure albite. Some of the rocks appear quite devoid of phenocrystic orthoclase, in others its presence is doubtful, while in others again it is about equal to albite in amount.

The most common ferromagnesian mineral is biotite, generally a good deal altered; in one slide, however, from the Mount Gilmore section hornblende has been recognised in amount comparable with biotite. No soda pyroxenes or amphiboles have been detected.

The groundmass is generally cryptocrystalline, often spherulitic or axiolitic, but sometimes partly glassy, and traces of flow-structure are frequent.

Two examples of tuffaceous types have been examined, one from a mass interbedded in the Burindi Series, and the other from the Mount Gilmore section. In hand specimen the latter is a very dense felsitic-looking rock of a greenish-grey colour with inconspicuous phenocrysts of felspar and little or no quartz. Microscopically the only recognisable phenocrysts in these rocks are albite and ilmenite with very little quartz. The groundmass is very full of little cuspate fragments of devitrified pumice, with glass, secondary quartz and felsitic material.

Brögger's name *Dellenite* may perhaps be employed to describe a rock associated with rhyolite on the east side of the Williams River, Seaham. In this orthoclase is present in notable proportion, but not to such an extent as the plagioclase, which appears to be oligoclase. The rock is otherwise indistinguishable from rhyolite, and may be regarded as a type transitional between rhyolite and toscanite.

Toscanites.—The rocks outcropping at the top of Mount Johnstone, and known by the convenient field designation of Paterson rhyolite, really belong to the type known as Toscanite, characterised by a fairly basic plagioclase, and in addition a notable though usually subordinate proportion of orthoclase. The chief minerals visible microscopically in the Mount Johnstone rock are, in order of abundance—plagioclase (zoned basic andesine), quartz, orthoclase and biotite. The groundmass has flow-structure, and is devitrified to some extent, with the production of some spherulitic structure. With the toscanites may also be included a rock from the top of Mount Gilmore, which is practically identical with the Mount Johnstone type.

Dacites.—By the decrease and virtual elimination of orthoclase the toscanites pass over into dacites. These are always porphyritic in quartz and felspar and generally show ferro-magnesian minerals as well. Under the microscope they are seen to be composed of plagioclase (andesine or acid labradorite), quartz, ilmenite, biotite and hornblende set in a groundmass which may be hypocrystalline or cryptocrystalline and is sometimes partly spherulitic. Orthoclase is an occasional porphyritic constituent, as in one of the flows at the top of the Eelah section. Generally both biotite and hornblende are present, the latter often being the more important. Quartz may sometimes be very subordinate among the phenocrysts.

What is probably a pyroxene dacite occurs about the middle of the Eelah section. The pyroxene, if such it be, is now represented only by chloritic pseudomorphs.

There is a group of dacitic rocks coming into the Mount Johnstone section which have distinctive characters. The specimens examined were collected east of the main road at the foot of Mount Johnstone. They are all distinguished by a very stony or felsitic appearance, the body colour being red, green or brown. Quartz is inconspicuous to the naked eye, the principal phenocryst being a white felspar. Examined under the microscope the rocks are seen to have been to some extent modified by the incoming of secondary silica, which has formed patches of microcrystalline quartz in the groundmass and has pseudomorphed some pyroxene(?) phenocrysts. Porphyritic plagioclase (andesine or labradorite), quartz, a little ilmenite and an occasional biotite flake are to be seen. The groundmass is cryptocrystalline and plentifully besprent with pumice fragments. A couple of specimens from a quarry on the road one and a half miles beyond Paterson show generally similar characteristics. One of them contains a number of angular fragments of soda felsite.

Andesites.—These naturally divide themselves into the biotite-hornblende and the pyroxene groups, but transitional forms exist.

Biotite-hornblende Group.—This is what is elsewhere referred to as the Martin's Creek type, from its extensive development in that locality. It is however of very constant occurrence all over the area, and has, within limits, very constant characters which enable it to be readily recognised in the field. It is usually of a blue-grey to pale grey colour, is porphyritic in felspar and hornblende, and often exhibits marked flow-structure in hand specimens, due to parrallelism of the phenocrysts. The felspar is andesine or acid labradorite, generally a good deal decomposed; orthoclase is absent. In addition to the hornblende the microscope reveals subordinate biotite and magnetite (? ilmenite) with a very little quartz occasionally. The base is cryptocrystalline, with a variable proportion of irregular glassy patches and streaks showing fluidal fabric.

Among the contemporaneous flows of the Burindi series there is found a type transitional to the pyroxene andesites, containing, in addition to the biotite and hornblende some augite and hypersthene. The plagioclase is a fairly basic labradorite, and the base is largely glassy.

Pyroxene Group.—These may be divided into two classes according to the nature of the groundmass. Perhaps the more common is the pitchstone variety in which the base consists of brown glass; the other, which in hand-specimens has a rather lithoidal appearance, has a holocrystalline to cryptocrystalline groundmass. The lowest flow in the Eelah section is a pyroxene andesite whose groundmass is composed of spongy-looking felspar grains with sutured junctions. Whether the cryptocrystalline types result from devitrification the evidence at present available is insufficient to decide.

The andesites are all abundantly porphyritic in stout columnar felspars, and in the lithoidal variety little pyroxenes may also be distinguished in hand-specimen. Microscopically the phenocrysts seen are basic plagioclase, pyroxene, magnetite and ilmenite. The felspar is very strongly zoned, the core being as basic as bytownite at times. The pyroxene, which may be hypersthene or augite or both, is often replaced by chlorite and carbonates.

General Notes.—Apart from field association, the evidence for the consanguinity of the rocks is very clear on mineralogical and textural grounds, as may be gathered from the foregoing notes.

There is no doubt that the rhyolites and dacites, with the intermediate dellenite and toscanites, are very closely related; this is shewn by the gradual variation in the composition of the plagioclase and the varying importance of the orthoclase, and by the constant presence of biotite, as well as by much similarity in textural characters.

The dacites are connected on the one hand with the rhyolite by the presence of quartz and biotite, and on the other with the pyroxene andesites by the characteristically zoned basic plagioclase, while the Martin's Creek andesite, with its almost unzoned andesine, and its hornblende and biotite, occupies a conspicuously intermediate position, which suggests, as does its field occurrence at the base of the series, that it may represent the original magma from which the extreme types were derived by differentiation.

Part II.

Glaciation Sequence and Correlation of the Permo-Carboniferous and of the Kuttung (mostly Middle Carboniferous) Strata of New South Wales, by Professor T. W. Edgeworth David.

(A) The correlation of the Burindi Series (Lower Carboniferous) which underlies conformably the Kuttung will be fully discussed in a paper about to appear in the Proc. Linn. Soc. N. S. Wales, by Prof. W. N. Benson, D.Sc., B.A., (research Cantab.) His conclusion that the Burindi Series is probably of Visean age is quite in accord with those of my co-author and myself. We hold that the Burindi strata with their extraordinary development of crinoids, their characteristic brachiopod *Syringothyris exsuperans*, their trilobites (*Phillipsia*, etc.) are probably to be correlated with the Osage Series of the Middle Mississippian. Judged by its plant remains the Burindi Series is probably not far removed from the horizon of the Burdiehouse Limestone of Scotland. It represents the Visean of Belgium, France and Russia. The Burindi Series is perhaps homotaxial with the Lipak Series of Spiti in the Himalayas.

In Australia the Burindi Series of New South Wales may be correlated with the coral limestones of Lion Creek, Stanwell, near Rockhampton in Queensland.[1]

[1] Geol. Surv. Queensland, Bull. No. 11—Report on the Geological Features of the Country between Warren and Mount Lion in the Rockhampton District, by B. Dunstan, F.G.S., Government Geologist. Ditto, Bull. No. 12, Coral from the Coral Limestones of Lion Creek, Stanwell, near Rockhampton, by R. Etheridge, Junr., and *ibid.* Oolitic Limestones from Lion Creek, by G. W. Card, A.R.S.M.

Lithostrotion and Syringopora are well represented at Stanwell. The Training Wall Quarries at Rockhampton are in rock probably of Burindi age. Part, at any rate of the Drummond Range marine fauna of Queensland also probably belongs to Burindi times.

It is doubtful whether the Burindi Series is represented elsewhere in Australia, though in the "Carboniferous" (or Permo-Carboniferous) Beds of the Irwin River area in West Australia there are no less than 17 species identical with those found in the Burindi Series, but, as shown later in this paper, the Irwin River strata are distinctly newer than Burindi in age, as 9 species out of 108 recorded are also found in the Productus Limestone (Permian) of the Salt Range of India.

(B) *The Kuttung Series.*—1. Analogues in Australia.

(i) Queensland.—This great series of fluvio-glacial conglomerates, tuffs, and lavas with Aneimites (Rhacopteris) by far its most abundant and characteristic fossil, is probably represented in Queensland by the coarse basal conglomerates underlying the Bowen River Coal-field, and by the Aneimites Beds near Herberton and in the Drummond Range. At the latter area, at Mount Budge Messrs. R. L. Jack and R. Etheridge, Junr.[1] have described the form *Aneimites austrina.* The Drummond Range beds are considered to belong to the Star Series. The Star strata of Queensland in their lower portion containing *Lepidodendron australe*, probably were contemporaneous with some part of the Burindi series and in their upper portion with the Kuttung? They contain a good deal of coarse conglomerate, but so far no trace of glacial striæ has been observed on the pebbles. Professor H. C. Richards of

[1] Geology and Palæontology of Queensland and New Guinea, by Jack and Etheridge, pp. 140-1, 191. Rep. Bowen River Coal-field, by R. L Jack, by authority, Brisbane 1879. Geology of the Dawson and Mackenzie Coal-fields, by B. Dunstan, by authority, Brisbane 1901.

Brisbane University states that a series like the Kuttung occurs near Warwick, in Queensland.

(ii) In the State of Victoria it is probable that the Kuttung series are in part represented by the red rocks of Mansfield famous for their fossil fish.[1] The Avon River sandstones of Victoria, containing *Lepidodendron australe* and a considerable thickness of tuff, lavas and conglomerate, and particularly the similar strata at Iguana Creek on the Lower Mitchell River, with *Cordaites australis* McCoy, *Sphenopteris iguanensis* McCoy (allied to *Sphenopteris artemisifolia* of the Lower Carboniferous rocks of Northumberland), and also the Mount Tambo, the Macallister and Wonnangatta Rivers rocks may also belong to Kuttung time. No other representatives of this remarkable formation are known from elsewhere in Australia, and there is no record of any such strata in Tasmania.

It would appear that this great "Flysch facies" of Australia, the "Upper Siwalik" of the late Palæozoic Himalayas of Australia, was more or less restricted to Queensland and New South Wales.

In attempting to correlate rocks of the Kuttung series with those of extra-Australian areas, one naturally relies on Dr. A. B. Walkom's palæophytological determinations herewith, which place its flora low down in the Middle Carboniferous, a flora either high in the Culm (Hessian Culm), or near the horizon of the Pottsville Conglomerate (Millstone Grit) series. One is also guided by the physical and geographical characters of the deposits, and their relation to diastrophism, mountain-building, and the special petrological suite which accompanies such types of fold mountains. One specially seeks too to find analogues, in

[1] Mem. Nat. Mus. Melbourne, No. 1, On a Carboniferous Fish Fauna from the Mansfield District, Victoria, by A. J. Woodward. F.R.S., Melbourne, 1906.

extra-Australian areas, of the remarkable glacial phenomena of the Kuttung series. From the last point of view five areas at once suggest themselves for comparison—three in U.S.A., one in France, and one in Germany.

2. Analogues in U.S.A.

(i) *Probable glacial evidences in the Caney Shales (Middle Carboniferous) near Oklahoma, U.S.A.*

A very interesting possible analogue to the Middle Carboniferous (Kuttung) glacial beds described in this paper is to be found in the Caney Shales, Oklahoma, U.S.A.[1]

The Caney shales are seen in the Arbuckle and Ouachita Mountains, in the central parts of the Choctaw and Chickasaw nations respectively. Their maximum thickness is 1,000 feet. They are mostly black and blue marine argillites passing locally into sandstone, and are considered to be on the horizon of the Pottsville Conglomerate of which the European equivalents are the Millstone Grit, "*l'étage infra houiller,*" "*Flotzleerer Sanstein,*" etc. Taff originally described boulders considered to exhibit glacial striæ from these beds.[2]

Dr. E. O. Ulrich who collaborated with Taff in examining these boulders, writes :—

"The assumption of locally frigid conditions in the early Pennsylvanian is based primarily on the fact that erratics of all sizes, some as much as 20 feet across and 5 or 6 feet thick occur in the Caney Shale of Eastern Oklahoma. These erratics, mostly formed of Ordovician limestone, were transported not less than 50 miles, and many probably were carried much farther. No other competent means of their transportation than ice—presumably heavy shore ice—has been suggested."

[1] Bull. Geol. Soc. America, Vol. 23, pp. 457–462, Pls. 23, 24, 1912. Boulder beds of the Caney Shales at Talihina, Oklahoma, by J. B. Woodworth.

[2] Bull. Geol. Soc. America, Vol. 20, 1908, pp. 701, 702. Ice-borne boulder deposits in Mid-Carboniferous Shales, by Joseph A. Taff.

Dr. Woodworth after examining a number of the striated boulders in the Caney shales at Talihina railway cut concludes (*op. cit.*, p. 459) that the striæ on the pebbles and boulders are an effect of interstitial motion and displacement subsequent to the deposition of the Caney shale. That is he considers the markings to be pressure striæ analogous to "Slickensides." He adds "I saw no stones in the Talihina cut which at the time of my visit struck me as scratched by ice action." At the same time Dr. Woodworth states that at the area specially examined by him (the Talihina cut) the Caney shales are highly contorted and crushed, conditions obviously most favourable for producing rock-pressure striæ, but he points out that Messrs. Ulrich and Taff have observed what they considered to be glacially striated boulders in areas where the Caney shales are disposed merely in gentle undulations.

Woodworth holds (quite apart from the question as to whether these boulders are glacially striated or not) that the transport of the boulders for 50 miles or more was almost certainly effected by floating ice.

(ii) *Squantum Tillite, Roxbury Conglomerate, Dighton and Seekonk Conglomerates, etc.*

In speaking of the Squantum Tillite described by Messrs. Sayles and La Forge from near Boston, Woodworth states (p. 462):—

"This presumable tillite bed is possibly of Permian Age, but its association with the underlying conglomerates and similar thick waterworn conglomerates of known Carboniferous (Alleghany) age in the Narragansett area point to the correctness of Shaler's theory of the glacial origin of the conglomerates as a whole."[1]

[1] U.S. Geol. Surv. Monographs xxxiii, Geology of the Narragansett Basin. N. S. Shaler, J. B. Woodworth and A. F. Foerste, Washington, 1899.

The above monograph by Shaler and his colleagues and that by Messrs. Sayles and La Forge, and the recent monograph by Robert W. Sayles[1] are very instructive on this subject. The Narragansett Coal Measures and the Conglomerates, possibly of Alleghany age, are considered to be newer than the Pottsville Conglomerate Series (Middle Carboniferous) and underlie both the Barren Measures (Elk River or Conemaugh Series), and the still higher Monongahela River Series; that is they lie below the top of the Upper Carboniferous proper. The Narragansett strata terminate upwards in massive conglomerates up to 2,000 feet in thickness—the Dighton and Seekonk conglomerates. If the Roxbury conglomerate of the Boston area is part and parcel of the overlying "Squantum Tillite" formation, as seems highly probable, and the Roxbury conglomerate is to be correlated with the Dighton and Seekonk conglomerates in the Narragansett Coal Measures, then there does not appear to be any more reason why the Squantum tillite should be considered Permian than Upper Carboniferous. At the same time the possibility of the age of the Squantum tillite being Permian is of course not excluded. Nevertheless, the similarity of the contemporaneously contorted "varve" beds in the Kuttung series of New South Wales to those figured by Robert Sayles is so extraordinarily striking as to suggest possible contemporaneity, in spite of the fact that the Kuttung flora is more Middle than Upper Carboniferous.

(iii) *Possible Glacial evidence in the Maroon Conglomerate of Colorado, U.S.A.*[2]

The Maroon Conglomerates of the Elk Mountains and Sangre de Cristo Range of Colorado are considered to be

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[1] Mem. Mus. Comp. Zool., Vol. XLVII, No. 1, Seasonal Deposition in Aqueoglacial Sediments, by R. W. Sayles, Cambridge, U.S.A., Feb. 1919.

[2] Geology: Earth History. Chamberlin and Salisbury, Vol. II, p. 552.

approximately on the horizon of the Pottsville Conglomerate and therefore to be of Middle (Lower Middle) Carboniferous age. They are described as being some 6000 feet in thickness, and are said to contain boulders up to 50 feet in diameter. The author is not aware that any striated blocks have as yet been identified in this wonderful series of conglomerates, but the occurrence of blocks of the above enormous size suggests the strong probability that ice was concerned in their transport. A careful search for possible glaciated pebbles in that series might well lead to useful results.

3. France.—*Possible Glacial Origin of the coarse Carboniferous breccias of Central France.*[1]

In the St. Etienne coal basin M. Julien believes that large masses of angular breccia, such as those of Mont Crépon, 250 metres thick, are of glacial origin. He states that striæ are extremely rare, but that the blocks of porphyry at Cellieu, and of hornblende schist at Dargoire, and mica-schist at Fouillouse are smoothed and striated. Vertical roots of Calamites are seen in the sandstones underlying the breccias, while their stems, as they pass upwards into the breccia, are crushed, a phenomenon very suggestive of glacial action. As regards their geological age Julien places it between Grand 'Eury's zone of Sigillariæ and that of the Cordaiteæ, which would make the age approximately near the top of the Middle Carboniferous. He considers that these "morainic breccias" were deposited by glaciers having their origin in the great early formed folds of the Hercynian ranges which were already rising to the north.

[1] Compt. rend. des Séances de l'Académie des Sciences, CXVII, (1893), pp. 255 - 257 and 344. A. Julien.

4. Germany.—The next area where possible glaciation in Pre-Permian—in this case Culm—time has been suggested is contained in a paper by Kalkowsky.[1]

The following summary may be given:—The Upper Culm in the Frankenwald district of Germany is estimated to be 1500 - 2000 metres in thickness, consisting for the most part of alternating layers of clay shales and greywacke.

At a point about 2·5 kilometres from Steinbach railway station a remarkable bed of pebbly shale (Geröllschiefer) occurs. The cobbles appear to have been originally of fluviatile origin. They are frequently of the size of a man's head, but their usual diameter is from 5 – 7 cm. Rarely these waterworn blocks attain a diameter of 40 – 50 cm. They are not in close contact with one another, but distributed through the shales "like raisins in dough." Streaks arising from rock pressure are discernible on their surfaces, but no true glacial striæ. The band in the Upper Culm containing these pebbles is about 18 metres thick. This is not considered to be in any sense a littoral deposit. It is removed at least 15 – 20 kilometres from the shore line of the Culm.

It is considered probable that the pebbles have been transported and dumped by floating ice, most likely ground ice, such as, at the present day does so much work in transporting pebbles in the Baltic. Similar pebbles occur in the Upper Culm of Thuringia.

(C) *The "Permo-Carboniferous" Glaciations* (specially in relation to the Upper limit of the Kuttung Series).

While the lower limit of the Kuttung Series is well defined its upper limit is obscure. At Seaham, as shown on Plate XXII, the upper limit is given as the Brandon Conglomerate, and at Lochinvar (see Plates XIX and XXIII,

[1] Zeitschr. Deutschen geologischen Gesellschaft, Vol. XLV, 1893, pp. 69 – 86, von Herrn Ernst Kalkowsky in Jena.

for sections) the upper limit is also given as a bed of conglomerate. It is assumed that the conglomerate bed is at the base of the "Permo-Carboniferous" Lower Marine Series, but this is not necessarily the case, for at the village of Gosforth, four miles N.N.E. of Lochinvar, an interesting series of marine fossils occurs apparently within a few feet of the surface of the top bed of tillite. They have been examined and identified by Mr. W. S. Dun, as follows:— Crinoid stems, *Fenestella internata*, *F. fossula*, *F. sp.*, *Seminula* sp. nov., *Martiniopsis subradiata*, *Spirifer* aff. *Tasmaniensis* a small type probably transitional, *Aviculopecten Englehardti*, *A. tenuicollis*, *A. limæformis*, (young species) *A. Mitchelli*, *Chaenomya sp.*, *Conocardium* sp.nov. *Moeonia* sp. nov., *Orthoceras sp.*

Mr. Dun considers these forms transitional between those of the Burindi Series and those of the Lower Marine Permo-Carboniferous Series respectively.

At Lochinvar marine fossils with plant stems not yet determined occur within 60 feet vertically above the surface of the top bed of tillite.

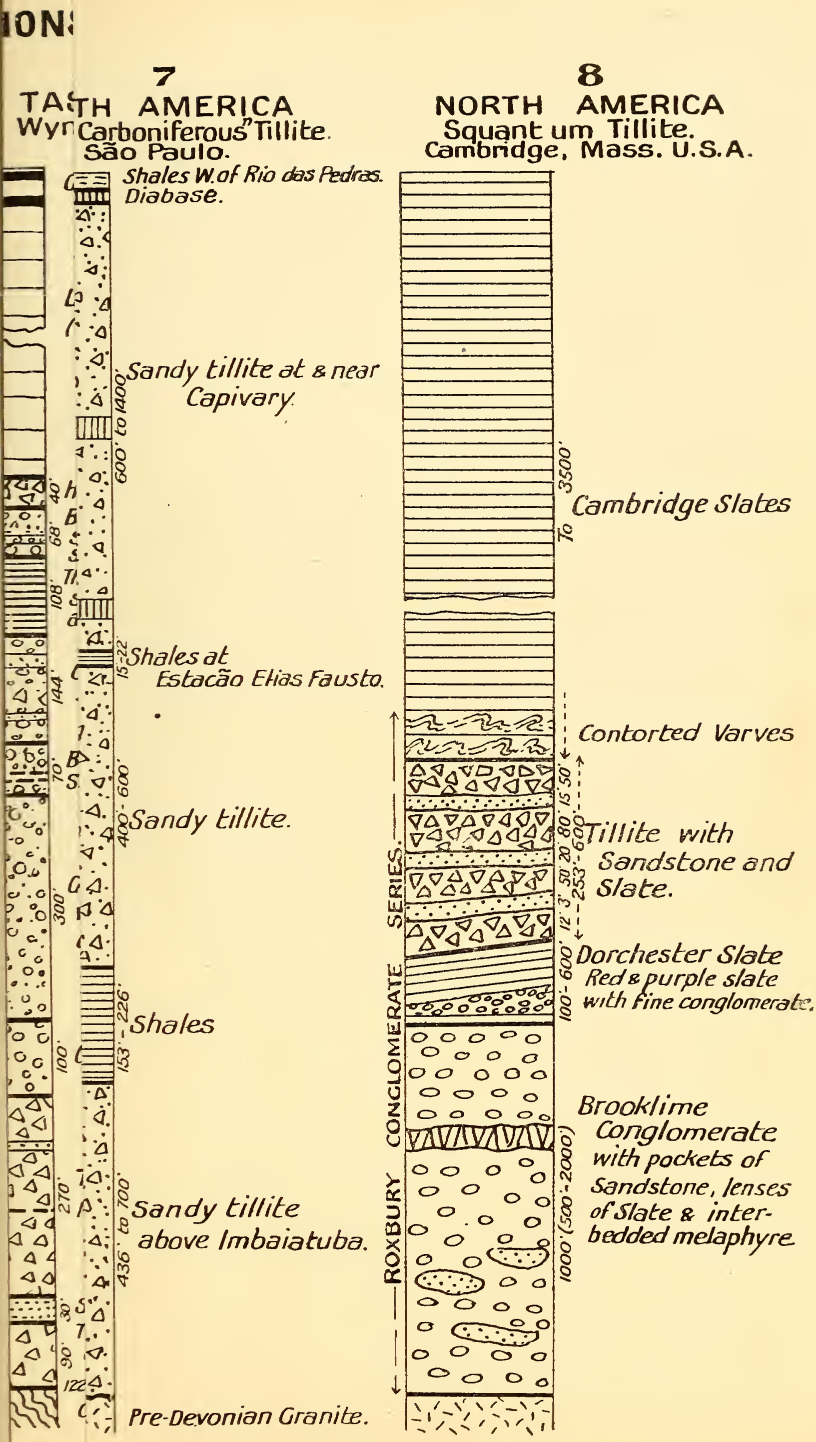
Gangamopteris has been identified on two horizons respectively, about 1300 and 1800 feet above the top tillite bed of the Kuttung. As regards the question of angular unconformity it may be noted that as shown on the section Plate XXIII, the angle of dip from Winder's Hill to the top bed of tillite is about 20°, while from the top tillite of the Kuttung into Lochinvar township the dip lessens, being at 15° to 16°. Both at Paterson and Seaham no such difference in the dip between the strata of the lower Marine Series and those of the Kuttung is observable. But at Mount Bright near Pokolbin there is a strong unconformity between the Rhacopteris shales, rhyolite tuffs and lavas of the Kuttung Series and the *Eurydesma cordatum* beds of the Lower Marine Series. There can be no question of a strong angular unconformity between these two horizons at the above locality.[1]

The *Eurydesma cordatum* horizon therefore of Pokolbin (identical with that of Allandale and Harpur's Hill, in the lower Marine Series) does not belong to the Kuttung series, but is distinctly newer.

The thickness of the strata which intervene between the top tillite of the Kuttung and the Allandale Eurydesma beds is approximately 2500 feet. While hereafter it may be found desirable to extend the Kuttung series upwards to embrace part of these beds, it is considered best for the present to consider them to be Uralian, *i.e.*, Upper Carboniferous (see Plates XXIX and XXX). As regards the important question of the age of the strata from the Eurydesma beds upwards to the top of the Newcastle series it is suggested that (*a*) the whole of this group may be termed Permo-Carboniferous or even Permian. The horizon of *Protoretepora ampla* and *Strophalosia Clarkei*, which at Allandale, immediately and conformably overlie the Eurydesma beds is very suggestive of a Permian age, and as shown on Plate XXX at Kashmir, the *Protoretepora ampla* shales of the Zewán beds overlie Glossopteris beds containing remains of the Permian labyrinthodont Archegosaurus; or (*b*) as suggested by Professor J. W. Gregory this group up to the top of the Upper Marine Series may be considered Uralian (Upper Carboniferous), while the remainder from the base of the Tomago Coal-measures up to the top of the Newcastle series may be considered Permian. The slight unconformity between the base of the Tomago Coal-measures and the top of the Upper Marine Series is an argument in favour of some break coming in at that horizon, but the Palæontological evidence on the whole seems distinctly at variance with this view,

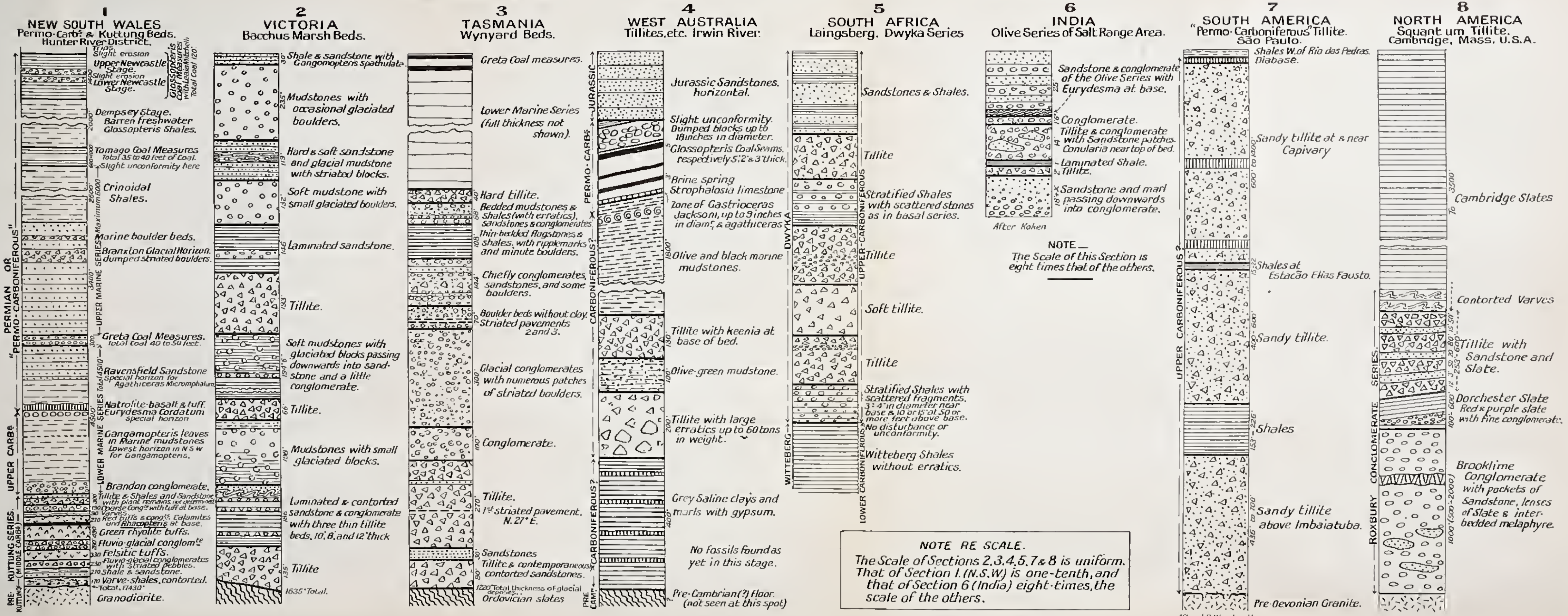
[1] Geology of the Hunter River Coal-fields, by T. W. Edgeworth David, Plate VIII.

Plate XXIX.



Partly after Robert W. Sayles.

SECTIONS OF NEWER PALŒOZOIC GLACIAL DEPOSITS IN N. & S. HEMISPHERES.



After J B Woodworth

Partly after Robert W. Sayles.

Erratum.—Section 4 is more correctly given in the notes from Dr. W. G. Woolnough on page 306 of this paper.

especially when dominant forms of fossils are considered, *e.g.*, *Protoretepora ampla* and long-spined forms of Strophalosia which are extraordinarily abundant and characteristic from high up in the Upper Marine Series down close to the top of the Eurydesma beds of the Lower Marine Series; and then the Glossopteris-Gangamopteris flora with Noeggerathopsis and Phyllotheca of the Greta coal-measures is persistent into the Tomago and Newcastle Coal-measures an argument for their inclusion in the same system. For the purposes of this paper all the strata from the Allandale Eurydesma beds upwards to the top of the Newcastle will be considered Permian, those from the Eurydesma beds to the Brandon conglomerate above the transition beds of the Kuttung, will be considered to be Uralian. On this basis the important question as to the various geological horizons for tillites in the Upper Palæozoic rocks of the type district of the Hunter can next be considered.

If the glacial beds of the Kuttung series be assumed to have been all referable to Upper Kuttung time, and if measurements be taken from the top tillite of the Kuttung it is found that, at Allandale, a horizon about 2400 feet higher coarse conglomerates occur with cobbles and boulders up to three feet in diameter. Although glacial striæ are scarce and faint, the evidence of dumped blocks with their principal axes often at right angles to such bedding as can be traced in these tuffaceous shales, suggests the action of shore ice around the neighbouring volcanic island of Blair Duguid. *Eurydesma cordatum*, Aviculopectens, Keenia and Platyschisma are abundant in these ice-foot glacial beds.

At a horizon from 1000 to 1500 feet still higher and ascending to within a hundred feet or so of the base of the Greta Coal Measures small erratics occur at intervals sporadically distributed through sandstones and mudstones. At about 1500 feet above the top of the Greta Coal measures a well marked glacial horizon is reached, that of the Branxton Beds in the Upper Marine Series. The glacial evidences there are in the form of groups of dumped blocks occasionally well striated, and up to three or four tons in weight. Their parent rocks are some 150 miles to the S.W.[1] These dumped blocks are in the midst of *Protoretepora ampla* and Fenestella shales, the latter often strongly indented through the impact of the falling blocks, as originally pointed out by R. D. Oldham.[2] A typical photograph is given in the work below.[3]

On a still higher horizon, at about 2400 feet above the top of the Greta Coal-measures, is a remarkable calcareous marine boulder-bearing conglomerate, almost a tillite. This is known as the Bolwarra Conglomerate.

With the exception perhaps of the dumped blocks described by R. L. Jack in the Middle Bowen (Permo-Carboniferous) series of Queensland, and the dumped blocks in the strata above the Irwin Coal Seams (Greta ? Seams) in West Australia and certain erratics in the marine Permo-Carboniferous rocks of Tasmania, these glacial horizons of the Upper Marine Series of New South Wales do not appear to be represented in Permo-Carboniferous rocks in other parts of the world. The main glacial horizons of late Palæozoic age in Australia and Tasmania (other than those of the Hunter District) are situated on a horizon below that of the Greta Coal-measures. For example, the Wynyard beds of Tasmania are below the Greta seams of Preolenna, and the tillites of the Irwin River are below the Greta Coal (see Plate XXIX, 4). The Bacchus Marsh

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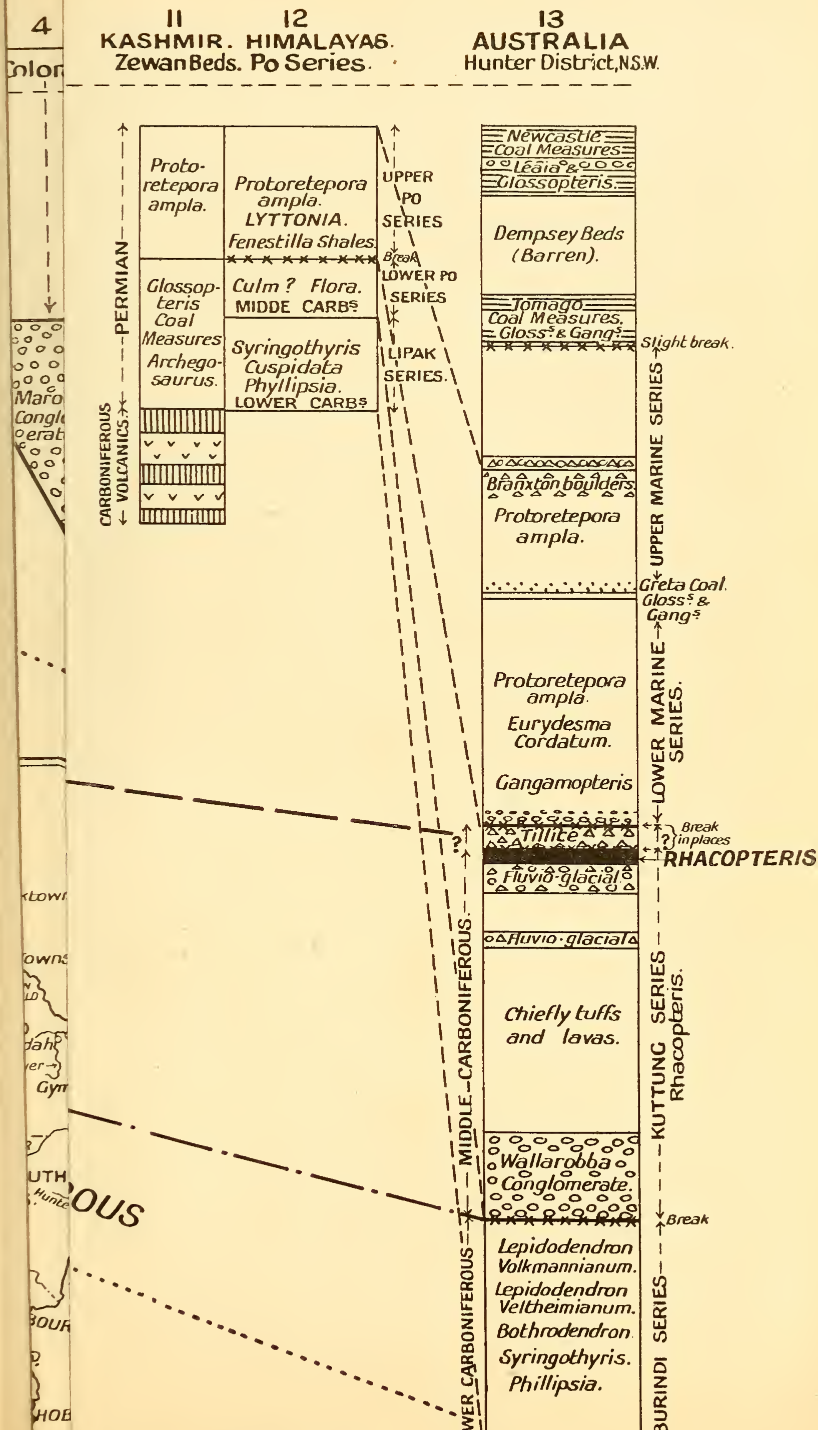
[1] This Journal, xxxiii, 1899, p. 156, and pl. 4, fig. 1.

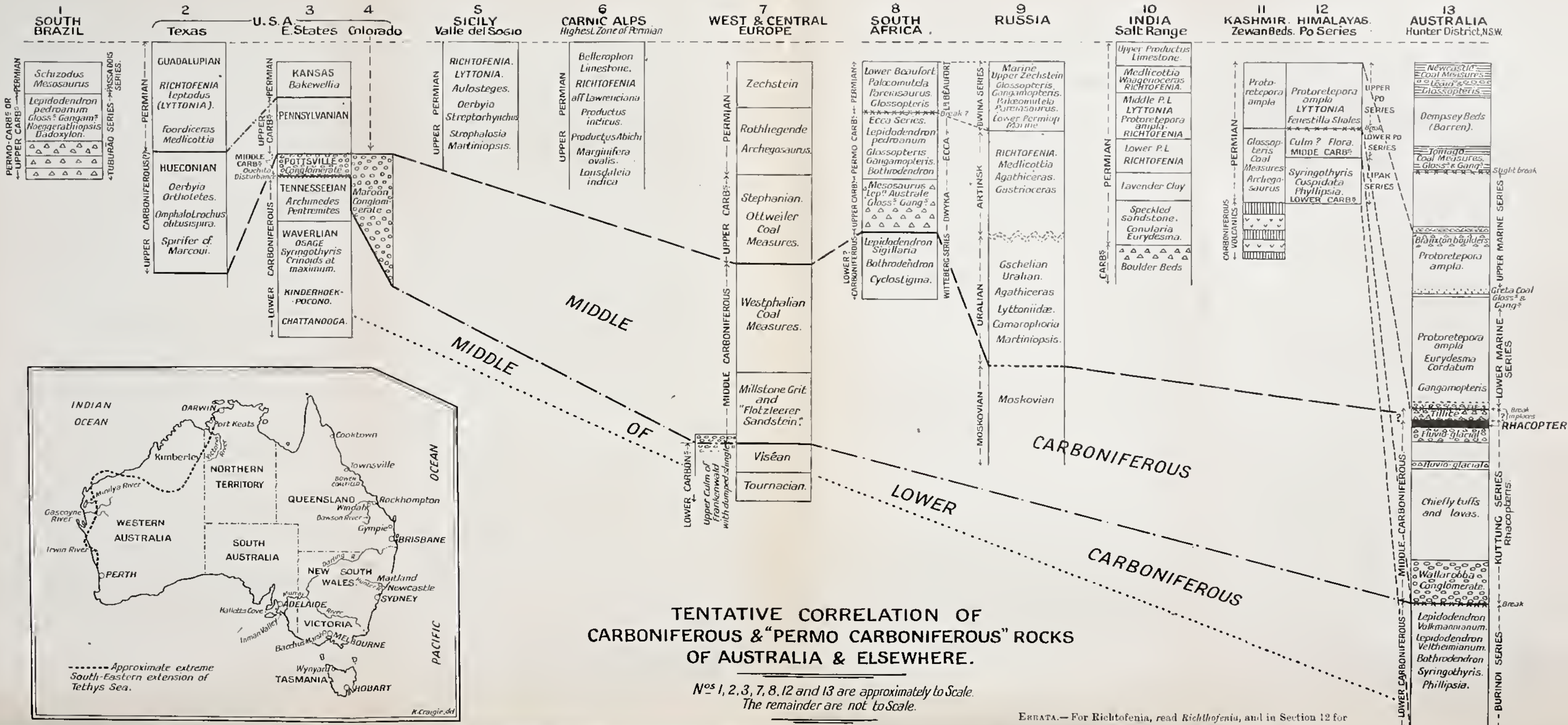
[2] Records Geol. Surv. India, xix, 41, (1886).

[3] Memoir Hunter River Coal-field, Plate xxiv.

Plate XXX.



hofenia, and in Section 12 for
psia read *Phillipsia*.



TENTATIVE CORRELATION OF CARBONIFEROUS & "PERMO CARBONIFEROUS" ROCKS OF AUSTRALIA & ELSEWHERE.

Nos 1, 2, 3, 7, 8, 12 and 13 are approximately to Scale. The remainder are not to Scale.

ERRATA.—For Richtofenia, read *Richthofenia*, and in Section 12 for Fenestilla read *Fenestella*, and for Phyllipsia read *Phillipsia*.

tillites of Victoria and the Hallett's Cove Beds of South Australia are certainly to be correlated with the Wynyard beds of Tasmania. It is probable that the Wynyard, the Bacchus Marsh and the Hallett's Cove tillites are on the same horizon as the tillites at the top of the Kuttung series, while there is quite a possibility that the Irwin tillites belong not so much to the topmost tillite of the Kuttung series, as to a somewhat newer glacial horizon near to the chief zone of *Eurydesma cordatum*, at Allandale and Harper's Hill in the Maitland District.

Eurydesma cordatum is of course associated with the tillite and boulder beds of India at the Salt Range, and *Eurydesma globosum* is associated with the Dwyka series of South Africa in South West Africa. But Eurydesma is a Pacific genus, and in order to refer its age to some reliable Northern Hemisphere standard it is necessary to examine a place like the Salt Range of India, where sediments of the Tethys actually make contact with the Eurydesma beds and their associated tillite. In Australia the "Permo-Carboniferous" sediments of the Tethys are well developed along the old shore line shown on the map on Plate XXX. But unfortunately no spot has yet been discovered in Australia where the Pacific type of Permo-Carboniferous fauna actually comes in direct contact with the Tethyan type. Nevertheless, as at the Irwin and Gascoyne River areas in West Australia, there is an immense development of the tillites and an extensive Tethyan marine fauna associated with them, it is very important to consider this critical area in some detail.

5. *Irwin River and Gascoyne River areas West Australia.* —With the aid of the reports of the Geological Survey of West Australia and notes kindly supplied me by Professor W. G. Woolnough, D.Sc., the following descending section

may be given at the Irwin River district near Nangetty Station (see Plate XXX, Section 4).

JURASSIC—

Strata, horizontal mostly freshwater ferruginous sandstones with occasional marine invasions bringing in Trigonia. Slight unconformity, limonite springs break out along this line.

LOWER PERMIAN OR PERMO-CARBONIFEROUS—

50 feet (or so) shales and sandstones with dumped blocks up to 18 inches in diameter.
5 feet coal seam with Glossopteris.
70 feet (?) brown clays.
2 feet coal seam with a few feet of clayey strata below.
60 feet brown clay.
3 feet (about) coal and shale.

URALIAN ? in part (thicknesses very approximate)—

30 feet (more or less) marine olive-green to grey mudstones and limestone with *Strophalosia* and abundant other brachiopods, beautifully preserved, the shells having a strikingly fresh and recent appearance.
1500 feet gypseous clays and shales.
10 feet *Gastrioceras Jacksoni* horizon.
750 feet shales, unfossiliferous.
100 feet tillite with Keenia at base associated with the boulders.
90 feet olive green mudstone.
150 feet tillite with large erratics up to over 50 tons in weight.

CARBONIFEROUS ? (possibly Middle or Lower Carboniferous)—

Dark grey clays.

PRE-CAMBRIAN—

Gneiss, etc.

An important feature of this section is that there are two distinct tillite horizons separated from one another by marine strata containing characteristic Permo-Carboniferous fossils. Keenia (*f*. Dr. W. G. Woolnough) occurs in abundance actually in the basal portion of the upper tillite bed. Both horizons are below a considerable mass (approximately 1800 feet) of marine strata. In ascending order we next meet Glossopteris coal measures (the equivalent probably of the Greta Coal-measures of New South Wales) and then succeed freshwater strata, up to the base of the unconformably overlying Jurassic strata. The Jurassic strata are there horizontal, whereas the Permo-Carboniferous coal seams are dipping at an angle of about 10°. In this freshwater stage of the Permo-Carboniferous, three seams of coal have been observed. These in descending order are respectively 5 feet, 2 feet, and about 3 feet thick, and contain hydrous coal with from 22% up to 24% of moisture.[1]

Mr. A. Gibb Maitland seems correct in considering them, though hydrous, the equivalent of the Greta Coal Seams. In his address to the Geological Section of the Aust. Assoc. Adv. Sci. for 1907, Mr. Maitland records having found "Lower Marine" fossils below the horizon of these coal seams. There is little doubt but that these are approximately the equivalents of the Greta Coal Measures of Eastern Australia. Blocks up to 18 inches in diameter, evidently dumped from floating ice, occur at intervals in the freshwater beds associated with the Irwin River Coal Seams.

The horizon of *Agathiceras micromphalum* just below the base of the coal-measures recalls the well known horizon for this fossil in New South Wales in the Ravens-

[1] Dr. W. G. Woolnough informs me that a coal seam eight feet thick has just been discovered there.

field Sandstone of the Lower Marine Series, about 1000 feet below the base of the Greta Coal Measures at West Maitland. The lower bed of tillite, separated from the upper by about 90 feet of marine mudstones, rests without any visible break or unconformity on dark shales, not on the calcareous shales with gypsum, and bun-shaped nodules of argillaceous limestones. Up to the present no fossils have been discovered in the strata immediately underlying the lower tillites. Beneath these grey argillaceous beds and separated from them by an immense unconformity are the Pre-Cambrian gneiss, schist and granite.

Before considering the palæontological evidence as to the age of the Irwin tillites reference must be made to the Wooramel, Gascoyne, Minilya Rivers area. Mr. A. Gibb Maitland's accounts of this area are to be found chiefly in the two papers below.[1] Mr. Maitland gives a section (*op. cit.*, p. 11) showing the boulder bed, three feet in thickness, underlying thick marine limestones. In the boulder bed itself the following fossils are recorded (*op. cit.*, pp. 14, 15).

Hexagonella dendroidea Hudleston sp.
Pleurophyllum australe Hinde; fragments of crinoid stems and Polyzoa.
Spirifera Hardmani Foord.
,, *lata* McCoy. *Reticularia.*
,, *lineata* Martin sp.
Athyris Macleayana Eth. fil.
Chonetes Pratti Davidson. *Productus.* cf. *P. tenuistriatus* Foord.
Aviculopecten tenuicollis (Dana).

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[1] Bull. No. 33, Geol. Surv. West Australia, "The Gascoyne Ashburton and West Pilbara Goldfields," by A. Gibb Maitland; also Rep. Aust. Assoc. Adv. Sci., Adelaide, 1907, pp. 131–157.

Kimberley.—Between the Gascoyne area and Darwin is the well known region, the Kimberley District of West Australia. The Permo-Carboniferous or Carboniferous fossils from the Kimberley district of West Australia are almost certainly the equivalents of those of the Irwin area, and have similar strata, barren of fossils and consisting of gypseous and saliferous strata, underlying them. It may be noted that Mr. R. Etheridge, Jun.[1] has recorded a Favosite *(F. Marmionensis)* from these strata. *Spirifera marcoui* (Waagen) is also characteristic, and would indicate a geological age probably near the base of the Uralian.

Northern Territory.—In the Port Keats bore between the Victoria River and Darwin in Northern Territory of Australia marine "Permo-Carboniferous" strata overlie dark shales containing Glossopteris. In addition to many species also met with at the Irwin area one finds in this marine fauna the genus Dybowskiella (*D. Geei* Eth. fil.) which ranges from Uralian to the top of the Upper Productus limestone of the Salt Range. Dybowskiella (Fistulipora) occurs also in the Guadalupian Series of Texas.

With the kind collaboration of Mr. W. S. Dun, Palæontologist to the Geological Survey of New South Wales and University Lecturer in Palæontology, the following table of Irwin River etc. fossils, largely taken from Ludwig Glauert's paper *(op. cit.)* has been prepared:—

[1] Bull. 58, Geol. Surv. West Australia, pp. 13, 14, pl. 1, 2.

Genus and Species.	Upper Carboniferous.		Upper Carb. and Permo-Carb. or Permian.		Lower Carboniferous.	Salt Range India. Permian.			Salt Range India. Upper Carb.							Carnic Alps.	Sicily.	U.S.A.	
	Irwin-Mingenew, West Australia.	Gascoyne Area, West Australia.	Northern Territory, Australia.	East Australia and Tasmania.	Burindi Series, East Australia.	Upper Productus Limestone.	Middle Productus Limestone.	Lower Productus Limestone.	Lavender Shales and Speckled Sandstone.	Permian.	Artinsk.	Uralian and Gschelian.	Moskovian.	Viséan.	Tournacian.	Bellerophon Limestone.	Valle del Sosio.	Guadalupian.	Hueconian.
Cornuspira involvens Reuss ?	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *Schlumbergi* Howchin	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nubecularia lucifuga var. *Stephensi* How.	×	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Frondicularia Woodwardi Howchin	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nodosaria Irwinensis Howchin	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Amplexus nodulosus Phillips	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
,, *pustulosus* Hudl.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *Selwyni* de Kon.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cyathophyllum depressum Hinde	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *virgatum* Hinde	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lonsdaleia indica	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...
Pleurophyllum australe Hinde?	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *sulcatum* Hinde	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Zaphrentis sp.	...	+	...	+	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Alveolites obscurus de Kon.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chætetes tumidus Phill.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hexagonella (Evactinopora) crucialis Hudl.	×	×	...	...	...	+	+	...	...	...	...	...	...	...	...	...	...	...	...
Pachypora tumida Hinde...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp. nov.	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp.	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Syringopora reticulata var. *patula* Hinde	...	×	...	...	...	...	...	...	...	...	...	+	...	...	...	...	...	...	...
,, sp.	...	+	...	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Symbathocrinus sp. (fide F. A. Bather)...	...	+	...	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Actinocrinus (?) sp.	+	+	...	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Platycrinus sp.	+	+	...	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Poteriocrinus crassus Miller	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Rhodocrinus (?) sp.	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cyathocrinus sp.	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Spirorbis ambiguus Flem....	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *omphaloides* Goldf.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fenestella plebeia McCoy } ,, *fossula* Lonsd. }	×	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
,, *bicellulata* Eth. fil.	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Polypora australis Hinde...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
,, *Smithii*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Protoretepora ampla Lonsd	×	×	...	×	...	...	...	×[1]	...	...	...	...	...	...	...	...	...	...	...
,, *antiqua* Lonsd.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ramipora sp.	...	...	+	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rhombopora tenuis Hinde	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
,, *Hindei* Eth. fil.	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Streblotrypa Brownii Eth.	...	...	×[2]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dybowskiella Geei Eth. fil.	...	...	...	...	...	+	...	...	...	...	...	+	...	...	...	...	...	+	...
Aulosteges baracoodensis Eth. fil... ..	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	...
Chonetes Pratti Davidson...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
Derbyia sp. cf. *senilis* Phill.	×	...	...	...	...	+	+	+	...	...	...	...	...	...	...	...	+	+	...
Orthis cf *Michelini* Martin	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	+	+	...
Orthotetes (Strepterhynchus) senilis Phill.	×	×	...	...	...	+	+	+	...	...	+	+	...	+	+	...	+	+	...
,, *perfidiabadensis*...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lyttonia Waagen. *leptodus* Kayser ...	...	...	...	...	...	...	+	...	...	...	...	...	...	...	...	...	+	+	...
Productus brachythaerus Sowerby ...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, var. Eth. fil.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *cora* D'Orb.	×	...	...	...	×	×	×	×	...	...	×	×	×	×	×	...	...	...	...
,, *margaritaceus* Phill.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *scabriculus* Mart.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *semireticulatus* Mart.... ...	×	×	...	...	×	...	...	...	...	...	...	×	×	×	×	...	...	...	...
,, var. *pugilis* Phill.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, cf. *spiralis* Waagen, and *sub-costatus* Waagen ...	...	×	...	...	...	×	×	×	...	...	×	...	...	...	...	...	...	...	...
,, *subquadratus* Morris	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *tenuistriatus* De Vern. ...	×	×	...	×	×?	...	...	...	...	...	×	×	...	...	...	...	...	...	...
,, ,, var. *Foordi* Eth. fil.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *undatus* Defr.	×	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *indicus*	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...

[1] In Zewán Beds of Kashmir.

[2] cf. *S. major* Ulrich, Keekuk Group, Kentucky, Iowa, Illinois and *S. radialis* Ulrich.

Genus and Species.	Upper Carboniferous.		Upper Carb. and Permo-Carb. or Permian.		Lower Carboniferous.	Salt Range India. Permian.			Salt Range India. Upper Carb.							Carnic Alps.	Sicily.	U.S.A.	
	Irwin-Mingenew, West Australia.	Gascoyne Area, West Australia.	Northern Territory, Australia.	East Australia and Tasmania.	Burindi Series, East Australia.	Upper Productus Limestone.	Middle Productus Limestone.	Lower Productus Limestone.	Lavender Shales and Speckled Sandstone.	Permian.	Artinsk.	Uralian and Gschelian.	Moskovian.	Viséan.	Tournacian.	Bellerophon Limestone.	Valle del Sosio.	Guadalupian.	Hueconian.
Productus Abichi	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...
Strophalosia Clarkei Eth fil.	×	×	...	...	...	+	+	+	...	...	...	...	...	...	...	...	...	+	...
" cf *Gerardi* King ...	×	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...
" cf. *Jukesii* Eth. fil.... ...	...	...	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Strophomena analoga Phill.	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Richthofenia Kayser ...	...	...	...	...	...	+	+	+	...	...	...	...	...	...	...	+	+	+	...
Actinoconchus cf. *planosulcatus* Phill. ..	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" sp. or *Cleiothyris* sp. ...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Athyris sp.	...	×	...	...	...	...	...	...	...	...	...	...	...	+	...	...	...	...	...
Cleiothyris (*Athyris*) *Macleayana* Eth. fil.	×	×	...	...	...	...	...	...	...	...	...	...	...	+	...	...	...	...	...
" , var. *baracoodensis* "	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" " sp. near *Macleyana* "	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *Roysii* Lev.	×	...	...	...	×	×	×	×?	...	...	×	...	...	...	...	...	...	...	...
" sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cyrtina carbonaria var. *australasica* Eth. or *Spiriferella* (?) *australasica* ...	×	...	...	...	×	...	...	...	...	...	...	[1]×?	...	...	...	...	...	...	...
Dielasma (*Terebratula*) *nobilis* Eth. fil. .	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
" *hastata*	×	...	...	...	×	...	×	...	...	...	×	...	...	×	...	...	...	...	...
" *amygdala* Dana (?)	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" (*Terebratula*) *cymbæformis* Morris ?	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" " sp	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reticularia crebristria Morris	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *lineata* Martin	×	×	...	...	×	...	...	×	...	...	...	+[2]	...	...	...	...	...	...	...
Retzia sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
Rhynchonella pleurodon Phill.	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Seminula subtilita Hall ?	×	×	...	...	×[3]	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Seminula sp.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Spirifera avicula Sowerby	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *convoluta* Phill.	×	×	...	...	×	...	...	...	...	...	...	...	...	×	...	...	...	...	...
" cf. " "	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *crassus* De Kon. ...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" (*Martinia*) *glabra* Martin ...	×	...	...	...	...	...	...	...	...	...	...	...	...	cf. ×	...	...	...	...	...
" *Hardmani* Foord	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *Kimberleyensis* Foord	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *lata* McCoy	×	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" var. with ribbed sulcus ...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *Musakheylensis* v *australis* Frd	×	×	...	...	...	×[4]	×[4]	×[4]	...	...	...	...	...	...	...	...	...	...	...
" *striata* Martin	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" cf. " "	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *Stucthburyi* (?) Eth. fil. ...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" (*Martiniopsis*) *subradiata* Sow.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" " *Darwini* ...	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
" *trigonalis* Martin	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *vespertilio* G. Sowerby... ..	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" spp	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" sp. (*Martiniopsis* sp.)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Syringothyris exsuperans De Kon. ...	×	×	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...
Anthracoptera sp.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Arca (?) sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Aviculopecten multiradiata (Eth. sen.)...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *sprenti* Johnst.	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *tenuicollis* Dana	×	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *Hardmani* Eth. fil. ...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" spp.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chænomya Mitchelli De Kon.	...	...	...	×	...	...	...	...	cf. ×	...	...	...	...	...	...	...	...	...	...
" (?) sp.	×	...	...	...	...	...	...	...	.	...	...	...	...	...	...	...	...	...	...
Conocardium (*Pleurorhynchus*)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" " sp. ..	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Deltopecten (*Aviculopecten*) *illawarrensis* Morris ?	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" *leniusculus* Dana	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
" *limæfomis* Morris	...	×	...	...	...	...	...	...	cf. ×	...	...	...	...	...	...	...	...	...	...

[1] Cf. *Spiriferella saranæ*, Tscher., which is extremely close to it.
[2] Four species in the Schwagerina zone.
[3] Found in the Upper Carboniferous of U.S.A.
[4] *Spirifera musakheylensis*.

Genus and Species.	Upper Carboniferous. Irwin-Mingenew, West Australia.	Upper Carboniferous. Gascoyne Area, West Australia.	Upper Carb. and Permo-Carb. or Permian. Northern Territory, Australia.	Upper Carb. and Permo-Carb. or Permian. East Australia and Tasmania.	Lower Carboniferous. Burindi Series, East Australia.	Salt Range India. Permian. Upper Productus Limestone.	Salt Range India. Permian. Middle Productus Limestone.	Salt Range India. Permian. Lower Productus Limestone.	Salt Range India. Upper Carb. Lavender Shales and Speckled Sandstone.	Permian.	Artinsk.	Uralian and Gschelian.	Moskovian.	Viséan.	Tournacian.	Carnic Alps. Bellerophon Limestone.	Sicily. Valle del Sosio.	U.S.A. Guadalupian.	U.S.A. Hueconian.
Deltopecten subquinquelineatus McCoy sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Eurydesma cordatum	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
,, *globosum*	...	...	...	×	...	...	...	...	×[1]	...	...	...	...	...	...	...	...	...	...
Edmondia spp.	×	...	...	...	+	...	...	...	...	...	...	...	...	...	...	...	...	+?	...
Myalina (?) *mingenewensis* Eth. fil. ...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, spp.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mytilops (?) sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mytilus sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp. (or *Modiomorpha*)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Parallelodon (*Palæarca*) *subarguta* DeKon	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp. (*Macrodon* sp.)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nuculana Basedowi Eth. fil.	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *Waterhousei* Eth. fil.	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pterinæa (*Merismopteria*) *macroptera* Mor.	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sanguinolites cf. *hibernicus* Hinde ...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Stutchburia cf. *Randsi* Eth. fil.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Allorisma cf. *curvatum* Morris	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *maximum* Portl.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pleurophorus (*Pachydomus*) *carinatus* Mor	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Conularia lævigata...	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
,, *tenuistriata*	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Baylea (*Ivania*) *Levellii* De Kon. ...	×	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Bellerophon costatus J. de C. Sowerby ...	×	...	×	...	...	×	×	×	...	...	...	...	...	...	...	...	...	...	...

Bellerophon decussatus Flem.	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *stanvellensis*	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	×[2]	...
,, sp	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bucania Emerii Eth. fil.	...	...	×	...	...	...	...	×[3]	...	...	...	...	...	...	...	...	...	...	...
Eumophalus spp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, spp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pleurotomaria carinata	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×[4]	...
,, spp....	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ptychomphalina Maitlandi Eth. fil.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *humilis* De Kon.	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Acroculia (*Platyceras*) sp	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cœlonautilus chesterensis Meek & Worthen	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Discites cf. *omalianus* De Kon.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nautilus (?) sp. (Mesozoic ?)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pleuronautilus multicostatus Eth. fil.	...	...	×	...	...	×[5]	...	...	...	...	...	...	...	...	...	...	...	...	...
Orthoceras spp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...
Gastrioceras Jacksoni Eth. fil.	×	...	...	...	...	...	...	...	...	...	+	...	...	+	...	...	...	+	...
Agathiceras micromphalum Morris	×	...	...	×	...	...	...	+	...	...	+	+	...	...	...	...	...	+	...
Phillipsia grandis Eth. fil.	...	×	...	...	×	...	...	...	...	+	...	...	+	...	...	...	...	...	...
Ostracoda (various species)	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Crustacean tracks ?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Edestus Davisii H. Woodw.	...	×	...	...	...	...	...	...	...	...	...	+	...	...	...	...	...	...	...

[1] Occurs also in South Africa.

[2] cf. *Bellerophon crassus* ? of the Guadalupian.

[3] cf. *Bucania kattaensis* of Lower Productus Limestone.

[4] cf. *Pleurotomaria discoidea* of the Guadalupian.

[5] cf. *Pleuronautilus transitorius* from Upper Productus Limestone Salt Range.

If now an analysis of the Irwin River Permo-Carboniferous fossils be attempted we find that out of 108 species recorded from the Irwin River

5	are Foraminifera	7	Gastropods
9	are Corals	6	Cephalopods
1	is Crinoid (6 gen. recorded)	1	Crustacean
2	are Serpulæ	1	Fish
11	Polyzoa	——	
48	Brachiopods	108	
17	Pelecypods	——	

Of these species there are some eighteen which are found in extra-Australian areas, and of these nine occur in the Productus Limestones of the Salt Range, or in the Zewán (Permian) beds of Kashmir. Three are common to the Productus limestone and the Artinsk formations, and may therefore be Permian to infra-Permian. One ranges from Ural to Artinsk (Infra-Permian) to Upper Carboniferous, one is Uralian, one is Viséan to Upper Carboniferous, while of the two cosmopolitan forms *Productus cora* and *Productus semireticulatus*, the former ranges from Lower Carboniferous to the top of the Permian, and the latter certainly ranges through the whole of the Carboniferous.

On the whole therefore specifically the Irwin River fauna both above and in association with the glacial beds is a "Productus limestone" fauna but for the five species *Productus semireticulatus*, *P. tenuistriatus*, *Seminula subtilita*,[1] *Syringothyris exsuperans* (?), *Baylea (Ivania) Levellei* (?). It may be added that it is doubtful whether the two preceding species have been correctly determined. On the other hand if one now compares this Irwin River fauna with that of the Burindi Beds (Middle Lower Carboniferous or Viséan) of East Australia, one finds no less

[1] Mr. R. Etheridge Junr. is careful not to call these forms Syringothyris, but Syringothyris-like-spiriferæ, Geol. Surv. West Australia, Bull. No. 58, Pt. VI.

than seventeen species common to the two, and four doubtfully common. But of these seventeen species four are also recorded from the Productus limestone of the Salt Range (Permian). This leaves thirteen species *distinctly* of Viséan age (Middle Lower Carboniferous) common to the Burindi and Irwin Series. One is therefore confronted with this curious and difficult problem in regard to the Irwin River fauna, viz., that in its relations to the typical Permian and Carboniferous rocks of the Northern Hemisphere it is, as tested by the age of the Productus limestone of the Salt Range, distinctly more Permian than Carboniferous, but tested by the Australian standard of Permian and Carboniferous (*e.g.* its relation to the Culm flora and underlying Burindi Marine beds of East Australia) it is distinctly more Carboniferous than Permian.

Here one must emphasise the extraordinary effectiveness of the Darwin to Adelaide mountainous land barrier which in "Permo-Carboniferous" or Upper Carboniferous time so completely isolated the West Australian and Northern Territory seas on the one hand from those of Eastern Australia on the other. Out of about two hundred species recorded in the Permo-Carboniferous marine fauna of East Australia and Tasmania only the following nine species are at present known to be common to the two:—*Nubecularia lucifuga* var. *Stephensi*, *Fenestella fossula* Lonsd., *Protoretepora ampla* Lonsd., *Productus subquadratus* Morris, *P. undatus* Defr., *Dielasma cymbœformis* Morris, *Aviculopecten Sprenti* Johnst., *A. teuicollis* Dana, *Nuculana Waterhousei* Eth. fil., *Agathiceras micromphalum* Morris.

Even in the case of some of the above species such as *Aviculopecten tenuicollis*, Mr. W. S. Dun considers it doubtful whether some of the above eastern and western forms respectively are specifically identical. An important and characteristic form in the Irwin region is *Cyrtina carbonaria* var. *Australasica* Eth. fil., otherwise known as *Spiriferella* (?) *Australasica.* This appears to be extremely close to *Spiriferella saranæ* of the Uralian and Artinskian Series of Russia. The great abundance of Gastrioceras near the top of the Irwin marine series also suggests a Pre-Permian age for the Irwin Beds. Gastrioceras ranges from Lower Carboniferous to the Artinskian. *Spirifer marcoui* of the Kimberley area suggests a lower Uralian age for the strata containing it. The fact must also be emphasised that corals as Pachypora and Syringopora are found at the Irwin River area, and Favosites in the Kimberley Beds, the latter probably homotaxical with those of the Irwin. These lend a distinctly Carboniferous character to the beds at the Irwin, *e.g.* Syringopora *(S. parallela)* occurs in the Gschelian Series (Upper Carboniferous) of Russia. It is suggested that in this problem of so large an assemblage of Carboniferous forms associated with the Permian in the West Australian Permo-Carboniferous rocks that we have to deal at the Irwin and Gascoyne River with a belated fauna, forms like Syringopora, *Rhynchonella pleurodon*, *Productus semireticulatus*, Syringothyris-like Spiriferæ, etc., surviving over in the West Australian bight of the ancient Tethys ocean from early Carboniferous into late Carboniferous, or even perhaps into Permian time. On the other hand in the Pacific fauna of Eastern Australia these Carboniferous types of the Burindi no longer survived over into the Permo-Carboniferous Seas of that region. Just as in nummismatics, in studying an assemblage of coins unearthed from one and the same deposit (the date of which it is desired to determine), if the coins show a variety of dates we naturally select the newest and not the oldest as giving the correct date for the deposit, so in a palæontological problem like the present, more weight is surely to be attached to dominant newer forms than to sparsely represented older forms. Provisionally one might perhaps sum up as follows:—

An Upper Carboniferous, probably Uralian age, can be assumed for the tillite beds of the western coastal areas of West Australia, though not necessarily for all the overlying marine and Glossopteris beds. This age, for the tillites at any rate, is in accordance with the classification at present adopted by the Government Geologist of West Australia, Mr. A. Gibb Maitland. At the same time it may be pointed out that until it has been found possible to do some zoning work on the fossils of the Irwin, Gascoyne, Kimberley and Northern Territory regions, it is unsafe to form any but very tentative conclusions.[1]

Obviously if the tillites of the Irwin are Carboniferous in age they are not as old as the Burindi Series, and the large number of marine species common to the Productus limestone of the Salt Range, associated with the Irwin Beds makes it probable that they are distinctly newer than the basal Rhacopteris-bearing part of the Kuttung Series (Middle Carboniferous) of New South Wales. There is little doubt that the tillite beds of the Irwin River are (tested by the New South Wales standard) pre-Greta in age, *i.e.* Post-Rhacopteris and Pre-Greta, belonging therefore (*a*) either to the small glacial horizon of the Eurydesma Beds 2400 feet above the top tillite of the Kuttung of New South Wales, or (*b*) to transition beds between the top tillites of the Kuttung and the basal beds of the Lower Marine Series, or (c) (and this seems quite possible) to the horizon of the top tillite of the Kuttung. Further it is quite possible that the whole of the marine strata in the Irwin area, that is, the Pre-Greta strata—may be Uralian. On this evidence it may be suggested that in the type district for the Permo-Carboniferous sequence in New South Wales—the Lower Hunter region near Maitland—all that

[1] Dr. W. G. Woolnough is now surveying the Irwin region and will probably contribute a paper on it to this journal, shortly.

part of the lower marine series which underlies the *Protoretepora ampla* shales with abundant *Strophalosia Clarkei* at Allandale, (a thickness of about 2400 feet of strata) may also be provisionally classed as Uralian, as already suggested (see Plate XXIX, Section 1).

In regard to the possible Permian age of the Upper Marine Series of New South Wales, Mr. W. S. Dun has called special attention to the number of giant forms present in the fauna of the Upper Marine. These comprise:–

Archæcidaris Selwyni Eth. fil., measuring, 100 mm., the mouth 45 mm. in diameter.

Monaster giganteus, measuring, span 170 mm., disc 30 mm.

Stenopora (flabellate form), imperfect 140 mm. by 130 mm.

" *crinita* (imperfect mass) 170 mm. by 140 mm,

Spirifera vespertilio, height 127 mm., breadth 3 mm.

Martiniopsis subradiata Sowb., measuring, height 127 mm. by 180 mm.

Aphanaia gigantea (1) measuring 410 mm. in length.

" (2) " 430 mm. "

Aviculopecten ponderosus Eth. fil. and Dun, measuring, height 175 mm., breadth 160 mm.

Deltopecten leniusculus Dana, measuring, height 145 mm, breadth 165 mm.

Eurydesma cordatum, measuring, breadth 160 mm., height 125 mm.

Cleobis grandis, measuring, breadth 160 mm. height 140 mm.

Keeneia, measuring, height 84 mm., diameter of body whorl at base 115 mm.

Conularia inornata Dana, measuring, 250 mm. in length (incomplete) by 27 mm. in diameter.

The abnormal size of these and other forms in Mr. Dun's opinion, heralds their approaching extinction. This extinction Mr. Dun thinks, belongs not so much to the epoch of the passage of Carboniferous into Permian forms, as to that which presaged the ending of Palæozoic and the beginning of Mesozoic time. Professor J. W. Gregory,[1] has commented on the distinctly Permian Age of the labyrinthodont *Bothriceps* "which can hardly be Pre-Permian, and Huxley indeed assigned it to the Trias."

This occurs on the horizon of the Newcastle Coal-measures of New South Wales, at Airly in the Western Coal-field of New South Wales, and has been described by Dr. A. Smith Woodward.[2] This is probably allied to *Platyceps Stephensi* of the Wianamatta Shales (Upper Trias) of New South Wales.[3]

Remains of a small labyrinthodont, imperfectly preserved (the head, limbs and tail are missing) have been recorded and roughly figured from the Latrobe Coal-measures, (Greta) at Railton, Tasmania.[4] The Latrobe Coal-measures are intercalated between Upper Marine and Lower Marine Strata, and are the equivalents of the Greta Coal-measures of New South Wales. A detailed examination of these Latrobe labyrinthodont remains might throw important light on the question as to whether the Greta Coal-measures belong to Lower Permian or to Upper Carboniferous time.

Before reviewing briefly "Permo-Carboniferous" Glacial evidences from other parts of the world it may be mentioned that so far no trace of Glacial deposits of late Palæozoic Age has been recorded from New Zealand. C.T. Trechmann[5] has recorded the occurrence of Aphanaia, Martiniopsis (?), Platyschisma etc., from rocks of the Maitai Series in New Zealand, so that Permo-Carboniferous marine fossils are present there, but hitherto no trace has been found, in New Zealand, of a Glossopteris-Gangamopteris Flora.

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[1] Rep. Brit. Assoc. Adv. Sci., 1917. Section C.

[2] Records Geol. Surv. N.S.W., Vol. VIII, pp. 317 – 319, pl. 41.

[3] Proc. Linn. Soc. N. S. Wales, Ser 2, Vol. IV, p. 476, (1889).

[4] Proc. Roy. Soc. Tasmania, 1900–1901, pp. 9, 10, with plate. Observations regarding the recent discovery by G. Thureau, F.G.S., of a fossil reptile in the Mersey Coal-measures at Railton. By R. M. Johnston.

[5] Geol, Mag., 1917, pp. 56 – 61.

6. *India.*—This and other extra-Australian evidence will be reviewed very briefly. The main lines of correlation are suggested in Plates XXIX and XXX. The glacial beds of the Salt Range so closely associated with Eurydesma and Conularia can probably be correlated with the Eurydesma glacial horizon about halfway down in the Lower Marine Series of New South Wales. This would make its age about Uralian (Upper Carboniferous), as already maintained by Vredenburg and G. de P. Cotter.[1] The entire absence of forms like Fusulina, Schwagerina, Archimedes etc. from the Australian Permo-Carboniferous rocks renders their correlation with strata in the Northern Hemisphere more difficult. It is important that Lyttonia has been recorded by Diener from the Fenestella shales with *Protoretepora ampla* of the upper division of the Po Series in the Himalayas. Lyttonia is specially characteristic of the middle Productus limestone of the Salt Range, where its age is considered to belong to Rothliegende. On the other hand the Lyttoniidæ have been found as low down as the Uralian in Russia, but the form described from there by Tschernzschew is ascribed to the genus Keyserlingina rather than Lyttonia. It may be provisionally concluded that the *Protoretepora ampla* shales of the Po Series in the Himalayas are approximately of Rothliegende age.

Vredenburg considers the Lower Productus limestone of the Salt Range as Artinsk and the Talchir boulder bed also as Artinsk. The "Speckled Sandstone" with its boulder beds he considers to be Upper Uralian. He thus recognises two distinct geological horizons for the late Palæozoic glacial beds of India, viz., Upper Uralian and Artinsk, respectively.

Cotter (*op. cit.* p. 33) in his table of Gondwanaland deposits does not appear to recognise two glacial horizons

[1] Geology of India, Table of Geol. For. in the Indian Empire, and Rec. Geol. Sur. Ind. Vol. XLVIII, pt. 1, 1917, pp. 23–33.

in the late Palæozoic rocks of India. He classes all the Permo-Carboniferous strata of New South Wales from the top of the Upper Marine Series to the base of the Lower Marine Series as Upper Carboniferous, and the Newcastle, Dempsey and Tomago beds as Permian.

7. *South Africa.*—For the sequence of these beds the author follows the classification by A .W. Rogers and A. L. du Toit.[1] The Witteberg Series (see Plate XXX, Section 8, at end of this paper) with its Lepidodendron, Sigillaria, Bothrodendron and Cyclostigma would appear to be of Culm age, and homotaxial partly with the Burindi Series, partly with the Kuttung Series of New South Wales.

This series passes up apparently without angular unconformity into the overlying Dwyka Series. The lower portion of the Dwyka is chiefly tillite, and the upper chiefly shales.

In the Dwyka shales of German South-west Africa, Schroeder[2] has described the occurrence of Conularia and *Eurydesma globosum.* The chief locality referred to is Ganikobis. The occurrence of these marine fossils links up the Dwyka Series with the "Speckled Sandstone" glacial deposits of the Salt Range, and perhaps with the *Eurydesma cordatum* glacial horizon of the Hunter District, New South Wales. The main masses of Dwyka tillite, underlying, as they do, shales containing *Lepidodendron australe* (Upper Devonian in New South Wales) can hardly be newer than Carboniferous. They are surely Pre-Greta, and may in fact belong to the top of the Kuttung Series of New South Wales.

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[1] Geology of Cape Colony, by A. M. Rogers, D.Sc. and A. L. du Toit, B.A., p. 245.

[2] Jahr. Kön. Preuss. Geol. Landesanstalt zu Berlin, 1908; Bd. XXIX, Teil 1, Heft 3, Berlin, 1909. Marine Fossilien in Verbindung mit permischen Glazialkonglomerat in Deutsch-Südwestafrika. Von Herrn H. Schroeder in Berlin.

The occurrence of Mesosaurus in the Dwyka shales overlying the tillites seems extraordinary, in view of the fact that elsewhere it is found in strata of Upper Permian (Zechstein) Age, as in Brazil, unless in South Africa also its age is Permian. In regard to Mesosaurus, R. Broom states :—

"Whatever be its affinities, it is agreed by all to be a true reptile, and one which has undergone considerable specialisation. As in no part of the world has any reptile ever been discovered in beds earlier than Permian, we seem justified in concluding that the Upper Dwyka shales are not older than Lower Permian. Mesosaurus is of further interest in that an almost identical form occurs in Brazil."

The Ecca series which overlies the tillites contains *Lepidodendron pedroanum* a form which links it up with the Tuburão Beds of Southern Brazil.

The Lower Beaufort series, which overlies the Ecca series, is obviously the equivalent of the Dwina series of Russia, as it contains the lamellibranchs *Palæomutela* and *Palæanodonta*, and Pareiasaurus among its numerous reptiles, together with Glossopteris and Schizoneura. The age of the Lower Beaufort series appears to be Zechstein, so that the age of the Ecca series and such parts of the Dwyka shales as contain Mesosaurus can be provisionally considered to be Lower Permian, or possibly Artinskian.

The *Eurydesma globosum* beds of South West Africa so closely associated with the Dwyka tillites are probably homotaxial with the Salt Range boulder beds of India, and the *Eurydesma cordatum* glacial horizon of the Hunter District in New South Wales, the Irwin River of West Australia, the Wynyard Beds of Tasmania, the Bacchus Marsh Beds of Victoria, the Hallett's Cove and Inman glacial beds of South Australia. Their age may tentatively be considered to be Uralian.

8. *South America.*—At Sao Paulo, in Brazil, in 23° to 23° 30′ S. Lat. Professor Derby has described what he believes to be a glacial conglomerate of Upper Palæozoic Age.

Lepidodendron and Gangamopteris have been found together in Permo-Carboniferous Rocks at Candiota in Southern Brazil in the Province of Rio Grande.[1]

The tillite beds are best developed in the State of Parana. It will be seen by reference to Plates XXIX, 7 and XXX, 1, that the tillites, as elsewhere in the "Permo-Carboniferous" rocks of the Southern Hemisphere, lie at the base of the series. In places, as in the area described by Dr. Woodworth there are three distinct beds of tillite. Above the tillites are coal-measures belonging to the Tuburão Series with an exclusively Gangamopteris Flora, as at Bacchus Marsh, appearing just above the Glacial Beds. Then as shown in Dr. White's classification a Phyllotheca, Glossopteris, Vertebraria, *Noeggerathiopsis Hislopi* flora succeeds, followed by the flora with *Lepidodendron pedroanum*, the latter occurring also in the Ecca Beds of South Africa. A *Dadoxylon meridionale* flora follows, and lastly a flora characterised by *Lycopodiopsis Derbyi.*

Above the Tuburão Series comes the Passa Dois Series with remains of Mesosaurus and Stereosternum at its base. These strata cannot be older than Permian, and are followed by Triassic Strata with remains of Scaphonyx. Dr. D. White considers (*op. cit.*, p. 381) that the whole of the

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[1] For an excellent general account of the flora of the Santa Catharina System of Southern Brazil, see Final Report on the Work of the Brazilian Coal Commission, by Dr. David White, and for accounts of the glacial horizons, *ibid*, Pt. I Geology, by Dr. I. C. White, and Annals of the New York Academy of Sciences, Vol. XXII, pp. 9-112, pls. ii-xxi, "Some Factors of Geographical Distribution in South America," by John D. Haseman; and Bull. Mus. Comp Zool. Harvard, Vol. LVI, No. 1. Geological Series Vol. X, Shaler Memorial Lectures. Dr. Woodworth.

Tuburão Series is Upper Carboniferous. It may be suggested that the tillites at any rate, and perhaps the *Gangamopteris obovata* beds which conformably succeed them may be of Uralian (Upper Carboniferous) Age. There can be little doubt that these South American tillites are the equivalents of the Dwyka tillites of South Africa.

The thickness of these sandy tillites with thin intercalated shales is, at Capivary and Imbaiatuba from 2000 to nearly 3000 feet. Near the Rio Negro Dr. Woodworth (*op. cit.*, p. 68) records a marine fauna intercalated in the tillites, but does not give details of the fauna. He considers that there were at least two distinct phases of the glaciation.

9. *The Falkland Islands.*—T. G. Halle[1] has described boulder beds at the base of the Permo-Carboniferous rocks on East Falkland Island. The overlying strata contain Gangamopteris, Glossopteris and Phyllotheca.

10. *North America.*—Reference has already been made earlier in this paper to the Squantum tillite, the Roxbury conglomerates of the Boston to Narragansett Bay areas, the conclusion provisionally deduced being that they are probably Stephanian (Uralian) in age. The Guadalupian Fauna of Texas, so excellently described by G. H. Girty[2] is obviously high up in the Permian. It contains Richthofenia Leptodus (Lyttonia), Medlicottia, Foordiceras etc. (See Plate XXX).

11. *Europe.*—(a) *England.*—Sir Andrew Ramsay[3] was of opinion that glaciated pebbles occurred in the Permian Breccias of England. There is, however, some doubt as to whether these scratches are really of glacial origin.

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[1] Bull. Geol. Inst. Univ. Upsala, 1912, 11, pp. 115 – 229.

[2] U.S. Geol. Sur. Prof. Paper 58, Washington.

[3] Q.J.G.S., 1885, pp. 185 – 205.

(b) *Germany.*—In the Ruhr coal-field of Rheinland Frech[1] has described a striated surface where the Permian basal breccias are resting on the surface of the Westphalian Coal-measures.

(c) *Netherlands.*—Van Waterschoot Van der Gracht[2] has described and figured striated fragments occurring under similar conditions in the Netherlands. The figured specimens have a somewhat doubtful glacial appearance, and unfortunately the area has been so disturbed tectonically that the possibility of "Slickensides" phenomena cannot be altogether excluded.

The above author points out that at the Preussen Colliery, near Lünen, the striated blocks of hard Carboniferous shale repose on a striated Carboniferous floor. He also states that it is probable that the striæ were not produced by earth movements, as shining 'slickensides' is absent. At the same time the fact must be emphasised that these supposed glacial conglomerates are situated in the main fault zone "the Courler Sprung" of the area. If this evidence of contemporaneous glaciation in Rothliegende time is genuine, the above author considers that it was possibly a purely local glaciation, the gathering ground for the glaciers being probably the plateau of Westphalia. The geological horizon of these conglomerates is Permian (Rothliegende, or Lower Zechstein).

(*d*) *Sicily.*—G. G. Gemmellaro[3] has published a very interesting account of the Fusulina Limestone of the Valle del fiume Sosio, Sicily. Streptorhynchus, Derbyia, Stro-

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[1] Lethæa Geognostica.

[2] Memoirs of the Government Inst. for the Geol. Exploı. of the Netherlands No. 2, by W. A. J. M. Van Waterschoot van der Gracht, with contributions on the fossil flora by Dr. W. Jongmans. p. 327 - 328, fig. 13, The Hague 1909.

[3] La Fauna dei Calcari con Fusulina della Valle del fiume Sosio. Palermo fascicole I - IV, and I Crostacei dei Calcari etc. Published at Naples 1890.

phalosia, Aulosteges, Richthofenia, Lyttonia, Waagenoceras, Medlicottia with Agathiceras and Gastrioceras are represented.

(*e*) *Carnic Alps, Tyrol.*—Schellwien and Kossmet have preliminarily described[1] a highly important fauna from the Bellerophon limestone of the Carnic Alps, including *Richthofenia aff. lawrenciana, Productus abichi, Marginifera ovalis, Lonsdaleia indica.* As these beds pass up conformably into the Trias, they are high in the Permian like the Guadalupian and Valle del Sosio beds, and they suggest a Permian age for the whole of the Productus Limestone of the Salt Range of India.

Summary.

The following appear to be salient features in the above observations:—

1. In the Lower Hunter District, and thence for a total distance of over 200 miles northerly, fluvio-glacial conglomerates, tillites and contemporaneously contorted "varve" shales are developed in a system of rocks for which we propose the term Kuttung Series. The greater part of these strata contains a flora considered by Dr. A. B. Walkom to be mostly low down in the Middle Carboniferous, but possibly ranging into the base of the Upper Carboniferous.

2. The dominant fossil in this series is *Rhacopteris (aneimites).*

3. The distinctly glacial members of this series are associated with extraordinarily massive conglomerates, coarse to fine tuffs of great thickness and extent and contemporaneous lavas (hypersthene andesites, rhyolites, keratophyres, etc.). One of us (C. A. Sussmilch) estimates the thickness of the Kuttung Series of the Lower Hunter at approximately 7000 feet, while Professor W. N. Benson,

[1] Palæontographica Vol. 39, pp. 1 *et seq.*, and *ibid.*, Vol. 41, pp. 237 *et seq.*

D.Sc., B.A., tells us that, in the Tamworth to Bingara district, he finds the series no less than 12000 feet thick, as will be detailed in a forthcoming paper by himself and W. R. Browne, B.Sc., and W. S. Dun in the Proc. of the Linnean Society of New South Wales.

4. This extraordinary mass of conglomerate etc., is probably to be correlated with the Maroon Conglomerate of Colorado, the Caney Shales with large erratics of Oklahoma, the Pottsville Conglomerate of the Eastern States, U.S.A., and the Millstone Grit Series of Great Britain, the glacial breccias of the St. Etienne coal-field France, and the Flotzleerer Sandstein beneath the Westphalian Coal Measures of Germany.

5. Downwards the Kuttung Series is sharply bounded at the base of the Wallarobba Conglomerate (a single mass from 1000 to 2000 feet in thickness) by the marine Burindi Series containing Syringothyris, Phillipsia, and a general fauna which indicates an age approximately Middle Mississippian (Osage) of U.S.A., and about the Viséan horizon of Belgium and Northern France.

6. Upwards no sharp or well defined limit can be assigned to the Kuttung Series. Rhacopteris has been traced to within 1300 feet of the topmost bed of tillite, provisionally included in the Kuttung Series, and marine fossils with apparently forms (as yet undescribed) intermediate between Carboniferous and Permo-Carboniferous types, occur within 60 feet of the topmost bed of Kuttung tillites.

7. Higher in the Series typical Permo-Carboniferous marine fossils may be observed associated with Gangamopteris, but not with Glossopteris.

8. (*a*) In the Seaham and Paterson areas no angular unconformity has been detected between the strata of the Kuttung (Rhacopteris) Series and those of the so-called

Permo-Carboniferous, (*b*) but where movement has been rapid as at the great anticline at Lochinvar there is evidence for slight angular unconformity, the average dips of the Kuttung being at about 20°, and those of the Permo-Carboniferous Greta Coal Seams at about 15°. (*c*) The splitting of the Permo-Carboniferous Greta Coal Seams by wedges of conglomerate whose thick ends point to the belt of Kuttung Hills, suggests some disconformity between the Kuttung and the "Permo-Carboniferous" as developed between Maitland and Lochinvar. (*d*) At Mount Bright, Pokolbin, 16 miles south-west of Maitland, there is distinct unconformity between the *Eurydesma cordatnm* horizon of the Lower Marine Series, and the lava and tuffs of the Rhacopteris Series.[1] The geological map accompanying the report quoted also shows strong disconformity between the above two series.

9. As regards the age of the "Permo-Carboniferous" tillites and their relations to the tillites and other glacial deposits of the Kuttung, the following tentative suggestions are made:—

(*a*) It is chiefly by means of the Indian Permo-Carboniferous fauna and flora that a correlation of the Kuttung and overlying Permo-Carboniferous strata with European and North American equivalents can be attempted.

(*b*) The Indian "Permo-Carboniferous" fauna is well developed on the coastal areas of West Australia and in Northern Territory between Darwin and the Victoria River, but a great land barrier extending from Darwin to south of Adelaide separated the Eastern ("Pacific") Permo-Carboniferous types from the Indian fauna of the Western half of Australia. (See map on Plate XXX.)

(*c*) Much of the so-called Permo-Carboniferous beds of India and Australia are probably really Permian for (1)

[1] The Geology of the Hunter River Coal Measures, New South Wales, by T. W. E. David, plate viii. Geol. Surv. Dep. Mines.

Schellwien and Kossmat, as quoted by Prof. C. Schuchert, have shown that the Bellerophon limestone of the Carnic Alps with its Richthofenia, *Productus indicus*, *Lonsdaleia indica*, etc., is to be directly correlated with the Productus Limestone of the Salt Range in which Richthofenia occurs throughout. Next that the Bellerophon limestone passes upwards conformably into the Werfen beds (Triassic); therefore the Bellerophon limestone is Upper Permian and the whole of the Productus limestone of India is consequently Permian, possibly Upper or Middle Permian. The conformably underlying "Lavender Shales" and "Speckled Sandstone" with the glacial boulder beds and tillites in the Salt Range and the *Eurydesma cordatum*, Conularia beds (Pre-Greta in age) are probably also Permian, for in New South Wales this fauna is associated with an extraordinary abundance of *Protoretepora ampla; Protoretepora ampla* is also very abundant and characteristic in the Upper Po Series of the Himalayas associated with Lyttonia, a brachiopod specially characteristic of the Middle Productus limestone of the Salt Range. Moreover in the Zewán beds of Kashmir the *Protoretepora ampla* shales overlie Glossopteris coal measures, and in the latter remains occur of the labyrinthodont Archegosaurus. The latter is considered to be not older than Lower Permian.

In regard, therefore, to the Greta Coal measures of New South Wales and the extraordinarily abundant *Protoretepora ampla* and *Strophalosia Clarkei* both in the Branxton Beds of the Upper Marine Series and in the Lower Marine Series just above the Eurydesma beds at Allandale, we may conclude provisionally that judged by the European standard the whole of it appears to be Permian.

Can the Eurydesma beds themselves and the 2400 feet of strata which separate this horizon from the top tillite of Kuttung also be considered to be Permian?

10. If it may be concluded that the whole of the Hunter River "Permo-Carboniferous" Series is really Permian, and the Rhacopteris-bearing Kuttung Series is Middle Carboniferous, what then has become of the equivalents of the Pennsylvanian, the Stephanian, the Ottweiler and all the other representatives of the Upper Carboniferous rocks of the Northern Hemisphere?

(i.) Are they represented by the unconformity between the "Permo-Carboniferous" (Lower Marine) Eurydesma beds and the Rhacopteris beds at Pokolbin etc. (in spite of the fact that elsewhere as at Seaham and Paterson the two series of the Kuttung and the Lower Marine appear to be quite conformable)?

(ii.) or does the disconformity come at the base of what we have included as the topmost tillite of the Kuttung, and is this particular tillite to be included in the Uralian rocks rather than at the top of the Kuttung? (See Plates XIX and XXII.) In West Australia marine fossils such as Keenia, *Aviculopecten tenuicollis* etc. occur in the same matrix with the Pre-Greta marine glacial beds, and for reasons already given indicate the age of the tillite of West Australia to be probably Uralian rather than Permian. In this case one introduces a disconformity, or slight unconformity in the lower glacial series itself as developed in the Lower Hunter area, making the top tillite of the Lower Glacial Series Uralian, and the lower tillites associated with Rhacopteris Moskovian. This at first sight appears improbable. Nevertheless it is the fact that at Wynyard in Tasmania, at Bacchus Marsh in Victoria, as well as at the Irwin River a Pre-Greta tillite lies at the base of the whole "Permo-Carboniferous" System, and is proved by the presence of the already quoted marine fossils and the Gangamopteris of Bacchus Marsh to be part and parcel of the "Permo-Carboniferous." One would expect therefore the main glacial horizon of the Lower Hunter to be at the base of the Pre-Greta Marine Series, and therefore to be Uralian, and, as seems probable, to be the equivalent of the Irwin River tillite, which is also probably Uralian.

(iii.) Or in accordance with Professor J. W. Gregory's[1] suggestion, is the whole of the Lower Marine, Greta Coal Measures and Upper Marine Series of New South Wales of Upper Carboniferous (Uralian) age, thus filling in the gap between the top of the Kuttung and the base of the Permian, the latter, according to Professor Gregory, beginning at the base of the Tomago Coal measures? This would be a very simple solution of the difficulty, but on the palæontological grounds, already given, we cannot accept it.

(iv.) Or does the Rhacopteris flora of the Kuttung range in New South Wales upwards into the Upper Carboniferous, and does the Kuttung, as we have defined it, include Upper Carboniferous as well as Middle Carboniferous forms, and thus are the *Upper beds of the Kuttung* though mostly barren of coal, the equivalents of the Pennsylvanian, Stephanian, Ottweiler coal measures, so that the latest Rhacopteris Flora of New South Wales survived into the time of the Neuropteris Flora of the Northern Hemisphere. Certainly Rhacopteris was a hardy form which survived the intense tuff showers of the Kuttung series, as well as the earlier glacial conditions.

11. Where so much is uncertain and unproved we can at any rate rest assured that in the Australian region there is evidence in the Newer Palæozoic rocks of at least three, if not four important glaciations, as follows:—(See Plate XXIX, Section 1.)

Permian Bolwarra Conglomerate and Branxton Beds Glaciation (Post-Greta). Time interval between Bolwarra

[1] Brit. Assoc. Adv. Sci. Report of Research Committee, Section C.

and next glaciation, Branxton, below, represented by about 900 feet of marine strata; time interval between the Branxton and the *Eurydesma cordatum* horizon, below, represented by 3500 feet of marine sediment, and 300 feet of Coal-Measures.

Uralian (Upper Carboniferous), (*b*) *Eurydesma cordatum* horizon with fluvio-glacial conglomerates. The time interval from the *Eurydesma cordatum* beds to the top tillite of the Kuttung at Lochinvar is represented by about 2400 feet of marine strata; that is, there is a total of 6900 feet of marine beds, and 300 feet of Greta Coal-Measures separating the Bolwarra glacial beds of the Upper Marine Series from the topmost tillite of the Kuttung series, and a total of no less than 9800 feet of strata between the Bolwarra glacial beds and the lowest glacial bed of the Kuttung series.

(*a*) Pre-Greta Tillites of Lochinvar, Macleay River in New South Wales, Wynyard in Tasmania, Bacchus Marsh, Victoria, Hallett's Cove and Inman Valley, South Australia, Irwin and Gascoyne area, West Australia—possible disconformity.

Middle Carboniferous or Culm lower glacial deposits of Kuttung Series, New South Wales associated with Rhacopteris.

12. From all the evidence quoted from Australia and elsewhere it would seem that the following conclusions may be provisionally adopted:—The great tectonic revolution known to the American geologists as the Ouachita disturbance, of which the probable equivalent in Europe was the late Culm or Post-Culm revolution, was part of a world wide diastrophism.

It initiated the building of great mountain chains. Already in early Middle Carboniferous time in New South

Wales the Wallarobba and Rocky Creek conglomerates, in Queensland the conglomerate of the Star series, in U.S.A. the Maroon Conglomerates of Colarado and the Pottsville Conglomerate of the Eastern States, and in Europe the Millstone Grit Series bear impressive testimony as to the magnitude of the mountain-building movements, and the denudation by which they were accompanied. The fluvio-glacial conglomerates and tillites associated with Rhacopteris, recently discovered by Mr. C. A. Sussmilch, at Seaham, and similar beds just discovered 200 miles northerly by Mr. W. R. Browne at Currabubula near Tamworth, prove that in Australia the glaciation which ended *probably* in Lower Permian time commenced as far back as Middle Carboniferous time, and probably attained its maximum in Upper Carboniferous time.

The evidence of the large erratics in the Caney Shales of Oklahoma, the great blocks in the Maroon Conglomerates of Colorado, the thick masses of breccia formed of erratics occasionally striated in the St. Etienne coal-field of Central France, and the groups of large cobbles in the fine shales of the Upper Culm at the Frankenwald in Germany all point to a world-wide development of glaciers in or about Middle Carboniferous time. These great orogenic movements in Eastern Australia continued throughout Uralian (Upper Carboniferous) time into the Permian, but entirely ceased before Upper Permian time. The maximum glaciation appears to date to an epoch in Upper Carboniferous time. The duration of the glacial conditions at all events in Australia, must have been very considerable for reasons already given. It is not unreasonable to suppose that the interval in time represented by this great thickness of strata may extend from low down in the Upper Carboniferous into the Lower Permian.

13. (*a*) The great tectonic movements of Middle and Upper Carboniferous and Lower Permian time, if not the

first cause of the glaciation were certainly an important contributing factor; (*b*) The unprecedented development of volcanic dust, produced in Kuttung time may also, on Humphreys' hypothesis,[1] have contributed to the glaciation by intercepting the sun's heat above the surface of the atmospheric stratosphere.

14. By giving so wide a choice of dates for the "Permo-Carboniferous" glacial deposits throughout the world the recent evidence from Australia collected by my co-author obviously adds to the complexity of the task of correlating these beds. At the same time it furnishes a truer view of this vast and fascinating problem, and should be a warning against any attempt to press on slender evidence for absolute contemporaneity in these Late Palæozoic glacial deposits, some of which may be separated from one another by a considerable time interval, an interval amounting probably to many millions of years.

More evidence is much needed, not only from Australia, but from every part of the world, where "Permo-Carboniferous" strata have been identified. Much may be expected from a detailed examination of the extensive Permian etc. deposits of Alaska.

Acknowledgements.—The author is specially indebted to Mr. C. A. Sussmilch for guidance in the field geology of the Kuttung series. Professor W. N. Benson has been most generous in supplying information about the equivalents of the Kuttung series to the west of the area from Tamworth to Bingara. To Mr. Ludwig Glauert of the Geol. Survey of West Australia is chiefly due the census in this paper of the Irwin River fossils. Mr. W. S. Dun has helped throughout with palæontological notes and references. Mr. W. R.

[1] W. J. Humphreys, Volcanic Dust and other Factors in the Production of Climatic Changes, and their possible Relation to Ice Ages. Bull. of the Mount Weather Observatory, Vol. vi, part 1, Aug. 20, 1913, pp. 1 – 26.

Browne has kindly permitted his section of the strata at Lochinvar (greater part of Plate XXIII) to be incorporated in this report. In addition to the acknowledgments already made in this paper the author desires specially to state how much he owes to the admirable paper of Professor Charles Schuchert,[1] and to the classic works of George H. Girty, on the Guadalupian Fauna of Texas, of Tschernyschew on the Permo-Carboniferous of Russia, and Waagen and Diener on the Permo-Carboniferous of India.

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,, XXVI.—Photograph of a specimen of folded varve shale.

,, XXVII.—Photograph of two specimens of folded varve shale.

,, XXVIII.—Striated boulder from Felspar Creek tillite, Seaham.

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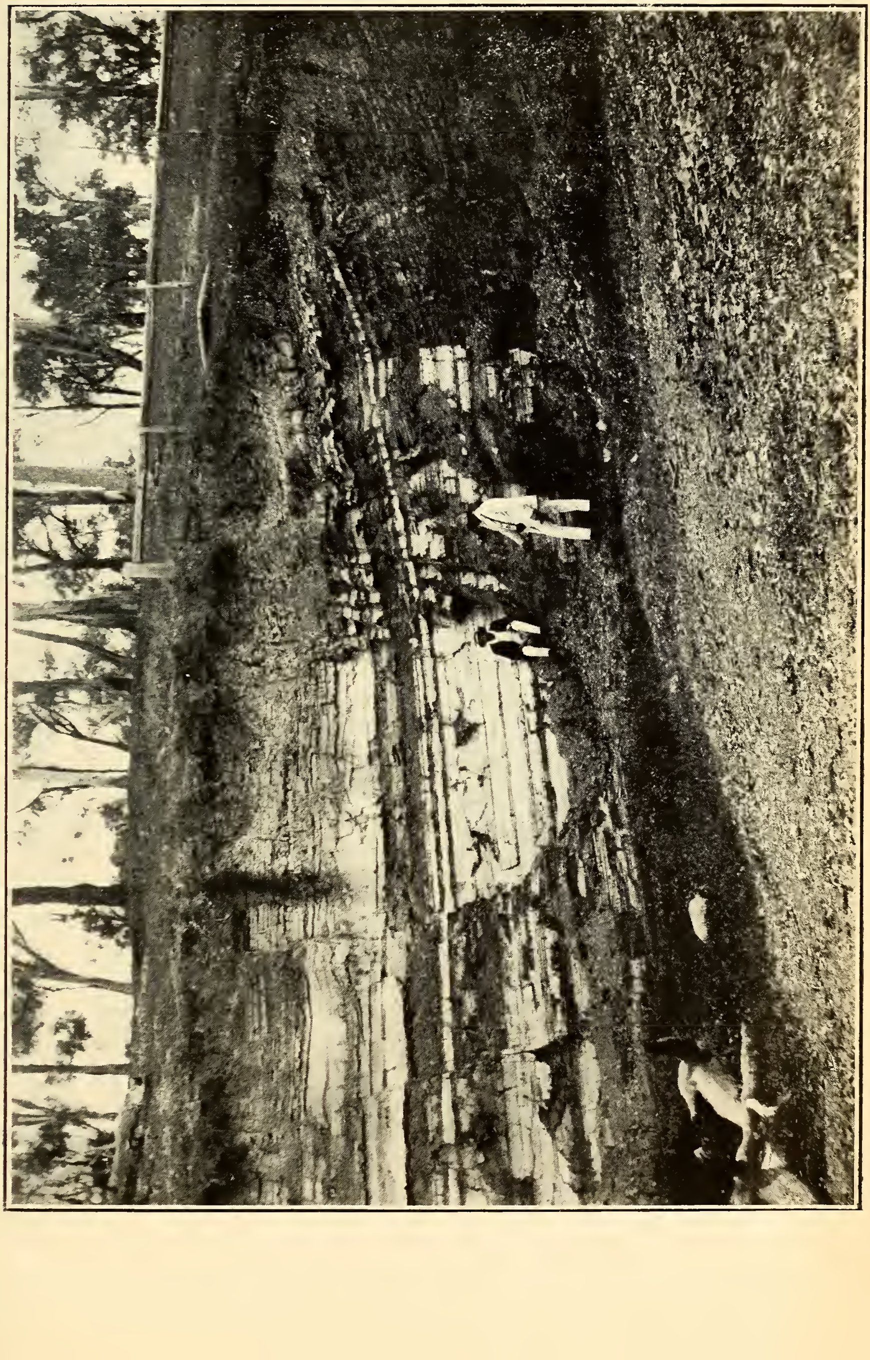
[1] Amer. Journ. Sci., Vol. XXII, pp. 29 – 158.

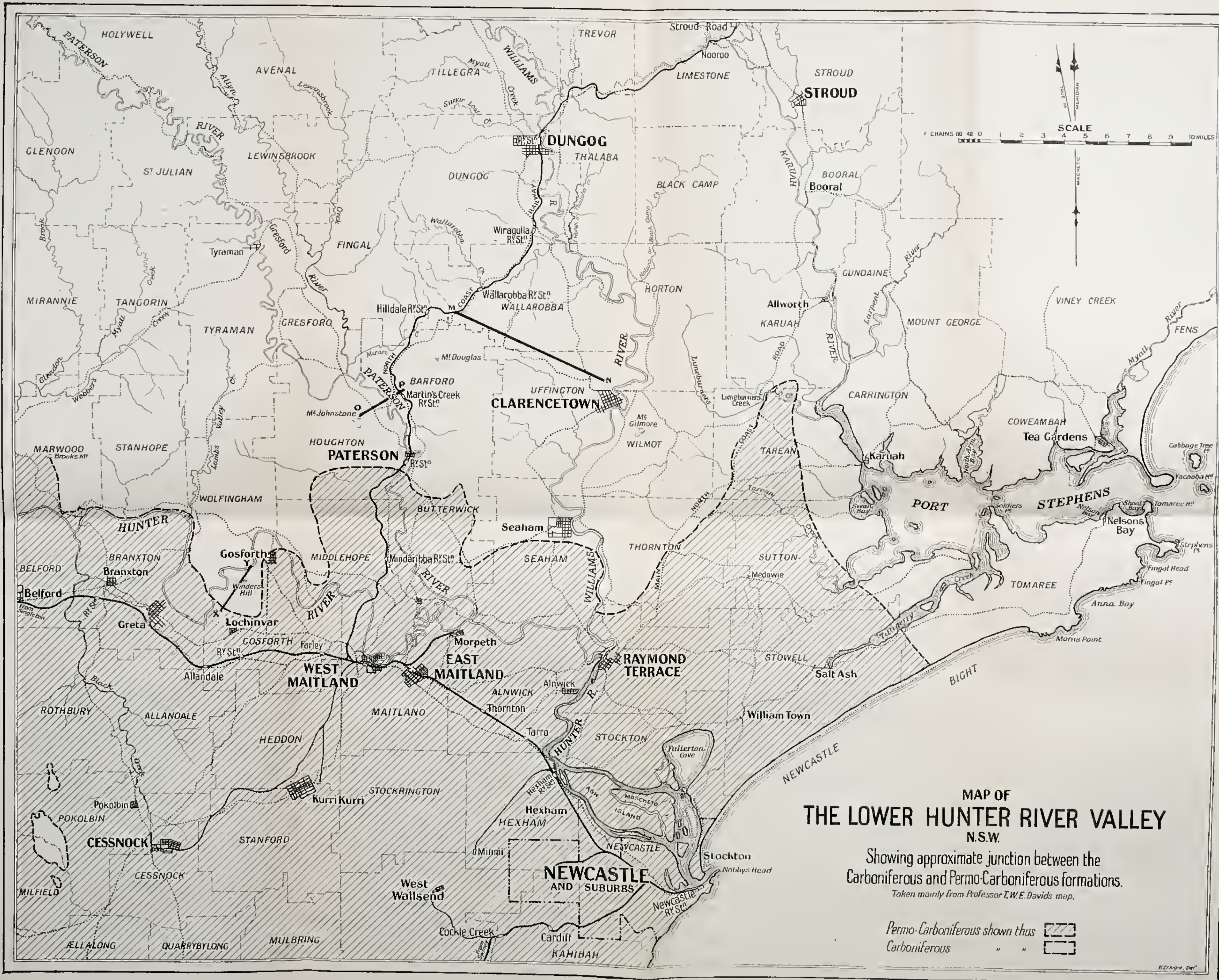
Plate XXIX.—Comparative Series of Vertical Sections of Permo-Carboniferous and Carboniferous glacial beds in Australasia and elsewhere.

„ XXX.—Tentative correlation of Carboniferous and Permo-Carboniferous Rocks, and map of S.E. shore-line of the Tethys Sea in Australia.

„ XXXI.—Map of the Lower Hunter River District showing the areas occupied by Carboniferous and Permo-Carboniferous strata.



"Varve" beds at Seaham, of Middle to possibly Upper Carboniferous Age.


MAP OF
THE LOWER HUNTER RIVER VALLEY
N.S.W.
Showing approximate junction between the
Carboniferous and Permo-Carboniferous formations.
Taken mainly from Professor T.W.E. Davids map.
Permo-Carboniferous shown thus
Carboniferous " "
SCALE
HOLYWELL
PATERSON
AVENAL
TILLEGRA
TREVOR
Stroud Road
Nooroo
LIMESTONE
STROUD
STROUD
GLENOON
LEWINSBROOK
DUNGOG
DUNGOG
THALABA
St JULIAN
BOORAL
Booral
BLACK CAMP
KARUAH
Wiragulla
Tyraman
FINGAL
GUNOAINE
MIRANNIE
TANGORIN
Wallarobba Ry Stn
WALLAROBBA
HORTON
Allworth
VINEY CREEK
Hilldale Ry Stn
GRESFORD
KARUAH
MOUNT GEORGE
TYRAMAN
FENS
Mt Douglas
BARFORD
Martin's Creek
UFFINGTON
CLARENCETOWN
CARRINGTON
Mt Johnstone
COWEAMBAH
Tea Gardens
HOUGHTON
WILMOT
MARWOOD
STANHOPE
PATERSON
TAREAN
Karuah
WOLFINGHAM
PORT
STEPHENS
BUTTERWICK
Seaham
Nelsons Bay
HUNTER
Gosforth
MIDDLEHOPE
Mindaribba Ry Stn
SEAHAM
THORNTON
SUTTON
BRANXTON
BELFORD
Branxton
Medowie
TOMAREE
Belford
Fingal Head
Winders Hill
RIVER
WILLIAMS
Anna Bay
Greta
Lochinvar
GOSFORTH
Morpeth
Farley
EAST
MAITLAND
RAYMOND
TERRACE
STOWELL
Salt Ash
WEST
MAITLAND
Allandale
ALNWICK
Alnwick
Thornton
BIGHT
ROTHBURY
ALLANDALE
MAITLAND
William Town
HEDDON
Tarro
STOCKTON
Fullerton Cove
NEWCASTLE
STOCKRINGTON
Pokolbin
Kurri Kurri
POKOLBIN
Hexham
HEXHAM
MOSCHETO
ISLAND
CESSNOCK
STANFORD
NEWCASTLE
Minmi
Stockton
Nobbys Head
NEWCASTLE
AND SUBURBS
CESSNOCK
West
Wallsend
MILFIELD
Newcastle
Cockle Creek
Cardiff
ÆLLALONG
QUARRYBYLONG
MULBRING
KAHIBAH

ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

MAY 7th, 1919.

The Annual Meeting, being the four hundred and fourth General Monthly Meeting of the Society, was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Mr. W. S. Dun, President in the Chair.

Forty members and two visitors were present.

The minutes of the General Monthly Meeting of the 4th December, 1918, were taken as read, as a time limit had been placed on the meeting owing to the prevailing pneumonic influenza pandemic.

The certificates of six candidates for admission as ordinary members were read: one for the second and five for the first time.

Messrs. A. B. Hector and A. J. Sach were appointed Scrutineers, and Mr. C. A. Sussmilch deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—Henry Herbert Baker.

The Annual Financial Statement for the year ended 31st March, 1919, was submitted to members, and, on the motion of the Honorary Treasurer, seconded by Mr. C. A. Sussmilch, was unanimously adopted :—

GENERAL ACCOUNT.

RECEIPTS.	£	s.	d.	£	s.	d.
To Balance, Cash on hand and at Bank, 1st April, 1918				50	12	1
,, Subscriptions—						
Annual	538	15	0			
Sectional Members	2	2	0			
				540	17	0
,, Rents—						
Offices	300	15	0			
Hall and Library	55	16	6			
				356	11	6
,, Sundry Receipts				32	11	6
,, Government Subsidy for 1918...				399	19	10
,, Clarke Memorial Fund—						
Amounts received to date				50	0	0
				£1,430	11	11

PAYMENTS.	£	s.	d.	£	s.	d.
By Salaries and Wages—						
Office Salary and Accountancy Fees ...	170	15	0			
Assistant Librarian	48	0	0			
Caretaker	152	6	0			
				371	1	0
,, Printing, Stationery, Advertising, Stamps, etc.—						
Stamps and Telegrams	30	11	7			
Office Sundries, Stationery, etc.	7	18	4			
Advertising	12	16	1			
Printing	40	4	3			
				91	10	3
,, Rates, Taxes and Services—						
Electric Light...	18	11	2			
Gas	8	4	8			
Insurance	23	10	8			
Rates	99	10	0			
Telephone	8	17	7			
				158	14	1
,, Printing and Publishing Society's Volume—						
Printing, etc.	361	12	9			
Book Binding...	69	18	3			
				431	11	0
,, Library—						
Books and Periodicals				1	6	0
Carried forward				1054	2	4

Payments—*continued.*	£	s.	d.	£	s.	d.
Brought forward				1054	2	4
By Sundry Expenses—						
Repairs...	145	11	10			
Lantern Operator (Rent of Lantern) ...	10	10	0			
Bank Charges	0	11	0			
Sundries	38	7	8			
				195	0	6
,, Clarke Memorial Fund—						
Repayment of Loan	50	0	0			
Interest on Loan	0	6	8			
				50	6	8
,, Building and Investment Fund—						
Interest on Mortgage				115	0	0
,, Balance—						
Credit Balance at Union Bank of Australia	15	10	4			
Cash in Hand	0	12	1			
				16	2	5
				£1,430	11	11

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.
Auditor.

Sydney 15th April 1919.

BUILDING INVESTMENT LOAN FUND.

Balance Sheet as at 31st March, 1919.

Liabilities.	£	s.	d.
Loan on Mortgage—			
Amount due to the Australasian Association Advancement of Science	2,300	0	0
	£2,300	0	0

Assets.	£	s.	d.	£	s.	d.
Cash, Government Savings Bank				264	5	0
Commonwealth War Loan				100	0	0
Balance as at 31st March, 1918	1,950	0	0			
Less: Interest received during the year...	14	5	0			
				1,935	15	0
				£2,300	0	0

Statement of Receipts and Payments, 31st March, 1919.

Receipts.	£ s. d.	£ s. d.
To Balance, 31st March, 1918, Government Savings Bank		250 0 0
„ Interest—Commonwealth War Loan	4 5 0	
Government Savings Bank... ...	10 0 0	
		14 5 0
„ Amount received from General Fund... ...		115 0 0
		£379 5 0

Payments.	£ s. d.
By Interest paid to the Australasian Association Advancement of Science	115 0 0
„ Balance, Government Savings Bank	264 5 0
	£379 5 0

Bookbinding Fund, 31st March, 1919.

Liabilities.	£ s. d.
Accumulation on 31st March, 1918	£87 10 0

Assets.	£ s. d.
War Saving Certificate	87 10 0

CLARKE MEMORIAL FUND.

Balance Sheet, 31st March, 1919.

Liabilities	£ s. d.	£ s. d.
Accumulation Fund—		
Balance as at 31st March, 1918		669 12 1
Additions during the year—		
Interest Savings Bank of N.S.W. ...	3 8 1	
„ Government Savings Bank	0 11 6	
„ Commonwealth Savings Bank	1 19 6	
„ Commonwealth War Loan	26 10 0	
„ Loan to General Fund ...	0 6 8	
		32 15 9
		£702 7 10

Assets.	£ s. d.	£ s. d.
Commonwealth War Loan		600 0 0
Cash Savings Bank of N.S.W.	28 8 1	
„ Government Savings Bank	47 0 3	
„ Commonwealth Savings Bank	26 19 6	
		102 7 10
		£702 7 10

STATEMENT OF RECEIPTS AND PAYMENTS, 31ST MARCH, 1919.

RECEIPTS.	£ s. d.	£ s. d.
To Balance 31st March, 1918		
Savings Bank of N.S.W.	25 0 0	
Government Savings Bank	19 12 1	
Commonwealth Savings Bank	25 0 0	
		69 12 1
,, Repayment from General Fund		50 0 0
,, Interest to date—		
Savings Bank of N.S.W.	3 8 1	
Government Savings Bank	0 11 6	
Commonwealth Savings Bank	1 19 6	
War Loan	26 10 0	
Loan to General Fund	0 6 8	
		32 15 9
		£152 7 10

PAYMENTS.	£ s. d.	£ s. d.
By Loan to General Fund...		50 0 0
,, Balance at date—		
Savings Bank of N.S.W.	28 8 1	
Government Savings Bank	47 0 3	
Commonwealth Savings Bank	26 19 6	
		102 7 10
		£152 7 10

On the motion of Mr. L. A. Cotton, seconded by Mr. Welch, Mr. W. P. Minell was duly elected Auditor for the current year.

A report on the state of the Society's property and the annual report of the Council were read :—

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1918-19.
(1st May to 30th April.)

The Council regrets to report that we have lost by death eleven ordinary members and one honorary member. Two members have resigned and sixteen members names were removed from the roll owing to non-payment of their sub-subscriptions. On the other hand, eighteen ordinary and one honorary member have been elected during the year.

To-day (30th April, 1919) the roll of members stands at 307.

During the Society's year there have been eight monthly meetings and eight Council meetings.

A Clarke Memorial Lecture entitled "Brain-Growth, Education and Social Inefficiency," was delivered by Professor R. J. Berry, M.D., on 12th June 1918.

Three Popular Science Lectures were given, namely:—

July 18—"The Planet Mars," by J. Nangle, F.R.A.S.

August 15—"Some Modern Phases of Agriculture," by H. W. Potts, F.L.S., F.C.S.

September 19—"Radium," by S. Radcliff, F.C.S.

Meetings were held throughout the session by the Sections of Geology, Agriculture and Industry.

Nineteen papers were read at the monthly meetings and these, with a good number of exhibits, afforded much instruction and interest to members of the Society.

The following members were honoured during the year:—Dr. James Adam Dick (Colonel A.A.M.C.) C.M.G. James Fraser, C.M.G. John Russell French, K.B.E. Frank Marshall (Colonel), C.M.G. Dr. Archibald Lang McLean (Captain), M.C. William T. Willington, O.B.E. Dr. C. J. Martin, C.M.G.

The President tendered a hearty welcome to Professors T. W. E. David and J. A. Pollock (members of Council), who had just returned from Active Service at the front.

It was announced that the following members had died during the recess:—Sir William Crookes, Sir James Fairfax, Rev. T. Roseby, and Mr. H. Taylor.

Letters were read from Lady Fairfax, Mrs. Roseby and Mrs. H. Taylor, expressing thanks for the Society's sympathy in their recent bereavements.

The Private Secretary to His Excellency the Governor wrote to convey His Excellency's appreciation of the resolution which had been passed at the general meeting in December in regard to the victory obtained by the Empire and the Allies, and the prospects of the World's peace, and intimated that a copy of the resolution would be forwarded through the proper channel to His Majesty the King.

The following donations were laid upon the table:—269 parts, 17 volumes, 11 reports, 1 calendar and 1 map.

The President, Mr. W. S. Dun, then delivered his Presidential Address.

On the motion of Professor David a hearty vote of thanks was accorded to the retiring President for his valuable address.

Mr. Dun briefly acknowledged the compliment.

There being no other nominations, the President declared the following gentlemen to be Officers and Council for the coming year:—

President:

Prof. C. E. FAWSITT, D.Sc., Ph.D.

Vice-Presidents:

R. GREIG-SMITH, D.Sc.	J. B. CLELAND, M.D., Ch.M.
T. H. HOUGHTON, M. INST. C.E.	W. S. DUN.

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.	J. NANGLE, F.R.A.S.
D. CARMENT, F.I.A., F.F.A.	F. H. QUAIFE, M.A., M.D.
Prof. T. W. EDGEWORTH DAVID, B.A., C.M.G., D.S.O., F.R.S.	HENRY G. SMITH, F.C.S.
C. HEDLEY, F.L.S.	C. A. SUSSMILCH, F.G.S.
J. H. MAIDEN, I.S.O., F.R.S.	Prof. W. H. WARREN, LL.D., Wh. Sc.

The out-going President then installed Professor C. E. Fawsitt as President for the ensuing year, and the latter briefly returned thanks.

It was decided on the motion of Mr. C. Hedley to place on record the Society's great appreciation of the valuable services rendered by Mr. J. H. Maiden, who had just retired from the position of Honorary Secretary, after a period in office of twenty-nine years, during two of which he was President, and twenty-two Honorary Secretary.

JUNE 4th, 1919.

The four hundred and fifth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor C. E. Fawsitt, President in the Chair.

Thirty-four members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of seventeen candidates for admission as ordinary members were read: five for the second, and twelve for the first time.

Messrs. L. Meggitt and A. B. Hector were appointed Scrutineers, and Dr. J. B. Cleland deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—Wilfrid Alexander Watt de Beuzeville, John Garlick, Alexander Hay, Robert Newby Kirk, and Willie Thomas Watkin-Brown.

The President announced that a Popular Science Lecture, entitled:—"On the Ectoparasites of Man," would be delivered by Professor S. J. Johnston, on Thursday, 19th June, 1919.

Ninety-nine parts, 1 report and 1 catalogue were laid upon the table.

THE FOLLOWING PAPER WAS READ:

"Some Experiments on the Prevention of Bunt (*Tilletia lœvis* and *Tilletia tritici*) on Wheat," by G. P. Darnell-Smith, B.Sc. Remarks were made by Messrs. J. H. Maiden, E. Cheel, R. W. Challinor, A. D. Ollé, E. Breakwell, T. I. Wallas, Drs. J. B. Cleland, R. Greig-Smith, and the President.

EXHIBITS.

Mr. J. H. Maiden, F.R.S., exhibited specimens of botanical or historical interest with the following notes:—

1. Ligneous framework of the so-called Rope Cactus (*Opuntia imbricata* Haw.). The specimen is 7 feet 6 inches high, and the greatest diameter of the stem 5 inches. It is stated to be forty years old. It was sent by Mr. H. A. Viney, Public School, Sedgefield, Singleton, and is the largest plant I have seen in New South Wales.

2. Section of the stem of a grape-vine 3 feet 3 inches in girth. It was cut 3 feet from the ground. "The vine is one of the old-fashioned purple preserving sort." It came from the property of Mr. H. L. White at Belltrees, Scone, and its history can be traced for about seventy years, but it is not known whether it was one of the earliest Busby vines, distributed from the Botanic Gardens from 1833 onwards, (see my notes on the history of the vine in New South Wales Agric. Gaz. N.S.W., p. 427, June, 1917).

3. An old fence-post and its wire, believed by Mr. White to be the remains of the first wire fence erected on the Hunter and probably in New South Wales. It was erected in 1858. It will be observed that the post is pointed and therefore it was driven. It is apparently Ironbark, and sound. The wire is No. 4 galvanised, and wire of this thickness has long since ceased to be used for the purpose. It came from Milgarra, Bunnan, the property of Mr. H. W. Bell. It was presented to the Botanic Gardens by the

well-known ornithologist of Belltrees, Scone, Mr. H. L. White, whose permission I have to transfer it to the Technological Museum.

Dr. J. B. Cleland exhibited a sprout $1\frac{1}{4}$ inches long from a log of *Eucalyptus trachyphloia* from Narrabri. The log had been hollowed out and used as a trough to hold water for several months, and the young shoot was supposed to be the result of recent rain.

JULY 2nd, 1919.

The four hundred and sixth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor C. E. Fawsitt, President, in the Chair.

Twenty-five members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of eighteen candidates for admission as ordinary members were read: twelve for the second and six for the first time.

Messrs. R. T. Baker and W. Welch 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:—George Henry Briggs, Frank Hambridge, Arthur Sidney Hoskins, Cecil Harold Hoskins, Frank Oakden, Archibald Boscawen Boyd Ranclaud, Arthur Spencer-Watts, Sydney Hartnett Stroud, George Fyfe Sutherland, Herbert John Swain, Harold Henry Thorne, Arthur Bache Walkom.

The President announced the death of Dr. C. Savill Willis.

Eighty-four parts, 4 volumes, 5 reports and 1 catalogue were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "On some Australian Freshwater Copepoda and Ostracoda," by Miss Marguerite Henry, B.Sc., (communicated by Professor S. J. Johnston).

2. "Some Notes on *Neurosoria pteroides*," by Rev. W. W. Watts.

3. "Notes on Eucalyptus, No. VII, with descriptions of new species," by J. H. Maiden, I.S.O., F.R.S. Remarks were made by Messrs. R. H. Cambage and R. T. Baker.

EXHIBIT:

Mr. C. A. Sussmilch exhibited some specimens of a large species of Strophomena, probably a new species, found in a bed of tuff about five miles from Gloucester.

AUGUST 6th, 1919.

The four hundred and seventh General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor C. E. Fawsitt, President in the Chair.

Thirty-four members and two 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. G. Hooper and W. Welch 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:—George Joseph Burrows, Herbert Vernon Bettley-Cooke, Edward Henry Cowdery, Robert Walter Hardie, Herbert E. Pratten, Walter L. Waterhouse.

The President announced the deaths of Dr. W. W. J. O'Reilly and Mr. F. W. Webb.

Letters were read from Mrs. O'Reilly, Mrs. Webb, and Mrs. Willis expressing thanks for the Society's sympathy in their recent bereavements.

A letter was read from the Official Secretary to His Excellency the Governor stating that His Majesty the King had commanded that an expression of His Majesty's appreciation of the resolution passed by this Society at the time of the signing of the Armistice be conveyed to the Society.

The President announced that the Council had resolved that in the nomination form for submission to the Society for the election of Council for the ensuing year, there shall be at least the names of three new members.

Seventy-four parts, 4 volumes and 1 report were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "Volume Changes in the Process of Solution," by G. J. Burrows, B.Sc., (communicated by Prof. C. E. Fawsitt). Remarks were made by Mr. T. I. Wallas, and Drs. G. Harker and H. S. H. Wardlaw.
2. "Note on Organo-Metallic Derivatives of Chromium, Tungsten and Iron," by G. M. Bennett, M.A., M.Sc., and E. E. Turner, B.A., M.Sc., (communicated by Prof. J. Read.)

The President presented Professor T. W. Edgeworth David with the Clarke Memorial Medal which had been awarded to him in 1917 during his absence on active service at the front. In returning thanks for the honour conferred upon him, Professor David referred to the great assistance he had received from the geological writings of the Rev. W. B. Clarke, and also from those of Robert Etheridge, Junr., and Charles S. Wilkinson.

SEPTEMBER 3rd, 1919.

The four hundred and eighth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor C. E. Fawsitt, President, in the Chair.

Thirty-seven members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of twenty-one candidates for admission as ordinary members were read: six for the second, and fifteen for the first time.

Messrs. E. Breakwell and F. A. Coombs 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:—David Benjamin, Launcelot Harrison, Charles James Hunt, James Montague Sandy, Eustace Ebenezer Turner, and Lionel Lawry Waterhouse.

A circular was read from the Honorary Secretary of the Tasmanian Museum, Hobart, drawing attention to a proposal in regard to a memorial for the late R. M. Johnston.

A circular was read from Dr. A. B. Rendle of the British Museum (Natural History) London, drawing attention to an Imperial Botanical Congress to be held in 1920.

The President announced that a Popular Science Lecture entitled "Science in Breadmaking," would be delivered by Prof. H. G. Chapman, on Thursday, 18th September, 1919.

One hundred and one parts, 5 volumes, 4 reports and 1 catalogue were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "Vocabulary of one hundred and fifty-four words of the Yuckaburra Dialect, spoken by the Munkeeburra, South

Kennedy District, Cape River, Queensland," by J. P. de Beuzeville, (communicated by W. A. W. de Beuzeville.)

2. "Notes on Eucalyptus, No. VIII, with descriptions of two new Western Australian species," by J. H. Maiden, I.S.O., F.R.S. Remarks were made by Mr. A. B. Hector.

3. "Note on a relation between the Thermal Conductivity and the Viscosity of Gases," by Prof. J. A. Pollock, F.R.S.

4. "Three new species of Leptospermum," by E. Cheel.

EXHIBITS:

Mr. Cambage exhibited a sample of quartzite containing over 98% silica from Ulladulla, and which is considered to be equal to the best silica known in the world for the manufacture of silica bricks.

OCTOBER 1st, 1919.

The four hundred and ninth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor C. E. Fawsitt, President, in the Chair.

Thirty members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of twenty candidates for admission as ordinary members were read: fifteen for the second and five for the first time.

Messrs. W. Welch and A. J. Sach 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:—Marcel Aurousseau, John Ralph Bardsley, Reginald Wheeler Bretnall, George Frederick

Earp, Frederick Lyle Grutzmacher, Max Henry, Ralph Liddle Houston, Henry Barton Madden, Robert Martin, Duncan McGeachie, William Henry McGlynn, Hector Oram, Hugh Raymond Guy Poate, Hugh Thomas and Robert George Kinloch Waley.

The President announced that a Popular Science Lecture entitled, "The Causes of Earthquakes," would be delivered by Mr. L. A. Cotton, M.A., B.Sc., on Thursday, 16th October, 1919.

A letter was read from the Secretary, Royal Society, London, stating that there was a difficulty in financing the publication of the International Catalogue of Scientific Literature on its former scale, and the President stated that the Council had replied urging that the publication be not curtailed, at least until some scheme has been considered for adequate national contributions.

The President announced that Australia had been invited to join the International Research Council, and in connection therewith the Royal Society of London had asked this Society to take steps towards forming a National Research Council in Australia. In pursuance of this request a conference of scientific societies had been held in Sydney and a provisional National Research Council formed.

One volume, 74 parts and 1 map were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "On the Hydrolysis of Urea Hydrochloride," by G. J. Burrows, B.Sc.

2. "Notes on the Elastic Properties of Selenium," by Assistant-Professor O. U. Vonwiller, B.Sc. Remarks were made by Professor J. A. Pollock, Messrs. A. B. Hector and E. E. Turner, and the President.

EXHIBIT:

Professor David exhibited a new meteorite from Bingara, weighing 6 lbs. 3 ozs. It comes under the Hexahedrite classification, while nearly all the Australian meteorites are Octahedrites. Two hexahedrites have been previously recorded, one from Bingara, the other from Barraba. This new meteorite has a very fresh appearance, and would give the impression that on all sides it is thumb-marked, and if it has not recently fallen to the earth, it is evident that nickel-iron can remain for years without undergoing appreciable oxidation.

Mr. A. B. Hector gave notice that at the next meeting he would move "that the time is now opportune to consider the advisibility 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 housing of the library, and more room and better facilities for the social intercourse of its members.

NOVEMBER 5th, 1919.

The four hundred and tenth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. R. Greig-Smith, Vice-President, in the Chair.

Forty-five members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of eight candidates for admission as ordinary members were read: five for the second and three for the first time.

Messrs. A. D. Ollé and R. W. Challinor 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:—Robert Gladstone Anderson, Frank Stanley Cotton, Clement Alfred Hack, Frederick L. Henriques, Hereward Leighton Kesteven.

A letter was read from Dr. Georgina Sweet of Melbourne stating that she would be glad to receive donations towards a memorial to Sir W. Baldwin Spencer on his retirement from the position of Professor of Biology, Melbourne University.

It was announced that as the President would be absent at the date of the annual meeting the Presidential Address would be delivered at the December meeting, and any papers presented at the December meeting would be taken as read.

The President announced that a Popular Science Lecture entitled, "Temperature: Its Control and Measurement," would be delivered by Mr. W. M. Hamlet, F.I.C., F.C.S., on Thursday, 20th November, 1919.

One hundred and fifty-nine parts, 3 volumes, 8 reports, 2 calendars and 1 map were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "Acacia Seedlings, Part V," by R. H. Cambage, F.L.S. Remarks were made by Messrs. J. H. Maiden, and E. Cheel, Drs. Cleland and Greig-Smith, and Professor Chapman.

2. "The Miscibility of Liquids," by Prof. C. E. Fawsitt, D.Sc. (Read by Mr. Burrows in Professor Fawsitt's absence). Remarks were made by Messrs. A. D. Ollé and H. G. Smith, and Drs. R. K. Murphy and R. Greig-Smith.

3. "A new method of measuring Molecular Weights," by J. G. Stephens, B.Sc., John Coutts Research Scholar, (communicated by Prof. C. E. Fawsitt). Remarks were made by Dr. Wardlaw, Mr. R. W. Challinor, Professor Pollock, Dr. Harker, and Mr. E. E. Turner.

EXHIBITS:

1. Mr. W. S. Dun exhibited on behalf of Mr. George Smith, Inspector of Mines, portion of the jaw of a cretace-

ous reptile from Lightning Ridge. The specimen is the anterior portion of the right maxillary, with four teeth, of a marine reptile related to the European form Simolestes, one of the Pliosaurs, and is converted into precious opal.

2. Mr. J. H. Maiden exhibited the following:—

(i.) Two photographs showing a single branch of *Eucalyptus macrocarpa* Turcz., from the York district, W.A. (C. E. Chapman). It bears no less than fourteen flowers, symmetrically arranged in two pairs of rows of three and four each. So large a number on one short branch (18 inches) has not been previously seen by the exhibitor.

Australian-produced Eucalyptus hybrids.

(ii.) Coloured drawings of the first hybrid Eucalypts that have been raised in Australia by the direct action of the plant breeder. The Algerian hybrids hitherto described are the results of accidents, plants having been selected in the plantation that could only have arisen as the result of the proximity of certain pairs of species. Many of the reputed natural hybrids referred to in Australian literature may or may not be true; to say that they are so seems justified by the facts in regard to a number of them. These artificial hybrids are the work of Mr. C. J. Weston, Afforestation Officer, Federal Territory, Canberra. They are

(*a*) *E. macrorrhyncha* × *Maideni.*

(*b*) *E. rubida* × *melliodora*, the former being the pollen parent in each case.

They were pollinated on 8th February, 1918, and 9th December, 1917, respectively. Mr. Maiden's specimen of (*a*) died in May last, when the seedling was two inches high. Of (*b*) he has two plants, 11½ and 12 inches high on 1st November 1919. They will be described in detail on a future occasion.

Mr. Maiden also read the following note on—

Grafts in Eucalyptus.

(i.) The cohesion of branches in trees is not common, and in Australia appears to be rare in Eucalyptus. I will take an opportunity later of publishing the evidence I have collected.

Adhesion or true grafting in Eucalyptus is very much rarer, and the only authentic case in literature known to me is recorded of two unsatisfactorily named species by M. Félix Sahut in France in 1864. He used two methods, the cleft graft, with moderate results only, and the graft by approach, or inarching, with much greater success.

The "Revue Horticole," published in 1893 an account of the budding of *E. globulus* on *E. resinifera* carried out by M. Justin Dugourd in Palestine. The "Gardeners' Chronicle" for 11th March, 1899, p. 145, may be turned to for a fuller account of both these experiments, and it is remarkable to what extent classical experiments on Eucalyptus from the horticultural aspect have been made by Frenchmen.

(ii.) Here I may invite attention to my paper in this Journal (xxxviii, p. 36) "On some natural grafts between indigenous trees," reprinted, with some additions, in my "Forest Flora of N.S.W.," vi, 79. The graft between the White Gum and the Stringybark is a perfect one, and the specimen is still available for examination at the Botanic Gardens, but the evidence in regard to most reports of grafts in which Eucalyptus is concerned breaks down on investigation.

Grafting by approach in Eucalyptus is easy when the plants are little past the cotyledon stage, according to some experiments by Mr. C. J. Weston of Canberra. In practice they sometimes result in pans of mixed seed, two diverse seedlings being accidentally pressed together in the operation of potting up.

In the nursery rows at Canberra are three sturdy plants of *E. rubida-maculosa.* When I saw them in July, they were about three feet high and spreading. One half of each plant has the typical *maculosa* character. Stripping the soil from the root shows perfect fusion of the two trees. This grafting by approach or fusing of two species by pressure applied at a critical time could hardly be avoided, in the bush, by the agency of animals treading amongst young seedlings.

(iii) During the present year, Dr. G. V. Perez of Teneriffe, well known for his experiments in scientific horticulture, informed me that in order to render more stable the beautiful, yet notoriously uncertain, *E. ficifolia* he had grafted it by approach on *E. calophylla* var. *rosea*, placing the stock in a large and long bamboo, "and attach it to the tree I wish to graft on and propagate." This, like the others, is but a preliminary note.

Owing to Mr. A. B. Hector having met with an accident which prevented his attendance at the meeting, the motion standing in his name in regard to the housing of the Society, was postponed until next year. On the motion of Mr. Maiden it was decided to forward to Mr. Hector an expression of the sympathy of members in his painful illness and their best wishes for a speedy recovery.

DECEMBER 3rd, 1919.

The four hundred and eleventh General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor C. E. Fawsitt, President, in the Chair.

Fifty members and two visitors were present.

The minutes of the previous meeting were read and confirmed.

The certificates of seven candidates for admission as ordinary members were read: three for the second, and four for the first time.

Messrs. E. Cheel and I. Ormsby 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:—Charles Oswald Hamblin, William Nichols Horsfall, and Walter George Lane Sear.

The death was announced of Mr. W. H. Twelvetrees of Tasmania, Clarke Medallist of 1912.

Sixty-three parts, 3 volumes and 2 reports were laid upon the table.

THE FOLLOWING PAPERS WERE TAKEN AS READ:

1. "Notes on Acacia, No. IV." by J. H. Maiden, I.S.O., F.R.S.

2. "Determination of the Increment of Trees by Stem Analysis," by W. A. W. de Beuzeville.

3. "Sequence, Glaciation and Correlation of the Carboniferous Rocks of the Hunter River District, N.S. Wales," by C. A. Sussmilch, F.G.S., and Prof. T. W. Edgeworth David, C.M.G., D.S.O., F.R.S.

The President, Professor C. E. Fawsitt then delivered his Presidential Address, taking for his subject "The Uniformities of Nature."

The early delivery of the address was made necessary owing to the contemplated absence of the President from Australia at the date of the Annual Meeting in May, 1920.

On the motion of Professor David, a hearty vote of thanks was accorded to the President for his valuable address.

Professor Fawsitt briefly acknowledged the compliment.

GEOLOGICAL SECTION.

ABSTRACT

OF

PROCEEDINGS OF THE GEOLOGICAL SECTION.

Monthly Meeting, 14th May, 1919.

Mr. R. H. Cambage in the Chair.

Six members were present.

Mr. J. E. Carne and Dr. C. Anderson were re-elected Chairman and Honorary Secretary respectively.

EXHIBITS:

1. From the Mining Museum:—Graphic granite, Japan; schist with indications of bedding, Euriowie; glacial till of Cambrian Age, Poolamacca; molybdenite crystals, Bow Creek, Deepwater; opal showing faulting, Mount Stuart Range, S. Australia; the mica vein showing gold, Amalgamated Tunnel, Hill End; pyromorphite crystals from the Cobar Gold Mine, Cobar, the White Flag Mine, Binalong, and Block 14 Mine, Broken Hill; slickensided pyrites, White Crystal Mine, Ardlethan; kaolin coloured by chromium (miloschite), Westonia, W.A.; chrysocolla, Block 14 Mine, Broken Hill; rhodochrosite with outer zone of manganese-zinc carbonate (zinc content appears to increase progressively outwards), Central Mine, Broken Hill; jarosite in graphite, Northampton, W.A.

2. Australian Museum:—Anatase crystals, Wild Kate Mine, Torrington; staurolite crystals, Cloncurry, Queensland; needle tin, Long Gully, near Tingha; crocoite crystals Dundas, Tasmania; native copper in selenite, Mount Elliott Mine, Cloncurry, Queensland; molybdenite vein in trap rock, Deepwater District.

3. Mr. W. T. W. Brown:—Gahnite, Silver Hill Mine, Broken Hill; olivenite, near Maranboy, N. Territory.

Monthly Meeting, 9th July, 1919.

Professor David in the Chair.

Six members were present.

EXHIBITS:

1. From the Mining Museum:—Polar magnetite from near Gulf Creek Mine, Barraba; avagonite in basalt, Cudgen, Tweed River; pegmatite with green felspar, Broken Hill; massive fluorite, Tingha (Connor's Claim); banded gneiss with layer of unaltered sediment, Broken Hill; chalcedony with inclusions, Moree.

2. Professor David:—Section of calcareous alga (?) burrowed by annelids from Field River, near Hallett's Cove, Adelaide. This is perhaps the oldest trace of animal life yet found in Australia. It comes from the geological horizon of the siliceous limestone (Proterozoic) below the Brighton limestone, about 3000 feet below the Archadocyathinæ limestone.

3. Mr. C. A. Sussmilch:—Carboniferous brachiopod (*Strophomena sp.*) from the Barrington River, five miles from Gloucester.

Monthly Meeting, 13th August, 1919.

Professor David in the Chair.

Seven members were present.

EXHIBITS:

1. Australian Museum:—Natrolite with apophyllite, Ardglen.

2. Judge Docker:—Crinoids from near Mount Buffalo, Victoria.

3. Mining Museum:—Specimens illustrating the formation of calcareous tufa, Cowan, near Yass; chiastolite,

Appollyon Valley, Broken Hill; asbestos, north-west of Western Australia.

PAPER:

Dr. A. B. Walkom gave an interesting and instructive account of his researches during the past six years on the Mesozoic Floras of Queensland. The fossil plants were dealt with mainly as regards their bearing on the solution of stratigraphical problems, and it was pointed out that at least five floras of Mesozoic age are represented amongst Queensland fossil plants. A discussion followed.

Monthly Meeting, 10th September, 1919.

Professor David in the Chair.

Nine members and four visitors were present.

EXHIBITS:

1. Mr. R. H. Cambage:—Limestone (travertine) from Stone Quarry Creek, near Picton. This limestone, which comes from the Wianamatta shale, was used for burning 60 or more years ago.

2. Mr. C. E. Tilley:—Photographs of contorted gneiss from the Pre-Cambrian of Yorke Peninsula, S. Australia.

3. Mr. L. A. Cotton:—Seismograph record of the recent earthquake obtained at Sydney Observatory. The record indicates a distance of the order of 30 miles.

4. Mr. L. F. Harper:—Rocks and ores from the Ardlethan tinfield, illustrating the origin and mode of occurrence of tin ore on the field.

5. Mr. W. R. Browne:—Rocks from Encounter Bay, S. Australia, in illustration of his paper.

6. Mining Museum:—Native bismuth, Ardlethan; graphic and terminated tourmaline, Broken Hill; watercress converted into travertine, Yass; chrysolite asbestos, Nullagine W. Australia; anthophyllite asbestos, Moora, W. Australia.

PAPER:

Mr. W. R. Browne gave an account of recent work on Differentiation in Igneous Rocks. After a short sketch of previous work, Mr. Browne described Dr. Bowen's work and experiments, as a result of which the conclusion is reached that the separation and sinking of crystals is the principal factor in differentiation, though liquation may also play a part.

A discussion followed, Professor David, Mr. Cotton, Mr. Tilley, Dr. Anderson, and the lecturer taking part.

Monthly Meeting, 8th October, 1919.

Professor David in the Chair.

Ten members and four visitors were present.

EXHIBITS:

1. Mining Museum:—Smaltite with scheelite, Cloncurry, Queensland; erythrite, Cloncurry, Queensland; scheelite, The Waratah Mine, Hillgrove; molybdenite in intensely folded crystals, Allies' Mine, Deepwater.

2. Mr. W. T. Watkin Brown:—Eckmannite from Mrs. Brown's Wolfram Mine, 30 miles S.E. of Pine Creek, Northern Territory.

3. Professor David:—Metallic meteorite (hexahedrite) from Bingara; it is probable that this iron, the original Bingara meteorite, and the Barraba meteorite are part of the same fall.

4. Mr. Alfred E. Stephen:—Phosphatic rock from Mansfield, Victoria. This aluminous phosphate has long been known and is now being exploited commercially, it contains up to 23 per cent. of phosphoric acid.

5. Mr. W. R. Browne exhibited the following specimens from Broken Hill:—Staurolite schist; cordierite—bearing pegmatite and granulite; albite aplite replacing schist;

quartz-garnet-magnetite rock; magnetite bearing pegmatite; pyritous albite aplite replacing schist; laminated quartz in dynamically metamorphosed pegmatite.

6. Dr. C. Anderson, (for Australian Museum) exhibited in illustration of his paper:—Artificial alum crystal specimens of ribbon scheelite and wolfram, and chrysotile veins in serpentine.

PAPER:

Dr. C. Anderson contributed a paper on "Crystal Pressure and its Geological Significance," in which he described the experiments of Becker and Day and of Professor S. Taber, and expounded Professor Taber's views on the origin of asbestiform minerals and on the mechanism of vein formation. In Taber's opinion the pressure of growing crystals, by virtue of which they push the walls of a vein apart, is a force of orogenic magnitude, and has played an important part in forming metalliferous and other veins. A discussion followed.

Monthly Meeting, 12th November, 1919.

Mr. J. E. Carne, F.G.S.. Government Geologist, in the Chair.

Nine members were present.

Mr. R. H. Cambage exhibited a sample of salt from the Bargo and Nepean Rivers, near Picton, the site of the discovery made by early explorers on 25th January, 1798.

Mr. W. R. Browne quoted an example of a small hanging valley on the bank of the Darling River near Wilcannia, which, he thought, shows as such only when the river is low.

Mr. Browne also suggested that tributaries flowing along the strike may form boat-hook bends, which, therefore, may not always be evidence of capture by the rivers into which the tributaries flow.

Monthly Meeting, 10th December, 1919.

Mr. J. E. Carne, F.G.S., Government Geologist, in the Chair.

Thirteen members and one visitor were present.

EXHIBITS:

1. Mining Museum:—Fuchsite, New Caledonia; crystallised chalcopyrite, Conrad Mine, Howell; native copper in sheared serpentine, Mount Hart Mine, Goobragandra.

2. Australian Museum:—Large terminated crystal of calcite, Garibaldi Mine, Lionsville.

3. Major Walker:—Concretionary magnesite, Sofala.

DISCUSSION:

Mr. C. A. Sussmilch and Professor David gave a synopsis of their joint paper "Sequence, Glaciation and Correlation of the Carboniferous Rocks of the Hunter River District, New South Wales," (see this volume, pp. 246), and a discussion followed in which Professor W. N. Benson, Dr. A. B. Walkom, Messrs. L. A. Cotton, W. R. Browne and the authors took part.

SECTION OF AGRICULTURE.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF AGRICULTURE.

Monthly Meeting, 12th May, 1919.

Mr. H. W. Potts in the Chair.

The retiring chairman delivered an address dealing chiefly with agricultural development during the war period, and indicated new lines of agricultural progress likely to be evolved in the near future. He mentioned that the producer must realise the convincing influence that a higher technical training had on his vocation, and the necessity in his own interests for abandoning conservative ideals. Reference was also made to the great value of research work.

The following officers were elected for the ensuing year: Chairman, Mr. A. E. Stephen; Vice-Chairmen, Drs. J. B. Cleland and G. P. Darnell-Smith; Hon. Sec., Mr. E. Breakwell; Committee, Professor R. D. Watt, Dr. Greig-Smith, Messrs. H. W. Potts, E. Cheel, E. Ward, P. Hindmarsh, A. D. Ollé, A. J. Sach, and provisionally, Messrs. A. Spencer Watts and A. L. Waterhouse.

Monthly Meeting, 10th June, 1919.

Mr. A. E. Stephen in the Chair.

Mr. E. Breakwell contributed a note referring to the changes that take place in the vegetation of New England as the result of cultivation. Coarse grasses could thereby be removed and palatable grasses like Chloris, Danthonia and Eragrostis would take their place.

Mr. A. A. Hamilton opened a discussion on "Popular versus Scientific Nomenclature of Plants," suggesting the feasibility of using botanical names. Mr. Breakwell considered that popular nomenclature was absolutely essential as far as the farmer was concerned. Dr. Cleland and Mr. Spencer Watts supported Mr. Hamilton's arguments, while Mr. Cheel considered that vernacular or trade names were necessary.

Monthly Meeting, 14th July, 1919.

Mr. A. E. Stephen in the Chair.

A letter was read from the Director of Agriculture intimating that experiments on the Fecundity of Fowls as recommended by the Section of Agriculture had been approved, and were now under consideration by Mr. Hadlington.

Mr. Cheel continued his remarks on Popular versus Scientific Nomenclature, and submitted a very extensive list of economic plants in which the vernacular names were coupled with the scientific.

Mr. H. W. Potts and Mr. W. Campbell also spoke on the necessity of standardising the vernacular names and coupling the scientific names with them.

Mr. E. D. E. Van Weenen read a comprehensive paper on "The Sheep—from an atom to its present status." He stated that Arabia was the first country to handle the sheep as a wool producer, then Africa and Asia, and later Europe.

Monthly Meeting, 11th August, 1919.

Mr. A. E. Stephen in the Chair.

It was decided to approach the Commonwealth Institute of Science and Industry with reference to the standardisation of the nomenclature of economic plants throughout

Australia by correlating the botanical names with a popular equivalent.

Mr. J. H. Maiden delivered a lecture on "The Economic aspect of the Weed Problem." Specific instances of the destruction caused by plants were cited, such as the Innes homestead near Port Macquarie, the Buddhist temples of Burmah and the prehistoric fanes of Yucatan. Sir Joseph Hooker had stated that none of the destructive agencies on the earth's surface was comparable to those of plants.

Monthly Meeting, 8th September, 1919.

Mr. A. E. Stephen in the Chair.

A report was received from Mr. Hadlington on the investigational work commenced at the Hawkesbury Agricultural College in connection with the Fecundity of Hens.

Mr. A. H. E. McDonald, Chief Inspector of Agriculture, delivered a lecture on "Co-operative Work between the Farmer and the Department of Agriculture."

Monthly Meeting, 13th October, 1919.

Dr. J. B. Cleland in the Chair.

The New South Wales Chamber of Agriculture invited the Section to nominate three of its Committee to co-operate with the Chamber in investigating the matter of Rural Finance, and Messrs. A. J. Sach, and E. Breakwell were nominated.

Mr. H. J. Rumsey delivered a lecture on "Seed Growing in Australia."

Monthly Meeting, 10th November, 1919.

Mr. A. E. Stephen in the Chair.

Mr. A. A. Hamilton exhibited Bunchy Top in Banana, and also some plants showing analogous formations. It was pointed out that abnormalities, such as fasciation (development of leaves instead of flowers) were often produced by insects, but a malformation like bunchy top, in which leaves were developed in great abundance at the crown of the banana plant, might be occasioned by climatic combined with soil conditions. This malformation differed slightly from ordinary fasciation in other plants in that all the leaves were united to the stem.

Remarks were made by Dr. G. P. Darnell-Smith.

Mr. H. J. Braund, Assistant Lands Settlement Officer, Irrigation Area, Griffith, delivered a lecture illustrated with lantern slides on "Irrigation Farming in New South Wales. He pointed out that much had been done towards selecting suitable varieties of various fruits, and of 56 kinds of peaches tried 14 were suitable, while of 100 kinds of grapes only 10 stood the test.

Remarks were made by Mr. Thompson.

Monthly Meeting, 8th December, 1919.

Dr. R. Greig-Smith in the Chair.

Dr. G. P. Darnell-Smith delivered a lecture on "Plant Diseases." The history of investigation into two diseases —rust in wheat and club root in cabbage—since 1787 was traced.

SECTION OF INDUSTRY.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF INDUSTRY.

Monthly Meeting, 11th June, 1919.

Mr. A. B. Hector in the Chair.

The Chairman gave an address on "Imagination in Business."

The following communications were read:—"Dust Precipitation," by Mr. B. J. Smart, B.Sc. "Zirconia as a Refractory Material," by Mr. W. M. Hamlet, F.I.C., F.C.S. "Canned Sardines—the formation of Amines and Ammonia during Storage," by Dr. R. K. Murphy. He pointed out that the amount of tin dissolved and presumably converted into a proteid compound was proportional to the amines and ammonia formed and to the period of storage. Cold storage brought about less change than storage at the ordinary temperature.

Dr. R. K. Murphy, Messrs. J. E. Bishop, E. Elliott, A. D. Ollé, A. E. Stephen, the Chairman and the Hon. Secretary took part in the discussion.

The following Officers and Committee were nominated and duly elected:—Chairman, Mr. A. B. Hector; Past Chairman, Messrs. Loxley Meggitt, W. T. Willington; Hon. Secretary, Dr. Greig-Smith. Committee, Dr. R. K. Murphy, Messrs. J. E. Bishop, B. J. Smart, B.Sc., S. H. Smith, F. W. Steel, H. J. Swain, B.A., B.Sc., B.E.

Monthly Meeting, 13th August, 1919.

Mr. A. B. Hector in the Chair.

Mr. E. T. Fisk gave a lecture and demonstration upon the subject of "Wireless Communication."

The lecture was illustrated by numerous lantern slides, and supplemented by mechanical and electrical experiments illustrating the principles of oscillations, resonance, and coupled circuits. At the opening and close of the lecture practical demonstrations were given of wireless telephony.

Music played at the wireless works in Clarence Street was received and clearly translated and heard in all parts of the Lecture Hall.

Monthly Meeting, 10th September, 1919.

Mr. A. B. Hector in the Chair.

Mr. Octavius C. Beale read an address upon "Some Scientific Points which arise in Cabinet Making."[1]

The communication was discussed by Prof. C. E. Fawsitt, Messrs. R. W. Challinor, R. T. Baker, by the Hon. Sec., and by the Chairman.

Monthly Meeting, 8th October, 1919.

Mr. A. B. Hector in the Chair.

Mr. F. W. Steel delivered a lecture on "The Manufacture of Sulphuric Acid," with lantern illustrations.

A discussion followed in which the following members took part:—Dr. R. K. Murphy, Messrs. J. Taylor, B.Sc., W. Poole, B.E., A. E. Stephen, and the Hon. Sec.

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[1] Published in Commonwealth Institute of Science and Industry Jour. Vol. II, No. 3, March, 1920.

Monthly Meeting, 12th November, 1919.

Mr. W. T. Willington O.B.E., in the Chair.

Mr. James Taylor, B.Sc., read a note upon "Workshop Physics." Remarks were made by Messrs. A. D. Ollé and J. E. Bishop.

Mr. J. E. Bishop read a communication upon "Eucalypts and Hickories compared."

Messrs. Victor Hardy and G. H. Olding contributed to the discussion.

Mr. C. S. Prentice exhibited the Dictograph Telephone System.

Monthly Meeting, 10th December, 1919.

Mr. W. T. Willington, O.B.E., in the Chair.

Messrs. E. Cheel and A. R. Penfold read a note upon "Castor Oil." It was pointed out that two distinct forms were found to be naturalised in this State, and in addition there were at least four varieties under cultivation.

A discussion ensued in which the following took part:—Drs. R. K. Murphy and L. Kesteven, Messrs. A. D. Ollé, R. W. Challinor, A. A. Hamilton, the Chairman, and the Hon. Secretary.

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