DEPARTMENT OF MINES, SYDNEY.



# RECORDS

OF THE

# GEOLOGICAL SURVEY OF NEW SOUTH WALES.

VOL. VIII, PART IV.

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DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.



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OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. VIII.] May, 1909. [Part 4.

# XVIII.—Mineralogical Notes (No. 11): by George W. Card, A.R.S.M., Curator and Mineralogist.

The chemical analyses quoted in this paper were all made in the laboratory of this Survey, under the direction of J. C. H. Mingaye, F.I.C.

The use of an asterisk denotes that the occurrence has been fully corroborated.

*Actinolite.*—Eight miles west of Trunkey.

**Analcite.*—Prospect Quarry, near Sydney. Small, opaque, white crystals.

*Asbestos.*—Two miles south of Moonbi. Amphibole variety, with an extinction angle of about fifteen degrees:—

| | | |
|---|---|---|
| Combined water | 2·68 | per cent. |
| Lime | 12·96 | ,, |
| Magnesia | 20·64 | ,, |

*Avanturine.*—Head of Highland Home Creek, Torrington.

*Barytes.*—Many localities, *e.g.*, Cooma, Cumnock, Glanmire, Hastings River, Lue, Merribindinyah (near Bethungra), near Tamworth, Mudgee, Wellington. Samples of excellent quality are sometimes collected.

*Beryl.*—A fine yellow stone from New England has been cut and exhibited.

*Blende* (*Marmatite*).—Webb's Consols Mine, Emmaville.

| | | |
|---|---|---|
| Metallic zinc | 50·59 | per cent. |
| ,, iron | 11·27 | ,, |
| ,, lead | 1·77 | ,, |
| ,, copper | 1·08 | ,, |
| ,, manganese | 0·37 | ,, |
| ,, silver | 0·03 | ,, |

Traces of gold, arsenic, and cadmium.

*Chalcotrichite.*—Molly Riley Mine, 7½ miles north-west of Cootamundra. Tiny crystals in oxidized lead-copper ore.

**Chiastolite.*—Greenswamp, Parish Melrose, County Roxburgh. In chiastolite slate.

*Chrysocolla.*—Two miles south of Godfrey's Creek. (From a shallow shaft.)

**Cinnabar.*—Pulganbar, Gordonbrook. 15-lb. nuggets of almost pure cinnabar have been found on the surface. It is associated in the lode with antimonite and copper ores.

**Cobalt.*—Flintoff's Mine, Gordonbrook. As cobaltiferous mispickel.

**Native Copper.*—Cadia Copper Mine. Beautiful spongy aggregates of crystals.

*Copper Glance.*—Wilcox's Mine, 4½ miles north of Trundle. Massive mineral.

*Dolomite.*—M.L. 4, Merrilla.

| | | |
|---|---|---|
| Carbonate of lime | 46·8 | per cent. |
| ,, magnesia | 35·4 | ,, |
| Ferric oxide and alumina | 1·7 | ,, |
| Gangue | 16·3 | ,, |
| | 100·2 | |

**Emery.*—Head of Warland's Creek, about fifteen miles (by track) from Murrurrundi.

| | | |
|---|---|---|
| Alumina | 60·74 | per cent. |
| Magnetic oxide of iron | 25·13 | ,, |
| Silica | 12·48 | ,, |
| Water | 1·36 | ,, |
| Manganous oxide | 0·10 | ,, |
| Lime | absent | |
| Magnesia | ,, | |
| | 99·81 | |

**Emery.*—Ten miles east of Nimitybelle.

| | | |
|---|---|---|
| Alumina | 56·02 | per cent. |
| Magnetic oxide of iron | 41·18 | ,, |
| Silica | 0·38 | ,, |
| Water | 0·32 | ,, |
| Lime | absent | |
| Magnesia and undetermined | 2·10 | ,, |
| | 100·00 | |

**Fahlore.*—Pride of the Hills Mine, Rosedale. A massive variety; rich in silver and carrying some gold.

*Fahlore.*—Bettowynd Creek, eight miles south of Araluen. In quartz.

*Fahlore.*—Eight miles from Goulburn, towards Crookwell. An argentiferous variety, also carrying gold.

**Fluorite.*—Eleven miles north of Nymagee. Associated with quartz.

**Fluorite.*—Talwong Mine, three miles south-east of Bungonia Caves. A rich emerald-green variety, with occasional tints of blue and violet. Transparent, and well cleaved. Found in a vugh in a mispickel ore-body.

*Galena.*—Manton's Claim, Nerremunga, Shoalhaven. Tiny cubic crystals, with octahedral modifications, seated on quartz.

*Gypsum.*—Crudine Creek. In the form of selenite; and also as a light spongy mass of tiny crystals.

*Gypsum.*—Lawrence, Clarence River. Small crystals, simple for the most part, found in a bed of clay.

**Gypsum.*—South Mine, Broken Hill. Masses of selenite, associated with galena and zinc-blende. Found in a vugh at the 725-foot level.

*Halloysite.*—Kallara Station, River Darling. A very meerschaum-like, unctuous variety, adhering strongly to the tongue. White in colour, earthy, and translucent only on thin edges.

| | | |
|---|---|---|
| Silica | 43·40 | per cent. |
| Alumina | 36·92 | ,, |
| Ferrous oxide | trace | |
| Ferric oxide | absent | |
| Lime | ,, | |
| Magnesia | trace | |
| Sulphuric anhydride | 0·84 | ,, |
| Water | 18·64 | ,, |
| | 99·80 | |

A little sulphate of sodium and a trace of chloride were taken out by distilled water.

*Idocrase.*—Seven miles south of Corona Station, Barrier Range. Massive form.

*Ilvaite.*—Five miles north-east of Tarana.

| | | |
|---|---|---|
| Silica | 30·06 | per cent. |
| Ferric oxide | 22·20 | ,, |
| Ferrous oxide | 22·32 | ,, |
| Lime | 12·52 | ,, |
| Alumina | 9·08 | ,, |
| Water | 2·48 | ,, |
| Manganous oxide | 1·07 | ,, |
| Magnesia | 0·59 | ,, |
| | 100·32 | |

*Magnetite.*—One and a half miles east of Muttama (R. Jenkins, Block 30). A massive form, displaying strong polarity.

*Manganese oxide.*—Putty Beach, Woy Woy. Thin seams in the Narrabeen Stage.

*Mispickel.*—

*Ettrema.

*Talwong.

*Marulan.

*Hawksview, nine miles from Albury.

*Tumut.

Massive ores.

*Molybdenite.*—Annandayle, Germanton.

*Bald Nob Tin Mine, Glen Innes. Earthy veins in greisenized granite.

*Cadia Copper Mine. With copper pyrites and calcite in the western adit.

Nine miles south-east of Marulan. Small flakes in white quartz.

*Monazite.*—Talbragar River, ten miles north-east of Dubbo. A small percentage of monazite in gold-bearing zircon sand. (*See* Platinum.)

*Nickel.*—Metz. Pyrrhotite has been found to carry 2½ per cent. metallic nickel.
Wyangle. Ironstone has assayed 1 per cent. metallic nickel.

**Orthoclase.*—Ten miles east of Wellington. Stout Carlsbad twinned crystals in granite.

| | |
|---|---|
| Silica | 65·54 |
| Alumina* | 16·68 |
| Ferric oxide | 1·14 |
| Ferrous oxide | 0·27 |
| Magnesia | 0·38 |
| Lime | 0·86 |
| Soda | 3·27 |
| Potash | 11·53 |
| Water | 0·42 |
| Baryta | trace |
| Strontia | ,, |
| Carbon dioxide | 0·01 |
| | 100·12 |

* Including any MnO, $TiO_2$, and $P_2O_5$ present.

*Phosphate of Aluminium.*—In the ranges between the Richmond and the Clarence Rivers. An encrustation on weathered rock.

**Phosphate of Copper.*—Portion 109, Parish Binalong, County Harden. Tiny crystals lining cavities. From a copper mine.

*Platinum.*—Talbragar River, ten miles north-east of Dubbo. In gold-bearing zircon sand. (*See* Monazite.)

**Prehnite.*—Prospect Quarries, Toongabbie. Beautiful sea-green masses of large size.

*Pyrrhotite.*—Twelve miles west of Yerranderie. Dense mineral, assaying 2 dwt. gold per ton.

**Quartz.*—Dundas Quarry, near Sydney. Doubly terminated crystals in calcite.

**Rhodonite.*—850-foot level, South Mine, Broken Hill. Translucent, with perfect cleavage.

| | |
|---|---|
| Water | 0·30 |
| Silica | 46·52 |
| Manganese | 33·84 |
| Iron | 9·45 |
| Alumina | 0·44 |
| Lime | 8·74 |
| Magnesia | 0·62 |
| Zinc oxide | trace |
| | 99·91 |

Barium oxide absent. A trace of carbon dioxide present.

*Ruby.*—McGlanglin River, fifteen miles south of Nimitybelle. A very small, pale-coloured stone.

*Rutile.*—Pheasant Creek, Glen Elgin. A small pebble.

*Sapphire.*—McGlanglin River, fifteen miles south of Nimitybelle. Blue and green stones of good colour, but small in size.

*Scheelite.*—Near Berridale. A red variety, associated with quartz.

*Twelve miles north-west of Germanton. Associated with tinstone and quartz.

*Gilgai, Tingha. Small fragments in tin-bearing alluvial.

*Soapstone.*—Near Wallendbeen.

| | | |
|---|---|---|
| Silica | 60·67 | per cent. |
| Magnesia | 27·25 | ,, |
| Moisture at 100° C. | 0·40 | ,, |
| Combined water | 2·14 | ,, |
| Alumina* | 2·34 | ,, |
| Ferric oxide | 1·00 | ,, |
| Ferrous oxide | 4·05 | ,, |
| Titanium dioxide | absent | |
| Lime | 1·72 | ,, |
| | 99·57 | |

* Including any phosphoric anhydride present.

**Tinstone.*—Davey's Mine. Two and a half miles east of Tingha. The tinstone is crystallized, and is intimately associated with bornite.

Near Narrandera. In granite.

Talbragar River, ten miles north-east of Dubbo. In gold-bearing zircon sand. (*See* Platinum and Monazite.)

*Twelve miles north-west of Germanton. With scheelite in granite.

Head of Isis River. Crystallized.

*Tourmaline.*—Moonbi Ranges. Large terminated crystals.

Oakey Creek, Copeton. In alluvial wash dirt.

**Tungstic Ochre.*—Pulletop. In yellow masses.

**Umber.*—Essington District. In the Brisbane Valley and the Sugarloaf Mines.

Thirteen miles north of Mudgee.

Bowraville, Nambucca River.

Kerr's Creek.

Six miles west of Coff's Harbour.

One mile west of Molong.

**Wolfram.*—Essington. In quartz.

*Ten miles south-east of Lionsville. Intimately associated with antimonite.

*Zircon.*—Twelve miles north-west of Burraga. Broken crystals and cleavage plates; all somewhat rolled.

# XIX.—Notes from the Chemical Laboratory (No. 2): by J. C. H. Mingaye, F.I.C., F.C.S., Analyst.

CONTENTS.



## I.—Experiments on the Estimation of Thoria in Monazite.

Monazite is essentially a phosphate of the rare earths of the Cerium group, (Ce, La, Di), $PO_4$, including thoria. C. W. Blomstrand* considers that monazites are normal Cerium and thorium phosphates, in which a portion of the phosphoric acid is replaced by silica. Penfield† regards the mineral as Cerium phosphates with mechanically admixed thorite.

The economic value of monazite lies principally in the thoria contents, used in the manufacture of mantles for the Welsbach incandescent gas-light.

In 1903, the Author‡ pointed out the occurrence of monazite in the beach sands of the Richmond River, and it has been found in small quantities in several other localities, and in one case *in situ* at Blatheran Creek,§ near Deepwater, New South Wales. Unfortunately, the New South Wales samples hitherto examined were found to be poor in thoria and, in consequence, of little commercial value.

With a view of ascertaining and comparing the accuracy of the various methods given for the separation of thoria from monazite, the following experiments were conducted on an average sample of Carolina monazite, received through the courtesy of Professor Baskerville, United States of America.

The mineral was finely ground in an agate mortar, thoroughly mixed, and placed in a glass-stoppered bottle.

The methods of analyses employed were those of Penfield,‖ Baskerville,¶ Fresenius and Hintz,** W. B. Giles,†† and Ludwig Haber,‡‡ with slight modifications.

For the determination of the total rare earths, 1 gramme of the powder was decomposed with 10 c.c. of sulphuric acid (1 : 1), the insoluble residue fused in

* Blomstrand—Zeits. für Kryst., IX, 1887, 160.
† Penfield—Am. J. Sci. XXIV, (3), 1882, p. 250; XXXVI, 1888, p. 322.
‡ Mingaye, Records Geol. Survey, VII, Pt. 3, p. 222.
§ Anderson, Records Aust. Museum, 1904, V, Pt. 4.
‖ Penfield—Am. J. Sci., 1882, XXIV (3), p. 253.
¶ Baskerville—Quoted by Nitze, *loc. cit.*, p. 677.
** Fresenius and Hintz—Zeitsch. Anal. Chem., XXXV, 548.
†† W. B. Giles—Chem. News, 1905, 92, 1-3, 30-31.
‡‡ Ludwig Haber—Journ. Chem. Soc., 1898, LXXIII and LXXIV, p. 295.

sodium bisulphate, and the earths in solution precipitated by adding an excess of oxalic acid, warming the solution, and the precipitate allowed to stand for forty-eight hours, filtered, washed, ignited, and weighed as oxides.

Two determinations made yielded as follows :—

| | I. | II. |
|---|---|---|
| Rare earths of the Cerium group, *i.e.*, $Ce_2O_3$, $La_2O_3$, $Di_2O_3$, $Y_2O_3$, $ThO_2$ | 62·99 per cent. | 63·0 per cent. |

*Experiment No.* 1.

The method used was that given in Zeitschr für Anal. Chemie.* The moist, well-washed oxalate precipitates obtained from 1 gramme of the material were treated with 60 c.c. of a cold saturated solution of ammonium oxalate, heated on the water-bath for four hours, then diluted to 300 c.c., and allowed to stand for two days. (1) Filtered, and washed with distilled water to which a few drops of a solution of ammonium oxalate had been added. (2) The residue was again re-treated with 20 c.c. more of ammonium oxalate solution, the liquid made up to 100 c.c. and allowed to stand for two days.

*Filtrates Nos.* 1 *and* 2.—To the solution, 6·7 c.c. of concentrated hydrochloric were added, and the precipitate formed allowed to stand for two days. The precipitate obtained by the addition of hydrochloric acid was filtered, thoroughly washed with distilled water containing a few drops of hydrochloric acid, ignited, and weighed as crude thoria.

| | I. | II. |
|---|---|---|
| (*a*) Crude thoria obtained ... | 5·06 per cent. | 4·34 per cent. |

The residue left after the two treatments with ammonium oxalate was ignited, dissolved in hydrochloric acid, and evaporated to dryness on a water-bath. Taken up with cold distilled water and a few drops of hydrochloric acid, gave a clear solution; made up to 200 c.c., 5 grammes of pure sodium thiosulphate added, warmed for four hours, allowed to stand for some time, filtered, washed, and ignited. The ignited residue was fused in sodium bisulphate, dissolved in distilled water, 2 c.c. of hydrochloric acid added—dissolved to a clear solution. Precipitated with ammonia, filtered, washed, dissolved in hydrochloric acid, and evaporated on a water-bath to dryness. Again taken up with distilled water and a few drops of hydrochloric acid, and the solution made up to 200 c.c. with distilled water, heated to boiling and precipitated with oxalic acid solution, allowed to stand for two days, filtered, washed, ignited, and weighed.

| | I. | II. |
|---|---|---|
| (*b*) Crude thoria obtained ... | 0·40 per cent. | 0·82 per cent. |

The two ignited precipitates of crude thoria (*a* and *b*) were fused in sodium bisulphate, acidified with 2 c.c. of hydrochloric acid, the solution made up to 200 c.c. precipitated with ammonia, filtered, washed, dissolved in hydrochloric acid,

* Zeits. für Anal. Chemie, 1897, XXXVII, p. 27.

and evaporated to dryness on a water-bath. Taken up with distilled water and a few drops of hydrochloric acid, and to the clear solution 30 c.c. of a cold saturated solution of ammonium oxalate added, and warmed for some hours on a water-bath, diluted with distilled water to 200 c.c., and allowed to stand for two days for the separation of any Cerium or Yttrium present.

The small amount of insoluble oxalates left were filtered, washed, ignited, and weighed as oxides, and the amount found taken off the crude thoria obtained.

| | I. | II. |
|---|---|---|
| Impurities found ... | 0·14 per cent. | 0·08 per cent. |

The impurities taken off the crude thoria obtained gave the percentage of thoria in Nos. 1 and 2 as follows :—

| | I. | II. |
|---|---|---|
| Thoria ($ThO_2$) ... | 5·32 per cent. | 5·03 per cent. |

*Experiment No. 2.*

The ignited oxalate precipitate obtained by treatment of 1 gramme of the sample was dissolved in hydrochloric acid, and evaporated to dryness on a water-bath, then taken up with water, a few drops of hydrochloric acid added, and the solution diluted with distilled water to about 25 c.c., warmed for four hours on a water-bath with 60 c.c. of a saturated solution of cold ammonium oxalate, diluted to 250 c.c. and allowed to stand for two days. The precipitate was then filtered, washed with water containing a few drops of ammonium oxalate solution. To the filtrate, 5 c.c. of concentrated hydrochloric are added, and the liquid allowed to stand for two days. The precipitate obtained was filtered, washed, ignited, and weighed—equals crude thoria.

(*a*) Crude thoria obtained ... 4·08 per cent.

The oxalates insoluble in ammonium oxalate solution were ignited, dissolved in hydrochloric acid, and evaporated to dryness on a water-bath, taken up with distilled water and a few drops of hydrocholoric acid. The solution was diluted up to 200 c.c., 5 grammes of sodium thiosulphate added, and warmed for two hours, allowed to settle, and filtered. The filtrate was again treated with 2 grammes of sodium thiosulphate, warmed for two hours, and the small precipitate obtained filtered through the same filter, well washed, ignited, and fused in sodium bisulphate. The melt was dissolved in distilled water and an excess of ammonia added, the small precipitate formed being filtered, washed, dissolved in hydrochloric acid, and evaporated to dryness on a water-bath. Taken up with distilled water and a few drops of hydrochloric acid, and the thoria precipitated with oxalic acid, allowed to stand for two days, filtered, washed, ignited, and weighed as crude thoria.

(*b*) Crude thoria obtained ... 1·84 per cent., or a total of 5·92 per cent.

The crude thoria precipitates obtained in *a* and *b* were fused in sodium bisulphate, the melt dissolved in water, precipitated by ammonia, filtered, washed, dissolved in hydrochloric acid, and evaporated to dryness on a water-bath. Taken up with distilled water and a few drops of hydrochloric acid, and warmed on a water-bath for four hours with 30 c.c. of a saturated solution of ammonium oxalate, diluted to 250 c.c., and allowed to stand for two days. The precipitate remaining is filtered off, washed, ignited, weighed, and taken off the crude thoria found.

The impurities were found to be 0·36 per cent.

Thoria ... ... ... 5 56 per cent.

*Experiment No.* 3.

By precipitation with Sodium Thiosulphate.*

The ignited oxalate precipitate obtained from the treatment of 1 gramme of the sample was dissolved in hydrochloric acid, evaporated to dryness on a water-bath, taken up with distilled water and a few drops of hydrochloric acid, diluted to 250 c.c. and warmed with 5 grammes of sodium thiosulphate for four hours, filtered, and the filtrate again treated with 2 grammes of sodium thiosulphate, the solutions being filtered through the one filter. The precipitate was well washed, ignited, and fused in sodium bisulphate, the melt being dissolved in water and diluted up to 200 c.c. The thoria was precipitated from a boiling solution by the addition of oxalic acid, allowed to stand for two days, filtered, washed, ignited, and weighed as crude thoria.

Crude thoria obtained ... ... 5·60 per cent.

To the filtrate for the "hypo" treatment, ammonia was added in excess, and the precipitated earths filtered, washed, dissolved in hydrochloric acid and evaporated to dryness on a water-bath. Taken up with distilled water and a few drops of hydrochloric acid, 30 c.c. of a saturated solution of ammonium oxalate added, and warmed for four hours on a water-bath, and filtered. To the clear filtrate 2·5 c.c. of concentrated hydrochloric were added and allowed to stand for two days. No precipitate formed. The crude thoria was fused in sodium bisulphate, the melt dissolved in water, the earths precipitated with ammonia, filtered, washed, dissolved in hydrochloric acid, evaporated to dryness on a water-bath, diluted with water and a few drops of hydrochloric acid, 30 c.c. of a saturated solution of ammonium oxalate added, and warmed for four hours on a water-bath. It is then diluted to 200 c.c., and allowed to stand for two days. The precipitate of insoluble oxalates—*i.e.*, Cerium, Yttrium, etc,—were filtered off, washed, ignited, and weighed, and taken off the crude thoria found.

The impurity was found to be 0·42 per cent.

Thoria ... ... ... ... 5·18 per cent.

* Fresenius and Hintz—Zeitsch. Anal. Chem., XXXV, 543.

*Experiment No. 4.*

The method employed is that of William B. Giles,* who uses "freshly-prepared moist lead carbonate" to precipitate the thoria. The ignited oxalate precipitates obtained in each case from 1 gramme of the monazite were dissolved in nitric acid, evaporated to dryness on a water-bath, diluted with distilled water and 5 c.c.'s nitric acid, dissolved to a clear solution. The solutions were saturated with sulphuretted hydrogen to reduce any ceric oxide to the Cerious state, and separate metals present in Groups I and II, filtered, and the clear solution boiled to expel the $H_2S$ gas. Diluted up to 200 c.c. with distilled water, and, when cold, treated with an excess of "*freshly-prepared moist lead carbonate*" of absolute purity, which, after acting for twelve hours, with frequent stirring, completely separates the thoria. (?) The precipitate containing the $ThO_2$ and some $PbCO_3$ is filtered, thoroughly washed with distilled water, dissolved in 5 c.c. of nitric acid dilute, and the lead separated by sulphuretted hydrogen. Filtered from the precipitate of lead sulphide, and the solution evaporated to dryness on a water-bath, dissolved in distilled water and 2 c.c. of hydrochloric acid, gave a clear solution. The solution was diluted to 200 c.c. warmed, and the $ThO_2$ precipitated as oxalate by an excess of oxalic acid, allowed to stand in the cold for twenty-four hours, filtered, washed, ignited, and weighed as oxides.

| | I. | II. |
|---|---|---|
| Thoria obtained ... ... | 5·94 per cent. | 6·08 per cent. |

The precipitates were fused in sodium bisulphate, and the thoria, with a small amount of other earths carried down, precipitated by ammonia. The precipitates were filtered, washed, dissolved in 2 c.c. of dilute nitric acid, and evaporated to dryness on a water-bath, taken up with distilled water and 2 c.c. of dilute nitric acid, and again treated with an excess of "freshly-prepared moist lead carbonate," and treated as in the previous method given.

| | I. | II. |
|---|---|---|
| Thoria obtained ... ... | 5·70 per cent. | 5·82 per cent. |

The precipitates when ignited were quite white in colour—showing the absence of traces of $Ce_2O_3$—and when dissolved in hydrochloric acid and evaporated to dryness, the slight acid solution, on treatment with 20 c.c. of a saturated solution of ammonium oxalate and warming, gave a clear solution.

*Experiment No. 5.*

According to Ludwig Haber,† "when a solution of thorium salt to which sodium acetate has been added is well boiled, a brilliantly white, crystalline precipitate of basic thorium acetate, $Th(OAc)_2\,(OH)_2 + H_2O$, is formed. Since Cerium,

* W. B. Giles—Chem. News, 1905, 92, 1–3, 30–31.
† Ludwig Haber—Journ. Chem. Soc., 1898, LXXIII and LXXIV, p. 295.

lanthanum, and didymium are not precipitated at all under the same conditions, this reaction affords an easy method of preparing thoria free from these metals. Zirconium is, however, precipated as a basic acetate of indefinite composition."

One gramme of the ignited oxalate precipitate was dissolved in hydrochloric acid, and evaporated to dryness on a water-bath, dissolved in distilled water, a few drops of hydrochloric acid added, and diluted to 250 c.c. The solution was rendered nearly neutral, and 5 grammes of sodium acetate added and well boiled. The nearly white basic precipitate obtained was quickly filtered, washed with boiling water, dissolved in hydrochloric acid, and evaporated to dryness on a water-bath. On the addition of water and a few drops of hydrochloric acid, and warming, a small insoluble residue was left, which was filtered off, washed, ignited, fused in sodium bisulphate, and added to the main solution. The solution was diluted to 200 c.c., and the thoria precipitated from a boiling solution with an excess of oxalic acid, allowed to stand for twenty-four hours in the cold, filtered, washed, ignited, and weighed.

(*a*) Crude thoria obtained ... ... 5·76 per cent.

The filtrate from the acetate precipitate was again treated with 2 grammes of sodium acetáte and, boiled, gave a further precipitate of a yellow colour. The precipitate was filtered hot, washed with boiling water, dissolved in hydrochloric acid, and evaporated to dryness on a water-bath. A small amount of residue was left insoluble in acid. This was fused in sodium bisulphate and added to the main solution, which was diluted to 200 c.c., an excess of oxalic acid added, boiled, and the precipitate formed allowed to stand for twenty-four hours, filtered, ignited, and weighed.

Oxides of the rare earths obtained ... 10·44 per cent.

The ignited precipitate obtained by the second treatment with sodium acetate was fused in sodium bisulphate, the melt dissolved in water and 2 c.c. of hydrochloric acid, and the earths again precipitated by the addition of an excess of ammonia, filtered, washed, dissolved in hydrochloric acid, and evaporated to dryness. Taken up with a few drops of hydrochloric acid, the solution diluted to 200 c.c., and twice precipitated with sodium thiosulphate in a warm solution, warmed for some time and allowed to settle, filtered, washed, and ignited. The ignited precipitate was fused in sodium bisulphate, the melt dissolved in water and diluted to 100 c.c., an excess of oxalic added and warmed for some time, allowed to cool and stand for twenty-four hours. The precipitate formed was filtered, washed, ignited, and weighed.

(*b*) Crude thoria obtained ... ... 0·36 per cent.

The crude thoria obtained from *a* and *b* was fused in sodium bisulphate, the melt dissolved in water and 2 c.c. of hydrochloric acid, precipitated by an excess of ammonia, filtered, washed, dissolved in hydrochloric acid, and evaporated to dryness on a water-bath. Taken up with a few drops of hydrochloric acid, warmed for four hours with 60 c.c. of a cold saturated solution of ammonium oxalate, diluted with water, and allowed to stand for two days. The insoluble residue left, *i.e.*, $Ce_2O_3$, etc., was filtered, ignited, weighed, and taken off the crude thoria obtained.

| | | |
|---|---|---|
| (*a*) Crude thoria | ... ... ... | 5·76 per cent. |
| (*b*) " | ... ... ... | ·36 " |
| Total crude thoria .. | = | 6·12 " |

The insoluble residue obtained weighed 0·66 per cent., and was of a dark red colour, due largely to $Ce_2O_3$.

| | | |
|---|---|---|
| Crude thoria | ... ... ... | 6·12 per cent. |
| Less impurities determined | ... | ·66 " |
| Thoria | ... ... = | 5·46 " |

*Result of Experiments.*

| | | | I. | II. |
|---|---|---|---|---|
| No. 1. | Thoria ($ThO_2$) | ........ | 5·32 per cent. | 5·08 per cent. |
| No. 2. | " | ........ | 5·56 " | ...... |
| No. 3. | " | ........ | 5·18 " | ...... |
| No. 4. | " | ........ | 5·70 " | 5·82 " |
| No. 5. | " | ........ | 5·46 " | ...... |

Baskerville* claims only "approximate results, and absolute accuracy cannot be vouched for"; it is substantially the same as Professor Penfield's† method, with a few modifications.

On comparing the percentages of thoria found by the different methods employed, the highest results are found in Nos. 2, 4, and 5.

The precipitate obtained by sodium thiosulphate cannot be ignited and weighed, as $ThO_2$, as it contains alkali, also weighable quantities of the other earths; and therefore requires to be again brought into solution and precipitated by an excess of oxalic acid, and the impurities, *i.e.*, $Ce_2O_3$, etc., separated by warming with a concentrated solution of ammonia oxalate.

The method of W. B. Giles appears to be a good one for the separation of the thoria. It was found that a second treatment with the moist lead carbonate was required, as the first thoria precipitate contained weighable amounts of the other earths. The method proposed by Ludwig Haber appears to be a quick and accurate method of separating thoria from the earths present in monazite.

No. 4757–05. Monazite from Wolfram Field, near Cairns, Northern Queensland.

In each case, 2 grammes of the finely-ground mineral were decomposed by treatment with sulphuric acid (1 : 1), and a precipitate obtained of the earths from a warm solution by oxalic acid.

* Nitze, H. B.—Rept. U. S. Geol. Survey for 1904-5, Pt. 4, p. 667.
† Penfield—Am. J. Sci., 1882, XXIV (3), p. 253.

An estimation of the percentage of rare earths gave—69·49 per cent., 69·67 per cent., 69·74 per cent., and 69·60 per cent.; phosphoric acid, 25·51 per cent.; specific gravity of mineral, 4·985.

The methods for separation of the thoria used were those of Fresenius and Hintz,* and William B. Giles.†

The first estimation was made in duplicate, as in Experiment No. 3 given in this paper, excepting that the thoria was weighed as crude thoria.

| | I. | II. |
|---|---|---|
| Crude thoria obtained ... | 4·20 per cent. | 4·42 per cent. |

The thoria was white in colour, and therefore not treated with ammonium oxalate solution, in order to separate any impurities present; the results are possibly too high.

In the second estimation, made in duplicate by the method of W. B. Giles, the neutral solutions of the nitrates were twice treated with a "freshly-prepared moist precipitate of lead carbonate," as in Experiment No. 4.

| | I. | II. |
|---|---|---|
| Pure thoria obtained ... | 3·94 per cent. | 3·87 per cent. |

No. 7725–07. Monazite from Black Swamp, Torrington, New South Wales.

| | I. | II. |
|---|---|---|
| Rare earths of the Cerium group as oxides, including thoria ($ThO_2$) | 69·40 per cent. | 69·28 per cent. |
| Thoria ($ThO_2$) ... ... ... | 4·12 ,, | 4·10 ,, |
| Phosphoric anhydride ($P_2O_3$) ... | 25·75 ,, | ...... |

The method used for the separation of the thoria is that given in this paper in Experiment No. 3.

The sample is the best so far examined of the New South Wales monazites, and, if it occurs in sufficient quantity, should prove of commercial value for the extraction of the thoria contents.

No. 1811–07. Gem sand from fifteen miles south of Oberon, near Mount Werong.

| | |
|---|---|
| Rare earths of the Cerium group as oxides ... | 7·32 per cent. |
| Thoria ($ThO_2$) ... ... ... ... ... ... | ·27 ,, |
| Metallic Tin ... ... ... ... ... ... | ·40 ,, |

Fine Gold at the rate of 22 oz. 1 dwt. 2 grs. per ton.
Fine Silver at the rate of 1 oz. 12 dwt. 21 grs. per ton.
Fine Platinum, less than 1 dwt. per ton.

The sand consists largely of zircons, titaniferous iron ore, monazite; also contains a small quantity of chrome iron ore, cassiterite, etc.

No. 6610–07. Zircons, sand, etc., from eighteen miles north-east of Dubbo.

Rare earths of the Cerium group as oxides ... 1·09 per cent.
Fine Gold at the rate of 6 oz. 11 dwt. 14 grs. per ton.
Fine Platinum at the rate of 10 grs. per ton.

* Fresenius and Hintz—Zeitsch. Anal. Chem., XXXV, 543.
† W. B. Giles—Chem News, 1905, 92, 1-3, 30-31.

## II. Colorimetric Method for the Estimation of Small Amounts of Platinum.

The ordinary gravimetric assay of platinum, especially where a number of assays are required to be made on poor material, is a lengthy and tedious process, requiring a large amount of the material to be taken for the separation and estimation of the platinum.

The colorimetric method, which has been worked out and in use for many years in the Chemical Laboratory, is based on the distinctive colour reactions given in dilute solutions of platinic chloride when stannous chloride or potassium iodide are added to the solution, the tints in colour varying with the amount of platinum present. It is particularly adapted for use in the assaying of beach sands or alluvial deposits, containing small amounts of platinum and platinum metals. The method is simple, easily performed, accurate, and enables a large number of estimations or "checks" to be put through in a comparatively short time.

* The New South Wales beach sands, in which platinum and other minerals occur, consist largely of coarse and very fine white and dark sand, zircons, quartz, titanic iron ore, with lesser amounts, according to concentration, of chrome iron ore, monazite,† cassiterite, platinum, iridosmine, gold, etc.

(*a*) On adding stannous chloride to a dilute solution of platinum containing hydrochloric acid, an intensely dark red or brownish-red colour is obtained, the platinic chloride being reduced to platinous chloride, no precipitate being formed. The colour varies in tints according to the amount of platinum present and dilution of the solution.

(*b*) Potassium iodide added in slight excess to a solution of platinic chloride, the platinum iodide is dissolved, the solution being of a deep red colour, varying in tint according to dilution, and in very dilute solutions a rose colour. F. Field‡ shows that very minute traces of platinum can be detected by potassium iodide, one part of platinum in 2,000,000 being readily detected by the test. A drop or two of acid added to the solution accelerates the development of the colour.

The process consists practically in obtaining the platinum in solution as platinic chloride, adding either stannous chloride solution or potassium iodide, and comparing the colour produced with a standard solution of pure platinic chloride. The strength of the solution used is 1 grain of pure platinum, as chloride, in 100 c.c. of water, which is kept as a standard solution. It has been found that dilute solutions of platinic chloride deposit after a time, and therefore require to be made up prior to use.

Ten cubic centimetres of the standard platinum solution is diluted with 90 c.c. of distilled water, giving a very weak solution, of which 1 c.c. = 0·001 grains of

* J.C.H.M., Journ. R. Soc. N. S. Wales, 1892, XXVI, p. 368.
† J.C.H.M., Records Geol. Survey, 1903, p. 222.
‡ W. Crookes, Select Methods of Chemical Analysis, p. 444.

platinum. From 2,000 to 4,000 grains of the material are taken for assay, according to the richness of the sample. The beach sands may contain from a few grains up to a few pennyweights per ton, according to the concentration they have been subjected to owing to wave action on the beaches.

The sand is fluxed in the ordinary way, litharge and a reducing agent added, placed in a crucible and melted, and the resulting lead button, containing the gold and metals in the platinum group, scorified to eliminate any tin present. The lead button is then cupelled with the addition of 5 grains of pure silver. The cupellation must be performed at a higher temperature than usual, and the button is left in the muffle for about five minutes after the usual iridescent bands have ceased to show up. The silver button, if containing platinum, shows a crystalline appearance. The button contains a small quantity of lead, from which it has been found impossible to free at the ordinary temperature obtainable in a muffle. Mr. A. Stansfield,* in experiments made at the Royal Mint, states:—"In the cupellation of pure platinum, buttons weighing from 0·002 to 0·01 grammes retain about 10 per cent. of their weight of lead, and those weighing from 0·04 to 2·0 grammes retain about 33 per cent." The button is parted in nitric acid of specific gravity 1·28, when the platinum goes into solution with the silver, leaving the gold and iridosmine. The solution is carefully decanted from the insoluble gold and iridosmine, washed with distilled water, and the silver precipitated as chloride by the addition of a slight excess of hydrochloric acid, warmed, allowed to settle, and filtered.

The clear filtrate containing the platinum, etc., is evaporated down to dryness on a water-bath, 2 c.c. of hydrochloric added, and again evaporated to dryness. Taken up with distilled water, to which a few drops of hydrochloric acid has been added, warmed, and allowed to cool, and stand for about one hour. It is then filtered from the trace of silver and lead chlorides present, and the clear yellow-coloured solution made up to 100 c.c., or 200 c.c.—according to the colour of the solution.

Fifty cubic centimetres of the solution are taken and placed in a Nessler glass, 1 c.c. of stannous chloride solution added, or a small crystal of potassium iodide, and the colour produced—brownish-red in the first case, and red to rose-coloured in the second—compared with the standard platinum solution.

The experiments are similar in every respect to the Nessler colour test used in the determination of free and albuminoid ammonia in waters. The gold and any iridosmine present is ignited, and weighed, dissolved in dilute nitro-muriatic acid, and any insoluble iridosmine left, weighed and taken off the first weight = pure gold.

Example, using potassium iodide as the colour test:—2,000 grains of beach sand was treated by the method given, and the solution containing the platinum

* T. K. Rose, The Metallurgy of Gold, p. 425.

made up to 100 c.c.—50 c.c. of the solution being taken for the determination. It was found that 12·0 c.c. of the platinum standard solution, made up to 50 c c., were required to correspond with the colour shown in the 50 c.c. of the solution taken. 12 c.c. × 0·001 = 0·012 grs. in 1,000 grs. of the sand, or, 7 dwt. 20 grs. of platinum per ton of sand.

Experiment, using stannous chloride as the colour test:—2,000 grains of beach sand used. The solution containing the platinum made up to 100 c.c. 50 c.c. taken and 1 c.c. of a solution of stannous chloride added—gave a brownish-red colour similar to the Nessler colour with ammonia. It was found that 11·0 c.c. of the standard platinum solution, made up to 50 c.c., were required to correspond with the colour shown in the 50 c.c. of the solution taken. 11 c.c. × 0·001 = 0·011 grs. in 1,000 grs. of the material, or, 7 dwt. 4 grs. of platinum per ton of sand. The platinum contents can readily be estimated down as low as a few grains per ton, and by using a larger amount of the material for assay, and keeping the solution containing the platinum down to 10 c.c, platinum has been estimated in these sands to 1 grain per ton. When the platinum contents go over 2 oz. per ton, the colorimetric method is not recommended, as the colour produced by the reagents added render the solution too dark in colour to accurately determine the depth of colour. If the gold has the appearance of still containing traces of platinum, it is wrapped in a small piece of assay lead, 1 grain of pure silver added, cupelled, and parted in the usual way, and the solution containing the silver and platinum treated by the method previously given, and the platinum estimated by the colour test.

On adding potassium iodide to the platinum solution, a slight yellow precipitate, due to lead iodide, is sometimes formed. In this case the solution is filtered, and made up to the 100 c c., or 200 c.c., according to the colour of the solution, and 50 c.c. of the clear filtrate compared with the standard platinum solution, to which a crystal of potassium iodide has been added.

The following is a typical sample of beach sand which has to some extent been concentrated, and is given here with a view of showing the various constituents present which have been determined.

No. 5774-06. Beach Sand, somewhat concentrated, Richmond River.

| | | |
|---|---|---|
| Metallic Tin | 40·80 | per cent. |
| Rare earths of the Cerium group | 18·45 | ,, |
| Thoria ($ThO_2$) | ·65 | ,, |

Fine Gold at the rate of 3 oz. 0 dwt. 15 grs. per ton of sand.

Platinum at the rate of 9 dwt. 3 grs. per ton of sand.

NOTE.—Contains a small amount of zirconia, titaniferous iron ore, chrome iron ore ($Cr_2O_3$) (less than 1·0 per cent.), etc.

## III.—Chemical Notes on Lode Material from Broken Hill containing Copper, Nickel, Platinum, and Platinoid Metals.

In the year 1889* several samples of supposed silver-lead ores from the Broken Hill district, on examination, were found to contain platinum, and in 1891 platinum was again detected in a felsitic and granite rock from the same district. On assay the material yielded from 4 dwt. to 1 oz. 9 dwt. 9 grs. of platinum per ton of ore.

In the year 1892,† Mr. J. B. Jaquet, A.R.S.M., Chief Inspector of Mines, furnished a report on the deposits, and reported—"That ore containing a small proportion of platinum could be obtained over a very wide area of the Broken Hill District, but that prospecting for the metal had been confined to two localities, viz., at Little Darling Creek, Parish of Tara, and at Mulga Springs, Parish of Moorkaie, these two places being distant about seven miles from each other."

The present find is situated in County Yancowinna, Parish of Moorkaie, fifteen miles due north-east of Broken Hill, on the north side of Mulga Springs Creek, and about three-quarters of a mile north-west of the previously recorded platinum deposits.

The nickel and platinum metals, viz., platinum, palladium, iridium, and a very small quantity of one of the platinoid metals—probably rhodium (?), were found in ironstone, impregnated with copper carbonates, and in chloritic schist, containing copper carbonates.

In view of the interesting occurrence of these metals in the Broken Hill District, the find somewhat resembling that of the Sudbury Mine, Ontario, Canada, and the possibility of profitably working and extracting the metals present, I suggested that samples be taken from various parts of the deposits by a Government Inspector of Mines.

Acting on instructions received from the Under Secretary for Mines, Mr. Inspector Sawyer obtained eight samples, which have been submitted to a searching examination for the various metals contained in them. The following samples were sent by prospectors to the Department of Mines for examination, and assays for nickel and copper were made by Messrs. White, Greig, and Gurney, assistants in the Chemical Laboratory.

PROSPECTING ASSAYS.

| No. | Description of Sample. | Copper. (Per cent.) | Nickel. (Per cent.) | Remarks. |
|---|---|---|---|---|
| 4723 | Copper-stained ironstone......... | 3·87 | ‡2·36 | Contain platinum. |
| 4724 | Slate and copper carbonates ... | 7·70 | ‡2·95 | Contain platinum. |
| 6121 | ,, ,, ... | 0·55 | ‡1·73 | Contain platinum. |
| 6526 | Pyrites and ironstone ...... ..... | ·35 | ·18 | Platinum, 3 dwt. 6 grs. per ton. |
| 6527 | Ironstone and copper carbonates | 8·36 | ‡1·72 | Platinum present. |
| 6528 | Quartz and copper carbonates... | 34·65 | ‡1·00 | Platinum, less than 10 grains per ton. |

* Journ. R. Soc. N. S. Wales, 1892, XXVI, p. 371.
† Ann. Rept. Dept. Mines, N. S. Wales for 1892, p. 142.
‡ Containing a very small amount of cobalt.

The samples received were too small to enable the platinum and platinoid metals to be estimated in four of the samples. Platinum was found in every case to be present, also palladium and iridium.

SAMPLES collected by Mr. B. Sawyer, Inspector of Mines, Broken Hill.

| No. | Description of Sample. | Copper. (Per cent.) | Nickel. (Per cent.) | Cobalt. (Per cent.) | Remarks. |
|---|---|---|---|---|---|
| (1) 1352 | Ironstone gossan .............. | 1·50 | 0·74 | 0·25 | Platinum, 0 oz. 5 dwt. 21 grs. per ton. Palladium and iridium present. Fine gold, a few grains per ton. |
| (2) 1353 | Ironstone and copper carbonates. | 5·72 | 1·14 | 0·27 | Platinum, 0 oz. 9 dwt. 18 grs. per ton. Palladium and iridium present. Fine gold, less than 1 dwt. per ton. |
| (3) 1354 | Ironstone pyrites, &c......... | 1·95 | 0·36 | ... | Platinum, 0 oz. 3 dwt. 6 grs. per ton. Palladium, 0 oz. 16 dwt. 0 grs. per ton. Iridium present. |
| (4) 1355 | Chloritic schist and copper carbonates. | 2·10 | 1·28 | 0·15 | Platinum, less than 1 dwt. per ton. Contains palladium and iridium much in excess of the platinum found. |
| (5) 1356 | Ironstone, chloritic schist, with copper carbonates. | 2·37 | 1·31 | under 0·25 | Platinum present, less than 1 dwt. per ton. Palladium and iridium detected. |
| (6) 1357 | Ironstone and copper carbonates. | 7·42 | 4·33 | under 0·10 | Platinum, 0 oz. 3 dwt. 6 grs. per ton. Palladium and iridium present. Fine gold, a few grains per ton. |
| (7) 1358 | Ironstone and copper carbonates. | 10·82 | 0·39 | trace. | Fine gold, 0 oz. 1 dwt. 7 grs. per ton. Traces of platinum and palladium detected. |
| (8) 1359 | Ironstone and schist ......... | 0·72 | ·35 | trace. | Fine gold, a few grains per ton. Traces of platinum and iridium detected. |

(1) From cap of ironstone cut in shaft at 25 feet depth. Width of ironstone, 12 inches to 15 inches.

(2) From lode at 25 to 30 feet in shaft.

(3) From lode 25 to 30 feet; only an effort made to include pieces showing sulphide ore.

(4) Special hand-picked sample from dump, showing green incrustation.

(5) Same as No. 4; effort made to include pieces of dump likely to give cobalt (?).

(6) From trench 3 chains north-east from shaft where iron lode is exposed; width, 9 inches.

(7) From old workings, 15 feet deep; width, about 1½ inches.

(8) From dumps of old workings (No. 7) site, where it is stated that cinnabar was obtained years ago. Hand-picked sample from dump.

Mr. Sawyer states that Nos. 1, 2, and 6 are average samples of the lode on ironstone deposit.

Three samples obtained from about half a mile from the previous find at Broken Hill were examined.

No. 2150–07.—Ironstone and copper carbonates.

| | | |
|---|---|---|
| Metallic Copper... | ... ... ... ... | 19·95 per cent. |
| „ Nickel | ... ... ... ... | 0·25 „ |
| „ Cobalt ... | ... ... ... ... | a trace. |

Fine Gold at the rate of 3 dwt. 21 grs. per ton of ore.

Fine Silver at the rate of less than 1 dwt. per ton of ore.

No Platinum or metals in the Platinum group detected.

No. 2151–07.—Ironstone and copper carbonates.

| | | |
|---|---|---|
| Metallic Copper | ... ... ... ... | 23·27 per cent. |
| „ Nickel* | ... ... ... ... | 1·51 „ |

Fine Silver at the rate of 16 oz. 12 dwt. per ton of ore.

Fine Gold at the rate of less than 1 dwt. per ton of ore.

**Fine Platinum at the rate of 19 dwt. 14 grs. per ton of ore.**

**Palladium, a trace; a small quantity of iridium present.**

No. 2152–07.—Ironstone and copper carbonates.

| | | |
|---|---|---|
| Metallic Copper ... | ... ... ... ... | 8·57 per cent. |
| „ Nickel*... | ... ... ... ... | ·90 „ |

**Fine Silver at the rate of 7 oz. 0 dwt. 20 grs. per ton of ore.**

**Fine Gold at the rate of 13 dwt. 2 grs. per ton of ore.**

**Fine Platinum at the rate of 15 dwt. 16 grs. per ton of ore.**

A very small quantity of palladium and iridium detected.

Mr. Jaquet, during a recent visit to the Broken Hill District, obtained a sample of the iron ore and pyrites, a portion of which was received for examination.

**No. 4120–07 A.**—Iron pyrites, slightly magnetic, picked as free as possible from the oxidised ore.

| | | |
|---|---|---|
| Metallic Nickel ... | ... ... ... ... | 0·48 per cent. |
| „ Cobalt ... | ... ... ... ... | ·28 „ |
| „ Copper ... | ... ... ... ... | ·89 „ |

**Platinum** at the **rate of** 16 dwt. 17 **grs.** per ton of pyrites.

**Gold** at the rate of under 1 dwt. per ton of pyrites.

**Silver** at the rate of under 1 oz. per ton of pyrites.

**A small amount of palladium, iridium, and a very small quantity of one of the platinum metals detected—probably rhodium (?).**

* Including a very small amount of cobalt.

On dissolving the pyrites in acid, a small insoluble residue was obtained, which consisted largely of small garnets and rhodonite.

No. 4120-07 B.—Oxidised portion practically free from pyrites.

| | |
|---|---|
| Metallic Nickel* ... | 0·64 per cent. |
| „ Copper ... | 1·54 „ |
| Insoluble matter (gangue) | 9·26 „ |

Platinum at the rate of 11 dwt. 17 grs. per ton of ore.

Gold at the rate of under 1 dwt. per ton of ore.

Silver at the rate of under 1 oz. per ton of ore.

Contains a small amount of palladium and iridium; also a very small quantity of one of the platinum metals—probably rhodium (?)

The occurrence of nickel, copper, platinum, and platinoid metals in the Broken Hill deposits is interesting, as the deposits somewhat resemble those found at the Sudbury Mine, Ontario, Canada; and the occurrence is worthy of further investigation.

"The source of the nickel and copper in the Sudbury nickel region is pyrrhotite and chalcopyrite. The nickel mineral pentlandite, which is the principal source of this metal, is distributed through all the ore bodies in greater or less amounts Its matrix is almost universally pyrrhotite, though a number of exceptions occur, notably at the Copper Cliff Mine.

"The ore delivered to the smelting furnaces averages about two-thirds the gross weight hoisted from the mines, one-third being rejected by hand picking. After this sorting, the ore averages from 1 to 3 per cent. of nickel, and 1 to 4 per cent. of copper. The material is smelted into matte, which is further Bessemerised to enrich the copper and nickel contents." †

The composition of the Sudbury mattes are as follow:—

| | I. | II. |
|---|---|---|
| Copper | 14 per cent. | 25·92 per cent. |
| Nickel | 17 „ } | 48·82 „ |
| Cobalt | 0·5 to 0·6 per cent. } | 0·000075 „ |
| Gold | trace | 0·001775 „ |
| Silver | 0·5 to 1 oz. per ton | 0·000430 „ |
| Platinum | 0·25 to 0·5 oz. „ | present |
| Palladium | 0·25 to 0·5 oz. „ | 0·000056 „ |
| Iridium | ........ | 0·000056 „ |
| Osmium | ........ | present |
| Rhodium | ........ | 2·94 „ |
| Iron | ........ | 22·50 „ |
| Sulphur | ........ | |

I. Average furnished by Professor A. P. Turner, from mattes of the Canadian Copper Company.
II. Matte from the Murray Mine, given by T. L. Walker. (Am. J. Sci., 1896, i (4), p. 112.)

* Including any cobalt present.
† The Ore Deposits of Sudbury, Ontario.—Trans. Am. Inst. Mining Eng., 1904, XXXIV, p. 4.

The oxidised ores examined from Broken Hill were ironstone, impregnated with copper carbonate, also containing some calcium and magnesium carbonates. In several of the samples no indications were shown of copper being present; others showed the green stains of copper carbonate. From several tests made on small patches of green material coating the iron oxide, it would appear as if the nickel was present as carbonate (zaratite) (?).

An attempt was made to isolate the platinum and platinoid metals present in the material, but, so far, with no success. A large portion of the material was carefully concentrated by hand and the concentrates examined under a powerful objective, no metallic particles being observed. Platinum may occur in nature alloyed with iridium, palladium, ruthenium, osmium, iron, rhodium, or with arsenic as a definite mineral—sperrylite. I think it highly probable that the platinum is present in the Broken Hill deposits as sperrylite ($PtAs_2$), and attempts are now being made to isolate the platinum metals from the material in hand. The concentrates were found to contain a small quantity of arsenic, which tends to support this theory. Charles Bullman,* in an interesting paper on platinum, states: "As yet, sperrylite has been identified only in the alluvial sands produced by the erosion of the nickeliferous strata, but there is reason to believe that the same compound exists in veins." Mr. Emmons describes a shaly diorite in which Mr. F. P. Dewey, of Washington, who made the analysis, found from a trace to 0·53 per cent. of platinum in the vein material of the mine. Mr. P. G. W. Bayley† records the occurrence of platinum in a hornblende diorite with chalcopyrite obtained from the Walhalla or Thompson's River Copper Mine, in Victoria. The ore contains from 2 dwt. 18 grs. to 7 dwt. 20 grs. of platinum per ton of ore.

Mr. Bayley remarks: "I have endeavoured to isolate the platinum mineral in the samples, but so far without success; there is some metal other than platinum present in all the samples."

In a discussion on the occurrence of platinum and palladium in certain copper ores obtained from the Rambler Mine, in Wyoming, Mr. T. T. Read states:‡ "The ore contains pyrite, chalcopyrite, and covellite. The platinum is present as sperrylite or metallic platinum, the palladium is present in five times the quantity of the platinum, and is probably contained in the small amount of argentiferous tetrahedite in the ore."

In several of the Broken Hill deposits the palladium found was largely in excess of the platinum, notably in one of the samples, No. 1354, which yielded 16 dwt. of palladium, and 3 dwt. 6 grs. of platinum per ton of ore. The Canadian ores carry nickel, copper, silver, gold, platinum, palladium, iridium, and rhodium. The

* Charles Bullman, Mineral Industry, 1892, I.
† P. G. W. Bayley, Bull. Dept. Mines Vic., 20.
‡ Review of American Chemical Research.

percentages of the precious metals are extremely minute, and the various processes by which they are recovered are naturally complicated. The Orford Copper Company, who owns most of the Canadian mines, are said to produce about 3,000 oz. of palladium annually. Palladium* was detected in a ferruginous and carbonate ore from Gowan Green, seven miles west of Stuart Town, New South Wales.

It is highly probable that the metallic contents in the ironstone deposits at Broken Hill have become enriched to some extent by the action of acidulated waters acting on the iron pyrites in the lode material.

The following analysis of water,† taken from a shaft about five miles south-east from Broken Hill Post Office, Parish of Nadbuck, is interesting, as showing the action of accidulated waters on lode material :—

A water highly charged with mineral matter, and containing ferrous oxide, alumina, copper, zinc, cobalt, nickel, potash, soda, lime and magnesia, also a small quantity of cadmium, arsenic, and manganese combined with chlorine and sulphuric acid.

An estimation of the following metals yielded as follows :—

| | | |
|---|---|---|
| Metallic Copper ... ... ... | 8·40 | grains per gallon. |
| ,, Zinc ... ... ... | 10·67 | ,, |
| ,, Cobalt ... ... ... | 21·82 | ,, |
| ,, Nickel ... ... ... | 6·71 | ,, |

Water strongly acid.

Mr. J. B. Jaquet,‡ in his report on the find of platinum at Little Mulga Springs and Little Darling Creek, at Broken Hill, states: "that they probably owe their origin to springs. The iron, platinum, and small quantities of other metals were probably carried into solution by these springs. The iron and copper were precipitated when they reached the surface, and were brought under the oxidising influence of the atmosphere, but the platinum seems to have been partially absorbed by the kaolin, and only a portion of it reached the surface."

From a scientific point of view, the occurrence of these minerals in the Broken Hill deposits are highly interesting. I understand that means are now being taken to thoroughly test the deposits, and am of opinion that they are worthy of a thorough investigation.

The estimations of the copper and nickel in several of the Broken Hill minerals were made by Messrs. White, Greig, and Gurney.

* Records Geol. Survey, N. S. Wales, 1905, VIII, Pt. 2.
† Records Geol. Survey, 1905, VIII, Pt. 2.
‡ Ann. Rept. Dept. Mines N. S. Wales for 1892, p. 148.

# XX.—Notes on the Permo-Carboniferous Producti of Eastern Australia, with Synonymy: by R. ETHERIDGE, Junr., Curator of the Australian Museum, and W. S. DUN, Palæontologist.

[Plates XLI—XLIII.]

## I. INTRODUCTION.

THE present paper may be considered both as an inquiry into the validity of the specific rank accorded by authors to our Permo-Carboniferous *Producti,* and an endeavour to establish certain types permanently by means of illustration and comparison.

The need for this has been long felt, as the conceptions of the Australian species of *Productus* by various authors have been so divergent, that we have entertained for a long time doubts as to the validity of our own determinations, more particularly in the case of the widely-distributed *P. brachythærus.*

For the purpose of our review, we have brought together several hundreds of specimens, and it was also found necessary to obtain reproductions of Morris' types, figured and described in Count P. E. de Strzelecki's "Physical Description of New South Wales and Van Diemen's Land." Our request was at once granted by Dr. A. Smith Woodward, Keeper, Department of Geology, Natural History Museum, London, and we have now before us accurate casts of *P. brachythærus* (G. B. Sby.), Morris, and *P. subquadratus,* Morris. When forwarding these casts, Dr. F. A. Bather sent some observations on the subject by his colleague, Mr. S. S. Buckman, who was then studying these species. Mr. Buckman's observations will appear in due course, and we have to express our gratitude for the ready help afforded by those gentlemen.

We are also in possession of casts of types and co-types of the specimens described by Dana, which were obtained during the voyage of the Wilkes' Exploring Expedition in 1838. The originals of these specimens are now deposited in the United States National Museum, Washington.

Three species of *Productus* have been described from the Permo-Carboniferous rocks of New South Wales:—

Productus brachythærus, *G. B. Sby.*
,, subquadratus, *Morris.*
,, fragilis, *Dana.*

**1844.**—*Productus brachythærus* was first described by G. B. Sowerby* as a subtrapeziform, short-hinged, sublobate shell, from Tasmania. He said:—"The most

* Darwin's Geol. Obs. Volc. Ist., 1844, p. 158.

remarkable characters of this species are the shortness of the hinge-line and the comparative width of the anterior part. Its outside is ornamented with small, blunt tubercles, irregularly placed."

This is practically all that Sowerby said, and his description was not accompanied by a figure. Some years ago one of the writers endeavoured to trace Darwin's collection, of which the type of this species formed a part, but without success.* At present it appears to us that the position is—if it can be shown that a *Productus* possessing a subtrapezoidal outline, short cardinal margin, and an expanded front exists in our Permo-Carboniferous, the term *brachythærus* must be restricted to that form. On the other hand, if no such type of shell can be found, one of the points for us to attempt to decide will be—what is *Productus brachythærus*?

**1845.**—The next writer on this subject was the late Professor John Morris,† who described the Mollusca and Brachiopoda collected by Strzelecki from the Permo-Carboniferous rocks of New South Wales and Tasmania. Morris seems to have more or less ignored Sowerby's diagnosis in his interpretation of *P. brachythærus* by selecting, in the first case, a shell, which, although trapeziform, possessed a *long* hinge line‡—"Hinge-line straight, and nearly the width of the shell," and, secondly, a robust internal cast of the Permian *P. horridus* type. §

Now, it is manifest that the *Productus*, represented by his figure 4c, will hardly agree with Sowerby's description of the type, and one of the questions before us deals with this aspect of the case—is *P. brachythærus*, Morris, also *P. brachythærus*, G. B. Sby.? The identification of Morris' figures 4a and b will be dealt with later. It appears to us that Morris seems to have stultified his description to a certain extent by also saying "the hinge-line is rather short," but again with the saving clause "a character which, however, varies according to the age of the individual." One point is clearly brought out in the figures—his figure 4c shows a by no means short cardinal margin.

Another *Productus* from Tasmania was briefly described by Morris as *P. subquadratus*,‖ but not figured. This form had a quadrate outline, flattened flanks, produced front, cardinal margin as wide as the shell, and a broad sinus in the pedicle valve. This species will be referred to in more detail later.

**1847.**—The next author to deal with *P. brachythærus* was Professor L. G. de Koninck, who gave a lengthy description of the species, based on a specimen in the possession of Alcide D'Orbigny. The author called attention to the presence of very short but broad auricles on the pedicle valve, bearing a row of five or six tubular spines. He also noticed the short swollen umbo, and expressed the opinion that the

* Etheridge.—Proc. R. Phys. Soc. Edinburgh, 1880, V, p. 285.

† Strzelecki's Phys. Descrip. N. S. Wales and V. D. Land, 1845, p. 284.

‡ *Loc. cit.*, t. 14, f. 4c.

§ *Loc. cit.*, t. 14, f. 4a, b.

‖ *Loc. cit.*, p. 284.

identity of Morris' figures, 4a, b, and c, respectively, was very doubtful,* in this anticipating that afterwards expressed by one of us. His figures 1a and 1b are original, 1c and 1d copies from Morris' figures.†

De Koninck concluded his remarks by saying that *P. brachythærus* is, perhaps, only a variety of *P. subquadratus*, Morris (in this he was clearly wrong). As *P. subquadratus* he also provisionally described and figured‡ another shell, admitting, however, his doubts as to its identity with Morris' species, and adding, "je suis très porté à croire qu'elle est identique avec le *P. brachythærus.*" The specimen was in the Mineralogical Collection of the Paris Museum.

**1846.**—The Expedition to the South Pole under Dumont D'Urville during the years 1837–40 obtained some Australian Permo-Carboniferous fossils, apparently from Tasmania, as a geological map of that State is published.§ The description of the last plate of the Palæontology Atlas contains "coquilles fossiles de la Nouvelle Hollande, determinées par M. Alcide D'Orbigny," and a pedicle valve of a supposed *P. brachythærus* is figured‖—a highly-restored illustration.

**1848–49.**—Professor J. D. Dana, acting as geologist to the Wilkes' United States Exploring Expedition in 1838–1842, collected *Producti* at Wollongong Point, Illawarra, which he referred to *P. fragilis*, Dana, and *P. brachythærus*, G. B. Sby.

The first is described as "subquadrate, tumid, laterally and in front abrupt, a little longer than high. Cardinal margin straight, about as long as breadth of shell. Beak small, not inflexed."¶ It is said to differ from *P. brachythærus* "in its much less prominent beak, and its longer hinge-line."

*P. brachythærus* was also referred to, Dana quoting in his synonymy Sowerby's description and *all* Morris' figures.**

**1877.**—It was twenty-eight years before any further descriptive work on the Permo-Carboniferous *Producti* was published. In 1877 the third part of Professor L. G. de Koninck's "Recherches sur les Fossiles Paléozoïques de la Nouvelle Galles du Sud" appeared. This work was based on the collections of the Rev. W. B. Clarke, and in it are described shells referred to *P. brachythærus*†† and *P. fragilis.*‡‡

He described the former of these very fully, and for the first time the internal structures of both valves are more definitely recorded; De Koninck re-states the opinion that under *P. brachythærus* Morris figured two distinct forms.

* Mon. Genus Productus et Chonetes, 1847, p. 102, t. 16, f. 1a, b, c, d.
† Strzelecki, *op. cit.*, t. 14, f. 4b, c.
‡ *Loc cit.*, p. 100, t. 14, f. 1 a–d.
§ Voyage au Pole Sud, &c., Géol., 1854, II, p. 217.
‖ *Id.*, Paléontologie, Atlas, 1846, t. 6 (9), f. 6, 7.
¶ Wilkes, U. S. Explor. Exped., Geol., 1849, p. 686, t. 2. f. 7 *a–c*. Preliminary descriptions of all the expedition fossil were also published in 1848 (Am. Journ. Sci., 1848, V).
** *Loc. cit.*, p. 686, t. 2, f. 8.
†† *Op. cit. supra*, p. 60, t. 10, f. 4, 4*a*, t. 11, f. 1.
‡‡ *Op. cit.*, p. 63, t. 10, f. 3, 3*a*.

The shell referred to Dana's species is equally fully described, and is said to be *easily* distinguished from *P. brachythœrus* by the length of its cardinal area (? hinge line) (margin), convexity of the brachial valve, and prominence of its muscular and vascular impressions. Unfortunately, his figures do not bear this out. Furthermore, the author again refers to Morris' debatable figures 4a and 4b, suggesting that they may be *P. fragilis*, Dana—this, later on, we show to be incorrect.

**1880.**—In 1880 the Queensland Bowen River fossils were described by one of us. Amongst these were three species of *Productus*, *P. subquadratus*, Morris' (?),* *P. brachythœrus*,† and a tentative species.‡

In the remarks on *P. brachythœrus*, it was pointed out that the length of the cardinal margin varies with age, a very important point, considering Sowerby's statement that it was short, and Morris' figures of specimens with fairly long cardinal margins; De Koninck's opinion that Morris had figured two distinct forms as *P. brachythœrus* was confirmed—one with a moderately long septal ridge in the brachial valve,§ the other with a very long septal ridge continued almost to the margin.‖

The opinion was further expressed, after an examination of the type, that *P. undulatus*, McCoy,¶ was not identical with *P. brachythœrus*, as supposed by De Koninck.**

It was suggested also that *P. fragilis*, Dana, was only a phase of *P. brachythœrus*, a statement in opposition to the opinion recorded by De Koninck. Lastly, certain silicified internal casts from Tasmania, assumed to be identical with Morris' figures 4a and 4b, were described from specimens in the Strzelecki and Jukes' collections in the British Museum.

**1892.**—During 1892 the "Geology and Palæontology of Queensland and New Guinea," by R. L. Jack and one of the writers, appeared. The, by this time, much discussed *P. brachythœrus* was re-described, and a fairly full discussion of its literature and that of its allies was given.†† Attention was also drawn to some thick-tested Productiform shells with an area from the "Darr" (? Don) River,‡‡ which we now believe to be distinct from *P. brachythœrus*.

A full description was also given of some large internal casts from Mount Britton and elsewhere‖§; these were referred to *P. subquadratus*, Morris.

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* Proc. R. Phys. Soc. Edinburgh, 1880, V, p. 283.
† *Id.*, p. 284, t. 8, f. 16, t. 9, f. 17, 18.
‡ *Id.*, p. 300, t. 14, f. 44–49.
§ Morris—*op. cit. antea.* f. 4c.
‖ *Ibid.*, f. 4, a, b.
¶ Ann. Mag. Nat. Hist., 1847, XX, p. 235, t. 13, f. 2.
** *Op. cit.*, p. 60.
†† Geol. Pal. Q'land., &c., 1892, p. 248, t. 12, f. 10–13, t. 13, f. 5 (?), *excl.*, t. 44, f. 14.
‡‡ *Op. cit.*, t. 44, f. 14.
‖§ *Op. cit.*, p. 252, t. 38, f. 7–0, t. 40, f. 5.

**1888.**—The only *Productus* figured by Mr. R. M. Johnston in his "Geology of Tasmania" was *P. brachythærus,* his figure illustrating a specimen with a septal ridge of moderate length, and the impression of a true productoid cardinal process.*

**1902.**—As *Productus,* sp., a form from Hartley was described by one of us in 1902.† An internal cast of the pedicle valve was the only specimen available, and presented an "outline . . . longitudinally elongated, the hinge-line very short, the ventral valve highly geniculate and arched, and its umbo projecting vertically downwards over the cardinal area." Further, "the ventral valve, instead of possessing a uniform convexity or a sulcus, exhibits a very narrow and sharp angular fold."

No more specimens of this interesting type have come under our notice—at the time of description it was regarded as a malformed *P. subquadratus,* Morris.

**1902.**—The last reference we have to record is that of Professor Frech's figure of a decorticated specimen of *P. brachythærus* from Nowra, Shoalhaven River—one of our typical localities of the rocks of the Upper Marine Stage of the Permo-Carboniferous, which he refers to the "Lower Dyas."‡

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## II.—DESCRIPTION OF THE SPECIES.

### PRODUCTUS BRACHYTHÆRUS, *G. B. Sby.*

(Pl. XLII, figs. 1–8; XLIII, figs. 5–11.)

*Productus brachythærus,* G. B. Sowerby, Darwin's Obs. Volc. Islands, 1844, p. 158.

" " Morris, Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 284, t. 14, f. 4c (*non* a and b).

" " De Koninck, Mon. Genre Productus et Chonetes, 1847, p. 102, t. 16, f. 1a and b (*non* 1c, d).

" " D'Orbigny, Dumont D'Urville's Voy. Pole Sud, Pal. Atlas, 1846, t. 6 (9), f. 6 and 7.

" *fragilis,* Dana, Am. Journ. Sci., 1848, IV (2), p. 153.

" " Dana, Wilkes' U. S. Explor. Exped., X, Geol., 1849, p. 686, t. 2, f. 7a–b.

" *brachythærus,* Dana, *loc. cit.,* p. 686, t. 2, f. 8.

" " De Koninck, Foss. Pal. N. Galles du Sud, Pt. 3, 1877, p. 60, t. 10, f. 4, 4a, t. 11, f. 1.

" *fragilis,* De Koninck, *loc. cit.,* p. 63, t. 10, f. 3, 3a.

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* Syst. Acct. Geol. Tas., 1888, t. 14, f. 2–4.
† Etheridge—Rec. Geol. Surv. N. S. Wales, 1902, VII, p. 67, t. 18, f. 4, 5.
‡ Roemer's Lethæa Pal., II, Atlas, 1902, t. 57 d, f. 1a and b.

*Productus brachythærus*, Eth. fil., Proc. R. Phys. Soc. Edinburgh, 1880, V, p. 284, t. 8, f. 16, t. 9, f. 17, 18.

" " Johnston, Syst. Acct. Geol. Tas., 1888, t. 14, f. 2–4.

" " Eth. fil., Geol. Pal. Q'land, &c., 1892, p. 248, t. 12, f. 10–13, ? t. 13, f 5 (*non* t. 44, f. 14).

" " Frech, Roemer's Lethæa Pal., II, Atlas, 1902, t. 57d, f. 1a, b.

*Obs.*—The synonymy we propose to accept for this, the most widely distributed of our Permo-Carboniferous Producti, is given above. The history is given in the introductory section, and has already been summarised by one of us.*

It has already been pointed out that some uncertainty attends all arguments connected with *Productus brachythærus* owing to Sowerby's unsatisfactory description of Darwin's specimens. This, also fully dealt with in the introduction, is further complicated by Morris' figures, which represent two types under the head of *P. brachythærus.*† We consider, however, that the synonymy we propose will put the matter on a more satisfactory footing, and taken in conjunction with figures accompanying this article, should give readers a clear insight into our argument.

In arriving at this stage we have been much assisted by Dr. F. A. Bather and Mr. S. S. Buckman, who have placed at our disposal notes on Morris' types.

Mr. Buckman's notes arrived when we were engaged on this inquiry, and we are pleased to find that our respective views on the subject practically agree. After careful examination of the specimens in the British Museum, he says :—

Morris, in Strzelecki, p. 284, and Pt. XIV, f. 4, describes two specimens as *P. brachythærus* ; one, fig. 4a, b, has a comparatively short hinge-linge, and is an undoubted Tasmanian specimen ; the other, fig. 4c, has a long hinge-line, and agrees in matrix with New South Wales specimens. Both these are in the British Museum [No. 96893a, b] ; but fig. 4c [96893a] has lost the ears figured by Morris, and therefore looks as if it had a short hinge-line . . . .

Thus there are three forms referred to *P. brachythærus* :—

1. Morris' long hinge, New South Wales.
2. Morris' short hinge, long septum, Tasmania.
3. Etheridge's short hinge, short septum, Queensland.

There is in the British Museum (Nat. Hist.) a specimen registered B. 19298 which is labelled "*Productus brachythærus*, inside of flat valve," and it bears the printed number "498." It is possible that this may be one of Darwin's specimens (his other specimens bear such a printed number), and be one of Sowerby's types. It agrees with the description of the second specimen mentioned by Sowerby in Darwin, p. 158, for the stone wherein it is embedded is "of a light rusty-brown colour." This specimen has a short hinge-line and a short septum, consequently it agrees with what Etheridge has figured as *P. brachythærus*, in fact with No. 3 ; but it certainly does not agree with the Morris specimen which Etheridge identified therewith, or with the specimen which De Koninck called *P. brachythærus*.

We consider that the description by one of us of Queensland specimens† to form a satisfactory diagnosis of this protean species.

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* Etheridge—Geol. Pal. Q'land, &c., 1892, pp. 248-52.
† Etheridge—Geol. Pal. Q'land, &c., p. 248.

For the length of the septum, ordinarily a very good character, we are inclined to allow some degree of latitude. On Pl. XLIII, figs. 8, 9, 10, will be seen figures of Producti, in outline undoubtedly agreeing with Morris' figure 4c, in which the septum is rather long and short according to individuals—in all cases the anterior portion of the septum is very faintly developed, while the posterior portion is a very definite structure.

If this contention be admitted, it will mean that too much stress must not be laid on the value, as a specific character, of the length of the septum, and that we can accept both long and short septate types associated with a long hinge-line, as constituting one species.

In this connection, the fact must not be overlooked that, in referring to the Tasmanian specimens, one of the authors drew attention to the shorter septum in the original of Morris' figure 4c, as compared with the silicified specimens from Point Puer (Morris' figures 4a and b)* ; he had before him Morris' types, and laid stress on this point as of determinative value. Now, however, this does not appear to have the same force; nevertheless, the one does possess a longer septum than the other. It is suggested that, when the Tasmanian forms have been examined in greater numbers, it may be possible to establish a variety on a character of this type, even if the other features of the shell, as, for instance, the highly developed muscles, as represented by the scars, will not demand its separation as a distinct species. We have endeavoured to obtain examples of this silicified shell, but without success.

What appears to us of considerable importance is, that in the large number of specimens in the collections of the Mining and Geological Museum and the Australian Museum, this character seems to be valid—all sub-trapeziform individuals have a hinge-line approximately equal to the length of the shell, and that there are no definitely short-hinged types.

The examination of this series of *Producti* has also established the fact that in our Permo-Carboniferous there are two types of *P. brachythærus*-like shells, agreeing as regards the internal characters of the brachial valve and surface ornamentation, but differing in the length and gibbosity of the pedicle valve. In these cases, owing to the greater length of the pedicle valve, the hinge-line is relatively shorter.

We suggest the varietal name *elongatus* for this type (Pl. XLIII, figs. 5 and 7, and XLII, figs. 2, 3, 7).

The whole difficulty which has attended the identification of this species, *P. brachythærus*, has arisen from the interpretation of the term "short hinge-line." We feel sure that Sowerby had before him examples in which the terminations of

* Etheridge—Proc. R. Phys. Soc. Edinb., 1880, V, p. 286.

the cardinal margins had been destroyed, as is the case of many that have passed through our hands—hence the discrepancy between his description and that of Morris.

D'Orbigny's figure appears to us to represent the external characters of *P. brachythærus* in a well-preserved condition, and is probably more or less a restoration.

Intermediate forms occur, linking the terminal types together. This holds good with regard to specimens of *P. brachythærus* from all localities in our widely-distributed Marine Permo-Carboniferous.

An examination of a well-prepared reproduction of the type of Dana's *P fragilis*, together with a comparison of one of his co-types of that species (which was presented to the Australian Museum by the United States National Museum), enables us to arrive at a clear conception of Dana's species, and we have no doubt as to its identity with *P. brachythærus*, as already pointed out by one of us.*

This species occurs with us at certain localities in great abundance and all conditions of preservation, but chiefly in the exfoliated or "decorticated" state.

### PRODUCTUS (?) SUBQUADRATUS, *Morris.*

(Pl. XLI, figs. 1–5.)

*Productus subquadratus*, Morris, Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 284.

" " Eth. fil., Proc. R. Phys. Soc. Edinburgh, 1880, V, p. 283.

" " *Id.*, Geol. Pal. Q'land, &c., 1892, p. 252, t. 38, f. 7–10, t. 40, f. 5.

*Obs.*—We can add but little to the description of this species given by one of us in the "Geology and Palæontology of Queensland, &c."

Morris did not figure this shell, and gave so brief a description that some doubt existed in our minds as to the accuracy of the determination made by one of us. This doubt, however, has now been set at rest by comparison with a reproduction of the type† kindly supplied by Dr. A. Smith Woodward. This cast and the Mount Britton fossils are, without doubt, one and the same species.

As an addition to the previous description, it may be remarked, as to the external appearance, that costæ in the strict sense of the word hardly exist, being replaced by the heavy long spine bases; the spines were thick, complete length unknown, but not great.

In the detailed description of *P. subquadratus* given by one of us,‡ an "area, short and triangular, transversely striate," was described as occurring on the

* Etheridge—Geol. Pal. Q'land, &c., 1892, p. 248.
† In the collections of the British Museum (Nat. Hist.).
‡ Etheridge—Geol. Pal. Q'land, &c., p. 252.

pedicle valve; also a "pseudo-deltidial aperture, triangular and very marked"; on the brachial valve, "area longer and narrower than on the ventral valve," and these features were described in relation to *Productus.*

Further consideration convinces us that *P. subquadratus* cannot satisfactorily be placed in that genus. As to which genus of the Productidæ it should be referred, we cannot definitely say, but it is nearest to *Aulosteges.* The absence of teeth and sockets and the form of the brachial scars places it far from *Strophalosia.* The first two characters again, and its massed adductor scar impression in the pedicle valve, separates it from *Daviesiella*; the area in the pedicle valve and large triangular delthyrium prevents its being considered as, at any rate, a typical *Productus*, although the other characters are those of that genus.

On the other hand, *Productus subquadratus* possesses the following features in common with *Aulosteges*:—

1. Size of the cardinal process, and presence of a strong deltidial callosity.
2. Triangular striated area in pedicle valve.
3. Linear area in brachial valve.
4. Absence of cardinal teeth.
5. Well developed and long septal ridge.

In contradistinction to these we find:—

1. Triangular and large delthyrium, as opposed to the narrow, long cleft of *Aulosteges.*
2. Form of the brachial scars.

On the whole, *P. subquadratus* appears to occupy a position between *Productus* and *Aulosteges*, and yet the characters distinguishing it are hardly sufficient, in our opinion, for the erection of a new genus or sub-genus to receive it.

Some further light may be cast on the question by a reference to the recently-described *Aulosteges baracoodensis** and its variety *septentrionalis.*†

The original specimen of *P.* (?) *subquadratus* is said to have come from Tasmania. Mr. R. M. Johnston does not figure it, but in the distribution table it is recorded as occurring in both the Upper and Lower Marine beds of Tasmania.‡

In Queensland it has been collected at Mount Britton, Pelican Creek, Sonoma-road, Marine Beds of the Bowen River, and from Lake's Creek, Rockhampton, and Yatton Gold-field, Gympie Beds.§

In New South Wales it has been recently collected for the first time from Cessnock and twelve miles from Drake, New England, by Professor T. W. E. David and Mr. E. C. Andrews, respectively. Both these horizons are in the Lower Marine Stage of the Permo-Carboniferous.

* Etheridge—Bull. Geol. Survey W. Australia, No. 10, 1903, p. 22, t. 2, f. 2.
† Etheridge—S. Austr. Parl. Papers, 1907, No. 55, Supp. (1906), p. 5, t. 1, f. 1-5.
‡ Syst. Acct. Geol. Tas., 1888, p. 118.
§ Geol. Pal. Q'land, &c., 1892, p. 254.

PRODUCTUS CORA, *var.* farleyensis, *nov.*

(Pl. XLII, figs. 9, 10, 11.)

*Obs.*—In the ferruginous sandstone of the Farley (Lower Marine) Stage, at Farley, occur internal casts and decorticated specimens of a *Productus* that, after extensive comparison, appears to represent a hitherto undescribed type.

We tentatively place it as a variety of *P. cora*—our material is limited and in a poor state of preservation. So far as it can be determined, we are dealing with a shell with the general outward appearance of *P. brachythærus*, but distinguished from it by its very fine, regular radial ornamentation, as fine in proportion to the size as that of the Indian *P. lineatus*, Waagen.* There are a limited number of scattered lachrymate spine-bases, a faint transverse puckering, and spines along the cardinal margin on the auricles. The flanks show faint transverse wrinkles, in two instances developing into definite corrugations over the entire pedicle valve.

It is very evident that it is not *P. brachythærus* proper; and although we have accepted a great range of characters for that protean form, it appears justifiable to separate this variety and consider it more nearly allied to *P. cora* than to the other. The costation resembles that of the European *P. striatus*, Fischer, as well as that of the Indian *P. lineatus*, Waagen, but is more regular than that condition in the former.

Again, it is remarkably like *P. cora*, D'Orbigny, not only in the costation, but also in the auricle-wrinkles which pass into indefinite body corrugations, and the few spines along each lateral portion of the cardinal margin. *P. cora* has already been recognised as an Australian species,† but from the Carboniferous.‡ There is this to be said, however, *P. cora* proper, like *P. lineatus*, is rather too narrow a shell for our specimens to be referred to. In two of our specimens the transverse wrinklings take on the undulating appearance so characteristic of *P. cora*.

*Loc.*—Road cutting, Farley, near West Maitland, N. S. Wales.

PRODUCTUS, *sp.*

*Productus brachythærus*, Morris, Strzelecki's Phys. Descrip. N. S. Wales, 1845, t. 14, f. 4a, b (*non.* 4c).

" " De Koninck, Mon. Genus Productus et Chonetes, 1847, t. 16, f. 1c and d (*non* f. 1a and b).

*Productus* (?) *sp.*, Etheridge, fil., Proc. R. Phys. Soc. Edinburgh, 1880, V, p. 300, t. 14, f. 44–49.

*Productus Strzelecki*, Eth. fil., m.s.

* Salt Range Fossils (Pal. Ind.), I, Pt. 4, fasc. 4, 1884, t. 66, f. 1, 2.
† Etheridge—Quart. Journ. Geol. Soc., 1872, XXVIII, t. 15, f. 1, 2.
‡ De Koninck—Foss. Pal. N. Galles du Sud, 1877, Pt. 3, t. 9, f. 1.

*Obs.*—This is one of the forms regarded by Morris as *P. brachythærus*, and so accepted by Dana. De Koninck was the first to point out the improbability of all Morris' figures representing the same species, and in this view he was followed by one of us.

To the published description* we have nothing to add, as our endeavour to obtain additional material from Tasmania has failed.

It was at first thought that this *Productus* might be either the young or a dwarf form of *P.* (?) *subquadratus*, for the structure is similar in every particular—so far as the specimens available for examination are concerned—with the exception of the form and size of the brachial scars, which in *P.* (?) *subquadratus* are productiform, while here they assume the Aulostegiform outline.

There can be no doubt that this form is generically very close to *P. subquadratus*, and will have to be placed in the same genus, or sub-genus, when that be decided upon.

*Loc.*—Point Puer, Tasmania.

### PRODUCTUS (?) SOLIDA, *sp. nov.*

(Pl. XLIII, figs. 1-4.)

*Productus brachythærus*, Eth. fil., Geol. Pal. Q'land, &c., 1892, p. 252, t. 44, f. 14.

*Obs.*—Some specimens of a Productoid shell from the Darr (Don ?) River, Queensland, presented to the Mining and Geological and Australian Museums by Prof. A. Liversidge, present several noteworthy features.

These specimens were originally referred to *P. brachythærus* by one of us, but a subsequent examination led to doubt that they were strictly referable even to *Productus* (*sensu strictu*).

The pedicle valve, as already pointed out, has a linear area, and the hinge-line is short, the most remarkable feature being the great thickness of the valve. The muscles have no clearly-marked attachment scars. The anterior portion of the valve thins rapidly, and is usually broken away from the specimens as preserved. The anterior portion of the massive region of valve bears deep vascular sinuses (Pl. XLIII, fig. 2).

In the more perfect specimens it is seen (Pl. XLIII, fig. 3) that the pedicle valve possesses well-marked auricles, but the hinge-line is always less than the width of the shell. The beak is strongly overhanging, and almost impinges on the hinge line.

* Etheridge—Proc. R. Phys. Soc. Edinburgh, 1880, V, p. 300.

The surface has a silky appearance, and the well-marked channels connected with the tubular spine bases, already commented on in *P. brachythærus*, are clearly shown. Radial markings are present, but are not distinct till the thinner marginal area is reached.

Of the nature of the brachial valve we are almost ignorant, except that in the cardinal region it is much thinner than was the case of the pedicle valve—the cardinal process as seen is a massive structure.

In some respects this form approaches those *Producti* for which Waagen proposed the sub-genus *Marginifera*,* with the difference that the marginal ridge is not a distinct structure, nor do the spines of the brachial valve possess a similar arrangement.

Examination of a more complete series of this interesting fossil may necessitate the erection of a sub-genus for its reception—for the present we content ourselves with regarding it as an aberrent *Productus* in which the valves are much thickened and the internal structures marked.

We proposed for it the specific name *solida*.

*Loc.*—Darr (? Don) River, Queensland.

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## XXI.—*Arachnophyllum* from the Halysites Limestone of the Mount Canobolas District, New South Wales: by R. ETHERIDGE, Junr., Curator of the Australian Museum, Sydney.

[Plates XLIV—XLVI.]

AMONGST the many interesting corals yielded by the Halysites Limestone of Spring and Quarry Creeks, in the Parish of Barton, County Ashburnham, to the researches of Mr. C. A. Süssmilch, none are more so than the subject of the accompanying notice—*Arachnophyllum* (?) *epistomoides*.

Full stratigraphical information will be found in a recently published paper by Mr. Süssmilch—"Note on the Silurian and Devonian Rocks occurring on the west of the Canobolas Mountains, near Orange."†

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* Salt Range Fossils, Pal. Indica, Ser. xiii, I, 1884, Pt. IV, fasc. 4, p. 713. In connection with this, it is interesting to note Hall and Clarke's remarks as to the necessity for the sub-genus—Pal. N. York, VIII, Pt. 1, 1892, p. 331.

† Süssmilch—Journ. R. Soc. N. S. Wales, 1907, XL, p. 130.

*Genus*—ARACHNOPHYLLUM, *Dana*, 1846.

(American Journ. Sci., 1846, I.)

Arachnophyllum (?) epistomoides, *sp. nov.*

(Plates XLIV—XLVI.)

*Sp. Chars.*—Corallum large, spreading, tabular, forming colonies of some considerable size; upper surface rounded. Corallites formed by a series of invaginated or semi-infundibuliform plates, spreading laterally to assist in forming copious intercalicular (so-called endothecal) tissue; on the surface indefinitely polygonal, the polygons only defined by the outward terminations of the septal costæ. Visceral chambers cylindrical, long (at least four inches), round, crateriform, monticulate at the mature or growing surface; combined septal-tabulate areas with an average diameter of twenty millimetres. Intercalicular tissue copious and delicate, separating the visceral chambers by variable distances, and composed of linear lenticular vesicles, with here and there other larger convex cysts between horizontal or rolling laminæ, the lateral extensions of the invaginated calices, the whole presenting the appearance of a rather dense tissue. Calices moderately deep, straight-walled above, and reverted to form the broad plano-monticulate indefinitely polygonal expansions. Septa forty to forty-five, primary only, lanceolate, and thickened in the calices, where they stop short and do not impinge on the central tabulate area on passing over the crateriform edges of the calices the septal lamellæ continue on the surface of each invaginated lamella, but those of one corallite do not appear to unite with those of its neighbours, leaving narrow zones of vesicular tissue between. Inter-septal dissepiments very numerous and closely packed, in regular cycles, and gradually merging in the intercalicular tissue. Central area occupied by incomplete close-set tabulæ, consisting of upwardly oblique, long, lenticular vesicles, convex above, forming a dome-shaped calicinal boss on the floors of the calices, and traversed longitudinally by columellarian rods.

*Obs.*—Mr. Süssmilch informs me the corallum occurs in the form of tabular or more or less flat masses with a rather convex upper surface, one seen by him measuring two feet long by twelve inches in height. No evidence of a basal or enveloping epitheca has so far come to light, and the method of increase is apparently by calicular gemmation.

A casual examination would reveal several features in common with *Endophyllum*, but a more critical examination of its structure would indicate others in no way compatible with that of the genus in question as redescribed and restricted by Dr. Clemens Schlüter.

The main or essential feature of the coral consists of a series of parallel cylindrical corallite tubes formed by a succession of very close invaginated or semi-infundibuliform plates, the free or upper edges of which turn over, or are reverted as horizontal or undulating laminæ to unite with similar laminæ from other visceral chambers to assist in producing a uniting vesicular tissue, the whole increasing upwards, or in height, by regular growth stages. It follows from this that the corallites possess no proper wall. The invaginated structure is distinctly visible in weathered specimens, and were these corallites single and not united by vesicular tissue, such a form and mode of growth would, to all intents and purposes, be that of the genus *Chonophyllum.* The vesicular tissue between the laminæ in question is remarkably fine, the vesicles mostly linear-lenticular, with here and there larger convex cysts, but none of the cavernous vacuities seen in *Endophyllum Schlüteri,* mihi.* So far, the structure is simply that of a coral which might be included in the genus *Endophyllum.*

At the surface of a completed growth stage the visceral tubes (or corallites) are crateriform, and the surface of the intermediate vesicular area is depressed below these crater-like prominences. There are certainly no walls to the corallites of these colonies, neither an outer proper wall nor an inner spurious mural investment; the apparent presence of the latter is accounted for by the close apparent union of the vertical or viscero-vesicular portions of the invaginated lamellæ.

The septa are all primary, and within the calices are thick, lanceolate, and stop short of the central area abruptly. Without the calices the septal lamellæ radiate over the recurved surfaces and become lost in the intercalicular tissue that intervenes between the respective corallites; it follows from this that the septal lamellæ of one individual are not continuous with those of another as in *Phillipsastrœa,* &c.; at any rate, this is the structure as far as I have been able to make it out. It is necessary, however, to utter a word of warning in connection with the structure of these septa. At first I was inclined to regard them as denticulate on their inner or distal free edges, but I now think this appearance is due simply to unequal chalcedonic silicification.

The central tabulate area as seen in weathered calices is always dome-shaped with vertical trabecular projections, unconnected with the septal lamellæ. When viewed by means of a thin longitudinal section we find this boss composed of highly vesicular close-set tabulæ, obliquely elevated or inclined at the sides, and comparatively horizontal in the centre; hence, in transverse weathered examples the inclined vesicles project as small trabeculæ, and in transverse thin sections as rather regular cut edges. There is no true columella, but this calicine boss is traversed vertically by lamellæ converging to, but not meeting, at the centre, and having no connection with the septal lamellæ. In a transverse microscopic section these columellarian rods appear to some extent club-shaped, and uniting one with the other, are the cut edges of the lateral and inwardly inclined tabulæ.

The generic relations of this coral are by no means clear. With *Endophyllum* it agrees in its general mode of growth, particularly the highly developed laminar

* Etheridge.—Rec. Geol. Survey N. S. Wales, 1898, VI, Pt. 1, t. 4, f. 1, t. 5, f. 3.

intermediate vesicular tissue. It differs, however, in the septa not extending on to the central tabulate area; in the presence of the columellarian boss; in the extension of the septal ridges on the surfaces of the invaginated laminæ for a greater or less distance from the calices, which, if I understand Dr. Schlüter's amended description of *Endophyllum* correctly, is not the case in that genus.

With *Arachnophyllum*, Dana (which, according to Lindström,* absorbs the corals erroneously referred by Edwards and Haime to *Strombodes*, Schweigger), there is the same resemblance as in *Endophyllum*. In addition, both *Arachnophyllum* and the present coral exhibit the same crateriform calices, lateral extension of the septal ridges, and there is certainly in Dana's genus some form of central boss, variously described by different authors, Edwards and Haime even venturing to use the term "pseudo-columella." On the other hand, the central tabulate area is small, and the entire corallum is more or less turbinate in consequence of its increase by calicular gemmation.

In 1873, under the name of *Darwinia*, Dybowski described† a coral that Schlüter believed to be synonymous with *Endophyllum*, but Lindström suggested‡ *Arachnophyllum*. The general features of growth described by Dybowski are essentially those of both *Endophyllum* and *Arachnophyllum*, but like those of the latter, and unlike those of the former, the septal ridges are continued beyond the immediate calices on the overturned surfaces of the invaginated laminæ. The primary septa, according to Dybowski, are carried to the calicinal centre, and meet to form a false columella, or, as he termed it, a "small tubercle," and in this belief he was supported by F. von Roemer.§ In *Darwinia rhenana*, Schlüter also speaks‖ of a "knob-like projection" at its calcinal centre. It appears to me that little difference exists in the structure of *Arachnophyllum* (*Strombodes*, Ed. and H.) and *Darwinia* (except that we know nothing of the reproduction of the coral so named by Dybowski), and that our present coral only departs from the structure of the latter to the same extent that it does, as I have already pointed out, from *Arachnophyllum* proper.

On reviewing the characters of the Canobolas coral, it is evident a greater community of structure exists with *Arachnophyllum* than with *Endophyllum*, and for the present, at any rate, it may be regarded as an *Arachnophyllum* with a more highly developed or specially differentiated central area.

The specific name *epistomoides*¶ is given in allusion to the plug-like appearance of the central tabulate area when seen in weathered specimens.

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* Lindström—Bihang K. Sv.-Akad-Handlingar, 1883, VIII. No. 9, p. 6.

† Dybowski—Mon. Zoantharia Scler. Rugosa, 1873, Pt. 1, p. 148 (*Darwinia*, Dybowski, 1873, *non* Spence Bate, 1857) = *Nicholsonia*, Schlüter (*non* Waagen and Wentzel, 1886, *nec* Kiar, 1899).

‡ Lindström—*Loc. cit.*, p. 8.

§ Roemer—Lethæa Pal., Lief. 2, 1883, p. 402.

‖ Schlüter—Verhandl. Nat. Vereines Preuss. Rheinl. Westfalens, 1881, p. 196.

¶ ἐπιστόμιον—a bung or stopper—and *oidos*.

# XXII.—An Organism allied to *Mitcheldeania*, Wethered, of the Carboniferous Limestone, in the Upper Silurian of Malongulli: by R. Etheridge, Junr., Curator of the Australian Museum, Sydney.

[Plates XLVII, XLVIII.]

The small, problematical oval or rounded bodies known as *Mitcheldeania* occur abundantly in the Carboniferous Limestone of Britain, at times almost forming entire limestone beds. In the most important species, *M. gregaria*, Nicholson, these calcareous bodies, averaging about ten millimetres in diameter, are made up of radiating capillary tubes, disposed in concentric strata, and with a diameter of from one-twelfth to one-fifteenth of a millimetre. These zoöidal tubes may be close to one another, in contact, separated by much smaller interstitial tubes, or scattered irregularly amongst the latter, which possess a diameter of one-twenty-fifth of a millimetre, or less. The larger zoöidal tubes communicate with one another by oval or circular, uniserial, comparatively large pores closely resembling the "mural pores" of perforate corals. The interstitial tubuli not only communicate with one another in a similar manner, but also branch irregularly and anastomose, giving rise, when seen in transverse section, to minute branching canals interspersed among the cut-ends of these tubuli. The zoöidal tubes are usually free of internal partitions, but, occasionally, horizontal floors resembling "tubulæ" are seen, but no trace of "septa" is ever to be found.*

Two species are known—the above and *M. Nicholsoni*, Wethered,† the latter a smaller form enveloping other organisms, or forming crusts on foreign bodies in the Carboniferous Limestone of the Forest of Dean, West of England. *M. gregaria*, on the other hand, occurs in great quantity in the Lower Carboniferous of South Scotland, and in places forms extensive beds of limestone.

The Rev. J. M. Curran recently presented to the Mining and Geological Museum a piece of limestone measuring five and a half inches by three and a half inches, and of a tabular shape. One surface is gently rounded or convex, the opposite more or less hollowed. These broad surfaces are, as regards the constituent organism, lateral, the upper and lower faces being represented by the narrow edges. There is no trace either of any membrane, such as an "epitheca," nor a nucleus of growth, or even a peduncle. The surfaces are scobinate, the roughening produced by the projecting of innumerable points representing the capillary and subradiating tubes about to be described. These, however, are not arranged in

* Nicholson—Geol. Mag., 1888, V (3), p. 18.
† Wethered—Geol. Mag., 1886, III (3), p. 535, t. 14, f. 6.

concentric strata. This is all that can be made out by macroscopic examination, the further examination depending on thin sections prepared for the microscope These reveal a structure more or less akin to that of ***Mitcheldeania.***

In a transverse section the eye is first struck by the general laxity of structure; in the second place by the protean outline of the zoöidal tubes. Indeed, it is, at first, most difficult to say which of the larger openings or spaces are and which are not of this nature. A careful study of this extraordinary organism has, however, led me to believe that all the larger openings are so. the many and strange shapes being the result of a partial breaking down of a copious cribriform tissue, rendering the zoöidal tubes, in a very large number of cases, confluent.

Before describing the structure in detail it is necessary to understand the condition of preservation. Thus, there are clear calcite cores of various shapes and dimensions, separated by dark structureless investment, either conforming to the outline of the calcite cores, or forming patches of greater or less extent, in which the latter are often isolated. In the first instance this material presents the appearance of tissue, as if forming walls enclosing the cores; in the second instance it is so dense as to certainly look like matrix; if it be all of this nature, it then follows that the calcite cores have no walls preserved. On the other hand, around the edges of the whole specimen a different state of preservation is present, and here there are undoubtedly tubes with well-defined walls of a light grey colour, and the interiors not filled with clear calcite. On the whole, therefore, I think the dark matrix-like boundaries, previously referred to, are tissue and not merely matrix. Without this explanation it would be impossible to render the following description intelligible. As it is, in the two general figures (Pl. XLVII), transverse and longitudinal, the zoöidal tubes are represented by the dark colour and the tissue by the white opaque portions, diametrically opposite to the natural condition of the specimen (Pl. XLVIII).

The greater number of the zoöidal tubes are primarily round or oval, with an average diameter of half a millimetre. A few are quadrangular, and either abut against one another (like the corallites of some Tabulate corals), or are separated by interspaces, as described above. By a copious development of uniserial communication pores, many of these zoöidal tubes become either simply confluent in pairs, or so connected one with the other as to produce the most varied and indescribable figures; some, however, are dumb-bell-shaped, double dumb-bell-shaped, crescentic, pyriform, boomerang-shaped, rhomboidal, or meandriform. It not infrequently happens in these irregularly-shaped figures, that at one or, possibly, two points the opposite sides converge towards one another, in all probability indicating the position of a former pore of communication. Without such indicators it would not be possible to account for the irregular outline of these tubes; even this explanation does not appear to suit every case, at the same time I cannot offer a better one. In common with the oval or round tubes these irregular spaces are filled with clear calcite.

In only two instances has any structure been noticed in these zoöidal tubes. In two, close together, are four septa-like projections, opposite in pairs; this may possibly be the result of fission.

The smaller, or interstitial tubes are scattered indiscriminately throughout the dark tissue; they are far less in number than the zoöidal tubes, of vastly smaller, although variable size, and resemble the similar tubes in *Mitcheldeania gregaria.** They are either single, or a few follow one another closely; they are transversely elongate, or canal-like occasionally, as if two or more had become confluent.

The longitudinal section is even more instructive than the transverse, and it is here the resemblance to *Mitcheldeania* is so striking. The zoöidal tubes appear as long cylinders coming into and retiring from the plane of the section in accordance with the angle of inclination. There are no floors resembling "tabulæ," but the communication pores giving rise to the cribriform structure are very apparent. It is by means of a longitudinal section that the tissue-nature of the dark subdivision walls and dark patches becomes apparent. Anyone accustomed to examining sections of Palæozoic corals will at once see the resemblance between it and the wall-structure of ordinary corallites. The much narrower interstitial tubes, to which attention has already been called in describing the transverse section, are also very apparent, and their continuity is much broken from a similar cause to that affecting the zoöidal tubes, and also by the highly porous nature of the walls common to the latter and themselves. The pores are of a most variable diameter, and so abundant that the whole organism appears to consist of a mass of cribriform tissue.

On instituting a comparison with *Mitcheldeania gregaria* we find as follows:—(1) Both possess thickened walls; (2) round or oval zoöidal tubes; (3) interstitial tubes of variable shape and diameter; (4) foramina piercing the walls of both kinds of tubes; (5) increase apparently by fission; (6) even the irregular interstitial spaces are not absent from Nicholson's figure of *M. gregaria,* for in his transverse section (1G), one may be seen at the upper left-hand corner.

On the contrary—(1) the form of the organism is quite different; (2) the existence of tabulæ has not been observed; (3) the cribriform structure is far more apparent in *M. (?) cribriformis* than in *M. gregaria*; (4) there is no clear evidence of the presence of branching tubuli in the Australian form.

Nicholson called attention to the structural resemblance of *Mitcheldeania* to the Hydrocorallines, particularly to that of *Allopora.*† Later, however, this opinion

* Nicholson—Geol. Mag., *loc. cit.*, f. 1G.
† Nicholson—Geol. Mag., 1888, V (3), p. 19.

was so far modified, that a general resemblance to forms like *Parkeria* was referred to, but perhaps his concluding remark is preferable—"provisionally placed among the Hydroid Zoophytes."*

It is rather a long jump from the Carboniferous beds of the Forest of Dean and the South of Scotland to the Upper Silurian strata of New South Wales, but the community of structure of the respective organisms found there is so strong I do not hesitate to refer our fossil to *Mitchelcleania* provisionally, as *M.* (?) *cribriformis.*

*Loc. and Hor.*—I have been favoured by the Rev. Mr. Curran with the following notes on the occurrence of this interesting fossil.

The coral-like fossil comes from a limestone in the Parish of Malongulli, on the bank of the Belubula, and about eighteen miles due south of the Canobolas. The organism forms masses several feet in diameter, and it seems to me to be an old reef builder. I particularly noted any evidence that might go to show it was merely an encrusting growth, but I believe it formed solid masses.

Occurring in the same beds is the *Orthis* I send you, and which I have not hitherto found in any part of the States.

The beds from which these fossils come are below the sandstones that occur to the north with *Lepidodendron* and fish-plates, and also below the sandstones to the west with *Lepidodendron* and the *Lingula* you have described as *L. gregaria.*

The limestone also contains abundant but imperfect outlines of a large Brachiopod, two to three inches and more in diameter.

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## XXIII.—Notes on Fossil Plants from Lower Mesozoic Strata, Benolong, Dubbo District: by W. S. DUN, Palæontologist.

[Plates XLIX, L.]

DURING the survey of the Eastern Boundary of the Artesian Area in the Dubbo District, Mr. C. E. Murton has collected well-preserved plants from various localities.

The specimens from Benolong, about twelve miles from Dubbo, indicate rocks of Lower Mesozoic age without doubt, and the general appearance of the flora is somewhat similar to that of the Ipswich Coal Measures of Queensland—though the cosmopolitan *Cladophlebis denticulata* (*Alethopteris australis*) is apparently wanting, its place being taken by fronds of the *C. Roylei* type.

As is the case with most of our fresh-water Mesozoic deposits, the remains of *Thinnfeldia* are by far the most common.

Mr. J. E. Carne, Assistant Government Geologist, informs me that, in his opinion, these beds represent the lower stage of the Hawkesbury Series.

* Nicholson—Man. Pal., 3rd Edit., 1889, I, p. 202.

### Baiera, *cf.* multifida, *Fontaine.*

(Pl. XLIX, Fig. 6; Pl. L, Figs. 3, 4, 5.)

A considerable number of more or less imperfect leaves of a *Baiera* are in the collection. The segments are long, linear, venation well marked, and altogether they are of the type of *B. multifida,* Fontaine.*

Representatives of this Mesozoic genus are abundant in Eastern Australia. *Gingko bidens,* T. Woods, as figured by Shirley† would appear to be a *Baiera,* but differs from the Dunedoo specimen in the form of the leaf and in the degree of venation.

*B. Simmondsi,* Shirley,‡ which both Arber§ and Seward‖ suggest is *B. multifida,* Fontaine,¶ differs from our specimen in the fact that the veins are much more numerous and finer—otherwise the general appearance is very similar.

Owing to the relatively imperfect state of preservation, the alliance only is pointed out, leaving the final naming till more suitable specimens are obtained.

This form appears also to be very close to Pomel's B. longifolia.**

For a general discussion of the Australian forms of Baiera and Gingko, reference may be made to Professor Seward's Memoir on the Jurassic plants of Victoria.††

### Cladophlebis, *cf.* Roylei, *Arber.*

(Pl. XLIX, Fig. 3.)

This fragmentary frond does not appear to be of the same type as the widely distributed *Cladophlebis denticulata,* Bgt.,‡‡ which is so abundant in the Jurassic beds of the Clarence River, Ipswich and Gippsland coal-fields.

From an examination of the specimen it is seen that the margins of the pinnules are entire and subacute; and that the venation, which is of a definite Cladophlebis type, approaches much more closely to that of *C. Roylei,* Arber§§ (= *Alethopteris lindleyana,* Royle), than to that of *C. denticula* (= *Alethopteris australis*).

Etheridge‖‖ and Shirley¶¶ both figure this type from the Ipswich Coal Measures of Queensland.

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* U. S. Geol. Survey, Mon. VI, 1883, t. 46, 47, f. 1, 2.
† Bull. Geol. Survey, Q'land, 1898, VII, t. 19, f. 1, t. 21.
‡ *Op. cit.,* t. 3.
§ Quart. Journ. Geol. Soc., 1902, LVIII, p. 4.
‖ Rec. Geol. Survey Victoria, I, Pt. 3, p. 179.
¶ *Op. cit.*
** Flor. Foss. Terr. Jurass. France, 1849, t. 8; and also Foss. Landpflanzen Rhät. u. Jurâ form. sud west deutschlands, Paleontographica, 1907, LIV, t. 20, f. 3.
†† *Op. cit.,* pp. 177–180.
‡‡ For synonymy, &c., see Seward, Rec. Geol. Survey Victoria, 1904, I. Pt. 3, pp. 171–174; also, Lester Ward Mon. U.S. Geol. Survey, 1905, XLVIII, p. 68; Seward, B.M. Cat. Jurassic Flora, I, 1900, p. 134.
§§ Geol. Mag., 1901, VIII (4), p. 548.
‖‖ Geol. Pal. Q'land., 1892, t. 17, f. 3, 4.
¶¶ Bull. Geol. Survey Q'land., 1898, VII, t. 13, f. 1.

### Cladophlebis Roylei, *var.* Murtoni.

(Pl. XLIX, Fig. 5.)

In the fragmentary specimen figured, it will be seen that the angle of insertion of the pinnules is narrow, the axis well developed, apices acute, and the secondary venation regularly spaced, at about 45 degrees, each vein giving off two or more branches, the last dichotomy being at a regular distance from the margin.

The venation is very similar to that figured by Feistmantel* in his *A. Whitbyensis*, Goppert, but in our frond the pinnule is more acute and the axial venation more definite.

Owing to the condition of preservation, the character of the margin is not clear, but it does not appear to be denticulate, only slightly flexuous.

### Stenopteris, *Saporta.*

(Pal. Franç., Ser. 2, Plts. Jurassiques, I, p. 290.)

### Stenopteris rigida, *sp. nov.*

(Pl. L, Figs. 1, 2.)

While bearing considerable resemblance to *Sphenopteris elongata*,† Carruthers, from the Ipswich beds of Queensland, the specimens figured here are separable by their more rigid appearance, regularly pinnate form, and symmetrical dichotomy.

As has already been pointed out by Professor Seward, the reference of Carruthers' species to *Sphenopteris* is now untenable, the form coming nearest to Saporta's *Stenopteris* of the Kimmeridgian.‡

In the description of the South African forms, which are referred to the Australian species, *Stenopteris elongata*, Carr., sp., Mr. Seward remarks that "there is no well-defined median rib in the majority of the specimens, but the striated appearance of the impression and the stout form of the branches point to a plant of a more woody texture than the frond of a fern."

The median rib is very accentuated in Carruthers' figure of the Queensland specimen, and in those figured by Tenison Woods,§ Etheridge,|| and Shirley¶ there appears to be an almost complete absence of this character, bringing them more into agreement with the South African form. A similar appearance is represented in the figure of a fragment from Cacheuta, in the Argentine, published by Szajnocha.**

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* Gondwana Flora, III, t. 23a, fig. 11a.
† Quart. Journ. Geol. Soc., 1872, XXVIII, p. 355, t. 28, f. 1.
‡ Ann. S. African Mus., 1903, IV, pp. 71-74.
§ Proc. Linn. Soc. N. S. Wales, 1883, VIII, t. 8, f. 7.
|| Geol. Pal. Q'land, p. 367, t. 18, f. 8.
¶ Bull. Geol. Surv. Q'land, 1898, p. 19, t. 5, f. 2; t. 10, f. 8.
** Sitz. k. Akad. Wissen. Wien, 1888, XCVII, Abth. 1, p. 5, t. 2, f. 2.

The Benolong specimens, for which the name *Stenopteris rigida* is proposed, enable us to add nothing to Professor Seward's notes on the Stormberg specimens.

It appears justifiable, as suggested by Shirley in 1898 and Seward,* to regard Ten. Woods' *Trichomanites spinifolium* as a form of *S. elongata.*

It is of interest to note also that Feistmantel has recorded *S. elongata* from the Hawkesbury Series of New South Wales.†

### Thinnfeldia odontopteroides, *Morr. sp.*

(Pl. XLIX, Figs. 1, 2.)

The most protean of our Mesozoic ferns is *Thinnfeldia,* the variation in form of pinnule, venation, and habit of growth being such as in many instances would lead to the institution of numerous species, were not large series available for comparison.

Preliminary discussions as to the specific types and their synonymy have already been given by Feistmantel, Etheridge, and Seward, and to the last-mentioned author's latest work reference for a general synonymy and suggestions as to the affinities of the genus may be made.‡

The central type and structure, for our purposes, may be accepted as that of *T. odontopteroides,* Morris, sp., from Tasmania,§ in which the pinnules are essentially elongate, spathulate, or subacute, and the midrib has a tendency to be a marked structure. A *Thinnfeldia* of Morris' type differs radically from those described by Feistmantel‖ as *T. odontopteroides,* in which the pinnules are thick, ovate, or semicircular, and in which the venation is divergent, springing from a common point of origin in the rhachis of the pinna. This form is well developed in the sandstones and shales of the Hawkesbury Series, more especially in the upper stages—the Hawkesbury Sandstone and Wianamatta Shales. So far as I know, no specimens showing the sub-elongate type of pinnule figured by Morris have been found in the Hawkesbury or Wianamatta; certainly none of his *lancifolia* type have.

There appears to be no reasonable doubt, however, that Feistmantel's *odontopteroides* is conspecific with that figured by Morris in his Figure 3.

This Hawkesbury type of *Thinnfeldia* has been referred to by Shirley as the type of a new variety, *T. odontopteroides,* var. *normalis.*¶

It appears possible to group the Gondwana land forms of *Thinnfeldia* in certain divisions, bearing in mind that the type of venation and the presence of a more or less marked midrib is dependent necessarily on the form of the pinnule.

* *Op. cit.*, p. 71.
† Abhandl. k. Bohm. Gesell. Wissen, Prague, 1889, III (VII), p. 61.
‡ Ann. S. African Mus., 1903, IV, pp. 50–57.
§ In Strzelecki, Phys. Descr. N. S. Wales and V. D. Ld., 1845, t. 6, f. 2-4.
‖ Mem. Geol. Surv. N. S. Wales, Pal. 3, pls. 23, 24, 25, and 26, figs. 1 and 2.
¶ Bull. G. Survey, Q'land, 1893, VII, p. 21, t. 11.

I.—Thinnfeldia odontopteroides.

Morris' type form (*op. cit., supra*), spathulate pinnules with a midrib usually developed. To this may be directly compared the forms figured by :—

*Seward*, Ann. S. African Mus., 1903, IV, Pt. 1, t. 7, f. 7, 8.

(?) *Feistmantel*, Abhandl. k. b. Gesell. Wissen., 1889, VII Folge, Bd. 3, t. 1, f. 6; t. 2, f. 1 ; t. 3, f. 8.

„ Uhlonosne Utvary, Tas., t. 8, f. 10.

*Etheridge*, Geol. Pal. Q'land., 1892, t. 17, f. 1 and (?) 2.

Close to this, and probably synonymous, are :—

*T. obtusifolia*, Johnston, Geol. Tas., 1888, t. 26, f. 7, 15.

*T. caudata*, *ibid.*, t. 26, f. 20.

*T. odontopteroides*, *ibid.*, t. 25, f. 1, 4.

The *lancifolia* and *indica* types to be referred to later on are a direct transition from this type of frond, and possibly intermediate is the Narrabeen type, with very large, subacute pinnules, with definite midrib.

Ettingshausen's *rhomboidalis* is a type not far separated.

II.—Thinnfeldia odontopteroides.

Feistmantel's type, already referred to. Pinnules subovate, decurrent, venation springing from the rhachis tending to become centralised in a point of origin ; pinnules decurrent and occasionally alate.

Under this group come the forms figured by :—

*Seward*, *op. cit.*, t. 7, f. 1 ; t. 8, f. 7, 8 ; t. 11, f. 2.

*Szajnocha*, Sitz. k. Akad. Wissen. Wien., 1888, XCVII, t. 1, f. 1, 2, 3.

*Feistmantel*, Abhandl. k. b. Gesell. Wissen, 1889, Folge 7, Bd. III, t. 1, f. 1–5 ; t. 2, f. 3.

„ Mem. Geol. Survey N. S. Wales, Pal. 3, 1890, t. 24 ; t. 25 ; t. 26, f. 1, 2, 2a ; t. 28 ; t. 29, f. 1.

„ Uhlon. Utv. v. Tas., 1890, t. 8, f. 5–9 t. 8, f. 11. = *Pecopt. caudata*, Johnston.

*Etheridge*, R. Junr. in Brown's Rept , 4. Leigh's Creek, 1891, t. 2, f. 1, 2.

„ Contrib. Pal. S. Austr. No. 12, 1902, t. 1.

*Pecopteris odontopteroides*, Carruthers, Quart. Journ. Geol. Soc. 1872, XXVIII, t. 27, f. 2, 2a, 3.

*T. odontopteroides*, var. *triangulata*, Shirley, Bull. Geol. Surv. Q'land, 1898, No. 7, t. 10, f. 2.

„ var. *normalis*, *ibid.*, *op. cit.*, t. 11.

*T. Feistmantelli*, Johnston, Procs. R. Soc. Tas., 1895, f. 2.

*T. polymorpha*, Johnston, *op. cit.*, f. 16.

(?) *T. subtrigona*, Feistmantel, Pal. Ind. Gondw. Flora, 1879, I, Pt. 4, t. 1, f. 7.

*T. obtusifolia*, Johnston, Geol. Tas., 1888, t. 25, f. 7, 9, 14 ; t. 26, f. 17, 21.

*T. caudata*, Johnston, Geol. Tas., t. 25, f. 13 ; t. 26, f. 6.

*T. sp.*, Johnston, Geol. Tas., t. 25, f. 3.

### III.—Thinnfeldia (*lancifolia* and *indica*).

Elongate-pinnule type, showing a tendency to formation of a distinct midrib, and spathulate or acute, decurrent or subpetiolate. Two main types—*T. lancifolia* and *T. indica.*

#### (i) *Lancifolia* type.

*T. odontopteroides*, Morris, *op. cit.*, t. 6, f. 3 (spathulate).

*T. lancifolia*, Morris, var. *op. cit.*, t. 6, f. 4 (obtuse, spathulate, decurrent).

,, Szajnocha, *op. cit.*, t. 1, f. 4b, 5, 6, 7. [= *T rhomboidalis*, Ett.]

(?) ,, Seward, Rec. Geol. Survey Vic., 1904, I, Pt. 3, t. 17, f. 29.

#### (ii) *Indica* type.

(Pinnules, acute and subacute, subpetiolate, decurrent.)

*T. indica*, Feistmantel, Pal. Indica, Gondw. Flora, I, 1877, t. 39, f. 1 ; t. 46, f. 1, 2.

,, var. *media*, Shirley, Bull. Geol. Survey, Q'land, No. 7, t. 5, f. 1 (acute, subpetiolate).

,, ,, *aquilina*, Shirley, *ibid.*, t. 6, f. 1 (decurrent).

,, ,, *falcata*, Shirley, *ibid.*, t. 7, f. 2 (markedly decurrent).

(?) *T. odontopteroides*, var. *superba*, Johnston, Proc. R. Soc. Tas. for 1885, p. 372.

*T. superba*, Johnston, Geol. Tas., 1888, t. 26, f. 415.

*T. odontopteroides*, Johnston, Geol. Tas., 1888, t. 25, f. 2.

*T. media*, Johnston, Geol. Tas., 1888, t. 24, f. 5.

*T. Buftoni*, Johnston, Proc. R. Soc. Tas., 1895, f. 18.

*T. media*, Johnston, Proc. R. Soc. Tas., 1885, p. 373.

Seward, Rec. Geol. Survey Vic. 1904, I, No. 3, t. 17, f. 29.

*T. media*, T. Woods, Proc. Linn. Soc. N. S. Wales, 1883, VIII, t. 6, f. 1.

*T. falcata*, *ibid.*, t. 8, f. 1.

*Gleichenia lineata*, *ibid.*, t. 8, f. 2.

(?) ,, *dubia*, Feistmantel, Mem. Geol. Survey, N. S. Wales, Pal. 3, t. 27, f. 3.

Feistmantel, Mem. Geol. Survey N. S. Wales, Pal. 3, t. 29, f. 2, 3, 4.

*T. media* (?), R. Etheridge, Geol. Pal. Q'land, t. 17, f. 2.

,, R. Etheridge, fil., and Mesoz. Foss. Cent. Austr. (S. Austr. Parl. Papers, 1893), t. , f. 14.

IV.—Thinnfeldia trilobita, *Johnston.*

Johnston, Proc. R. Soc. Tas. for 1885, p. 372.

,, Geol. Tas., 1888, t. 26, f. 12 ; t. 24, f. 6.

Feistmantel, Uhlon. Utvary v. Tas., 1890, t. 8, f. 12.

,, Abhandl. k. b. Gesell. Wissen, 1889, Folge 7, Bd. III, t. 2, f. 2.

V.—Thinnfeldia (?) caudata, *Johnston.*

Geol. Tas., 1888, t. 26, f. 1 and (?) 2.

VI.—Thinnfeldia McCoyi, *Seward.*

Rec. Geol. Survey Victoria, 1904, I, Pt. 3, t. 17, f. 28.

VII.—Thinnfeldia saligna, *Schenk.*

Feistmantel, Uhlon. Utvary v. Tas., t. 8, f. 13.

(?) = Pecopteris caudata, Johnston.

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## XXIV.—On a New Labyrinthodont from Oil Shale at Airly: by A. SMITH WOODWARD, LL.D., F.R.S., of the British Museum.

[Plate LI.]

LABYRINTHODONT remains have already been recorded from the Hawkesbury Formation of New South Wales,* but each new specimen of so imperfectly known a group of fossils is worthy of study and description. The greater part of a skeleton, apparently of a new species, discovered in the Commonwealth Oil Corporation's shale mine at Airly, has therefore been submitted to me for examination by the Government Geologist.

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* *Bothriceps australis*, T. H. Huxley, Quart. Journ. Geol. Soc., Vol. XV (1859), p. 647, pl. xxii, fig. 1. *Mastodonsaurus* (?), W. J. Stephens, Proc. Linn. Soc. N. S. Wales, Ser. 2, Vol, I (1886), p. 932. *Platyceps wilkinsoni*, W. J. Stephens, *loc. cit.*, Vol. I (1887), p. 1175, pl. xxii.

This skeleton is completely flattened by pressure and exhibited in the counterpart halves of a slab of kerosene shale. Most of the bony tissue is preserved, thus causing the fossil to be conspicuous in the rock and easily photographed (Pl. LI); but details are obscure, and the greater part of the limbs and tail are lacking. The head is broken away from the trunk, and the number of vertebræ in front of the pectoral limbs is thus not exactly determinable. With the skeleton are mingled the carbonised remains of plants, including *Glossopteris.*

The head is so much flattened that the parasphenoid is crushed into contact with the cranial roof, while the occiput has slipped backwards. The snout is short and rounded, while the occipital border is nearly straight, with very little indication of auditory notches. The orbits (*orb.*) are ovate, with the long axis directly antero-posterior; and for the greater part of their length they are within the front half of the skull. The interorbital width is about equal to the orbital length. The pineal foramen cannot be seen, owing to the peculiar flaking of the cranial roof and the adpressed parasphenoid. There are traces of the usual ornamentation, in which antero-posteriorly radiating ridges are the most conspicuous, though some reticulation can be distinguished. Epiotic cornua are not clear, but they may have been obscured by the crushing, which has pushed backwards the lower part of each epiotic bone (*epo.*), with the exoccipital (*exo.*) beneath it. The slender mandibular rami (*md.*) are partly seen at the side of the skull, but the teeth cannot be distinguished and must have been small.

The original condition of the vertebral column is uncertain, but the notochord must have been completely surrounded by thin, smooth ossifications, which were either a series of cylinders or the more numerous elements of a "rhachitomous" arrangement. The ribs are short and curved, with a small unossified core, and not expanded at the distal end, where they appear to have been tipped with only partially ossified cartilage. In the hinder half of the trunk they begin to shorten, and seem to become somewhat less curved.

There are at least seven rib-bearing vertebral segments in advance of the remains of the pectoral limb. The humerus (*h*) is a slender bone, slightly constricted at its middle, and evidently capped with much cartilage at each end. The length of the ossified part, both of the radius and the ulna, somewhat exceeds half the length of the ossification of the humerus. One fragment of bone (*x*) may perhaps be part of a scapula, but otherwise there is no trace of the pectoral arch. The remains of the pelvic limbs occur at about the twentieth vertebra behind the pectorals, but they are too obscure for interpretation.

No dermal armour is seen.

This new skeleton evidently represents an Archegosaurian, but differs from such typical members of the family as *Archegosaurus* and *Actinodon* in the shape of the ribs, which are not expanded at the distal end. Its skull agrees very closely with the Australian specimen already described as *Bothriceps australis*, and there is no reason why it should not be referred to the same unsatisfactorily known genus. It may even belong to the same species as the skull in question; but since the state of preservation does not permit accurate comparison, and since the relative size of its orbits appears to be slightly smaller, the Airly specimen may best receive the new name of *Bothriceps major*. The roof of the skull measures 15 cm. in length whereas that of the type species has a length of only 8 cm., and the skulls of *Bothriceps huxleyi*,* from the Karoo formation of South Africa, are still smaller.

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## XXV.—The Trilobite *Illænus* in the Silurian Rocks of New South Wales: by R. ETHERIDGE, Junr., Curator of the Australian Museum, Sydney.

Two species only of this interesting genus of Trilobites have been recorded from the Silurian rocks of Australasia. Prof. L. G. de Koninck described a pygidium (tail) from the Upper Silurian at Boree, New South Wales, which he provisionally referred to *I. wahlenbergianus*, Barr.,† and a glabella by the writer from the Despatch Limestone (Silurian) at Zeehan, Tasmania, as *I. Johnstoni*.‡

The Mining and Geological Museum has lately been enriched by the presentation of portions of three cephalons in a flesh-coloured limestone, from Borenore, near Orange, collected and presented by Miss L. Sweet, of the latter town.

The body rings of this Trilobite are not preserved, and therefore their number is unknown, the character on which, Mr. J. W. Salter founded his sub-genera; still, the positions of the eyes, facial sutures, and the length of the axal furrows indicate *Illænus* proper as the section for the reception of this fossil. It is of the type of *I. Murchisoni*, Salter,§ and I refer it to *I. Johnstoni*, mihi, with the following augmented description:—

### Illænus Johnstoni, *Eth. fil.*

*Illænus Johnstoni*, Eth. fil., Tasmania. Report Secretary for Mines for 1895–96 (1896), p. xliii, pl., f. 3.

*Sp. Chars.*—Cephalon (of which the posterior margin is not preserved) 25 mm. long, by 36 mm. wide (approximately), very convex both longitudinally and transversely; front, although rounded, is very steep, almost straight-walled; surface

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* R. Lydekker—Catalogue of Fossil Reptilia and Amphibia in the British Museum, Pt. IV (1890), p. 172, fig. 41.
† De Koninck—Foss. Pal. Nouv. Galles du Sud. 1876. Pt. 1, p. 70.
‡ Etheridge—Tasmania. Report Secy. for Mines for 1895–6 (1896), p. xliii, pl., f. 3.
§ Salter—Mon. Brit. Trilobites, Pt. 4, 1867, pl. 26, f. 1, *a* and *b*.

equally divided into three lobes by the axal furrows, the glabella proper, and the two free cheeks. Axal furrows do not extend forwards beyond the anterior margins of the eyes, and are separated from the latter by spaces of 4 mm.; their entire course is not preserved, but what is so, is straight; the depth is not uniform, but opposite each eye is an oblong depression representing the anterior glabella furrows, and backward from these two others, the anterior ends of which just fall short of the posterior eye margins; these represent the middle pair of glabella furrows. Eyes small, narrow, and faintly crescentic, with shallow depressions beneath them. Facial sutures are imperfectly semicircular, with slight sigmoidal curvatures in front of the eyes. Free cheeks are obtusely-deltoid, and steeply inclined, the posterior margins apparently simply rounded and non-lobate. In advance of and alongside the eyes the surface of the glabella is micro-pitted, giving place posteriorly to fine anastomosing raised lines; the free cheeks are similarly pitted.

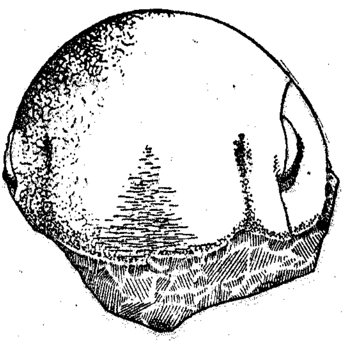

FIG. 1—Cephalon viewed from above.

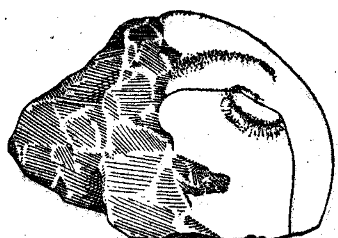

FIG. 2—Cephalon viewed from the side.

*Obs.*—This Trilobite cannot possibly be the species recorded by De Koninck, for in the latter the posterior angles of the free cheeks are produced into short spines; here the latter are broadly rounded. From the cephalon of *I. Murchisoni*, Salter, our specimen differs in the form of the free cheeks, outline and proportions of the eyes, and by a somewhat less rounded antero-posterior curvature along the middle line. In the former the facial sutures are decidedly sigmoidal, here, almost straight and oblique; the axal grooves are also far more pronounced in relation to the size of the cephalon than in the European species, *I. wahlenbergianus*, Barr.*

The closest allies I can find are *I. Esmarki*, Schlotheim,† and *I. Dalmani*, Volborth,‡ of the East Baltic Silurian. In both instances the form of the cephalon is the same, but the facial sutures resemble those of the former more than they do those of the latter.

* Barrande—Syst. Sil. Boheme, I, p. 684, pl. 34, f. 19*a*—25.
† Holm—Mém. Acad. Imp. Sci. St. Petersbourg, 1886, XXXIII (7), No. 8, p. 47, pl. 1, f. 1-6.
‡ Holm—*Ibid.*, p. 93, pl. 1, f. 7-14.

The Tasmanian form, *I. Johnstoni*, of which the type is before me, is based on imperfect material, but the size and form, so far as it can be gauged, and position and length of the axal furrows, induce me to believe it to be identical with the New South Wales cephalon; were the facial sutures of the former visible, a more definite opinion could be advanced.

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# XXVI.—Notes on the Physiography and Geology of the North-eastern Watershed of the Macquarie River: by L. F. Harper, F.G.S., Geological Surveyor.

[Plates LII, LIII.]

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Whilst examining a large area of gold-field reserves in the Counties of Wellington and Roxburgh, an opportunity to observe the physiography, and study the geology of the area passed over, was afforded, the following notes being the result of observations made and deductions arrived at.

It may be pointed out that time did not permit of a detailed examination of the whole of the area traversed, nor the continuous tracing of rock boundaries over an extensive belt of country; but sufficient information was obtained to give a clue to the geology of the district visited, whilst the physiographical notes are tentative, pending a more extensive examination of the whole watershed of the Macquarie.

Although every opportunity to check levels was availed of, they must be taken as approximate only.. Unfortunately, palæontological evidence was not always obtainable in the differentiation of the Silurian and Devonian systems; but from comparison with their contact in other parts of the State, one has no hesitation in stating that the lithological difference in the rocks of these two periods is so marked, that after a close association and careful study there is not much difficulty in defining their boundaries.

Sufficient palæontological evidence was obtained, however, to considerably increase the area hitherto assigned to the Devonian rocks.

## Physiography.

The country examined is practically the north-eastern watershed of the Macquarie River, and extends down that river to the junction of the Cudgegong.

Portion of the main Dividing Range of the State, extending from Rydal to Capertee, forms the eastern boundary of the area dealt with, and this is crossed by the Mudgee railway line, at Piper's Flat and Capertee, the altitude of the former being 3,089 feet above sea level, whilst the latter is 2,641 feet. Naturally the railway crosses the Divide in gaps, and the Sunny Corner and adjoining spurs reach an altitude of over 4,000 feet. There is evidence to indicate the existence of one great peneplain level from the Dividing Range to Wellington.

Even the headwaters of the Macquarie River do not drop very rapidly, and no falls of more than a foot or two were observed, but the grade becomes less and less as the stream is descended. The Macquarie River has an altitude of 1,500 feet above sea level at the junction of the Turon, and the level at the Cudgegong junction is about 1,000 feet. The distance separating the two points is fifty-four miles along the course of the river, which gives an average fall of only 9¼ feet per mile approximately.

It is considered that the Macquarie River is a *consequent stream*, resulting from the protracted uplift of the main Dividing Range, which resulted in one plain sloping gently to the west and another more steeply to the east. A number of isolated and connected mountain ranges and table-lands still remain as evidence of this western peneplain, and Sunny Corner, Cherry Tree Hill, Hill End, and Hargraves may be cited as examples.

The uplift gradually decreased east and west of the Dividing Range axis, with the result that the original grade of the plain approached that of the present river system; and whilst the eastern slope was much steeper, the western slope was far more gradual and unbroken. It is estimated that the Macquarie River peneplain, as it is proposed to call the western fall, sloped towards the west at a grade of about thirty-seven feet per mile, whilst the eastern slope would have averaged fifty feet per mile were it not for the north and south faulting and folding at the foot of the Blue Mountains, which practically reduces the actual slope to fifty miles, or a grade of eighty feet per mile.

Subsequent streams formed as the Macquarie deepened its channel, as represented by the Turon and Cudgegong Rivers.

It would seem probable that the Dividing Range uplift commenced in the early Tertiary period, and was maintained throughout the greater part of that period, with occasional protracted stages of quiescence.

The evidences in favour of this interpretation are the presence of at least two distinct lava flows and drift beds, separated by about one thousand feet vertical distance, both flows being considered to be of Tertiary age, and the fact that the river, after cutting through the second lava flow, has formed the present bed six hundred feet below it.

It appears probable that even in early Tertiary times the present Macquarie River valley contained at least three principal streams, uniting in their lower reaches to form one large river. These three streams are now represented by the headwaters of the Macquarie proper, the Turon, and the Cudgegong Rivers respectively. The evidence in favour of this supposition is the presence of Tertiary basalt and drift in each of the three branches, many feet above the present streams, but approximately following their channels, and separated by high land uncapped by basalt.

Thus we have in the Cudgegong Valley the Gulgong basalt; in the Turon, the Cherry Tree Hill and Monkey Hill basalts; whilst the main Macquarie Valley contains basalt at Hill End and Edge Hill.

These lavas have been classified as belonging to the *Early Tertiary flows*, whilst the lower basalts in the Macquarie Valley proper may be spoken of as the *Later Tertiary flows.*

After the early Tertiary lavas had filled up the principal valleys, the uplift continued slowly, and the streams proceeded to cut new channels in the basalts, and regrade the unfilled valleys.

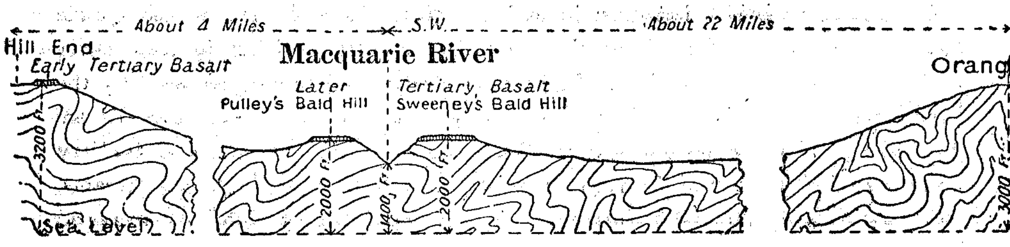
Sufficient time elapsed before the later Tertiary flows were outpoured, to permit of the rivers cutting a channel through the first lavas and several hundred feet into the underlying rocks.

The later tertiary basalt then filled up the main valley of the Macquarie River, but not that of the Turon and Cudgegong. It would seem probable that at this stage the two latter rivers had not been thoroughly graded, but the lava flows down the Macquarie, together with the uplift, would accomplish the grading.

Nature then resumed her work with the streams, and eventually cut through the later Tertiary basalt, and at least six hundred feet into the underlying strata. At this stage, the uplifting movement of the Divide appears to have practically ceased, and the rivers reaching base level were no longer able to remove all the waste from the uplands, with the result that the Macquarie River below, even if not above, the Turon junction, had to regrade itself in the accumulated beds of drift, thus becoming a *filled valley*, the present stream being at least thirty feet above the old valley bed.

This has been proved within the area worked by the gold dredges, for an old channel, thirty feet below the present river, meanders across the present stream course, and at times passes beneath the flood-plain banks.

Plate LIII serves to show the interpretation of the physiographical features of this area, whilst the section face of the diagram indicates roughly the geological features of part of the east and west watersheds.




Transverse section across Macquarie River.

The absence of the early Tertiary basalt on the right-hand side of the section is explained by it having flowed down the left-hand tributaries only, and was not sufficient in volume to flood the peneplain, but its contemporary is found along the Western railway line from Orange.

## Geology.

The geological examination was of necessity very restricted, but sufficient evidence was obtained of several interesting points to justify their being placed on record, and it is with the hope that the observations may prove of sufficient value to afford a working basis for any future geological survey of this area that these notes have been compiled.

The geological formations met with are as follows :—

*Sedimentary.*

1. Silurian—(*a*) Ordovician (?) slates, schists, and tuffs; (*b*) Upper Silurian, dark blue shales, siliceous slates, quartzites, and limestones.
2. Devonian—Quartzites, sandstones, siliceous shales, conglomerates, and limestones.
3. Permo-Carboniferous—Conglomerates, sandstones, and shales, with coal seams.
4. Mesozoic—Sandstones and shales.
5. Tertiary—River gravels.

*Igneous.*

*a.* Contemporaneous flows.
   1. Silurian lavas.
   2. Devonian ,,
   3. Tertiary ,,

*b.* Intrusive.
   1. Granites and porphyries.
   2. Diorites.
   3. Dolerite.

1. *Silurian.*

(*a.*) The western portion of the area examined consists mostly of slates and tuffs. The slates are in places highly compressed and fissile, thus giving rise to what is known as a "knife-edged" outcrop. They occasionally become silicified, with the result that the cleavage planes are largely lost, and a more solid and compact rock occurs. In places quite a gneissic or schistose character was observed, as in Clear Creek, Parish of Winburn, County Roxburgh.

The beds are all very much folded, and several well-marked anticlines and synclines occur. It is in the slates thus folded that the auriferous reefs of Hill End, Hargraves, Quartz Ridge, and Long Creek are found.

The prevailing Silurian rock throughout a large portion of the area examined is a massive tuff, and this class of rock predominates in the belt of country on the east side of the Macquarie River, extending from the Turon to the Cudgegong River.

The tuffs are very massive as a rule, and exhibit few bedding planes, but the joint faces are pronounced. In appearance they are medium-grained in texture, and mottled dark grey in colour. In places the tuffs become very arkose in character, and the component parts are almost entirely individual quartz and felspar grains, very slightly waterworn.

On the other hand, the rock is found exhibiting all the characteristics of a normal tuff, and the coarse fragments of volcanic rock embedded therein are distinctly seen. The tuffs at times, in hand specimens, have all the appearance of a quartz-felspar-porphyry, and even in the field the examination of isolated areas would lead one to think that they were of the nature of an intrusive rock. A more extensive examination of large areas discloses the fact that they are of a sedimentary nature, for alternating belts of tuff and slate are seen to merge both laterally and longitudinally into one another. The marginal zones of the respective rocks occasionally consist of alternating thin bands of tuff and slate.

From field observations the writer is inclined to consider the tuffs as of a true sedimentary or redistributed nature.

A belt of country about twelve miles wide was found to consist mainly of tuffs, with a steeply inclined dip, and it is probable that this great apparent thickness is to be accounted for by the beds repeating themselves, due to sharp anticlines and synclines.

Ascending Tucker's Hill, on the Mudgee-Hargraves Road, a very good section of the strata is seen. At the foot of the hill slates predominate, and indications of ripple marking were observed. Tuff bands are interbedded with the slates, but towards the summit the former rocks predominate.

At the 21-mile post, contemporaneous lava is seen, and at least two successive flows were observed. Massive tuffs then occur up to the 23-mile post, when the belt of slates running through Hargraves is encountered, and it is in these slates that the auriferous saddle reefs occur. Though occasional massive quartz reefs are found in the tuffs, it is noticeable, in the area examined, that no payable reef has yet been found in these rocks.

With such an abnormal development of tuffs, a number of lava flows intercalated with them would be expected; but such is not the case, for although several occurrences of that nature were observed, they are not numerous. These flows are referred to under the heading "Silurian Lavas" (6).

The persistent northerly and southerly strike of the Silurian rocks throughout the area examined is most noticeable, and ten degrees either way is the most they depart from a longitudinal strike, with a dip mainly to the west.

(*b*) *Upper* (?) *Silurian Rocks.*—Within the watershed of Cheshire Creek, about fourteen miles northerly from Bathurst, a series of rocks somewhat resembling the Devonian strata occur. They consist of shales, siliceous slates, and quartzites, with beds of limestone. A number of fossils have been collected from these beds, and sufficient evidence obtained to classify them as of distinctly Silurian age.

It is difficult to reconcile these Silurian beds with the dense tuffs and slates lying to the north-west, and it would seem probable that they are of Upper Silurian age, whilst the beds lying to the north-west are very probably much older, and may even be contemporaneous with the Ordovician rocks of Cadia and Mandurama districts.

### 2. *Devonian.*

The beds of this age within the area examined differ very much from the adjoining Silurian rocks. Palæontological evidence was not found over the whole area, but the marked lithological dissimilarity to the Silurian rocks, and the continuity observed, would appear to indicate that the area hitherto assigned to Devonian beds within the belt of country examined must be considerably extended.

The boundaries on the accompanying sketch map are necessarily imperfect, as it was only within certain areas that a junction was determined, whilst other parts were not visited. The information obtained, however, was sufficient to justify an attempt to more correctly fix the boundary of this system within the area visited.

The most characteristic features of the Devonian rocks in this area are their high state of silicification, the presence of beds of massive purple conglomerates, and the predominance of quartzites.

The angle of dip of these beds was found to vary from three degrees in an easterly direction to almost vertical, but the easterly dip predominates, whilst the strike, like that of the Silurian beds, is longitudinal.

There is a very marked unconformity between the Devonian and Ordovician (?) rocks throughout the area examined, but it was not found so pronounced between the Devonian and the Upper (?) Silurian rocks of Cheshire Creek.

The base of the Devonian beds is marked in places by a horizon of tuffs, varying in thickness, whilst the conglomerates occur much later.

Contemporaneous lava flows are very numerous, and have been dealt with under a separate heading.

The quartzites are sometime highly vitreous in appearance, and the individual component grains hardly distinguishable, but a gradation from almost a normal sandstone was observed.

The purple conglomerates form well-marked horizons in places, and one bed was found extending from the Turon River, in Parish Dulabree, to the boundary of Parish Castleton, a distance of about sixteen miles, whilst the thickness may be estimated at about three hundred feet.

The conglomerates consist mainly of boulders of igneous rocks, closely cemented by silica and iron oxide, the whole having a purplish tint, due to the presence of iron. Associated with the conglomerates in places are beds of purple shales and quartzite.

Quartzites and sandstones predominate at the southern end of the area examined, and in the Parish of Castleton a large area composed of these rocks was examined, and numerous fossils found, *Rhynconella pleurodon* and *Spirifer disjuncta* predominating.

Extending from Palmer's Oaky to Mitchell, a series of lenticular patches of Devonian limestone are met with. The rock appears to be very siliceous as a rule, and the beds are irregular in shape and size.

About eight miles east of this limestone horizon, several patches of limestone of excellent quality have been opened up in the neighbourhood of Portland.

Subsequent to the geological survey of the country in the neighbourhood of Portland, the operations of the Commonwealth Portland Cement Company revealed the presence of strata of undoubted Silurian age in the pit now (1908) being worked for shale on portions 52 and 80, Parish Cullen Bullen. Mr. E. C. Saint-Smith, geological field assistant, has recently made an examination of the locality, and has arrived at the conclusion that the occurrence represents a small inlier of Silurian shale, surrounded by limestones of Devonian age and conglomerates belonging to the Upper Marine Series. The dip of the beds constituting the inlier was found to vary from E 10 S to E 50 S at 26 degrees. As suggested by him this inlier might very possibly represent a portion of strata forced up from a depth by the porphry which is seen outcropping in the vicinity along Willawa Creek. The presence of decomposed porphyry in a prospecting hole, sunk by the company about 150 yards away in a northerly direction from the shale pit, seems to strengthen this suggestion, as also the fact that the shales pass rapidly into hard blue slate as the quarry increases in depth. Additional evidence of the near proximity of an igneous intrusion at this spot seems to be afforded by the presence of quartz veins, averaging 10 to 12 inches in width, traversing the shale. The extent of the inlier, as proved up to the present by quarrying operations, is about 160 yards in length by 50 yards in width. The most abundant fossil found was the Trilobite *Phacops meridianus*, and the attention of the Department was drawn to this interesting occurrence by Mr. W. Kelly, of the public school, Portland, who first collected from this horizon. Good specimens of *Actinoceras* are likewise found in the shale.

With regard to the extension of the Devonian rocks towards Mudgee, it is to be regretted that no palæontological evidence as to the age of the beds north-west and south-east of that town was obtained.

The only reasons for classifying them with the Devonian beds are their lithological resemblance and the apparent conformity with which they can be traced into known Devonian rocks.

The boundary given is only very approximate, as no opportunity to examine the beds in detail has so far presented itself.

*Permo-Carboniferous.*

On some of the high land along the eastern portion of the area examined, beds of Permo-Carboniferous age occur.

These have already been examined or surveyed by Mr. J. E. Carne, F.G.S., Assistant Government Geologist, and it is therefore unnecessary to indicate even their approximate position on the accompanying map. Outliers of the Upper Marine Series, consisting of sandstones and conglomerates, are found resting on the upturned edges of the Devonian beds, but no difficulty is experienced in distinguishing these beds when examining any extent of country.

The fresh-water beds of the Permo-Carboniferous period throughout the area visited are mostly thin, and the coal seams inferior in quality and limited in extent.

*Triassic.*

Rocks of this age also occur on portions of the main Dividing Range within the area under consideration, and these also have already been mapped by Mr. Carne.

*Tertiary.*

No palæontological evidence as to the geological age of the drift beds above the present river channels was obtained, but the Gulgong drifts have been proved to be of this age, and there is very little doubt that the high-level drifts all belong to the Tertiary period.

That this period is represented by at least two stages is amply borne out within the area examined, but it was not found possible to determine the ages, and they have been referred to as the early and later stage. The Tertiary beds within the area under consideration consist almost entirely of beds of river gravel capped by basalt; but on the high ranges in Parish Turon, occasional thin belts of horizontally bedded ferruginous shales and sandstones were seen resting on the upturned edges of the Devonian rocks, and the writer is inclined to classify them as of Tertiary age.

It was not found possible to correctly estimate the thickness of the Tertiary drifts, as no good exposed face was seen.

The early and later drift beds have both received attention from the miner, and extensive work has been carried out under the later Tertiary basalt along the Macquarie River.

The great drawback to the profitable working of these drifts, which are known to contain gold gems and diamonds, has been the difficulty of obtaining water for sluicing purposes.

Efforts have been made to both pump water from the Macquarie River to the drift (about six hundred feet above) and to send the wash down to the river, but the great cost, together with the uncertain commercial value of the drift, has hitherto resulted in the industry not paying continuously.

Efforts are at present being made at Monkey Hill, Parish of Cunningham, County Wellington, to thoroughly test the early Tertiary drift.

The Mount Wells Gold and Gem Company are driving a tunnel under Monkey Hill, some feet below the bottom of the drift, which they are testing by means of "jump-up" bores every few feet apart.

The tunnel was in five hundred feet at the time of my visit, and several encouraging prospects had been obtained.

Gem sand containing gold, monazite, and a diamond has been proved, but sufficient work had not been done to prove the presence of payable gutters.

Although numerous diamonds have been obtained in the present bed of the Macquarie River and tributaries, diamond mining has never become an industry of that region.

In view of the comparatively small and isolated belts of Tertiary drifts now remaining, it is evident that a very large area of them must have been ground-sluiced by Nature, and the gold and gem contents concentrated into the present river channels. Such being the case, the Tertiary drifts cannot be expected to prove as rich as the present river drift, and the hopes of discovering rich deposits of either gold or gems in them is consequently discounted.

Of the two Tertiary drifts, however, there should be better prospects in the later drift than the early one, and there appears no reason, once the water difficulty is surmounted, why they should not be profitably worked.

### *Igneous Rocks.*

The igneous rocks within the area visited may be classified as follows :—

*a.* Contemporaneous Lava Flows—

1. Silurian. 2. Devonian. 3. Tertiary.

*b.* Intrusive—

1. Granites and Porphyries. 2. Diorites. 3. Dolerite.

It was not found possible to make an extensive collection of the above rocks, nor has a microscopic examination yet been made of all the specimens collected, so only a brief description of their mode of occurrence is given.

#### *a.* Contemporaneous Lava Flows.

1. *Silurian Lava Flow.*—Notwithstanding the great development of tuffs in the Silurian rocks of this district, only a few insignificant contemporaneous lava flows were identified. It is probable that a more detailed examination would reveal a number of others.

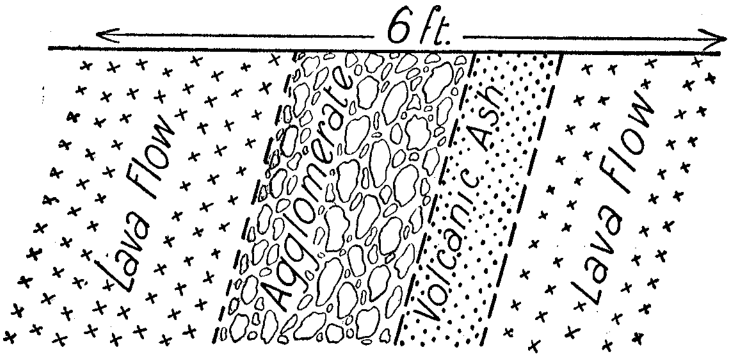
Near the 21-mile post on the Mudgee-Hargraves Road, at least two successive flows were observed, with a total thickness of between three hundred and four hundred feet.

In a tunnel being driven under Monkey Hill, in the Parish of Cunningham, County Wellington, a belt of igneous rock about ten feet thick has been cut. The rock proved to be a highly crushed quartz-felspar-porphyry, and it appears very probable that it was poured out as a lava flow during Silurian times.

In the neighbourhood of Hill End, several occurrences of quartz-felsites are to be found in the belt of slates containing the saddle reefs, and field evidence points to their being contemporaneous lavas.

2. *Devonian Lava Flows.*—Within the area examined, an extensive development of Devonian lava sheets are found.

These lavas consist of augite, andesite, felsite, rhyolites, &c., and that they are contemporaneous lava flows is borne out in many places where good outcrops are found. The best exposure indicating their origin was seen near Portion 2, Parish Dulabree, County Roxburgh, about one mile south of the Turon River. In a creek bed in the above portion, the following section was observed :—




Other good sections of the flows, with beds of volcanic ash, or agglomerate, are seen on the Turon River at the south end of Portion 1, Parish Stewart, County Roxburgh, and ascending Palmer's Oaky Creek, about two and three-quarter miles above its junction with the Turon River.

In the neighbourhood of the village of Cudgegong, a further development of what are considered to be Devonian lavas are found. The area was not examined to any extent, but by comparison with other contemporaneous lavas in the area examined, the writer feels justified in assigning this origin to the occurrence.

3. *Tertiary Lava Flows.*—There are evidences of at least two distinct periods during which Tertiary lavas invaded the earlier valleys of the Macquarie River system.

As has been pointed out in the physiographical portion of this paper, it is proposed to call the older flows the "early Tertiary," and the younger ones the "later Tertiary" lavas.

*Early Tertiary Lavas.*—It is considered that the early Tertiary lavas were poured out during that period, and subsequent denudation has left them about 1,600 feet above the present rivers.

There would seem to be two distinct classes of lava belonging to the early Tertiary period, but not both occurring together ; and whilst that of Cherry Tree Hill is more acidic, and resembles a tinguaite, the Hill End, Monkey Hill, and Tatuali, or Edge Hill, rock is a typical olivine basalt.

Six disconnected and widely-separated exposures of early Tertiary lava were located, but their contemporaneity is thought to be borne out by physiographical relations.

The absence of any corresponding lavas in the main Macquarie River channel above the junction of the Turon River would seem to indicate that these lavas had emanated from a source somewhere north-east of the Wallerawang-Mudgee railway line, and flowed down the north-easterly branches only into the Lower Macquarie River.

The greatest remaining thickness observed in these lavas is on Monkey Hill, where a thickness of two hundred and twenty-five feet was measured.

The later Tertiary lavas consist of a dark blue basalt, and are only found in the valley of the Macquarie River proper.

They occur as a capping to a number of hills on either side of the Macquarie River, and are spoken of locally as Bald Hills. This name was assigned to them in all probability from the fact that in many cases the timber has been cleared to improve their grazing capacity.

Eleven disconnected exposures were located, but there is very little doubt that they originally formed one extensive sheet covering the later Tertiary bed of the Macquarie River.

Subsequent denudation has removed the greater part of these lavas, and now only disconnected masses, averaging about one hundred feet in thickness, remain as evidence of these once extensive flows.

From the fact that the later Tertiary lavas were not found above the junction of the Turon and Macquarie Rivers, it is considered that their source was situated to the westward of that point, and may have been in the neighbourhood of the Canoblas Mountains, Orange District, where volcanic vents are known to occur.

The evidence in favour of there being two Tertiary periods of flow within the area under consideration is based largely on physiographical features, for from the nature of their original mode of occurrence (they occupy separate river valleys) the flows could not occur more closely associated.

Evidence in favour of the two periods of flow is best seen at Hill End, Bald Hill, and Pulley's Bald Hill, situated above the Macquarie River, in the south-west corner of Parish Ulmarrah, County Wellington.

At the Hill End Bald Hill the early Tertiary basalt is one hundred and eighty feet thick, and occurs at an elevation of about 3,200 feet above sea level, whilst Pulley's Bald Hill basalt is about 2,000 feet, and has a thickness of one hundred feet approximately.

These two points are six miles apart, and there is no evidence of the intervening country having been faulted. A similar occurrence is seen between Tatuali Mountain and Suttor's Bald Hill, Parishes of Tatuali and Trianbil, County Wellington.

*b.* Intrusive Rocks.

1. *Granites and Porphyries.*

(*a*) *Bathurst Granite.*

The boundaries of this rock within the area included in the accompanying sketch map were not traced out, but only seen in a few places.

W. J. Clunies Ross, B.Sc., F.G.S., in a paper read before the Australian Association for the Advancement of Science (Proceedings, ii, p. 420), estimates the area occupied by this granite to be something like four hundred and fifty square miles, but only a small portion of this area is included in the country examined. Quartz, felspar, and muscovite mica are the principal constituents, and the rock is medium-grained in texture, but great variations, both in component minerals and texture, were observed.

Granite predominates in the south-west corner of the map, and from the fact that it is seen intruding the Devonian rocks near Yetholm, it is considered that this rock, like many of our New South Wales granites, is of Carboniferous age.

(*b*) On the main road from Capertee to Mudgee, in Parish Tabrabucca and adjoining parishes, an extensive intrusion of granite occurs.

The rock is very coarse in texture, and in places becomes a porphyritic granite.

The component minerals are quartz, felspar, and biotite mica, some of the felspar crystals being nearly three centimetres in length, and Carlsbad twinning is noticeable. The quartz is somewhat smaller in grain, whilst the mica crystals are of normal granite dimensions.

The intrusion is first seen near the 30-mile peg on the Capertee–Mudgee Road, and is continuous until Aaron's Pass is descended, and the 24-mile post passed. The northern boundary was not seen, but the southern termination is passed over at one point, about one and a half miles from the main road, on the road to Crudine.

(*c*) In Parish Avisford another granite intrusion occurs, but an examination was not made of this area.

(*d*) Several intrusions of a porphyritic rock occur in the neighbourhood of Sunny Corner; and in Parish Castleton, a rock consisting of porphyritic crystals of quartz and pink felspar embedded in a dark-coloured groundmass is to be seen.

2. *Diorites.*—

(*a*) Ascending Tobin's Oaky Creek, in the Parish of Dulabree, an intrusion of a dioritic rock occurs. There is no great extent of this rock, and outcrops are all very weathered.

(*b*) On the Sofala-Hill End Road, near the 35-mile post, in Parish Cunningham, County Wellington, a small patch of a dioritic rock is seen. The rock is very decomposed, and the mode of occurrence was not determined, but it is probably an intrusive dyke.

(*c*) On the Sydney-Bathurst Road, near the village of Yetholm, a dioritic rock occurs, forming the northern boundary of the granite referred to under *b*, 1 (*a*). This occurrence may prove to be a phase of the granite; but, on the other hand, a more detailed examination of that area might reveal the presence of a diorite dyke.

3. *Dolerite.*—

On Boiga Mountain, in Parish of Baiga, County Wellington, an extensive occurrence of a doleritic basalt is seen. This exposure forms a plateau, some nine hundred acres in extent, and well marked prismatic structure was observed near the centre of the table-land.

No conclusive evidence as to the origin of the occurrence was obtained; but from its isolated position, the fact that as regards level it does not fit in with either of the Tertiary lava flows, the entire absence of drift round the sides of the mountain, and the distinctive character of the rock, the writer is inclined to assign an intrusive origin.

In conclusion, I would like to express my indebtedness to Mr. G. H. Legge, Staff Surveyor in the Lands Department, who accompanied me throughout my inspection. Mr. Legge has an extensive knowledge of the area dealt with, and his knowledge was of great assistance in the sketching of formation boundaries.

With regard to the remarks on the physiography of the area dealt with, I have to acknowledge the assistance given by Mr. E. C. Andrews, B.A., Geological Surveyor.

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## XXVII.—On some Microzoa from the Wianamatta Shales, New South Wales; by FREDERICK CHAPMAN, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne.

[PLATE LIV.]

INTRODUCTORY REMARKS.—The minute fossils about to be described have been obtained from a hard, grey, calcareous shale, by crushing the rock immersed in water. The organic particles are very numerously distributed throughout, appearing as myriads of minute white granules. For the greater part, the original shape of these small organisms is lost, on account of their being preserved only as casts. In several instances, however, the actual shell remains, and those selected are examples of such.

For the rock-sample containing these specimens I am indebted to Mr. W. S. Dun, who sent it me about six years ago. It was put aside for a time, because of the unsatisfactory nature of the specimens then obtained. Another, more careful, search has now resulted in the present interesting series of specimens. These undoubtedly represent a brackish or estuarine fauna, having a curious intermingling of Rhaetic and Lower Jurassic types, with others more properly referable to the Upper Palæozoic of Europe.

### *Description of the Fossils.*

### OSTRACODA.

Family *Beyrichiidæ.*

*Genus.*—BEYRICHIA, *McCoy.*

*Beyrichia mesozoica*, sp. nov.

(Plate LIV, figs. 1*a*, *b*.)

*Description.*—Valve subtriangular, tapering anteriorly, rounded at both ends. Anterior lobe moderately tumid and rounded in outline; median lobe narrow, with a slightly curved margin, above which is the broadly depressed median sulcus; posterior lobe large, almost reniform, and swollen. The middle of the latter lobe forms the thickest part of the valve. Carapace seen edgewise, generally wedge-shape, with a deep depression in the middle. Surface smooth.

*Dimensions.*—Length, ·384 mm.; greatest height, ·23 mm.; greatest thickness of carapace, ·154 mm.

*Remarks.*—Besides the figured specimen, other fragments were noticed in the washings, which seem to point to the existence of this interesting form in some numbers; but the fragility of the carapace and the poorness of its preservation renders it impossible to procure a satisfactory number for purposes of comparison. The figured valve is hollow and the structure is calcareous; the shell is of a pale greenish tint.

*Affinities.*—No described species of *Beyrichia* appears to approach the present excepting *B. siliqua,* T. R. Jones.* In this little Silurian species the median lobe is narrow, and traverses the median area obliquely, whilst in our specimen it is broad, and confined to the ventral side of the valve. The similarity of the contracted anterior in both species is very striking. This appears to be the first occurrence of a *Beyrichia* in rocks of undoubted Lower Mesozoic age. In Europe it is unknown from deposits later than the Carboniferous. The Ordovician and Silurian species are typically tuberculate, whilst the Carboniferous species are often smooth.

* "Notes on the Palæozoic Bivalved Entomostraca. No. 1. Some species of Beyrichia from the Upper Silurian Limestone of Scandinavia." Ann. Mag. Nat. Hist., Ser. ii, 1855, p. 90, pl. v, fig. 22.

Family *Darwinulidæ.*

*Genus.*—DARWINULA, *G. S. Brady.*

(?) *Darwinula australis,* sp. nov.

(Plate LIV, figs. 2*a*, *b*.)

*Description.*—Carapace small; seen from the side, elongately suboval; anterior extremity obliquely rounded at the dorsal angle, more evenly at the ventral angle; posterior extremity evenly rounded. Dorsal margin slightly curved, ventral long and straight. Edge view of carapace elongate-ovoid; the overlapping of the right valve is not seen, as the specimen is imperfectly preserved, being a cast.

*Dimensions.*—Length, ·125 mm.; height, ·125 mm.; thickness of carapace, ·154 mm.

*Affinities.*—In general form the above species resembles *Darwinula globosa,* Duff sp.*, from the Rhaetic of Linksfield, N.B.; but is altogether broader, whilst the dorsal and ventral margins are more nearly parallel. Two examples were found, one of which has since been lost.

Family *Cytheridæ.*

*Genus.*—CYTHERIDEA, *Bosquet.*

(?) *Cytheridea* cf. *moorei,* Jones.

(Pl. LIV, fig. 3.)

*Cytheridea moorei,* Jones, 1894, Quart. Journ. Geol. Soc., L, p. 165, pl. IX, figs. 7 *a-c*, 8 *a*, *b*.

The specimen here doubtfully referred to the above species is a cast or replacement of an ostracod generally resembling that form, but it is not very well preserved. Professor Jones' example came from the English Rhaetic of Beer Crowcombe. The Rhaetic specimens generally show a large amount of variability, and ours agrees in its straight ventral border with fig. 8 on plate IX, *loc. cit.*, whilst in the evenly rounded extremities it is like fig. 7*a*.

## FORAMINIFERA.

Family *Miliolidæ.*

*Genus.*—NUBECULARIA, *Defrance.*

*Nubecularia nitida,* sp. nov.

(Pl. LIV, figs. 4*a*, *b*.)

*Description.*—Test minute, compressed; commencing with an irregular spiral series of chambers; somewhat angulated at the periphery at each septum. Rectilineal series short (in the present specimen there is only one segment).

*Dimensions.*—Length, ·27 mm.; breadth, ·173 mm.

* "On the Rhætic and some Liassic Ostracoda of Britain," T. R. Jones, Quart. Journ. Geol. Soc., 1894, L, p. 163, pl. ix, figs. 3, 4*a*, *b*,

*Affinities.*—This species resembles in some respects the form referred by Messrs. Jones and Parker* to *N. tibia*, from the Lias of Chellaston (formerly recorded as Trias).

*Remarks.*—The genus, besides occurring in the Carbo-Permian of New South Wales, Tasmania, and Western Australia, is also found in other secondary rocks in England as well as the Lias before mentioned, as for instance in the Oxford clay of Weymouth, where the shells of *Gryphæa*, &c., are often partially covered with a reticulum formed of the adherent tests of a species of *Nubecularia*. Dr. H. B. Brady has recorded it from the Upper Lias of Banbury, in Oxfordshire (Walford coll.).

### Family *Lituolidæ*.

### *Genus.*—HAPLOPHRAGMIUM, *Reuss.*

### *Haplophragmium emaciatum*, Brady.

(Pl. LIV, fig. 5.)

*H. emaciatum*, Brady, 1884, Chall. Rep., IX, p. 305, pl. XXXIII, figs. 26–28.

Chapman, 1895, Ann. Mag. Nat. Hist, Ser. 6, XVI, p. 315, pl. XI, fig. 6.

Chapman and Howchin, 1905, Mem. Geol. Surv. N.S.W., Pal. No. 14, p. 7, pl. I, figs. 10*a*, *b*.

The thin, compressed test of our example at first sight makes it seem comparable to *H. foliaceum*, Brady. It differs substantially, however, in having the spirally arranged central series partly hidden by the outer whorls, and in the fewer chambers. *H. emaciatum* has been recorded from the Carbo-Permian of New South Wales, from the Rhaetic of Somerset, England, the Upper Jurassic of Switzerland, and the Upper Greensand of Guildford. In recent soundings it occurs in moderately deep water.

### *Genus.*—ENDOTHYRA, *Phillips.*

### *Endothyra* cf. *globulus*, *d'Eichwald*, sp.

(Pl. LIV, figs. 11*a*, *b*.)

*Nonionina globulus*, d'Eichwald, 1860, Lethæa Rossica, I, p. 350, Esp. 24, pl. XXII, figs. 17*a–c*.

*Endothyra globulus*, d'Eichwald sp., Brady, 1876, Pal. Soc. Mon. (Carb. and Perm. Foram.), XXX, p. 95, pl. V, figs. 7–9.

Our fossil is comparable with the above species in all respects, except the subangulate periphery. It is a well-known form in the Carboniferous series of England and Scotland, and it also occurs in rocks of the same age in Belgium and Russia.

* "On some Fossil Foraminifera from Chellaston, near Derby," Quart. Journ. Geol. Soc., 1860, XVI, p. 455, pl. xx, figs. 48–51.

Family *Rotaliidæ.*

*Genus.*—DISCORBINA, *Parker and Jones.*

*Discorbina* cf. *parisiensis*, d'Orbigny sp.

(Pl. LIV, figs. 6*a–c*.)

*Rosalina parisiensis*, d'Orbigny, 1826, Ann. Sci. Nat., VII, p. 271, No. 1; Modèle, No. 38.

Our specimen shows nearly all the characters of the living and the fossil Tertiary examples, with the exception that it has fewer chambers than usual, and a slight concavity of the inferior surface.

*Discorbina cymbaloporoides*, sp. nov.

(Pl. LIV, figs. 7*a-c*.)

*Description.*—Test subcircular, surface convex on the superior, more or less concave on the inferior, surface, and excavated in the region of the umbilicus; periphery bluntly keeled. The superior aspect shows the last series of chambers only; the inferior, the last and vestiges of the penultimate whorl interlocked. This latter feature, and the presence of numerous chambers with straight sutures, suggests the specific name, in its resemblance to the inferior aspect of *Cymbalopora tabellæformis*, Brady.

*Dimensions.*—Greatest width, ·423 mm.; thickness of test, ·154 mm.

*Affinities.*—One of the nearest related forms of *Discorbina* to the above is *D. saulcii*, d'Orb. sp., which, however, has the whole of tho whorls of the superior face visible.

*Genus.*—TRUNCATULINA, *d'Orbigny.*

*Truncatulina boueana*, d'Orbigny.

(Pl. LIV, figs. 10*a-c*.)

*T. boueana*, d'Orbigny, 1846, Foram. Foss. Vienne, p. 169, pl. IX, figs. 24–26. Brady, 1876, Pal. Soc. Mon. (Carb. and Perm. Foram.), p. 139, pl. VI, fig. 11.

A typically-shaped example occurs in the Wianamatta Shales, and is generally comparable with the specimens described by Brady from the Belgian Carboniferous, excepting in having fewer chambers.

*Genus.*—PULVINULINA, *Parker and Jones.*

*Pulvinulina insignis*, sp. nov.

(Pl. LIV, figs. 8*a*, *b*; 9.)

*Description.*—Test compressed, elongate-ovate. Periphery rounded; inferior surface flat and depressed in the central area, with the sutures straight and radially arranged; upper surface convex, with a few straight sutures, and with an apertural slit extending across the periphery on one side. Apex of shell faintly marked by a circlet. General surface smooth.

*Dimensions.*—Length of longest specimen, ·48 mm.; breadth, ·308 mm.; thickness, ·115 mm.

*Remarks.*—This peculiar species seems to be most nearly related to *P. haueri*, d'Orb. sp. but instead of having obliquely curved septa, they are, in our species, nearly straight, and of subequal length. This form is moderately frequent in the Wianamatta Shales.

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## XXVIII.—Notes on a Collection of Graptolites from Tallong, New South Wales: by T. S. HALL, M.A., D.Sc., University of Melbourne.

[Plate LV.

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I HAVE to thank Mr. E. F. Pittman, the Government Geologist, for the opportunity of examining the graptolites dealt with in this report. They were found by Mr. J. E. Carne, Assistant Government Geologist, at Tallong, on the Upper Shoalhaven River, about nine miles from Marulan Railway Station. They are preserved in a highly siliceous blue shale, which was so hard that it turned the edges of my tools, and made it impossible to further expose concealed parts.

The following species occur:—

*Dicellograptus elegans*, Carruthers.

*Dicellograptus*, sp.

*Dicranograptus nicholsoni*, Hopkinson.

*Dicranograptus hians*, T.S.H., var. *apertus*, nov.

*Dicranograptus* cf. *cyathiformis*, Elles and Wood.

*Dicranograptus*, sp.

*Diplograptus carnei*, T.S.H.

*Diplograptus foliaceus*, Murchison.

*Climacograptus bicornis*, J. Hall.

*Climacograptus*, sp.

*Cryptograptus tricornis*, Carruthers.

*Glossograptus quadrimucronatus*, J. Hall.

### REMARKS ON THE SPECIES.

The identification of the Dicranograptedæ is a matter of considerable difficulty, and in spite of the revisions of Miss Elles and Miss Wood, and of Ruedemann, considerable doubt still exists as to the limits of many species. The former writers attach great weight to the form of the thecæ, but these seem to be always so badly preserved in shale or slate that the criterion fails.

*Dicellograptus elegans.*—The differences between this species and *D. affinis*, mihi, are very slight, and I am not sure whether *D. affinis* is more than a variety, with longer basal spines.

*Dicranograptus hians*, var. *apertus*, nov.—I was at first inclined to refer this to *D. arkansasensis* (Gurley),* but he says the biserial portion is 9 mm. long, and Ruedemann refers it to *D. ramosus* as a variety.† The specimens before me have the biserial portion respectively, 2, 3, and 4 mm. The last specimen, of which counterparts are preserved, is doubtfully referred to this species. As far as I can judge from the material, the species is spinose, while *D. arkansasensis* is not. It resembles then *D. hians*, mihi, and differs in the much wider angle between the uniserial portion (see Fig. 1).

*Dicranograptus* cf. *cyathiformis.*—This form resembles *D. cyathiformis*, E. and W.‡ The form shown in Fig. 2c by Miss Elles and Miss Wood is only doubtfully referred by them to that species, so that I quote the identification with reserve, the appearance of the hydrosome being so different from that of the type form (see Fig. 2).

*Diplograptus foliaceus* and *Glossograptus quadrimucronatus* are, according to Ruedemann, very easily confused.§ Ruedemann moreover gives reasons for referring Hall's *Graptolithus quadrimucronatus* to *Glossograptus*. My material does not throw any light on the question.

*Climacograptus bicornis.*—This is the typical form, with rather short basal spines.

*Cryptograptus tricornis.*—I omitted this species from the Stockyard Creek list. It occurs there, but is not common, and is, of course, a species that is easily passed over, unless one is familiar with it.

*Climacograptus*, sp.—I have figured (Fig. 3) a species, of which severa pecimens occur, but which I am unable to identify. It is, I think, new, bu not well, enough preserved for description.

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* Ann. Rep Geol. Surv. Arkansas, for 1890 (1892), v. 3, p. 416, pl. 9, f. 1, 2.
† N. Y. State Museum, Memoir II, 1908, p. 329.
‡ Pal. Soc. Mon. Brit. Grap. pt. 4, 1904, pl. 25, f. 2c.
§ *Loc. cit.*, p. 390.

The grouping of the fossils is very similar to that at Mount Wellington and the Thomson-Jordan District in Victoria, and closely resembles that of the other New South Wales localities already dealt with in these Records. At present, we are unable to subdivide the Upper Ordovician of Australia. It is quite unsafe to apply the facts of distribution of Europe and America to our rocks, in spite of all the definite opinions to the contrary.

Sydney: William Applegate Gullick, Government Printer.—1909.

# PLATE XLI.

Productus (?) subquadratus, *Morris.*

Fig. 1. Pedicle valve, showing the large diductor scar and marked median sulcus. From a plaster model of Morris' type.

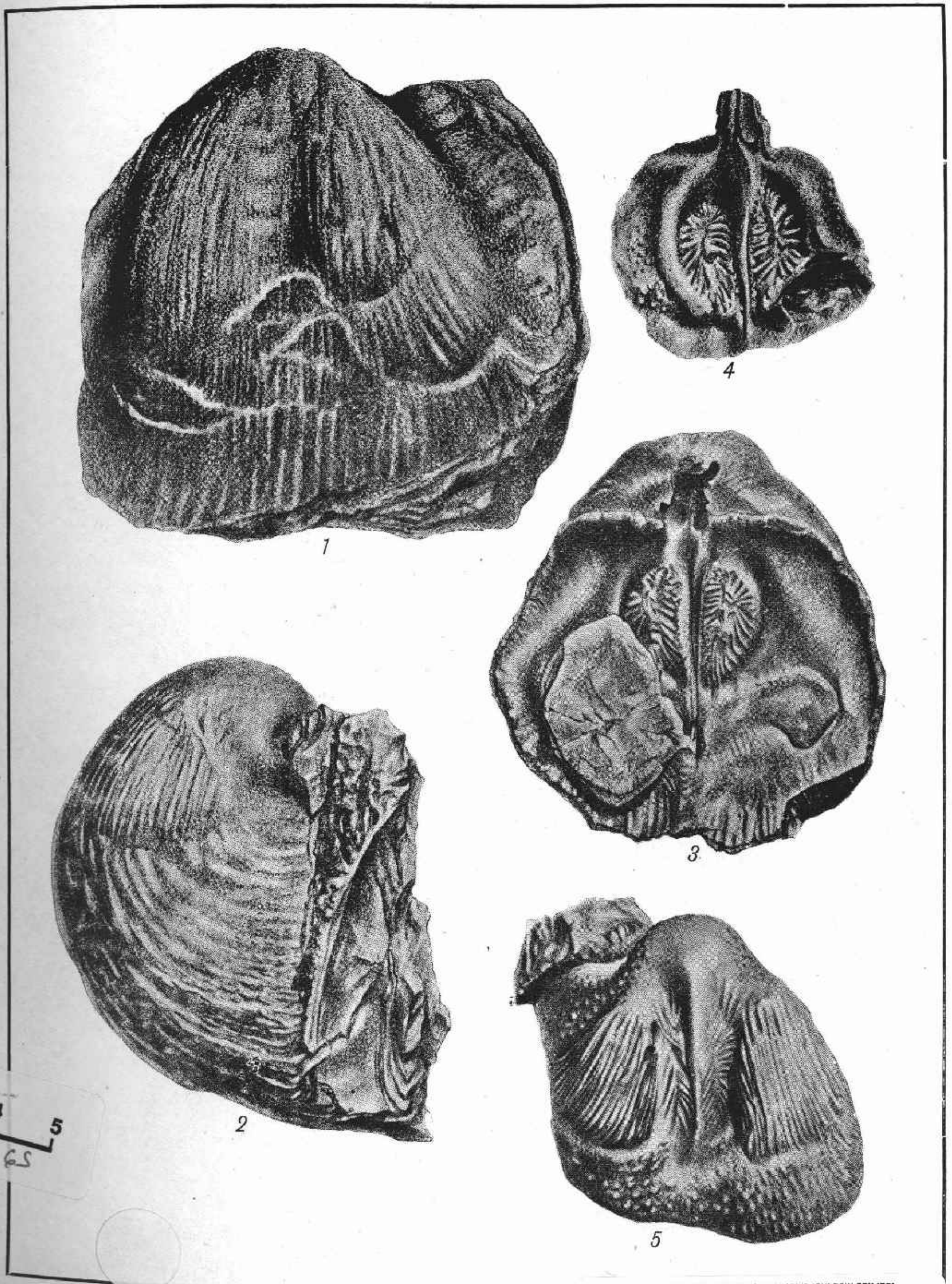
Fig. 2. Side view of pedicle valve, showing the flank extension of the diductor scar; Mt. Britton gold-field, Queensland.

Fig. 3. Internal cast, showing the brachial valve structures—the space left by the prominent cardinal process, the median septum, the dendritic adductor scars, and the brachial impressions; Mt. Britton, Queensland.

Fig. 4. Wax impression of specimen figured in fig. 3, showing the form of the cardinal process, &c. The process is more markedly bifid than is shown by the impression.

Fig. 5. Internal cast of pedicle valve, showing the diductor and anterior and posterior adductor scars; Mt. Britton, Queensland.





# PLATE XLII.

*Productus brachythærus, G. B. Sby.*

Fig. 1. Pedicle valve of partially decorticated specimen, showing the auriculate flanks; from Dapto.

Fig. 2. Var. *elongatus*, showing the relatively greater length of the shell; Shoalhaven Heads.

Fig. 3. Var. *elongatus*. Side view of specimen shown in fig. 2.

Fig. 4. Typical form, showing the breadth of the valve, and the spine bases, prominent on the ear-like expansions.

Fig. 5. Brachial valve of typical form, showing the well-marked lateral expansions and the long hinge margin; Golden Age Mine, Boorook.

Fig. 6. Typical form, showing the ornamentation; Nowra.

Fig. 7. Var. *elongatus*. Internal cast of the pedicle valve, showing the diductor scars and the curvature. F. 102.

Fig. 8. Typical form; pedicle valve, showing the spine bases. F. 1316.

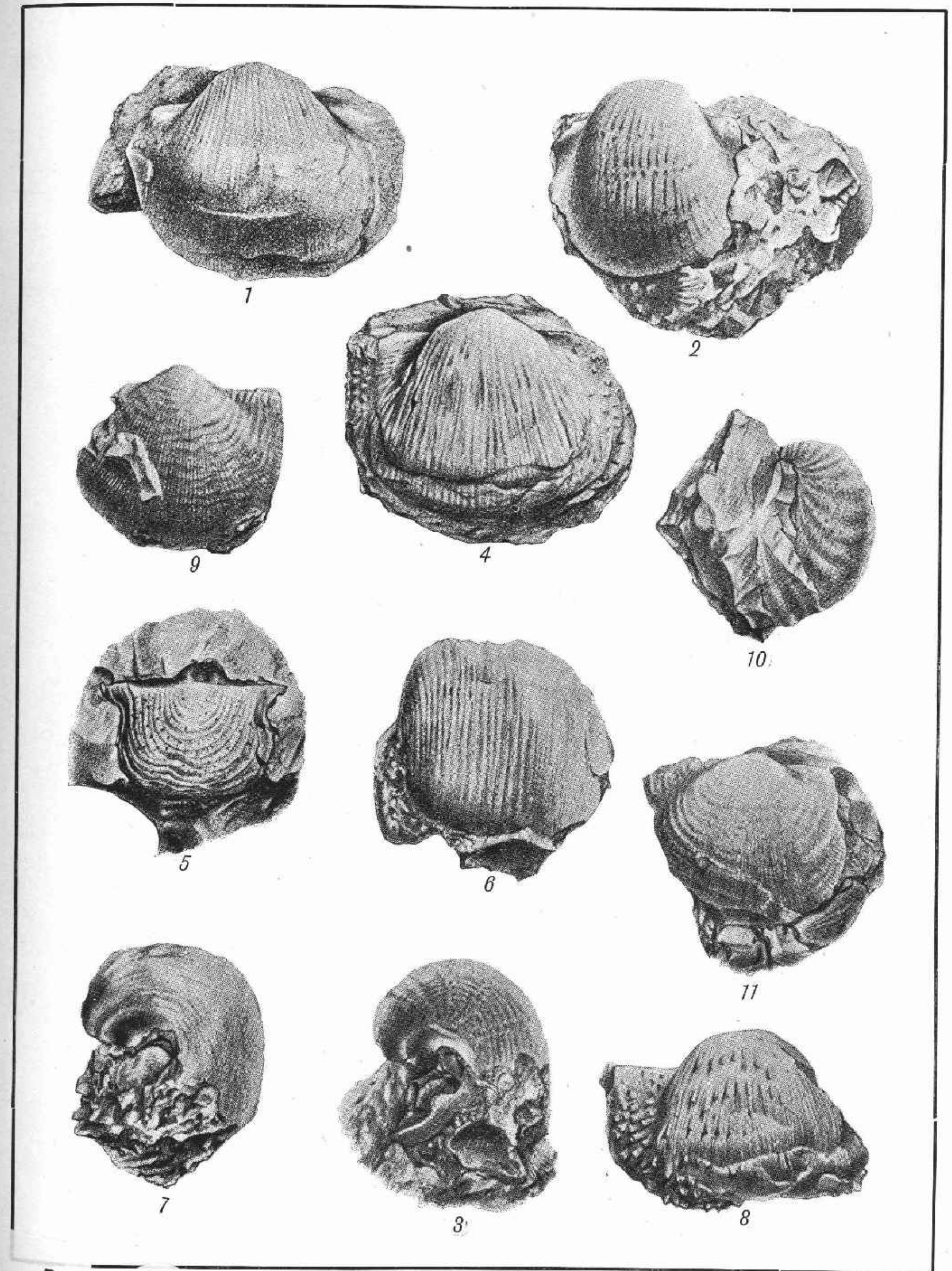
*Productus cora, var. farleyensis, nov.*

Fig. 9. Pedicle valve, showing the ornamentation, the long hinge line, and the ear-like expansions. Farley.

Fig. 10. Side view of pedicle valve, showing the fine striate ornament and the transversely wrinkled surface. F. 260.

Fig. 11. Pedicle valve of specimen shown in fig. 10.





# PLATE XLIII.

Productus (?) solida, *sp. nov.*

Fig. 1. External view of pedicle valve.

Fig. 2. Internal view of the same valve, showing the hinge line, the great thickness of the valve, and the vascular markings.

Fig. 3. Pedicle valve, showing the hinge line—x 2.

Fig. 4. Crushed pedicle valve, showing the great thickness. Figs. 1–4 from Don (?) River, Queensland.

Productus brachythærus, *var.* elongatus *nov.*

Fig. 5. Pedicle valve in profile. F. 2374.

Fig. 7. Pedicle valve showing the contour of beak region.

Productus brachythærus, *G. B. Sby.*

Fig. 6. Internal mould of brachial valve, showing the extent of the septum. F. 1158.

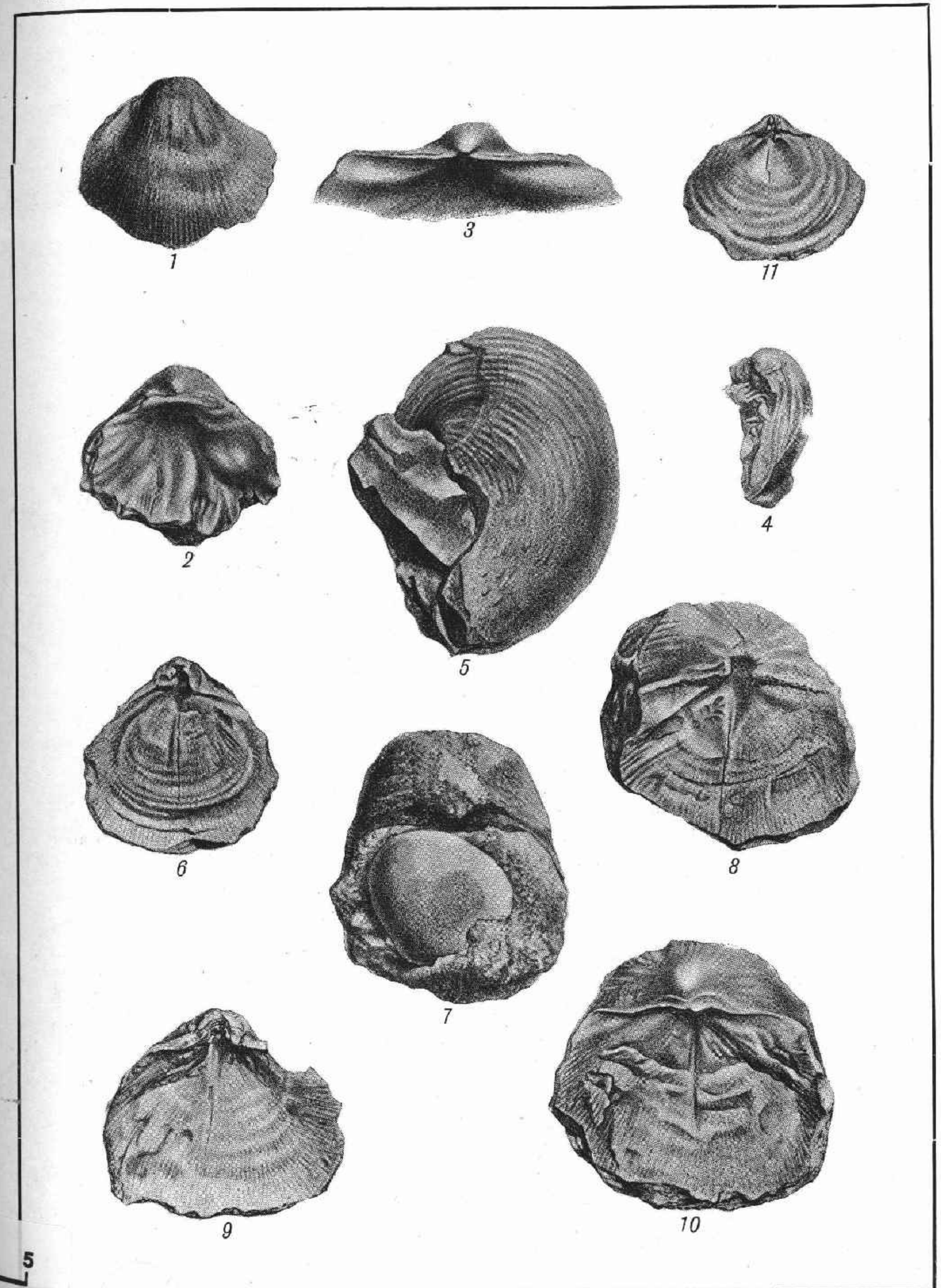
Fig. 8. Internal mould of brachial valve, showing the septum extending almost to the margin of the valve. F. 10936.

Fig. 9. Internal mould of brachial valve, showing the septum extending almost to the margin of the valve. F. 10945.

Fig. 10. Internal mould of brachial valve, showing the septum extending almost to the margin of the valve. F. 10937.

Fig. 11. Another specimen showing the septum extending only about half way to the margin. F. 10943.





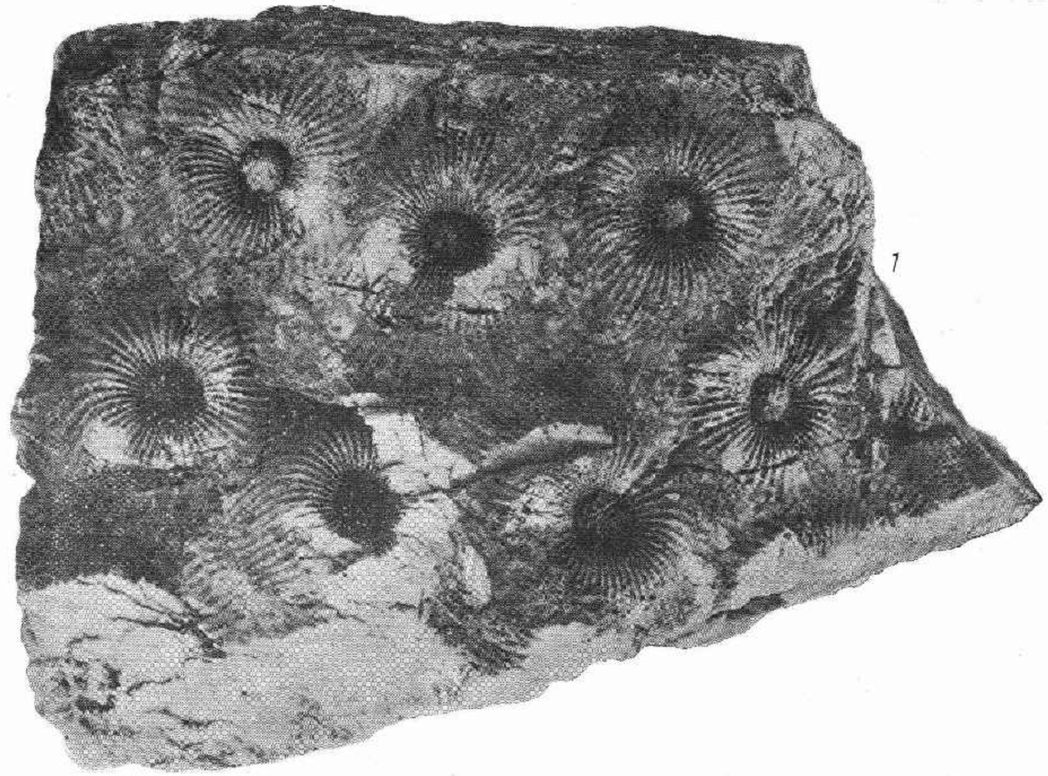
# PLATE XLIV.

Arachnophyllum (?) epistomoides, *Eth. fil.*

Fig. 1. Portion of a corallum exhibiting the outline of the corallites as indicated by the extent of the septal ridges, the crateriform appearance of the calices, and the central columellarian boss.

Fig. 2. Longitudinal section prepared for the microscope. In the centre of the figure is a corallite, and on either side the copious intercalicular tissue ; on the corallite may be seen the upwardly directed vesicular tabulæ—x 3.





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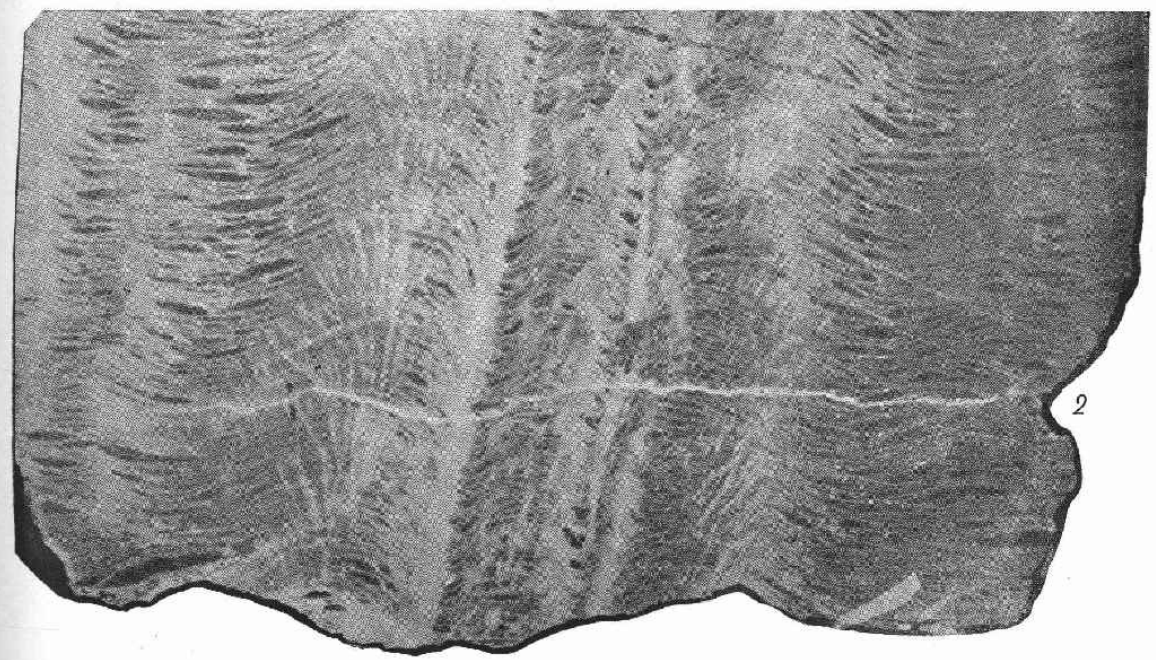

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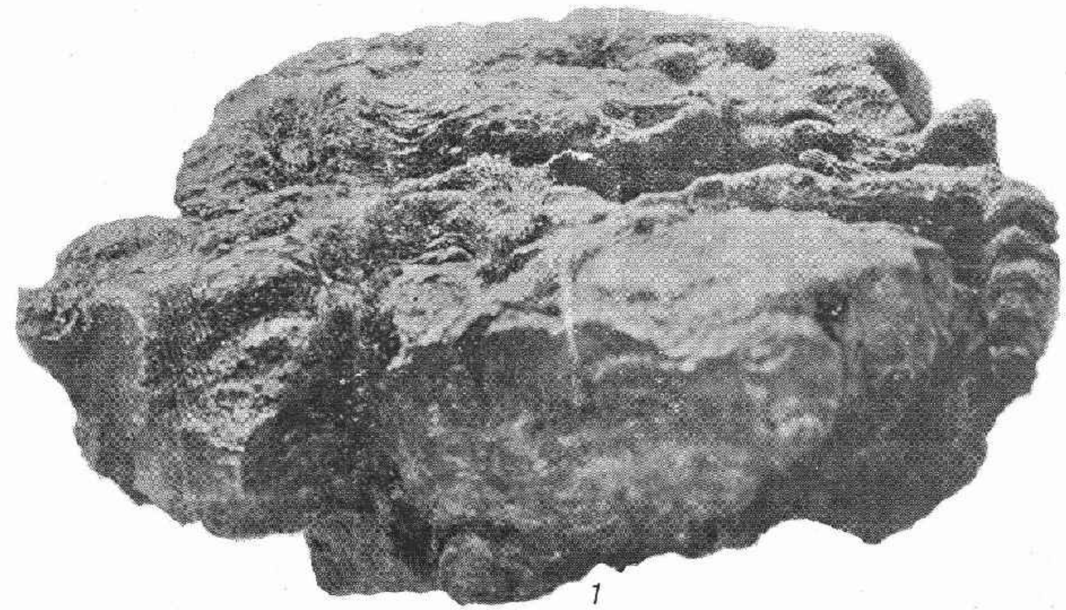
# PLATE XLV.

Arachnophyllum (?) epistomoides, *Eth. fil.*

Fig. 1. Portion of a weathered corallum, taken rather obliquely to show the superimposed laminæ and vesicular tissue; several visceral chambers are also visible.

Fig. 2. Portion of another weathered corallum in natural longitudinal section, with a visceral chamber exhibiting septa in the centre, and passing from it the invaginated superimposed laminæ and vesicular tissue.





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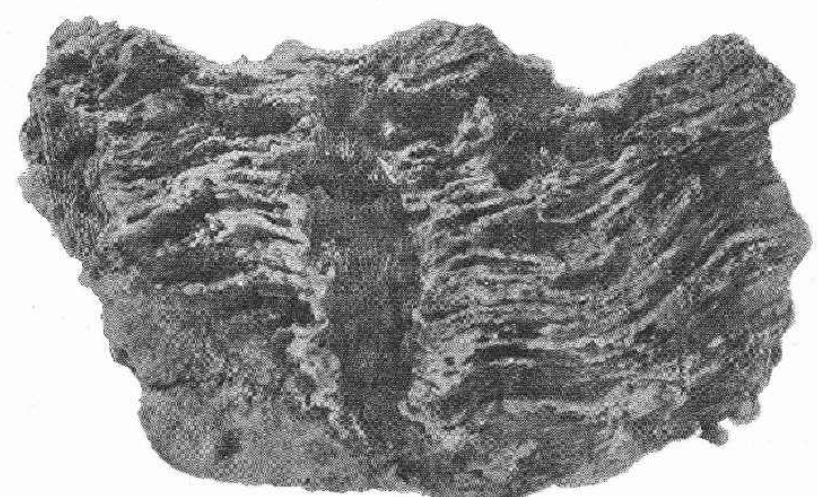

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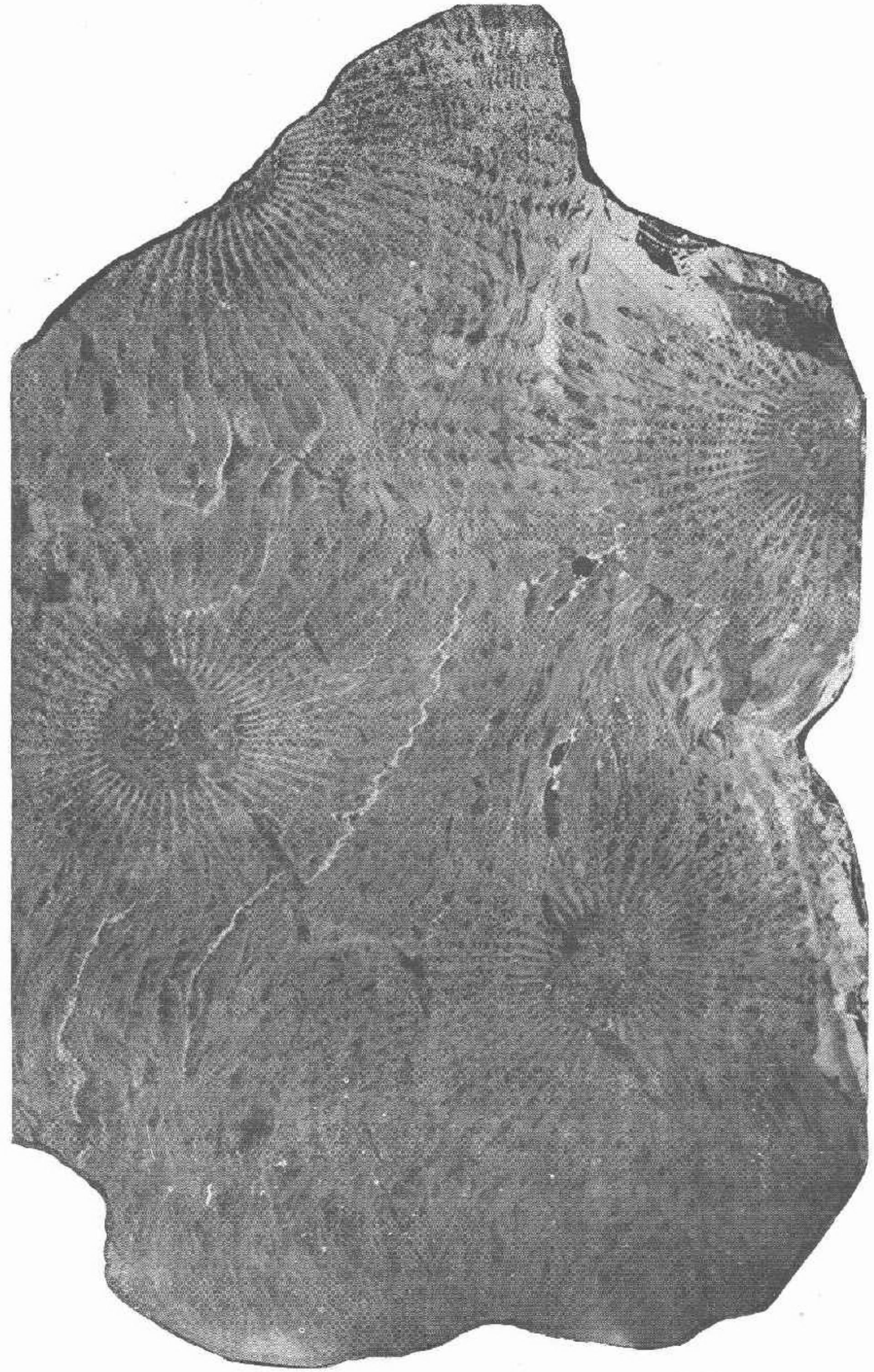
## PLATE XLVI.

Arachnophyllum (?) epistomoides, *Eth. fil.*

Transverse section prepared for the microscope, showing portions of five corallites, more or less. The ill-defined polygonal outlines, septa, intercalicular vesicular tissue, and central boss-like tabulate areas are plainly visible—x $2\frac{1}{4}$.





## PLATE XLVII.

Mitcheldeania (?) cribriformis, *Eth. fil.*

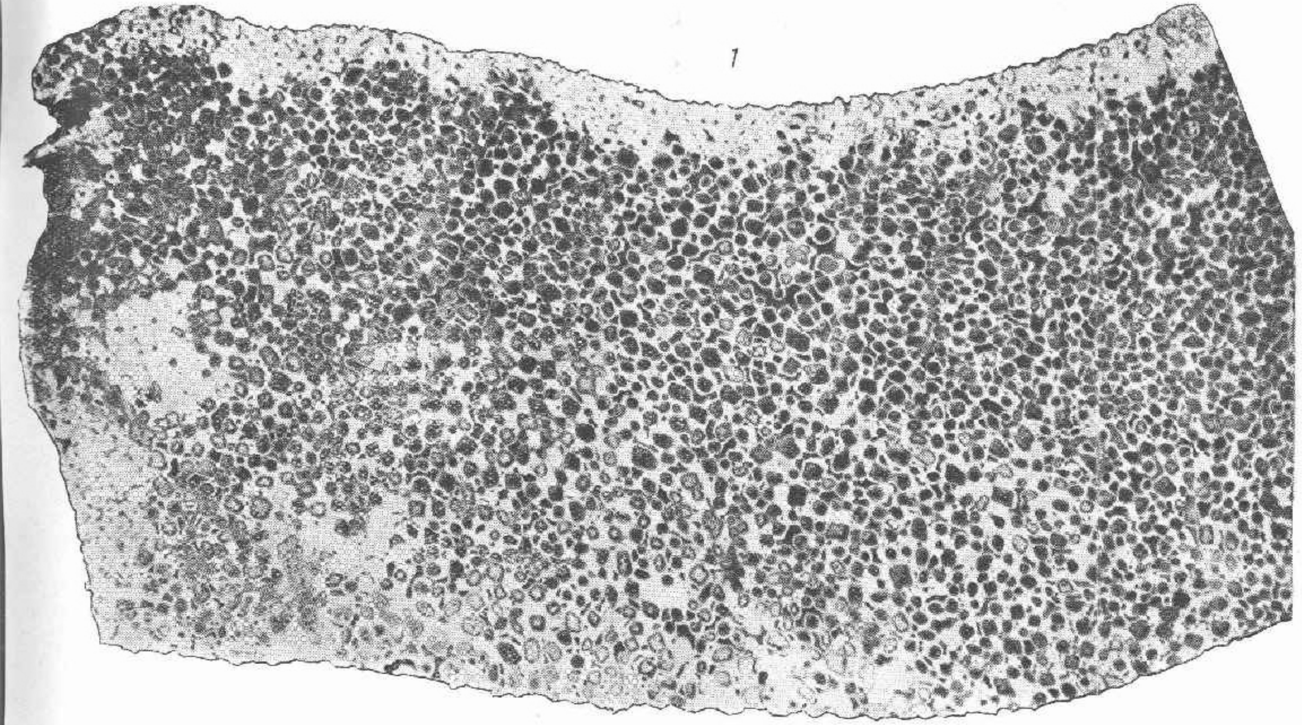
Fig. 1. Transverse section of the entire specimen prepared for the microscope. The tissue is represented by the white tint, the infilling of the zoöids by the black—x $4\frac{1}{2}$.

Fig. 2. Longitudinal similar section displaying highly cribriform structure—x $4\frac{1}{2}$.





1



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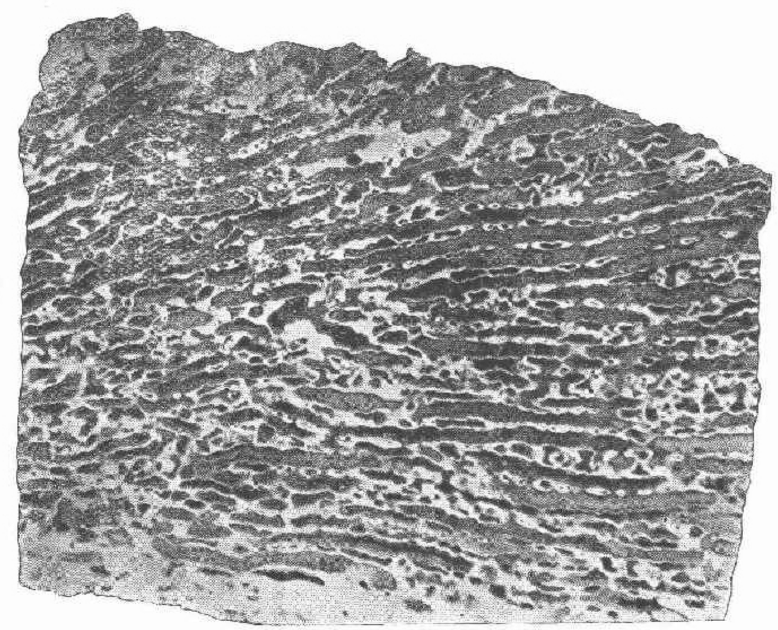


H. Barnes, Junr., Austr. Mus., micro. photo.

# PLATE XLVIII.

Mitcheldeania (?) cribriformis, *Eth. fil.*

Fig. 1. Group of zoöids exhibiting diversity of form. The central tube is quadripartite; obliquely above and below it are Y-shaped zoöids, also indications of interstitial tubes and canals—x 28.

Fig. 2. Another group in which the round zoöids are united end to end, the points of union representing the positions of the pores of communication; interstitial canals are here well-marked—x 28.

Fig. 3. Group of variously shaped zoöids with interstitial tubes—x 27.

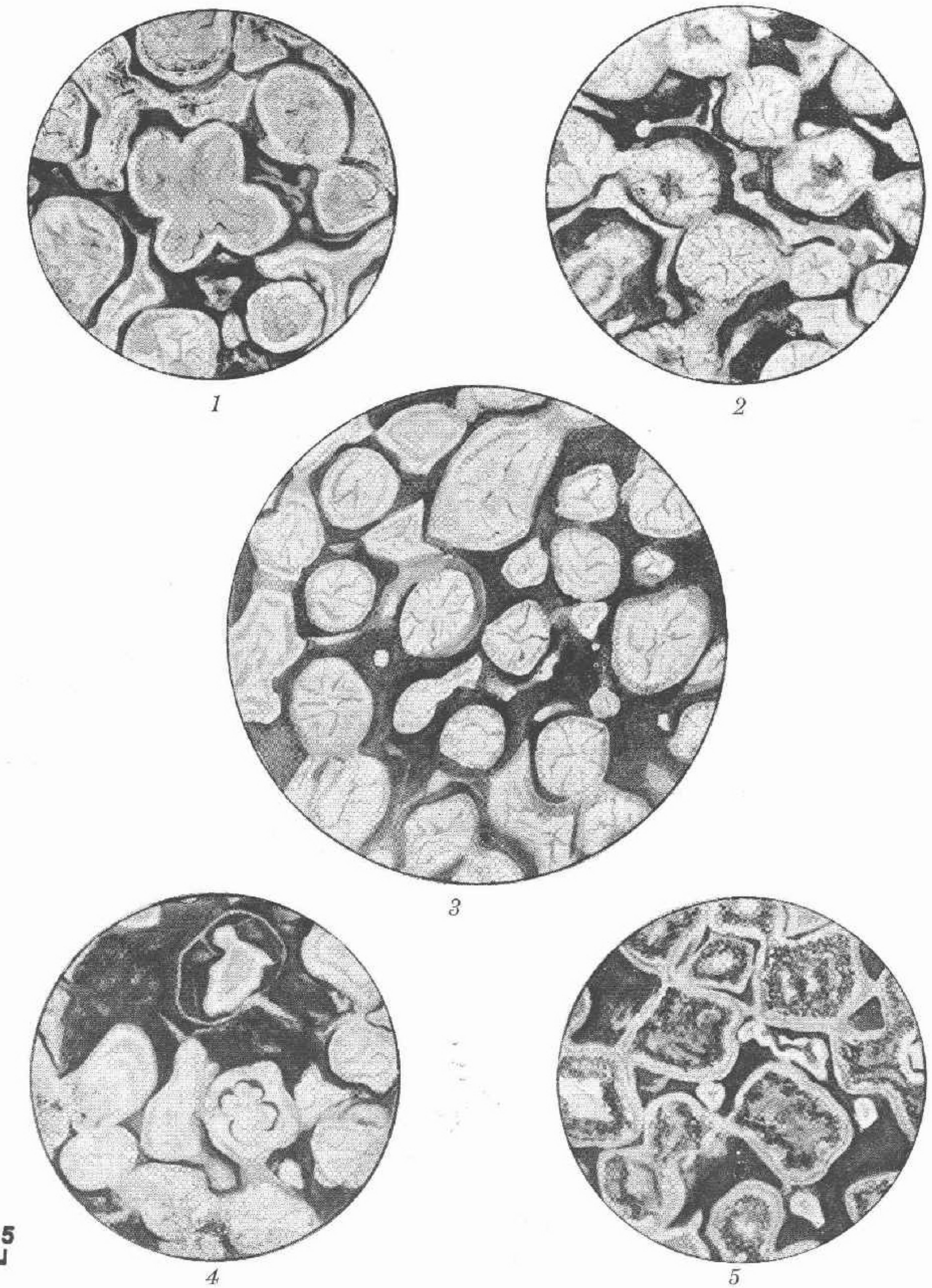
Fig. 4. Quadripartite zoöid, with wall inflections resembling septa—x 28.

Fig. 5. Zoöids, in a rather different state of preservation to those represented by figs. 1–4, with evidence of definite walls—x 28.

In these sections the light shade represents the calcite infilling of the tubes, and the dark indicates tissue, exactly the opposite to that of Plate XLVII.








A. R. McCulloch, Austr. Mus., del.

# PLATE XLIX.

Fossil Plants from Dunedoo.

Thinnfeldia odontopteroides, *Morris sp.*

Fig. 1. Portion of a dichotomous frond, with elongate subacute pinnules.

Fig. 2. Specimen showing rounded pinnules.

Cladophlebis Roylei, *Arber.*

Fig. 3. Portion of frond showing the venation.

Thinnfeldia (?).

Fig. 4. Unique specimen, showing a distinct midrib and oblique venation. It may represent an abnormal Thinnfeldia frond in which the pinnules are not differentiated.

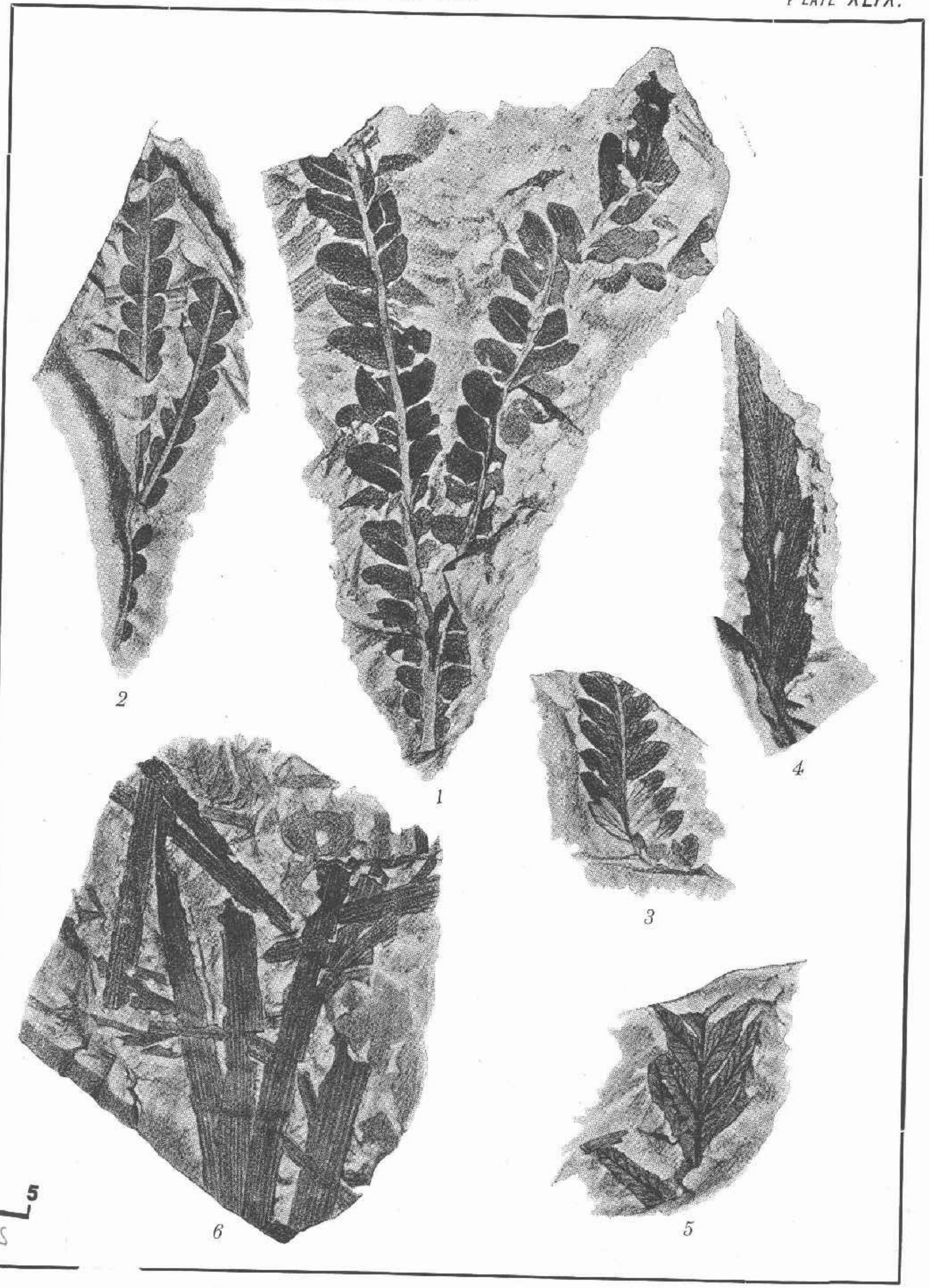
Cladophlebis Roylei, *var.* Murtoni, *nov.*

Fig. 5. Portion of pinna, showing the elongate, acute pinnules with definite midrib.

Baiera *cf.* multifida, *Fontaine.*

Fig. 6. Imperfect leaves.





## PLATE L.

Fossil Plants from Dunedoo.

Stenopteris rigida, *sp. nov.*

Figs. 1 and 2. Terminal portions of branches, showing the dichotomous habit and the dense leaves.

Baiera *cf.* multifida, *Fontaine.*

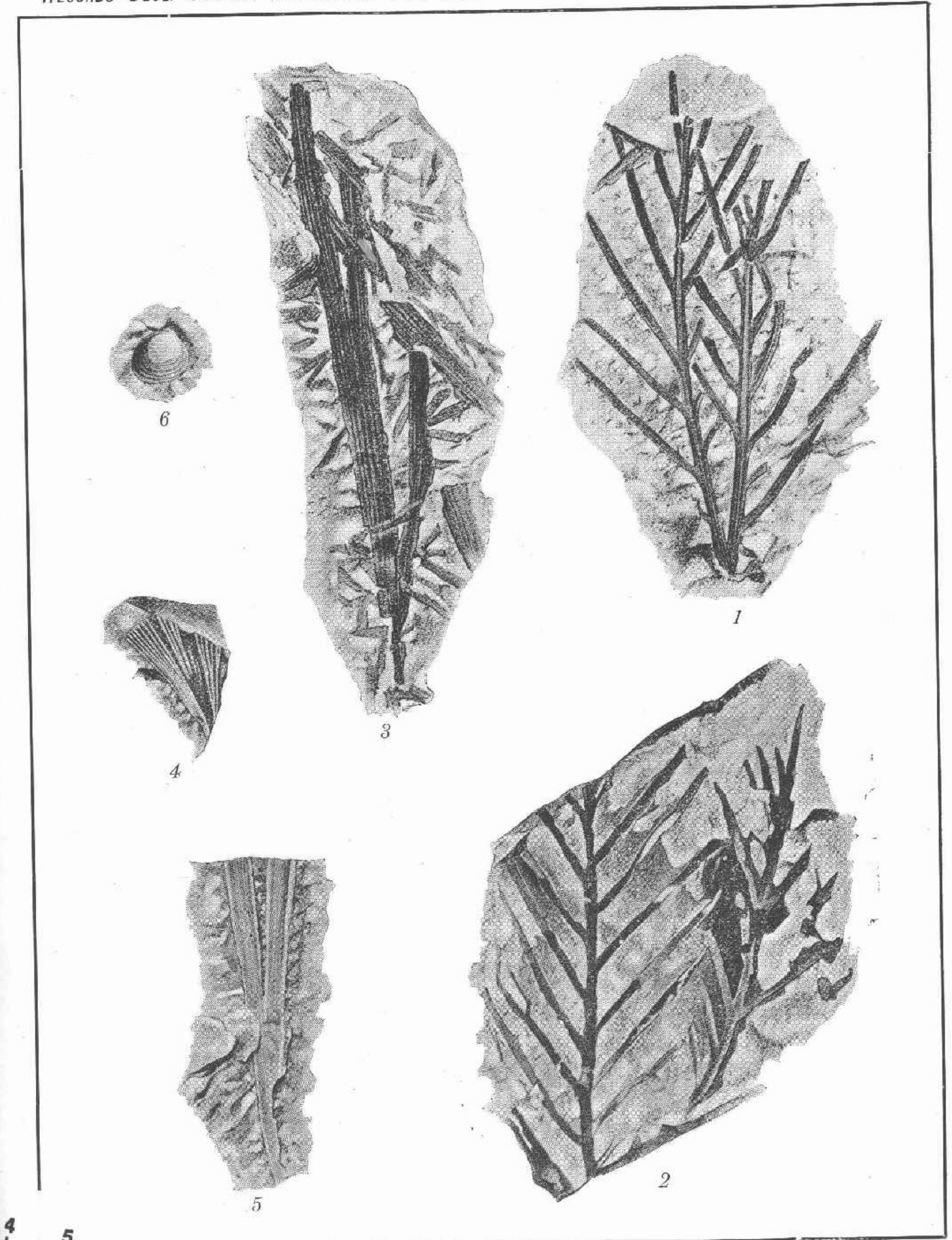
Fig. 3. Portion of long leaf.

Fig. 4. Termination of leaf showing ribs—x 2.

Fig. 5. Portion of leaf.

Estheria *cf.* mangalensis, *Jones.*

Fig. 6. Valve, unique, of the general proportions of E. mangalensis, shows distinct concentric growth ridges.

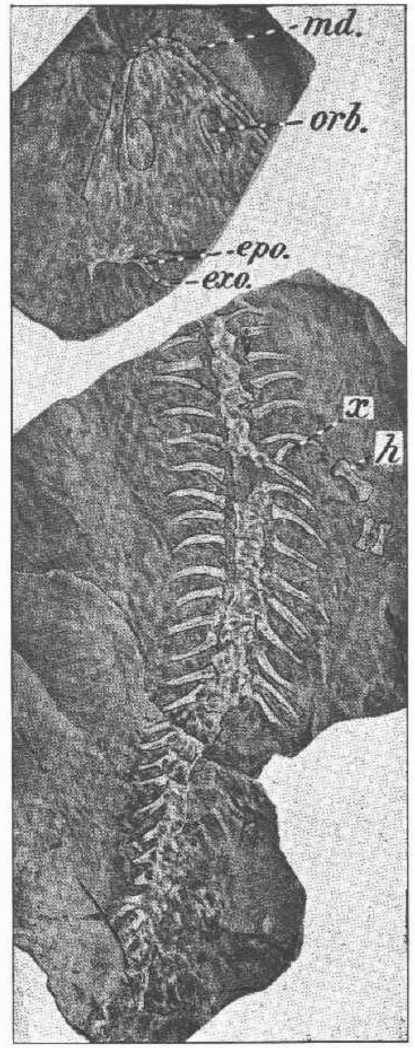


## PLATE LI.

Bothriceps major, *sp. nov.*

Imperfect skeleton about one-fifth natural size.—Hawkesbury formation; Airly. *Epc.*, epiotic; *exo.*, exoccipital; *h*, humerus; *md.*, mandible; *orb.*, orbit; *x*, perhaps part of scapula.






Bothriceps major, *A.S.W.*

# PLATE LII.

Geological Sketch Map of part of the North-eastern Watershed of the Macquarie River.

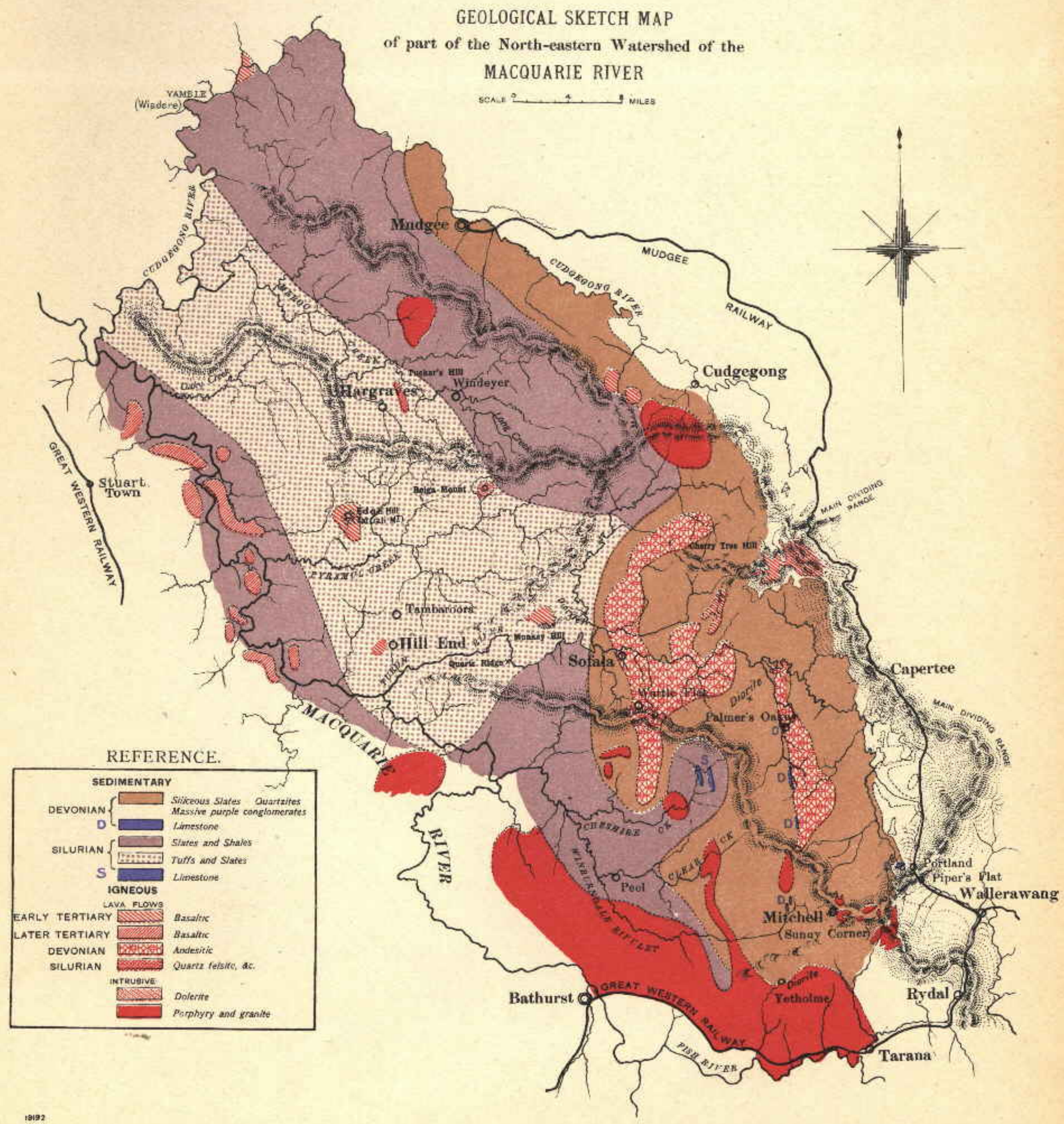



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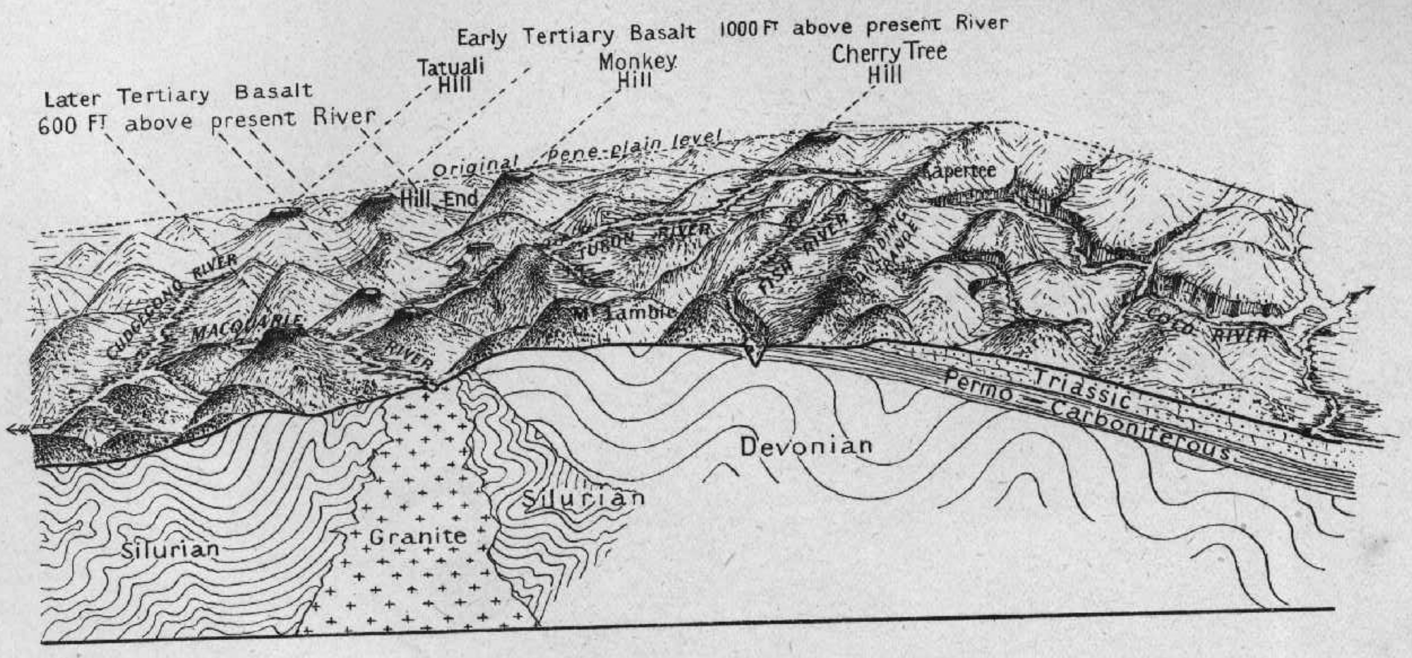
PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

# PLATE LIII.

Generalised Profile and Section of North-eastern Watershed of the Macquarie River.





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# PLATE LIV.

Fig. 1. *Beyrichia mesozoica*, sp. nov.—*a*, left valve ; *b*, edge view.

Fig. 2. (?) *Darwinula australis*, sp. nov.—*a*, left valve ; *b*, edge view of carapace (somewhat restored).

Fig. 3. (?) *Cytheridea* cf. *moorei*, Jones—right valve.

Fig. 4. *Nubecularia nitida*, sp. nov.—*a* and *b*, opposite faces.

Fig. 5. *Haplophragmium emaciatum*, Brady.

Fig. 6. *Discorbina* cf. *parisiensis*, d'Orb. sp.—*a*, superior ; *b*, inferior ; and *c*, peripheral aspect.

Fig. 7. *Discorbina cymbaloporoides*, sp. nov.—*a*, superior ; *b*, inferior aspect.

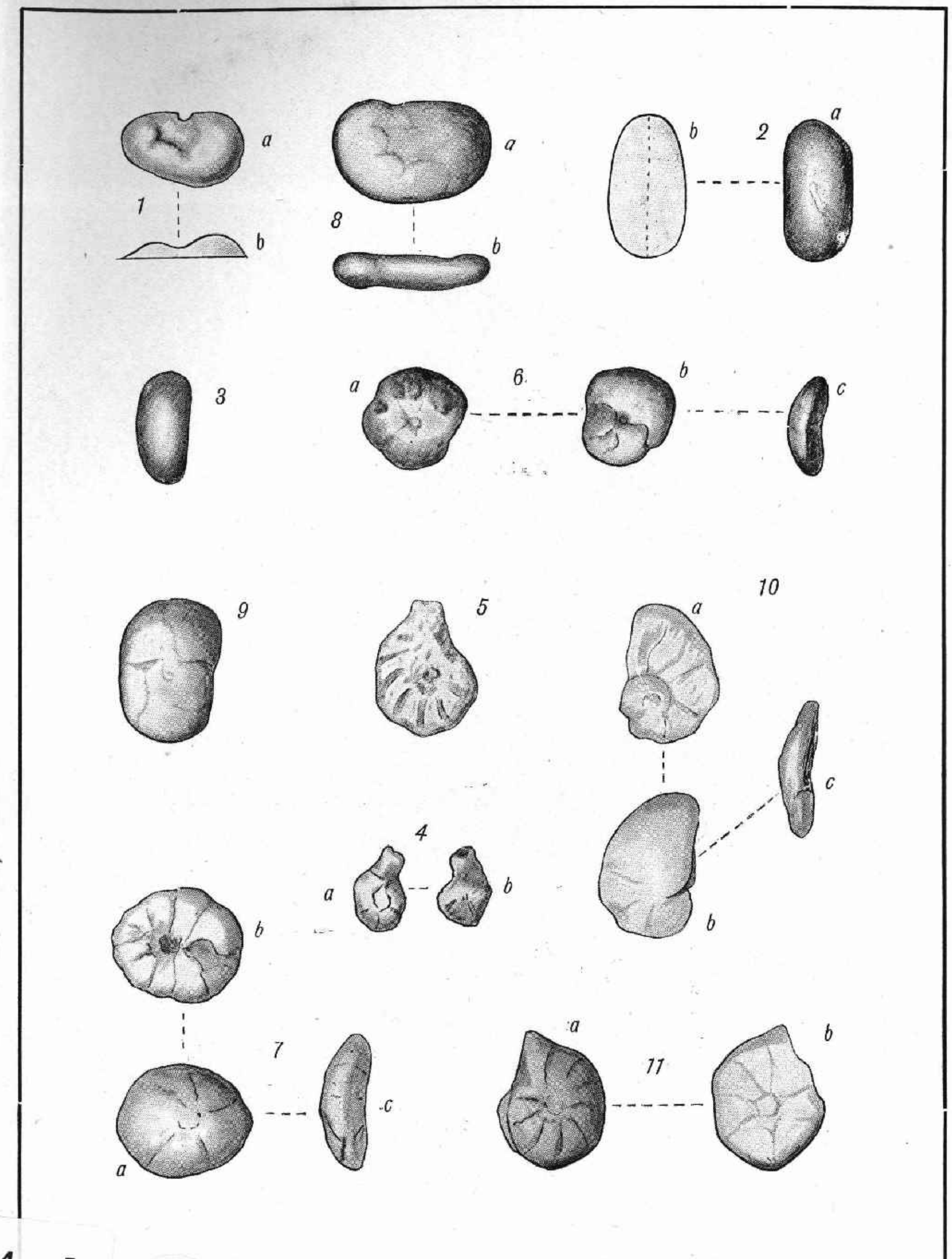
Fig. 8 *Pulvinulina insignis*, sp. nov.—*a*, inferior ; *b*, peripheral aspect.

Fig. 9. *Pulvinulina insignis*, sp. nov.—Another specimen ; superior aspect.

Fig. 10. *Truncatulina boueana*, d'Orb. sp.—*a*, superior ; *b*, inferior ; and *c*, peripheral aspect.

Fig. 11. *Endothyra* cf. *globulus*, Eichwald sp —*a*, *b*, lateral aspects.





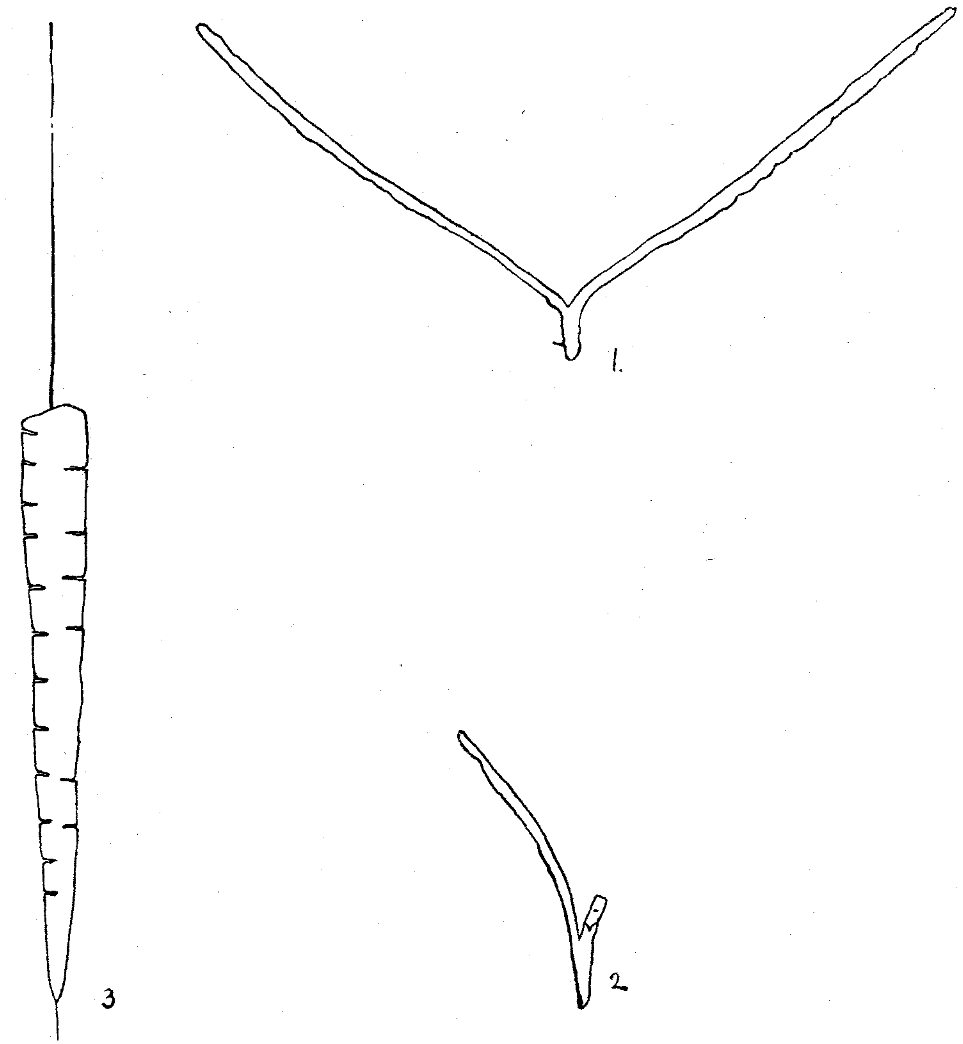
# PLATE LV.

## DESCRIPTION OF FIGURES.

1. Dicranograptus hians, *var.* apertus, *var. nov.*
2. Dicranograptus *cf.* cyathiformis, *Elles and Wood.*
3. Climacograptus, *sp.*

All the figures are magnified three diameters, and are traced from projected photographic enlargements.





# GEOLOGICAL MAPS AND PUBLICATIONS ISSUED BY THE DEPARTMENT OF MINES, SYDNEY.

## (1.) MAPS.

Map showing Mineral Areas of New South Wales. Scale, 16 miles to 1 inch.
Do do do . Scale, 50 miles to 1 inch.
Geological Sketch Map of New South Wales, compiled from the Maps of the late Rev. W. B. Clarke, M.A., F.R.S., by C. S. Wilkinson, L.S., F.G.S., Government Geological Surveyor-in-charge. Scale, 8 miles to 1 inch.
Do do do do Scale, 22 miles to 1 inch.
Do do do prepared under the direction of E. F. Pittman, &c., &c., Government Geologist. Scale, 16 miles to 1 inch.
Geological Map of the Districts of Hartley, Bowenfells, Wallerawang, and Rydal, by C. S. Wilkinson, L.S., F.G.S.
Geological Map of Hill End and Tambaroora, by E. F. Pittman, Geological Surveyor.
Geological Map of the Vegetable Creek Tin-mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor. Scale, 58 chains to 1 inch.
Index Map of the Vegetable Creek Tin-fields, by T. W. E. David, B.A., F.G.S. Scale, 80 chains to 1 inch.
Geological Map of the Forest Reefs District, by H. Y. L. Brown, Geological Surveyor.
Map of the Silver-mining Country, Barrier Ranges, by C. S. Wilkinson, L.S., F.G.S.
Vertical Sections of New South Wales Upper Coal Measures, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Diagrams showing the Thickness, Character, and Portion mined out of Coal-seams in the Coal Measures of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Plans showing the Outcrop, Thickness, and Dip of the Coal-seams in the Northern, Southern, and Western Coal-mining Districts of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Geological Sketch Map showing boundary of the Cretaceo-Tertiary Formation in the County of Cowper, by William Anderson, Geological Surveyor, 1889.
Geological Sketch Map of Tertiary Deep Lead, Tumberumba, by William Anderson, 1890.
Sketch Map showing Geological Features between Peak Hill and Tomingley, by William Anderson, 1890.
Geological Map showing the principal Stanniferous Leads in the Tingha and Elsmore Districts, by the late C. S. Wilkinson, F.G.S., F.L.S., and T. W. E. David, B.A., F.G.S., 1895.
Geological Sketch Map of the country in the vicinity of Sydney, 1904.
Geological Map with sections of Kiama and Jamberoo, by J. B. Jaquet, 1904.

## (2.) PUBLICATIONS.

Annual Reports from 1875 to 1899 inclusive.

Mines and Mineral Statistics, 1875. [Out of print.]

MINERAL PRODUCTS OF NEW SOUTH WALES, 1882, containing:—
1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. Description of the Minerals of New South Wales, by Archibald Liversidge, M.A., F.R.S., F.C.S., F.G.S., &c., Professor of Chemistry and Mineralogy in the University of Sydney.
4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.

MINERAL PRODUCTS OF NEW SOUTH WALES. 2nd Edition, 1886, containing:— [Out of print.]
1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. The Collieries and Boghead Mineral Mines of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal Fields.

MINERAL RESOURCES—
1. Notes on Chromic Iron Ore, by J. E. Carne, F.G.S. (8vo. Sydney, 1898.)
2. Notes on the Occurrence of Tungsten Ores in New South Wales, by J. E. Carne, F.G.S. (8vo. Sydney, 1898.)
3. Notes on Gold Dredging, by J. B. Jaquet, A.R.S.M., F.G.S. (8vo. Sydney, 1899.)
4. Notes on the Occurrence of Bismuth Ores in New South Wales, by J. A. Watt, M.A. (8vo. Sydney, 1898.)
5. Report on the Wyalong Gold-field, by J. A. Watt, M.A. (8vo. Sydney, 1899.)
6. The Copper Mining Industry and the Distribution of Copper Ores in New South Wales, by J. E. Carne, F.G.S. (8vo. Sydney, 1899.)
7. Mercury or Quicksilver in New South Wales, by J. E. Carne, F.G.S. (8vo. Sydney, 1900.)
8. Report on Hillgrove Gold-field, by E. C. Andrews, B.A. (8vo. Sydney, 1900.)
9. Report on Yalwal Gold-field, by E. C. Andrews, B.A. (8vo. Sydney, 1901.)
10. Report on the Kiandra Lead, by E. C. Andrews, B.A. (8vo. Sydney, 1901.)
11. Molybdenum, by E. C. Andrews, B.A. (8vo. Sydney, 1906.)

The Mineral Resources of New South Wales, by E. F. Pittman, A.R.S.M. (8vo. Sydney, 1901.

## GEOLOGICAL MAPS AND PUBLICATIONS ISSUED BY THE DEPARTMENT OF MINES, SYDNEY—*continued*.

### (2.) PUBLICATIONS—*continued*.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

*Geology.*

1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor.
2. The Iron Ore Deposits of New South Wales, by J. B. Jaquet, A.R.S.M., F.G.S. (4to. Sydney, 1901.)
3. The Kerosene Shale Deposits of New South Wales, by J. E. Carne, F.G.S. (4to. Sydney, 1903.)
5. Geology of the Broken Hill Lode and Barrier Ranges Mineral Field, New South Wales, by J. B. Jaquet, A.R.S.M., &c. (4to. Sydney, 1894.)

*Palæontology.*

1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales, and Australian Museum, Sydney. (4to. Sydney, 1888.)
2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen, Prof. of Botany, University of Graz, Austria. (4to. Sydney, 1888.)
3. Geological and Palæontological Relations of the Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in Eastern Australia and Tasmania, by Ottokar Feistmantel, M.D. (4to. Sydney, 1890.)
4. The Fossil Fishes of the Hawkesbury Series at Gosford, by A. S. Woodward, &c. (4to. Sydney, 1890.)
5. A Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales. Part 1, Cœlenterata: Part 2, Echinodermata, &c., by R. Etheridge, Junr. (4to. Sydney, 1891–92.)
6. Descriptions of the Palæozoic Fossils of New South Wales, by the late L. G. de Koninck. Translated by Professor T. W. E. David, &c., Mrs. David, and W. S. Dun. (4to. Sydney, 1898.)
7. The Mesozoic and Tertiary Insects of New South Wales, by R. Etheridge, Junr., &c., and A. Sidney Olliff, &c. (4to. Sydney, 1890.)
8. Contributions to a Catalogue of Works, Reports, and Papers on the Anthropology, Ethnology, and Geological History of the Australian Aborigines, Parts I—III; by R. Etheridge, Junr. (4to. Sydney, 1890–95.)
9. The Fossil Fishes of the Talbragar Beds (Jurassic), by A. S. Woodward, &c. (4to. Sydney, 1895.)
11. A Monograph of the Cretaceous Invertebrate Fauna of New South Wales, by R. Etheridge, Junr. (4to. Sydney, 1903.)
13. A Monograph of the Silurian and Devonian Corals of New South Wales; with illustrations from other parts of Australia. Part I.—The genus Halysites, by R. Etheridge, Junr. (4to. Sydney, 1904.)

*Ethnology.*

1. Aboriginal Carvings of Port Jackson and Broken Bay, by W. D. Campbell, L.S., F.G.S. (4to. Sydney, 1899.)

RECORDS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.
Vols. I–VIII, Pt. 3 (Sydney, 1889–1907).