GEOLOGY OF TASMANIA.

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Tasmania is a geological outlier of Eastern Australia. Its Pre-Cambrian and early Palæozoic history can be delineated only imperfectly. In Mesozoic times some connection existed with the Australian part of Gondwana Land. In the early Tertiary it was separated from the adjacent island continent; subsequently the land connection was restored, to be again broken, since when it has remained an island. Dr. A. W. Howitt and Mr. C. Hedley have pointed out that the last land connection was between Wilson's Promontory in Victoria and Cape Portland in Tasmania, *viâ* Flinders Island and the Kent group, and that an elevation of from 200 to 300 feet would lay dry a tract of country between Victoria and Tasmania.

The rugged nature and the remoteness of the mountain fastnesses of the island have been great impediments to geological research. In spite, however, of the physical difficulties, it has been possible to fix the stratigraphy of a large portion of the State, though the lower Palæozoic strata need further study before they can be satisfactorily determined. As far as examination has proceeded, the following systems can be recognised:—

(1) Pre-Cambrian.
(2) Cambrian.
(3) Ordovician.
(4) Silurian.
(5) Devonian.
(6) Permo-Carboniferous.
(7) Trias and Trias-Jura.
(8) Tertiary.
(9) Quarternary.

(1) *Pre-Cambrian.*—The diagnosis of the Pre-Cambrian must be accepted as provisional. It is probable that they belong to the Algonkian division of the group. Among them may be mentioned the quartzites and mica schists of the Port Davey districts. These are strongly developed in the south-west of the island as biotite and muscovite schists, greatly contorted, alternating with white saccharoidal quartzites, all striking north-west and dipping south-west. High headlands of quartzites, which have resisted denudation, jut out on the south coast, with bare, snow-white crests visible for many miles. Ores of copper, antimony, and lead occur in these schists. The contorted quartz schists and white quartzite of Rocky Cape, on the North-West Coast, are also considered as Pre-Cambrian. These are traversed by granitoid and basic dykes carrying copper ore. The quartzitic and micaceous schists west of the King William and Denison Ranges belong to the Pre-Cambrians. Garnetiferous amphibolite in the Collingwood River Valley, the amphibolite of the Rocky River, enclosing lenses of magnetite and pyrrhotite and copper pyrites, and the zoisite-amphibolite of the Forth River, are also ascribed to the Pre-Cambrian group.

(2) *Cambrian.*—This system is represented by friable yellow sandstones, containing casts of Dikelocephalus, Orthis, Bellerophon, &c. These occur at two widely-separated localities on nearly the same meridian, one being on Caroline Creek, between Railton and Latrobe, the other on the Humboldt Divide in the Florentine Valley. Mr. R. Etheridge reports that the fossils appear to be of Upper Cambrian age. The crystalline sandstones, quartzites, and conglomerate of which the Thumbs and the Denison Range are composed are believed to be Cambrian.

(3) *Ordovician.*—The slates and sandstones of the goldfields of Lefroy, Mount Victoria, Mathinna, Mangana, &c., in the northern and eastern parts of the island are referred to this system, though few fossils of any stratigraphical value have been found. Their bearing is either east or west of north, and anticlinal axes are long and continuous. The gold quartz reefs which traverse them began to form apparently at the close of the Upper Silurian. Large and important mines have been opened on these reefs, and every geological consideration that can be adduced points to the permanency of the goldfields.

The conglomerates and sandstones at Beaconsfield, together with the blue limestones which prevail in that district at Blyth's Creek and Winkleigh, as well as the Chudleigh and Railton limestones, may be provisionally regarded as of Ordovician age. The Blyth's Creek limestone has yielded imperfect casts of corals, and the Railton quarries contain remains of Actinoceras and other cophalopods.

A series of clay slates occurs between Zeehan and Mount Read, known as the Dundas slates, and believed to be of this age. Ill-preserved traces of graptolites have been noticed in them. These slates extend to Mount Read, Mount Black, and the Red Hills, and along their junction with intrusive quartz porphyry rocks (felsite, keratophyre, granophyre, porphyroid, &c.) large lenses of complex gold and silver bearing sulphide ores of zinc, lead, and copper have been formed.

Another group of rocks at the base of the Ordovician is the Gordon River series of limestones, sandstones, and slates. The limestone in this group is fossiliferous. The organic remains include Favosites, Orthoceratites, Raphistoma, Orthis, Rhynchonella, Euomphalus, Murchisonia, &c. The limestone reappears to the north-east of Mount Farrell, in the bed of the Mackintosh River, a short distance above its junction with the Sophia River. East of the Valley of Rasselas these rocks occur again in the Florentine Valley and at the Junee.

(4) *Silurian.*—The Silurians are strongly developed at Zeehan on the West Coast, at Middlesex, and Mount Claude, Heazlewood, and the Eldon Valley, Queen River, &c.

At Zeehan conglomerates and tubicolar sandstone underlie the limestones, slates, and sandstones, which are intersected by the numerous galena-bearing lodes which have yielded the ore for which this field is so well known.

The fossils found in limestone and quartzite belong to the genera Hausmannia, Asaphus, Illaemus, Cromus, Rhynchonella, Strophodonta, Lophospira, Murchisonia, Eunema, Tentaculites, and the beds are considered by Mr. R. Etheridge to be homotaxially equivalent to the lower portion of the Upper Silurian.

Similar tubicolar sandstone occurs near Bell Mount, Middlesex, and on the Five-mile Rise, and casts of Hausmannia (or Phacops), Rhynchonella, Orthis, and coral have been found.

Clay slates in the Eldon Valley, containing fossil casts of Calymene, Orthis, Cardiola, are considered to belong to the Upper Silurian.

At the Heazlewood limestone and sandstone have yielded remains of Hausmannia, Cromus, Cornulites, Rhynchonella, Tentaculites, and Favosites.

Sandstones and limestones in the Queen River District have been identified as Silurian (Middle or Upper Silurian). These are west of Queenstown. Brachiopods and trilobites have been found also on the east side of the Lyell Razorback, indicating a similar age for rocks on the Lyell and Lyell Blocks mining properties there. The Queen River sandstones are charged with casts of Spirifera and Orthis.

Trilobite-bearing Silurian rocks also occur north of the Pieman River, near the Wilson River.

In the Zeehan field the Silurian slates are largely accompanied by contemporaneous and intrusive sheets and dykes of vesicular melaphyre. The igneous rock corresponds very closely with the German spilite, an amygdaloidal diabase, sometimes called lime diabase.

Massive conglomerates crown most of the West Coast mountains, the Dial Range on the North-West Coast, Mts. Roland, Claude, &c. These have generally been ascribed to the Devonian, but more recent data point to the commencement of the Silurian as more probable, and even a still greater age is possible.

The quartz-porphyries or felsites which form the backbone of the West Coast Range are the geographical axes of Mts. Darwin, Jukes, Huxley, Tyndall, Read, Murchison, and Farrell. They carry copper ore associated with lenses of hematite and magnetite, chloritic and felspathic copper-bearing schists, some of them probably schistose porphyries, flank them and are enclosed in them. The felspathic schists of Mt. Lyell belong to this group. Sufficient is not known of this geological formation to enable its age to be stated definitely.

Associated with the rocks of the Silurian system in the northern and western parts of the island is an extensive development of serpentine, the altered form of gabbro and its appendages, peridotite and pyroxenite. This rock is found in the Heazlewood district, at Trial Harbour, in the Dundas district, in the Forth Valley, and near Beaconsfield. The difference of age between it and the Devonian granite is slight. Chronologically some of the granite is later.

(5) *Devonian.*—Granite occurs in a meridional line down the East Coast, extending from Flinders Island to Maria Island. It forms Mt. Cameron, Mt. Stronach, the Blue Tier, Freycinet's Peninsula, and is exposed at Ben Lomond and at the base of Mt. Arthur. Exposures are also seen at the Hampshire Hills, Granite Tor, Middlesex, the Magnet and Meredith Ranges, Heazlewood, &c. The quartz-porphyry dykes at Mt. Bischoff, the tourmaline lodes at Mt. Black and in the Dundas district, the stannite lodes and quartz porphyry dykes at Zeehan, all denote a granitic reservoir below a large portion of the mineral fields of the West Coast. No granite intrusion into Permo-Carboniferous strata has been observed. The normal granite is a dark mica one, but muscovite and lithia micas appear in the tin-bearing varieties. Tin-bearing lodes occur on Ben Lomond and Mt. Heemskirk, while on the Blue Tier floors or stocks of altered granite form huge tin ore-bodies of low grade. Porphyry dykes at Mt. Bischoff have shed the vast accumulation of tin ores which has been mined by the Mt. Bischoff Company for the last 34 years with wonderful success.

(6) *Permo-Carboniferous.*—The base of the system is formed by glacial conglomerates, grits, micaceous sandstones and flagstones, well seen on Bruni and Maria Islands and elsewhere in Southern Tasmania. Fossiliferous mudstones and limestones form a lower division of the system, while the upper division comprises the Tasmanite shale and coal measures of the Mersey Basin, with upper marine mudstones and shales in the Mersey Basin and at Hobart, and the coal measure series of Mt. Cygnet and Southport. The characteristic fossil plants of the coal measures of this system are Glossopteris, Gangamopteris, Noggerathiopsis. The seams average from 1½ to 2 feet in thickness, and the analyses show from 36 to 42 per cent. fixed carbon, 41 to 48 per cent. gas, 2 to 9 per cent. ash, and 8 to 12 per cent. moisture. They are known as the lower coal measures of Tasmania.

South of Wynyard and at Barn Bluff cannel coal or kerosene shale is met with. The Wynyard or Preolenna seam of this coal is in sandstone, overlying fossiliferous mudstones, and assays up to 76 per cent. volatile matter. The Barn Bluff cannel coal has only been observed in loose blocks, supposed to have been disturbed by glacier action.

At the close of the system, or during Mesozoic times, a local intrusion of alkaline rocks, alkali and nepheline syenites, &c., occurred, traversing the Permo-Carboniferous strata south of Hobart, from Oyster Cove and Woodbridge on the Channel to the Huon River in a N.E.-S.W. line.

Auriferous quartz and pyrites have been developed near the line of contact of these igneous rocks with the Permo-Carboniferous sandstones and mudstones, and a good deal of free gold has been shed into the flats.

(7) *Mesozoic.*—The fresh-water beds, which succeed the Upper Palæozoic, belong to the Mesozoic division, but cannot as yet be subdivided with certainty. The nearest approach to a subdivision would be as follows, but the reference to European equivalents is nothing more than an attempt at correlation homotaxically:—

(*c*) Cretaceous (?)—
4. Diabase in intrusive masses, sills, and dykes.

(*b*) Jura (or Rhætic)—
3. Upper coal measure sandstones.

(*a*) Trias (?)—
2. Sandstones and shales with coal at Ida Bay.
1. Variegated sandstones with remains of heterocercal fishes and amphibians.

The variegated sandstones occur at Knocklofty, the Domain, Ross, &c. Remains of Adrolepis have been found at Knocklofty and Tinder-box Bay. Bones of an amphibian (labyrinthodontine?) have been obtained from the Government House quarry in the Domain.

The upper sandstones are readily recognised by their soft felspathic nature. They are generally greenish-grey to yellow-

ish-brown, sometimes white. They are widely distributed throughout Eastern and South-eastern Tasmania, and occur also in the extreme south. They are largely interrupted by intrusions of diabase. They flank the central, eastern, and western tiers, and fringe isolated mountains, *e.g.*, Mt. Nicholas, Mt. Victoria, Ben Lomond, Ben Nevis, Mt. Dundas, Cradle Mountain, &c. From Fingal and Mt. Nicholas they extend on the outskirts of the diabase ranges southward to Seymour, Bicheno, Llandaff, Spring Bay, and all over South-eastern and a large part of Southern Tasmania.

These measures enclose the coal seams, averaging from 4 to 12 feet, which are worked at Mt. Nicholas, Cornwall, York Plains, and Sandfly collieries. The analyses of this coal range from 53 to 60 per cent. fixed carbon, 23 to 31 per cent. volatile matter, 9 to 16 per cent. ash, 2 to 4 per cent. moisture, and the coal is not a coking one. A sub-anthracite coal is raised at York Plains, and at the Sandfly Mine a seam of anthracite occurs containing 80 per cent. fixed carbon and 8 per cent. volatile matter.

The fossil flora from these measures must be regarded as characteristic for the Mesozoic. The list includes Thinnfeldia, Pecopteris, Tæniopteris, Sphenopteris, Alethopteris, &c.

The diabasic intrusions cut up the coal measure areas into different basins, and cover large portions of the Central, Eastern, and Southern districts.

(8) *Tertiary.*—A great stratigraphic break exists between the Mesozoic and the succeeding strata. This Tertiary system cannot be subdivided as in Europe. Two divisions, Palæogene and Neogene, are adopted in Tasmania. According to this arrangement the subdivisions are as follows:—

(*a*) Neogene (= approximately to Pliocene).
Under this head would fall various river terraces and estuarine deposits.

(*b*) Palæogene (= Eocene to Miocene).

3. Basalt lavas.
2. Fluviatile and lacustrine clays and sands, tin ore drifts, and deep leads.
1. Fossiliferous marine beds at Wynyard (= Eocene).

The marine fossiliferous beds at Wynyard are covered with the basalt which, generally throughout the island, appears to separate the Lower from the Upper Tertiaries. The extensive lacustrine deposits within the watershed of the Tamar cover an area of 600 square miles, and embrace widely-spread pre-basaltic or Palæogene clays and sands, which form a series 900 to 1000 feet thick. Such sediments with fossil leaves of European genera occur at Launceston, Dilston, Windermere, Beaconsfield, Waratah, Strahan, St. Helens, Burnie, and on the Derwent. In the north-east and east the sub-basaltic gravels are worked on a large scale for tin ore, and yield most of the alluvial tin of the State.

At the close of the Palæogene a great outpouring of basaltic lava took place, and this rock is very general throughout the island, though rarer on the West Coast.

The rock is usually olivine basalt, but nepheline basalt occurs on the Shannon Tier, and at Sandy Bay, Hobart.

The Neogene valley terraces can only be distinguished from the earlier Tertiaries by position and lithological characters. Some of the gravel drifts of the Derwent, of the Longford Plains, and in the neighbourhood of Launceston belong to this subdivision. The close of the Tertiary, or the beginning of the Quarternary, witnessed a glacier epoch in the west and centre of the island. The highlands round Barn Bluff, Mts. Tyndall, Lyell, Sedgwick, Jukes, Darwin, &c., and the western edge of the great central plateau abound with tarns, ice-scratched stones, and moraines. No proof of glacier condition in this period in the eastern part of the island has been adduced yet.

Tin and gold ores are the most important products of the deposits of the Tertiary system. They are won from the alluvial gravels and leads of the period. The sands in the Savage River and other tributaries of the Pieman and Huskisson have been worked for osmiridium. Zircon sand, near Table Cape, has also been exploited. Tertiary clays are used largely for brick-making and pottery, the gravels for road-making. Lignites exist, but are not yet industrially important. Though there has been great volcanic activity, there are no signs of Tertiary metalliferous veins.

(9) *Quarternary.*—These deposits may be classed as follows:—

(*b*) Recent.

3. River alluvium and sand dunes.
2. Raised beaches and helicidæ sandstones.

(*a*) Pleistocene.

1. River drifts.

The later terrace drifts in the valleys of existing rivers are referred to the Pleistocene. Sand dunes, consolidated to shelly sandstones, occur on Cape Barren, Badger, Kangaroo, and other islands in Bass Straits, containing shells of helix, succinea, &c. These sandstones sometimes overlie a raised beach. The raised beaches on the North and South Coasts indicate elevation within the Recent period. Some of the glacier phenomena may belong to the Pleistocene, and have continued even to the Recent period.

(10) *Ore-deposition.*—The period during which the deposition of metalliferous ores was most active was the interval between the Upper Silurian and Permo-Carboniferous. Ore-deposition has been associated principally with the consolidation of the gabbroid and granite masses. Nickel sulphide and osmiridium owe their origin to the serpentine at the Heazlewood, Trial Harbour, and Dundas. On the other hand, the granite magma is responsible for the lodes of silver-lead all over the island, whether these pierce quartz-porphyry, as at the Devon and Mt. Tyndall, slate, sandstone, and limestone, as at Zeehan, or ultra-basic dyke rock, as at the Magnet. The pyritic lead, zinc, or copper ores of the West Coast Range (Mt. Lyell, Mt. Read, Mt. Black, &c.) are also most probably due to the action of the acid magma. Tin and wolfram ores are naturally referred to the same source, and the quartz reefs of the Ordovician strata must

be regarded as the result of the expiring effort of the cooling magma to get rid of its surplus available silica. A few veins of barren quartz occur in the Permo-Carboniferous strata, but beyond the exceptional case of the alkali porphyries at Port Cygnet, the chapter of metal-bearing lode action closed, as it began, with the Devonian period. Within that period, therefore, were accumulated the great stores of mineral which the mining industry of Tasmania is now drawing upon. The mines of gold, silver, lead, copper, and tin rank high among the famous mines of the world. Her mineral wealth may, in fact, be considered remarkable when, despite the small area of the island (26,000 square miles), the value of the mineral produced for the year ending 31st December, 1907, amounted to £2,277,159. The industry is thriving, is on a sound and established basis, and with the careful administration and care which it receives it may with confidence be expected to continue a highly important asset of the State for a quite indefinite period of time.