

OUTLINES OF THE GEOLOGY OF TASMANIA.

By W. H. TWELVETREES, F.G.S., *Government Geologist.*

TASMANIA, a small geological outlier of Eastern Australia, offers a highly interesting field to the geological student. It must, however, be conceded that its physical history in pre-Cambrian and early Palæozoic times can only be dimly guessed at. In later Palæozoic times, the conditions appear to have been insular; in the Mesozoic, there was evidently a connection with the great Gondwana continent, which sank beneath the Indian Ocean prior to the Tertiary period. The greater part of the island has since remained above sea-level.

The inaccessible nature of the highlands has greatly retarded geological research; still, in spite of the physical difficulties, the progress made in this direction has been considerable. In 1841-5, Count Strzelecki published some geological notes on the Island. From 1851 to 1855, Dr. J. Milligan, then Secretary of the Royal Society of Tasmania, reported on a large portion of the East and South Coasts. In 1855, Mr. A. R. C. Selwyn reported on coal seams. In 1861-7, Mr. Chas. Gould, Government Geologist, prepared numerous important reports and maps. Mr. S. H. Wintle contributed various geological notes, 1865-1882; Rev. J. C. Tenison-Woods has written several papers on Tertiary geology and palæontology; Mr. C. P. Sprent, Deputy Surveyor-General, from 1876 to 1887, wrote on the Western geology of the Island; Mr. Thos. Stephens, M.A., from 1863 to the present date, has constantly contributed to our knowledge of the geology of the State; in 1888, Mr. R. M. Johnston's monumental work, "The Geology of Tasmania," appeared under Government auspices, and for many years this author has enriched our geological literature. The late Professor G. H. F. Ulrich, in 1874-6, reported upon Mounts Bischoff and Ramsay. Our Government Geologists, Messrs. G. Thureau, Alex. Montgomery, M.A., and Mr. Jas. Harcourt Smith, B.A., have, in no mean degree, extended our

knowledge of the general geology of the Island. Mr. W. F. Petterd has contributed his "Catalogue of Minerals of Tasmania," and several papers on the eruptive rocks. Other workers, Professors David, Tate, Krause, Hogg, Feistmantel, Mr. R. Etheridge, Jun., Mr. J. Dennant, have added the results of their researches, while the names of authors of papers read before the Royal Society of Tasmania (Messrs. W. F. Ward, Alex. Morton, Danvers Power, T. B. Moore, Graham Officer, &c.) suffice to show that this Society has had an honourable share in the construction of the literature of the subject.

Mr. R. M. Johnston, the *doyen* of Tasmanian geologists, has worked out thoroughly the stratigraphy of the Tertiary, Mesozoic, and Upper Palæozoic systems, and successive Government Geologists have contributed to our knowledge of detached areas in different parts of the Island; but the lower Palæozoics still require much study before they can be properly defined. In this sketch, the main developments of each system, as far as at present known, will be briefly referred to.

Pre-Cambrian.

The massive quartzites at Port Davey are usually referred to this age, but their stratigraphical relations need working out. The mica-schists and gneiss-like rocks at the Dove River, and the hornblende zircon-gneiss of the Upper Forth, are also possible members. In the North-West, the hornblende and talc schists, with associated dolomitic limestone in the Rocky River district, enclosing deposits of pyrrhotite and copper pyrites, need investigation. These rocks are well seen at the Rocky River Mine, and at the Rio Tinto, further north, on the same strike. The hornblende schist runs through to the junction of the Nine-mile Creek with the Whyte River.

Cambrian.

The only strata which can be definitely referred to the Cambrian system are the friable yellow sandstones at Caroline Creek, between Railton and Latrobe. These have a strike (E. 60° S.) different from the prevailing direction of the Silurian strata of the Island, and contain *Dikelocephalus tasmanicus* (R. Eth., Jun.), *Conocephalites stephensi* (R. Eth., Jun.), *Asaphus* sp., *Scolithus tasmanicus* (R. M. Johnston), *Leptaena*. These are the most ancient fossils yet found in our rocks. The elucidation of the relations of these strata with the adjacent schists and limestones is much needed.

Silurian.

The divisions of this system are still largely tentative. The following scheme, in which the eruptive rocks of the period are included, must be taken as provisional:—

Upper and Middle Silurian.

5. Quartz porphyries and felsites at Mounts Darwin, Jukes, Owen, Tyndal, Read, Red Hills, Black, Murchison, Farrell;
4. Gabbros, peridotites, pyroxenites, and serpentine at Dundas, Trial Harbour; Heazlewood, Forth, Anderson's Creek;
3. Brachiopod sandstone, at Middlesex, Heazlewood, Queen River; slates, sandstones, and limestones, with melaphyre lava, at Zeehan;
2. Schists, conglomerates, and limestones, at Mount Lyell; greywacké series at Dundas; slates and argillaceous schists, at Mounts Read and Black.

Lower Silurian.

1. Limestone, at Gordon River, Railton, Chudleigh, &c.; slates and sandstones, at Beaconsfield, Lefroy, Mangana, Mathinna, Scamander, &c.

The Silurian system is strongly developed in Tasmania, especially in the N.E., N.W., and W. Owing to paucity of fossils, its subdivisions are unreliable, except in a few instances, and its boundary-lines with the Cambrian rocks are still obscure. The lower division is represented on the West Coast by the Gordon River series, and on the East by the slates, in which our gold reefs occur at Lefroy, Beaconsfield, Mathinna, &c. The limestones along the Gordon River are fossiliferous, containing *Favosites*, *Orthoceratites*, *Raphistoma*, *Orthis*, *Rhynchonella*, *Euomphalus*, *Murchisonia*, &c. They reappear to the N.E. of Mount Farrell in the bed of the Mackintosh, a short distance above its junction with the Sophia River. The limestones of Chudleigh, Mole Creek, and Ilfracombe are placed provisionally in the lower division. They are non-fossiliferous, and the only way of fixing their age is to connect them stratigraphically with the Caroline Creek Cambrian beds. The slates and schists between the Heazlewood and Corinna belong to an undetermined horizon in the system, and some of them may be pre-Silurian. The slate and schist reefs which run out to sea on the N.W. Coast can only vaguely be referred to as Silurian; at Rocky Cape, they are probably lower in the geological record.

The auriferous slate series, with sandstones and conglomerates, appear at Beaconsfield, Lefroy, Waterhouse, Gladstone, Mount Victoria, Mathinna, Scamander, Fingal, &c. Fossils are extremely rare. They comprise doubtful fucoid casts, worm tracks, and, in one instance, a graptolite is recorded from the Lisle slates. The specimen was found by the late Mr. G. Thureau, and subsequently lost; but, from inquiries, it seems nearly certain that it was a *Diplograptus*. Unfortunately, the range of this genus is too great for use in determining the horizon of the beds. The metamorphic sandstones of the St. Helens and Scamander districts are referred doubtfully to the same horizon as the slates.

It is difficult to locate the so-called schists (slates and argillites) of Mounts Read and Black. These are charged with complex gold and silver-bearing sulphidic ores of zinc, lead, and copper. They may be low down in the system; or, on the other hand, they may be contemporaneous with the Lyell schists. The latter also cannot be placed definitely, but, from fossil brachiopods found at Gormanston, it seems possible that they belong to the Queen River series, greatly metamorphosed. The King and Queen River slates and sandstones, charged with fenestellidæ and encrinites, and casts of brachiopods (*spirifera* and *orthis*), belong to the Middle Silurian or the lower part of the Upper Silurian. Silurian sandstones at the Heazlewood, towering above the road at the 14-mile, and on the old Godkin Amalgamated, are referred by R. Etheridge, Jun., to the lower part of the Upper Silurian. They have yielded the following fossils:—*Hausmannia meridiana*, *Cromus murchisoni*, *Cornulites tasmanicus*, *Rhynchonella capax*, *Tentaculites sp. ind.* (*Favosites grandipora* in limestone). At Zeehan, the sandstones, slates, and limestones, which are traversed by argentiferous galena lodes, appear to occupy the same geological horizon, and carry the following fossils:—*Hausmannia meridiana* (in the Despatch limestone), *Asaphus sp. ind.* (in the Despatch limestone), *Illænus johnstoni sp. nov.* (in the Despatch limestone), *Cromus murchisoni* (in slate), *Rhynchonella cuneata* (in slate), *Rhynchonella borealis* (in slate), *Strophodonta sp. nov.*, *Leptodomus (?) nuciformis sp. nov.* (in the Despatch limestone), *Lophospira* (in quartzite), *Murchisonia* (in quartzite), *Eunema montgomeri* (in the Despatch limestone), *Tentaculites sp. nov.* (in slate), *Raphistoma (?) sp. nov.* (in white sandstone).

The general trend of the Zeehan beds is west of N. and east of S., and their dip is to the N.E. at angles of from 60° to 70°. It may be mentioned that a high angle of dip

characterises the Silurian strata throughout the Island. Interbedded with the sedimentary beds at Zeehan are sheets of Silurian basalt (melaphyre), known locally as "white rock." This is often tuffaceous and vesicular. In the Oonah and Montana mines, it may be seen in the form of contemporaneous sheets.

Of about the same age are slates, sandstones, and limestones in the Bell Mount district, between the Forth and Wilmot rivers. The sandstones there and at Mount Claude contain abundant casts of fucoid stems; fenestella, trilobites, and rhynchonella also occur at Bell Mount and the Five-mile Rise. Clay slates, with calymene, orthis, cardiola, in the Eldon Valley, are referred to the Upper Silurian.

Associated with the rocks of the system in the N. and W. is an extensive development of serpentine, the altered form of gabbro and its appendages, peridotite and pyroxenite. Dykes of it cross the Silurian strata on the road between Waratah and the Whyte River, and the rock underlies metamorphosed sandstones at the Heazlewood. A great variety of gabbros and pyroxenites may be seen along this road. Nickel Hill, at the Sixteen-mile, is a mass of serpentine rock, containing nickel ores, and Bald Hill, immediately to the west, is likewise serpentine as far as the Nineteen-mile, where it impinges against Silurian slates. A pyroxenite dyke in Silurian strata carries the silver-lead lode at the Magnet Mine. Gabbro, pyroxenite and serpentine occur in the Dundas district, and reappear west of the Comstock, and again at Trial Harbour. In the Valley of the Forth, and at Anderson's Creek, west of Beaconsfield, further areas of serpentine are exposed, and at the latter place the rock is often asbestiform, and is mined for asbestos. It is difficult to assign a precise age to our gabbros and serpentine. They have been thought to be pre-Silurian; but the Heazlewood intrusions suggest the close of the Silurian as a possible date.

Very important rocks are the quartz-porphyrries, or felsites, which form the backbone of the West Coast Range. These are the geographical axes of Mounts Darwin, Jukes, Huxley, Tyndal, and continue northwards through Mount Murchison, and on the east side of Mount Farrell. They are the home of copper ores, and enclose characteristic deposits of hematite and magnetite. Chloritic copper-bearing schists, some of them probably schistose porphyries, flank them, and are enclosed in them. On the whole, the quartz-porphyrries are massive, but it occurs also laminated. It was probably intrusive, but this can only be decided after

further investigation. Its tendency to assume laminated forms indicates that it was involved in the foliation of the Silurian rocks. Its connection with our granites has not been worked out. It is placed with some hesitation at the close of the Silurian.

A belt of felsite, a little to the west of this zone, can be traced through Mounts Read and Black, across the Pieman River, at the railway crossing. The green augite-syenitic rock at Lynchford has probably some connection with the felsites.

Devonian.

3. Dial Range and West Coast upper conglomerates.
2. Soft slates at Fingal.
1. Granite in North, East, and West Tasmania.

Our granites are considered to be of Lower Devonian age, *i.e.*, soon after the close of the Silurian. No granite intrusion into Permo-Carboniferous strata has been observed, while it is frequently intrusive into the Lower Silurian slates, and has been established as intrusive into Upper Silurian at Middlesex. Evidence has been forthcoming recently, at the Heazlewood and at Mount Agnew, showing that the consolidation of the granite was subsequent to that of the gabbroid rocks. There is an exposure of granite, generally tin-bearing, running down the eastern side of the island from Mount Cameron and Mount Stronach to the Blue Tier and Ben Lomond, St. Marys, Seymour, Bicheno, Freycinet's Peninsula, Maria Island, as far south as the Hippolyte rocks. It occurs again in the Middlesex Field, at Granite Tor, Mount Farrell, Hampshire Hills, Mount Housetop, Magnet and Meredith Ranges, Mount Heems-kirk, Mount Darwin, and evidently underlies the whole of the West Coast. The quartz-porphry dykes at Mount Bischoff, the tourmaline lodes at Mount Black, Renison Bell, and elsewhere in North Dundas, the stannite lode and spherulitic quartz reef at Zeehan denote the granitic reservoir below a large portion of the mineral fields on the West Coast. The normal granite is a dark mica one, mostly spotted with large porphyritic crystals of orthoclase felspar. In its tin-bearing varieties the magnesian mica disappears, and gives place to muscovite and lithia micas.

The Fingal slates, of a soft sandy nature, have been doubtfully retained in the Devonian, on the strength of a fossil resembling *Anodonta jukesii*; but it is uncertain whether they can be stratigraphically separated from the Silurian slates at Fingal.

The horizontal beds of conglomerate, which lie as heavy caps on the Dial Range and most of the Western Mountains, have been assigned to this system. These massive conglomerates crown Mount Farrell, Murchison, Lyell, Owen, Jukes, Roland, Claude, &c.

Permo-Carboniferous.

These rocks consist of sandstones, mudstones, grits, conglomerates, and limestones, with shales and thin coal seams. The most productive coal measures in Tasmania do not belong to this system, but are Upper Mesozoic, probably Jurassic. The Permo-Carboniferous strata have been thoroughly examined by Mr. R. M. Johnston, and his classification is adopted:—

Upper—

7. Elæolite syenites, phonolites and trachytes, at Port Cygnet.
6. Southport, sandstones and shales.
5. Mount Cygnet and Adventure Bay, sandstones and shales.
4. Upper marine mudstones overlying Mersey coal; Porter Hill shales and sandstones, Sandy Bay.
3. Lower coal measures; Mersey Basin.
2. Tasmanite shales.

Lower—

1. Lower marine mudstones, limestones, conglomerates, and grits, throughout S.E., N.E., and Midlands.

Conglomerates, grits, and micaceous sandstones and slaty flagstones, in thick beds, form the base of the system. These conglomerates, at One Tree Point, North Brunni, at Darlington, the northern point of Maria Island, below the limestone beds, contain large blocks of granite, porphyry, &c. The angular blocks on Maria Island are over a ton in weight, and on Brunni, too, they are very large. The Lower Marine series of limestones and mudstones comprises, in Southern Tasmania:—

3. Fenestella mudstones, at Porter Hill, The Grange, Cascades, &c.
2. Spirifera and strophalosia mudstones, Huon Road, &c.
1. Limestones, on Maria Island, at Bridgewater; also at Fingal, Middle Arm, &c., in the North. They contain *favosites*, *spirifera*, *productus*, *conularia*, *pachydomus*, *notomya*, *aviculopecten*, &c.

These marine beds occur all along the Derwent, from Brunni Island to New Norfolk. At Porter Hill, south of the Alexandra Battery, on the Brown's River Road, sections are exposed of the lower marine series, with its common fossils,

passing upwards into shales and sandstones of the upper division of the system, with *Gangamopteris* and *Cythere tasmanica* (Johnston).

Fossiliferous limestones and mudstones occur at Variety Bay. At Eaglehawk Neck, the sea beach exposes grits and conglomerates with rectangular joints filled with oxide of iron, forming a natural "tesselated pavement" greatly admired by visitors. The jointing is probably due to the vicinity of a concealed body of intrusive diabase. At the Middle Arm of the Tamar, near Beaconsfield, the fossiliferous limestones repose on Silurian rocks. Dally's old quarry abounds with *Eurydesma cordata*. Fossiliferous mudstones, with *spirifera*, *productus*, *terebratula*, *pachydomus*, *eurydesma*, occur on the Meander, near Cheshunt. At Mount Cygnet, the succession is—3, fenestella zone; 2, spirifera zone; 1, shaly mudstones. The spirifera sandstones occur all round Lovett and Lymington.

On the West Coast, the lowest conglomerates of the system are composed of pebbles of schist and quartzite, and rest on ancient schists in the Barn Bluff district.

The upper division of the system comprises sandstones and shales, which contain the coal of the period, and includes marine mudstones, overlying the coal in the Mersey district. In the Mersey Basin, notably, near the Great Bend of the river, near Latrobe, beds of variously-coloured clays enclose thin layers of bituminous shale, called Tasmanite, from the abundance of fossil spore cases of the lycopod *Tasmanites punctatus* (Newton), which contains over 25% of resinous matter. The exact relation of these shales to the other beds in the Mersey Basin is not settled.

The beds of the Mersey coal measures are grits, variegated sandstones, marls, and the coal plant remains are the forms characteristic of the Permo-Carboniferous, viz.:—*Glossopteris*, *Gangamopteris spatulata*, *G. obliqua*, *Noeggerathiosis media*. Mr. Johnston has also recognised a *schizoneura* (rare). The coal of these measures is superior in quality to the coal in the Jurassic measures, but the seams are not of such importance. They are overlaid by marine marls and limestones, sandstones, and conglomerates, with *Fenestella plebeia*, *Spirifera tasmaniensis*, *Terebratula sacculus*, *Pleurotomaria morrisiana*, *Pachydomus*, *Aviculopecten*, *Cardiomorpha*, *Pterina*, &c. These are called the Upper Marine Beds in Tasmania.

The upper zones of sandstones and shales at Porter's Hill, in the South, correspond with the Upper Marine beds of the Mersey. Two hundred feet of the former are exposed along the Derwent, containing *Cythere tasmanicus* (Johnston),

Gangamopteris, *Spirifera tasmaniensis*, *S. darwinii*, *S. duodecimcostata*, *Terebratulula sacculus*, *Avicula*, *Arca*, *Aviculopecten*, *Eurydesma sacculus*, *Edmondia*, *Inoceramus*, *Pachydomus pusillus*, *Pleurotomaria morrisiana*, *Conularia*, *Theca*, &c.

On the north bank of the Henty River, on the West Coast, between the Henty and Badger, the lower coal measures are hard dark grey shales, which contain *Gangamopteris spatulata* (McCoy), *G. obliqua* (McCoy), *Noeggerathioopsis media* (Ettingsh.). Above these are mudstones and impure limestones, with *Fenestella plebeia*, *F. internata*, *Protoretepora ampla*, *Stenopora tasmaniensis*.

In the North-East part of the Island, foraminiferal limestone of this system has been found by Mr. Thos. Stephens. At Harefield, in the Fingal Basin, a diamond-drill bore has revealed the existence of 97 feet of conglomerates, sandstone, and shales, resting on Silurian slates, at a depth of 674 feet in the bore-hole. These underlie the Upper Marine beds. Very little coal was found, but the shales contained imprints doubtfully referred to *Schizoneura* and *Gangamopteris*. The Upper Marine beds overlying these were 313 feet thick, and consisted of fossiliferous blue shale, limestones, mudstones, &c.

At Mount Cygnet, the lower coal measures rest on the fenestella beds, and are overlaid by 200 feet of grey sandstone. The coal shales contain impressions of *Vertebraria australis* and *Gangamopteris spatulata*.

At Adventure Bay, on Bruny Island, lower coal measure shales and seams lie conformably on the lower marine mudstones, conglomerates, and sandstones. They contain dwarfed forms of *Gangamopteris spatulata*, *G. obliqua*, *Glossopteris browniana*, var. *præcursor* (Brongt.).

At Southport, brown sandstone is overlaid by carbonaceous shales, with imprints of *Vertebraria australis*. The Adventure Bay and Southport series form the uppermost beds of the system.

The elæolitic and trachytic rocks, which are developed at Port Cygnet and Oyster Cove, are referred provisionally to the close of this period. Some of them appear to be fluidal, and interbedded with the Permo-Carboniferous mudstones and sandstones, but further examination is requisite. The majority are intrusive rocks, forming parts of a mass of elæolite-and alkali-syenite, with associated dykes of phonolitic, tinguaitic, and trachytic porphyries. The accessory minerals of the nepheline rocks, nosean, ægirine, sodalite, melanite, &c., are present here in all the wonderful variety characteristic of that group. Mounts Livingstone and

Mary, on either side of Lovett, and the beach south of the Regatta Ground, show these rocks in great variety. A good deal of free gold has been shed into the alluvial flat at Lymington. The source of the metal is believed to be the line of contact between the porphyries and the Permo-Carboniferous sediments. This belt of rock passes S. to the other side of the Huon River, and N. across to Oyster Cove.

Mesozoic.

The series of freshwater beds which succeed to the Upper Palæozoic belongs 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 quite provisional:—

Cretaceous (?)—

4. Diabase (dolérite) in intrusive masses, laccolites, sills, and dykes.

Jura—

3. Upper coal measure sandstones.

Trias—

2. Sandstones and shales, with coal seams, at Ida Bay, containing *Pecopteris lunensis* (R. M. Johnston).
1. Variegated sandstones, with *Vertebraria australis* (McCoy), and remains of heterocercal fishes and amphibians.

1. The sandstones at the Government House Quarry, in the Domain, at Knocklofty, at Ross, &c., belong to the Lower Mesozoic. Mr. R. M. Johnston considers the Lower Sandy Bay mudstones, exposed three miles from Hobart, on the Brown's River Road, to be the base of the system. They contain obscure plant impressions. The variegated sandstones of Lower Sandy Bay are supposed to overlie them conformably. In the Domain, the sandstone has yielded bones of amphibians (*Labyrinthodonts*?). From the Cascades to Knocklofty, there are about 1000 feet of these sandstones, from which the heterocercal fish, *Acrolepis hamiltoni* (Johnston and Morton), has been recorded. Messrs. Johnston and Morton give the section in ascending order, as follows:—

	<i>Feet.</i>
1. Yellow fissile sandstone	20
2. Flaggy sandstone, with fish remains	5
3. Mottled shales, with plants	60
4. Thick sandstone beds, quarried for building	715
	800

The sandstone near Tinderbox Bay is on the same horizon as the Knocklofty beds, and contains remains of a fish described by Messrs. Johnston and Morton, under the name of *Acrolepis tasmanicus*. This sandstone overlies conformably the uppermost beds of the Permo-Carboniferous mudstones.

This series of sandstones and shales contains the plant remains called *Vertebraria australis* (McCoy). Recently, *Vertebraria* has been regarded as the rhizome of glossopteris. In Tasmania, it is confined to the Lower Mesozoic, and the passage beds at Southport, which are just the strata in which glossopteris has not been found.

3. The sandstones which enclose the Mesozoic coal seams are readily recognised by their soft, felspathic nature; they are generally greenish-grey to yellowish brown, sometimes white. They are widely spread throughout East and South-East Tasmania, and occur also in the South. The maximum development observed is about 1000 feet. They are largely interrupted by intrusions of diabase, which breaks through, and, to all appearances, locally overspreads, them. Whether this overspreading is real, or only apparent, is still a matter of dispute. They flank the Central, Western, and Eastern Tiers, and fringe isolated mountain caps of diabase at Mount Nicholas, Mount Victoria, Mount Saddleback, Ben Nevis, Mount Elephant, Mount Dundas, Cradle Mountain, Ben Lomond, Tower Hill, &c.

From Fingal and Mount Nicholas they extend on the outskirts of the diabase ranges southwards to Seymour, Douglas, and Denison rivers, Llandaff, Spring Bay, and thence all over South-East and a good deal of South Tasmania, besides encircling the whole of the elevated central part of the Island with a narrow girdle. In the South-East they are cut up very much by intrusive diabase. In this brief description detailed mention of localities is impossible. Well-known occurrences are those on Ben Lomond, Schouten Island, Triabunna, Okehampton, New Town, Sandfly Rivulet, Tasman Peninsula, Upper Derwent, Campania, York Plains, Norwich, &c. The fossil flora from these beds must be regarded as characteristic for the Upper Mesozoic. The plants have been scheduled by Mr. R. M. Johnston, as follow:—

Filices—

Alethopteris Australis	(Morris)
" serratifolia	(R. M. Johnston)
Cardiopteris Tasmanica	"
Cyclopteris? Australis (possibly a Salisbury)	"
Danaea Morrisiana	"

Gleichenia dubia	(M'Coy)
Glossopteris moribunda	(R. M. Johnston)
Macrotaeniopteris Wianamattae.....	(Feiston)
Neuropteris antipoda	(R. M. Johnston)
" Tasmaniensis	"
Odontopteris crispata	"
Pecopteris Buftoni.....	"
" caudata	"
" odontopteroides	(Morris)
Rhacophyllum coriaceum	(R. M. Johnston)
Sagenopteris Tasmanica	(Feiston)
Sphenopteris Morrisiana	(M'Coy)
Sagenopteris salisburioides	—
Sphenopteris alata.....	(Brongt)
" elongata	(Carruthers)
" Tasmanica	(R. M. Johnston)
Strzeleckia gangamopteroides.....	"
" tenuifolia	"
Taeniopteris morrisiana	"
" tasmanica	"
Thinnfeldia buftoni	"
" feistmantelii	"
" obtusifolia	"
" media	(T. Woods)
" polymorpha	(R. M. Johnston)
" superba	"
" trilobita	"
Trichomanides ettingshauseni	"
" spinifolium	(T. Woods)
<i>Equisetaceae.</i>	
Annularia australis	(Morris)
<i>Cycadaceae.</i>	
Podozamites distans?	(Presé)
Pterophyllum dubium.....	(R. M. Johnston)
" risdonensis	"
" strahani	"
Sphenozamites feistmantelii.....	"
Ptilophyllum oligoneurum	(T. Woods)
<i>Coniferae.</i>	
Baiera tenuifolia.....	(R. M. Johnston)
Ginkgophyllum australis.....	"
Salisburia hobartensis	"
Zeugophyllites (poa-cordaites) elongatus	"

The sandstones are extensively broken by intrusions of diabase, or dolerite, which cut up the coal measure areas into different basins. Dykes of diabase traverse the beds. This rock, called dolerite in England and diabase on the Continent, is a holocrystalline mixture of augite, labradorite, felspar, and titaniferous iron ore, or magnetite. Its effusive equivalent is basalt; gabbro forms its plutonic roots. It appears to have been a subterranean intrusion of molten

material, which never succeeded in reaching the surface, or if it did, its superficial, subaërial portion has been removed by denudation. The masses now visible, as at Mount Wellington, and crowning the Tiers, may be looked upon as huge laccolites and sills. Up to the present, no evidences of lava flow have been found in the structure of this rock. It is devoid of ore-deposits.

Tertiary.

A great stratigraphic break exists between the Mesozoic and the succeeding strata. The Tertiary system cannot be subdivided as in Europe. Mr. R. M. Johnston has proposed the two divisions, palæogene and neogene, which are here adopted. According to this arrangement, the Tertiaries will be subdivided, as follows:—

Neogene (= approximately to pliocene)—

4. Glacier moraines of the Western highlands.
River terraces and estuarine deposits.

Paleogene (= Eocene to miocene)—

3. Basalt lavas.
2. Fluvial and lacustrine clays and sands, tin-ore drifts and leads.
1. Fossiliferous marine beds at Table Cape (= Eocene).

1. The researches of J. Dennant and the late Professor Ralph Tate have shown the marine fossiliferous beds at Table Cape to be of Eocene age. These strata are covered with the basalt, which, in the Island, appears to separate the lower from the upper Tertiaries.

2. The extensive lacustrine deposits within the watershed of the Tamar and its tributaries were described long ago by Mr. Johnston, under the apt title of sediments of the Launceston Tertiary basin. They cover an area of 600 square miles, and embrace the pre-basaltic or palæogene clays and sands, which are spread all over that part of the Island, as well as the post-basaltic, or neogene, valley terraces. The thickness of these beds is from 900 to 1000 feet.

At Launceston, the ferruginous sands and clays of the Windmill Hill are palæogene. They contain fossil impressions of the plant genera, *Betula*, *Fagus*, *Quercus*, *Cinnamomum*, *Banksia*. At Dilston, Windermere, and Muddy Creek similar beds occur. At Carr Villa, the boring-core showed an impression of *Betula* at a depth of 500 feet. A bore at Belmont went down in the palæogene sandstones and

shales to 894 feet, without reaching bottom. This is equivalent to about 200 feet below sea-level. At Beaconsfield, palæogene clays rest in a gutter of palæozoic rocks, 270 feet below sea-level, and their lowest layer is rich in fossil fruits (*Spondylostrobos*, *Platycoila*, *Cordia*, &c.), and a leaf of *Cinnamomum* has been recorded. Fossil conifers are also found in this bottom clay. In the N.E., the high plateau of sand and gravel, containing alluvial tin-ore, near Derby and Branxholm, which is capped with basalt, marks the ancient course of the Ringarooma River before it was choked with lava, and diverted to its present channel. At Burnie, in a white pipeclay below the basalt, imprints of leaves of European types have been found. At Waratah, leaf-imprints have been obtained from a greyish Tertiary sandstone, beneath 45 feet of basalt, at a height of 2000 feet above sea-level. These leaves have been determined by Mr. R. M. Johnston, as follows:—*Eucalyptus kayseri* n.s., *Laurus sprentii* n.s., *Quercus bischoffensis* n.s., *Ulmus tasmanicus*, *Cycadites microphylla* n.s. Leaf-beds of similar age, and containing impressions of *Cinnamomum*, also occur in the cliff at Strahan. Tertiary leaf-beds also exist in the tin-drift in Thureau's deep lead at St. Helens. The basin of the Derwent exhibits a series of Tertiary sands and clays, the latter of which, at Cornelian Bay, Sandy Bay, One Tree Point, Glenora, &c., contain the usual impressions of *Quercus*, *Fagus*, *Salix*, *Cinnamomum*, &c. The so-called travertin, at Geilston, contains *Cypris alburyana* (Johnston), conifer stumps, and leaf impressions of *Quercus*, *Fagus*, *Salix*, *Cinnamomum*. At the head of Oyster Bay, near Swansea, there are Tertiary, probably palæogene, clays, which contain a good deal of clay ironstone. Beds and seams of lignite occur at Dilston, Evandale Junction, Kelly Basin, and other places in Tertiary areas. At Kelly Basin, such beds contain fossil resin, and at Evandale Junction the beds also enclose resin globules.

3. 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. Three types of basalt have been met with up to the present:—1, olivine basalt; 2, nepheline bearing olivine basalt; 3, melilite basalt, associated with nephelinite. The first type is the common variety of the Island. It has overspread the Campbell Town and Conara plains, and widely conceals sediments in the Launceston Tertiary basin. Its mineral constituents are uniformly felspar + augite + olivine. Its texture is doleritic on the coast N. of Lefroy, at Mount Horror, at Paddy's Peak, Hampshire. Fine

columnar structure may be seen in the quarry near the breakwater at Burnie. Dykes of this basalt traverse the granite at Lottah, and at the summit of the Blue Tier. At One Tree Point, Sandy Bay, a basalt is exposed which contains the red-iron olivine fayalite, visible under a hand-lens, as dark red spots (described by O. E. White and W. A. Macleod). Basalt-glass, or tachylyte, occurs in the basalt in several parts of the Island, *e.g.*, Waratah, Richmond, Bothwell, &c. No craters are known.

The second variety of basalt is that forming the remarkable bluffs at Circular Head and Table Cape. The late Professor Ulrich at one time determined it to be nepheline-bearing, but afterwards withdrew the reference to nepheline, believing the mineral in question to be apatite. Apatite is abundant in the rock, but recently microscopical examination has shown nepheline to be present also. The structure is doleritic; the mineral constituents are plagioclase + augite + olivine + nepheline.

The third type is melilite basalt, with typical nephelinite, or nephelinite-dolerite, at the Shannon Tier, near Bothwell. The geological horizon has not yet been determined, but the age is believed to be Tertiary.

4. *Neogene*.—The post-basaltic valley terraces can only be separated from the earlier Tertiaries by position and lithological characters. Some of the gravel drifts of the Derwent, of the Longford plain, and in the neighbourhood of Launceston, belong to this division. The lignite beds of the Henty River contain leaves of *Fagus jonesii* (Johnston) and *Acacia meiringii* (Johnston), both closely resembling existing species.

The close of the Tertiary, or the beginning of the Quaternary, witnessed a glacier epoch in the western part of the Island. The highlands round Barn Bluff, Mounts Tyn-dal, Sedgwick, Jukes, Darwin, &c., and the western edge of the great central plateau, abound with tarns, ice-scratched stones, and moraines. Signs of ice-action have been traced to sea-level on the West Coast, but the most abundant evidence is to be found above the 2000-foot level. No proof of glacier conditions in this period in the Eastern part of the Island has been adduced yet.

Tin-ore and gold-ore are the most important of the mineral resources of the Tertiary system. These occur in the alluvial gravels and leads of the period. The sands in the Savage River, and other tributaries of the Pieman, have been worked for osmiridium, and, at Mount Stronach, for monazite. The zircon sand, near Table Cape, was also exploited a few years ago. Tertiary clays are used largely

for brick-making and pottery; the gravels for road-making. Though there has been great volcanic activity, there are no signs of Tertiary lode-deposits.

Quaternary.

Recent—

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

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 overlies a raised beach. The raised beaches on the North Coast indicate elevation within the recent period.

The foregoing sketch does not pretend to do more than merely outline the general geology of the Island. Much information has been drawn from the labours of Mr. R. M. Johnston, here acknowledged, but many important matters still require attention. Among these are—(1) age of the schists of Mounts Lyell and Read; (2) age of the hornblende schists of the Rocky River; (3) age of the quartz-porphyry, or felsite, of Mounts Jukes and Darwin, and its relation to the granite; (4) age and nature of the Barn Bluff schists; (5) age of the gneiss and schists of the Upper Forth; (6) connection (if any) of the Lynchford augite-syenite-porphyry with the felsites on Mount Jukes and Mount Read; (7) geological occurrence of the Mesozoic diabase; (8) origin of the obsidian "buttons"; (9) connection of the nepheline basaltoid rocks at Circular Head and Table Cape with the prevailing normal basalts; (10) age of the elæolite syenites and phonolitic rocks at Port Cygnet and their boundaries; (11) origin of the lake basins in glacier areas and on the Tiers; (12) the nepheline and melilite rocks at Shannon Tier; (13) the occurrence of garnetiferous chlorite schist in granite at St. Helens, and numerous other questions fraught with interest to the geologist.

These remarks may be closed by mention of the names of resident geologists, to whom inquirers may address themselves for information:—In the South: Mr. R. M. Johnston, stratigraphy and palæontology; Mr. Thos. Stephens, M.A., Hobart, stratigraphy; Mr. O. E. White, Hobart,

eruptive rocks. In the North: Mr. W. F. Petterd, Launceston, mineralogy and petrology of the Island; Mr. Geo. A. Waller, Assistant Government Geologist, Launceston, geology and ore deposits. In the West: Mr. F. J. Ernst, Zeehan, eruptive rocks and ore deposits; Mr. T. B. Moore, Strahan, glacial geology. In the East: Mr. Henry Grant, St. Helens, granites and tin-ore deposits.

Suites of Tasmanian rocks, fossils, ores, and minerals may be seen at the Tasmanian Museum, Hobart (Mr. Alex. Morton, F.L.S., Curator); the Victoria Museum, Launceston (Mr. H. H. Scott, Curator); the Zeehan School of Mines (Mr. Reid, Director); the Government Geologist's Office, Launceston. A complete collection of Tasmanian minerals is owned by Mr. W. F. Petterd, Launceston.