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The Tasmanite Shale Fields of the Mersey District

BY

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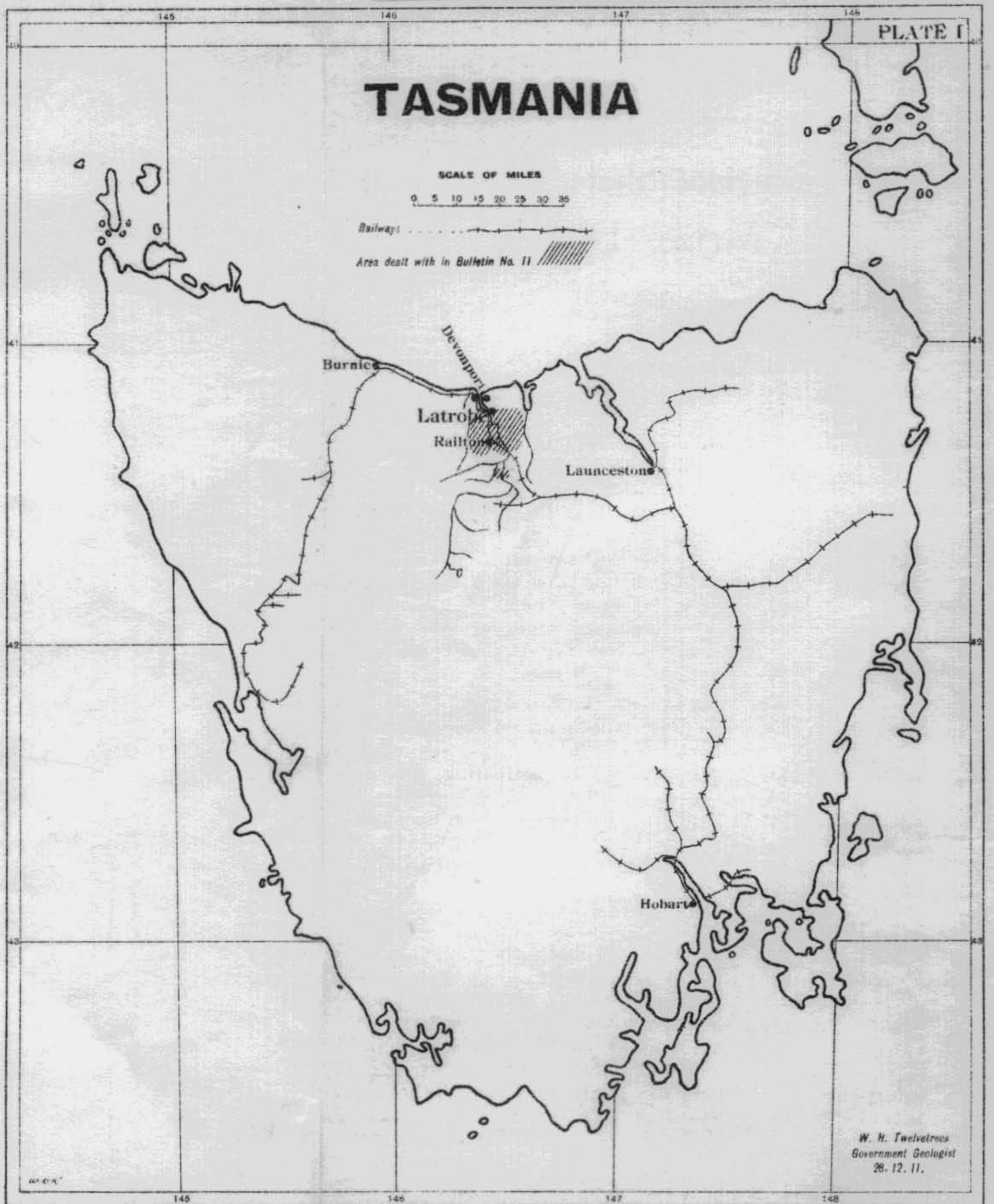

LOCALITY PLAN

Photo Algraphed by John Vail Government Printer Hobart Tasmania

The Tasmanite Shale Fields of the Mersey District.

I.—INTRODUCTION.

THE part of the island under review in the present bulletin is—

(1) Approximately that embraced within the boundaries of the Mersey mineral chart, issued by the Mines Department of Tasmania. The town of Latrobe is on its northern limit; those of Sheffield and Kimberley are on its southernmost parallel. The Don River forms its boundary on the west, the Rubicon on the east. This area covers about 120 square miles.

(2) An area of 4 or 5 square miles, situated 6 miles west of Dunorlan Railway-station, between the Minnow and Mersey Rivers.

Resinoid shales occur in both the above areas, the occurrence at the Minnow being 9 miles south of the most southerly one in the northern area.

The present demand for fuel oil (increasing, too, at a rapid rate) makes the examination of likely sources of supply a matter of urgency. It is, moreover, recognised by British and Commonwealth Naval authorities as desirable that all possible sources within the bounds of the Empire should be utilised.

Liquid fuel is now being largely used all over the world. In southern Russia it has long been employed for railway locomotives and the steamers on the Caspian Sea. Throughout this part of Russia increasing numbers of factories are burning this fuel. In the great plains area of western America, where coal is costly, oil fuel is used by every mill and steam-plant throughout the entire territory. The United States railways are also consuming enormous quantities of oil on their lines. The great advantages of the use of this kind of fuel for marine engines, particularly by navies, are now fully realised. Among these may be mentioned:—

(1) Superior thermal efficiency, compared with coal (1·75 : 1).
(2) Ease in shipping, as fuel tanks can be filled without labour.
(3) Possibility of fuelling while the ship is at sea.
(4) Smokeless fuel under ordinary conditions.
(5) Power of forcing boilers in emergencies.
(6) Easy storage and handling; and economy of space.

The submarines in the Navy are equipped with petrol engines, and, of course, motor spirit is the support of the automobile industry. Crude oil is used in metallurgical roasting furnaces, in scrap-iron melting furnaces and rolling mills, and other industrial establishments. It has also been tried in oil-flotation processes in ore-concentrating works.

Crude oil is being used to great advantage for the improvement of roads, and in the future it will no doubt be increasingly utilised for this purpose. The trials which have been made have proved eminently satisfactory, and there is this important feature in its application in this direction—that an inferior oil will answer the purpose of binding the road sand and dust. The chief factor in satisfactory results appears to be the determination of the precise quantity to be used, which is said to be from 1000 to 2000 gallons per mile. The oil is said to require using twice a year for allaying the dust nuisance in towns, and only once a year for macadamised country roads.*

Valuable lubricating oils are also obtained from shale, their manufacture being a matter of fractionisation.

The Royal Commission on coal supplies in 1903 did not consider there is any likelihood of oil displacing coal as a fuel generally, as although there are particular uses to which it may advantageously be put, the visible sources of supply are far too inadequate to admit of a general substitution.† Nevertheless, there are plenty of indications in the news published from all parts of the world that strenuous work is proceeding, with the object of augmenting available stocks.

* See Economic Geology of the Independence Quadrangle, Kansas, by F. C. Shrader and E. Haworth. United States Geol. Surv. Bull., No. 296, 1906, p. 38.

† "Petroleum," by Sir Boverton Redwood, London, 1906, p. 699.

The fact that the resinoid (tasmanite) shale of the Mersey basin, when submitted to destructive distillation, yields an oil suitable (among other things) for fuel, has made it incumbent on the Department of Mines to initiate a survey of the district, and to publish a record of all that can be learned of its occurrence, and the possibilities of the area generally. Owing to the growing world-need of oil supplies, the question becomes nationally important. No one can question the desirability of making sure that the conditions for establishing this new industry are present in Tasmania.

II.—PREVIOUS LITERATURE.

The earliest record appears in the "Papers and Proceedings of the Royal Society of Van Diemen's Land" (Vol. II., Part I., 1852), in a paper read 9th July, 1851, by J. Milligan, on the coal said to have been found at the Don River, &c. The following extracts refer to the tasmanite shale:—

"There is on the right bank of the river (Mersey), from the upper side of this eruptive dyke (basalt), and dipping towards it a series of beds of a brown schist (allied to dysodile) of a nature highly combustible; its surface is usually finely punctated," &c. (Page 96.)

"The same brown combustible schist presents itself a mile higher up the river, and on the same side, but at an elevation of more than 100 feet above the water," &c. (Page 96.)

"The brown combustible schist exhibits at the elevation last mentioned a thickness of 6 to 7 feet in one distinct seam, passing upwards into laminated clay rock of a yellowish colour, interstratified with thin layers of the schist." (Page 97.)

The next mention appears in the "Proceedings of the Royal Society of Van Diemen's Land," May 12, 1852, page 315:—

"A specimen of the combustible schist (dysodile?) from the Mersey River forwarded some time ago to Lieut. Clarke by Mr. Wheeler, of Port Sorell, was presented."

In the "Proceedings of the Royal Society of Van Diemen's Land," 14th September, 1853:—

"The Secretary reported having recently received from Mr. James Macarthur, of Calstock, a small quantity of a fine pulverulent substance washed by that gentleman from the combustible schist found at the Mersey (of which specimens have been repeatedly exhibited to the Society), which Mr. Archer had examined with a pocket microscope and pronounced to be resin. Mr. Archer described it as being in minute, smooth, flattened grains, giving the impression that it had exuded from the leaf or bark of the plant or tree, by which it may have been produced, nearly of the size and form which it now possesses; that it probably fell like small dust on the surface of the ground, where, from its nature, it would remain unaltered until swept by rain and other causes, intermixed with fine argillaceous particles into a lake or estuary, where it would be deposited, and thus eventually form the thick beds in which it is now met with."

In A. R. C. Selwyn's "Report upon some of the Coal Seams of Van Diemen's Land," 12th May, 1855, tasmanite shale is alluded to as "Yellow Coal":—

"Mr. Johnstone has found the coal cropping 2½ miles south-east from Mr. Williams' on Crown land. It appears to be the same seam, about 2 feet 2 inches thick, and butts against the yellow coal."

In 1855, also, Prof. Penny, of the Andersonian University, Glasgow, describes the results of his examination in the "Proceedings of the Royal Society of Van Diemen's Land" for that year.* He describes the shale as being a mixture "of clay and sand highly impregnated with a combustible substance analogous to resin, on the presence of which all its peculiar, as well as useful, properties depend." (Page 113.)

At the same time he points out that "generally speaking resins are more or less soluble in alcohol, ether, naphtha, and oil of turpentine: but this mineral is very little acted upon by these solvents." (Page 112.)

His analysis of it yielded (page 110):—

Volatile Matter. %	Fixed Carbon. %	Ash. %	Sulphur. %	Water. %	Total.
20·41	5·50	71·20	0·73	2·16	100

On distillation in a closed vessel it yielded an oil, a strong acid, and tarry matter, leaving a carbonaceous residuum.

In 1861 a Tasmanian House of Assembly Paper (No. 8) appeared, entitled "Resinous Shales (Dysodile at Latrobe)," by Charles Gould, then Government Geologist (May 23, 1861). In this report the outcrops at the Great Bend of the Mersey are described, and reference is made to a company formed for the purpose of proving the deposit. The seam is recognised as a marine deposit, containing, though somewhat sparingly, the remains of species of productus, pecten, platyschisma, pachydomus, &c., which also occur in the beds immediately above and below it. Mr. Gould estimates the area underlaid by the dysodile at the Bend at about 400 acres, and the maximum thickness worth extracting from the seam at 5 feet.

* "Report on the Chemical Qualities and Analysis of a Combustible Mineral Substance from the Mersey River, Tasmania," by Prof. Penny (read 13th September, 1854).

In 1861 a House of Assembly Paper (No. 135) also appeared, entitled "Report upon the Mersey Coalfield," by Chas. Gould (October 29, 1861), in which it is mentioned that "dysodile has been found in waterworn fragments in a tributary of Caroline Creek, but the outcrop has not yet been discovered." (Page 9.)

In 1862 the Rev. W. B. Clarke (in Cat. Nat. and Indust. Prod., N.S. Wales, as quoted by Mr. J. E. Carne, in his "Memoir on the Kerosene Shale Deposits of New South Wales," page 298), mentioned that these Mersey schists are charged with resin, and may be valuable as a source for the manufacture of mineral oil. He found the specific gravity of some of the substance to be 1·204.

In the "Intellectual Observer," September, 1862, page 144, an article appeared on dysodile. The writer stated:—

"In the Museum of Practical Geology, in Jermyn-street, will be found a large mineral mass labelled somewhat in the following style:—'Combustible matter from the banks of the River Mersey, north side of Tasmania.' Specimens of the same substance are also to be seen in the Tasmanian Court of the International Exhibition, and it seems certain that this 'combustible matter' is nearly identical with a rare mineral described as dysodile in Chapman's mineralogy. It presents the appearance of a brownish-grey slate, rather than that of any kind of fuel; yet it burns freely, though with a very offensive smell, when held in a flame. It has been employed in the locality of its occurrence instead of coal.

"Examined with a magnifying lens of low power, the combustible constituent of dysodile is seen to be disseminated pretty uniformly through the mineral in the form of small flattened drops of a pale brownish-yellow colour, and marked wtih a few ridges, radiating from the centre of each disc. When a piece of dysodile is crushed in a mortar and the fragments warmed with strong hydrochloric acid, these discs float in the liquid, and may be easily separated. They are nearly, if not quite, insoluble in ether, alcohol, and benzine, thus differing from solid paraffin; they require a high temperature to melt them, and have been found on analysis to contain, in addition to carbon and hydrogen, a small percentage of sulphur. Dysodile in its native state can scarcely be termed 'combustible' matter. By far the largest part of it is inorganic and incombustible, as the following analysis shows:—Combustible matter 36·51; water, &c., 2·30; mineral matter or ash containing silica, alumina, iron, soda, &c., 61·19; total, 100."

In 1864 a paper appeared in the "Philosophical Magazine" (Vol. XXVIII., pages 465-470), entitled "On Tasmanite, a New Mineral of Organic Origin," by A. H. Church. From this paper the following extracts are given, as the publication is not readily accessible to the general reader:—

"The true dysodile, from Glimbach, near Giessen, analysed by Delesse, does not seem to be identical either in chemical or physical constitution with the Tasmanian mineral. Dysodile is said to occur at Mellili, near Syracuse, and at Salzhausen, in Hessia." (Page 465.)

"Density of the tasmanite substance = about 1·18; hardness, 2; translucent; of a reddish-brown colour; lustre resinous, and fracture conchoidal." (Page 466.)

"The ash mainly consists of silica and alumina; it contains also a small quantity of ferric oxide, and of some soluble sulphate; this latter compound being derived in all probability from the oxidation of the sulphur contained in the tasmanite proper." (Page 468.)

"Alcohol, ether, bisulphide of carbon, benzole, turpentine, mineral turpentine, and paraffin oil do not appear to exert the least solvent action upon tasmanite, even on the application of heat; the result might be different under an increased pressure."

"When tasmanite is heated in the air it burns readily with a very smoky flame and offensive odour. Submitted to destructive distillation it fuses partially, and yields oily and solid products, having a disagreeable smell, recalling that of some specimens of Canadian petroleum. One is tempted to suggest that the natural rock oils may in some instances originate in the action of heat upon substances similar to tasmanite shale." (Page 467.)

"That the sulphur detected was an integral part of the carbonaceous matter itself, and was not owing to the presence of an inorganic sulphide or sulphate, was proved in several ways, and was further confirmed by the observation that the more completely the mineral matter had been removed, the more sulphur was found in the specimen of tasmanite operated on." (Page 467.)

"Tasmanite is believed to be the first carbonaceous mineral which has been found to contain a large amount of sulphur in combination—not with a metal, as in pyritic coal, but in intimate union with the carbon and hydrogen of the substance. It would seem to be allied to retinite, although that mineral contains no sulphur."

"Formula for retinite, $C_{40}H_{64}O_4$."

"Formula for tasmanite, $C_{40}H_{64}O_2S$." (Page 469.)

"It is suggested that these minerals may be derivatives of a turpentine $C_{20}H_{32}$, or the radical I have assumed them to contain may be a homologue of benzoyle"—

"$C_7H_5O + 13CH_2 = C_{20}H_{31}O$" (Page 470.)

Since Prof. Church's paper the name dysodile for the Tasmanian mineral has been dropped and tasmanite used in its stead.

In 1865, Volume VI. of the "Transactions and Proceedings of the Royal Society of Victoria" for 1861-1864 was published. This contained the abstract of a paper by T. S. Ralph, read May 27, 1861, entitled "Observations on the microscopical characters presented by a mineral (Dysodil) from Tasmania":—

"The author showed that the mineral was a kind of shale containing, besides a bituminous substance, a large amount of algae, of a spherical form, which were preserved by their being coated by a resinous substance." (Page 7.)

In 1872, R. M. Johnston recognised the nature of the sculpturing on the tasmanite sacs, and in 1874 described the same in his "Field Memoranda for Tasmanian Botanists."

In 1875, in the "Geological Magazine," E. T. Newton, after examining a specimen of tasmanite from the Mersey, expressed the opinion that there could be no question as to the tasmanite sacs being vegetable organs, although the plant to which they belong is at present unknown. Their size and form seemed to indicate that they were more nearly allied to *lycopodiaceous macrospores* than to anything else. He proposed that the spores (or rather, the plant to which they belong) should be called *Tasmanites*, with the specific title of *punctatus*, in allusion to the surface markings. (See also Proc. Roy. Soc., Tasmania, 1876, page 2.)

In May, 1883, a report on the Mersey coal deposits was prepared by G. Thureau, Geological Surveyor for Tasmania, and published as a House of Assembly Paper (No. 52), and Legislative Council Paper (No. 61). In it the author says:—

"Dysodile or Tasmanite.—This interesting rock—for it occupies a place in the Upper Marine (Palæozoic) beds—

occurs at and near the Great Bend on the Mersey. Several other localities have been, it appears, reserved for this mineral, but so far I was not successful in finding any but those abovementioned. It evidently belongs to the bituminous schists (pyro-schists of Hunt), and so far it does not appear to have any special value at present."

In 1888 the "Systematic Account of the Geology of Tasmania," by R. M. Johnston, was published. In this the author described the occurrences at the Great Bend of the Mersey, alluding to them as flags of tasmanite shale composed of very fine arenaceous particles interspersed with myriad minute discs of the sporangia or spore cases of a supposed Lycopodiaceous plant termed by Professor Newton *Tasmanites punctatus*. He referred to his own discoveries 3½ years before the publication of Professor Newton's observations. In accounting for the origin of the deposit he stated:—

"We must conclude therefore that tasmanite is chiefly the product of the sporangia of certain cryptogams allied to the club-mosses; that the said sporangia were washed down by some ancient river and mixed with fine particles of muddy sediment, to which the resinous bodies readily adhered, and were finally deposited in the quiet bottom of an arm of the Upper Palæozoic sea, and that among the sediment thus accumulated the marine organisms lived and died." (Page 140.)

The author was unable to arrive at any definite conclusion as to the relative age of the tasmanite shale to the Mersey coal measures. He remarked:—

"Mersey Basin.—Although for the sake of convenience I have divided the members of the Upper Carboniferous division in this basin into two separate groups—viz., the *Tasmanite Beds* and the *Lower Coal Measures*—it must not be inferred that there is clear evidence of separation as regards stratigraphy or contemporaneity. It would be difficult to say whether the fine, grey flags and sandstones associated with the bituminous tasmanite are on the same horizon as the lower intercalated marine beds of the lower coal measures of the district, or whether they may not rather be related to the upper marine beds overlying the principal coal seams. They are of such limited extent that it is possible one or the other of the marine beds associated with the lower coal measures, if followed horizontally, may merge into the tasmanite beds near to them in the same basin." (Page 129.)

In 1902, Hartwell Conder, M.A., contributed an article to the "Australian Mining Standard" (May 1, page 597) on oil shales in Tasmania, in which he described the tasmanite occurrences on the Mersey near Latrobe.

In 1903, J. E. Carne, Assistant Government Geologist for New South Wales, gave a considerable amount of information concerning tasmanite in his "Memoir on the Kerosene Shale Deposits of New South Wales." He furnished a synopsis of the literature up to that date, and stated that he had been informed by Professor David that "the associated fossils are characteristic of the Greta horizon (lower coal measures) in the Hunter River Coalfields of New South Wales." (Page 298.)

In the Annual Report of the Secretary for Mines (Tasmania) for 1908, a condensed report by the writer of this Bulletin appears on shale deposits in Tasmania. Brief reference is made in it to the tasmanite shale, and to the results obtained by Dr. J. G. A. Black and T. Esdaile in their laboratory experiments for the Tasmanian Shale and Oil Syndicate in 1902.

In the recent Text-book of Geology, by Lake and Rastall (London, 1910), the authors state:—

"A microscopic examination of certain seams—for example, the Better Bed Coal of Yorkshire—has shown that the coal consists to a very large extent of the spores of lycopods. Now, the spores of modern lycopods are very resinous, and will not sink in water, so that a coal composed of them must of necessity have been formed on a land surface. The so-called tasmanite, or white coal, of Tasmania, is a lignite of comparatively recent date, having a similar structure." (Page 157.)

The last sentence in this extract indicates a misapprehension of the age and nature of tasmanite shale.

III.—PHYSIOGRAPHY.

The physical features of the country round Latrobe comprise valley and plain, mountain and table-land. Dooley's, or Latrobe, Hill shelters the town on the north; the Sassafras Plateau, between the Mersey and the Rubicon, at an average height of about 400 feet, is the great land mass to the east. Latrobe and Tarleton are situate in the great valley of the Mersey River on a plain about 4 miles in width, beyond which, to the west, are the hills bordering the River Don. To the south is the valley of the ancient Mersey, between the vestigial fragment of Brown Mountain on the west, and the Dulverton and Mersey Hills on the east, through which the present river winds its way.

Latrobe itself, 15 to 20 feet above the river, is built on the shingle-covered former flood plain of the Mersey. This plain is low compared with the surrounding country. There has been time in the history of the Mersey for the stream to have graded its channel and widened its valley. Near Latrobe it is what is called a mature river.

When we stand on the Sassafras plateau and view the country to the west, we see its broader features, and we are able to form a general idea of the land forms which show the structure of the country. No one can resist the conviction that what he is gazing at is a dissected peneplain—a worn-down surface buried beneath a sheet of basalt lava, raised to some height and cut down into by the rivers which traverse it. The channel of the Mersey has evidently been deepening. After the old flood-plain was formed the river, probably assisted by a rise of the land surface, cut its channel down to below the level of the plain, and has since been eroding its banks and forming a new flood-plain at a lower level than the old terrace, which may be seen on each side of the stream at some distance from its banks. It seems as if this process has been repeated, the first plain being composed of the gravel and sand-bank as far back east as Elliston's farm.

The high plateau at Sassafras is repeated between the Don and the Forth, and again between the Forth and Leven; and beyond between the Leven and the Blythe, and between the Blythe and Emu, and so on along the coast.

The same features present themselves higher up the river, at Kimberley and Dynan's Bridge; lava sheets on the table-land, and the river flowing at a great depth below.

The change of course of the Mersey from its old bed at Railton to its present channel north of Native Plain is interesting. One is tempted to speculate on the cause which impelled the river to leave its broad, easy channel through Railton and Dulverton, and to cleave the schist-rocks through which it now forces its passage. The explanation is probably that, guided by elevation of the land, the stream simply followed a natural gradient, and the rocky gorge has been formed since.

The plateau country has been cleared of timber and cultivated. Thriving farms abound on it, and it seems to be generally agreed that from a farming point of view the Sassafras land is the best on the coast.

The country between Native Plain and the Rubicon, and between Fossil Bank and the Don, is, generally speaking, timbered. For a long time this timbered country has been regarded as unsuited for cultivation, but of late years it has begun to be realised that comparatively poor land can be turned to account in orchard-growing. Everywhere throughout the district trials in this direction are being made, with successful results.

Owing to its position near the coast and its proximity to the high hinterland, the Latrobe district enjoys a satisfactory rainfall, somewhat in excess of the precipitation at Launceston and Hobart. The figures available for Latrobe are too incomplete for use, and the weather bureau has now no one in charge of observations; but the average yearly fall appears to be between 35 and 40 inches, as compared with 27·7 for Launceston, and 23·2 for Hobart.

IV.—GEOLOGY.

The geology of the district is varied, quite half a dozen geological periods being represented, besides some large developments of igneous rocks. For the most part, however, economic interest is centred in the beds of one system—the coal and shale measures of the Permo-Carboniferous system. These have attracted attention for the past 60 years. Here and there some veins of quartz in the Pre-Cambrian and Cambrian rocks have from time to time raised hopes of the discovery of gold, but the indications cannot be described as favourable for the occurrence of that metal in appreciable quantities. Coal, shale, clay, and limestone must be regarded as the staple products of mine or quarry.

The earliest rocks (the Pre-Cambrian) are present; and also the youngest (Tertiary); but several members of the geological succession are unrepresented. The various developments are referred to under their respective headings.

(1)—Pre-Cambrian.

A belt of sericitic quartz-mica and mica-schist extends along the course of the Mersey for about 4½ miles from north to south, and attaining a maximum width of upwards of a couple of miles. Its northern limit is Bonney's Creek, near Latrobe, though a small exposure of slate which probably belongs to the same system occurs on Cherry Hill, ½-mile further north. It extends southwards uninterruptedly to H. Kimberley's 640 acres, on the east bank of the Mersey, near Hogg's Bridge. Further south it reappears at Kimberley.

Outside the district it occurs to the west, in the valley of the Forth River, and at Ulverstone; and to the east in the Asbestos Range, between the Rubicon and the Tamar.

It belongs to the Algonkian, or dominantly sedimentary division of the great Pre-Cambrian group.

On it rest, with a strong unconformability, the Cambrian conglomerates of the Dulverton-road; and elsewhere, as at Oliver's farm, the Latrobe pumping-station, on James' block, at Paramatta, &c., it is succeeded by the upper members of the Permo-Carboniferous system.

Its general strike is north-westerly, and the dip south-west. North of the old Deloraine-road, east of Gray's 25 acres, a crystalline sandstone or quartzite appears as a member of this group. It contains here a quartz lode, trending north-west to south-east, and dipping south-west, on which a little abortive prospecting work has been done. The outcrop is gossanous; the quartz is cellular in texture, and white to yellow in colour. Under other geological conditions the stone would be considered as promising for the occurrence of gold.

(2)—CAMBRIAN.

Strata at present referred to this age are found developed at Railton and the Badgers. They are grouped as follow:—

III. Dikelocephalus sandstone and slate at Railton and Caroline Creek.

II. Slate, sandstone, and quartzite, south of Railton, and flanking the Badgers.

I. West Coast Range conglomerate on the Badgers and along the Railton-Dulverton-road.

A certain degree of hesitation which is felt in assigning horizons to Groups I. and II. disappears in considering Group III. The latter, by its organic remains, constitutes one of our most important geological horizons in Tasmania. The fossils determined by Mr. R. Etheridge are the following:—

Crustacea.—Dikelocephalus tasmanicus (Eth.).

Crustacea.—Ptychoparia* stephensi (Eth.).

Gasteropoda.—Ophileta.

Lamellibranchia.—Raphistoma.

The only other definitely Cambrian fossil which has been found in Tasmania was obtained by Mr. T. Stephens in 1902 from the north-west slope of Tim Shea (Mt. Stephens), at the head of the Florentine Valley, and was named *Dikelocephalus florentinensis*. The writer found some fragmentary trilobite remains in the same neighbourhood, on the east side of the Humboldt Divide.

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* Formerly Conocephalites.

Dikelocephalus*, ptychoparia, and ophileta are characteristic Cambrian fossils; raphistoma is Cambrian and Silurian. Mr. Etheridge regards it more than probable that the Caroline Creek sandstone is on the horizon of the Lingula Flags or Menevian beds of Great Britain, and the Potsdam sandstone of North America.

In Great Britain the Upper Cambrian Tremadoc slates and Lingula Flags are characterised by the occurrence of dikelocephalus.

In North America the Upper Cambrian Potsdam sandstone contains dikelocephalus and ptychoparia.

Ptychoparia is an organism which is found in all three divisions of the Cambrian.

The writer collected on the range above the Dulverton Range from the Cambrian beds quartzite with the ill-understood arenicolites, supposed to be worm burrows; also at Caroline Creek, at the second railway-crossing, sandstone faced with obscure discoidal impressions, the nature of which it has as yet been impossible to determine.†

(I.)—*Basal Conglomerate.*

This is the heavy conglomerate which forms the backbone of the Badgers and the crest of the hill at the Rifle-range, Railton, and extending northwards along the top of the hill east of the Dulverton-road as far as Wakeham's turn-off. It forms the precipitous northern front of Gog Mountain, whence it extends to Mt. Roland; and it is on the crest of the hill west of the Minnow River, on the Dynan's Bridge-road. It is identical with the conglomerate seen on the West Coast and Denison Ranges, and on Mt. Zeehan.

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* Prof. E. Haug remarks, (Traité de Geologié II.) :—" The upper Cambrian of Australia and of Western America are both characterised by the genus *Dikelocephalus,* which is met with in Eastern America as far as the Appalachians, while it is absent from the whole of the North Atlantic Province. On the other hand the genus *Olenus* so abundant in the latter is wanting in the countries in which *Dikelocephalus* is found. There exists then in the Cambrian, outside the North Atlantic Province, a *Pacific Province* which comprises China, Australia, North America to and inclusive of the Appalachians, and which can be defined by the presence of *Ceratopyge* in the Georgian and Acadian (Lower and Middle Cambrian), by the absence of *Paradoxides* from the Acadian, by the presence of *Dikelocephalus* and the absence of *Olenus* in the Potsdam (Upper Cambrian)."

† Similar impressions, but of larger size, have been found at Zeehan and in the Loddon Valley.

The only place at Railton where any dip can be observed is at the Rifle-range, above Gould's farm, where an isolated outcrop is exposed on the hillside. The dip is here north-easterly, and this seems to be confirmed by some imperfectly-exposed stone in the drain on the road below. This underlay is somewhat unexpected, and indicates the existence of a break between here and the limestone quarry. The strike is north-westerly. The quartz and quartzite stones, of which the conglomerate is composed, have been shed into the shale basin to the east, and are found everywhere in the surface soil. There is no other exposure for the whole length of the Dulverton Hill, and the existence of the conglomerate in that direction can only be inferred from the nature of the stones on the surface of the ground.

Four miles west of the Railton Rifle-range is the high hill called the Badgers, rising to 1300 feet above sea-level. The central part of this hill, which extends for 4½ miles in a north-west to south-east direction, consists of a narrow belt of coarse conglomerate, with steep scarps on each side. The general strike of the belt is about N. 12° W., but the dip of the bed is very uncertain, as the large quartzite pebbles are set promiscuously in the matrix without any definite arrangement, and the division-planes in the rock are unsafe criteria. At the northern end of the mountain these are vertical, with, perhaps, a tendency to incline to the south-west. At the southern end the strike is E. 5° N. and the dip northerly at an angle of 35°.

The conglomerate in this district is unfossiliferous. Elsewhere—on Mt. Lyell, on the track south from the Comstock Mine—it contains obscure tubular casts, supposed to represent the burrows of annelids.

The precise origin of this extensive conglomerate formation is not yet perfectly understood. It reappears on different meridians, and, subjected to great faulting evidently, marks a definite geological horizon. Diastrophic processes* have dislocated the rock-masses without deforming the rock, and hence it shows no signs of schistosity or crumpling except where argillaceous layers are interbedded with it. For a long time it was supposed to form a horizontal transgressive layer on the tops of our mountains, and was then regarded as of Devonian age. More recent observations showed that this interpretation was ill-founded. Where its base has been seen (marked by the presence of a pronounced breccia bed) it rests

* Diastrophism comprises the dislocation and deformation of strata by earth movements subsequently to their original deposition.

unconformably on the Pre-Cambrian schists; and its component pebbles are of schist and quartzite derived from Pre-Cambrian rocks. No stones from the Cambro-Ordovician porphyroids and breccias have been detected in it.

A glacial origin is sometimes vaguely claimed for the formation. No evidence has been collected or advanced in support of this reference. Its nature is, perhaps, more likely to be that of a marine margin on which accumulated the waste derived from the degradation of a high Pre-Cambrian coastline.

(II).—*Slate, Sandstone, and Quartzite.*

A series of ferruginous slates and crystalline sandstones flanks the base of the Badgers on their eastern side, and extends into the country south of Railton. It forms a hidden, violently unconformable junction with the limestone, somewhere in the Railton township.

The impression of a large raphistoma was found by Mr. Blenkhorn in the yellow gritty beds near the Methodist Church; and the cast of an undetermined brachiopod was obtained from the sandstone on Section 4860-M, 263 acres, at the foot of the Badgers.

The strike of the beds exposed in the road-bank at Railton is north-westerly, and their inclination from vertical to north-east; but on Section 4860-M the strike observed was 295°, and the dip northerly. This was in a small cut made in yellow sandstone and slate, in which was exposed a thin vein of vitreous-looking quartz, containing some dark hematite and specular iron ore. A fruitless attempt had been been made here to discover gold-bearing stone.

Tune's reef, described in Bulletin No. 5, has been worked in similar beds south of Railton.

These strata are intersected by numerous veins of quartz, which, however, have not yet proved to be gold-bearing. The stone is hard, brittle, and of vitreous aspect. The presence in it of iron in yellow patches has sometimes led to favourable comment, but the iron oxide seems to be the result of infiltration from the highly ferruginous country-rock, rather than of decomposition from original pyrite.

Indurated and pebbly sandstone and slate occur at the north end of the Badgers, on the Barren Hill, and north of Sheffield. The Badgers conglomerate, in fact, appears to be an incidental bed in a broad belt of other sediments, and on the accompanying chart no systematic distinction has been made between them. Whether this is correct or not must be left for future research to determine.

(III.)—*Dikelocephalus Sandstone.*

This upper member of the Cambrian system is exposed by beds which lie immediately below the limestone at Blenkhorn's quarry. The strike is north-westerly, and the dip south-westerly, but there is a slight unconformability between the rocks of the two systems. The beds are composed of yellow to purple grits, sandstone, and slate, the fossiliferous sandstone being rather friable. The width of the belt behind the quarry does not exceed a couple of hundred feet. Its eastern boundary is formed by the Mesozoic diabase.

It continues along the Dulverton-road, for the most part, however, only indicated by the nature of the soil in the road-bank, and is exposed on the roadside at about a mile past the quarry in an outcrop of jointed purple and yellow sandstone, with some obscure pittings, but no definite fossils. This is again seen at the second railway bridge over Caroline Creek, where yellow and chocolate-coloured sandstone and slate with trilobite remains still strike north-west, and dip south-west. The width of the belt here is probably ¼-mile, but the beds on each side of the rail are concealed below Quaternary gravels.

(3)—Silurian.

This system is represented by the limestone, which constitutes the floor of the Permo-Carboniferous strata. It is confined to the west of the Mersey, dipping north-east at its western edge on the Don River, and south-west at its eastern edge at Blenkhorn's quarry, Railton. At this quarry it dips to the south-west at an angle of 45°. It succeeds the Cambrian slate and sandstone to the east of the Dulverton-road. Its western extension is covered by Tertiary or Recent gravels, but from exposures on Dally's, Ramsdale's, and Langmaid's land west of the railway-line it has a width at Railton of about ¾-mile. Hy. Law's shaft and bore, 160 feet west of the railway-line, and a little north of Railton railway-station, were in the limestone all the way down to 550 feet, but the reddish Tertiary or Pleistocene gravels cover the underlying strata all over the Railton township until the Methodist Church is reached, when fossiliferous slate and sandstone occur in the road-bank in vertical beds or dipping steeply to the north-east.

The limestone is bluish-grey in colour, roughly laminated, and carries occasional bands of an argillaceous character.

For a long time in Tasmanian geology it has been regarded as occupying a position at the base of the Lower Silurian, or what would now be called Ordovician. The progress made, however, by the Geological Survey in correlating the exposures of this limestone in different parts of the island has led to its removal from the Ordovician to the Silurian proper. The fossils most frequently found in it at Mr. Blenkhorn's quarry are remains of Actinoceras. Recently Mr. Blenkhorn discovered in it some shell impressions, which were submitted by the Survey to Mr. Robt. Etheridge, of the Australian Museum, Sydney, who so frequently undertakes the examination of Tasmanian fossils. That gentleman, owing to their imperfect condition, could only refer them to one of the brachiopod genera Orthis or Strophomena. The Actinoceras specimens could not be assigned to an exact age, as the genus possesses an extended geological range--from the base of the Ordovician to the Carboniferous limestone—but Mr. Etheridge thought it would probably be Middle Silurian.

The Zeehan limestones, which yield a more extensive suite of fossils, are perhaps on the same horizon, and have been determined as Silurian by Mr. R. Etheridge and Mr. W. S. Dun.*

The Railton limestone is slightly, almost imperceptibly, unconformable with the Cambrian strata on its eastern boundary, and though its junction with the older beds to the west is concealed, appearances suggest a fault.

(4)—Permo-Carboniferous.

This system in Tasmania comprises the strata between the Silurian and the Lower Mesozoic. The existence of Devonian strata has not been established, and Carboniferous rocks, such as in New South Wales are characterised by the remains of Lepidodendron, Rhacopteris, Productus semireticulatus, Phillipsia, &c., are entirely absent.

The basal members of this system in Tasmania consist of conglomerates, grits, limestones, and sandstones, frequently containing stones and boulders of granitic and gneissic rocks, indicating transport by ice. These beds form a

* See Mr. L. K. Ward's chapter in Geol. Surv. Bull., No. 8, 1910. The Ore Bodies of the Zeehan Field, page 39.

Lower Marine glacial horizon. They evidently correspond with the similar horizons of the New South Wales Lower Marine, the South African Dwyka conglomerate, the Indian Talchir conglomerate, and the boulder bed of the Salt Range, N.W. India.

The peculiar assemblage of Tasmanian and New South Wales fossils, Martiniopsis darwini, Aviculopecten limaeformis, Conularia, found in our basal beds, is repeated in the Salt Range boulder bed. Moreover, the fossils Eurydesma globosum, Eurydesma, cordatum, Spirifera vespertilio, Productus brachythaerus, Martiniopsis darwini, Aviculopecten limaeformis, &c., contained in the Salt Range sandstones and lower limestones which succeed the Conularia boulder bed, are also common forms in the Tasmanian Lower Marine beds, which succeed the "Erratic" beds at the base of the system.

The remarkable correspondence of fauna and flora in the Salt Range and Gondwana areas (the one an open sea basin and the other a continental area), in South Africa and South America enable a general correlation of the Australian and Tasmanian Permo-Carboniferous formations to be made with those of the countries mentioned. The comparisons may be extended, though less completely, to the Permo-Carboniferous and Permian of Europe.*

The Lower Marine beds in the Mersey Basin are succeeded generally by Upper Marine beds without any decided change in the nature of the fossil fauna, but in the coal area in this basin land and freshwater beds are intercalated between the two series. These coal-bearing beds are considered as belonging to the Greta horizon of New South Wales, where coal measures also intervene between the Lower and Upper Marine. They are replete with remains of the Glossopteris flora:—

Glossopteris browniana (Brongn.).
Glossopteris ampla (Dana).
Glossopteris indica (Schimper).
Gangamopteris angustifolia (McCoy).
Gangamopteris cyclopteroides (Feistmantel)
Noeggerathiopsis hislopi (Bunbury).

These occur in the brown and dark shales overlying the coal west of Latrobe.†

* *Cf.* Goniatites (Agathiceras) micromphalus of the Styx River, Tasmania, and of the Lower Marine, New South Wales (Ravensfield stage), with the Lower Uralian (Upper Carboniferous) Agathiceras of Russia.

† Remains of an amphibian (labyrinthodont?) were found by G. Thureau on the spoil heap of a shaft sunk in the coal measures in the Mersey Basin, but the locality has not been identified.

An almost identical flora characterises the Ecca beds of the South African Karoo, the Talchir slates of the Gondwana, and the coal-bearing strata in Brazil and the Argentine (except that in Brazil there is an admixture of the Lepidodendroid flora).

In the Mersey field the coal measures are overlaid by Upper Marine strata containing for the most part similar organic remains to those of the Lower Marine, but some familiar species of the latter division appear to be absent.

It is necessary to emphasise, however, that in the part of the field where tasmanite shale occurs, the Lower and Upper Marine beds *form a continuous series without any interruption by land or freshwater deposits.*

These Upper Marine beds close the sequence as developed here. There is no evidence within the Mersey basin of the higher Tomago, Dempsey, and Newcastle series of New South Wales.

The general correlation of the deposits of this system thus does not appear to present much difficulty. It is only when we approach the question of nomenclature that controversy arises. Much of this is caused by different applications by various authors of the names of the systems—Carboniferous, Permo-Carboniferous, and Permian.

The Permian and Carboniferous systems share many palæontological characters in common, and in recent years authors have shown an increasing inclination to unite them. Dr. W. Waagen, in his monograph on Salt Range Fossils,* proposed for the Carboniferous and Permian systems together the name of Anthracolithic epoch. Professor T. Haug (in his " Traité de Géologie,"† follows this practice, and outlines the following scheme:—

PERMIAN	Thuringian (=Zechstein)	Upper Anthracolithic.‡
	Saxonian	
	Artinsk (Autunian)	Middle Anthracolithic.
CARBONIFEROUS	Uralian (Stephanian)	
	Moscovian (Westphalian)	Lower Anthracolithic.
	Dinantian	

The Artinsk étage is the marine equivalent of the Autunian; the Uralian the marine equivalent of the Stephanian; and the Moscovian the marine equivalent of the Westphalian.

* Salt Range Fossils, Geological Results by W. Waagen. Palæontologia indica, Vol. IV, Part 2, 1891.

† Traité de Géologie, Vol. II., Page 753.

The Permo-Carboniferous of Australia and Tasmania is the middle Anthracolithic of the above scheme. By doing away with the terms Carboniferous and Permian the controversy relating to the names of the passage beds is largely allayed. In using the term Permo-Carboniferous in Australia, the Uralian-Artinsk horizon may be understood,* and the term had perhaps better be retained in Tasmanian geology until the classification is revised.†

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* See E. Haug, *op. cit.*, Page 812:—"One may conclude that the Brachiopod beds of Australia belong to the Uralian or at most to the Artinsk, and not to the Upper Permian, where some recent authors have placed them." On the other hand F. Noetling assigns a Permian (Zechstein) age to the Brachiopoda of the Salt Range. See F. Noetling, "Gliederung der Dyas in der Salt Range." Lethaea Geognostica, 1902, page 641.

† A. C. Seward, in his Fossil Plants, Vol. II., 1910, page 513, remarks:—"In Australia, South Africa, Brazil, and Argentina, and in the Indian Coal Fields, Gangamopteris is a characteristic genus of Lower Gondwana rocks. These strata are usually spoken of as Permo-Carboniferous, in order to avoid the danger of attempting on insufficient data a precise correlation with European formations."

Fossils.—The following is a complete list to date of the organic remains found in the Lower and Upper Marine beds of the Mersey, Don, and Kimberley districts:—

UPPER MARINE.

ECHINODERMATA ...	Asterozoan, cf. Palaeaster clarkei (de Koninck)	In tasmanite, Nook-road Valley
BRACHIOPODA	Spirifera tasmaniensis (Morris)	do Mersey Bend
	Chonetes	do do
	Productus	do do
	Productus brachythaerus (G. Sowerby)	Mersey River, above Kimberley
	Dielasma	Above coal, Caroline Creek
POLYZOA	Fenestella	Above coal
LAMELLIBRANCHIA.	Eurydesma hobartense (Johnston)	Above tasmanite, Mersey Bend
	Cardiomorpha gryphoides (de Koninck)	In tasmanite, Mersey Bend
	Pteronites latus (de Koninck)	do do
	Aviculopecten sprentii (Johnston)	do do
	Aviculopecten fittoni (Morris)	do do
	Aviculopecten latrobensis (Johnston)	do do
	Deltopecten subquinquelineatus (McCoy)	do do
GASTEROPODA	Pleurotomaria morrisiana (McCoy)	do do
	Pleurotomaria woodsii ? (Johnston)	do do
	Keeneia twelvetreesi (Dun)	Above tasmanite, Mersey Bend

LOWER MARINE.

ACTINOZOA	Stenopora tasmaniensis (Lonsdale)	Below coal at Tarleton
BRACHIOPODA	Spirifera tasmaniensis (Morris)	Below coal at Tarleton
	Dielasma sacculum	do
POLYZOA	Fenestella plebeia (McCoy)	do
GASTEROPODA	Pleurotomaria morrisiana (McCoy)	do

On the parallel of Latrobe the Permo-Carboniferous strata extend over the country between the basalt plateau east of the Mersey and the Don River, dipping gently to the north or east of north. Southward they stretch on both sides of the Brown Mountain to New Bed, near Railton, and to the head of the valley traversed by the Nook-road. Northwards they spread over the Spreyton Plain on the west of the estuary of the Mersey.

The uppermost strata in the tract west of the Mersey are bluish-grey marls and mudstones, with marine fossils. These are about 100 feet in thickness, and are found to repose on some 300 feet of land and freshwater beds, sandstone, marl, coaly shale, and conglomerate. In this series the Mersey coal seam is found, about 1½ feet thick. It is usually overlaid by a coarse, loosely-aggregated sandstone, known to the coal miners as the rough sandstone, and is an indication of the proximity of the seam. The horizon of the seam is in the upper 100 feet of this series. The beds rest upon a Lower Marine series of pebbly sandstone and conglomerate, mostly fossiliferous, which were found by the 1884 Government bore at Tarleton to be there 105 feet thick, and to lie on Silurian limestone. This limestone probably forms the floor of the basin over a wide area. It is seen at the Don River plunging below the Permo-Carboniferous sandstone, which rises 600 feet on Kelcie's Tier. This tier drops rather suddenly to the level of the Mersey Valley. Its eastern front appears to be sheared off by a fault, which has depressed the diabase at Latrobe to river-level. The limestone outcrops on the Don River form the western edge of the Permo-Carboniferous basin of this district. On the west bank of the Mersey, north of the mouth of Caroline Creek, a bore put down by Messrs. Henry Law and Co. to a depth of about 700 feet is said to have bottomed on limestone, which is very probable.* Further south, on Dally's, Ramsdale's and Langmaid's land outcrops of limestone reveal the floor of this basin.

At Railton a fruitless endeavour to find coal was made in sinking a shaft near the railway-station to 150 feet in this limestone, and then boring an additional 400 feet in the same rock.

On the eastern flank of Brown Mt. a recent bore passed through 447 feet of Permo-Carboniferous sandstones (Lower Marine?). The freshwater series of beds occupy a good deal of the country west of the railway-line, but east of the line, parallel with the Railton-Dulverton-road, they abut against a ridge of the older rocks (Caroline

* No means are available of verifying the depth of this bore-hole or its final core. It is reported that tasmanite shale was passed through in boring, but no evidence on this point is obtainable.

Creek Cambrians, and West Coast Range conglomerate), on the east of which the Marine beds recur.

Although the marine fossiliferous beds on the flank of Brown Mountain are 200 or 300 feet above the coal seam at its base, and have on that account been thought to belong to the Upper Marine, it is quite possible that their geological horizon is lower. The dip of the beds is northerly, and the diabase sill, which now covers the crest of the mountain, has been fractured by a movement which let down the coal measures to the level of the plains. Unfortunately the stupendous faulting in Post-Mesozoic times, together with the work of denuding agencies, have wrought such changes in the stratigraphy as to make interpretations difficult. The Permo-Carboniferous sea spread over a very large portion of Tasmania. The change from marine to freshwater deposits, and again to marine conditions, in the Mersey coalfields indicates that the marginal land zone here was not greatly elevated above sea-level. The deposits are found in the interior at a height of 4000 feet above the present coast or strand line. The tremendous scarps seen on the eastern faces of the Tasmanian tiers show that great vertical displacements have occurred since the intrusion of the diabase, probably connected with a positive movement of the strand line or subsidence of the adjacent ocean floors.* On the other hand, in still later times an elevatory movement affected the northern coast of Tasmania, as evidenced by the coastal plains and dissected tablelands.

All these displacements, besides numerous minor faultings, render the interpretation of the stratigraphy of the district exceedingly difficult.

The Permo-Carboniferous beds dip below the basalt plateau of Sassafras in a north-easterly direction, and the beds emerging further east should naturally belong to a higher horizon in the system; but proofs exist of repeated upthrow faults, which bring the lower beds to the surface and complicate the interpretation wherever determinative fossils are absent.

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* *Vide* "The Face of the Earth," E. Suess (Sollas tr.), 1906, Vol. II., page 204 :—"The absence of middle Tertiary deposits over the whole of the eastern coast of Australia and Van Diemen's Land, in contrast to their rich development on the south coast of Australia and in Bass Strait, leads to the supposition that the continent east of the existing coast has only in comparatively recent times subsided to the great depths which are now known to occur in this region."

(5)—Tertiary.

Sediments of Tertiary age are found on the fringe of the Sassafras basaltic plateau, between 300 and 400 feet above sea-level. These are high above the Mersey Valley, and are evidently unconnected with the course of the present river.

Sandy and clayey beds occur along the western edge of the plateau south of the Latrobe-Sassafras-road, and on each side of the Latrobe-Fossil Bank-road, for upwards of a couple of miles, flanked on the west by the Saggers basaltic range, below which they pass. The sand often carries stones of conglomerate and quartzite, and constitutes what the local farmers call their poor land in the neighbourhood of the rich basaltic soil. At the northern end of the deposit on Mr. Spurr's land the yellow ferruginous beds of this system rise to the summit of the high basalt plateau east of the Quarry Reserve, about 350 feet above Latrobe. A deep cutting on the farm road there exposes nearly 20 feet of bedded sands, dipping to the north-east.

On M. Roache's 64 acres, on the Fossil Bank (Paramatta)-road a few shafts were sunk in earthy laminated shale by Michael Bourke 25 or 30 years ago. The shale partakes of the nature of brown coal, and burns with a tarry or oily odour. This and its laminated character have led to it being looked upon as a variety of tasmanite shale.

(6)—Pleistocene and Recent.

It is not always easy to separate these. Gravels of Pleistocene age extend from Merseylea to the mouth of Caroline Creek, near Latrobe, along the course of the railway-line, covering the ground for about half a mile in width, but expanding at Railton to double that width. These, in all probability, mark the course of the ancient Mersey River, which subsequently deviated from its old channel and carved out a new one, *via* Hogg's Bridge and the Great Bend. In all likelihood the beds of yellow pebbly clay and sand along the railway-line eastwards from Railton belong to this period, and also the boulder bed in the Great Cutting, consisting of bedded pink, bluish, and yellow clays, with large boulders of sandstone and quartzite, which have been cut through to a depth of 30 feet.

At Latrobe the Pleistocene and Recent deposits, extending back from each side of the river, cannot be safely distinguished from one another without closer work.

On Mr. Elliston's farm is a well 12 feet down on a bed of heavy shingle, which is not the modern gravel of the river, but a member of the more ancient sandy sediments which form the Latrobe flat, on the bank of which Rudge's farmhouse is situate. Probably an estuarine sheet of water originated these in Post-Tertiary times.

The mature valley of the Mersey, near Latrobe and Spreyton, suggests an existence stretching back to the Pleistocene epoch while the dissection of the basalt plateau, which the river appears to have effected, would lead to the supposition that the stream is at any rate younger than Mid-Tertiary. Its age has to some extent a bearing on the determination of the age of the last glacier development in Tasmania. The glaciers discharged their moraine material into existing river valleys; and if these valleys can be shown to be younger than the basaltic eruptions the fact will be of assistance in fixing our conceptions.

The general aspect of the valley round Latrobe indicates that the river is in its revived stage. The recent uplift of the land has caused the stream to cut its channel down below its old flood-plain. The checking of the current by the narrow rock-bound exit at Devonport has originated a wide expansion of the river below Latrobe, where much of the river waste is dropped and accumulates, so that we see here a process of gradual deposition of silt, which has been allowed to continue to an extent that has impaired the former navigability of the river.

(7)—Igneous Rocks.

No igneous rocks have been observed in the Mersey district in any way related to the processes of ore-deposition. Two varieties occur which are closely allied to one another in composition and not greatly different in point of age, but which are distinct in their geological occurrence. These are diabase and basalt.

Diabase.—This basic irruptive covers the top of the Brown Mountain as a crystalline sheet about 400 feet in thickness, with its lower limit 900 feet above sea-level. It also forms the bulk of Dooley's Hill in the Latrobe township, where it is from 150 to 200 feet thick, and descends to sea-level. A thin sheet of it occurs on the summit of

Kelcie's Tier, 700 feet above the Don River. It is found in loose blocks above the retorts on the Tasmanian Shale and Oil Company's lease, and must have crossed the river in the form of a dyke, for numerous boulders are noticeable on the river bank, and occur also mixed with the basalt stones on Desbrow's 30 acres.

Further south some patches of it are seen on the sections 2545, 2541, and 2540, leased by the Latrobe Shale and Oil Company. Still further south it occurs on Section 4628 and on Blenkhorn's quarry block, as well as on the western side of the railway north of Railton. On this parallel it forms the range which borders the Rubicon River further east, and covers also the Long Hill on Winspear's estate north and east of Kimberley.

The changes which have been wrought in the topography during comparatively recent geological time can be appreciated if we attempt a reconstruction by uniting these scattered occurrences.

It must further be remembered that the diabasic material was not a lava stream flowing at surface in the open air, but was injected as a sill or intrusive sheet into the strata underground, and consequently the subsequent removal of a certain thickness of overlying sedimentary rock has to be accounted for. The present differences in level between the respective occurrences must be due to the faults so frequent in the district, which may have occurred during the Tertiary uplift, but the low altitude of the diabase as a whole (not exceeding 1000 feet above sea-level), compared with its elevated position on the Cradle Plateau not far to the south-west, is probably due to the stupendous fracturing to which the tableland of the interior has been subjected.

Microscopical examination of the rock shows that mineralogically it consists of augite and a basic plagioclase, and that very little interstitial matter is present. In most respects it resembles the ordinary Mesozoic diabase of the island so closely as to render a detailed description of its micro-structure in this bulletin unnecessary.

The intrusion of the diabase is regarded as having taken place at the close of the Mesozoic era. It was Post-Jurassic, for the Jurassic coal measures have been affected by it, and it was antecedent to the Palaeogene basalts, because these have penetrated it. An instance of the latter may be seen behind Mr. Jas. Blenkhorn's house at Railton, where a plug of Tertiary basalt, which has ascended through the surrounding diabase, protrudes from the surface for a height of about 25 feet. Proof of a similar phenomenon has been afforded by a microscopical slice of basalt at Bothwell, in which small fragments of diabase are seen to have been caught up in the lava. The rock-folding or mountain-building processes with which the formation of our mineral veins has for the most part been connected came to an end prior to the intrusion of the diabase. It is accordingly devoid of ore-deposits. Its chief use is in metalling roads and the construction of rough masonry. For roads it is an exceedingly hard and durable material, but is too hard to use without extraneous blinding. For common use in building it is too tough and too irregular in its fracture to be dressed easily, but for rough walls and for foundations generally it is highly suitable.

Although in chemical composition it approximates to basalt, it does not originate the fertile chocolate soil which the latter is famous for producing on disintegration. This is probably due to the fact that it decomposes slowly, and the decomposition products are carried away before there is time for them to form soil.

Basalt.—This occurs as a sheet of lava covering the Sassafras plateau, the New Bed plateau at Railton, and on the Railton-Kimberley tableland. The general elevation of the peneplain is from 400 to 500 feet above sea-level. The sheet appears to have been dissected by the rivers. The possibility suggests itself of it having moulded itself in its flow to the hollows of large valleys like that of the Mersey, descending from the higher ground into the pre-existing valley floor. No traces of this, however, present themselves, especially in the area round Railton, where the gravels of the old channel of the Mersey are still preserved. Invariably, the lava flow is confined to the summit of the tableland, which it covers to a depth nowhere exceeding 100 feet, and frequently much less. The same phenomena show themselves all along the North-West Coast, where the rivers uniformly cut their channels through the basaltic covering into the older rocks below. Examples are the Rivers Don, Forth, Leven, Penguin, and Sulphur Creek, Rivers Blythe, Emu, Cam, &c. The inference to be drawn is that the eruptions of basalt were antecedent to the formation of the present river valleys. Prof. T. W. E. David however has recently detected indications of an old Forth river valley antedating the latest of the basalts. According to his observations it was a more mature valley than the present Forth near Wilmot, which has been rejuvenated through a comparatively recent uplift.

Here and there the basalt forms isolated knobby eminences, *e.g.*, on the Tasmanian Shale and Oil Company's leases, and at Railton, which may perhaps be interpreted as ascending pipes which at one time had normal ash cones. The general absence of crater forms and scoriae, however, has led to the conclusion that the lava emissions have for the most part proceeded from fissures, accompanied only sporadically by the more familiar type of explosion vents.

The chocolate-coloured soil produced by the disintegration of the basalt is extremely fertile, and admirably adapted to cultivation for oats and root crops.

Microscopical examination of the rock shows that it is a mineralogical combination of plagioclase felspar and augite, with abundant crystals of olivine as the porphyritic constituent. It belongs to the class of olivine basalts.

(8)—Geology of Kimberley.

Kimberley is a small township on the Western railway-line, and near the banks of the River Mersey, 61 miles from Launceston, and 177 feet above sea-level. Its railway traffic is fed by the farming districts of Beulah and Minnow, into which good roads lead. It has a comfortable inn, a school, a couple of stores, and a few houses cluster round these. At the inn are the cross roads to Dunorlan, Sheffield, Railton, and Minnow. The picturesque Dasher Falls are distant to the south about 3 miles, and are easily accessible.

The geological systems represented here are:—(1) Pre-Cambrian. (2) The Permo-Carboniferous. (3) The Tertiary. (4) Quaternary.

(1)—*Pre-Cambrian.*

The rock composing the hill behind the hotel and crossing the Mersey at the White Rock Bridge is of Pre-Cambrian age. At the bridge it is a white saccharoidal quartzite; in the hill itself it presents numerous varieties ranging from a hard-grey quartzite to a conglomerate. The hill face south of the bridge forms massive cliffs of this rock on the east bank of the Mersey, and in the river itself strong conglomerate beds strike N. 20° W., with an indeterminate dip. On the west side of the river above the bridge a glistening mica schist has been found.

These strata are members of the series of Pre-Cambrian schists which are exposed further north along the Mersey, near Latrobe. They underlie our oldest Palæozoic sediments.

Beyond silicification the quartzites, as a rule, show little metamorphism. Occasionally some deformation is denoted by the presence of filmy sericite. But as a whole, in these respects no more intense metamorphism is noticeable than is exhibited by some of our Palæozoic rocks. These sediments belong to the Algonkian division of the Pre-Cambrian, and are not distinguishable essentially from fossiliferous strata of later date. No fossils have been found in them in Tasmania, but their nature is evidently not such as to preclude the possibility of such a discovery. The highly-developed life forms found in the Cambrian are generally held to require an antecedent fauna in the Pre-Cambrian.

(2)—*Permo-Carboniferous.*

The Permo-Carboniferous is the next system which is represented in the Kimberley area. The mudstones and sandstones of Native Plains doubtless pass below the Mersey flood plain at Merseylea, and underneath a part of the basalt west of Kimberley. A ridge of Algonkian quartzite probably underlies this basalt covering running parallel with the railway-line, and is perhaps fringed on each side with Permo-Carboniferous strata. The latter may be assumed to be present below the Tertiary and Quaternary deposits in the valley of the Mersey towards Merseylea, and even below the township of Kimberley itself. Some sandstone is seen in the creek on Rogers' farm west of the river, but owing to its softness and friability its age is somewhat uncertain. Survivals of sandstone beds also fringe the Long Hill opposite, but whether these too are Permo-Carboniferous, Jurassic, or Tertiary cannot be decided at present.

On the west flank of the Algonkian Divide fossiliferous Permo-Carboniferous strata are exposed at Murfet's, east of the Mersey, and in the cliff by the roadside on the opposite side of the river. On Mr. Murfet's farm is a knob of fossiliferous pebbly marl, bluish and yellowish in colour, and much decayed. Fenestella and other fossils are present. This is at about 60 feet above the Mersey, but below these beds, and down nearly to river-level, are conglomerate sandstones similar to those usually developed towards the base of the Permo-Carboniferous.

The cliff opposite these, on the west side of the river, shows about 40 feet of soft fossiliferous conglomerate (with Spirifera tasmaniensis, Productus, Fenestella, &c.,), surmounted by 50 feet of brown, clayey, pebbly sandstone, which passes below the basalt capping of the higher part of the hill. The fossil remains are not very conclusive as to the division of the Permo-Carboniferous to which these beds belong. The probabilities are in favour of the upper division; however, the shale and coal measures of Railton and Dulverton are not represented at Kimberley. At the outset of the present reconnaissance it was rather anticipated that some beds of those measures would be found to continue through to Kimberley and connect with the shale beds at the Minnow, but the extensive faulting met with all through this part of the country makes it very hazardous to indulge in general anticipations.

(3)—*Tertiary.*

Surviving fringes of Tertiary sediments flank the valley of the Mersey at Kimberley. The banks and hills of soft ferruginous sandstone and heavy shingle occurring along the railway-line at Merseylea are either Tertiary or Pleistocene, and the sedimentation was probably prebasaltic. The road drain on the west side of the Mersey at Kimberley shows yellow sand, resembling Tertiary sediments, about 30 or 40 feet above the river, possibly a fragment of the old deposit which once covered the site of the present Kimberley flat.

About a mile south-west of Kimberley the Mersey flows through a series of beds of lignitic clay, with alternate layers of lignite and whitish or grey clay. These beds are seen in the east bank of the river in a singular position, being vertical. Towards the top of the bank, however, beds of pipeclay occur, and to account for the vertical position of the lignitic strata the supposition of a slide from a higher position seems to be necessary. Small pieces and logs of well-preserved wood occur in the deposit. Lumps of resinous matter are also found. These lignitic beds were evidently at one time concealed below the basaltic sheet, through which the modern river has cut its channel. They are of no economic value.

(4)—*Quaternary.*

This division comprises all Post-Tertiary sediments (Pleistocene and Recent). At Kimberley the ferruginous cement or pan which is found below the grass roots in the road drains appears to belong to this era. The railway-station stands on the gravels of the Mersey plain, which extends north to the foot of the Long Hill and Coiler's Creek. This creek is here a clear stream, half a chain wide, about 18 inches deep at low water, flowing into the Mersey a little north-west of Kimberley.

Waterworn stones from the Mersey are found on the surrounding hills 50 or 60 feet above the present river level, and are evidences of the long-continued process of corrosion which has deepened the river-bed to its present position. On the other hand, the erosion of its banks has produced a widening of the valley, which leads to the inference that the latter is now fairly mature. It is apparent that the present Mersey is a river of Quaternary age. The existence of an older Mersey is, however, suggested by the lignitic deposits.

Warm Spring at Kimberley.

This has long been known to exist, and has aroused much interest from time to time, many conjectures being made concerning its origin and real nature.

It is situated about 200 yards north-west of the hotel, on the Mersey and Deloraine Tramway Company's land, east of the Mersey, and about 20 feet above the present banks of that river. The ground surrounding it is a pebbly drift compacted with a ferruginous cement. What is below this is conjectural. The nearest bed-rock outcrop is the Pre-Cambrian quartzite of the hill above the road to White Rock Bridge. The quartzite borders the flat in which the spring is situated, and probably junctions with concealed Permo-Carboniferous strata.

The pool measures about 2 chains in length by a chain in width. Watercress grows thickly around its edges and down the small creek, which is its outlet. In summer the water-level is said to be a foot higher than in winter. It is possible that this is due to extra growth of the weed choking the small outlet. It is strange to see cress growing here, but the sites of the old prisoners' huts are seen north of the spring, and it may have been planted by them at that time. The general appearance of the banks of the pool, forming a basin-shaped outline a few feet above the level of the present rim, suggests that the volume of water has shrunk. In recent years no diminution of volume has been noticed, though Mr. Walker, of the Kimberley Hotel, fancies that the activity of the bubbles is not so intense as formerly.

The general depth of water is 3 or 4 feet, deepening to 5 or 6 feet. The water is beautifully and singularly clear. In the south-east corner of the pool gas bubbles are continually rising to the surface of the water from the gravelly bottom, and this apparently is the part of the pool in which the spring is situate.

The pool has been formed by the spring, and the water escaping at the lowest point has formed a creek, which runs down to the Coiler's Creek, passing below the railway near the station.

A carefully taken sample of the water was analysed by Mr. W. F. Ward, Government Analyst, and yielded:—Solid matter, 20 grains per gallon, chiefly carbonate of lime, equal to 285 parts per million; chlorine, 1·4 grains per gallon, equal to 20 parts per million.

This would fall into F. W. Clarke's class of carbonate waters, to which a large number of lake and river waters, and many springs of the usual potable type, belong.*

Mr. Bartow calls attention to Dr. A. C. Peale's suggestion, that springs with a temperature above 70° F. should be classified as thermal; those between 70° and 98°F. should be called tepid or warm; and all above 98° F should be called hot.†

The chlorine in the Kimberley spring is higher than the normal content of river water at Kimberley should be. This element decreases in streams in proportion to the distance from the sea, and thus it is generally possible to trace isochlors (lines of equal normal chlorine) on maps, following in some measure the coastal outline.

The temperature of the water remains constant at 74° F. It is said locally to be warmer in winter, but it would naturally feel warmer by reason of contrast with the temperature of the air. In the winter season a vapour is visible among the trees, rising from the pool and the effluent creek.

In attempting to use the temperature as a means of determining the depth from which the water is derived, difficulties present themselves.

Below the superficial zone of seasonal changes a progressive, but irregular, increase of temperature, with

* The data of Geochemistry, by F. W. Clarke, p. 149, U.S. Geol. Sur. Bulletin No. 330, Washington, 1908.

† See "The Mineral Content of Illinois Waters," by E. Bartow. Illinois State Geol. Sur. Bull. No. 10., 1909. p. 22.

increasing depth, takes place. Observations show differences, not only in different countries, but at different points in the same country, and even at different levels in the same shaft or opening.

Chamberlain and Salisbury* ascribe many of the numerous variations to inequalities of topography, differing conductivities of rock, unequal circulation of underground water, rock compression, and to chemical action, oxidation, carbonation, &c., but think that after making these allowances it is still doubtful whether a uniform average gradient can be arrived at.

The Underground Temperature Committee of the British Association in 1889 reported an average gradient of 1° F. for every 64 feet.† Credner states an average result in deep bores in Germany as 1° Centigrade for every 30 metres (= 1° F. in 54 feet)‡. De Lapparent, after concluding that the mean geothermic degree§ itself tends to increase with depth, goes on to state that the results obtained from artesian wells in France and Germany show a very constant figure, about 1° Centigrade in about 31 metres down to 600 metres (= 1° F. for every 56 feet down to 1968 feet).‖

Professor J. Joly¶ quotes some of the determinations of the underground temperature gradients as follows:—

- Prestwich, 1° C. in 24·3 metres (= 1° F in 44 feet).
- Lord Kelvin, 1° C. in 27-5 metres (= 1° F. in 50 feet).
- Schardt, 1° C. in 32·0 metres (= 1° F. in 52 feet).
- Geikie, 1° C. in 27 to 32·4 metres.
- British Association Committee, 1° C. in 32·4 metres (= 1° F. in 53 feet).
- Clarence King, 1°C. in 38·9 metres (= 1° F. in 71 feet).

and takes 32 metres as the average (= 1° F. in 52 feet).

The usual practice is to assume that the geothermic degree corresponds with a vertical measurement of from 50 to 60 feet.

Reckoning a mean annual surface temperature at Kimberley of + 4° F., an increase of 20° would mean that

* Geology, 1904, Vol. I., p. 544.

† "Text book of Geology," by Sir A. Geikie, Vol. I., 1903, p. 62.

‡ "Elemente der Geologie" H. Credner, Leipzig. 1897, p. 9.

§ Geothermic degree=the depth to which it is necessary to descend to produce an increase of temperature of 1°.

‖ Traité de Géologie, par. A. de Lapparent, Paris, 1906, p. 503.

¶ "Radioactivity and Geology," London, 1909, p. 71.

a temperature of + 74° F. would be obtained at a depth of between 1000 and 1100 feet.

Owing to the alluvial covering of the Kimberley flat, the bedrock round this spring is concealed from view. The probability is that the water issues from a fissure or fault-plane dividing the Pre-Cambrian quartzite from Permo-Carboniferous strata. Possibly Silurian limestone underlies the Permo-Carboniferous beds at this spot. The latter, however, are themselves often highly calcareous. Again, it is quite possible that the water may bring its solid content from limestone exposed further north, but the underground drainage sets thence in a northerly direction, so that the surface exposures of that soluble and fissured rock do not help much in locating the origin of the Kimberley waters. That the spring has a plutonic source is out of the question. It is essentially meteoric water escaping through a channel at a lower level than that where it entered the ground.

(9)—Sequence of Geological Events.

A mere statement of the stratigraphical succession is insufficient for the formation of a definite conception of the physical events which constitute the geologic history of the region. For this it is necessary to reproduce the past in such a way as to bring it before the mind's eye at present.

The earliest geological formation in the district is the Pre-Cambrian schist and quartzite floor. These old rocks now exposed at the Great Bend and between there and Native Plain, and again at the White Rock Bridge, Kimberley, were in that remote past laid down in the ordinary course of sedimentation round pre-existing landmasses.

The only traces so far known in Tasmania of any pre-existing rocks consist of loose specimens of gneiss, which perhaps in every instance have been preserved for us in the basal Permo-Carboniferous conglomerates. Such specimens occur in the glacial conglomerate of the Wynyard beds at Table Cape, and in the conglomerate west of the Deloraine-road, near the Stone House. The boulder of gneiss noticed by Mr. G. A. Waller on the track from Liena to Barn Bluff possibly was released from similar conglomerate. At any rate, this gneiss, which possibly belongs to the old Archæan platform, has not yet been seen *in sitû* anywhere. The only formations known to us beneath the Cambrian are the sediments known as Algonkian.* Mr. L. K. Ward, from observations made during his exploratory journeys in the western part of the island, has divided this system into an upper and a lower division, the upper one consisting of a great thickness of saccharoidal quartzites resting horizontally on the more intensely metamorphosed and contorted schists of the lower series.

In this district the only formation likely to belong to the Upper Algonkian is the bedded quartzite at Kimberley.

We may therefore figure to ourselves the sequence of events in Algonkian times as follows:—First, the deposition of the sediments on the sea-floor everywhere in this part of Tasmania. Then deformation and metamorphism of the same, followed by an uplift and subsequent depression, during which the Upper Algonkian beds were laid down until an elevatory movement again set in, marked by the strong unconformity between these and the succeeding Cambrians. This was the close of the set of periods which are grouped together as Pre-Cambrian, and about which very little real knowledge exists. The indications, however, are that they represent periods of time as great as all subsequent periods put together. No organic remains are known from the Tasmanian Algonkian, but there is nothing in the nature of the sediments which would *primâ faciê* preclude the possibility of their existence. The metamorphism of the quartzites in the upper series is comparatively slight, and the conditions for the preservation of fossils are apparently favourable. Nevertheless, there is a significant absence of the ancestral forms of Cambrian life.

The continental interval prior to the Cambrian subsidence has left no trace of its existence. The Cambrian period was ushered in by the deposition in shallow water of conglomerates, the material of which was derived from the Pre-Cambrian land. Fragments of these conglomerates survive, as the Badgers, the hill behind the Rifle Range at Railton, and along the Dulverton-Railton-road. The succeeding sediments were the quartzites and crystalline sandstone at the base of the Badgers and at Railton.

* Mr. Ward has recorded the occurrence of pegmatite veinlets of similar constitution in the Collingwood valley at a point close to the junction of the Collingwood and Cardigan Rivers. (See Surveyor-General's Annual Report, 1907-1908.) These he now correlates with this gneissic variety of rock. Probably to the same age may be referred the quartz tourmaline stones found by Mr. T. B. Moore in the neighbourhood of Moore's Look-out on the Macquarie Harbour-Port Davey track. These appear to be intrusive members of the Algonkian.

The latest strata in the Cambrian period were the trilobite sandstones at Railton and Caroline Creek.

At the close of the Cambrian in this district there is a great gap in the geological record.

Land conditions appear to have prevailed here during the time that the Cambro-Ordovician slate-porphyrite series were accumulating at the Minnow, Barrington, Dial Range, &c. ; and a marine phase followed only when, after the great Pre-Silurian crustal movements, a subsiding sea-floor received the sediments which are preserved as limestone at Railton, Dulverton, and the Don.

During the succeeding Devonian period, which was one of marked diastrophism accompanied by the consolidation of the granite magma of this period throughout the island, dry land prevailed. After this, the Permo-Carboniferous marine transgressions supervened, and the shallow sea of the period laved the low-lying coasts with a local interval of freshwater sedimentation. The land at this time nourished the plants, remains of which are met with in the coal seams and associated beds at the beginning of the period. The climatic conditions were frigid, and the land connections were with India, South Africa, and probably Antarctica.

At this period of the earth's history the continents of the two hemispheres formed two separate masses, one in the north, the other in the south, which were divided by a great mediterranean sea (called Thetys by Suess). The southern continent comprised India, South Africa, South America, and Australia, probably also Antarctica.

The Permo-Carboniferous sea in Tasmania covered part of the submerged shelf or margin of this continent. It spread over the whole of the Mersey area, moulding its deposits to the configuration of the ancient schist and conglomerate shores, and, indeed, its sediments are found at the present time as residuals scattered over nearly every part of the island.

None of the succeeding Trias-Jura deposits appear to have been preserved in the Latrobe district. The Gondwana land continental phase persisted, though the deposits have been removed by denudation. At the close of the phase widespread diabasic intrusions took place in the form of dykes and sills, during which time the land possibly participated in an elevatory movement. The diabasic masses on Brown Mountain, Kelcie's Tier, Latrobe Hill, the Rubicon Range, &c., came into being, but existed as intrusive sheets below the Trias-Jura beds, which have since disappeared. Similar phenomena are present throughout the island. Apart from the western districts, nearly the whole of the island is a high mass of Permo-Carboniferous, Trias-Jura and diabasic rocks, rising to elevation of 3000-5000 feet above sea-level. Singularly enough, the diabasic component is absent from Victoria, but present in Antarctica.

The continental tableland seems to have broken down in Tasmania at some time in the Tertiary period. The great step-faults facing the east are so many signs of the subsidence of the continental shelf. Oscillatory movements succeeded, some of the signs of which are found in the basaltic flows, the Quaternary glacier deposits, the destruction of the land-bridge between Tasmania and Australia, the raised fossiliferous limestones of Bass Strait, the elevated beaches round the island, &c. To trace the events of Tertiary and Quaternary history would involve a too prolonged discussion for the pages of this bulletin; and, moreover, they have not yet been sufficiently studied to admit of entirely decisive interpretation.

After the great basalt eruptions a period of subsidence ensued, followed by a rise of the land, but the history of the various oscillations has yet to be written.* Subsequently to the elevatory movement, or during it, the Alpine glaciation set in. Later oscillations are still *sub judice*.

* Dr. Fritz Noetling has endeavoured to trace the successive movements of the land in Tasmania since the Quaternary glacier period. See his paper on "The Antiquity of Man in Tasmania," Proc. Roy. Soc. Tas., 1910, pages 231-261.

V.—ECONOMIC GEOLOGY.

(1)—NOMENCLATURE OF TASMANITE SHALE.

The earliest references to this shale describe it as "combustible schist"; already in 1852 it was alluded to doubtfully as "dysodile." In 1854 Mr. A. R. C. Selwyn refers to it as "yellow coal." In 1861 Mr. Chas. Gould, in his report on "Resinous Shales," adopts the name "dysodile." The first author who put forward the name of "tasmanite" was Prof. Church, in 1864.* As regards the application of the term "white coal," there is some confusion in the references, some of these relating to Australian occurrences. Mr. J. E. Carne† thinks it probable that the term applies to "tasmanite, the spore-bearing shale of the Mersey River, Tasmania." It may have an allusion to the light-grey colour of the shale as contrasted with black coal, or to the white appearance of the residue after burning on an open hearth.

Up to the present time the name "dysodile" has been preserved in the departmental maps and publications; but Professor Church has pointed out that "the true dysodile from Glimbach, near Giessen, analysed by Delesse does not seem to be identical either in chemical or physical constitution with the Tasmanian mineral.*" The dysodile of German geologists, sometimes called paper-coal (papierkohle) is a clayey, very thinly laminated, brown coal. A specimen of this, labelled "dysodile (stink-coal)" is preserved in the Museum of the Technical College, Sydney. It comes from Salzhausen, Wetterau, and has the appearance of a dark-brown shale in thin leaves.

The term "tasmanite" is now thoroughly incorporated in scientific literature, and tasmanite shale may very well be substituted for dysodile in the official literature.

Sterry Hunt* applied the name of pyroschist to argillaceous rocks (the so-called bituminous shales) containing in a state of admixture a brownish, hydrocarbonaceous matter allied to lignite or coal, and capable of yielding volatile hydrocarbons allied to petroleum by destructive distillation at elevated temperatures. This term appears to be the equivalent of the German Brandschiefer, and it

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* Phil. Mag., 1864.

† The Kerosene Shale Deposits of New South Wales, by J. E. Carne, 1903, page 40.

‡ Chemical and Geological Essays, 1897, page 169.

has been revived lately by Canadian writers. It is, however, not altogether free from objection. It implies something more than mere lamination or fissility. It involves foliation, which is the result of an intense earth pressure, and is accompanied by recrystallisation and a development of new minerals. This rearrangement of the material in more or less parallel bands proceeds until the rock becomes wholly crystalline, and is called a schist. The pressure originating these phenomena is connected with mountain-building movements of the earth's crust, and generally folds and deforms the strata over a considerable area, producing what is called regional metamorphism. Such orogenic movements have not manisfested themselves in Tasmania later than the Devonian or close of the Silurian period, and it would seem altogether inappropriate to apply the term schist to the unmetamorphosed beds of shale incidental to the Permo-Carboniferous series of clays and sandstones.

The term oil-shale, too, seems somewhat of a misnomer. The oil does not exist as such in tasmanite shale, but is obtained by subjecting it to destructive distillation.

(2)—Mode of Occurrence of Tasmanite Shale

The exposures of the Tasmanite shale occur in the bank of the River Mersey, in the beds of small creeks, in the scarp faces of faults, and at the edge of beds fringing or passing below basalt lava. The occurrence at the Minnow, which is only known in the form of loose slabs, may be referred to high country falling to the Mersey.

As a general rule it may be said that the drainage channels of the country have been the exposing agents. In some cases the exposure has been very slight, and it is quite possible that discoveries may still eventuate in unsuspected places. On the other hand, all the discoveries which are now known date from many years back, though their significance was not then realised.

The outcrops weather very slowly, and though with the efflux of time the volatile content of exposed shale must diminish, the good quality of surface material is remarkable. In this it agrees with the Scotch shale, which remains for years on the dump without much loss of hydrocarbons. Outcrops in banks or the face of cliffs show feather edges with intervening bands of clay, and it is not always easy to determine whether the outcropping slabs are actually *in sitû* or not. In most cases, however, it may be predicted that if the seam be followed under cover it will be found solid and of normal size.

Large slabs of shale may very easily drift down stream if they fall from an outcrop into the river, and flat blocks seen lying under water on river bottom should always be regarded with suspicion until it is ascertained that they are *in sitû*. Thus, the slabs lying in the Mersey below the water-supply pumping-station are not free from uncertainty. It is just possible that they may have drifted. In many cases slabs of mudstone seen under water resemble in appearance exposures of shale. At the railway bridge, above Latrobe, some shelves of what is probably mudstone occur in the river-bed near the water's edge, but have been described to the writer as being shale. They need examination when the river is low.

Pieces of shale found opposite Bell's Wharf must be viewed with suspicion, for many years ago shale lying on the wharf for consignment was swept away in a phenomenal flood, and this would account for the discovery of odd pieces thereabouts.

Specimens of shale from the known outcrops have from time to time been collected and carried about the country between Latrobe, Sassafras, Railton, and the Nook, so that the discovery of stray pieces in unlikely places is not uncommon, and must not be relied upon as an indication. But where slabs of shale are turned up in ploughing fields, as on Oliver's farm and at the Minnow, the seam may be searched for with confidence, notwithstanding that it is hidden below a fair thickness of surface soil.

Appearances lead to the conclusion that the schist and ancient conglomerate formed the land against the shores of which the tasmanite shale was deposited, and if no faulting had happened the shale might have always been expected to thin out towards its junction with the older rocks. There is reason, however, to believe that the present junctions are not invariably in their original respective positions, and consequently the thinning at the extreme edge of the shale area, where it impinges on the schist, is not always to be seen. At the same time, wherever the respective original positions have been preserved, the seam will probably be found to feather out against the ancient margin. In the Mersey basin the seam outcrops are found always hugging the schist boundary, to wit, at the Mersey Bend, at the river shafts above the Pumping-station, on James' Block, at No. 6 shaft near Barry's, at Carey's, on Bennett's Creek, on China Flat, &c.; and a question to be determined by future borings is how far from the schist does the shale extend? Is there a deeper part of the basin, say below the basalt plateau of Sassafras, into which it can be followed? Or does it, after attaining its normal thickness, gradually diminish as it recedes from the schist shore? One thing is certain, namely, that the seam has not yet been found far from the older rocks. If it is discovered in the Rubicon area, it will form an exception to this.

(3)—Composition and Physical Characters of Tasmanite Shale.

The shale is a brown or grey laminated rock, consisting of mud or sand mixed with yellowish-brown resinous-looking seed-like bodies of discoidal shape and minute size, flattened and pressed together in layers, the whole forming a tough and leathery rock. Mr. R. M. Johnston, who was the first to work out some of the structural characters of this substance, microscopically describes the little discs as presenting the appearance of diminutive flattened, flabby gooseberry skins, nearly always fractured on one side, as if rent open by sporadic emission. These discs or spore cases are generally 0·30 to 0·50 mm. in diameter, and in thin section are circular in outline where not deformed by shrinkage or compression. In transmitted light they are transparent, with a peripheral external wall, and crowded with rod-like wedge or gash-shaped cavities of minute size, disposed for the most part sub-radially within each sac or spore case, and suggestive of the presence of some cellular structure, faint traces of which are occasionally revealed.* Professor David refers to minute bodies in the spore cases found in the kerosene shale of Joadja Creek, and states that they recall the appearance of zoospores in some form of alga.† The microscopic structure of the sacs of tasmanite has only a very superficial resemblance to that of the somewhat similar sacs in the kerosene shale of New South Wales, which have been determined by Professors Bertrand and Renault as constituting the thallus of a floating alga, named by them *Reinschia australis*. A somewhat similar alga com-

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* Nevertheless, one cannot feel certain that these peculiar cavities are not of secondary origin.

† Proc Linn. Soc., N. S. Wales, 1889.

‡ "Reinschia Australis," C. E. Bertrand and B. Renault, Autun, 1894; also "Nouvelles Remarques sur le Kerosene Shale de la Nouvelle-Galles du Sud," C. E. Bertrand, Autun, 1896.

poses the bulk of the Boghead of Autun, named by Professor Bertrand *Pila bibractensis*, and also found in the Australian kerosene shale of Doughboy Hollow, N.S.W.

For illustrations of Reinschia and Pila see the following works:—"*Reinschia australis*," by Bertrand and Renault, Autun, 1894; "Fossil Plants," by A. C. Seward, Vol. I., Cambridge, 1898; "The Natural History of Coal," by E. A. Newell Arber, Cambridge, 1911.

The tasmanite sac, however, differs from these bodies in possessing a peripheral cell-wall which encompasses the entire sac; traces also of interior cellular structure survive here and there. A higher type of structure than that possessed by Reinschia and Pila seems to be disclosed.

For the present it must be admitted that the resemblances are not algal, but point rather to some lycopodiaceous plant.

Professor Penny* states that the material is more analagous to resins than to any other known substance, but that it is very little acted upon by resin solvents, such as alcohol, ether, turpentine, &c. Professor Church† states that resin solvents have not the least solvent action on tasmanite. Mr. J. C. H. Mingaye is quoted by Mr. Carne‡ as reporting from 0·28 to 1·58 per cent. as amenable to these solvents.

From this it has been thought that the substance is not strictly resin. Professor Church, however, regards it as allied to retinite, a fossil resin approximating to amber, though retinite has no sulphur in its composition.

The peculiar characteristic of tasmanite is that it contains a large amount of sulphur in combination with its carbon and hydrogen. The sulphur content of the shale is further increased by accessory pyrites in variable quantity, mostly associated with the contained fossils.

Recent determinations of sulphur by Mr. W. F. Ward, Government Analyst of Tasmania, have been from 1·5 per cent. to 2·5 per cent. Mr. Mingaye, Government Analyst of New South Wales, as quoted above, found a sulphur content of 1·208 per cent.

The expulsion of the sulphur in retorting has been looked upon very generally as a rather intractable problem, but in working practice a good deal of it is got rid of, and analyses made lately in Launceston of the produced oil by Mr. Loftus Hills, B.Sc., show that the

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* Proc. Roy. Soc. V.D.L., 1855, page 112.

† Phil. Mag., 1864, Vol. XXVIII., page 467.

‡ "Kerosene Shale Deposits of New South Wales," 1903, page 200.

objectionable element in the oil can be reduced to 0·6 per cent., which is below the Admiralty limit. Mr. Hills, in his experiments, obtained varying results, some of which were in the neighbourhood of a 1 per cent. content, either over it or below it. The experiments seem to show that the requisite extraction of sulphur is not an insoluble problem, but that it is essentially a question of treatment.

Determinations of the specific gravity of the resinoid substance by reputable authorities are 1·18 and 1·75.* That of the shale varies according to the proportions of the associated sand and pyrites.

The good-quality shale can be cut with a knife, and some of it is somewhat curled. When quite freshly broken, glistening streaks on the surface are said to be an indication of richness in oil. The shale splits readily along its bedding-planes, but in any other direction is very difficult to break.

It burns readily on a hearth, and even on the application of a match while held in the hand, emitting a strong flame with a sooty smoke and a highly resinous, somewhat unpleasant, odour.

When retorted it yields an oil which can be fractionated into various products, suitable for heating, illuminating, lubricating, engine-driving, &c.

It seems to be established that the calorific power of the crude oil is in the neighbourhood of 22,000 B.T.U.†, compared with that of Scottish shale oil, 18,000. There is an absence of paraffin, and the fuel oil can be conveyed in pipes without danger of congealing at any temperatures it is likely to be exposed to in Tasmania.

Mr. Geo. Cox, the Tasmanian Shale and Oil Company's Chemist, at Latrobe, states that the flash-point of the fuel oil manufactured recently is from 235° to 260°, and could be made still higher if desired; and the specific gravity is ·936 to ·950 in the product made in the experimental laboratory. Bulk figures would probably be a little lower.

(4)—Origin of Tasmanite and the Formation of Seams.

Considerable attention has been paid to the essential structure of the plant organisms, of which the tasmanite

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* Prof Church and Mr. J. C. H. Mingaye. The difference, however, is considerable. Probably the latter figure was derived from an impure sample.

† British Thermal Unit = the amount of heat required to raise 1lb. of water one degree Fahrenheit.

seam is composed, but their real nature, it must be confessed is still shrouded in uncertainty. The earliest guess (approximating, too, to some *i* the more recent theories) was Dr. Ralph's idea, in 1861, that the seed-like bodies were algae coated with a resinous substance; but R. M. Johnston, in 1872, identified them by microscopical examination as sporangia, or the spore-cases of an acotyledonous plant. He was followed by E. T. Newton in 1875, who compared them with Lycopodiaceous macrospor.s.

Professor David, in 1889,* suggested that the oily character of the closely-allied kerosene shale of New South Wales might be chiefly due to showers of minute spores or sporangia, or seeds, and after a description of the minute structure of Joadja Creek shale advances the possibility of the spherical bodies in it proving hereafter to be some variety of fresh-water algae.

In 1894, Professor C. E. Bertrand and Dr. B. Renault determined Australian kerosene shale to be algal coal, the result of an accumulation of fresh-water algae, to which they gave the name of *Reinschia australis* and *Pila australis*.†

These researches had a far-reaching effect on theories of the nature and origin of coal in general, and "oil shales" in particular. The cannel coals, bogheads, and kerosene shales are classed apart, as what are called sapropelic coals, the matrix of which is believed to have been the residual gelatinous slime resulting from the decay of algae, diatoms, and other aquatic organisms in still water, not excluding spores of land plants‡. This theory has met with wide acceptance, though lately it has been impugned, and the Bogheads declared to be exclusively spore coals.§

The Reinschia of the Australian kerosene shale and the Pila of the Scotch and French Boghead are not considered by Mr. A. C. Seward as possessing characters sufficient to justify separating them generically. He also thinks it

* Proc. Linn. Soc. N.S.W., Vol. IV., "Note on the Origin of Kerosene Shale."

† "Reinschia australis et Premières Remarques sur le Kerosene Shale de la Nouvelle Galles du Sud." C. E. Bertrand et B. Renault, 1894. See also "Nouvelles Remarques sur le Kerosene Shale, &c.," C. E. Bertrand, 1896, and "Caractéristiques du Kerosene Shale du Northern Coal Field, &c.," C. E. Bertrand, 1897.

‡ "The Natural History of Coal," by E. A. Newell Arber. Cambridge, 1911, page 124.

§ Prof. E. C. Jeffrey, "Rhodora," Vol. XI., page 61, 1909, quoted by E. Newell Arber, page 125.

difficult to accept the explanations suggested of an organic derivation, while at the same time it is admitted that the conception of a purely inorganic substance assuming such forms is almost impossible. His final conclusion appears to be that while the so-called algae may be definite organic bodies, their nature has not been established.*

Mr. E. A. Newell Arber, on the other hand, favours the view that in this class of coal we have a substance which has been derived to a great extent from algae and spores.†

It is difficult to believe that the forms presented by tasmanite can be other than organic. Nevertheless, for the present the real nature of the plant to which it belonged cannot be accepted as definitely determined. More particularly, we are unable to decide whether we are dealing with algal organisms or terrestrial cryptogams, though the balance of evidence is in favour of the latter. One thing, however, is certain, namely, that the seam was formed in salt-water, either in coastal waters or in such as were open to the sea. Remains of the land plants which flourished in this epoch in the Mersey district are entirely absent from the tasmanite shale. On the other hand, littoral or neritic representatives of marine life are common, such as spirifera, chonetes, aviculopecten, eurydesma, keeneia, and asterzooans, and the seam is enclosed in a series of marine strata. If tasmanite is derived from land plants, the sporangia of these must have been carried by streams or wafted by winds into the salt-water basin where they accumulated in sufficient quantity eventually to form the seam. If it is of algal origin‡ the aquatic organisms simply settled to the bottom, where they became embedded in accumulating silt. The tas-

* "Fossil Plants," A. C. Seward, Vol. I., 1898, page 183.

† "The Natural History of Coal," E. A. Newell Arber, 1911, page 127.

‡ Those interested in the algal theory may be referred to United States Geological Survey Bulletin, No. 294, 1906, in which Mr. H. Foster Bain, writing on the Zinc and Lead Deposits of the Upper Mississippi Valley, discusses the occurrence of an "oil rock" consisting of brown to black shale interbedded with limestone of Ordovician age. The name oil rock is due to the petroleum odour which it emits when it is burned. It yields a heavy oil containing an appreciable amount of sulphur. An interesting point in connection with it is that microscopic sections show flattened yellow cells horizontally matted with sedimentary matter. These are diagnosed as collapsed unicellular gelosic algae, comparable to the existing Protococcales. Mr. David White concludes that "these pelagic or floating algae fell in prolonged showers in quiet or protected areas where the air was presumably somewhat charged with tannic or humic solutions conducive to the early arrest of anaerobic bacterial decomposition." (Page 27.) This material is compared by the author with the torbanite of Scotland, Central France, and New South Wales.

manite bed seems to have formed a deposit fringing the shores of the ancient land measures. *

(5)—Geographical Distribution of Tasmanite.

The discoveries which have been made so far are virtually restricted to the basins of the Mersey and Don Rivers. The principal deposits are on each side of the Mersey, between Railton and Latrobe, and their occurrence appears to be governed by the presence of the range of schist through which the river has carved its course. The South Spreyton or Nook-road deposit is in the Don basin, and is not connected in any way with the Mersey field. Its development seems to have been dependent upon a shore-line of ancient rocks, now partly represented by the Barren Hill. There are no grounds for supposing that the Nook seam ever extended to the Mersey over the area now occupied by the Brown Mountain. That area was one covered by coal measures, and there is no evidence to show that shale and coal were ever mutually superimposed; on the contrary, where shale outcrops it is fruitless to sink for coal, or where coal outcrops, for shale. The shale appears to have been associated with marine conditions; coal, however, with a land and fresh-water phase. If shale awaits discovery on the eastern flank of the Brown Mountain the most likely locality is on R. P. Symmons' sections, between the Badgers and Brown Mountain, for the trend of the older rocks from the Nook lies this way. But everything points to this fringe belonging to the coal measures series.

The only other district in which tasmanite has been discovered as yet is that occupying the divide between the Rivers Mersey and Minnow, south of Kimberley. Here, too, the beds flank the older conglomerate. Instead of viewing the tasmanite deposits as filling a wide marine basin continuously between here and Latrobe, it appears more correct to conceive of their deposition as having followed the trend of the ancient shore-line forming a strip or zone which was never of any very great width. This shore-line can be traced through Kimberley, but faulting has caused the removal of the tasmanite fringe between Native Plain and the Minnow.

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* The writer is indebted to Mr. H. H. Scott, Curator of the Victoria Museum, Launceston, for assistance in the preparation and examination of microscopic slides of tasmanite.

The indications, therefore, of the existence of tasmanite may be sought wherever along the boundaries of the ancient rocks Upper Marine Permo-Carboniferous beds are found in comparatively undisturbed positions. If the faulting has been too great, the lower beds of the system are brought up to the surface, and prospecting will be useless.

The only other part of the island where strata of this epoch are exposed is at Porter Hill, on the Brown's River-road, near Hobart, where they are associated with a gangamopteris flora, but an ancient shore-line is absent.

(6)—Geological Horizon of Tasmanite Shale.

The mudstone beds containing the seam of shale belong to the upper division of the Permo-Carboniferous system as developed in Tasmania. Their position may be represented:—

I. Loose stones at surface from conglomerate.........

H. Yellow and bluish-grey mudstones and mudstone conglomerates, fossiliferous .... 400′

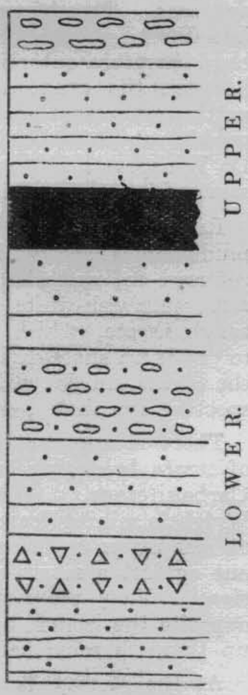
G. Seam of tasmanite shale with marine fossils .... 7′

F. Mudstone, sparsely fossiliferous, resting on heavy conglomerate .... 100′

E. Mudstone conglomerate ...
D. Soft yellowish-white sandstone and mudstone conglomerate...... .... } 100′

C. Fossiliferous mudstone ...... 500′

B. Fossiliferous bluish-grey mudstone conglomerate, glacial?........................
A. Bluish-grey, brown, and dark-sandy mudstone and shales .... } 80′



This must be looked upon as an attempt to furnish an idea approximately of the development observed in different parts of the district. The interpretation is not always free from doubt, for the exposures are frequently disconnected, and the numerous faults add to the difficulty.

A, B, C.—These are the lowest beds belonging to the system in the district. An exposure of them may be seen on H. Knight's 48 acres, $\frac{3}{4}$-mile north-west of the Stone House, on the descending track, where bluish-grey mudstone containing stones of granite and sandstone dips north-east. Below this, in the creek, are brown and dark arenaceous mudstones and shales. This is about 80 feet below the mudstone on the Main-road, at Shadbolt's Creek. On the same strike, further north-west, in the southern part of M. A. Rockliffe's 118 acres, numerous small boulders of gneiss, granite, and porphyrite lie on the surface of the soil in the scrub. Travelling westward from here stones of tourmalinic gneissose-looking granite are seen. These granitic stones occur also on the fall into Flemingham's Creek, 2 miles to the south-east. The beds therefore enter into the composition of the high hill between the Stone House and Deep Creek, and strike north-west to south-east, with a dip to the north-east. The pebbly sandstone on Mark Aylett's 500 acres, and on W. D. Winspear's 760 acres, appears to be a member of the same series, though no boulder beds are seen in it.

Rising from below these basal beds a grey fossiliferous mudstone is met with in the ascent of the hill above referred to, and the top of the hill is occupied by (D) soft yellowish-white sandstone and (E) sandy mudstone conglomerate, which must still be ranked as belonging to the infra shale division. The D series probably include the strata on W. D. Winspear's back run, where prospecting for shale has been carried on.

There is apparently a development of 500 or 600 feet of strata belonging to this division of the Lower Permo-Carboniferous. Whether they run back into H. E. Wright's mining lease is a question which can only be set at rest by prospecting. It is possible that they may run out against a schist barrier at the south end of that section. They reappear on the west side of the Mersey opposite the island, below the bridge, having been faulted up there to some height above the seam of tasmanite.

At the Mersey Bend, where the Tasmanian Shale and Oil Company is operating, the section of strata above and below the shale seam is fairly well exposed.

The seam is from 80 to 100 feet above the river, and immediately below it is dark-grey and bluish indurated clay or mudstone, sparsely fossiliferous and containing few pebbles. This mudstone, with some sandstone beds, rests upon a puddingstone or mudstone conglomerate, with large stones of sandstone somewhat loosely compacted. This is seen at river-level and at the water's edge in such a way as to preclude complete examination. Consequently, correlation with the conglomerates previously mentioned is difficult. A mile to the east, on James' 500 acres, loose stones of quartz-porphyry are scattered on the surface, which indicates the extension in this direction of those conglomerates. However, possibly the conglomerate at the Bend may belong to division E of the column given.

All the beds hitherto dealt with are of marine origin, and correspond conventionally with what are called the Lower Marine beds in Tasmania, separated from the Upper Marines by the intervening terrestrial and freshwater beds of the Mersey coal measures.

The relations between the Mersey coal measures and the seam of tasmanite shale becomes, therefore, one which it is important to establish. Mr. R. H. M. Johnston, in his "Geology of Tasmania,"* leaves the question undecided owing to lack of evidence. The coal measures dipping on the whole to the north and north-east, and the shale measures situate to the north-east having the same dip, the possibility of the prior deposition of the former is suggested; but the matter is not so easy of solution as would appear at first glance.

The shale measures have been bored through in several places to the lower conglomerates and to the underlying ancient floor of the basin, schist or Cambrian conglomerate, but the coal measures have not been disclosed. On the other hand the coal measures, which are confined to the area west of the Mersey, have been bored through to the underlying Silurian limestone without revealing the presence of the tasmanite shale seam. In the marine beds above the coal seam (Don coal shaft) similar fossils occur to those which are met with in the beds above the tasmanite seam; and below the shale horizon pebbly rocks passing down into a basal conglomerate prevail, just as happens below the coal measures.

The coal measures on the west side of the Mersey, south of Sherwood, and on Caroline Creek, are separated from

* "Geology of Tasmania, 1888," pages 129 and 137.

the shale measures only by the Mersey, and east of the Creek not even by that, for the latter evidently cross the river into Richards' sections.

The height of the coal seam throughout the district varies from river level to 400 feet above it; while that of the tasmanite seam also ranges from the water's edge to 400 feet above sea-level.

The facts seem to indicate that both were contemporaneous, the coal measures being formed under land or freshwater conditions, and at the same time that the little sacs of tasmanite were drifting together along the adjacent sea-shore, or at most in open estuaries. If there is any age difference at all, the coal measures would appear to slightly antedate the shale beds.

The fossils met with in the seam of shale and in the mudstone beds immediately above and below it are identical, and all are marine or open estuarine. They are most abundant in the overlying beds, but not quite so plentiful in the seam itself, and are rather rare in the underlying clay or mudstone.

Certain genera were recorded by Mr. Chas. Gould (Productus, Pecten, Platyschisma, Pachydomus); but a revised list was published by Mr. R. M. Johnston in his "Geology of Tasmania,*" with species as under:—

Spirifera tasmaniensis (Morris).
Cardiomorpha gryphoides (de Kon).
Pachydomus hobartensis? (R. M. Johnston).
Pleurotomaria morrisiana (McCoy).
Pleurotomaria woodsii? (R. M. Johnston).
Pteronites latus (de Kon).
Aviculopecten latrobensis (R. M. Johnston).
Aviculopecten subquinquelineatus (McCoy).

In addition to these the two following in tasmanite matrix from the Bend of the Mersey are preserved in the National Museum, Melbourne:—

Aviculopecten fittoni (Morris sp.).
Orthotetes (Fischer).

Mr. W. S. Dun, Government Palæontologist, New South Wales, has very kindly examined some fossils collected recently from the shale seam and the mudstones immediately above it,† and has furnished some notes thereon,

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* Page 135.

† Presentations of fossils to the Geological Survey, greatly appreciated, are acknowledged from Mr. W. J. Hall, General Manager of the Tasmanian Shale and Oil Co., Dr. H. Z. Stephens, Mr. H. J. Ray, and Mr. Leslie Jolly. These are preserved in the Victoria Museum, Launceston.

which will be published as a Geological Survey Record. His determinations are as follow:—

An asterozoan of the type of De Koninck's Palaeaster clarkei.
Aviculopecten sprentii (Johnston).
Eurydesma hobartense (Johnston).
Keeneia twelvetreesi (Dun).

Mr. J. E. Carne, in his work before referred to, mentions Professor David's opinion to the effect that the marine mollusca of the tasmanite beds are characteristic of the Greta horizon in the northern coalfield of New South Wales. This well known member of the Permo-Carboniferous system in that State occupies a position between the Lower Marine and the Upper Marine series analogous to the position of the Mersey coal measures in Tasmania. In the literature of other countries the Mersey coal-bearing strata are often erroneously referred to a still higher horizon—that of the Newcastle coal measures of New South Wales. The latter étage is higher than the Upper Marine, as well as the overlying Tomago and Dempsey series, and contains remains of Phyllotheca, Zeugophyllites, and Sphenopteris, which have not been recorded from the Mersey measures.

To correlate the Mersey coal measures with the Newcastle beds of New South Wales, the basal conglomerates would have to be referred not to the Tasmanian Lower Marine divisions, but to the base of the Upper Marine, similar to what is met with in New South Wales above the Greta measures. Such a correlation, however, lacks stratigraphical support.

The land and fresh-water beds of the Mersey coal measures are sandwiched between marine series above and below. The tasmanite seam, assumed to be contemporaneous with the coal beds, is, on the other hand, a marine deposit, and there is no break in the continuity of marine conditions between the upper and lower series. It is, consequently, difficult to draw any line of demarcation in the area from which coal is absent between Upper and Lower Marine. The beds of these two divisions are continuous in the shale area, and the deposition of the tasmanite seam forms a mere incident in an uninterrupted sequence.

The yellow and bluish-grey mudstones and pebbly mudstones which overlie the tasmanite seam are very characteristic. The buff tint is confined to the weathered zone; in deeper ground it is replaced by a grey or bluish colour. The cavities and decomposed kernels remaining from contained pebbles lend the rock an appearance by which it is easily recognised during prospecting. It is more clayey than sandy, and in this respect differs from somewhat similar rock overlying the coal measures or prevalent at a lower horizon in the system.

These upper mudstones visible at surface wherever the tasmanite seam exists are usually covered with a sprinkling of stones, which have been released from a bed of conglomerate broken up and destroyed by weathering.

An interesting occurrence in the Supra-Tasmanite mudstone at No. 7 shaft on the Tasmanian Shale and Oil Co.'s lease and on Mr. Ray's farm on the Nook-road is that of crystal bunches of the calcareous pseudomorph named Glendonite by Prof. T. W. E. David and T. Griffith Taylor, and considered by them as having replaced glauberite in the Upper Marine Permo-Carboniferous rocks of New South Wales (Occurrence of the Pseudomorph Glendonite in N.S. Wales by T. W. E. David and T. G. Taylor, Rec. Geol. Surv., N.S.W., 1905). Prof. David has kindly identified the Tasmanian specimens.

VI.—SHALE MINING AND PROSPECTING AREAS.

(1)—The Mersey Area.

(a) *Tasmanian Shale and Oil Company, No Liability.*

Leases 4508-M, 313 acres; 4164-M, 256 acres; 3996-M, 314 acres; 3995-M, 320 acres; 4163-M, 117 acres; 3994M, 100 acres.

The property is reached at 2¼ miles south of Latrobe by a road along the right bank of the Mersey River. The extraction works have been erected on Section 4164, and the principal mining work has been carried out on the same section. The river here makes a pronounced double curve, the most northerly one being known as the Great Bend of the Mersey. The ground between the curves of the river rises into a steep hill composed nearly entirely of schist and fringed on each side by a seam of tasmanite shale. On the western side the seam is at river-level; on the eastern side it is about 100 feet higher. There is reason to suppose that the seam is one and the same; that at one time it was continuous round the edge of the schist; and that the present difference in level is due to faulting.

On reference to the early literature it will be seen that already in 1851 these outcrops of the seam were known, and the material called combustible schist. In 1860 or 1861 a company did some prospecting work on the high-level seam, and Mr. C. Gould, then Government Geologist, reported on the deposit. A quarry was opened and a shaft sunk at the point selected by the present company for opening up its mine.

The high-level seam which continues above the river eastwards into the adjoining 500-acre lot was, together with the low seam at river-level, examined in 1901-1902 by Mr. T. Esdaile and Professor J. G. Black on behalf of the Tasmanian Shale and Oil Syndicate of Adelaide.

Referring to the low seam at the river, Dr. Black reports:—" A fine outcrop dipping north-east about 1 in 25, partly in the river and crossing it towards the 100 acres on the west side and partly in the bank, showing 6 or 7 feet. A shallow shaft 40 yards away went down through 4 feet, yielding 65 gallons crude oil per ton. All the outcrops yield from 44 to 65 gallons, and are parts of the same continuous unbroken shale bed."

The present company started operations in June, 1910, by sinking several prospecting shafts in different parts of the property.

Attention was first paid to the outcrop on the river south of the pumping-station. In the south-west corner of the 256-acre section, the seam is exposed in the bank and bed of the river, extending into the stream in the form of broad flat shelves. These shelves have been seen for more than half-way across the river, but have not been traced as far as the western bank. The seam here seems to be 6 or 7 feet thick, and is overlaid by 2 feet of thinly laminated fossiliferous mudstone, which in its turn is beneath 3 feet of sandy clay beds. Seven feet of heavy river shingle rest upon the whole. The dip of the seam is north-easterly.

A chain or two south-east of the outcrop a shallow shaft (No. 1) has been sunk through 22 feet of pebbly mudstone with fossil marine shells, and through the 7-feet seam of good shale into 2 feet of pebbly mudstone below.

Four chains south-east of the preceding, another shaft (No. 2) has been sunk to a depth of 48 or 50 feet, but was abandoned in consequence of the influx of water. The ground in this shaft was loose for the first 18 feet, and then boulder or heavy shingle was passed through for 2 feet. The upper bluish mudstones, with a few pebbles, then continued to the bottom of the shaft. From the absence of the seam it was thought that some variation in the dip had occurred, which was interpreted as having changed to the south-east. This, however, is doubtful, unless there is faulting.

Six chains south-east of No. 2 is No. 3 shaft, which has been sunk about 10 feet in detritus at the toe of the schist hill, and has not touched solid rock.

The dip of the beds against the hill indicates that they were not laid down in their present position against the schist mass, but that they have been faulted against it.

The area of this patch of seam is consequently extremely limited. It is 2 or 3 chains wide by, perhaps, a few chains long.

North of this patch the schist descends to river-level, and is cut through by a dyke of basalt 6 or 7 chains wide, crossing the river in a south-westerly direction. The steep escarpment of the dyke towards the top of the hill has contributed to the formation of extensive screes, from which stones are taken for road-metalling.

Five chains north of the dyke is the pumping-station, where the river-water is pumped to the reservoir for the Latrobe water-supply, a height of 200 feet above the river. Beneath the station, at river-level, schist is seen outcropping, with a strike of N. 40°. W. The dip is south-west, nearly vertical.

East of the pumping-station, and 30 feet above the river, is a small shaft on the hillside, which has be-n sunk to 20 feet in the pebbly mudstone which usually overlies the shale seam. The area north of the station, and to the company's boundary fence, is occupied by Permo-Carboniferous strata, and apparently by the shale measures. Some shale has been taken from large slabs in the bed of the river here, and when the water is low these flat shelves of shale are easily seen. Some doubt has been expressed as to whether they are actually *in situ*. Even if not, it is quite possible that they may not have moved far from their outcrop, for there is every reason for believing that the seam may exist here at somewhere about the level of the bed of the river. This level would be a very inconvenient one for working.

In view of the information gained on the western side of the hill the company turned its attention to the ground on the north-eastern side, east of the large basaltic dyke which forms a ridge running north and south through the section.

After prospecting by means of several shafts, some of which, owing to prevailing bad weather, were not sunk to the desired depth, a site for a tunnel on the high-level seam was selected in the gully leading down to the Mersey at the Bend about 4 chains west of the western boundary of the section and 80 to 100 feet above the river. A tunnel wide enough for a double line of rails has been driven in a north-westerly direction on a strong seam of tasmanite shale which outcrops in the gully. The seam as opened upon is 7 feet in thickness, with its central part of varying size, and of poor quality. In the outcrop portion, therefore, this seam is larger than any seen south of the Bend, but whether it will maintain its size when it is followed well under cover remains to be seen. These outcrop indications are somewhat uncertain guides. Its covering is a pebbly mudstone or sandy clay, and the beds below it are of compact, dark mudstone, with a few sparsely scattered pebbles. The upper mudstone may be usually differentiated from the lower beds by its habit of perishing and splitting into thin laminae when broken and exposed to the air for a little time. Below all these mudstones there are at the river-level beds of coarse mudstone conglomerate (pudding-stone), containing large stones in a rather loosely aggregated matrix. These are probably the conglomerates of the Lower Marine division. They may be distinguished from the older conglomerates by the absence of quartz pebbles and quartz veins.

The shale seam crops out along the bank in each direction from the approach to the tunnel. Westwards it must junction with the schist in the hill at 8 or 9 chains from the tunnel. The last outcrop is seen in the bank at 6 or 7 chains from the gully, where it presents the following section:—

	ft.	in.
Clayey sand at surface	5	0
Tasmanite shale	1	3
Laminated clay	1	8
Tasmanite shale, good quality	0	9
Clay	1	6
Tasmanite shale, poor quality	4	0

The exposure is in shelves or slabs, and the seam will no doubt be more solid and continuous under better cover.

Close to the tunnel mouth is an old shaft (No. 10), which has been cleaned out by the present company, and shows the seam 7 feet 5 inches thick.

Three chains west of the tunnel is another shaft (No.9), which was sunk by the Adelaide Company, and this has also been cleaned out, and the seam is stated to have been passed through at 26 feet down.

The dip of the seam round the tunnel workings is about 10° in a direction to the east of north. The seam will therefore plunge into the north-western corner of this section, and cross below the northern boundary into Dyson's 49 acres. The ground rises in that direction, and it will be of interest to know at what depth the seam is lying in that part of the property.

No. 4 shaft, which is 14 chains N. 28° W. from the mouth of the tunnel, and on ground 75 feet higher than the latter, was sunk by the former Adelaide Company to a depth of 44 feet, and has been continued to 83 feet by the present company in the upper mudstones without reaching the seam. The water presenting too much difficulty, further sinking was abandoned. From the appearance of the material on the tip the bottom of the shaft must be within a very short distance of the shale. In fact, with a dip of 10° from the tunnel, the seam should be met with within the next few feet of sinking.

North of the inclined tramway, and about 7 chains away from the approach to the tunnel, is a small cone of basalt several chains across, which is on a line with two other patches of similar rock on the north side of the line. This is an inconvenient feature, and some careful boring trials will have to be made if it is desired to know beforehand how this volcanic rock affects the continuity of the seam. Meanwhile as wide a berth as possible is being given to this disturbing factor by working to the rise towards the schist hill on the south.

At some distance north-west from the tunnel, and a chain north of the tramway-line, a hole has been put down 101 feet by hand-boring in rather loose, sandy ground, without reaching the seam. No definite information was obtained from this bore, and when loose sand filled up the hole for 30 feet the work was suspended. As the collar of the bore is only 75 feet above the tunnel, and the position is nearly on the level course, shale ought to have been met with. The extent to which this strip of country north of the tramway may have been disturbed by the Tertiary volcanoes is uncertain, and will have to be ascertained by further exploration and work.

On the chart accompanying this report an area of about 120 acres on this part of Section 4164-M has been hatched as almost certain to be shale-bearing. Accordingly as the poorer band in the 7-feet seam varies in size, the net tonnage of the seam over this area on the basis of 1500 tons per foot of seam per acre, and for 4 feet of seam, would be about 720,000 tons of shale.

On the west side of the schist hill, and about 200 feet above the river, south of the basalt dyke, a fringe of the upper mudstone and clay beds has survived coming round the north end of the hill. A little work has been done here to ascertain whether the seam exists below these beds. The result, however, has shown that it is absent. A 61-feet bore was put down, which finally brought up particles of schist. A little lower down a couple of deep cuts were put into the hill, and these exposed the usual yellow and bluish clay only. About 60 or 70 feet still lower down the hill is solid schist. The absence of the seam here may be accounted for by supposing that the beds are the uppermost of the series, and were deposited at the edge of the basin.

Private land bounds this section on the north, but north of the old Deloraine-road the company has a 314-acre section (No. 3996-M), on which, west of M. Gray's 25 acres, the shale measures apparently continue to its northern side-line. There is a little interruption by volcanic rock, but there does not appear to be any reason for excluding the seam from this part of the property. Boring might be undertaken here with advantage. On the remainder of the section, east of Gray's, there is no hope of finding shale, because the rocks belong exclusively to the schist series.

North of the Deloraine-road in the schist area is some quartzite or crystalline sandstone, which although not exactly schistose, most probably belongs to the Pre-Cambrian. It is also found elsewhere in the district associated with the schists. A gossanous quartz lode occurs in this rock at the foot of the hill, striking north-west to south-east, with a south-west dip. The quartz is cellular, and of white and yellow colour. It is not unfavourable-looking for gold. This quartzite appears to ascend the hill to the east, but on the very summit, overlooking W. Barry's farm to the north, is a small patch of Permo-Carboniferous ground. This is a clayey yellow sandstone with lines of bedding and ferruginous segregations. It contains no pebbles, but it can be matched exactly with some varieties of the buff rock in the shale measures.

No. 5 shaft south of Barry's fence has been sunk at the northern base of this schist hill for a few feet only in soft decayed schist. About 5 chains to the east of this a small pit is also in soft schist.

The creek near the south-east corner of Barry's appears to mark the junction of shale-measures country with the schist. The tasmanite seam is exposed in the bed and banks of the creek, and has been reached in No. 6 shaft, which has been sunk 18 feet to creek-level in Section 3995.

About 12 or 15 chains east of this is No. 7 shaft, sunk in the same favourable-looking country, apparently to a depth of about 30 feet. The rock is bluish mudstone, and the bottom of the shaft is in all probability not far from the horizon of the seam. Some stones of limestone have been found embedded in the mudstone. The ground falls to the south and south-east, and this tract of country is in every way encouraging for exploration.

Half a mile to the north-west is No. 8 shaft, near the south-east corner of G. Atkinson's (jun.) 50-acre freehold. This has been sunk a few feet in laminated, pebbly, and fossiliferous mudstone, with every prospect of shale, if continued.

All these shafts were sunk during continued wet weather, and work was suspended until the drier season. As it has turned out, there has been no renewal of work, and the results from the expenditure have been largely indecisive. In resuming exploration it would be better to abandon most of these shafts altogether, and employ the core drill, which would very rapidly give the information needed.

The shale measure ground extends right up to the northern line of Section 3995, where a few stones of diabase are seen.

This section is one of great prospective value, for it contains nearly 300 acres of what seems to be undisturbed shale-measure ground. In the south-west part of the section only is there schist, occupying between 30 and 40 acres.

The occurrence of the seam at No. 6 shaft, 70 or 80 feet above the seam at the Bend, shows that a favourable faulting has taken place, bringing up to within easy working distance from the surface shale which otherwise would have been carried by its underlay to a depth of 1000 feet. The existence of numerous faults all through the Mersey district makes it impossible for mine owners to dispense with underground exploration, but the seam is probably nowhere at any great depth from surface.

It is a little unfortunate that such a likely portion of the company's ground should be so distant from the works site, but there would be no difficulty in connecting by means of a tramway if needed. It would probably have to run some distance west along the old Deloraine-road before turning south to the works.

The company has two sections south of the Mersey, but these are of minor importance. One of them—4508-M, 313 acres—is composed entirely of rocks belonging to the schist and quartzite series, excepting in its south-west corner, where shale-measure country comes in. Along the western side-line of the section are quartzites and drab glossy slates, evidently members of the same series as noted on the north side of the river. Exactly what relation these rocks bear to the schist is uncertain.

The schist ground of this section is the continuation of that on the north side of the river, and the Permo-Carboniferous beds which appear in the south-west corner are in continuity with those in the Latrobe Shale and Oil Company's sections to the south.

In the north-west corner of the company's section 3994-M, 100 acres, a small shaft has been sunk to a depth of 25 feet through the buff clay-beds into bluish mudstone. This is situate half a chain from the northern line of the section, and a chain and a half from Wakeham's fence on the west. These beds are those which characteristically overlie the shale seam, and the shaft should be continued or the ground bored to the requisite depth, as the result would prove the value of the rest of this section. The south-western half of the section appears to be the channel between the schist on one side and the ancient conglomerate on the other, in which the Permo-Carboniferous strata have survived, and along which they pass until interrupted by the basaltic dyke or chain of volcanoes to the north-west.

Not sufficient work has been done yet to determine the net workable size of the seam. In common with all the outcrops in the district the quality of the shale is not uniform throughout the entire thickness of the seam. A band of poorer shale with an admixture of clay in varying proportions exists in the middle of the seam. Sometimes this band is somewhat under 1 foot thick, or again it increases in size to a couple of feet or so. Estimates therefore of the quantity of shale available on this property must in its present unproved state be merely approximate. The seam on the Latrobe Shale and Oil Company's property, which has been more extensively proved than any other, appears to be about 4 feet in thickness, and fears may be entertained that in working the 7-feet seam further underground the size of the poor band will increase and the net size of the seam approximate more closely to that observed elsewhere. In the present tunnel there are signs of an unfavourable variation in size, but this may possibly be due to its being so near to the edge of the basin along the schist border. At any rate, in making estimates of tonnage it will be safer not to assume a thickness exceeding 4 to 4½ feet.

An attempt has been made to indicate on the map by hatching the area over which the seam may be expected to extend. This comprises about 120 acres on the section at the Bend and 280 acres on the northern section, in all approximately 400 acres. Taking the specific gravity of the seam material as 1·6, and calculating per the method explained elsewhere in this report at 6000 tons per acre for 4 feet of seam, the total weight of shale in the 400 acres would be about 2,400,000 metric tons. In this calculation the little patch of shale at water-level near the river shafts, and any possible shale under the works' site, have been neglected, as being within the influence of the water of the Mersey, and difficult to be worked profitably.

Although the shale is called an "oil shale," it does not carry any free oil, but in common with coal, peat, wood, and most organic substances, to obtain oil from it it must be subjected to destructive distillation in retorts. The industrial enterprises of this nature in Scotland, France, New South Wales, &c., are regarded as constituting what is called "The Shale Oil Industry."

The Tasmanian Company's works for retorting the shale are situate on the western slope of Section 4164-M, near its northern boundary, and overlook the Mersey. An endless stream-driven rope-haulage conveys the shale in trucks on a wooden tramway from the tunnel mouth to the top of the hill, a distance of half a mile. Thence the trucks run down a self-acting incline to the rock-breaker, in which the stuff is broken into small pieces (2 or 3-inch size). From this the latter is carried by a conveyor to the top of the retorts.

Four of these retorts have been built on the general lines of a pattern patented by Mr. W. J. Hall, the company's general manager, who, with his assistant (Mr. Palmer), designed and constructed the first vertical shale oil retorts erected in New South Wales.* Each of the retorts is supposed to treat daily 4 or 5 tons of shale, which is subjected to slow distillation, during which process the gas from the retorted shale passes into a cooler and through the condenser, and the crude oil finally flows into the stock tanks. The lighter oils and spirit having been extracted by distillation, the remainder is residual, or fuel, oil. The spent shale is stacked for sale for manurial purposes.

Some twenty odd tons of oil have been produced at these works, but before all the various initial difficulties incidental to the starting of new installations had been completely overcome, operations were suspended, owing to insufficiency of capital.

During the execution of the preliminary work connected with the opening-up of the mine and the erection of the retorts, bulk tests have been made in the company's experimental laboratory at Latrobe, and small parcels of oil and spirit put on the market and supplied for working trials. In this way the practicability of producing—besides the residual, or fuel, oil—motor spirit or petrol, a substitute for turpentine, and a light engine oil has been conclusively established. This experimental distillation

* See "The Kerosene Shale Deposits of New South Wales," by J. E. Carne, Mem. Geol. Surv. N.S.W., No. 3, 1903, page 88.

plant was under the charge of Mr. Geo. Cox, the company's chemist.

In December last the mine was visited by Admiral Sir Reginald Henderson, in the course of his journey through the Commonwealth, for the purpose of reporting to the Federal Government on the question of naval defence. He was accompanied by Captain (now Rear-Admiral) Cresswell, who was interested in the matter of oil-supply for the new Australian destroyers. On the visit of the party to Devonport a practical and successful trial was made of the fuel oil by using it for driving the municipal electric generating plant.

Efforts by previous syndicates were in the direction of pushing fractional distillation to its furthest limits, and exhibiting how many different varieties of oil could be produced. The programme of the present company, on the other hand, is to restrict the production to the four products mentioned above, each of which will find a ready sale. In this way easily marketable products are obtained, the successive losses of numerous fractionating processes are avoided, and the necessity of providing a much more costly plant is obviated.

The spent shale, though not containing any large proportion of the elements of plant food, has by virtue of its physical properties been found by many who have tried it very suitable for application to the heavy clay soils of the North-West Coast. The total produce of this commodity has been placed for the next three years.

For remarks on the quality of shale see the chapter on Cost of Production and Value of Products.

(*b*) *Latrobe Shale and Oil Company, No Liability.*

Leases 2540-M, 100 acres; 2541-M, 100 acres; 2542-M, 100 acres; 2543-M, 100 acres; 2544-M, 100 acres; 2545-M, 100 acres; 2546-M, 299 acres; 4619-M, 107 acres; 4626-M, 116 acres; 4627-M, 302 acres; 4628-M, 297 acres; 4777-M, 242 acres; 4791-M, 270 acres; 4792-M, 199 acres; 4804-M, 256 acres; 4805-M, 320 acres; 4806-M, 292 acres; 4807-M, 265 acres; 4808-M, 209 acres; 4865-M, 88 acres; 4945-M, 68 acres; 4946-M, 69 acres; 5031-M, 84 acres.

This company's leases are situate on both banks of the Mersey, roughly speaking, between the Railton-Dulverton-road on the west, and Paramatta or Fossil Bank on the east. Those on the western side of the river, on what is known as China Flat, contain the most important developments of the shale seam, while on those near Paramatta the prospects are somewhat limited.

The river valley is bordered by hills composed of Pre-Cambrian schist, in which the Mersey in recent times has cut its channel. This schist forms the rim rock of the shale measures on the eastern side of China Flat, and would, if the flat were drilled to a sufficient depth, be found to constitute the foundation on which the superincumbent strata have been laid down. The rim rock on the western side **is** the conglomerate which forms a hill range extending in a north-westerly direction parallel with the Railton-Dulverton-Latrobe-road from the southern to the northern boundary of the company's property. This ancient conglomerate (of Cambrian or Cambro-Ordovician age) itself doubtless rests upon the great schist formation, and to some extent probably directly underlies the shale measures, more especially towards their western limits. The Permo-Carboniferous strata, in fact, may be described as lying here in a natural basin formed by the more ancient rocks.

Towards the north this basin or ancient gulf contracts in width, the schist on the north-east gradually encroaching on its area until, beyond the bounds of the company's land, a very narrow strip is left available for its connection with the shale area north of the Mersey Bend. A connection with that area evidently existed at one time, but has since been interrupted by intrusions of diabase and dykes of basalt, besides by faulting, to some extent. Some intrusive diabase has pierced the shale measures in one or two of the company's sections, and this rock evidently disturbs the continuity of the seam towards the northern part of the ground.

In a southerly direction the Permo-Carboniferous strata continue to the extreme limit of the company's property and pass across the river to the Native Plain, but within half a mile of the Native Plain (Hogg's Bridge), and higher up the river, the lower beds of the system are brought up by a fault which cuts the shale measures off in that direction. The latter are seen at the bridge, and probably cross the river there, and exist below the alluvium of the plain at Hogg's farm, but do not continue much further up the river.

No precise knowledge can be gained as to the aggregate thickness of the Permo-Carboniferous strata in this basin. They seem to be thinner towards the north and thicker in a southerly direction. The distance between the rim rock on either side is so small that their maximum thickness anywhere is not likely to exceed 200 or 300 feet, and over a large extent of the area they must be much thinner than this. On this side of the river they extend in a narrow belt about ½-mile wide for about 4 miles from north to south, and carry at slightly different levels what must be regarded as one and the same seam of tasmanite shale.

The company has defined the extent of this seam by a judicious scheme of diamond-drill boring. It has put down boreholes a few chains apart on lines across the Permo-Carboniferous belt, as shown on the accompanying map. By this means the width and thickness of the seam in this belt has been ascertained. Naturally the company has carried out the drilling programme for its own benefit, and not for the information of the public. The results of the prospecting operations are consequently not available, and the geologist has to be guided to his conclusions by observation, his knowledge of the country, the surface outcrops, and the stuff thrown out from the numerous shafts which have been sunk from time to time. Valuable information has also been obtained from local prospectors and others. Under these circumstances the hatched shale area marked on the map must be regarded as an attempt to indicate only approximately the area over which the seam will be found to exist. The full width of the Permo-Carboniferous belt has not been taken for this purpose, as owing to the surface-covering of detritus its exact boundaries are a little uncertain, and it is possible that towards its edges the shale deposit may thin out gradually. On this account the area near the edges of the hatched portion must be looked upon as somewhat doubtful, and the whole representation interpreted in a liberal sense. The company's borings have doubtless afforded precise information.*

The shale deposit on the property is most strikingly exposed on the B and C lines.

On the former line, which is in Sections 2542-M and 2540-M, a large excavation has been made in a surface outcrop of the seam, and a shaft has been sunk 40 feet north of it cutting the same seam. Water is lying in the bottom of the quarry, and this prevents a thorough examination, but from what is exposed the seam appears to consist of

* Since these remarks were penned the writer has been favoured with information regarding the results of boring, which, generally speaking, confirms the views expressed in this bulletin.

3 feet of shale in its upper part and 1½ foot of shale in its lower portion, separated by a band of clay 1 foot in the middle. The quality for the most part is excellent, and without doubt a high-grade product will be obtained from the seam at this point.

Further west of the above is a shaft (No. 2), sunk about four years ago by F. Hedditch and party, through about 30 feet of bluish mudstone to a 4-feet seam of shale. The shale here is of the highest quality. Some of it was sent to Melbourne for testing, and is stated to have yielded 60 gallons of oil per ton. When freshly broken it shows the glistening streaks, which are looked upon as an indication of richness. It is very light and compact, and consists of a closely-packed mass of spore cases. It is sectile when cut with a knife, and burns freely on the application of a match. Samples taken from the dump at mouth of shaft have been assayed by Mr. W. F. Ward, Government Analyst, with the following result:—

Mineral Matter.	Volatile Matter.	Fixed Carbon.	Moisture lost at 212° F.	Sulphur.
58·0	37·3	3·4	1·3	2.6

The calculated yield of oil would be 50 gallons per ton of shale.

About a mile to the south-east of B line is C line, but no bores appear to have been put down on this parallel, probably because the shale crops out at surface or is not far below the soil. On this line is Richards' quarry, where a good seam of shale is exposed, apparently about 4 feet thick, with, as usual, the poorest quality in the middle. This outcrop is on a low brow, where it can be easily worked and handled. Samples, taken from a heap of shale which had been broken from this quarry for testing purposes were assayed by Mr. W. F. Ward, Government Analyst, with the following results:—

Fixed Carbon.	Volatile Matter.	Ash.	Moisture.
2·83	22·07	74·2	0·9

Calculated yield of oil, 29·4 gallons per ton of shale. This material was evidently broken before the nature of the middle band was recognised.

The best part of the deposit is that from the B line southwards. It widens out somewhat here, and, though no outcrops are visible, must continue south-east to Hogg's Bridge. A hasty interpretation of the field evidence might lead to the conclusion that at a short distance south of

C line the seam has disappeared as a result of erosion, but if faulting is assumed this inference is unnecessary. That the strata have been faulted south of C line is pretty evident from the beds visible on the road at the bridge. Here the overlying fossiliferous mudstones descend to river-level, and in all probability the shale seam exists below them. From appearances at the bridge the Permo-Carboniferous basin is deepening in this direction, and on the Native Plain most likely all the lower beds of the system would have to be passed through before reaching the underlying floor of schist. Originally the Upper Permo-Carboniferous strata must have been continuous over Native Plain and Merseylea, as there is a concealed line of schist and conglomerate in that direction, against the edges of which the younger Palæozoic beds were laid down. Subsequent faulting, however, has brought the lower beds to the surface and shattered all hopes of finding shale measures in this area.

Between the east end of C line and the Mersey for a width of a $\frac{1}{4}$-mile or more a belt of Pleistocene gravel fringes the river, and to that extent the shale measures appear to have been eroded. This is outside the company's leases.

The shale measures continue north from the B line of bores, but between B and A the western part of the belt shows in places stones of diabase in the soil, suggesting an intrusion of that rock. The large boulders indicate that the solid rock is near at hand, and near the northern boundary of Section 2541-M the general appearance is that of diabase country. The same rock is found also further south near the western end of B line, and again still to the south a little east of Blenkhorn's limestone quarry. The exposures of this intrusion may therefore be said to follow here the direction of a meridional line, which may possibly affect the development of the shale seam between the lines A and B.

Between A and H lines a narrow belt of Upper Permo-Carboniferous strata continues north-west to the northern boundaries of the company's land, but the ancient conglomerate on the west and the schist on the east hem in this belt of country, which eventually disappears below the basalt soil of the farms. Half of Section 4627-M is schist country, and Section 4865-M is entirely schist. H line is very near the schist range to the north, and this implies that the ground is shallowing. Even if the upper strata are visible at surface, the seam of tasmanite will most likely to be found to be absent. Conglomerate or schist cannot be far below the surface.

Near the south-east corner of Wakeham's farm, and south of the road, on Section 4792-M, is Campbell's shaft, sunk about nine years ago for Dr. Stewart. In the bottom—about 25 feet—is coarse sandstone below the usual bed of buff clay rock. To the west of this is the ancient conglomerate rock.

South-east from the above, and near Section 4627, are three shafts, sunk by Hedditch three years ago. Some limestone has been thrown up from these, and Mr. Hedditch states that in the most easterly shaft a drill-hole in the bottom was bored 2½ feet into solid limestone. This stone belongs to the Silurian limestone beds exposed in the Railton quarry, but its occurrence here is difficult of interpretation.

Owing to successive faulting the seam as exposed at surface or in the bottom of shallow shafts exists at different levels on the property. Some of the difference is due to the inclination of the seam; and some of the difference in depth below the soil is owing to differences of surface configuration. It is clear, however, that though a beginning may be made to quarry in open-cut excavations, this cannot be continued, and methods of underground mining will have to be resorted to. Coal-mining methods of opening up the seam will be those adopted, but the shale is singularly tough and resistant, and the mining costs may prove to be a little in excess of the usual cost of working coal.

It is not at all likely that the depth of the seam below surface will anywhere exceed 200 feet, and for the most part it will certainly be less than 100 feet. This compares favourably with the depths at which oil shales are worked in Scotland (in places at depths of over 1000 feet from surface).

The maximum thickness of the seam observed was 5 feet 6 inches, and this includes a band of clay rock about a foot thick, which would reduce the retortable shale to 4 feet 6 inches. In places, however, the shale is only 4 feet thick, and there are points, no doubt, where it will be found that the seam has suffered a still further decrease in size. It will very likely be found that 4 feet will prove to be a fair, full estimate of the average size of the workable seam.

To arrive at an idea of the tonnage contents a certain specific gravity must be taken as a datum figure. The specific gravity of the seam material varies greatly. That of the hard calcareous tasmanite rock in the main quarry is as high as 2·29. That of the rich 50-gallon shale is only 1·5. That of the 40-gallon quality is 1·6, and for the purposes of calculation this figure may be used. The result according to the method referred to elsewhere in this report,* making a deduction for faults and waste in working, &c., neither so high as one-third nor so low as one-fourth, but at a rate between these two figures, would be a net weight of 1500 metric tons per foot of seam per acre; or 6000 tons for a 4-feet seam.

The outside estimate of the area of shale-bearing ground on this side of the Mersey is about 600 acres, the extent shown by the hatching on the map. This estimate is not to be used as a basis for company flotation, but is made rather for the purpose of furnishing the Government with an idea of the approximate area over which it is highly probable that some sort of a seam exists. The seam most likely thins out at its edges, and, moreover, the borders as shown must not be interpreted too strictly, for the boundaries cannot be contoured without close boring. The northern part of the belt is also subject to an uncertain amount of interruption by igneous rock, rendering precise calculations out of the question. Consequently, by trimming the area and calculating an average width of 30 chains for the greater part of the belt and 20 chains for the northern part over an aggregate length of nearly 2⅓ miles, the net average works out at about 500 acres.

What the exact thickness of the seam is over this area can only be stated from the boring results; but assuming a probable average thickness of 4 feet the tonnage of shale, reckoned at 6000 tons per acre, would amount to 3,000,000 metric tons, with a crude oil content of 120,000,000 gallons.

The company has seven sections on the east side of the Mersey, but as will be seen by the map a large proportion of this ground is hopeless for shale, being Pre-Cambrian schist. A belt of high schist hills borders the river for 20 to 30 chains back from the bank. On the east side of these the Upper Permo-Carboniferous strata reappear. Shale measures are apparently developed over about 200 acres, between the schist border on the west and the Para-

* 1 acre = 43560 □′ × 1·6 sp. gr. × 62·35 lbs. = 4,345,545 lbs. = metric tons 2172·7 less one-third = 1448 tons per acre for one foot of seam. Or if only one-fourth is deducted for waste, faults, etc., the tonnage would be 1629 tons per foot per acre.

matta township on the east. It is difficult to trace any connection between this occurrence of shale beds and the belt on the west of the Mersey. It was probably at one time continuous with the eastern measures on James', Roache's and Carey's blocks further north. The Mersey shale beds as a whole must be regarded as fringes of the ancient schist peninsula; and there are two of these fringes—an eastern and a western one. These Paramatta sections show a surviving fragment of the eastern fringe. The Permo-Carboniferous country west of the north and south road is covered with the usual pebbles from conglomerate. The superficial strata are clay and mudstone, the mudstone of the kind invariably found overlying the tasmanite seam. The limits of probable shale-bearing measures are represented on the map with considerable hesitation, as the ground to the east is difficult of interpretation. Although from the dip the ground may be expected to deepen in that direction, faulting has evidently occurred, as the Lower Marine beds are brought to the surface further east. This complicates the problem of the eastern extension of the seam. The value of any estimate at all of probable extent of the shale seam on these sections is extremely doubtful. The acreage must be below 200 acres, and the probable tonnage under 1,000,000 tons.

The boundary of the schist sweeps through the centre of Smith's 149 acres and enters the company's Section 4808, following the course of a creek which flows in a north-westerly direction, emptying into the Mersey on James' freehold. North of this creek are Permo-Carboniferous beds. Possibly some of these may belong to the shale measures. Indications exist, however, of the conglomerates of the Lower Marine. If the tasmanite seam exists at all in this part of the lease it cannot have any extent worth considering.

From what has been said it is apparent that the shale measures on the company's leases east of the Mersey form a subordinate feature of the property. The development of the seam there will in all likelihood be found to be too restricted to admit of it being worked as a self-contained centre. Its exploitation would have to be in connection with works on China Flat or at the Mersey Bend. Its position is about midway between the two, but its distance from either is inconvenient. It is evident that the company's main source of supply must be its seam west of the Mersey.

The commercial value of the products derivable from tasmanite shale—a matter affecting not this company alone, but also others which are contemplating or have started the exploitation of their seams—is discussed in another part of this report.

From what has been said it will be seen that this company possesses a property on which a fine development of shale exists, and in carrying out any general scheme for the industry of the district the company's seam must necessarily play an important part. At the same time it is evident that the company's own shale reserves are ample for an independent enterprise.

(c) *Freehold Lot* 358, *Jno. James*, 500 *acres*.

The Tasmanian Shale and Oil Syndicate of Adelaide took over this property in 1901, and in 1902 it was subjected to a prolonged examination by Dr. J. G. Black, M.A., University of Otago, and T. Esdaile, late lecturer in chemistry at the Adelaide School of Mines.

It fronts the Mersey with high banks at the Bend, and adjoins the property of the present Tasmanian Shale and Oil Company on the west and north. The tasmanite seam at present worked by that company continues into this ground, and can be traced outcropping at intervals for about half a mile eastwards along the river bank.

About 4 chains above the south end of the island in the river the Pre-Cambrian schist descends to the river and forms the eastern rim of the Permo-Carboniferous basin at the Bend. This schist boundary of the shale measures continues north to the limit of the block, and beyond that trends in a north-westerly direction past Gray's farm and as far as Bonney's Creek. Traces of its continuation still further north are seen in the occurrence of slate at the foot of Cherry Hill.

The block of Permo-Carboniferous country over which the tasmanite shale seam may reasonably be expected to extend in this part of the 500 acres measures a little over 100 acres.

In the eastern part of this shale area the seam has evidently been successively raised by three step faults 20 or 30 feet at a time, as shown by outcrops in a gully. These outcrops must be regarded as parts of one and the same seam. No satisfactory evidence exists for the occurrence of a multiplicity of seams on this or neighbouring properties.

The true thickness of the seam cannot be stated until some of these outcrops are followed under cover and into solid and undisturbed ground. The exposures on the river bank especially present feather edges to view, alternating with bands of clay, and making it very unsafe to estimate the workable size of the seam. Some of these slabs may have moved bodily for a little distance from their original position, giving a misleading appearance. If they are followed in under the overburden possibly some of them may disappear, but by continuing into the hill the seam in its full thickness will be met with. The measurements of these exposed slabs, with the intervening clays, are of doubtful value in estimating the size of the seam, for by taking the sum of the measurements a fictitious thickness may be easily obtained. In some instances the dark mudstone has been mistaken for shale, and added to the thickness of the seam (*e.g.*, 9 feet).

It is probable that the workable size of the seam will prove to be between 4 and 5 feet.

The hill in the north-west corner of the block rises to about 400 feet above the river, and forms a body of overlying rock below which there is every reason to suppose that the tasmanite seam extends. Whether the latter continues to fall away to the north-east, increasing its depth, or is brought up again nearer to the surface by some concealed fault, cannot be seen.

Exactly how the seam is behaving in this part of the property cannot be learned until a boring programme has been carried through; but assuming that its continuity is not disturbed, and its size proves to be about 4 feet, the quantity of shale existent should be about 600,000 metric tons.

The belt of schist country traversing the block from north to south is about ½-mile wide, and at about ¼-mile from the eastern boundary-line gives place again to Permo-Carboniferous strata.

South of the road the surface in the south-eastern part of the property is strewn with porphyry and other stones released from conglomerates, an indication of beds belonging to a lower horizon than that of the tasmanite. At a chain north of Rice's boundary a pit has been sunk for 15 feet in soft greenish or grey clay slate. It is stated that there were indications of shale measures coming in when work was suspended. It is rather doubtful, however, whether the rock belongs to the Permo-Carboniferous system; and if it does, its position suggests a low horizon.

North of Bennett's Creek the country changes to the shale measures. Outcrops of the seam exist outside the eastern sideline on Michael Bourke's 24 acres (now

Roache), and another on Carey's 18 acres, beyond the north boundary. In the north-eastern corner of the property a small pit has been sunk in the characteristic yellow rock, but not deep enough to touch the seam. This part of the property is occupied by the rock which usually overlies the shale, and may be considered as a shale area. Its extent may be estimated at nearly 50 acres. Judging from the nearest outcrops it might not be safe to reckon more than 4 feet for the size of the seam here, or about 300,000 tons of shale. At the same time, it must be borne in mind that the area is unprospected, and that the calculation assumes what nevertheless is a reasonable anticipation, that the seam continues through it from one boundary to the other.

The prospecting work which has been carried out at different places on this property has been for the most part confined to outcrops. To enable sound opinions to be formed as to the value and extent of the deposit systematic boring with the core-drill is a necessity. The extent to which barren schist prevails is greater than was at first realised, and the behaviour of the seam near the schist boundaries has yet to be ascertained.

Some of the river-front outcrops can be quarried for a short time, but the seam dips away from the river, and underground mining will be necessary for continuous work.

The quality of the shale is excellent, and will prove in bulk to be similar to that of the adjoining property.

The experiments conducted by Messrs. Black and Esdaile in 1902 were mainly directed towards establishing values of refined oils obtainable. Refining methods were devised, with a view of producing different classes of oils and selecting such as might command a market as occasion offered. Of course, if such aims are carried out, the necessary plant is costly, and working losses are appreciable.

Mr. Esdaile reported that in the Mersey petroleum compared with other petroleums there is:—

(1) A very much greater proportion of heavy viscous oils suitable for lubricating oils.

(2) A greater proportion of the higher hydro-carbons

(3) A greater proportion of nitrogenised bodies, from some of which azo-colouring matters and other valuable by-products will be obtained.

(4) A large proportion of olefines and napthenes in the oils.

He claimed to have prepared from this shale the following descriptions of oil:—

(1) Benzine or petroleum spirit, useful for varnishes, paints, &c., as a rubber solvent, for linoleum manufacture, and of wide application in commerce.

(2) Benzoline for oil-engines, motor-cars, &c.

(3) Lighting oil for household use in two qualitites.

(4) Lighting oil for lighthouses and railways.

(5) Light lubricating oil for sewing-machines and light machinery in two qualities.

(6) Medium lubricating oil for agricultural machinery, sawmilling, and mining plant, in two qualities.

(7) Heavy lubricating oil for heavy machinery, in two qualities.

The following are Mr. Esdaile's results:—

	Refined Oil recovered. ozs.	Gallons per ton of average Shale.	Same with 5% allowance added for smearing loss in manipulation.	Estimated Cost of Production per Gallon.	Sp. gr. of Oil.
				d.	
Petroleum Spirit ("Benzine").....	21	5·626	5·907	6½	·776
No. 1 Lighting Oil (Photogene)...	25	5·754	6·042	6½	·819
No. 2 ditto (Lighthouse Oil)	15¼	3·335	3·501	6½	·858
Light Lubricating Oil, No. 1........	9¼	1·979	2·078	7½	·882
ditto No. 2........	22½	4·705	4.940	7½	·897
Medium Lubricating Oil, No. 1....	22½	4·552	4·779	8 to 12	·927
ditto No. 2....	15	3·005	3·155	8 to 12	·937
ditto No. 3....	15	3·200	3·360	8 to 12	·951
Heavy Lubricating Oil, No. 1......	12	2·349	2·466	10 to 15	·958
ditto No. 2......	11	2·135	2·242	12 to 24	·967
Total.........	168½	36·640	38·470	...	...
% of original weight	56·2	...	...	...	...
% of original volume	...	60·86	63·9	...	...

Mr. Esdaile also states the general results of refining by Nos. 1 and 2 methods, as follow:—

Products.	No. 2 Process, by weight.	No. 1 Process, by weight.
	%	%
Refined Oils	55·50	56·2
Coke Residue	10·40	6·2
Smearing and other losses	8·00	5·7
Converted to Gas and saved as such	13·02	8·4
Sludge Oils	8·62	18·0
Lost in washing	4·46	5·5
	100·00	100·00

(In 100 parts of Crude Oil.)

In 1902 Dr. Black gave a statement of oil products obtained by Esdaile's No. 2 method from 144 oz. of crude oil, or about 39⅓ lb. of good shale:—

	Weight.	Fraction of gallon of product	Temperature of steam distillation.	Sp. Gr. at 20° C.	Flashing temperature. Degrees F.	Firing temperature. Degrees F.	Gallons per ton.
	Ozs. Grs.						
Gasolene or Heavy "Benzine" ...	12·390	·1128	Up to 115°C	·779	Fires at once	Ord. temp.	6·429
Light Burning Oil (Photogene)...	13·270	·1115	Up to 140°C	·834	88° F	120° F	6·355
Heavy Burning or Lighthouse Oil	6·60	·0496	140° to 160°C	·846	140° F	161° F	2·827
No. 1 Light Lubricating Oil	8·70	·0642	160° to 180°C	·870	180° F	225° F	3·659
No. 2 ditto	11·36	·0882	180° to 200°C	·914	250° F	272° F	5·027
No. 3 ditto	3·31	·0230	200° to 220°C	·900	260° F	283° F	1·311
No. 1 Medium Lubricating Oil ..	11·25	·0355	220° to 240°C	·924	272° F	290° F	4·873
No. 2 ditto	6·00	·0433	240° to 270°C	·947	310° F	351° F	2·468
No. 3 ditto	6·00	·0429	300°C	·966	371° F	398° F	2·445
	78·88	·6210					35·394

It should be borne in mind that these trials were of shale from ground now held separately by the Tasmanian Shale and Oil Company and the old Adelaide Company, whose ground included both properties.

Dr. Black* says:—"The shales are very different in origin and composition from the paraffin shales of Scotland, New South Wales, and New Zealand, and the oils are different. They are heavier than the parallel oils of the Scotch shales: specific gravity about ·932, as against the ·892 of the Scotch product. The oil does not exist ready formed in the shale, but is produced and distils over freely at a temperature lower than that required for the coaly and paraffin shales of Scotland and New Zealand. Owing to this the production of crude oil will be less costly. The gasolines or light 'benzines' are of very fair quality, and as there is a pretty large contingent of that brand it should, like the lubricating oils, be made an important product of these shales."

It is a pity that the whole of the shale property at the Bend does not belong to the same owners, for the most advantageous way is to work it as one property, and the dimensions of the deposits are such as to suggest making one good shale proposition of the two contiguous estates.

(*d*) *Lease* 4890-M, 40 *acres, J. Rice.*

This is situate south of James' 500 acres. The portion abutting on the river consists of Pre-Cambrian schist, which dips eastwards below Permo-Carboniferous conglomerates occupying the rising ground towards the gate on the old Deloraine-road. Among the pebbles which are strewn over the surface are stones and blocks of quartzite, quartz-porphyry, and conglomerate, indicating the presence of the lower beds of the system. Consequently the indications are unfavourable for the existence of the tasmanite seam.

(*e*) 24 *acres, Freehold, Michael Bourke.*

This land, owned by Mr. Roache, adjoins James' 500 acres on the east, and is situate at the western foot of a basalt-capped range. The shale measures on James' land enter Roache's block near Bennett's Creek in the south-west corner, and the tasmanite seam is exposed in a flat floor in the creek bed. A cut into it near the bank has

* Report 12th March and 14th April, 1902.

turned out a small heap of fair-looking shale, but it has been taken out for a long time now, and has a decayed aspect. Where the track crosses the creek the tasmanite is light and indistinguishable from the good shale anywhere on the Mersey. This is about 3 chains from James' line. The ground across the creek to the east consists of Tertiary grit and gravel, which apparently passes below the basalt capping. Whether the shale seam passes below the gravel or has been eaten away by the Tertiary streams depends upon how deep the Tertiary basin is here. If it has been excavated to any depth, prospecting for the seam in that direction is likely to be fruitless.

(*f*) 18 *acres, Freehold, Carey.*

At about a chain east of the western sideline of this block, and 5 chains from the south-east corner of Section 3995, a shallow pit has been dug in the creek bed, and at about 4 feet from surface some good-quality tasmanite shale has been struck. Pieces are lying about at surface, thrown out of the hole.

This seam is no doubt continuous with that on Bennett's Creek further south, and, like that outcrop, is also situate near the eastern edge of the shale measure country, for at a little distance further east the hill-slope is composed of Tertiary gravels and basalt, forming the Saggers Range. The exposed measures form here only a narrow strip between schist and basalt. Just as we have the tasmanite bed on the western boundary of the schist, so it exists here on the eastern side. Towards the north-west it doubtless continues to the exposure at No. 6 shaft on the Tasmanian Shale and Oil Company's lease, following the edge of the schist in that direction.

(*g*) 50 *acres, Freehold, J. Oliver.*

This farm is on the high land of the basaltic dyke, or line of volcanic necks crossing the Mersey from Section 4164. The basalt runs through Desbrow's and Atkinson's land into Oliver's, and continues thence through Wakeham's, and across the Dulverton-road.

At about 10 or 12 chains from the north boundary a strip of tasmanite shale is exposed. The beds apparently lie on schist, and pass westwards below basalt. F. Hedditch first sank a shaft on the shale nine years ago, but loose pieces had been turned up with the plough a long time before then. An 8-feet pit has been sunk through the capping rock to the roof of the tasmanite, but not through the seam. A solid bed of shale appears to show its edge just protruding in the field. The ground below it to the east, and descending to the little creek, is Pre-Cambrian schist, veined with quartz. The shale measures would appear to rest on this schist. This curious little fragment of the seam would, by prospecting, probably be proved to extend northwards nearly to the boundary of the farm, as the colour of the soil keeps light in that direction. Unless its continuity is interrupted by the basalt, it should extend also into Richards' Section 4823-M, 79 acres. Southwards the ground is continuous with that of the southern shalefield.

Possibly to the north it extended as a fringe along the edge of the schist to the river low-level outcrops on Section 4163-M, 117 acres, although faulting has since altered the respective levels, the river outcrop now being 100 feet below the seam on Oliver's.

The value of this property from a shale point of view depends nearly entirely on future discoveries on neighbouring mining leases, for no great extent of seam is provable on the farm itself.

(*h*) *Leases* 4822-M, 53 *acres;* 4823-M, 79 *acres; and* 4864-M, 200 *acres; F. Richards.*

Section 4822-M is on the west bank of the Mersey River, opposite the Latrobe water-supply pumping-station. The ground rises gently from the river, and with its grassy carpet and over-arching wattle trees is admirably suited for a reserve. A bridge across the Mersey near here would save nearly 2 miles for people from Railton. Sand and heavy surface shingle form the top of the bank, and these probably cover shale measures which rise into the hill to the west.

Section 4823-M occupies high ground composed of Upper Permo-Carboniferous mudstone measures, which in all likelihood cover the shale seam. A little work was done here nine or ten years ago. A small pit was sunk about 18 feet in soft laminated dark-coloured mudstone. From the appearance of the rock the shale seam is possibly not much deeper, but the influx of water caused the work to be suspended. Higher up the hill is a cutting a few feet deep in yellow fossiliferous claystone, passing into the dark mudstone.

The idea of this work was evidently to intersect the seam coming from Oliver's, and the chances may be described as very fair. Whether the seam is also under the intervening basalt depends upon whether the latter is purely a superficial lava flow here, or is an intrusive body such as a dyke or neck. Although the section is a narrow one (15 chains wide) the ground from north to south extends for about a mile, and is well worth prospecting for the seam.

The 41-acre block of freehold land in the name of Joseph Lobley, and situate north of Section 4822-M, fronts the river, and is covered with sand, which probably conceals shale measures.

South of Dawson's fence and opposite the shale works gate fossiliferous mudstone is exposed in the river bank, continuous, no doubt, with the mudstones on the other side. It is quite possible that the seam crosses here below the river. Farther north there must be a junction with the coal measures series. Unfortunately this is concealed below the shingle of the old bed of the Mersey.

(*i*) *W. B. Smith's Freeholds,* 149 *acres and* 25 *acres.*

These purchased blocks are of interest as adjoining an undoubted shale area, and it might easily be of importance to know whether the seam extends into them.

The western part of the 149 acres is composed of schist, which continues west to and across the Mersey; but the eastern half consists of Permo-Carboniferous country which may reasonably be ranked in the upper division. It is of the same nature as that exposed in the road-cutting at Fossil Bank, and as that of the shale section to the south. It cannot, in fact, be distinguished from the latter by any physical characteristic, and occupies the same relative position to the outcropping schist. The existence of shale is therefore very likely.

A tongue of basalt extending from the main basaltic sheet in a southerly direction reduces the available area somewhat.

The southern part of the 25-acre block consists of similar country, the northern part being occupied by basalt.

(2) *The Paramatta Leases.*

These comprise Section 4916-M, 51 acres, and 4917-M, 21 acres (C. Kennedy); 5054-M, 69 acres, and 5041-M, 30 acres (J. A. Crisp); and 5162-M (Hobart-Latrobe Shale Oil Association, No Liability); also 4915-M, 240 acres. H. E. Wright.

The road at Fossil Bank descending from the basalt plateau exposes in the bank light-coloured yellowish fossiliferous clays and sandstone, evidently the strata which overlie the tasmanite seam.

The eastern boundary of the Mersey River schist is from ½-mile to ¾-mile west of the road, and the area between the road and the schist at Paramatta may be pretty safely regarded as a shale area.

It is very difficult, however, to judge how far the seam extends eastwards. All the Hobart properties are situate on the eastern extension of this ground, and judging from their position they ought to contain the extension of any shale existing west of Fossil Bank near the schist.

Proceeding eastwards from Paramatta, Kennedy's sections are the first traversed on the old Deloraine-road. No solid rock is seen, but there is a general lightness of soil, and the scattered pebbles on the surface are characteristic of shale areas. A suitable place for boring would be on the flat near Deep Creek.

Across the Creek bridge are Crisp's and Wright's sections. Crisp's first section comprises level country with open timber, extending to Deep Creek, which forms the section boundary. In the southern part of the section the soil is somewhat sandy, and the surface stones are absent, or at least not so profuse as nearer Paramatta. On the southern section the ground falls gradually to Deep Creek on the north-east. The surface consists of light clayey sand and ironstone. Tabular ironstone fragments are rather a feature. Patches of country with conglomerate stones occur.

H. E. Wright's 240 acres, on the west side of the road, are composed of the same Permo-Carboniferous country, strewn with stones of quartz schist, sandstone, &c. This continues into W. D. Winspear's 160 acres, where an unsuccessful bore-hole has been put down recently, indicating the beds as being low down in the system.

All these sections occupy a somewhat uncertain position. At Fossil Bank are beds belonging to a horizon above the tasmanite seam, and on Winspear's beds exist which are apparently lower. The sections in question are between these two occurrences, but exactly where the upper beds disappear can only be ascertained by boring. Rocks which can be classed decisively as the upper mudstones are not seen east of Fossil Bank, though some possess a certain resemblance. The uncertainty can only be cleared up by a systematic boring programme. East and west boring lines across J. A. Crisp's sections and across H. E. Wright's section would put the matter beyond doubt. The geological horizon of Section 5162-M (Hobart-Latrobe Shale Oil Association, No Liability) would also be settled by these bores. The surface appearance of this section is similar to that of the others.

(3) *The Native Plain Estate.*

This is the large estate on the east bank of the Mersey from near Native Plain bridge to Kimberley. It comprises the river-flat country opposite Merseylea and the timbered run of the Long Hill between the Mersey and the road from Latrobe to Deloraine.

Considerable interest attached to it recently in consequence of boring trials being instituted on it, with a view of ascertaining whether the tasmanite shale known to exist on the adjoining mineral property west of Native Plain (Hogg's) Bridge extends into this.

In the roadcutting descending to the bridge on the Railton side of the river some sandy, yellowish, fossiliferous beds, 6 or 7 feet thick, are exposed; and below them is bluish mudstone (also fossiliferous), pitching south-east at 5°. These are the Upper Marine mudstones, and below them without doubt is the tasmanite seam, which in all probability passes underneath the river into Hogg's farm, and ought, in the natural course of things, to continue into the Native Plain estate. Most likely it does so continue for a short distance, but on ascending the river as far as the south boundary of Section 4777-M it is apparent that a fault has intervened, bringing to surface the lower beds of the system. At this point, opposite the island in the river, horizontal strata are exposed in the cliff face about 80 feet above the river. These comprise Lower Permo-Carboniferous conglomerates below beds of mudstone. This fault has had the effect of raising the infra tasmanite beds to the surface all over Native Plain, and makes it hopeless to expect shale within that area.

The first bore-hole was put down on Lot 1311, about 15 chains east of the Mersey, on the old river flood-plain. Below 6 feet of loam, river shingle came in, consisting of stones of basalt, sandstone, diabase, quartzite, and the rocks generally of the surrounding hills. The shingle rests on mudstone.

A second bore was put down on Lot 451 near the Merseylea cage to a depth of 133 feet. The descending section of this was:—

	ft.
Loam	2
Sand	7
Alluvial	9½
Mudstone	51½
Sandstone, with layers of calcareous mudstone*	63
Total	133

*Fenestellidae in mudstone.

The bottom core was in grey, pebbly sandstone. Where no coal or shale seams exist it is sometimes difficult to distinguish between the Upper and Lower Marine beds. In this bore at 100 feet down strips of carbonaceous material were met with. The calcareous mudstone and pebbly sandstone strata are probably below the coal or shale horizon.

The flank of the Long Hill, ½-mile east of this borehole, is composed of fossiliferous sandstone and mudstone reposing on light-grey sandy conglomerate, with fossil shells. The probability here too is that the Lower Marine is present.

The Long Hill or its continuation extends north-west through the estate behind the homestead with diabase exposures on the crest at intervals. The body of the range is composed of light-grey argillaceous sandstone, gritty and pebbly claystone and sandy mudstone beds, none of which show any definite resemblance to the beds usually overlying the shale seam. Near the western boundary of Lot 1312 the ground is strewn with conglomerate pebbles, and has rather a favourable appearance for the occurrence of the beds usually found above shale. Owing, however, to the non-exposure of any solid rock the true horizon must remain uncertain.

A third bore has been put down on the Native Plain Estate at the western foot of the hill above alluded to, first passing through the heavy shingle characteristic of the surface of the plain, and then into mudstone, apparently belonging to the lower division of the system.

A fourth bore was drilled on the back run of the estate, and was carried down to a depth of 78 feet. It is situate on the 160-acre block, and is close to the old road from Paramatta to Deloraine. The section of the beds passed through is as follows:—

	ft.
Sandstone	38
Pebbly sandstone, with thin layers of conglomerate	17
Conglomerate	12
Mudstone and clayey sandstone	11
	78

The sandstone is fossiliferous, and frequently contains fragments or stones of schist. The schist strata are seen about ½-mile north of the bore, on the east side of the road between the two forks of Deep Creek, on Mark Aylett's 500 acres. These sink below the Permo-Carboniferous strata to the west, but evidently connect at a shallow depth with the schist on Hy. Kimberley's estate, near the Mersey.

It is very difficult to determine the horizon of these sedimentary beds in the system, but the few indications available point to the lower division.

It may be mentioned here that the prospects of the Hobart mineral leases further along the road to the west are not entirely governed by the result of this bore, as a tongue of schist appears to intervene between the two basins, and an age difference between them may prove to exist.

The pebbly sandstone of Winspear's back run and Aylett's ground continues in a south-easterly direction along the old Deloraine-road, fringing the diabase of the Long Hill, and dips below the upper measures near the junction with the main road.

The bores which have been put down on the property* have proved that the seam of tasmanite shale which had every appearance of entering the Native Plain ground below Hogg's Bridge has not done so, and have rendered further expenditure in this direction unnecessary. The existence of coal seams is likewise highly improbable, as there is reason to believe that the beds are below the coal measures horizon.

* By the Goldfields Diamond Drilling Co., under contract with Mr. Winspear.

(4) *The Rubicon Leases.*

These are 4875-M, 319 acres (L. E. Ditcham); 4842-M, 248 acres (F. Robinson; 4850-M, 301 acres (F. Robinson); 4851-M, 320 acres (F. Robinson).

They are situate east and west of the Sassafras-Deloraine-road, a little over a mile north of the old Junction, and nearly 3 miles south of the Stone House. Eastwards they extend to the Rubicon River, and westwards for about a mile along the old Deloraine-road towards Paramatta.

In the chapter on "Geology" the superficial covering of the country from No. 5 shaft eastwards towards the Rubicon has been considered as of Tertiary or Quaternary age. It forms a bed of soft white sandstone running into loose sand, and apparently filling the inequalities of the surface, for at No. 5 shaft west of the main-road it is 30 feet thick, while in bore-holes east of the road it descends only 10 to 14 feet below the soil.

The rock west of the road, as disclosed by some shafts which have been sunk by the syndicate, is undoubtedly the normal clay and mudstone belonging to the beds, which on the Mersey have been found to overlie the shale. Identical yellow, pebbly clay-beds, with grey or bluish mudstone, have been penetrated by the shafts.

A series of five shafts have been sunk west of the main-road on a north-west-south-east line to a depth of from 30 to 40 feet. When the property was visited the Government survey had not been effected, and owing to this the precise position of the shafts on the map has not been located. Operations were continued in wet weather, until it became apparent that the water was too strong to cope with, and hand-boring was resorted to. The pebbly nature of the ground made the work difficult, and then the boring operations were transferred to the sections east of the road. Here a couple of holes were put down, and work was continued till June this year, when the results obtainable by means of a hand auger were realised as unsatisfactory, and boring was suspended.

The five shafts which were sunk give the following information:—

No. 1 is the most north-westerly shaft, and has been sunk 34 feet in dark fossiliferous pebbly mudstone, which is decayed and lumpy, and has an appearance altogether unlike the usual laminated mudstone overlying the shale measures. Fragments of fossil marine shells and fenestella are numerous. Whether these beds are below or above the geological horizon of the shale is extremely difficult to say. They may perhaps be provisionally classed with the lower beds. This shaft is below the camp, 150 to 200 yards north-west of the latter, and on the fall to a head fork of Steep Creek.

No. 2 shaft is at the camp, and has been sunk 25 feet deep, first through 6 feet of soil, and then through the buff beds, until hard blue mudstone was struck in the wet bottom.

No. 3 shaft, south-east from camp, with water in bottom, was sunk 37 feet through 4 feet of buff pebbly clay and 33 feet of blue fossiliferous mudstone and buff conglomeratic clay. This mudstone splits into laminæ as it decays, after the habit of the Mersey rock above the shale.

No. 4 shaft, situate about 20 feet higher than No. 3, has been sunk about 40 feet, first in 10 or 15 feet of buff clay, and then 25 to 30 feet of the usual bluish mudstone. The bottom is under water.

No. 5 is the highest shaft, and on a level with and 3 chains west of the road, and has been sunk about 43 or 45 feet. It passed through 30 feet of the soft white sandstone and sand alluded to above, then through 8 feet of buff rock and into 2 feet of the bluish mudstone.

The ground tested by the shafts is identical with that which overlies the shale seam at the Mersey, and is the only indubitable exposure of these strata so far noticed between here and Paramatta.

On the other side of Winspear's fence, south of the old Deloraine or Fossil Bank-road, the rock is a sandstone conglomerate, exposed in the bank of the Deep Creek fork at about 10 chains south of the line of shafts. The strata there dip gently to the east. They appear to belong to the lower division of the Permo-Carboniferous system, and are similar to the beds bored into recently on the back run of the Native Plain estate, and to those on Aylett's 500 acres. They would therefore be below the shale horizon, and boring or sinking in them for shale or coal would be useless.

The dip of the shale-measure beds in the shafts is difficult of determination. The normal underlay of these strata generally is northerly or north-easterly, but in an old cut just north of the camp a westerly dip is shown. Some faulting of the strata on the flank of the Long Hill has taken place, and this complicates the matter.

On the whole, the aspect of the material thrown out from No. 1 shaft favours the idea that the strata there are below the shale horizon, and if so, the present shafts higher up the hill would not have to be sunk much deeper before reaching the seam, supposing that it exists here. It must not be assumed that because the characteristic country-rock of the shale measures occurs here the seam necessarily exists, but there is a fair probability of it doing so, and at any rate this is a proper area in which to prospect for it.

About ½-mile east of the main-road, on Sections 4850 and 4851 (F. Robinson), some bores have been put down with the auger. Bores Nos. 2 and 3 are close to one another, and No. 4 is ½-mile east or south-east from these. The bank east of the main-road is the divide between the Mersey and Rubicon drainage basins, and the ground east of this has a gentle fall to the Rubicon. The Parkham-road runs south-east through this ground, which carries open timber, and is sometimes a treeless plain. A light sand covers the surface.

In bore No. 3 this white and yellow sand continued down to 16 feet, and then gave place to a dark sandy clay, similar to the shale and coal measure mudstone, but with no indications sufficiently distinctive to admit of it being referred to one or the other. At 70 feet a harder rock was struck in the bore, and could not be penetrated.

No. 4 bore has been put down to upwards of 50 feet. At 10 feet from the surface it entered a dark-bluish clay or mudstone, with pebbles of schist, slate, and sandstone, and hard kernels of mudstone. At the bottom of the bore the rock seems to be growing harder.

From here eastwards to the Rubicon the superficial covering of the country consists of sand and clay, with no indication of the nature of the underlying beds.

These are probably of Permo-Carboniferous age, and the area is a suitable one for prospecting for shale. It is desirable to know more of the concealed strata than can be gleaned by surface inspection.

Hand-boring, however, can only give unsatisfactory results. The core drill is the only efficient instrument for obtaining the information desired. With this 50 or 60 feet can be bored per 24 hours at a moderate cost, and in addition to being expeditious positive results are obtained.

The Rubicon sections are a good distance from the known shale outcrops on the Mersey, but the indications, especially at the shafts, are favourable; and when the industry at Latrobe and Railton becomes established, prospecting here, which has been recently suspended for a time, will no doubt be resumed.

Crown Land South of A. Elphinstone's Freehold on the Rubicon.

This land is situate between the Latrobe-Deloraine-road and the River Rubicon. Nine hundred and sixty acres of it were applied for last year for shale prospecting purposes, but operations were not proceeded with. During the excitement caused by the initiation of work at Latrobe nearly all the available Crown land in the district was applied for, in many cases quite irrespective of the likelihood of shale being discovered on it.

The land applied for near the Elphinstone property was unsuitable for prospecting, consisting, as it does for the most part of diabase. Once fairly away from the main-road, the igneous rock comes in, and with the exception of a few sandy patches, continues to the Rubicon River, which is here ½-chain wide, and flows in a channel in the same rock. The diabase on the west side of the river forms a meridional range, continuing southwards as far as Crawley's 527 acres. The Crown land between Crawiey's and the road is fairly level sandy country, consisting, where solid, of soft clayey grey and yellow sandstone, probably low in the system. In the road bank north of the Launceston syndicate's shaft a change has occurred, for the usual shale-capping rock is exposed, and between here and the Rubicon the country may be regarded as suitable for shale prospecting.

(5) *Leases on the Brown Mountain and Badgers.*

These are leases held on the summit of the Brown Mountain and on its eastern flank, as well as at the foot of the eastern face of the mountain range of conglomerate known by the name of the Badgers.

In all, 3124 acres have been taken up, and in the following names:—R. P. Symmons, Sections 4859-M, 319 acres; 4860-M, 263 acres; and 4861-M, 313 acres—comprising the Badgers leases. R. P. Symmons, Sections 4858-M, 214 acres; 4871-M, 143 acres—at the southern end of Brown Mountain. R. P. Simmons, Sections 4824-M, 320 acres, and 4879-M, 148 acres, at the northern end of Brown Mountain, west of Caroline Creek. F. Robinson, Sections 4835-M, 316 acres; and 4836-M, 305 acres—on the eastern slope of Brown Mountain. L. E. Ditcham, Sections 4837-M, 290 acres, on Brown Mountain toward its northern end; and 4838-M, 296 acres, on its eastern slope. R. W. Stringer, Section 5055-M, 197 acres, on the summit of Brown Mountain.

It is understood that two companies—the Devonport and the Central Devonport Shale and Oil Companies (now amalgamated)—hold the interests in these properties.

No tasmanite shale has yet been found on any of the leases, and it is to be feared that some misapprehension exists with respect to the geological conditions. Doubtless it was considered likely that the shale seam was once continuous over the area between the Mersey Bend and the Nook, and that some survival of it would be discovered. The fact of an old Government reserve for dysodile having existed on this side of Brown Mountain probably contributed to the strengthening of hopes. Mr. Chas. Gould also, in his 1861 report, mentioned that dysodile (now tasmanite) had been found in waterworn fragments in a tributary of Caroline Creek, but the outcrop remained undiscovered. This statement would appear to support the expectation of finding the seam on the east side of Brown Mountain. It has, however, to be shown that it does not rest on a report of the same nature as the unverified rumours to the same effect which exist to-day. So many rumours are found, when pursued, to apply to a shale which is not tasmanite shale that caution is needed. Again, the tasmanite shale in the Nook-road valley has been known for a long time, and tracks across the mountain are ancient, and specimens may have found their way to the east side of the range by means of travellers.

If the view that the coal measures and shale measures—the one being fresh water, and the other marine—are mutually exclusive be correct, then a search for shale in this part of the field will be fruitless, for the coal measures and associated beds occupy the area at surface.

The Brown Mountain, a long diabase-crowned range, rising to 1400 feet above sea-level, is the dominant feature in this district. The crown or sill of igneous rock has an exposed thickness of about 400 feet, and at that distance below the crest junctions with Permo-Carboniferous beds. R. W. Stringer's Section 5055-M, 197 acres, is at the top of the mountain, and shows the igneous rock exclusively. Probably it has been taken up more for the purpose of securing a connection with the Nook properties than anything else.

At 600 or 700 feet below the summit the Central Devonport Company arranged with the Goldfields Diamond-drilling Company to put down a bore on Section 4835-M. A bore bringing up a $1\frac{7}{8}$-inch core was put down to a depth of 447 feet in dark, sandy, micaceous mud shales, sometimes pronouncedly calcareous, and carrying veins of calcite. The cores showed fossil remains of fenestella. Water was taken for the drill from a little creek near by and saved by being returned to it, but this source failed as the season advanced, and finally boring had to be discontinued.

About 80 feet above the drill-hole, and to the west of it, a small shaft has been sunk 45 feet in a white and yellow clayey sandstone, somewhat resembling the buff rock overlying the shale. This overlies the mud shale in which the drill went down. Fifty feet further south a bore was started in diabase.

The evidence furnished by the organic remains in the core is insufficient to show whether this fringing belt of country belongs to the Upper or Lower Marine. From its high position it might be thought that the geological horizon is high, but against this we have the absence of coal in the bore, and the presence of the Silurian limestone floor a little lower down the hill. In any case, the discovery of tasmanite is unlikely.

The western part of Sections 4858-M, 4861-M, and 4860-M (R. P. Symmons), consists of yellow slates, pebbly sandstone, and quartzite, which fringe the eastern base of the Badgers; but north of Black Creek these are succeeded by Permo-Carboniferous strata, which further east contain seams of coal. On 4860-M, 263 acres, a small cut in the laminated yellow sandstone and slate has exposed a narrow vein of vitreous-looking quartz, with some specular iron ore. This is east of Cooper's Gorge. The strata have a strike here of 295°, and dip steeply to the north. The northern part of the section is in coal-measure country.

From prospecting and mining operations it is evident that the coal-bearing strata extend eastwards as far as Caroline Creek. Consequently the likelihood of tasmanite shale being found between Brown Mountain and the railway-line must be considered as remote.

(6) *The Nook-road Properties.*

Tasmanite shale has been long known to exist in the upper end of the valley of the road from South Spreyton to the Nook. This is a long narrow valley between the Brown Mt. on the east and the hills fringing the Don River on the west. The strata forming the floor and sides of the vale are sandstones and pebbly clays belonging to the coal measures and Lower Permo-Carboniferous. The mudstones and sandy beds bear some resemblance to those of the shale measures. This is especially the case at the site of Mr. Bott's new sawmill, a little north of the branch road to Barrington. A well has been sunk here in yellow and bluish mudstone, apparently, however, non-fossiliferous. A rumour exists as to the discovery of shale on McGuinness' farm, further south, but whether this was tasmanite is very doubtful. The coal measure beds continue south as far as Ray's Sawmill Creek, where the mudstones abut against pebbly mudstones of a different series, enclosing the seam of tasmanite shale.

This seam underlies the farm lands occupied by Mr. Keep and Mr. Ray in the valley betwen hill ranges on both sides. Mr. Ray's farm is Lot 10,237, 102 acres, charted in the name of Alexander Bryan; and Mr. Keep's land adjoins it on the north. The Devonport Shale and Oil Company has been formed to exploit the seam on the former property, besides holding various leases under "The Mining Act." The Lewis Syndicate, of Devonport, is interested in the deposit on Keep's farm.

The shale is continuous from one property into the other, and its description in one property will apply to the other.

(*a*) *Keep's Freehold.*

Close to the southern boundary fence an open excavation has exposed a seam of fairly good-quality tasmanite shale. The full thickness of the seam has apparently not been established, but a total of 3 to 4 feet has been passed through, including clay parting. The latter appears to feather out and make into a continuous seam, which passes into the rising ground to the north under 7 feet of overburden. The whole occurrence has not been too well exposed in the workings. Samples taken from the seam were assayed in the Government Laboratories with the following result:—

Fixed Carbon	Volatile Matter.	Ash.	Moisture.	Gals. Oil per ton.
2·5	31·3	65·6	0·6	41·7

The underlay of the seam is that of the mudstones in which it lies, viz., 5° to the north-east.

A few chains west a pit has been sunk in the overlying rock, but not deep enough to reach the shale. This farm requires to be bored before the full area of the seam can be stated. The latter probably exists below the overlying mudstone as far north as the Sawmill Creek. Near Keep's gate fossiliferous bluish mudstone is seen in his creek, such as usually overlies the seam, and the overlying rock occurs also on the west side of the road opposite the gate.

The north-easterly dip of the mudstone which overlies the shale and of the mudstone conglomerate which underlies it is noticeable in the eastern creek on Keep's property. This dip is contrary to that of the coal-measure shales and sandstones on the flank of Brown Mountain, a little higher up towards the east, where they underlie west. The faulted junction of the two series of beds must exist on the slope a little above the creek.

On the west side, outside the boundary fence of the farm, a narrow strip of coal-measure sandstone also exists. The shale measures here seem to occupy a trough, and to owe their present position to trough or block faulting.

The working of the seam should not be difficult, as it will be possible to start somewhere in the north-eastern portion of the property and work to the rise. The width of the shale belt is, however, in all probability not greater than 20 or 25 chains at the outside, and the property should be worked conjointly with the adjoining deposit on Ray's farm.

(b) Ray's Freehold.

Keep's seam has been cut by Mr. H. J. Ray on the south side of the dividing fence; and in the creek has been exposed by several cuts and pits, showing a thickness varying from 4 to perhaps 6 feet. It appears in the creek bottom in the form of large flat shelves, still, however, gently dipping to the north-east. Isolated pebbles occur in the shale, and in the lower part of the seam are casts of marine shells (Aviculopecten, Platyschisma, &c.). The upper part of the seam is understood to yield the highest quantity of oil, while the bottom also is soft and good. The middle portion, as usual, is the poorer. A couple of tons of the shale was sent to Latrobe and passed through the experimental retort of the Tasmanian Shale and Oil Company, yielding 50 gallons oil per ton. Samples assayed by Mr. W. F. Ward, the Government Analyst, yielded the following results:—

Fixed Carbon.	Volatile Matter.	Ash.	Moisture	Calculated Gals. Oil per ton.
3·0	37·70	58·6	0·7	50·3

As will be seen, the shale is of very good quality. It is light, tough, and leathery, and has all the physical properties of a first-class shale.

The shale-measure mudstones continue east of the creek up the hill into C. W. Roberts' 150 acres, but how far the seam extends in that direction has not been ascertained.

Its occurrence up the hill to the west shows that it extends below the farm land towards the road, and is probably brought up near the surface by faulting.

South of Ray's land, on W. Atwell's land, are older strata belonging to the Badgers conglomerate and sandstone series. These comprise purple, pebbly sandstone and grey and brown sandstone, striking north and south with a westerly dip. Prolonged to the south they pass below the basalt on W. Campbell's land immediately west of the coarse conglomerate beds on the Badgers.

Estimated Quantity of Shale in the Nook-road Valley.

The seam appears to be confined to the two properties described above. There is every reason to suppose that it will be found to extend over 130 to 140 acres, which, on the basis of a 4 to 5-feet calculation, would give 800,000 to 1,000,000 tons of shale. The geological boundaries of the area are such as forbid hope of any increased extent of the seam being discovered here.

The connection of the deposits of tasmanite in this valley with those in the Mersey basin is difficult to trace. There was no intervening Brown Mt. at the time they were laid down, and the coal measures which now flank that mountain on each side were then no doubt continuous. It is, however, doubtful whether a similar continuity existed with respect to the tasmanite seam. The probability is that this was confined to the littoral fringing the older schists and conglomerates.

A good road exists between this valley and Tarleton and Spreyton railway-stations, or to the town of Devonport.

If retorts were erected here the outcrops of coal adjoining the shale deposits, and referred to elsewhere in this Bulletin, would prove a highly advantageous factor in the manufacture of oil.

(*c*) *Lease* 4868-M, 31 *acres* (*A. P. Manton*).

The likelihood of work being started on the Nook Valley shale has caused sections to be taken up in the vicinity from considerations of position. This is one of such.

The strata consist of white friable conglomerate or pebbly sandstone rising into a high hill range bordered on the east by the basaltic farm land at the head of the Nook

Valley, and on the west by the River Don, which here flows in a deep gorge. The rock disintegrates into clean white sand and gravel, which accumulate on the hill flank. These strata form a parallel north and south belt west of the Badgers. The succession in ascending order seeems to be—

3. White conglomerate on Barren Hill.
2. Brown and purple pebbly sandstone and slate on Atwell's and Ray's.
1. Coarse conglomerate on the Badgers.

The sandstone is nearly vertical, with a slight westerly dip. The dip of the conglomerates cannot be ascertained. Whether these are all members of one geological system or not must remain for the present undetermined.

(*d*) *Lease* 4880-M, 185 *acres* (*R. P. Symmons*).

This adjoins A. P. Manton's lease on the north, and is another section which has apparently been taken up on the possibility of the shale in the valley extending into the hill. Permo-Carboniferous beds exist in the eastern part of the lease. These, however, belong to the coal measures and to the lower division of the system; except, perhaps, at the northern corner, where the shale-measure mudstones enter from Keep's, south of Ray's Creek. The lower part of Barren Mountain here consists of yellow pebbly grit (pebbles of schist and quartz), apparently belonging to the Lower Permo-Carboniferous.

The section lies west of the shale body on Keep's and Ray's farms. The Barren Hill extends into it from Manton's lease. If any shale exists at all on the section, its area can only be trifling.

(7) The Minnow Shale Field.

This shale field is situated about 7 miles south of the railway-line at Railton, and 5 miles west of Dunorlan station. It occupies the divide between the Minnow and Mersey Rivers. A good road connects it with Kimberley (9 or 10 miles) and with Dunorlan, passing to the latter over Dynan's bridge across the Mersey.

The shale area is about 500 feet above sea-level, and comprises the land west of the road, extending southwards to the northern boundary of the Parish of Loxbere, and northwards to a little distance within the Mersey and Deloraine Tramway Company's grant. Roughly, the measures cover an area of a mile square, and, as at Latrobe and Railton, are associated at their margins with conglomerate and sandstone (and also porphyrites) of Cambrian and Cambro-Ordovician age.

About a chain west from the main-road, on a 97-acre block in the name of Gregory, some loose fragments of shale occur in and on the surface soil. One large slab lies in the bracken, and has evidently come down a very short distance on the slope of the low hill to the north. Another piece occurs below a foot of soil, and lies immediately on the buff capping rock which usually covers the seams of shale. This fragment was plainly broken from the seam a long time ago. The time interval which has elapsed has been sufficient to admit of the formation of deep soil, and consequently it is quite possible that the solid seam no longer outcrops anywhere. A good burn-off, however, to remove the luxuriant fern growth, would facilitate search considerably. A possible method of search is by no means of holes on the low hill mentioned, but on the slope and summit the overlying rock may be thicker than at the base, and probably the best way to prospect would be to sink near where the fragments are found and find the seam before trying higher up.

The seam when found will probably show a dip in a northerly or north-easterly direction. It has most likely been denuded from the flat land to the west, and the hill across the paddock in that direction does not afford much area for it, even if the shale horizon is continued so far. Any prospecting in the paddock will be geologically below it.

The rising ground north and west indicates the direction for extensive prospecting. It continues for $\frac{3}{4}$-mile north to the boundary-fence of the Mersey and Deloraine Tramway Company, rising gently to 120 feet above the road.

Beyond Gregory's fence the Crown land is timbered with bastard stringy-bark and peppermint. Buff sand composes the soil, which is strewn with stones of the nature usually found in shale areas. Some of these are doubtless the result of the disintegration of an overlying bed of Permo-Carboniferous conglomerate; others have been shed directly from the adjoining conglomerate of more ancient date. These loose pebbles lying on the surface are characteristic of tasmanite shale areas, and cannot be wholly traced to the wasting away of existing beds. The only way of accounting for their presence is by assuming the former existence of a bed of conglomerate over the present capping mudstone. They are, however, not absolutely trustworthy indicators of underlying shale, as although they are generally noticeable where shale exists, they are also met with in the shale measures where the seam has not been developed.

No outcrops of the Upper Permo-Carboniferous are seen on this piece of land. Pieces of yellowish sandstone are exposed in the roots of some of the fallen trees, but these are not numerous enough to admit of positive identification with the typical shale capping-rock so familiar in the other shale districts. However, judging from position, there is reason to suppose that the surface beds are those which normally overlie the shale seam.

These strata continue eastwards along the Mersey and Deloraine Tramway Company's fence, and into Fowler's land, where some of the usual bluish mudstone has been exposed by an uprooted tree. Descending to the main-road from here, the ancient sandstone is exposed as the underlying rock in the road drain on the 13-acre block, but following the road eastwards towards the Mersey the buff-coloured capping-rock continues. Somewhere north of the road, however, the older rock must outcrop, for the soil has a more ferruginous aspect, and occasional boulders of hard crystalline sandstone and dark quartzite are seen in the soil. A. G. Fowler's paddock, too, shows good grass feed, as if a change of bed-rock had occurred. Nevertheless, the yellow capping-rock continues, till at about 80 feet above the Mersey, it disappears below the alluvial of the former bed of the river.

The Mersey here is 2 chains wide, and is crossed by a substantial bridge, which was built a few years ago. This is known as Dynan's Bridge. The old ford is 10 or 11 chains higher up the stream. At this time of the year (March) the water at the bridge is low, not exceeding 5 or 6 feet in depth. Dynan's farm is on the flood-plain, on the east bank of the river.

East of the bridge, on Kelly's land, there is an exposure of pink crystalline sandstone or quartzite, striking north-east, and dipping to the north-west at an angle of 20°. From its appearance the rock belongs to the conglomerate system west of the Minnow River. On this side of the Mersey no shale measures are met with, but on the road up the hill towards Dunorlan, at about 60 feet above the river, yellow fenestella sandstone shows in the drain. This probably belongs to the Lower Permo-Carboniferous, and no tasmanite shale need be sought in or below it. Signs of the old bed of the Mersey are seen up to 120 or 130 feet above the present river, when the basaltic lava sheet covers the farm land of the plateau, which is here 200 or 300 feet above river-level. At the corner of the South-road are some large boulders of diabase (one 3 feet by 3 feet by 2 feet), lying in the soil, betokening the close proximity of this intrusive rock.

The position of the lower beds of the Permo-Carboniferous on the east side of the Mersey relatively to that of the Upper Marines on the west side appears to indicate the presence here of a line of faulting.

On the west side of the Mersey the shale measures continue north of the fence between the Crown land and the Mersey and Deloraine Tramway Company's grant for a short distance, but contract and terminate in that direction against a barrier of the ancient pink crystalline sandstone, and further north are cut off by the intrusive diabase.

The same sandstone forms the boundary of the shale measures on the west. It occurs as a belt of country about ½-mile in width, in which the deep gorge of the Minnow River has been excavated, and rises to form part of the hill on the west side of the Minnow. It varies in character from a crystalline sandstone to a characteristically pink quartzite like that prevailing in so many of the quartzite bands in the West Coast conglomerate. Conglomerate of this nature forms the crest of the hill ridge. The stones in the conglomerate consist for the most part of pink quartzite, and are from 2 to 6 inches in diameter. No orientation of the constituents of the conglomerate is observable, and hence the dip cannot be determined. From analogy, however, the conglomerate must be regarded, not as a horizontal layer, but as the backbone of the ridge. From the summit Mt. Roland is visible to the west and Gog Mountain to the south, both presenting stupendous scarp faces of similar conglomerate.

Between the Minnow quartzite and the crest of the hill red porphyrite soil is seen, indicating the existence of a band of that rock between the quartzite and conglomerate. This is another of the associations which are common on the West Coast, and its interpretation will have to take its part in the solution of the problem of the age of the West Coast conglomerate.

The porphyrite or felspar-porphyry rock bounds the shale area on the south in the 50-acre section before reaching the northern boundary of W. Hart's 688 acres. In the fern-covered paddock on the top of Hart's Hill loose stones of red and yellow schistose porphyrite are frequent, and owing to their brown colour on weathered surfaces and the readiness with which they split have been mistaken locally for tasmanite shale. The fancied similarity could, however, mislead only such as are very imperfectly acquainted with tasmanite. This paddock, surrounded by stringy-bark timber, was doubtless selected owing to the porphyry soil, and would not have been cultivated if the ground had consisted of the poorer Permo-Carboniferous beds.

Hart's Hill falls away southwards about 400 feet down to Rabbit Valley, a little grassy bottom 4 or 5 chains wide. The strike of the porphyrite is here seen to be north-west. The south boundary of Hart's is across the creek and a little way up the peppermint-wooded hill between here and Gog Mountain, still on porphyrite soil. Further south the ridge is said to be composed of sandstone. Porphyrites and slate continue westwards to the old silver and barite mine on the southern boundary of T. Jessop's land.

All this piece of country is evidently outside the Permo-Carboniferous area, and the search for shale, which was begun in it, need not be continued. It is, however, a likely area for mineral veins.

The shale area may be regarded as not greatly exceeding 1 square mile, and may be expected to yield 1500 tons of tasmanite shale per foot of seam thickness, after making the necessary allowance for loss in working, &c.

The quality of the shale appears to correspond with that of the tasmanite of Latrobe and Railton.

Efforts doubtless will be made to locate the shale *in sitû*, and to prove its extent within the area indicated by this geological reconnaissance. The absence of streams on the ground (apart from the Minnow) is a drawback to boring operations.

If the seam is found to extend all over the area which here appears to be geologically on the shale horizon, it will probably contain over 3,000,000 tons of shale, of which a good proportion will be within the properties which are now being taken up for exploration. This quantity will be sufficient to warrant the establishment of works for treatment. The outlet for the production will be Kimberley (11 miles). This is a little further than Dunorlan, but it is all down hill, once Hart's hill has been negotiated.

VII.—ESTIMATE OF QUANTITIES OF SHALE IN THE AREA EXAMINED.

The methods used for calculating the contents of coal seams may be applied, but as the specific gravity of the tasmanite material differs from that of coal, the empirical rules frequently used for calculating coal quantities cannot be employed.

The specific gravity of tasmanite itself is 1·2, but that of the ordinary 40 to 50-gallon quality shale is about 1·6

Therefore, to find the solid content per foot of seam per acre, make the following calculation:—

$$1 \text{ acre} = 43{,}560 \text{ square feet} \times 1{\cdot}6 \times 62{\cdot}35^{*} = 4{,}345{,}545 \text{ lb.} = 2172{\cdot}7 \text{ metric tons.}$$

It is usual in practice to deduct one-quarter or one-third for loss in working, and for faults, pinches, &c. If a quarter is allowed for this, the quantity available would be 1629 tons per acre for each foot of seam, or if a third is deducted, the net tonnage would be 1448 tons per acre.

For purposes of calculation, in the present case 1500 tons per acre may be adopted as the probable tonnage per foot of seam.

The seam of shale throughout the districts examined is slightly inclined, but the inclination is not sufficient to necessitate it being taken into account in the calculations.

It is hardly possible until more underground work has been done to say what the workable size of the seam will prove to be. Where a 7-feet seam is shown at the outcrops, it is almost certain that the thickness will diminish when the shale is followed underground. Five feet will probably be the maximum thickness of shale of standard quality on some of the properties, and for estimating ton-

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* 62·35 lbs = the weight of a cubic foot of pure water at the standard temperature of 62°F.

Redmayne (Modern Practice in Mining, Vol. 1, p. 73) gives the following formula for computing the coal in inclined beds—

Let A = the map area.

B = Sec. θ, where θ is the angle dip of the bed.

C = Thickness of bed in feet.

D = The percentage of mineral obtainable

E = The number of cubic feet in one ton of the mineral.

Q = The quantity in tons.

$$\text{Then } Q = \frac{A \times B \times C \times D}{E}$$

nages it would be safer to take 4 feet as an average size all through.

In the first glow of excitement nearly 17,000 acres of Crown land were applied for, and numerous purchases of, and options over, private properties negotiated. During the present departmental examination it became apparent that the shale seam is of far less extent than was imagined. Its outcrops are now for the first time definitely charted, and it is possible to furnish a rough idea of the quantity of shale possibly existing in the fields under review.

Using the method of calculations explained above, the possible total tonnage may be estimated as follows:—

	acres.	tons.
Tasmanian Shale and Oil Co.'s leases..........	400	2,400,000
James' Freehold (now Adelaide block)	150	900,000
Latrobe Shale and Oil Co.'s leases	670	4,000,000
Bennett's Creek and Oliver's farm	50	300,000
Total in Mersey District...	1270	7,600,000
At Nook Road..	140	800,000
At the Minnow (possibly)........................	600	3,600,000
Total	2010	12,000,000

The individual estimates must be regarded as of varying value, according to the amount of prospecting carried out on the respective properties. Thus the boring programme carried out on the Latrobe Shale and Oil Company's leases will enable the owners to form a more useful idea of the extent of the seam on that property than could be arrived at with respect to, say, the Minnow field, which is absolutely unprospected. As far as regards the latter field the estimate must for that reason be looked upon as expressing possibilities only.

Apart from these considerations, the figures represent the writer's attempt to show in a general way the probable capabilities of the districts examined in respect of the existence of tasmanite shale.

Future discoveries may possibly be made on the Rubicon fall and in the eastern part of Latrobe township, as well as immediately south of it, but the productive area known at present cannot be estimated as greatly exceeding 2000 acres in the aggregate.

VIII.—COST OF PRODUCTION AND VALUE OF PRODUCTS.

Widely differing views have been expressed as to these, and in the minds of the general public considerable uncertainty exists as to the working margin between profit and loss. Naturally only a hazy idea is prevalent of the actual value of a ton of shale. At the outset it may be taken for granted that mining speculation is largely absent from this enterprise, and that calculations must run on industrial lines.

For a long time the oil shale industry in Scotland was carried on with intermittent success, but the introduction successively of improvements in the processes of distillation and manufacture, and the increasing utilisation of the various by-products, have put it more firmly on its feet. The seams vary from 2½ feet to 16 feet in thickness, and the deepest workings are 1200 feet from the surface.* The yield rarely exceeds 30 gallons crude oil per ton, and shales even as poor as 10 to 15 gallons per ton are worked, owing to the increased yield of ammonia in the poorer seams.†

The producing costs in Scotland are not quite comparable with those which should rule in Tasmania, for the Scottish products pass through costly refineries,‡ turning out naphtha, lamp oils, intermediate oils, lubricating oils, paraffin, &c., while the Tasmanian practice is intended not to go further than the first distillation and rectifying the spirit obtained during that process.

However, it may be of interest in a general way to learn the normal unit costs and profits of the industry in Scotland. Dr. Ells, in the Canadian Geological Survey bulletin referred to above, says (p. 57): "At the present time (1909) the average cost of mining and manufacturing products from 1 ton of shale in Scotland may be given as 8s. 3d.; and the net profit on the products of a ton of shale may be given as 3s. 4d."

Sir B. Redwood, in his "Treatise on Petroleum" (1906), says with reference to mining or winning oil shale:

* Petroleum, by Sir B. Redwood, London, 1906, Vol. 1. p. 429.

† The Bituminous or Oil Shales of New Brunswick and Nova Scotia, by R. W. Ells. Geo. Sur., Canada. Ottawa, 1909, p. 50.

‡ *Ibid.*, p. 54 "The cost of a refining plant is £11,000 per million gallons of crude oil run, and a refinery to deal with ten million gallons of oil per year would cost, approximately, £200,000, everything included."

"The cost of production varies between 4s. and 6s. per ton delivered at the works." (Vol. 1, p. 429.)

In a report by Mr. A. de Bavay to the Latrobe Shale and Oil Company, No Liability, the Pumpherston Oil Company in Scotland, is credited with a statement to the effect that the cost of mining and breaking shale there exceeds 4s. 4d. per ton.

As regards the Mersey, until the mining and retorting operations are in full swing, the costs must necessarily remain a little uncertain. At the beginning, when it was thought that the outcrops could be benched and everything mined by open-cut, a very low mining cost was assumed; but it soon became apparent that ordinary underground mining would have to be resorted to, and that owing to the toughness of the shale the cost per ton would probably be a little more than that of coal-getting. A reasonable estimate is that it will be found possible to deliver the shale to the retorts from the mines at about 6s. per ton.

Retorting costs in Scotland per ton of crude oil are quoted as 1s. 2d. by the Pumpherston Oil Company in the report above alluded to. Mr. W. J. Hall, general manager of the Tasmanian Shale and Oil Company, estimates the cost of retorting a ton of the Mersey shale at 1s. 6d. He does not state whether in this is included the cost of preparation of the light products (outside fuel oil) which it is intended to place upon the market. Perhaps in calculations it may be safer to double this, so as to allow for additional cost in this respect and for increased cost of labour and other materials in Tasmania. The cost per ton of shale would then be—

	s.
Mining and delivering to retorts	6
Retorting	3

The laboratory assays of numerous samples of the Mersey shale have yielded figures varying from 29 to 50 gallons oil per ton. Dr. Black reported results from various outcrops as from 44 to 65 gallons of crude oil per ton. Experiments made with average-quality shale showed that from 35 to 36 gallons per ton of various refined oils could be obtained by retorting and subsequent distillation processes.

Some bulk samples from the Latrobe Shale and Oil Company's seam sent to the Pumpherston Oil Company for test purposes, with a view of producing crude and refined oils, gave results which showed the upper and lower parts of the seam contained 54·92 gallons and 27·34 gallons of crude oil per ton. Neglecting a poorer band (9·92 gallons quality), which appears to exist in all the Mersey outcrops, the average of the remainder was 41 gallons per ton. Mr. Hall has adopted 40 gallons per ton as a working basis for the shale at the Mersey Bend, and his valuation of the products obtainable is as follows:—

Produce of 6 tons of Shale.		s. d.	£ s. d.
11% Motor spirit, viz.......	27 gallons @	1 0	1 7 0
10% Turpentine substitute	24 gallons @	1 6	1 16 0
9% Engine oil	22 gallons @	0 6	0 11 0
Residual (fuel) oil	167 gallons @	0 4	2 15 8
1 ton oil =	240 gallons		6 9 8
Less packages on fuel oil			1 10 0
Value of 6 tons =			£4 19 8

or 16s. 7d. per ton of shale.

The market price of the fuel oil is variable. At the present time it is about 3½d. per gallon, or £3 8s. to £3 10s. at shipping port, which might be equal to £3 at the Mersey works. This would reduce the above estimate by 13s. 11d., or to 14s. 2d. per ton of shale.

The gross profit thus appears at about 5s. per ton of shale. It will be seen that a great deal depends upon the accessory products, which help to swell the total value to something considerably over that of the mere crude oil. Mr. Hall's figures are reproduced here without endorsement, as in estimates of this kind a great deal depends upon the quality of the product obtained.

As a matter of fact, motor spirit can be sold at Latrobe for 1s. 5d. per gallon, and the price of ordinary turpentine is 4s. to 4s. 6d. per gallon. The spent shale is saleable at 4s. or 5s. per ton, which provides an unexpected margin for the above calculations.

Eventually the oil will be conveyed to the port by pipeline, and economy in transport will be effected when working on a sufficiently large scale. Naturally for a company operating nearer Railton the transport costs will be higher than for oil despatched from the present works site near Latrobe. If the latter be adopted as a central site for works for the district (and this may have to be done if operations on a large scale are contemplated), tramway communication will be a necessity.

According to Dr. Ellis* the cost in Scotland of erecting retorts (without a complete crude oil plant) which will treat daily 4 tons each of shale is about £260 each. The Henderson retorts are quoted as costing from £60 to £70 per ton of shale put through daily; and a Pumpherston retort £350 (including condenser, ammonia scrubber, and receiving tanks). The practice in Scotland is so different from the requirements at Latrobe that these figures cannot be used for the industry in Tasmania. The Tasmanian Shale and Oil Company must by this time have a fair idea of what the necessary plant may be expected to cost here. This company has fire-clays for brick-making on its leases, as well as firewood and mine timber. The ground overlooking the Mersey, on Section 4164, has a slope which admits of the fullest use of gravitation in the processes of manufacture, and it is within easy distance of Latrobe. Retorts, too, could be erected on the Latrobe Shale and Oil Company's property near Railton, and the outlet for the product would be *via* Railton.

Spent Shale.

The spent shale from the retorts seems capable of being made a source of revenue, as farmers who have used it in the neighbourhood on their land speak well of it as a manure, and are ready purchasers. It is being sold at Latrobe as "Shale Residue Compound," on the following analysis by the Government Analyst:—

	%
Carbon	10·10
Volatile matter	1·10
Potash	0·51
Phosphoric Acid	0·19
Nitrogen	0·17
Insoluble in Acid	81·60

The analysis does not disclose a large proportion of fertilising elements, but the physical constitution of the material is apparently such as to make it suitable for breaking up the soil, and benefiting the land in that way. It is also probably capable of being used as a manurial base, with which other ingredients could be advantageously blended. By leaving a certain proportion of oil in it, it might be utilised as an insecticide and deodoriser. The first thing that strikes one on examination of this analysis is that there appears to be very little direct plant food in the substance. The amounts of nitrogen,

* *Ibid.*, pp. 26-27.

potash, and phosphoric acid are small, the insoluble contents are high, and the remainder is inert carbon. On the other hand, the reports of its use by cultivators are extremely satisfactory, so much so that the analytical results have been somewhat despised locally. The reported benefit derived from the use of the shale residue may probably be attributed largely to its mechanical effect in lightening the soil, and thus increasing the productiveness of the latter. Thus, the value of the material is something beyond its direct value as a plant food. This breaking-up of imperfectly aerated, heavy soil, such as is common in the farm lands of the North-West Coast, assists plant growth and facilitates the absorption of nutriment. It appears certain that the process of nitrification in which, by the action of bacteria, atmospheric nitrogen is transformed into organic nitrogen and finally made available for assimilation by plants, is promoted by increasing the porosity or permeability of the soil, thus admitting the air; and in this way a disintegrating material like the shale residue probably has an otherwise unsuspected value. At any rate there is a strong local demand for it, and it can perhaps be still further turned to account by utilising it as a base for blending with it additional ingredients.

In Scotland the spent shale, which represents 80 to 85 per cent. of the raw shale retorted, is sent to the dumps as of no value, though some use has been made of it for brick-making, &c. The Scottish spent shale contains 2·5 per cent. of fixed carbon, and is essentially an aluminium silicate.*

* Report on the Oil Shale Industry of Scotland, by R. W. Ells. Geol. Survey of Canada. Ottawa, 1909, p. 44.

IX.—THE MERSEY COAL MEASURES.

These measures consist of the fresh-water and terrestrial beds containing what is known as the Mersey seam of coal. They occupy a great extent of country between the Mersey and Don Rivers, surrounding or fringing the diabase-topped Brown Mountain, Kelcie's Tier, &c., and extend as far north as Spreyton and as far south as Dulverton.

According to Mr. Jas. Fenton* coal was discovered between the Don and Mersey Rivers in March, 1850. A company was formed to work it. A large amount of money was expended on the enterprise, but eventually the works filled with water and were abandoned.

In 1861 Mr. C. Gould† reported that at that time the Alfred and the Don Collieries‡ were the only works in operation, the Denison and Sherwood Mines, together with those of the Mersey Coal Company, having been abandoned.

At the Sherwood Colliery the 2-feet seam of coal was struck in the shaft at 60 feet. A bore about 6 chains south of it showed that two thin seams—one a foot thick and the other only 6 inches—overlie the main seam.

The Denison Colliery was close to the southern corner of the Tarleton township, and its operations were restricted to small areas of seam between faults, which seem to have thrown down the higher marine beds, cutting off the coal.

The Alfred Colliery's seam, a mile east of Tarleton, was also limited by faults. In boring at this colliery a 1 ft. 6 in. seam of coal was struck at a depth of 80 ft. 6 in. from surface. An attempt was made to find another seam below this, and the ground was bored to an additional depth of 250 feet, ending in grey sandstone, without intersecting any coal. This bore appears to have been put down in 1858.

The Mersey Coal Company carried on operations in the old days both in the vicinity of the River Don,§ and on a 100-acre section half a mile west of Latrobe. In the tunnel on the latter section the bed of shale, containing

* A History of Tasmania, by Jas. Fenton. Hobart, 1884, p. 259.

† Mersey Coal Field, by C. Gould, 29th October, 1861. House of Assembly Paper No. 135.

‡ The Don Colliery was situate within the north-eastern boundary of lot 328,500 acres. W. B. Dean.

§ On lot 438, 500 acres, J. W. Gleadow and R. W. Nutt.

impressions of Glossopteris, occurred immediately overlying the coal. The same relations existed in the shaft of the Alfred Colliery, near Sherwood.

A seam of coal has been recently worked by Mr. Crocker west of Caroline Creek, at the foot of the Brown Mountain.

Allison's (Spreyton) coal mine, in the southern part of the township of Tarleton, is being regularly worked at the present time. The coal is won from shallow adit workings from a seam averaging 19 inches in thickness and much broken by faults.

The assay of Allison's coal by the Government Analyst (Mr. W. F. Ward) resulted as follows:—

Fixed Carbon.	Gas, &c.	Ash.	Moisture.
36·5	46·6	4	12·9

The coal finds a ready sale at Latrobe and in the neighbourhood, but the output is limited—from 1500 to 2000 tons yearly. It emits a good heat, and burns well on an open hearth. For domestic use the pyrite which it contains is a disadvantage. Otherwise, for steam and forge purposes, it is a coal of considerable value.

The Illamatha Coal Mine, at Spreyton, is being worked on a small scale.

Further south-west of Dulverton are some coal mines which are at present idle. These are the Dulverton and Teasdale's collieries. The seam in that district has been worked intermittently for many years, but its small size and the faulted nature of the ground make profitable working difficult. Coal deposits also occur in the Nookroad Valley, at about 400 and 500 feet above sea-level. On A. Bryan's 45 acres (now Conley) a seam of good, bright coal was found in the creek by Mr. J. Sloane some years ago. This is at about the same level as the tasmanite shale seam on the adjoining farms of Messrs. Keep and Ray.

On the eastern side of the valley, on the part of J. Bott's 83 acres occupied by M. Sloane, a coal seam has been exposed on the flank of the hill, dipping westerly down towards the tasmanite basin. This seam seems to be about 20 inches thick, and lies below dark shaly beds containing fragments of leaves belonging to members of the Glossopteris flora. Tasmanite shale was believed to exist here in immediate contact with the coal seam, but a misconception has arisen, due to the presence of resinous looking particles in the coal. A fault exists between the coal and shale measures, the dips of which are in opposite directions.

The existence of coal in this valley will prove highly advantageous should it be decided to retort the tasmanite shale on the spot.

Although the coal throughout the Mersey and Don district is found at varying levels, there are no grounds for believing that more than one main seam is represented. Many fruitless efforts have been made to discover a lower seam by boring and sinking. The difference of level between the lowest occurrence and the highest outcrop (nearly 500 feet) is an expression of the displacement which has taken place subsequent to the formation of the seam.

The quality of the coal in the Mersey seam may be learned from the following analyses made by Mr. W. F. Ward, Government Analyst. The first four are of standard samples taken by the Inspector of Mines for the district, and are representative of the seam worked. The last two are of such samples as could be obtained during the present examination, the seam being only partially exposed :—

Mine.	Fixed Carbon.	Volatile Matter.	Ash.	Moisture.	Sulphur.
	%	%	%	%	%
Allison's	36·5	46·6	4·0	12·9	...
Illamatha	36·6	41·2	9·8	12·4	...
Dulverton	40·5	44·4	5·8	9·3	...
Brightburn......	41·7	48·0	2·4	7·9	...
Bryan's Nook	45·4	41·2	4·9	8·5	...
Bott's Nook	43·17	33·03	10·60	9·20	4·0

The Mersey coal differs from the coal occurring in the Mesozoic or Upper Coal Measures in Tasmania in that it has a greater proportion of volatile matter, less fixed carbon, and, generally speaking, less ash. The sulphur content is higher.

Experience has shown that nowhere can the seam be worked continuously without being interrupted by faults, which give rise to blanks in the ground operated on and discourage the development of the industry. The field as a whole is more favourable for small enterprises than for the establishment of large collieries. In the future, no doubt, fresh points of attack here and there will be selected, and as industries and population increase, local demand for the coal will increase also.

X.—LIMESTONE AT RAILTON.

A quarry is situate a mile north of the railway-station at Railton, on Lot 5876, and is owned by Mr. Jas. Blenkhorn, who is raising the stone from a somewhat deep excavation, which is drained by a lower adit. Crushing-mill and kiln are attached to the quarry, and the installation is sufficient to meet the demands of the neighbourhood. The original quarry was opened 60 years ago. The present owner came here in 1885, and the stone has been worked intermittently throughout the whole period.

The limestone beds strike north-west and dip south-west at an angle of 45°. The rock is of the dark-grey or bluish colour usual in the Silurian limestones, and is fairly hard, with occasional softer argillaceous bands.

The following analysis of the lime has been made by Mr. H. J. Colbourn, the Government Agricultural Chemist:—

	Per cent.	
Lime Carbonate	75·10	
Combined water	0·55	
Phosphoric Anhydride	1·02	(= Phosphate of lime 2·2°/$_{o}$)
Magnesia	0·54	
Protoxide of Iron	2·88	
Snlphuric Anhydride	4·66	
Alumina	3·05	
Silica	12·20	
	100·00	

It is slightly hydraulic, as might be expected from the proportions of the constituents, which are those characteristic of many hydraulic limes, there being a good percentage of carbonate mixed with a fair proportion of clay. The Imperial Institute in 1910 tested samples of the rock forwarded by Mr. Blenkhorn, and found that it carried from 7 to 12 per cent of insoluble matter, principally argillaceous, and consequently favourable for the manufacture of cement, but considered it doubtful whether the amount of alumina present is sufficient to make the rock suitable for this purpose without the addition of more clay; at any rate, it does not appear suited for the manufacture of high-class cement. Still, the tests made are not considered quite conclusive, and further samples are being forwarded for more exhaustive trials.

Although these hydraulic limes (natural cement) set more rapidly than Portland cement, the tensile strength of the latter is much higher, and its usefulness consequently much greater.

The Railton lime is a good article for builders, and the limestone is also being used for metalling the roads of the neighbourhood. Its most important application, however, will be found perhaps in the direction of liming farm lands. The favourable action of lime on agricultural soils may be regarded as being of a twofold character, viz., (1) the purely mechanical one of breaking-up heavy soils; (2) the chemical one, of supplying an ingredient of plant growth, of promoting nitrification in soils, and combining and neutralising free acids in the decaying ground.

The chemical action of lime forms an important part of the processes which affect the organic constituents of soil, involving the transformation of the insoluble organic nitrogen compounds in the soil into soluble nitrate compounds suitable for plant food. This transformation (called nitrification) is a decomposition effected by microbes, and has the great advantage of producing a form of nitrogen which can be readily assimilated by the crop. There is also evidence to the effect that nitrogen-fixing bacteria living on certain plants have the power of absorbing free nitrogen from the atmosphere and cause it to combine with other elements to form food compounds.

Mr. Blenkhorn is crushing and powdering both the raw stone and burnt lime, so that the powder can be used by the farmer at the same time as he sows the seed, and those who have used the product speak favourably of the results.

For leguminous crops the application of lime has been long known to be highly beneficial. Mr. Colbourn, in one of his useful articles in the "Agricultural Gazette,"* advises applying finely powdered limestone to the potato crop, which is a lime-consuming plant, but which appears to be rendered more susceptible to attacks of fungoid disease when *burnt* lime is used as a dressing. He emphasises, however, the necessity for grinding the stone very fine if it is to be made suitable for other than very sour soil.

The Railton limestone contains 1 per cent. of phosphoric acid, which, when rendered soluble by the action of natural acids in the soil, distinctly adds to its value as a

* July, 1911, p. 375.

fertilising agent. Mr. Colbourn's remarks thereon may be quoted here:—

"As an agricultural lime it must possess a high value, from the fact that it contains, apart from the lime, several important crop constituents in appreciable quantity, notably 1 per cent. of phosphoric anhydride, which is equal to rather more than 2 per cent. (2·2) of tricalcic phosphate of lime. Owing to the recent burning this would be easily available for the growth of any crop requiring it. The lime slacks easily, and crumbles to a fine powder upon a short exposure to the atmosphere, so would quickly be ready for application to the land."

Ground limestone will naturally be slower in its action than burned or caustic lime, as it is called. The former simply neutralises the acidity of sour soils, while the latter in addition attacks and assists the decomposition of the organic matter in the soil, acting therefore as a strong stimulant, and the humus must be maintained by concurrent use of farm and green manures. If the organic matter thus destroyed is replaced, and the phosphorus and potash removed by crops are made good, the application of caustic lime can be made profitable.

Much controversy seems to take place about the relative advantages of caustic lime and ground limestone. The local opinion at Railton is that the latter is too costly and slow.

Authorities, however, mostly agree that the advantage of lime over limestone is only marked for the first year or two, but that for subsequent years the effect of ground limestone is greater than that of burned lime. The American trials are of interest in this respect. In the Pennsylvania experiments, extending over 20 years, every product showed a greater yield with limestone than with caustic lime. In the Maryland experiments, extending over 11 years, the carbonate of lime gave decidedly better results than the caustic lime. Professor C. G. Hopkins, of the University of Illinois, in his work on "Soil Fertility and Permanent Agriculture," sums up the position as follows*:—

"No trustworthy investigations support the use of burned lime in preference to ground limestone, although we have ample information showing that on many soils a moderate use of burned lime in connection with a liberal use of farm manure and green manures yields profitable

* New York, 1910, p. 168.

returns, which would no doubt be still more profitable if the burned lime were replaced with ground limestone."

One gathers from the literature that the caustic lime is the more rapid stimulant and produces quicker effects, while the raw stone is slower in its action and of more permanent value.

The present selling price of the lime for agricultural purposes is £1 per ton, or 25s. if ground; raw limestone, powdered, 10s. a ton.

This Railton industry, which has been for some time patiently cultivated, will probably grow with the growing population of this part of the country, as the uses of the stone become better known.

XI.—BARYTES AT MINNOW.

About a mile east of the Minnow township boundary are some deposits of barytes, partly on Crown land and partly on Thos. Jessop's freehold.

The strata in which the lodes are enclosed consist of slate belonging apparently to the Cambro-Ordovician series, striking here east and west, with a steep dip to the south. On Gregory's and Hart's land, to the east, the schistose porphyries of the same series prevail.

The barytes mine is now idle, and it is not easy to see exactly what has been done; but there appear to be a couple of parallel lodes and more than one tunnel. A shaft has been sunk on the lode at the foot of the hill to a depth of 40 feet, and a short drive and stope opened out from the bottom. This is now filled with water. The lode is said to have been 3 to 3½ feet in size at its widest part; at surface it shows from 7 to 16 inches.

The ore is dense crystalline barytes, with threads and specks of galena and blende. Some of it is decidedly pyritic, and has been picked out from the rest of the stuff broken. Samples of this variety were assayed by the Government Analyst, with the following result, for gold and silver:—

Gold, 1 dwt. per ton.
Silver, ·19 dwt. 4 gr. per ton.

The pure barytic ore yielded, on assay, 97 per cent. of sulphate of barium.

Over 50 tons of this ore was recently raised and sent to Devonport for sale, and it is understood that the quality was satisfactory. The difficulty evidently consists in maintaining the quantity. The margin of profit, too, cannot be large, the value of the crude ore at Devonport being between 30s. and 40s. per ton, and the cartage from the mine to the railway-station at Kimberley being somewhere in the neighbourhood of 12s. per ton. Mining has been carried on in a very primitive way, and no reliable conclusion can be drawn at present as to the quantities actually available.

XII.—CONCLUSION.

The country dealt with in this bulletin has been subjected to a comprehensive general examination. The geological horizon of the coal and shale measures has been ascertained, and the distribution of the shale outcrops throughout the area determined as far as our knowledge at present extends.

In the course of the investigation it has become apparent that a very extensive development of tasmanite shale exists in the districts examined, and it is satisfactory to be able to place this fact on record, and thus dispose of doubts expressed by some as to there being any great amount of workable shale available.

As far as can be judged there is a very high probability that the area over which the shale seam extends totals 2000 acres, and if the seam does not decrease in size below 4 feet this acreage represents a quantity of 12,000,000 metric tons of shale. Apart from the prospecting work carried out near Railton, Paramatta, the Mersey Bend, and in the Nook-road Valley, little has been done in the way of testing the ground; and, indeed, it may be said that the only work proving the extent and limits of any deposit is the boring done by the Latrobe Shale and Oil Company on its ground. At and near the Bend of the Mersey, though the existence of shale has been abundantly proved, its extent is practically unknown. And at the Minnow, though the existence of shale is unquestionable, nothing is known of the size of the seam or its extent.

For such areas the estimates made depend largely on geological considerations.

It is also possible that shale may be found in places where at present no outcrop can be located. The geological conditions for its existence are favourable in the country north of the Junction, on the Deloraine-road; and it may be discovered along Deep Creek, near Paramatta, where sections are held by some Hobart syndicates. Mr. Chas. Gould stated that it was reported to crop out north of Deep Creek on land now held by W. and C. Knight. From recent examination of that part of the country such an occurrence is deemed unlikely; but, on the other hand, the extension of the seam north of Paramatta even below the basalt lava sheet of Sassafras is within the bounds of possibility.

Again, Mr. Gould records shale fragments as having been found in Caroline Creek, and infers its existence at the eastern base of Brown Mountain (formerly Bonney's Tier). This is coal country, and no shale has yet been located there. Its occurrence is not to be expected; still in country so subject to faulting, a discovery would not be surprising.

At the Minnow the shale-measure country is definitely circumscribed by easily-recognisable boundaries. Between Beulah and Kimberley is some ground which from its appearance may be judged to have possibilities.

The country south of the township of Latrobe and on its eastern boundary-line may be considered as worth prospecting for tasmanite.

From the recent examinations the possibility of a generalisation seems to emerge, namely, that the shale is absent where the Lower Marine beds of this geological system (Permo-Carboniferous) are separated from the Upper Marine beds by intervening coal measures; but when tasmanite shale is present it will be found that the Upper and Lower Marines form a continuous series.

In the search for outcrops it is advisable to secure the services of prospectors who have a wide local knowledge—men who know every creek and farm, and have, so to speak, a keen scent for shale. Much time and useless expense are saved thereby, and much valuable information is gained.*

Unfortunately, since the present examination was made the industry has received a set-back through the financial difficulties of one of the companies interested, and the reluctance of another to undertake the risk of embarking on a new enterprise. These conditions arose somewhat suddenly, and affected adversely the other syndicates in the field.

The oil industry throughout the world, however, is steadily increasing in importance, and the writer's conviction is that the initial difficulties are temporary, and not invincible. If sound business judgment and technical efficiency are combined in the direction of the enterprise it will succeed; otherwise it will fall into the hands of others, who will profit by the mistakes of the past. There are really no solid grounds for taking a pessimistic view of things, even though at the start there has been an

* The writer desires to acknowledge his indebtedness under this head especially to Mr. Frank Hedditch and E. Broomhall of Latrobe; also to Mr. H. J. Ray of the Nook.

untoward conjunction of events. The value of the products obtainable from the shale appears in the opinion of those connected with the enterprise, and who have a working knowledge of oil manufacture, to be a few shillings per ton of shale in excess of the gross working cost per ton. The problem would therefore seem to be one of laying out work generally, and employing appropriate methods of extraction; in a word, a question of good and economical management.

It cannot, however, be disguised, that there are working difficulties. The question of reducing the proportion of sulphur in the residual oil is an important one if sales to the Admiralty are to be a main source of revenue. The 2 per cent. to 3 per cent. sulphur which exists in the raw shale has to be reduced for this purpose to 0·75 per cent. in the oil. It has not yet been shown whether this is feasible on a working scale, but various trials on an experimental scale have produced oil with a sulphur content a little above and a little below 1 per cent., and an assay has been obtained as low as 0·6 per cent. These varying results tend to prove that the elimination of the sulphur to the requisite degree is not an inherent impossibility, but a question of treatment, and need not prove an insuperable difficulty, especially as some of it is due to a variable admixture of pyrites. Even if complete success in this respect is not attained at once, other outlets for that variety of oil can be sought, and with the increasing use of oil for different purposes it should not be difficult to discover them.

It is a mistake to think that the value of the shale depends entirely upon that of the residual or fuel oil. Other products enter largely into the question of total values. By-products saved the Scottish industry from ruin, and though the ammonia value is not high in the Mersey shale, various spirits and the spent shale add considerably to the aggregate realisation figure. The spent shale may possibly be made a manurial base, and could also be used as a base for the manufacture of a deodorant and agricultural germicide.

With a material like shale, which leaves a comparatively low unit margin of profit, the scale on which it is worked ought to be as large as possible, and the work laid out so that supplies converge on retorts built in a central position. To secure such advantage it is sometimes desirable to consolidate existing interests. In the Mersey district the shale outcrops are not altogether conveniently situated for treatment at central retorts to serve different properties, but if ever a general amalgamation takes place this matter will have to be carefully considered. At present even on one and the same property the deposits are so awkwardly situated that some of them have to be neglected when selecting a retort site. To have separate works in separate parts of the properties will involve an undesirable expenditure for working and maintenance. The whole question of works sites needs study. Proximity to the deposits, proximity to water, proximity to firewood, and easy communication with Latrobe or Railton, are factors which will govern the decision. The Minnow deposit is a self-centred proposition, and any scheme for work there must be an independent one. It is also rather difficult to see how the Nook shale can be worked in conjunction with the Mersey undertakings, unless by having separate retorts on the spot. James' freehold, at the Bend of the Mersey, has some fine outcrops, but in its present imperfectly prospected and undeveloped state is of little value to its owners. Its manifest destiny is union with the adjoining property.

At one time it was anticipated that much of the shale would be quarried in open-cuts, and that the cost of getting it would be trifling. It is now plain, however, that very little shale will be quarried, and underground mining must be the rule. At the same time, no excessive depths are to be apprehended. The seam will probably nowhere be found to be deeper than 200 feet from surface, and in most places where it will be worked its depth does not exceed 100 feet. These depths are trivial in comparison with those ruling in the Scottish shale mines.

The precise products which it will be most profitable to prepare for market will have to be determined before any great outlay on works or work sites is decided upon. The work for some time to come must be to some extent experimental, and a good many data relating to nature of products, economical working and realisation of output remains to be obtained before the remunerative stage can be entered upon.

All these considerations tend to show that the problem of how best to start the industry is many-sided, and success can only be expected from a judicious combination of several factors.

That the elements of success, present or future, exist there can hardly be any doubt, and it is to be hoped that the endeavours which are being made to lay the foundations of an industry fraught with great potential benefit to the State may attain their aim.

W. H. TWELVETREES,
Government Geologist.

Launceston, 28th December, 1911.

XIII.—APPENDIX I.

PARTICULARS OF GOVERNMENT BORE PUT DOWN AT TARLETON IN 1884.

Coal Measures.

	ft.	in.
Clay	15	0
Sandstone	33	9
Conglomerate	3	0
Shale or laminated mud-rock	5	0
Coal	1	6
Sandstone	36	6
Conglomerate	2	0
Dark sandstone	6	6
Shale or mudstone	2	0
Sandstone	2	0
Shale or mudstone	5	0
Marl	32	3
Sandstone	2	0
Pebbly marl	8	6
Pebbly marl, with thin layers of carbonaceous matter	32	6
Pebbly marl and sandstone with carbonaceous matter	77	3
Total in coal measures	264	9
Lower Marine Beds.		
Pebbly sandstone with marine shells	20	9
Conglomerate with marine shells	36	0
Conglomerate and sandstone with marine shells	30	9
Conglomerate	17	9
Bottom of Permo-Carboniferous beds	370	0
Silurian limestone bored into	30	6
Total depth	400	6

Among the marine fossils the following were identified (by R. M. Johnston):—*Stenopora tasmaniensis*, *Fenestella plebeia*, *Spirifera tasmaniensis*, *Terebratula saccula*, *Pleurstomaria morrisiana*.

EXPLANATION OF PHOTOMICROGRAPHS OF SECTIONS OF TASMANITE.

FIG. 1.—Longitudinal section of Tasmanite shale, showing its microscopic appearance when cut through vertically to the bedding-planes. Some of the sacs are now filled with calcite. The effects of shrinkage and compression are visible in the distorted forms. Plain light × 19.

FIG. 2.—Transverse section of Tasmanite shale, showing the flattened sacs when cut through horizontally. The exterior wall of the sac is shown occasionally. Plain light × 19.

XIV.—APPENDIX II.

A report on petrol made by the Tasmanian Shale and Oil Company from the Mersey tasmanite has recently been communicated to the Agent-General for Tasmania in London by Professor Wyndham R. Dunstan, F.R.S., Director of the Imperial Institute, South Kensington. The report is as follows:—

REPORT ON PETROL FROM TASMANIA.

The petrol which is the subject of this report was forwarded to the Imperial Institute by the Agent-General for Tasmania in London, with letter (No. 3684) dated 13th September, 1911. It was stated that the petrol had been obtained from shale found near Latrobe, in Tasmania.

Description of Sample.

The sample consisted of about 3½ pints of a pale yellowish oil, having the characteristic odour of shale oil.

Result of Examination.

The examination of the petrol gave the following results:—

Specific gravity	0·760
Flash point below......................	15·5°C
Bromine absorption	113 per cent.

The sample was submitted to fractional distillation, with the results given in the following table:—

Boiling Point.	Fraction.	Specific Gravity.	Flash Point.	Bromine Absorption.
	Per cent.			Per cent.
75° to 80°C	0·3	—	below 15·5°C	—
80° to 100°C	20·7	0·740	do	115
100° to 120°C	47·0	0·758	do	112
120° to 150°C	28·0	0·774	do	109
above 150°C	4·0	—	38°C	—

The foregoing results are characteristic of the "naphtha" obtained by the distillation of shale.

It was not found possible to remove the somewhat strong odour of the sample by the methods usually employed for American oils without destroying the valuable low-boiling fractions. A similar difficulty is encountered in dealing with the shale spirit distilled in Scotland.

Remarks and Conclusions.

This petrol would be quite suitable for use as a solvent and for various other purposes to which petrol is applied. As regards its employment for internal combustion engines (*e.g.*, in motor-cars) it would probably be necessary to fractionate the oil and use only the portion boiling below 120° C. for the purpose.

The following table gives the average results of the distillation of well-known "motor-spirits" obtained from petroleum:—

Boiling Point of Fractions.					Original Oil.	
Below 100°C.	100°-120°C.	120°-133°C	Above 133°C.	Loss.	Specific Gravity.	Began to Distil at
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
65·0	24·8	6·0	3·0	1·2	0·713	58°–65°C
66·6	23·9	5·0	3·1	1·4	0·717	60°-65°C
66·5	23·7	5·8	2·8	1·2	0·717	63°–65°C
39·0	49·0	7·5	3·5	1·5	0·739	70°C
86·5	11·5	—	0·5	1·5	0·700	56°C
73·0	17 5	5·0	3·0	1·5	0·705	55°C

These figures illustrate the composition of ordinary motor-spirit, and on comparing them with the results cf the examination of the petrol from Tasmania, it will be seen that the latter contains a much larger percentage of high-boiling oil. The fraction boiling above 120° C. amounts to 32 per cent. in the Tasmanian petrol, whereas the maximum in the commercial samples is only 11 per cent.

If petrol similar to this sample from Tasmania were used for motors without further distillation, trouble might occur owing to the large percentage of high-boiling oil. This point, however, could only be definitely settled by technical trials with a large quantity of the petrol.

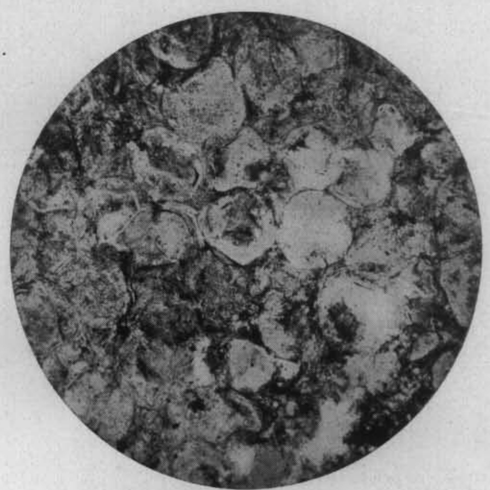
(Signed) Wyndham R. Dunstan.

28th November, 1911.

PLATE. A

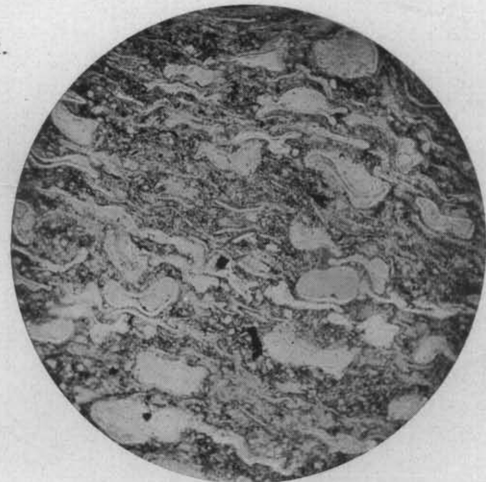
PHOTOMICROGRAPHS.

FIG. 1.



X 19.

FIG. 2.

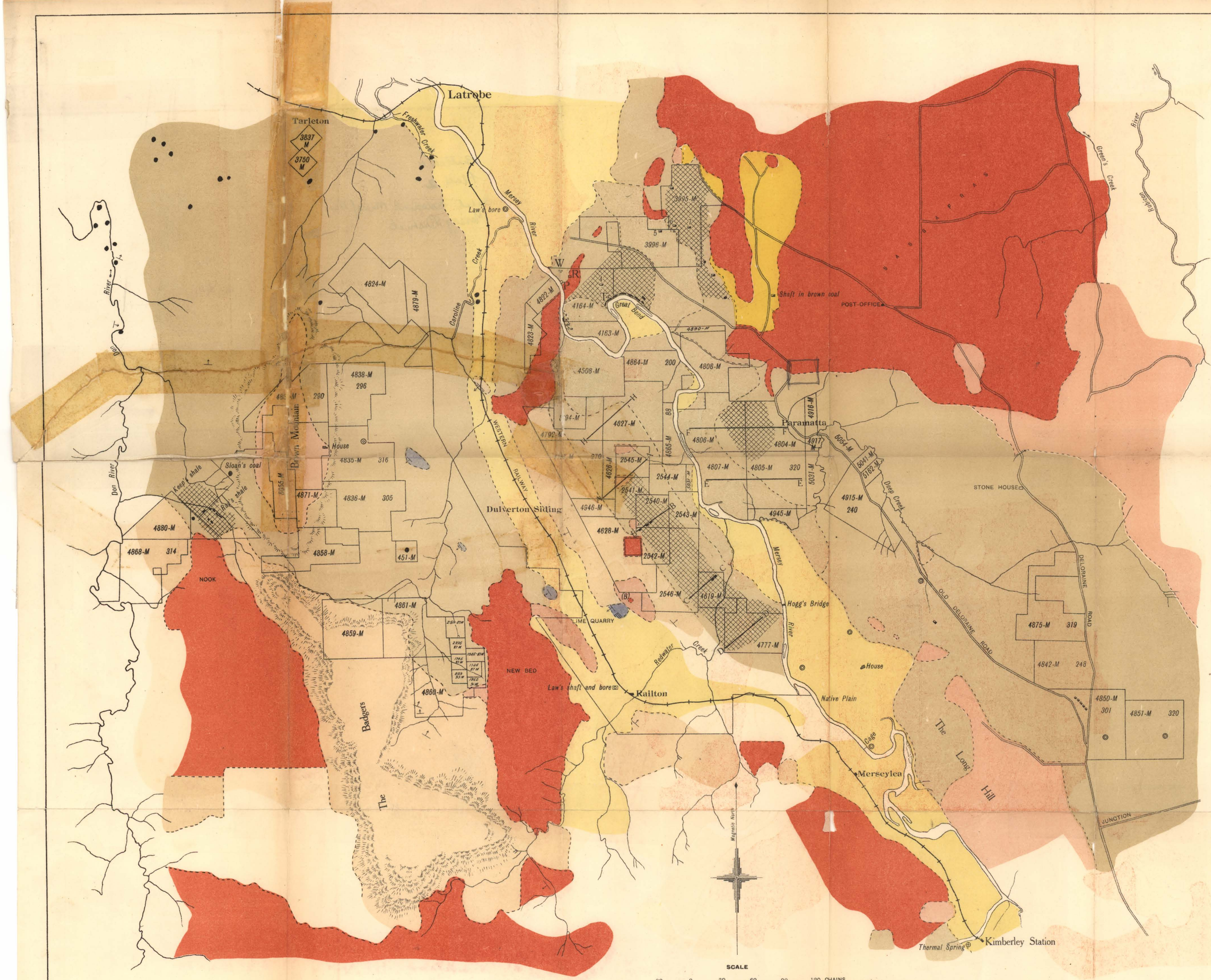


X 19.

TASMANITE SHALE.

5 cm

PLATE II



LEGEND

SEDIMENTARY

- PLEISTOCENE AND RECENT — Various Gravels and Flood Plains
- TERTIARY — Soft Sandstone and Lignitic Clay Beds
- PERMO-CARBONIFEROUS — Sandstone, Mudstone, and Conglomerate Beds
- SILURIAN — Limestone
- CAMBRIAN — Sandstone, Quartzite, Slate, and Conglomerate Beds
- PRE-CAMBRIAN — Sericitic Quartzite and Mica-Schist, and beds of Quartzite and Slate

IGNEOUS

- BASALT — Volcanic Pipes, Dykes and Lava Sheets of Tertiary Age
- DIABASE — Sills and other intrusions at the close of the Mesozoic Era

- Tasmanite Shale Areas
- Bores for Coal or Shale
- Outcrops of Shale
- Strike and Dip of Strata
- Tasmanian Shale and Oil Co.'s Works (W)
- Tasmanian Shale and Oil Co.'s Tunnel (T)
- Geological Boundaries
- Lines of Bores for Shale
- Coal Seams
- Shafts
- Basalt Neck (B)
- Latrobe Pumping Station (P)
- Reservoir for Latrobe Water Supply (R)
- Boundaries of Mineral Leases

KEY TO NUMBERS OF MINERAL SECTIONS.

Number of Section.	Acres.	Lessee.
3994-M	100	Tasmanian Shale and Oil Co., N. L.
3995-M	320	
3996-M	314	
4508-M	313	
4163-M	117	
4164-M	256	
2540-M	100	Latrobe Shale and Oil Co., N.L.
2541-M	100	
2542-M	100	
2543-M	100	
2544-M	100	
2545-M	100	
2546-M	299	
4619-M	107	
4626-M	116	
4627-M	302	
4628-M	297	
4777-M	242	
4791-M	270	
4792-M	199	
4804-M	256	
4805-M	320	
4806-M	292	
4807-M	265	
4808-M	209	
4865-M	88	
4945-M	68	
4946-M	69	
5031-M	84	
4824-M	320	R. P. Symmons
4858-M	214	
4859-M	319	
4860-M	263	
4861-M	313	
4871-M	143	
4879-M	148	
4880-M	185	
5162-M	30	Hobart Latrobe Shale Oil Assocn., N.L.

Number of Section.	Acres.	Lessee.
4835-M	316	F. Robinson
4836-M	305	
4842-M	248	
4850-M	301	
4851-M	320	
4822-M	53	F. Richards
4823-M	79	
4864-M	200	
4837-M	290	L. E. Ditcham
4838-M	296	
4875-M	319	
5041-M	30	J. A. Crisp
5054-M	69	
4916-M	51	C. Kennedy
4917-M	21	
4868-M	314	A. P. Manton
4915-M	240	H. E. Wright
2511-87M	32	Formerly Dulverton Coal Sections
2295-87M	20	
1745-87M	20	
1744-87M	20	
1046-87M	20	
1862-91M	20	
809-93M	20	
451-M	40	
5055-M	197	R. W. Stringer
3837-M	40	J. Allison and J. Allison, jun.
3750-M	40	
4890-M	40	J. Rice

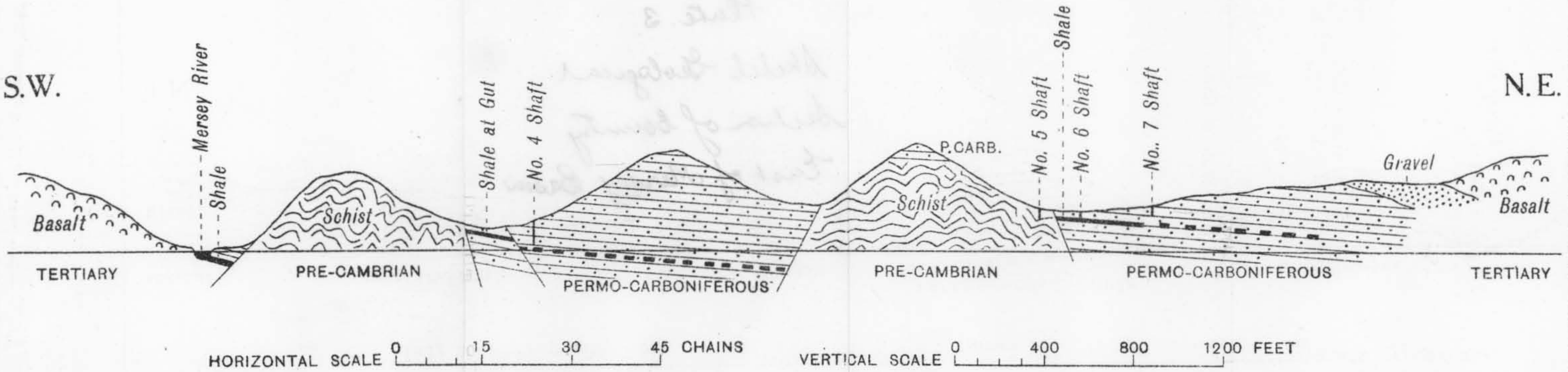
W. H. Twelvetrees
Government Geologist
28. 12. 11.

SKETCH GEOLOGICAL MAP OF THE MERSEY DISTRICT

Photo-lithographed by John Vail, Government Printer, Hobart, Tasmania.

PLATE III

SKETCH GEOLOGICAL SECTION OF COUNTRY EAST OF MERSEY BASIN



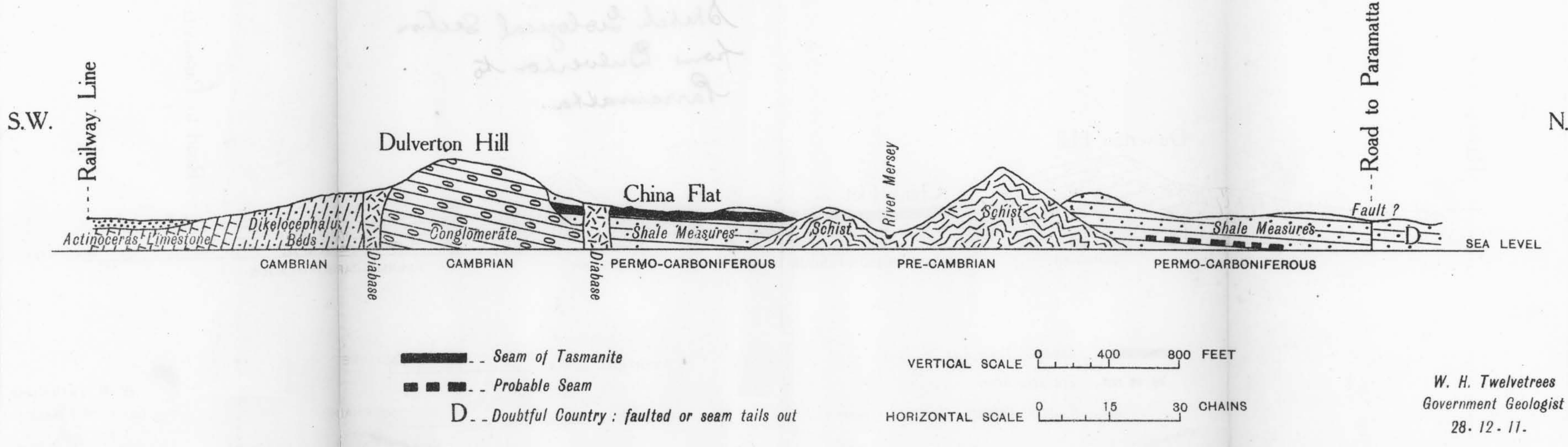
W.O.R.

W. H. Twelvetrees
Government Geologist
28. 12. 11.

Photo Algraphed by John Vail Government Printer Hobart Tasmania

PLATE IV

SKETCH GEOLOGICAL SECTION FROM DULVERTON TO PARAMATTA



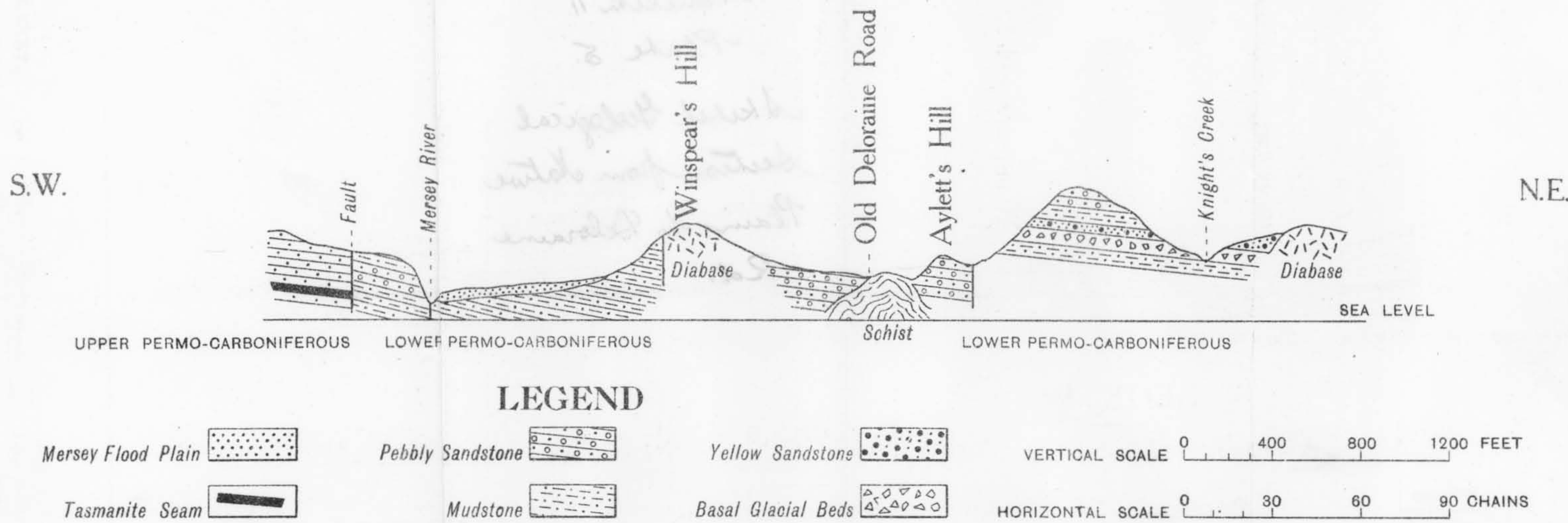
W. H. Twelvetrees
Government Geologist
28. 12. 11.

Photo Algraphed by John Vail Government Printer Hobart Tasmania.

5 cm

PLATE V

SKETCH GEOLOGICAL SECTION FROM NATIVE PLAIN TO DELORAINE ROAD

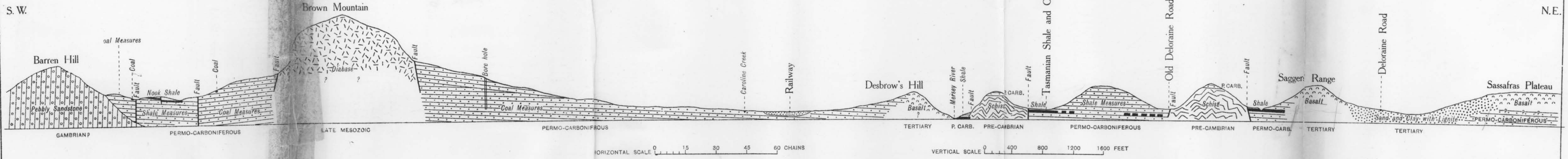


W. H. Twelvetrees
Government Geologist
28. 12. 11.

Photo Algraphed by John Vail Government Printer Hobart Tasmania.

PLATE VI

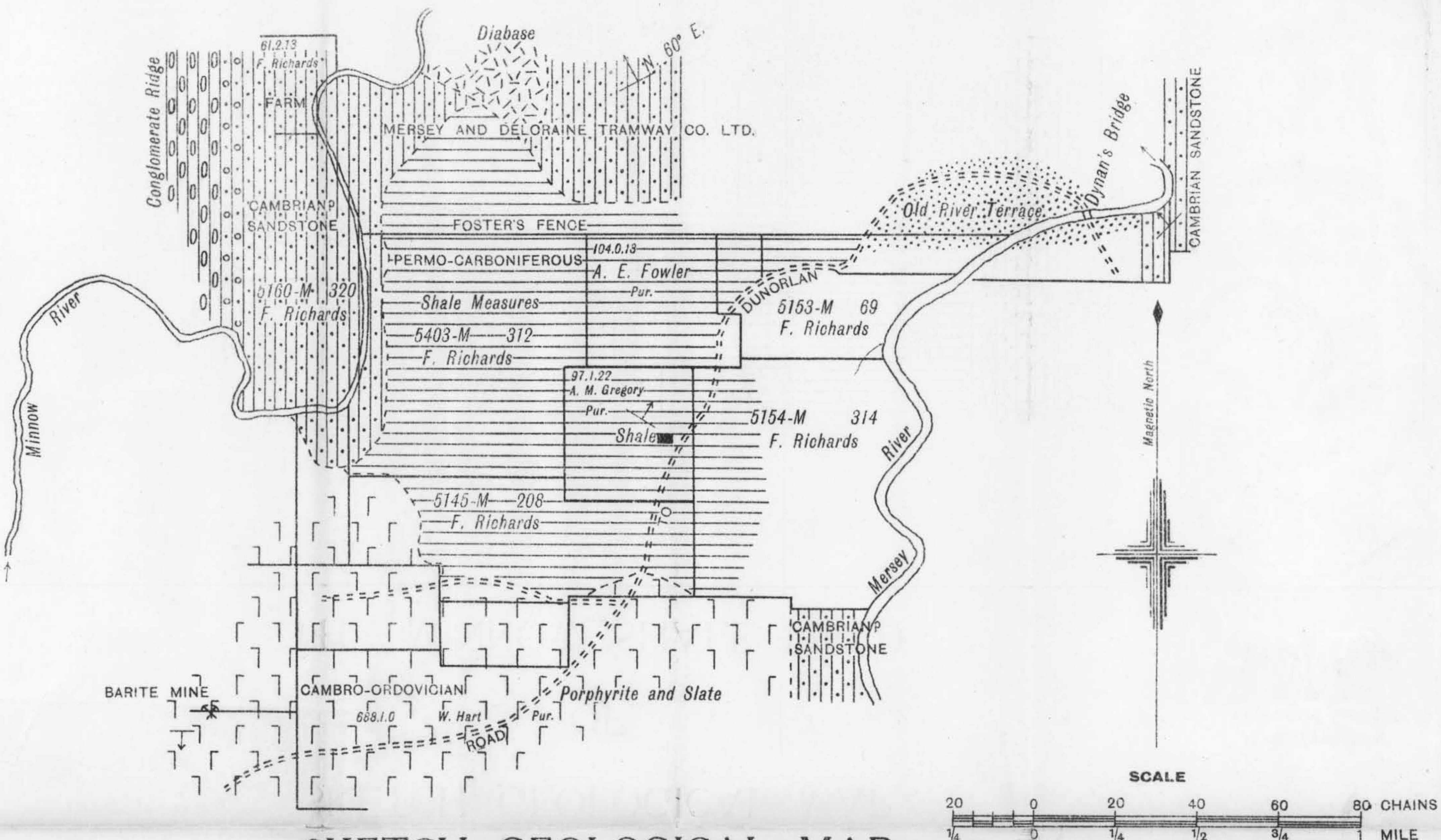
SKETCH GEOLOGICAL SECTION OF COUNTRY FROM NOOK VALLEY TO SASSAFRAS



W. H. Twelvetrees
Government Geologist
28 . 12 . 11.

Photo-lithographed by John Vail, Government Printer, Hobart, Tasmania.

PLATE VII



SKETCH GEOLOGICAL MAP OF THE MINNOW SHALE FIELD

W. H. Twelvetrees
Government Geologist
28.12.11.

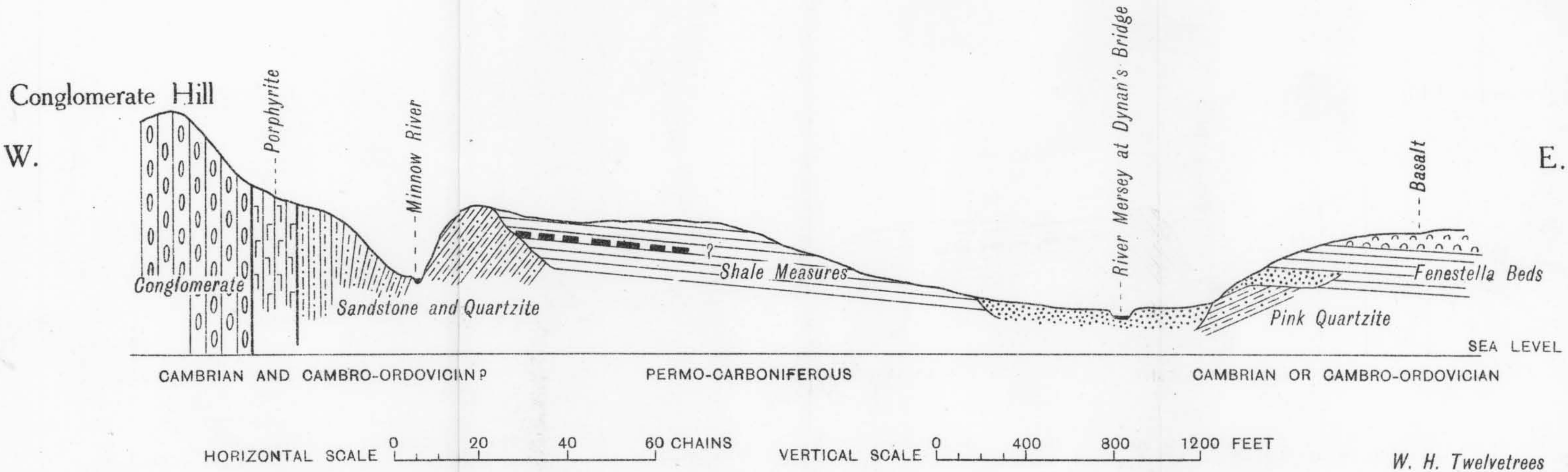
5 cm

W.D.R.

Photo Lithographed by John Vail Government Printer Hobart Tasmania

PLATE VIII

SKETCH GEOLOGICAL SECTION OF SHALE COUNTRY AT THE MINNOW

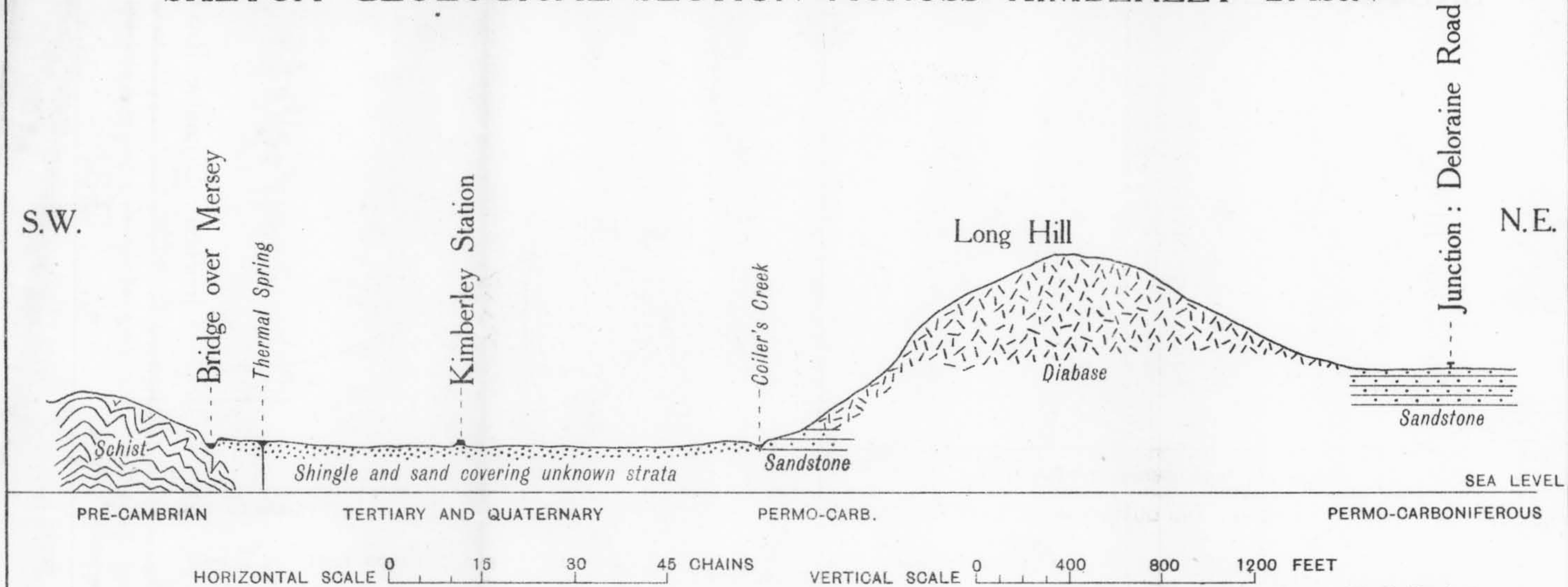


W. H. Twelvetrees
Government Geologist
28. 12. 11.

Photo lithographed by John Vail Government Printer Hobart Tasmania

PLATE IX

SKETCH GEOLOGICAL SECTION ACROSS KIMBERLEY BASIN



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28. 12. 11.

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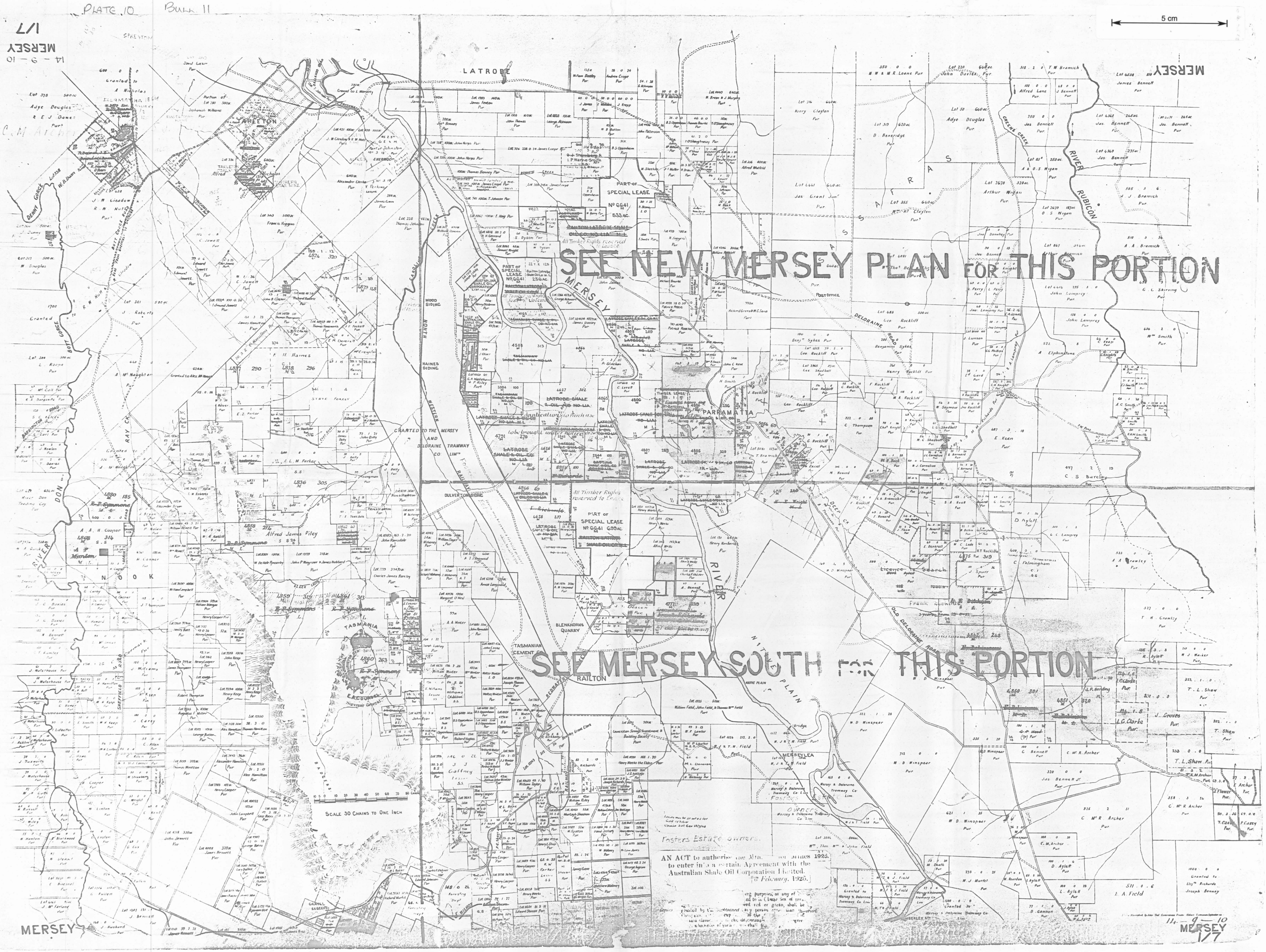

PLATE 10
Bull. 11
5 cm
MERSEY
1/7
14 - 9 - 10
MERSEY
LATROBE
TARLETON
SEE NEW MERSEY PLAN FOR THIS PORTION
SEE MERSEY SOUTH FOR THIS PORTION
PARRAMATTA
MERSEY
RIVER
RIVER RUBICON
NOOK
RAILTON
MERSEY LEA
BLENKHORNS QUARRY
TASMANIAN CEMENT
WOOD SIDING
HAINES SIDING
DULVERTON SIDING
GRANTED TO THE MERSEY AND DELORAINE TRAMWAY CO LIM
PART OF SPECIAL LEASE No 6641
DELORAINE ROAD
OLD DELORAINE ROAD
NOTH PLAIN
DON RIVER
STATE FOREST
POST OFFICE
Licence to Search
All Timber Rights reserved to Lessee
SCALE 30 CHAINS TO ONE INCH
Fosters Estate owners.
AN ACT to authorise the Min... to enter into a certain Agreement with the Australian Shale Oil Corporation Limited.
MERSEY
MERSEY
1/7