[*Registered with the Postmaster-General for transmission through the post as a book*]

Tasmania

DEPARTMENT OF MINES

UNDERGROUND WATER-SUPPLY PAPER

No. 4

The Campbell Town-Conara-St. Marys District

BY

P B. NYE, M.Sc., B.M.E., Government Geologist

Issued under the authority of
The Honourable J. A. LYONS, M.H.A.
Premier and Minister for Mines for Tasmania

Tasmania:
Wholly set up and printed in Australia by
JOHN VAIL, GOVERNMENT PRINTER, HOBART

29680 1926 Price 2/6

TABLE OF CONTENTS.

V.—ECONOMIC GEOLOGY—*continued.* PAGE

The Campbell Town-Conara-St. Marys District.

I.—INTRODUCTION.

(1)—Preliminary Statement.

The Campbell Town-Conara-St. Marys district, in which the following investigation was carried out, forms portion of the Midlands of Tasmania. The Midlands has a low rainfall, which varies from 1804 to 2541 points. On account of this comparatively small amount of rainfall, the agricultural industry has been more or less uncertain, and has not been followed as much as it might have been. Instead of this industry the land has been devoted to the pastoral industry (particularly sheep), with the resulting tendency for formation of comparatively large estates. The district is thus sparsely populated, and though traversed by the main line railway, it brings only a relatively small amount of business to the State-owned railway.

In dealing with the development of the State, the State Development Advisory Board considered the possibility of the greater exploitation of the land in the Midlands. The principal object was to place more people on the land, thus increasing the population of the State, and also to increase the value of the products produced from the same area. As a further result, the State would also benefit by the increased business on its railway.

To achieve these objectives, the abovementioned Board discussed the question of subdivision of the larger properties, where suitable, for greater use as agricultural areas, and also that of irrigation of these areas. The absence of a topographical plan of the districts concerned was immediately felt, and one of the first steps taken, therefore, was to request the preparation of such a plan by the Geological Survey similar to those already published in connection with the Underground Water-supply Papers. At the same time a request was made for general information as to soils and other factors with any bearing on irrigation.

In accordance with these requests, a topographical, geological, and general irrigation survey was conducted of those portions of the Midlands not included in the above papers.

(2)—General Statement.

The field work in connection with the above investigation was carried out during the periods between the 1st December and the 20th December, 1924, and the 23rd January and the 9th February, 1925, respectively.

The mapping was performed with the aid of the land charts of Cornwall (No. 1 and No. 2), Somerset (No. 1), and Glamorgan (No. 1). Numerous topographical features were added, and local names given to these and other features not named on the charts. Contours drawn at 100-foot intervals are shown on the plan, and further illustrate the topography. These contours are based on altitudes determined by aneroid readings, the datum points used being the stations on the Main Line and St. Marys railways.

II.—PREVIOUS LITERATURE.

The following reports contain descriptions of parts of the district under review, particularly in the vicinity of St. Marys, Fingal, Avoca, St. Paul's River, and the flanks of Ben Lomond:—

Milligan, J.: Reports on the Coal Basins of Van Diemen's Land, Proc. Roy. Soc. V.D. Land, Vol. I., Part I., 1849.

Milligan, J.: Notes on a Geological Excursion Around Ben Lomond, Proc. Roy. Soc. V.D. Land, Vol. II., Part I., 1852.

Lelwyn, A. R. C.: Report on the Geological Relations of some of the Coal Seams of Van Diemen's Land, Papers and Proc. Roy. Soc. V.D. Land, Vol. III., Part I., 1855.

Gould, Chas.: Coalfields (Fingal and East House of Assembly Paper No. 9, Legislative Council Paper No. 7, 1861.

Gould, Chas.: Gold at Mangana, House of Assembly and Legislative Council Paper No. 20, 1869.

Thureau, G.: Ben Lomond and St. Paul's River, House of Assembly Paper No. 108, 1881.

Thureau, G.: Report on Fingal and Mt. Nicholas Coal Deposits, House of Assembly Paper No. 90, and Legislative Council Paper No. 91, 1883.

Krause, F. M.: The Auriferous Drifts of the South Esk Valley in the Neighbourhood of Fingal, Tasmania, House of Assembly Paper No. 91, and Legislative Council Paper No. 92, 1883.

Thureau, G.: Mount Victoria, Dan Rivulet, Black Boy, and Mangana Goldfields, Parliamentary Paper No. 61, 1885.

Johnston, R. M.: Geology of Tasmania, 1888.

Montgomery, A.: Report on the Ben Lomond District, Secretary for Mines' Report, 1891-92.

Montgomery, A.: Report on the Discoveries of Tin Ore on the Brookstead Estate, Parliamentary Paper No. 125, Secretary for Mines' Report, 1892-93.

Montgomery, A.: Report on the Roy's Hill Tin Mine, 1893.

Montgomery, A.: Second Report on the Brookstead Estate Tin Lodes, 1893.

Twelvetrees, W. H.: Report on Some Tin Mines in the St. Paul's River Valley, near Avoca, 1899.

Waller, G. A.: Report on the Tin-mining District of Ben Lomond, 1901.
Twelvetrees, W. H.: Report on Coal Seams at Thornedale, near Thompson's Marshes, and the Jubilee Colliery, near St. Marys, 1901.
Twelvetrees, W. H.: On Coal at Mt. Rex., 1905.
Reid, A. McIntosh: The Avoca Coalfield—The Coal Resources of Tasmania — Geol. Sur. Mineral Resources, No. 7, 1922.

III.—GEOGRAPHY AND PHYSIOGRAPHY.

(1)—LOCATION AND EXTENT.

The district described in this report is situated in the eastern-central part of Tasmania, and includes portions of the counties of Cornwall, Glamorgan, and Somerset. It consists of an irregular-shaped tract of country extending along the valley of the Soutn Esk River and its tributaries from St. Marys to Conara, and then extending southwards from Conara along the valley of the Macquarie River and its tributaries. The Municipalities of Fingal and Campbell Town include nearly the whole of the district, in which occur the townships of Campbell Town, Conara, Avoca, Fingal, and St. Marys.

The total area of the country geologically examined is about 280 square miles.

(2)—ACCESS.

The district is readily accessible, both by road and railway, from Launceston, the chief centre of northern Tasmania, and also from Hobart, the capital of Tasmania, and the principal centre and port of the southern portions of the State. The Main Line from Launceston enters the district at Conara, 35 miles from Launceston, and passes through Campbell Town ($42\frac{1}{4}$ miles), Ross ($49\frac{3}{4}$ miles), Tunbridge (59 miles), Woodbury ($62\frac{3}{4}$ miles), &c. The corresponding distances from Hobart of Woodbury and Conara are $70\frac{1}{4}$ and 98 miles respectively. The main-road from Launceston to Hobart follows a similar route, and passes through Conara at 33 miles, Campbell Town (40) miles, Ross (48 miles), Tunbridge (56 miles), and Woodbury (59 miles), the latter place being 62 miles from Hobart.

The branch railway and road off the Main Line Railway and road respectively run in a general easterly direction up the valley of the South Esk River. The townships of Avoca ($16\frac{3}{4}$ miles), Fingal ($33\frac{3}{4}$ miles), and St. Marys ($46\frac{3}{4}$ miles) are passed through by both the railway and road. St. Marys is connected by road with the north-eastern and south-eastern parts of the State.

(3)—TOPOGRAPHY.

(a) *General Description*.

The topography varies greatly in different parts of the district, some being of very high relief, while others are of very low relief. It is essentially that of a district with a drainage system composed of several fairly large streams with numerous very small tributaries. The areas of low relief are restricted to the valleys of the major streams, such as the South Esk, Break-o'-Day, St. Paul, Elizabeth, and Macquarie Rivers. Apart from these valleys, excepting the Ross-Conara area, the country is generally of high relief. The mountain of Ben Lomond (5160 feet) is not only the highest mountain in the vicinity, but also in Tasmania. The least elevated land occurs along the courses of the South Esk and Macquarie Rivers.

(*b*) *Mountains.*

The examination of the district was confined to the more level and low-lying parts, but numerous high mountains occur in the immediate vicinity. The highest mountain is Ben Lomond (5160 feet), to the north of Avoca, which, with its foothills, forms the most mountainous and elevated portion of the district. Tower Hill is much lower, but is conspicuous to the east of Ben Lomond. The Mt. Nicholas Range (2812 feet) forms the northern side of the Break-o'-Day Valley, and the Fingal Range (2800 feet) forms the southern side thereof.

The Break-o'-Day River joins the South Esk River near Fingal, and the Fingal Range continues to the south-west as an elevated region between the South Esk River on the north and the St. Paul River on the south, St. Paul Dome (3368 feet) being the highest portion of this region. Elevated country occurs along the south side of the St. Paul River, Snow Mountain being the highest peak, and continues easterly towards Conara. It then runs in a southerly direction along the eastern side of the plains around Campbell Town and Ross, where it is known generally as the Eastern Tiers, one of the highest points being Campbell Town trigonometrical station, 2356 feet in height. The western boundary of the plains of the Midlands is marked by minor ridges, which eventually give place to the foothills of the Western Tiers, and then this elevated range itself up to 4000 feet above sea-level.

(*c*) *Plains.*

The Midlands district includes the largest areas of level and low-lying country in Tasmania. Actually, these areas are not perfect plains, but are gently undulating tracts of country, broken by minor ridges, though, in comparison with other portions of the State, they may be regarded as plains. The majority of these features are not due to the formation of plains along the courses of the present streams, but are a direct expression of the geological history and structure of this part of Tasmania.

The plains of the Midlands begin in the vicinity of Woodbury, in the south, and extend to the north through Tunbridge, Ross, Campbell Town, and Conara, and still further north and west. Around and to the north of Conara the plains have a relatively poor soil, so the investigation was not extended in that direction.

Apart from the above a number of narrow tracts of plain country occur along the course of the South Esk River and its tributaries. The most prominent of these are those between Fingal and Mathinna, and between Fingal and St. Marys, the latter being known as the Break-o'-Day Plain. Another tract that is extending upstream along the St. Paul River from Avoca, portion of which is known as the Benham Plains:

(d) *The Streams.*

The whole of the drainage of the district is part of the major drainage system of the South Esk River. This stream rises to the north of Ben Lomond and flows in a circuitous course through Mathinna, Fingal, and Avoca, and then out of the district in a general northwesterly direction.

The Break-o'-Day River rises by means of numerous small streams in the country around St. Marys, and flows in a general west-south-westerly direction to join the South Esk, near Fingal, receiving numerous small tributaries on the way.

Between Fingal and Avoca the South Esk River receives many creeks both from the north and south. The next important tributary is the St. Paul River, which rises on the south side of the Fingal Range and flows first south-westerly and then westerly to join the South Esk at Avoca.

The Midlands proper is drained by the Macquarie River and its tributaries. The Macquarie River itself rises in Tooms Lake, and flows in a general westerly direction towards Ross, whence it traverses the district in a general north-north-westerly direction towards Lincoln. The Elizabeth River is the chief tributary. This latter stream has its source in the elevated country of the Eastern Tiers, and flows in a westerly direction to join the Macquarie River a few miles to the west of Campbell Town.

(4)—Climate and Meteorology.

The climate of the Midlands is essentially a mild and dry one. Snow is unknown on the less elevated regions, but often falls on the most elevated parts like Ben Lomond. Frosts are frequent in the winter, and are moderately severe.

The rainfall during the year is only moderate. In the Midlands proper it varies from 1804 points to 2451 points, and in the valley of the South Esk and Break-o'-Day Rivers it varies from 2015 points at Avoca to 3846 points at St. Marys. Full particulars of the monthly and yearly rainfall are given in Table I. for all stations within the district. The distribution of the rainfall throughout the year is generally similar for the different stations. January has about the average monthly rainfall, while that for February is below the average, and is usually the driest month of the year. March has a low rainfall, and at some places has the lowest for the year. April and May rainfalls are usually above the average, while June is generally the wettest month of the year. July and August have rainfalls below the average, and are two of the driest months of the year. September has an average or greater rainfall, while October is one of the wettest months, sometimes having the greatest rainfall. November is a month of low rainfall, and is followed by a high rainfall in December.

Table No. 1.

Monthly and Annual Rainfall Data.

Station.	No. of Years' Record	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec	Average.	
														Month.	Year.
Woodbury	15	143	101	136	167	158	195	131	128	148	178	150	201	153	1836
Ross (Beaufront)	35	171	109	125	149	157	180	134	138	151	183	131	176	150	1804
Ross (Roseneath)	9	143	154	94	147	193	230	178	147	203	231	173	185	173	2078
Bendeemer	25	195	160	172	205	249	296	238	260	265	290	166	240	228	2736
Campbell Town (Quorn Hall)	35	194	120	138	168	166	198	157	160	195	223	159	189	173	2067
Campbell Town (Institute)	9	181	158	106	154	230	260	198	155	243	316	207	243	204	2451
Rothbury	11	152	139	120	171	273	298	221	193	262	268	192	179	205	2468
Avoca	27	144	115	126	160	159	250	171	183	180	211	144	172	169	2015
Ormley	37	180	110	162	197	201	294	206	182	200	214	138	172	188	2256
Fingal	41	192	150	178	196	189	342	220	218	207	219	165	160	203	2436
Mangana	8	195	232	190	212	304	467	282	250	320	291	199	144	257	3086
Cullenswood	30	200	214	285	235	264	456	276	298	244	226	177	216	257	3091
St. Marys	19	238	324	460	277	268	554	341	271	305	250	269	289	320	3846

IV.—GEOLOGY.

(1)—Introduction.

The results of the geological survey are shown in the Geological Sketch Map on Plate I. In this map the various geological formations which outcrop at the surface, are indicated, and the boundaries between these formations are shown.

The oldest rocks occurring within the district are the slates and sandstones (Mathinna series) of the Cambro-Ordovician system. These rocks are intruded by granite of Devonian age. Sedimentary strata of the Permo-Carboniferous and the Trias-Jura systems overlie the above rocks. Diabase of Mesozoic age intrude the above. Gravels, grits, sands, and clays occur along the valley of the South Esk River and tributaries and also in the Midlands, and are regarded as being of Lower Tertiary age. Tertiary basalt overlies these Lower Tertiary sediments. Upper Tertiary to Recent sands and alluvium have been formed overlying the basalt and along the courses of the present streams respectively.

(2)—The Sedimentary Rocks.

(a) *The Cambro-Ordovician System.*

The rocks of this system consist of slates, sandstones, and quartzites. The slates which outcrop at the surface are light buff-coloured varieties, but at depth they are very dark in colour. They are thinly laminated parallel with the bedding planes. The sandstones have been largely altered to quartzites, which, as in the case of the slates, are light-coloured near the surface and darker at depth. The lighter colour of the rocks near the surface is due to alteration by superficial weathering.

The rocks of this system occupy a considerable tract of country to the north and west of Fingal. To the north they extend through Mangana, Tower Hill, and Mathinna, and thence to Alberton. To the west they extend towards Ben Lomond, while to the south-west a narrow tract extends to Avoca and to portions of the St. Paul River valley. Another area occupied by these rocks is that to the north, east, and south-east of St. Marys.

The general strike of these strata is from north-north-west to south-south-east. The dips are at high angles, and in both easterly and westerly directions. It is evident that the strata are highly folded into anticlines and synclines. The complete structure was not worked out on this examination, but could be by a more detailed examination of the areas occupied by these rocks. One main line of folding and faulting occurs to the west of Fingal, and is probably continuous with that reported at Mangana.

No fossils have been found in these rocks in north-eastern Tasmania, so that their age cannot be definitely fixed. Lithologically and structurally they are similar to Cambro-Ordovician strata in other parts of Tasmania, and are especially similar to the Ordovician rocks of Victoria. For the present, they are referred to the Cambro-Ordovician system.

(*b*) *The Permo-Carboniferous System.*

The rocks of this system consist of shales, mudstones, sandstones, and limestone, with one or two thin coal seams. There are many intermediate types between the above, and the impure sandy shales and mudstones form the bulk of the system. The sandstones are normal quartz sandstones, and are similar in appearance to the Ross sandstones of the Trias-Jura System. The limestones are light grey, dense types, highly fossiliferous, and form a band 80 to 100 feet thick.

These rocks occupy several areas in the Avoca-St. Marys district. The most western is that along the St. Marys to Swansea road, and it extends to the south and south-east beyond the country examined. The same rocks outcrop along the Break-o'-Day Plain and on the southern flanks of the Mt. Nicholas Range and portions of the northern flank of the Fingal Range. Another area is that between the St. Paul River and the South Esk River in the vicinity of Avoca. Similar rocks occur on the northern side of the South Esk River and the flanks of Ben Lomond.

These strata are generally horizontally bedded or dip at low angles up to 10°. The full thickness of the strata of this system is exposed in the district, and amounts to 400 to 600 feet. The basal members consist of conglomerates of varying degrees of coarseness. These pass up through coarse quartz grits into normal quartz sandstones. The thickness of these basal beds varies, and, while in adjacent areas it ranges up to 200 feet, about 50 to 100 feet is the average thickness within the district. In the upper part of these sandstones one or two thin seams of coal occur. Two seams outcrop in the gullies at the head of Wardlaw Creek on the southern flank of Mt. Elephant. One seam is reported in the Harefield bore at a distance of 74 feet above the base of the Permo-Carboniferous strata. It is impossible to state whether these coal seams are on the Greta horizon, as are the seams in the lower portion of the Permo-Carboniferous in other parts of Tasmania.

The impure shales and mudstones, with the interbedded limestones, succeed the sandstones. These rocks are highly fossiliferous, the typical genera of the Permo-Carboniferous period such as fenestella, protoretepora, spirifer, &c., being present. The limestone zone is 140 feet thick in the Harefield bore, and is 177 feet above the base of the Permo-Carboniferous system. In the Killymoon bore the limestone is 133 feet thick, and is 250 feet above the base of the system. It would appear that these fossiliferous shales and limestones are analogous with similar beds elsewhere in Tasmania, which are referred to the Lower Marine series. Generally in Tasmania the coal seams occur above the Lower Marine series (including the limestone), whereas in this district the coal seams are below the limestone. There are two possible explanations of these relations. Firstly, the shales and limestones may represent the Lower Marine series, or even a complete sequence from the Lower to the Upper Marine series, and the coal seams may represent an horizon below the Greta and one not yet recognised elsewhere in Tasmania. Secondly, the coal horizon may represent the Greta, the underlying Lower Marine series being absent, and the overlying fossiliferous shales representing the Upper Marine series.

The basal members of this system overlie the Cambro-Ordovician rocks and the Devonian granite with a marked unconformity. The summit of the system is distinguished by the basal conglomerates of the Trias-Jura system which overlie the Permo-Carboniferous, either conformably or disconformably.

These rocks have been referred to above as belonging to the Permo-Carboniferous System. The above field relations prove the system to be post-Devonian and pre-Permo-Carboniferous. The fossils found in these rocks indicate that they are analogous to the Permo-Carboniferous rocks of Eastern Australia, and they are therefore referred to this age.

(c) *The Trias-Jura System.*

The rocks of this system consist of conglomerates, grits, sandstones, felspathic sandstones, and mudstones, with interbedded coal-seams. The conglomerates and grits consist of pebbles and grains of quartz. The sandstones are the normal quartz sandstones of the Ross sandstone series so often described from Eastern Tasmania. The felspathic sandstones consist chiefly of decomposed felspars, with smaller amounts of quartz, mica, &c. The mudstones vary in colour from light buffs and greys to dark greys and blacks.

These rocks occur at separated areas throughout the district, being most plentiful in the western portion thereof, The largest area exposed is that on the southern flanks of the Mt. Nicholas Range. Other areas are those at Mt. Elephant, south-east of Harefield Rivulet, on the northern flanks of the Fingal Range, on the flanks of St. Paul Dome, and along the valley of the St. Paul River. In the south-western parts of the district, around Ross and Campbell Town, small and isolated areas of these rocks also occur.

The strata are either horizontally bedded or dip at very small angles up to 10°, the usual dip being below 5°.

The basal members of the Trias-Jura system in Tasmania consist of conglomerates and grits, which pass up into sandstones of the Ross series. These beds are not conspicuous in the St. Marys-Fingal area, being 200 feet, and even less, in thickness. There is a considerable thickening towards the Midlands, in the southern portions of which up to 700 feet of the Ross sandstones occur. The Ross sandstones are overlain by 700 to 800 feet of the felspathic sandstone series, containing eight coal seams. These are, in turn, overlain by 200 feet of the Upper Sandstone series on the Mt. Nicholas Range. The total thickness of the system is, therefore, 1000 to 1200 feet.

The felspathic sandstone series yield an abundance of fossil plants, containing such genera as cladophlebis, thinnfeldia, phoenocopsis, &c. Owing to an admixture of Triassic and Jurassic forms, the system has been referred to as Trias-Jura, but a recent examination by Dr. Walkom (1) has enabled a more precise determination to be made. Thirty-three specimens occur in the Tasmanian flora, and seventeen of these are found in other floras in Australia.

---

(1) Walkom, A. B., D.Sc.: Notes on some Tasmanian Mesozoic Plants, Parts I. and II., Proc. Roy. Soc., Tas., 1924 and 1925.

Of the latter, thirteen species occur in the Ipswich series of Queensland, which is of Upper Triassic age. The Tasmanian rocks are correlated with the Ipswich series, and regarded as being of Triassic age.

(*d*) *Tertiary Era.*

A more or less continuous series of deposits have been formed in the Midlands and the valleys of some of the present streams, from the Lower Tertiary to the Recent times. In some parts of the district it is difficult to refer the deposits to their correct periods, and so they have all been mapped as Tertiary, the only exception being the alluvium of Recent origin. In the following descriptions the Tertiary basalt has been used as a reference horizon.

Lower Tertiary (*Pre-Basaltic*).—Basalt occurs along the valley of the South Esk River from Avoca westwards, and also in a large portion of the Midlands. At some localities the present streams have corroded their courses through the basalt and exposed underlying Tertiary beds. Exposures of these beds are not numerous, but it is evident that such beds underlie practically the whole of the area covered by the basalt flows.

The most easterly of these exposures is on the south side of the St. Paul River, adjacent to the bridge, three miles from Avoca, on the road to Royal George. A road cutting at this point shows basalt overlying impure and iron-stained sands the under-surface of the basalt dipping to the south. Another good exposure is in a cliff face, two miles up-stream from Llewellyn, where 30 feet of basalt overlies 40 feet of sands, clays, and fine gravels. A similar section is exposed 1½ miles west of Llewellyn, on the south bank of the South Esk River. Several feet of sands and white clays are exposed below the basalt in the deep ditch on the east side of the main road, one and a half miles south-east of Conara.

In parts of the district, such as that between Fingal and St. Marys, where basalt is absent, it is impossible to state whether Lower Tertiary beds occur owing to the covering of later sediments, although it is probable that they exist underlying the latter.

No fossils have been found in these sediments, but on general lithological and structural grounds they are referred to the Tertiary era. They represent the southern extension of the beds of the Launceston Tertiary basin. In common with other deposits in districts such as Ringarooma Valley, Sassafras, Waratah, Hobart, Richmond, &c., where they are overlain by basalt, the latter is regarded as closing the Lower Tertiary era, and the underlying sediments are referred to as Lower Tertiary.

Upper Tertiary (Post-Basaltic).—Throughout the Campbell Town and Conara areas the basalt is generally overlain by a small thickness of unconsolidated rocks. These consist chiefly of loose quartz sand. At some localities impure oxides of iron are largely developed, and have probably been formed by decomposition of the underlying basalt. To the north of Conara these beds extend and form the upper portion of the sediments of the Launceston Tertiary basin. In the above part of the district the beds have a maximum thickness of 40 to 70 feet, but the existing thickness is much less due to denudation.

Similar deposits, but of less thickness, extend up the valley of the South Esk, and also up the valley of the St. Paul River. They are prominent to the east of Avoca and on the Benham Plains.

From a point about four miles upstream from Avoca basalt is not found in the valley of the South Esk River. It is, therefore, difficult to separate the Upper and Lower Tertiary beds in the Fingal and St. Marys areas. There was probably a more or less continuous deposition throughout these areas, and both series are probably present.

Around St. Marys the problem is even more difficult. Here the numerous small creeks have added their quota of gravels, &c., often containing pebbles of diabase, right up to recent times.

The beds overlying the basalt are regarded as Upper Tertiary as the basalt is generally referred to as closing the Lower Tertiary age. It is probable that the basalt does not represent any long interval separating the two periods of deposition, but that the two periods merely represent slightly disconnected portions of the same one. The upper limit of the Upper Tertiary era cannot be satisfactorily determined.

(e) *Recent.*

Recent river alluvium and gravels have been formed along the courses of the present streams. The alluvium is the typical black type common along streams. The gravels contain pebbles and boulders of the harder rock types, such as diabase and Cambro-Ordovician quartzites. These Recent deposits are not very thick, but cover fairly wide areas along the valleys of the major streams.

(3)—The Igneous Rocks

(a) *Devonian.*

Granite outcrops over a small area in the vicinity of Avoca, but is more plentiful immediately to the north of this township. It occurs chiefly to the north of the South Esk River, and to a less extent between the South Esk and St. Paul River, and along the valley of the latter.

The granite is a coarse-grained, holocrystalline rock, composed essentially of felspar, quartz, and mica. It is generally even in grain, but frequently the felspar is porphyritic. The porphyritic felspar appears to be chiefly plagioclase, though orthoclase has been reported from the Ben Lomond area. The quartz is the clear, glassy variety usually found in granites. Biotite is the usual mica present, but it is rather less in amount than in the average granitic rocks. The biotite was the first mineral to crystallise, and, as is common in the granites of north-eastern Tasmania, numerous flakes are included in the porphyritic felspar crystals. The rock is generally referred to as granite, but it is probable that the plagioclase exceeds the orthoclase felspar, and that the rock should be termed a granodiorite, or an intermediate type (adamellite) between the above two types.

The bodies of granite represented by the separated outcrops would join at no great depth and form one main body which, in itself, is an outlying portion of the batholith of north-eastern Tasmania.

The granite intrudes the Cambro-Ordovician rocks, and has metamorphosed them at and near the contact, and is therefore younger than them. To the north of the South Esk, and on both sides of the St. Paul River valley, the basal beds of the Permo-Carboniferous System overlie an eroded surface of the granite. The granite is, therefore, post-Cambro-Ordovician, and pre-Permo-Carboniferous. In common with other granites in Tasmania, it is regarded as being of Devonian age, the intrusions having accompanied the period of diastrophism at the close of the Silurian sedimentation.

(b) *Mesozoic.*

Diabase occupies a considerable extent of the surface of the district. This rock is a medium to coarse-grained type, consisting essentially of plagioclase felspar and augite. It is similar in every respect to the typical diabase found elsewhere in Tasmania, and needs no further description.

The intrusions assume several forms within the district. The diabase on the Mt. Nicholas Range has been shown [2] to be in the form of a sill, while that on Mt. Elephant probably also assumes this form. The diabase capping Ben Lomond, and certain bodies in the Mt. Christie and Merrywood areas of the Avoca coalfield, are also in the form of sills [3]. The diabase of the Fingal Tier, between St. Marys and Avoca, is in the form of a large transgressive body, as is also that extending from Avoca towards Conara, and then southerly as the Eastern Tiers. The diabase along the Macquarie River is also in the form of transgressive bodies.

Evidence of the intrusive nature of the diabase is afforded by the metamorphism of the Trias-Jura sandstones at the contact with the diabase. Such alteration is evident on the hills to the south-east of the St. Marys road, two miles from Fingal, and also on the south side of the Elizabeth River, two miles west of Campbell Town.

The diabase is intrusive into the rocks of all systems up to, and including that of, the Trias-Jura, but reaches its maximum development in the Permo-Carboniferous and Trias-Jura Systems. It is, therefore, later than these systems, and is post-Trias-Jura. In the Midlands the Lower Tertiary sediments, basalt, and Upper Tertiary sediments lie on an eroded surface of diabase, which, in some localities, projects as islands above them. The diabase is there pre-Tertiary in age. The above two limits fix the age as Middle or Upper Mesozoic. It is probable that the cessation of the Trias-Jura sedimentation, the elevation and faulting of these strata, and the intrusion were more or less contemporaneous events. If this is so, and the age of the Trias-Jura is Triassic, as recently determined by Walkom [4], then the diabase may be regarded as having been intruded at the close of the Triassic period. Such a view would bring it into line with other dolerites and diabases, which, in South Africa, South America, and North America, intruded Mesozoic strata at, or just after, the close of the Triassic period.

---

[2] Reid, H. G. W.: The Nicholas-Fingal-Dalmayne Coalfield; Tas. Geol. Surv. Mineral Resources No. 7, p. 31, 1922.

[3] Reid, A. M.: The Avoca Coalfield; Tas. Geol. Surv. Mineral Resources No. 7, 1922.

[4] Walkom, A. B., D.Sc.: Notes on some Tasmanian Mesozoic Plants, Pts. I. and II.; Proc. Roy. Soc., Tas., 1924 and 1925.

(c) *Tertiary.*

Basalt occupies a considerable portion of the surface of the Midlands between Ross and Cleveland, and also extends up the valleys of the South Esk and St. Paul Rivers for a few miles above Avoca.

It is a light-coloured, fine-grained type, and is generally somewhat vesicular. A microscopic examination ([5]) of a specimen from between Ross and Tunbridge proved the rock to be a normal basalt consisting essentially of plagioclase felspar and augite.

The basalt which outcrops represents parts of one large extensive flow which filled an ancient valley in the Midlands. This valley is not coincident with that of the present Macquare River, but is parallel to it, and to the east thereof. To the south of the district under review, and in the vicinity of Mona Vale, the two valleys coincide, the basalt outcropping along the present Macquarie River. It is evident that the basalt flows filled the valley of the former Macquarie River, or its estuary where it entered the lake of the Launceston Tertiary Basin, which was situated several miles to the east of its present position.

The average thickness of the basalt is 100 feet throughout the Midlands. The basalt is thickest in the area to the east-north-east of Campbell Town. In this latter area it also rises to heights of 1500 feet above sea-level, whereas on the plains its general elevation is 700 to 800 feet. It is obvious from the field occurrences that part at least of the flows of the Midlands originated in this area. Fissure irruptions occurred in the valley of the Elizabeth River of those times, and the lava from them flowed down it to the west and entered the lake, or an estuary thereof, of the Launceston Tertiary basin. At the same time these basalt flows filled up the valley of the river and diverted it to its present course, several miles to the south of the original one.

The basalt overlies the rocks of all ages up to, and including, those of the Lower Tertiary era, and is overlain by a small thickness of sediments which have been referred to the Upper Tertiary era. In common with other districts in Tasmania, where basalt overlies Lacustrine sediments, the latter are regarded as of Lower Tertiary age, and the basalt as closing the Lower Tertiary era.

([5]) Nye, P. B.: The Underground Water Resources of the Midlands; Tas. Geol. Surv. W. S. Paper No. 1, p. 66, 1921.

(4)—Metamorphic Rocks.

The largest development of metamorphic rocks are those of the Cambro-Ordovician system at their junction with the Devonian granite. The original clays and sands of these rocks were altered by consolidation and regional metamorphism to shales and sandstones, but at the contact with the granite the contact metamorphism has further altered them to quartzites and phyllites. The latter alteration is particularly developed to the east of Avoca and along the south side of the valley of the St. Paul River.

The diabase has also produced metamorphic rock types by the contact metamorphism at its junctions with the Permo-Carboniferous and Trias-Jura strata. Some of these types have already been described above.

The Tertiary basalt flows have metamorphosed the immediately underlying rocks, but no exposures of such types were available.

(5) Structural Geology.

(a) *General.*

The basement rocks of the district are those of the Cambro-Ordovician system. These were highly folded and intruded by granite of Devonian age. Before the commencement of the Permo-Carboniferous period the land surface composed of the above rocks was reduced to a peneplain, with the granite occupying part of the surface. On this peneplained surface the sediments of the Permo-Carboniferous and Trias-Jura periods were deposited. Large intrusions of diabase occurred into the above, particularly the horizontally-bedded Permo-Carboniferous and Trias-Jura strata. Associated with these intrusions there occurred extensive faulting and movements of relative elevation and depression. These movements affected the equality of the surface of the peneplain and its covering of horizontally-bedded strata, large blocks being raised or lowered to different levels. A drainage system was then established similar to the present one, the initiation of it being largely determined by the faulting and displacements of the faulted blocks. Following a long period of denudation a relative depression of the land resulted in the Lower Tertiary deposits being formed in the lake of the Launceston Basin and along the valleys of the present river system. Tertiary basalt flows covered the greater part of these sediments to a depth of 100 feet, and were, in turn, covered by a thin depth of Upper Tertiary sediments.

(*b*) *Folding.*

The Cambro-Ordovician strata are the only ones which have been subjected to earth-movements causing folding. They have been folded into a number of anticlines and synclines, the general strike of the axes of these folds being from north-north-west to south-south-east.

(*c*) *Faulting.*

The majority of rocks, especially those of the Lower Palæozoic, Upper Palæzoic, and Mesozoic eras, have been subjected to faulting. It is very difficult to detect in the Cambro-Ordovician rocks, particularly that associated with the folding of the rocks. These rocks, and also the granite intrusive into them, have also been affected by a part of the extensive block faulting which is apparent in the Permo-Carboniferous and Trias-Jura systems. Most, if not all, of this latter faulting was associated with the intrusions of the Mesozoic diabase, and it has, together with the subsequent erosion, been the principal determining factor of the present topography. The most important fault is that already described by A. M. Reid ([6]) on the south-western side of Ben Lomond. This fault has a direction from north-west to south-east, and a downthrow on the flanks of Ben Lomond of 2000 feet to the south-west. A branch fault should leave the above between Ben Lomond and the South Esk River and encircle Ben Lomond to the east, passing between this mountain and Tower Hill.

Another large fault occurs to the north of Fingal. It has a general north to south direction, and is parallel to the South Esk River for several miles of its course. This fault does not appear to extend either to the south or west of Fingal, but part, at least, of the displacement represented by it, is taken up by the diabase of that vicinity. It would appear, too, that this displacement follows the line of the diabase to the south-west, being parallel to, but one to three miles to the south-east of, the South Esk River. In this south-westerly continuation it would junction with the Ben Lomond fault described above. The total displacement of this fault is not known. On the

([6]) Reid, A. M.: The Avoca Coalfield; Tas. Geol. Surv.; Mineral Resources No. 7. p. 202, 1922.

two sides of the diabase immediately to the west of Fingal there is a downthrow of 400 to 700 feet to the east. It is possible that this does not represent the total downthrow of the fault, and a branch fault may traverse the valley of the South Esk River to the south-west, with a downthrow to the south-east.

Keid (7) shows two parallel faults crossing the Mt. Nicholas Range and extending to the south-south-east. The western one of these two—the Silkstone fault—crosses the railway to the west of Mt. Nicholas station, but it is difficult to locate it on the Break-o'-Day Plain. The eastern, or Cornwall, fault passes through St. Marys and continues in a south-easterly direction parallel to the Swansea road, and one mile to the south-west thereof. On the southern fall of the Mt. Nicholas Range this fault, after its junction with the Gould fault, has a downthrow of 500 feet (8). Near the Harefield bore, however, the downthrow must be 700 to 800 feet to the south-west. It is probable that a fault branches off this Cornwall fault to the north of the Harefield bore, and has a general east-west trend, connecting either with the diabase to the south-west of Cullenswood station, or, perhaps, with the Silkstone fault.

(d) *Igneous Intrusions and Extrusions.*

Granite.—The granite outcrops chiefly to the north of Avoca, with isolated areas along the St. Paul River valley. These bodies are undoubtedly connected at depth, and the whole forms an outlying part of the batholith of north-eastern Tasmania intrusive into the Cambro-Ordovician System.

Diabase.—As already described above (9), the diabase intrusions assume two distinct forms. Those on the Mt. Nicholas Range, Mt. Elephant, Ben Lomond, and in the Mt. Christie and Merrywood areas assume the sill form, while those of the Fingal Tier and its south-westerly continuation, the Eastern Tiers, and along the Macquarie River, are transgressive bodies.

Basalt.—The basalt of the Midlands and the South Esk and St. Paul River valleys is in the form of thin surface sheets or flows.

---

(7) **Keid, H. G. W.: The Mount Nicholas-Fingal-Dalmayne Coalfield; Tas. Geol. Surv. Mineral Resources No. 7, p. 31. 1922.**

(8) **Keid, H. G. W.: The Mount Nicholas-Fingal-Dalmayne Coalfield; Tas. Geol Surv. Mineral Resources No. 7, p. 31, 1922.**

(9) **See p. 17.**

(6)—Geological History.

(a) *Cambro-Ordovician Sedimentation.*

The geological history of the district, as represented by the rocks at the surface, began with the period of Cambro-Ordovician sedimentation. Beds of clay and sand were deposited under conditions of moderately shallow depths. The basement rocks on which this sedimentation occurred are nowhere exposed.

(b) *Periods of Diastrophism.*

At one or more periods after the deposition of the above sediments they were subjected to earth-movements, involving folding and faulting of the beds. At the same time the beds were consolidated, and eventually altered into shales, slates, sandstones, and quartzites. It is probable that the most important of these periods was that which occurred at the close of the Silurian sedimentation in other parts of Tasmania.

(c) *Devonian Igneous Intrusions.*

After the close of the Silurian sedimentation, and probably contemporaneous with the period of diastrophism, large intrusions of igneous magma occurred throughout Tasmania. In the present district these were of an acidic nature, and the consolidation thereof resulted in the formation of the granitic rock.

(d) *Period of Ore Formation.*

The closing phases of the consolidation of the granitic magma resulted in the passage through, and from it into the intruded rocks, of vapours, solutions, and ore-magmas. These gave rise to the formation of the tin, tungsten, and gold deposits of the district. The tin and tungsten deposits were formed in the granite, and the gold ones in the Cambro-Ordovician rocks.

(e) *Period of Denudation.*

From the close of the Cambro-Ordovician sedimentation until the commencement of the Permo-Carboniferous, the land surface of Cambro-Ordovician rocks was subjected to a more or less uninterrupted period of denudation. Towards the end of this period the granite was exposed at the surface, the overlying cover having been removed, and the whole of the surface reduced to a peneplain.

(f) *Permo-Carboniferous Sedimentation*

Sediments were deposited over the whole of the district in the Permo-Carboniferous period. These were deposited chiefly under marine conditions, but at two or more stages lacustrine or land conditions prevailed during which the coal seams were formed. This sedimentation occurred on the peneplained surface of the granite and Cambro-Ordovician rocks.

(g) *Trias-Jura Sedimentation.*

After a short interval of time the Trias-Jura sedimentation followed that of the Permo-Carboniferous, the beds being deposited on the horizontal ones of the latter system. Several hundred feet of grits and sandstones were first deposited under sub-arid estuarine or lacustrine conditions. These were followed by 700 to 800 feet of felspathic sands and clay beds under lacustrine or terrestrial conditions. Coal seams were formed at 7 or 8 horizons in the series. The felspathic sandstone series were followed by a few hundred feet of sandstones similar to the lower series.

(h) *Mesozoic Diabasic Intrusions.*

At the close of the Trias-Jura sedimentation, diabase intrusions occurred on a very large scale. These intruded the older rocks, but are chiefly developed in the Permo-Carboniferous and Trias-Jura strata.

(i) *Period of Diastrophism.*

Probably contemporaneous with the diabase intrusions extensive earth-movements occurred during which the district was elevated, and faulting took place to a considerable extent. Some of the faulting of the Permo-Carboniferous and Trias-Jura rocks is intimately associated with the diabase intrusions and may not extend into the basement of older rocks.

(j) *Period of Denudation.*

A cycle of denudation began at the close of the above earth-movements, and resulted in the formation of the ancestors of the present streams and drainage system.

(*k*) *Period of Relative Depression of the Land and Lower Tertiary Sedimentation.*

The above faulting and subsequent denudation resulted in the formation of a low-lying tract of country corresponding to the present Midlands. In common with other parts of Tasmania, a relative depression of the land occurred, and the large lake of the Launceston Tertiary Basin formed. Several hundred feet of gravels, sands, and clays, were deposited in this lake, but the thickness cannot be great within the present district, as it was situated at the southern, and probably shallow, extremity of the lake.

(*l*) *Extrusion of Tertiary Basalt.*

At the assumed close of the Lower Tertiary sedimentation, the outbreak of volcanic activity caused flows of basaltic lava to cover the sediments of the lake, and also to partly fill up the valleys of the streams entering the lake. The average depth of the flows was about 100 feet. One of the principal sources of irruption was in the valley of the former Elizabeth River, five miles north-east of Campbell Town.

(*m*) *Upper Tertiary Sedimentation.*

After the basalt flows, lacustrine or fluviatile conditions again prevailed in the Midlands, and a small thickness (40 to 70 feet) of sands were deposited.

(*n*) *Present Cycle of Denudation.*

It is probable that the land was elevated to a slight extent either after the basalt flows or the Upper Tertiary sedimentation, and the present cycle of denudation then commenced. The upper portions of the streams are coincident with those of Lower Tertiary time, but where flooded by basalt, particularly in the Midlands, the present courses are different to those of Lower Tertiary time. This applies especially to the Macquarie River, Elizabeth River, and South Esk River.

V.—ECONOMIC GEOLOGY.

(1)—Introduction.

This examination was carried out to prepare a topographical map of the district, and to deal with the underground water resources thereof. In addition, parts of the district contain deposits of valuable minerals such as tin, gold, coal, &c. These will not be described here, but a list of publications dealing with them will be given below. The underground water resources, possibilities of irrigation, &c., will be dealt with more fully.

(2)—Tin Deposits.

These deposits occur chiefly on the southern flanks of Ben Lomond, and also in the valley of the St. Paul River. The following publications deal with portion or the whole of these areas:—

Thureau, G.: Ben Lomond and St. Paul River, House of Assembly Paper No. 108, 1881.

Montgomery, A.: Report on the Ben Lomond District, Secretary for Mines Report, 1891-92.

Montgomery, A.: Report on the Discoveries of Tin Ore on the Brookstead Estate, Parliamentary Paper No. 125, Secretary for Mines Report, 1892-93.

Montgomery, A.: Report on the Roy's Hill Tin Mine, 1893.

Montgomery, A.: Second Report on the Brookstead Estate Tin Lodes, 1893.

Twelvetrees, W. H.: Report on Some Tin Mines in the St. Paul River Valley, near Avoca, 1899.

Waller, G. A.: Report on the Tin-mining District of Ben Lomond, 1901.

(3)—Tungsten Deposits.

These deposits are associated with some of the above ones of tin, the tungsten being present as wolfram in the tin lodes. The mixed tin-tungsten deposits occur chiefly at Storey's Creek and Gipps Creek, and have been dealt with in the following publications:—

Montgomery, A.: Report on the Ben Lomond District, Secretary for Mines Report, 1891-92.

Waller, G. A.: Report on the Tin-mining District of Ben Lomond, 1901.

Hills, Loftus: Geological Survey Mineral Resources No. 1, Part I., 1916.

(4)—Gold Deposits.

Both alluvial deposits and quartz reefs have been worked for gold at Mangana and Mathinna. Mathinna is a few miles outside the district, and so only the reports for Mangana are given below:—

Gould, Chas.: Gold at Mangana, House of Assembly and Legislative Council Paper No. 20, 1869.

Thureau, G.: Report on the Mt. Victoria, Dan Rivulet, Black Boy, and Mangana Goldfields; also Remarks After Examination of the Tullochgorum Prospecting Area; Parliamentary Paper No. 61, 1885.

Montgomery, A.: Report on Some Portions of the Mangana Goldfield, Secretary for Mines' Report, 1894-95.

Twelvetrees, W. H.: Report on the Strata in the Shaft of the New Sovereign Mine, Mangana, Secretary for Mines' Report, 1899-1900.

Twelvetrees, W. H.: Report on the Abbotsford Creek Gold Mine, 1903.

Twelvetrees, W. H.: The Mangana Goldfield. Tasmanian Geological Survey Bulletin No. 1, 1907.

(5)—Coal.

Coal seams occur along the Mt. Nicholas Range at Mt. Elephant, Fingal, on the flanks of Ben Lomond, and in the St. Paul River valley. The following reports refer to the coalfields, but the lastnamed (the Coal Resources of Tasmania) is the most comprehensive:—

Milligan, J.: Reports on the Coal Basins of Van Diemen's Land, Proc. Roy. Soc. V.D. Land, Vol. I., Part I., 1849.

Selwyn, A. R. C.: Report on the Geological Relations of some of the Coal Seams of Van Diemen's Land, Papers and Proc. Roy. Soc. V.D. Land, Vol. III., Part I., 1855.

Gould, Chas.: Coalfields (Fingal and East Coast), House of Assembly Paper No. 9., Legislative Council Paper No. 7, 1861.

Thureau, G.: Report on Fingal and Mt. Nicholas Coal Deposits, House of Assembly Paper No. 90, and Legislative Council Paper No. 91, 1883.

Twelvetrees, W. H.: Report on Coal Seams at Thornedale, near Thompson's Marshes, and the Jubilee Colliery, near St. Marys.

The Geological Survey of Tasmania: Mineral Resources No. 7, the Coal Resources of Tasmania, 1922.

(6)—Underground Water-Supply.

(a) *Introduction.*

The general factors in connection with the occurrence, development, and use of underground water have been fully described and discussed in previous reports ([10]). Repetition of these is unnecessary, and so this part of the present report will be devoted to a brief description of the formations and areas in which underground water will be likely to occur. Further, a summary of the results already obtained by boring for underground water will be given.

The district is generally well watered owing to the number of fairly large streams which traverse it. The most important are the South Esk River, Macquarie River, Elizabeth River, St. Paul River, and the Break-o'-Day River. The tributary streams are, however, very small, and contain only a small amount of water, and become dry in the summer and other dry periods. Thus, while the localities near the large, permanent streams have plentiful and certain water supplies, those distant from these streams have uncertain supplies. In some of the latter supplies of underground water occur and would provide permanent supplies if developed.

(b) *Rocks and Formations Likely to Contain Underground Water.*

Underground water is derived chiefly from the rainfall on the earth's surface, and the important factors in determining its existence, or otherwise, are the nature of the rocks in any district and the geological structure thereof.

The rocks must be those capable of containing, and also allowing the passage of, considerable quantities of water, or, in other words, they must be porous and permeable. The geological structure must be such that the porous and permeable beds outcrop at the surface so that they may receive water directly from the rainfall, and from streams

([10]) Nye, P. B.: Tas. Geol. Surv., U.G.W.S. Papers Nos. 1, 2, and 3.

flowing over them. The quantity and nature (artesian, sub-artesian, &c.) of the supplies are dependent on the structure, and also the topography, of the district.

The porous rocks within the district under review are numerous and varied, and include the following:—Recent alluvium and gravels, Upper Tertiary sands, Lower Tertiary sands, Ross sandstones of the Trias-Jura System, and the felspathic sandstones of the same system. Little or no water will be obtained from the Permo-Carboniferous rocks, the Cambro-Ordovician rocks, and the igneous rocks—granite, diabase, and basalt. The basalt may contain slightly larger supplies than the other rocks just referred to. In the granite and diabase small supplies may be obtained from the joints therein, and any superficially decomposed portions.

(c) *The Underground Water Basins.*

The occurrence of the above porous rocks, and the geological structure of the district containing them, may be such that underground water may be present over a considerable area. Each of these areas may be described as a "basin," and they will be briefly described below.

(i.) The Macquarie River Basins.

The Macquarie River has a general north-westerly course from Ross, and flows for the most part through diabase. Small areas of more or less porous rocks are present in the valley. To the north-west of Ross, a considerable tract of Recent alluvium, and, probably, Tertiary, sediments occur on a bedrock of Permo-Carboniferous rocks and diabase.

Further to the north-west, near the Morningside Bridge, a small area of Trias-Jura sandstones exists. The sandstones should yield a small supply of water at depths up to 100 feet.

Still further to the north-west the valley opens out, and wide plains of Recent alluvium and Tertiary sands occur. Supplies of water should be obtainable from these formations, particularly towards the river and less likely on the flanks of these formations.

(ii.) The Ross-Campbell Town-Conara Basin.

This basin includes all the country along the main road and railway line between the above townships, which is shown on the geological map as being occupied by Upper Tertiary sediments, basalt, or Lower Tertiary sediments.

The Upper Tertiary sands occur in some parts of this basin as thin layers overlying the basalt. Small supplies of water are likely from these, but probably could not be depended upon in long periods of dry weather.

The basalt filling the valley of the former Macquarie River is 100 feet or more in thickness. Small quantities of water would probably be obtained from the basalt. The water would occur in fissures, joints, and vesicles in the rock.

The largest and most dependable supply of water would probably be obtained from the Lower Tertiary sediments below the basalt. This would apply particularly to any sandy beds met with in these sediments. In some parts it might be difficult for the rain water to percolate through the basalt into the underlying rocks, but this would apply more to the western portion of the basin.

(iii.) The Llewellyn-Ormley Basin.

The valley of the South Esk River, between Llewellyn and Ormley, consists generally of a long and narrow plain, bounded on the north and south by steeply rising hills. The hills are composed of diabase, granite, and Cambro-Ordovician slates and sandstones. The narrow plain is composed of Lower Tertiary sediments overlain by 20 to 40 feet of basalt, which is, in places, overlain, in turn, by a small thickness of Upper Tertiary sediments. Recent alluvial deposits occur along the courses of the South Esk, St. Paul River, &c. The probabilities of obtaining supplies underground in the Upper Tertiary sands, the basalt, and the Lower Tertiary sediments, are similar to those in the case of the Ross-Campbell Town-Conara basin.

(iv.) St. Paul River Basin.

The St. Paul River, between Avoca and Leipsic, has a fairly wide and open valley, bounded by fairly steep hills.

The plain tract along the course of the river is composed of Recent alluvium, Upper Tertiary sands, basalt, and Lower Tertiary sands and clays. The probabilities of obtaining water in these rocks are the same as discussed above for the other basins.

(v.) The Ormley-Fingal Basin.

A narrow plain, averaging about one mile wide, occupies the valley of the South Esk River, between Ormley and Fingal. Recent alluvial plains cccur along practically the whole length of the river in this tract of country. Tertiary deposits, ranging in age from Lower to Upper, form the remainder of the plain, and extend to the bordering foothills of diabase or Cambro-Ordovician slates and quartzites.

Supplies of water should be available in these Tertiary and Recent deposits. At localities near the river such supplies would not be required, as a plentiful supply could be obtained from the stream. The closer the approach to the foothills bounding the valley, the less chance there is of obtaining supplies.

(vi.) The Fingal-Mathinna Basin.

An extensive plain extends along the South Esk River, between Fingal and Mathinna. It has a width ranging from one to four miles, and averaging between two and three miles. The hills bounding this plain are composed chiefly of Cambro-Ordovician slates and sandstones. The plain is formed of Tertiary sands and gravels, but these have been largely modified along the course of the South Esk River and extensive alluvial flats formed. Supplies of underground water should be obtained in these Recent and Tertiary deposits at shallow depth. Such supplies are, of course, not likely to be utilised near the river, but may be made use of further away.

(vii.) The Fingal-St. Marys Basin.

The wide and open Break-o'-Day Plain extends from St. Marys to Fingal along the course of the Break-o' Day River. It ranges in width from two to five miles, with an average of nearly three miles.

The southern side of the plain is formed of diabase, with isolated areas of Trias-Jura sandstones on its flanks. The northern side is formed by the Mt. Nicholas Range, composed principally of Trias-Jura sandstones, protected by a capping of diabase.

The plain is composed of numerous formations from Recent to Permo-Carboniferous in age. The Permo-Carboniferous rocks (mudstones and limestones) form the bedrock of practically the whole of the plain, and outcrop from Fingal to Mt. Nicholas siding. Trias-Jura sandstones form the bedrock in the eastern part near St. Marys. Isolated areas of diabase occur at a few places. Tertiary to Recent deposits occupy a large proportion of the surface of the plain in the form of shallow layers.

Supplies of underground water should be available in some of the above rock formations. The Recent and Tertiary formations should yield supplies at shallow depths. The Trias-Jura sandstones should also yield supplies, but probably at greater depths (up to 100 feet). It is uncertain as to whether supplies could be obtained from the Permo-Carboniferous rocks.

(*d*) *Results obtained by Boring.*

During the past five years, geological surveys have been made of the Midlands south of Ross, and the adjacent districts to the south thereof. The principal object of these was to determine the existence or otherwise of supplies of underground water, and it was concluded that small basins existed in numerous localities throughout these districts. In 1922 the Mines Department purchased a Victorian drilling plant suitable for putting down wells in these basins. Advantage has been taken of the drilling plant, and numerous landowners between Nala and Tunbridge have had wells sunk for water. Altogether eight wells have been put down for the purpose of obtaining water supplies, and all have been successful. The quantity and quality of the water are different in the respective wells, and full information is given in the tables below. It is to be noted the quality ranges from 136 to 700 gallons per hour, or 3200 to 16,800 gallons per day. The quality has been determined by the formulæ and principles given in previous reports ([11]). The waters are generally suitable for providing supplies for stock, and this represents the most important use of the water. A few are suitable for drinking and household purposes, but the remainder are useless for this purpose. The quality for irrigation purposes ranges from fair to bad, and with those of poor and fair quality care would have to be exercised in the selection of the soil and the drainage thereof.

([11]) Nye, P. B.: Tas. Geol. Surv., U.G.W.S. Papers Nos. 2 and 3.

The bore-holes referred to in the tables are numbered as follows:—

I. Nala Railway Station.
II. Mr. A. F. Burbury's property, "Glenmorey," Woodbury.
III. No. 1 Bore, Mr. H. P. Hood's property, "The Braes," Woodbury.
IV. No. 2 Bore, Mr. H. P. Hood's property, "The Braes," Woodbury.
V. Burbury Bros.' property, "Saltpan," Woodbury.
VI. Mr. H. E. R. Oldmeadow's property, "Lowes Park," Woodbury.
VII. No. 1 Bore, Mr. C. E. Triffitt's property, Tunbridge township.
VIII. No. 2 Bore, Mr. C. E. Triffitt's property, Tunbridge.

TABLE No. 2.

Analyses of the Waters.

(Quantities expressed in parts per million.)

Constituent.	Sample.							
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Total Solids	686·43	1675·29	5196·45	2468·0	1680·03	924·07	1036·02	2592·06
Calcium (Ca)	71·19	135·57	446·93	154·29	51·43	68·54	56·80	128·58
Magnesium (Mg)	25·42	54·76	266·40	96·15	129·29	43·56	34·85	100·00
Sodium (Na)	134·88	427·23	984·23	494·72	333·15	132·43	169·14	630·01
Ferric oxide (Fe_2O_3) and Alumina (Al_2O_3)	14·71	11·00	139·99	80·00	28·0	11·14	72·14	60·00
Silica (SiO_2)	20·86	33·00	...	36·00	12·00	56·07	328·00	124·00
Chloride (Cl)	207·98	658·77	2672·01	1047·74	689·16	344·15	172·57	1142·88
Sulphate (SO_4)	20·56	45·26	123·45	61·71	24·72	17·72	21·30	98·76
Carbonate (CO_3)	156·40	...	297·20	198·72	214·58	92·83	170·00	247·79
Bicarbonate (HCO_3)	...	629·95	...	...	...	...	...	...
Volatile Matter	35·14	...	66·00	310·72	176·86	143·30	10·15	63·86

All analyses were carried out in the Mines Department Laboratory, Launceston.

The above determinations include both suspended and dissolved mineral matter, as these were not separated, but the amount of suspended matter is, however, relatively small.

TABLE NO. 3.

Details of Wells and Quantity and Quality of Waters.

Bore.	Depth of Well.	Quantity in Gallons.		Quality for		
		Per Hour.	Per Day.	Drinking and Household.	Watering Stock.	Irrigation.
	Feet.					
I.	120	200	4800	Good to fair	Good	Fair
II.	150	150	3600	Poor to bad	Good	Poor
III.	310	136	3264	Bad	Fair to bad	Bad
IV.	150	360 +	8640 +	Poor	Satisfactory	Poor
V.	100	600 +	14,400 +	Poor	Satisfactory	Poor
VI.	100	700 +	16,800 +	Good	Good	Fair
VII.	34	600 +	14,400 +	Good	Good	Fair
VIII.	100	200	4800	Bad	Satisfactory	Poor

(7)—Factors Connected With Closer Settlement of the Midlands.

(a) *Introduction.*

The chief obect of the investigation was to prepare a topographical map of the district similar to those embodied in previous geological reports ([12]) on the Midlands. This map together with the previous ones are required for the purpose of preliminary consideration of the questions of closer settlement and irrigation of suitable parts of the Midlands. General information in connection with soils and other information relating to irrigation had also to be obtained. The various factors affecting the above questions will be discussed separately below.

(b) *Topographical Considerations.*

A topographical map of the Midlands district from Oatlands to Conara is given in Plate II. This includes all the country which could be considered to come within the scope of irrigation schemes in which the water would be obtained from the Macquarie River or Lakes Sorell and Crescent and the Blackman's River. It also includes all the land which, in conjunction with the irrigation schemes, might be utilised for the purposes of closer settlement.

This plan has been prepared with the aid of the lands charts of Somerset Nos. 1 and 2. The topographical features have been largely added to, and the local names of the most important of them adopted. Contours are drawn on the map at intervals of 100 feet, and further illustrate the topographical features. These contours are based on altitudes determined by aneroid barometer, the datum points used being the stations along the main line railway.

The general factors essential in areas that are to be irrigated are that it should be possible to distribute the water by a simple system of main and subsidiary channels, and, further, that it should be possible to easily and efficiently spread the water over large areas from these channels. The topographical features necessary to comply with these factors are large areas of plain country with sufficient and suitable slopes for the distribution of the irrigating water. Such areas are represented on the map

([12]) Nye, P. B.: Tas. Geol. Surv., U.G.W.S. Papers Nos. 1, 2, and 3.

by portions in which the contours are widely spaced. An inspection of the map shows that areas of this description occur only from Woodbury northwards throughout the Midlands. The whole of this tract of country does not conform to these conditions. Many small regions of hilly and broken country exist, and the intervening regions of plain-like country are limited in extent, and more or less separated from one another. Several of these latter regions exist, and will be described, together with the soil on them, below.

(c) *Soils.*

(i) Introduction.

In making the present investigation it was requested that general information should be obtained about the soils. As a result of this, and a previous examination of the Midlands ([13]), such information is available, and will be given below. It must be remembered that such does not represent the results of a complete and detailed soil survey. Such a survey would, in itself, involve several months' field investigation.

Soils, however, are direct results of certain definite geological processes, and are formed from the underlying rock formations. The geological maps accompanying this report, and a previous one ([14]), will, therefore, indicate, in a general and fairly satisfactory manner, the soils of the Midlands. Further, a description will be given below of the typical soils derived from the various rock types and formations, which will, together with the above maps, furnish a general idea of the soils of the Midlands. These descriptins will not include every type of soil, because even on one rock formation they will vary slightly from point to point. Further, there will be all gradations from one type of soil to another, *e.g.*, in the case of a diabase hill with sandstones on the flank and an alluvial flat further away from the hills, there will be a typical diabase soil on the hill which will pass through various transitional types to a sandstone soil on the sandstones, which will, in turn, pass through various intermediate types on to the typical black alluvial soil. However, the greater part, especially as regards area, of the soils will be included in these descriptions.

([13]) and ([14]) Nye, P. B.: Tas. Geol. Surv., U.G.W.S. Paper No. 1, 1921.

(ii) Diabase.

This soil is formed directly from the weathering of the diabase rock. It is generally a dark-coloured, brownish to reddish soil. The decomposition products of the felspar and augite in the rock are generally of a clayey nature, so that the soil is heavy and sticky when wet, and hard when dry. The diabase is very resistant to the weathering agencies, and it decomposes and so gives rise to soil at a very slow rate. This rate is very little, if any, faster than the rate at which the soil can be removed by the agents of denudation, so that only a very thin layer of soil accumulates. Thus, areas occupied by diabase are generally rocky and covered by only a small thickness of soil, and very little agriculture can be carried out on such areas. Under suitable conditions, such as at the foot of the diabase hills, or a low-lying and level diabase area, a greater thickness of soil will accumulate, and it is then often used for agricultural purposes. The only area in the Midlands where such a depth of soil exists is that to the south and south-east of Tunbridge. Under such conditions it forms a very fair to good soil, particularly when it has been well worked.

Diabase occupies a considerable portion of the surface of the Midlands, including almost all the hills and mountains, so that such portion is almost entirely useless for agricultural purposes, and is suitable only for grazing.

(iii) Basalt.

Basalt soil is formed by the weathering of the underlying rock. It is a black and rather heavy soil. It is somewhat different to the rich, chocolate basalt soils of the north-west and north-east coastal districts due to the fact of a distinct difference in the rock type. The basalt of the coastal district is an olivine one, whereas that of the Midlands is a normal (olivine-free) basalt. This difference in mineral constitution affects the rate of decomposition of the rock, and also the nature of the soil produced. The decomposition of the felspar and augite in the basalt results in clayey products and the typical heavy and clayey soil. Though not as resistant as diabase, the basalt does not decompose very rapidly and not much faster than the rate at which the soil can be removed by denudation agencies. The areas occupied by basalt are therefore inclined to be rocky and to have only a thin layer of soil.

This, again, forms a contrast with the northern coastal areas due partly to the difference in mineralogical composition, and also to the difference in the rainfall.

Basalt outcrops over a large area along the Macquarie River to the south of Ross and along the railway through the Midlands past Campbell Town and towards Conara. Satisfactory depths of soil occur around Ross and Campbell Town, especially the latter, and agriculture is carried out on these areas. The greater part of the basalt areas is, however, used for pastoral purposes for which it forms the best land in the district. Around Ross some of the soil is a mixture of basalt soil and sand derived from overlying Tertiary sand, and this mixed soil is nearly all used for agriculture.

(iv) Sandstone.

The ordinary sandstone of the Trias-Jura system yields on weathering and disintegration a very light, sandy soil. The sandstones consist mainly of small grains of quartz sand, with a small amount of cementing material such as clay. On weathering and disintegration the grains of sand are liberated and form the soil. The sandstone weathers easily, and there is generally a fair to good depth of soil on these areas. On steep hillsides the soil is easily washed away, and cliffs are readily formed.

The sandstones occupy areas around and to the east and north-east of Tunbridge, in the vicinity of Ross, and on the flanks of parts of the Eastern Tiers. The soils are generally poor and sandy, but often they are of better quality and are used for agricultural purposes. In the vicinity of Tunbridge these soils are largely used for agricultural purposes and give good results in years of suitable rainfall. The largest area of these soils that are used for agriculture is that around Oatlands.

(v) Felspathic Sandstone.

Soil is produced from these rocks by weathering and disintegration. They are composed of grains of felspar and quartz, the nature of the former ranging from fresh to completely decomposed material (kaolin). Some of the fresh grains of felspar may enter into the composition of the soil, but it is probable that they become decomposed to a large extent. The soil will then consist of grains of more or less altered felspar and quartz, together with the kaolin (clay), which is derived from the felspar, and is present partly as grains and partly in the form of clay. The resulting soil is a light, friable one, and one of the best soils in the Midlands. The sandstone weathers easily, and there is generally a good to moderate depth of soil. This soil is generally cultivated wherever it exists, but if not used for this purpose it makes excellent pastoral land. The largest area of it within the Midlands occurs around York Plains and the Mt. Pleasant Closer Settlement, where a large proportion of it is cultivated with excellent results. Another large area occurs to the east of Woodbury, and includes parts of the properties of Lowes Park, The Braes, Glenmorey, and Salt Pan. A smaller area exists around Green Sugarloaf to the east of Ross.

(vi) Tertiary.

Several types of Tertiary formations occur, and the soil from these vary with the nature of the formation.

The Upper Tertiary deposits, between Ross and Campbell Town, consist of unconsolidated sands. These give rise to a loose, sandy soil, which supports a growth of white gum and peppermint trees. The soil is very poor, and the land occupied by it is generally left in its virgin state. This soil occupies large tracts of country extending along the foot of the Eastern Tiers from Ross to Conara, and then throughout Epping Forest. On the western side of the railway line, between Ross and Campbell Town, the soil is not so sandy, and is improved in quality by an admixture with alluvial material along the drainage courses, and it is largely used for agricultural purposes. Towards Ross this soil is admixed with that from the underlying basalt, being greatly improved in quality, and it is largely used for agricultural purposes.

At various localities around Antill Ponds, Woodbury, and Tunbridge, extensive deposits of Tertiary river gravels occur along ancient stream courses. These deposits consist chiefly of diabase pebbles and boulders in a matrix of alluvial material derived from diabase, but contain a proportion of sandy material. The soil formed from these is similar to diabase soil, but is of better texture, due to the admixture of sand. These areas are largely devoted to agriculture around Woodbury (including Little Plains) and the township of Tunbridge. When not cultivated the soils form good pasture lands.

(vii) Permo-Carboniferous.

The rocks of this system which occur in the Midlands consist chiefly of very fine-grained white silicious mudstones. They do not cover any very large tract of country, and outcrop only to the east, west, and south of Ross. The soil is formed by disintegration of mudstones, and is generally a light-coloured, light type of soil. It is of poor quality and used only for grazing purposes. The area of this soil, where it is of somewhat better qualtiy, is that immediately to the north of Ross.

(viii) Alluvial.

Alluvial material is that formed along the courses of streams, and it is composed of the waste of all rocks in the area drained by the streams. The soil derived from this is a heavy, black one. It is generally of very good quality, but sometimes suffers from the fact that it is very badly drained.

The soil at the foot of hills and near a stream generally shows a gradual change in type from the typical alluvial soil of the river flat to that of whichever rock forms the hill.

The largest area of this soil exists along the Macquarie River to the north and south of Ross. Other areas occur along the Blackman's River to the west and north-east of Tunbridge; along the York Rivulet, near Lowes Park; on some of the black bottoms on the Tunbridge Plains; and along the Curryjong and Stringybark Creeks near Woodbury.

(d) The Necessity for Irrigation.

In the Midlands there appear to be large tracts of more or less level land which, at present, are devoted to pastoral purposes, but which, from a casual inspection, one would expect to be used for agriculture. A closer examination reveals the fact that though the soil is suitable in many parts for agriculture, there are many other parts in which it is unsuitable. Even on the former parts, however, agriculture is not practised to the extent that it might be, and the reason for this is found in the rainfall of the district.

In Table I. the average monthly and yearly rainfall figures are given for all stations between Woodbury and St. Marys. In this table those stations in the district under review are Woodbury, Ross (Roseneath and Beaufront), and Campbell Town (Quorn Hall and Institute). The respective yearly rainfalls for Woodbury, Ross (Beaufront), and Campbell Town (Quorn Hall) are 1836, 1804, and 2067 points. The data for Ross (Roseneath) and Campbell Town (Institute) are somewhat higher—2078 and 2451 points respectively—but these records have been taken over short periods compared with the other stations. The average rainfall of the Midlands may, therefore, be said to range from 1800 to 2000 points per annum. While agriculture may be successfully carried out with such a rainfall, the conditions are approaching those under which methods of dry-farming have to be resorted to. The minimum annual rainfall of the Midlands ranges from 1000 to 1200 points. Under such conditions, it is doubtful if agriculture can be carried out without the aid of irrigation.

The distribution of the rainfall throughout the growing season is even more important than the total amount per annum when considering the growing of crops. The sowing season in the Midlands is generally between March and June, and as early a sowing as possible is effected. This enables a certain amount of progress to be made before the cold winter restricts the growth. The main growing season begins in August or September and continues until about December. Assuming that half of the year's rainfall occurs during the main growing season, 900 to 1000 points would fall in years of average rainfall, and 500 to 600 points during years of minimum rainfall. Exact figures are not available as to the requirements of crops during the growing seasons, but it is probable that 1200 to 2400 points are necessary. It is, therefore, seen that there is a deficiency of 300 to 1400 points in average years and 700 to 1800 points in the driest years. This deficiency can only be made good by irrigation, and 300 to 1800 points of water would have to be added in this way. While this addition would probably be made throughout the months from July or August to December, it would need to be greatest during the very dry month of November.

(e) *Topographical and Soil Considerations in Connection with Irrigation on Certain Plain-like Areas.*

(i) Glenmorey Area.

This area is situated several miles to the east of Woodbury station. It includes the country to the east of the

York Rivulet or Tin Dish Creek, and to the north of Bald Hill. Parts of the properties of Lowes Park, The Braes, Glenmorey, and the Salt Pan, or eastern portion of Ballochmyle, are within this area.

The Northern flank of Bald Hill is very steep, and is composed of diabase. From the foothills a plain extends to the north with a more or less regular surface and a uniform slope to the north. The southern portion of this plain is occupied by felspathic sandstones and the soil from these rocks. The northern portion is an alluvial plain along the unnamed creek flowing westerly from Glenmorey, and there is a gradual transition from the felspathic to alluvial soil. Another alluvial flat occurs between the Tin Dish Creek and the Curryjong Rivulet. The felspathic sandstone area continues through Glenmorey and on to the Salt Pan run, where it is bounded by a diabase dyke and to the north of which normal sandstones occur.

The total area comprises about 3000 acres, the greater part of which could be irrigated by a main channel along the flanks of Bald Hill and branch channels therefrom. Felspathic sandstone soil forms the greater portion of this tract, and it forms one of the best agricultural regions in the Midlands. The alluvial soil along the Tin Dish Creek is also good, but that along the unnamed creek from Glenmorey is of poorer quality.

From the points of view of topography and soil this region forms one of the best for possible irrigation.

(ii) Little Plains Area.

This area is situated one mile to the north of Woodbury railway station. It is a relatively small area extending westwards from the Curryjong Rivulet near its junction with the Tin Dish Creek towards and west of the railway line. The north and south boundaries are low hills of diabase. The plain itself is formed of ancient river gravels of Tertiary age. These are composed of numerous diabase pebbles in a matrix composed of detrital and decomposed matter from sandstones, diabase, &c. A good soil covers the plain, and it is largely used for cultivation.

The area of this plain in the vicinity of Little Plains is about 600 acres. Though this is adjacent to the Glenmorey it is probable that it would have to be irrigated from a separate channel.

It embraces portion of the Little Plains property and adjacent ones.

(iii) Woodbury Area.

This area is situated to the west and south of Woodbury. It represents only a small area, and is more or less continuous with that of Little Plains. The plains are formed of Recent alluvial deposits along the Curryjong Rivulet, Stringybark Creek, and other small streams, and slightly more elevated terraces of older alluvium and gravels. The former give the typical black alluvial soil, but forms only a small proportion of the area. The latter occupy the greater portion of the area, and yield a soil similar to that on Little Plains. The greater part has been used for cultivation at various times in the past.

The maximum area is about 1000 acres. Portion could be irrigated from the channel to Little Plains, and the remainder from that to the Glenmorey area.

(iv) Tunbridge and Salt Pan Area.

This area includes the country around Tunbridge and the Salt Pan Plains to the east and north-east thereof. The southern and eastern boundaries are diabase hills, while the northern may be taken as the basalt hills along the southern bank of the Macquarie River, and the western boundary as the Blackman's River. The whole of this area is not a true plain, but the surface is broken by many minor ridges. The total area is 8000 acres, but it is probable that the topography would not allow of the whole of it being irrigated. The exact proportion could only be determined by a detailed survey.

The rock formations and soils are not constant over the whole of the area. The greater part is composed of Ross sandstones and the sandy soil derived therefrom. These formations occur in the Salt Pan Plains and yield a very loose sandy soil, many tracts of which would probably be too poor in quality to warrant irrigation. In many localities the sandy soil is modified by an alluvial soil formed on "bottoms" and places which are swampy in wet weather. The basalt hills along the Macquarie River, and above the Ballochmyle homestead, are too small in extent. and the soil is too rocky for irrigation and cultivation. The country to the immediate east of Tunbridge is generally very level, and consists of Tertiary deposits. These are largely of a sandy nature, but portions are similar to the diabase gravels of Little Plains. This region has been, and still is being, largely used for cultivation.

(v) Ellenthorp Area.

This area is situated to the north-east of Tunbridge. It is traversed by the branch road which runs to Ellenthorp from the Tunbridge-Interlaken-road. There are about 7000 acres of more or less plain country in this vicinity, but it is generally of little or no use for agricultural and irrigation purposes. It is occupied chiefly by Tertiary deposits, generally of a sandy nature, which yields a poor sandy soil, while other parts of the surface soil contain abundant "buck-shot gravel" (oxides of iron). A small amount of agriculture is carried on in the northern portion near Ellenthorp.

(vi) Ross Area.

Large tracts of flat country exist along the valley of the Macquarie River, between Mona Vale and Ross, in the form of a long, narrow plain. The western boundary is formed by the foothills of the steeply rising College Hill. The eastern boundary is not so steep, and is formed by various rocks such as diabase, basalt, sandstones, &c.

The plain is composed of alluvial deposits which pass uninterruptedly into the detrital material of the foothills. From Mona Vale this plain extends to a locality about two miles north of Ross, and comprises in all some 4000 to 5000 acres. A large portion has been devoted to agriculture at various periods, but it is now largely used for grazing purposes. The southern portion was formerly irrigated by water from the Macquarie River, and many of the irrigating channels still carry water for some of the pasture land.

(vii) Ross-Campbell Town Area.

A large tract of plain country exists between Ross and Campbell Town. The eastern boundary is formed by the Eastern Tiers, and the western boundary by Mt. Augusta, both these features being composed of diabase. Between these the country is occupied by basalt overlain by a thin layer of Upper Tertiary sands. The soil from the latter is very sandy and poor, and of no use for agriculture. Over a part of the country the sands have been removed by denudation, and the underlying basalt exposed. On this part the soil generally consists of a mixed basalt and sandy soil, and it is further modified by the passage of small streams over it. The area of such soils is about 5000 acres.

(viii) Campbell Town Area.

To the north of the Elizabeth River at Campbell Town a considerable tract of plain country extends towards Conara.

A large proportion of this tract consists of more or less unmodified basalt soil. Altogether the area of such soil is about 8000 acres. It is bounded to the east by the Eastern Tiers, and to the west by low diabase hills west of the main-road. To the north the basalt is bounded by poor sandy country, which will be described below.

(ix) Conara Area.

Around Conara, and extending northwards through the Epping Forest, a very extensive tract of plain country occurs. The surface is occupied by Tertiary sediments, which give rise to extremely poor soils. They are, in the main, very loose, sandy, or gravelly soils, but in some portions contain abundant "buck-shot" or "ironstone" gravel. Except in a few parts, the soils are totally unfit for agricultural purposes.

(*f*) *Water Supply.*

(i) Introduction.

If the areas of suitable soil are sufficiently large, and the topography of such areas is satisfactory for irrigation purposes, the problem of providing supplies of water then becomes a vital one. Two schemes have been referred to, one being that of the upper portion of the Macquarie River and the other embracing lakes Sorell and Crescent, and the upper portion of the Blackman's River. A third possible scheme is that of the South Esk River, which has the largest catchment area of any stream near the Midlands, the elevated region of Ben Lomond. It is, however, rather remote from the southern portions of the district, and would involve pumping of the water.

The writer has no complete information of the Upper Macquarie River or the South Esk River schemes, but has examined practically the whole of the catchment area of the Lakes and Blackman's River scheme. A large amount of information can, therefore, be given in connection with the latter scheme, and though it is somewhat of a general nature it should be useful to those undertaking the more detailed surveys and examinations. This information is given below.

(ii) Catchment Areas.

Lakes Sorell and Crescent.—Lakes Sorell and Crescent have areas of 18·95 and 6·43 square miles respectively, the total being 25·38 square miles. The outlet from the lakes forms the Clyde River, which flows in a south-westerly direction past Bothwell and enters the River Derwent near Hamilton.

TABLE No. 4.

Raintall Data.

Station.	No. of Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Bow Hill	14	190	148	263	237	202	265	206	178	208	250	244	227	2618
Interlaken	17	208	186	223	269	246	299	243	198	258	313	203	209	2855
Dog's Head	13	220	224	245	238	298	582	380	267	215	313	244	228	3454

The catchment area, apart from the lakes themselves, is not large, and probably does not exceed 60 square miles. Rahbek [15] estimated the catchment area of Lake Sorell, including the lake, to be 55·7 square miles. The catchment area of Lake Crescent is four square miles, and with the lake itself the total is 10·43 square miles. The total catchment area of the two lakes is, therefore, 66·13 square miles.

Upper Blackman's River.—If the above scheme was proceeded with it is probable that a dam to conserve water would be constructed on the Blackman's River, near the entrance to the Gorge. Under these circumstances the upper part of the Blackman's River system can be regarded as an additional catchment area. The Midlands investigation showed that the total catchment area of this part of the stream is 27 square miles.

(iii) Rainfall.

The rainfall data for the three stations—Bow Hill, Interlaken, and Dog's Head—within the catchment areas are given in Table No. 4. The average yearly rainfall of the Lakes area may be taken as 32 inches, and that of the Upper Blackman's River as 26 inches. In water conservation schemes it is the better practice to adopt the average rainfall over a period of consecutive dry years rather than the yearly average, unless the conservation is sufficiently large to allow for supplies over the whole of any cyclical period of maximum and minimum rainfall. A period of three consecutive dry years is often used, and the average rainfall over such a period may be taken as 75 per cent. of the average yearly rainfall. On this basis the rainfall figures to be used would be 24 inches per annum for the Lakes and 19·5 inches per annum for Upper Blackman's River.

(iv) Estimated Quantity of Water Available.

Lakes Area.—The Lakes (25·3 sq. miles) themselves receive as direct rainfall 24 inches per annum, or a total quantity of 32,384 acre-feet.

From the remaining 41 square miles of the catchment area, assuming that the total run-off is 33 per cent. (the area is composed almost entirely of diabase), the quantity

(15) Rahbek, K. L.: Proposed Lake Sorell Water Conservation scheme, Parliamentary Paper No. 46, 1902.

entering the lakes would be 17,493 acre-feet. The total amount of water entering the lakes annually would, therefore, be 49,877 acre-feet.

Rahbek ([16]) estimated that the evaporation from the lakes, with a rainfall of 36 inches, would be 22·5 inches per anunm, which is equivalent to 30,360 acre-feet per year. Deducting this amount from the above the amount available would be 19,517 acre-feet. This would not be sufficient to provide for the 100,000 cubic yards per day, or 22.624 acre-feet per annum, which have to be allowed to flow down the River Clyde, according to Act of Parliament (1 Ed. VII. No. 53 and 62 Vict. No. 62).

If, instead of the above figure of 24 inches, the average yearly rainfall of 32 inches be used, the amount available, after allowing for evaporation, would be 36,144 acre-feet. This would leave a surplus of 13,520 acre-feet per annum for other purposes.

Upper Blackman's River Area.—This area is occupied by diabase and Trias-Jura sandstones, and the total run-off may be taken as 25 per cent. With the area of 27 square miles, and rainfall of 19·5 inches, the total quantity of water available per annum would be 7020 acre-feet. Using the average annual rainfall of 26 inches, the quantity would be 9360 acre-feet.

(v) Conservation Facilities.

Lakes Area.—If the lakes be embodied in any water scheme, the natural conservation of them could be made use of for this purpose. Additional conservation could be obtained by erecting dams at the south end (Interlaken) of Lake Sorell, and the outlet from Lake Crescent into the River Clyde. The former site has been reported on by Rahbek ([17]). With regard to the latter the western shore of Lake Crescent is very flat and is elevated to only a slight extent above the level of the lake. Comparatively long walls would thus be necessary. No great height would, however, be required as the water would be distributed over a large area. As a matter of fact it is probable that a high wall would need to be of great length owing to the topography of the area, in order to achieve the purpose for which it would be erected.

([16]) Rahbek, K. L.: Proposed Lake Sorell Water Conservation Scheme, Parliamentary Paper No. 46, 1902.

([17]) Rahbek, K. L.: Proposed Lake Sorell Water Conservation Scheme, Parliamentary Paper No. 46, 1902.

Blackman's River.—From the south-western end of Mike Howe Marsh the Blackman's River has a very flat grade for a distance of about four miles downstream until opposite the hill known as Flat Top, the total fall in this distance being less than 200 feet. Downstream from this point the stream enters a very deep, narrow, and steep-sided gorge. These features are a direct expression of the geology of the area, the marsh being formed in the soft and easily-denuded Trias-Jura sandstones, while the gorge has been eroded through hard and resistant diabase. The diabase has retarded the work of the stream, the development of which has not advanced beyond the cutting of the gorge. In the softer sandstones upstream the stream has reached a much more mature stage in its development, having formed an open valley on the south-eastern side, and having a very flat grade.

These conditions are favourable for a water conservation scheme. A dam of short length, and of moderate height, would cause the water to flood the valley for considerable distances upstream. Sufficient storage could be readily obtained for the quantities of water calculated above. The most suitable and economical site would have to be determined as the result of a detailed survey.

The eastern side of the proposed dam site is occupied by Trias-Jura sandstones. These are somewhat porous, and a small amount of water might be lost by passage through them, but it is not anticipated that it would reach such dimensions as to affect the proposal.

The greater part of any such leakage would find its way into the Stringybark Creek, and could be returned to the Blackman's River by a race two miles in length at a point suitable for distribution to the Midlands.

The very steep and rocky sides of the gorge below the proposed dam site presents difficulties, although not necessarily insurmountable, to the construction of channels. If hydro-electric power schemes are not combined with the irrigation the conserved water could be allowed to flow down the river and be taken off by channels further downstream, where their construction would not be so difficult

(vi) Means of Delivering the Water to the Midlands.

If it is decided to make use of any surplus water from the lakes, there are two possible schemes to deliver the water from the lakes to the Midlands.

(1) From the north-eastern corner of Lake Sorell a tunnel of approximately 40 chains in length would deliver the water on to the slopes of the Western Tiers and into the heads of Flood Creek. It could then be taken either from this creek at a lower level, or from the Mill Brook into which it flows. No suitable sites for dams to conserve any large quantities of water exist along this creek. The steep slopes of the Tiers would permit of the water being used for hydro-electric power schemes.

The above tunnel would be in diabase for the greater part of its length.

From the south end of Lake Crescent tunnels of 60 to 80 chains in length would conduct the water into Fern Creek or one of the other numerous head-water streams of the Blackman's River. If the tunnel be driven from Fern Creek the tunnel would be in the comparatively soft Ross sandstones, but if driven further west it would be in the hard and tough diabase for a large part of its length. The water would then flow down the Blackman's River and enter the conservation scheme discussed above [18]. The conditions for hydro-electric power schemes are not so suitable as at Flood Creek, but moderate pressure heads could be obtained.

(vii) Possible Combined Schemes for Irrigation and Hydro-electric Power.

These depend upon whether any surplus water in the lakes to be made use of, and, if so, from what locality is it taken.

(*a*) If the water be taken from the north-east corner of Lake Sorell and allowed to flow down Flood Creek the conditions would be generally favourable for hydro-electric power schemes. From the outlet of the proposed tunnel a fall of 900 feet could be obtained in a distance of 40 to 50 chains; 1100 feet in 110 chains; 1300 feet in 160 chains; and even greater falls with larger distances, and without in any way affecting satisfactory distribution of the water to the Midlands.

(*b*) If the water be conducted from Lake Crescent into the Blackman's River, the conditions are not so suitable for hydro-electric schemes. A fall of 500 feet in a distance of 100 chains, or 700 feet in 160 chains, could be obtained.

(*c*) Further use could be made of the above water, together with that conserved from the Upper Blackman's

(18) See page 49.

River. A channel with a length of 200 chains would give a head of 600 feet. Slightly greater heads could possibly be obtained without affecting the distribution of the water to the Midlands.

(viii) Conclusions.

In the above discussions it has been seen that there are two possible sources of water supply, viz., Lakes Sorell and Crescent and the Upper Blackman's River. In the case of the lakes, a surplus of water depends upon whether the rainfall for purposes of calculation exceeds 27 inches per annum. Using the average annual rainfall of 32 inches, the surplus would be 13,520 acre-feet per annum, but with the average rainfall for a period of three consecutive dry years, which is 24 inches, there would be a deficiency of 3107 acre-feet. It is therefore very desirable that the question of surplus water should be checked by stream gauging. The water would have to be taken from the lakes by means of tunnels of lengths from 40 to 50 chains. From Lake Sorell the water would be allowed to flow down Flood Creek, while from Lake Crescent it would be conducted to the headwaters of Blackman's River.

The upper part of the Blackman's River drainage system could also be used to provide water supplies. The conditions are generally suitable for dam sites at the north-eastern end of Mike Howe Marsh, or near the entrance to the Gorge. With such a dam water could be obtained from a catchment area of 27 square miles, which would give a yearly supply of water ranging from 7000 to 9000 acre-feet depending upon whether the rainfall figure adopted be taken as 26 inches (the average figure for three consecutive dry years) or 19·5 inches (the average annual rainfall). The same dam could also be used to store the water delivered from Lake Crescent.

On the whole it would probably appear preferable to commence by developing the Upper Blackman's River scheme. By means of this water several thousand acres could be irrigated. If it was then desired to irrigate any further land, any surplus water from the lakes could be taken from Lake Crescent and conducted to the Blackman's River. This procedure would admit of determining whether there is any surplus of water available in the lakes.

(*g*) *Conclusions and Recommendations.*

From the above general discussions it is seen that a supply of water could be obtained from the Upper Blackman's

River, the minimum annual quantity being 7000 acre-feet. Further supplies may be obtained from the lakes, but this needs careful investigation to ascertain whether there is any actual surplus or not. The conditions are generally suitable for dam construction at the north-eastern end of Mike Howe Marsh and the conservation of water in this marsh. The water could be conducted by the Blackman's River and by channels the short distance of a few miles to areas in which tracts of irrigable land exist. Such tracts exist around Woodbury and Tunbridge. Other tracts exist further to the north, but besides being further from the source of the water, they do not offer the same advantages as regards soil.

The Glenmorey, Woodbury, and Little Plains areas probably include in all 4600 acres of irrigable land. The 7000 acre-feet of water from the Upper Blackman's River scheme would allow of a duty of 18 inches on this area. If the required duty of water be less than this, say 12 inches, 7000 acres could be irrigated and the excess of the above 4600 acres could be obtained in the Tunbridge area.

It is therefore recommended that, in the event of the scheme for closer settlement and irrigation being proceeded with, the following procedure should be adopted.

Firstly, detailed surveys should be made of—

(*a*) The Upper Blackman's River catchment area. This will determine the actual catchment area, and in conjunction with the rainfall data and estimation of run-off, will enable the amount of water available to be estimated. The establishment of a stream-gauging station at the north-eastern end of Mike Howe Marsh should also be effected in order to arrive at the latter figure.

(*b*) The north-eastern end of Mike Howe Marsh and the entrance to the Gorge. This would enable the most suitable site for a dam to be selected in order to conserve water in Mike Howe Marsh.

(*c*) The portion of Blackman's River below the dam and the country in the vicinity of Antill Ponds, Woodbury, "Glenmorey," and Tunbridge. This survey will, in conjunction with the selection of suitable tracts of soil, enable the delineation of areas suitable for irrigation. Further, the necessary intake from the Blackman's River and the channels necessary to conduct the water to the irrigable areas will be determined.

Secondly, as a result of the above, it will then be possible to estimate the cost of construction of the dam, channels, and all other works in connection with the irrigation scheme. The number of acres of irrigable land to which the water can be conveniently conducted being also known it can then be determined whether the scheme is economically sound.

Thirdly, if all the above surveys and estimations prove satisfactory, and the constructions be proceeded with, the further questions of obtaining water supplies from the lakes, if such are available, and of irrigating other areas to the north could be investigated.

P. B. NYE, M.Sc., B.M.E., Government Geologist.

Hobart, February, 1926.

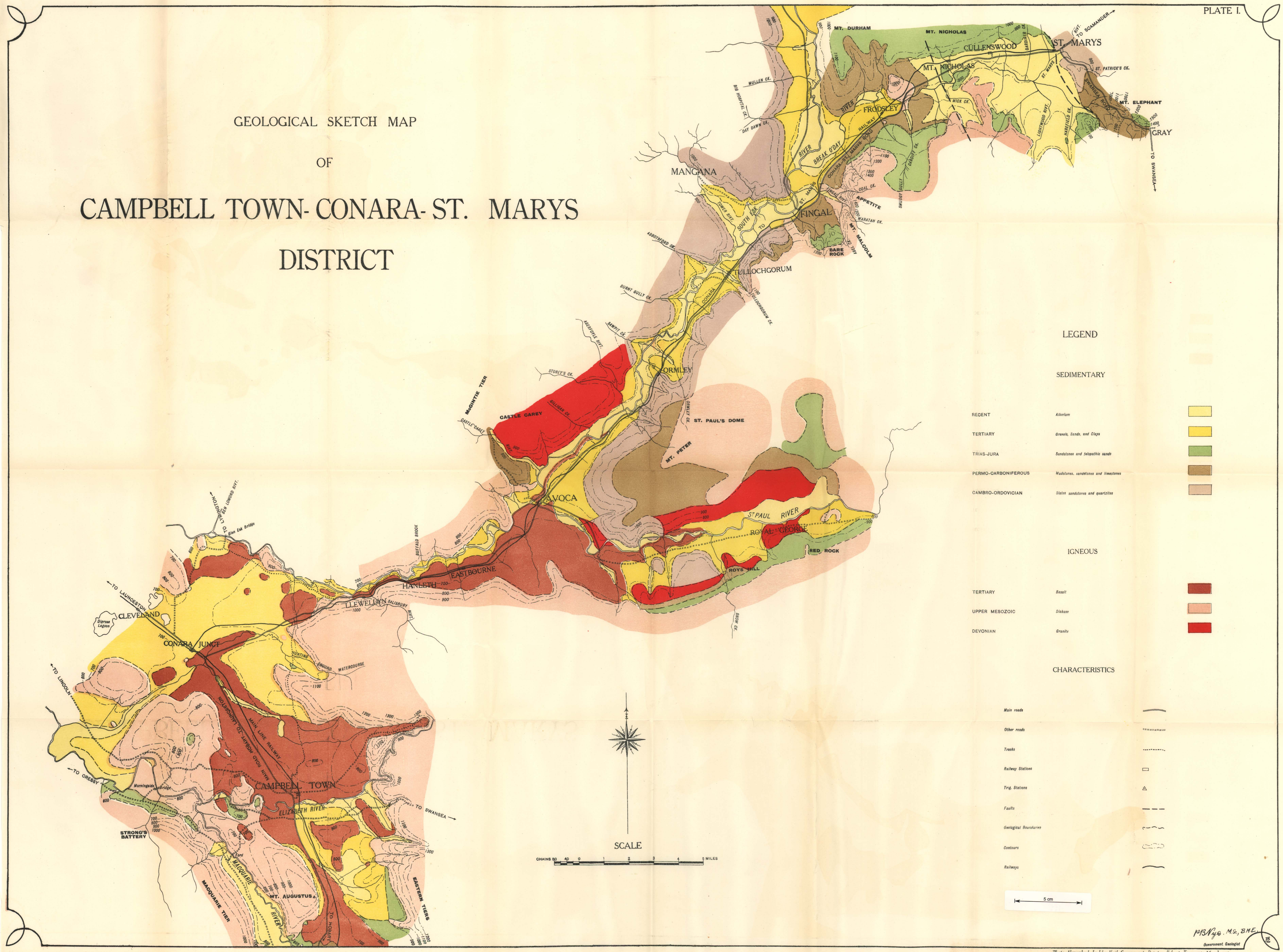

Photo Algraphed by John Vail Government Printer Hobart Tasmania March 1926

PLATE II.

TOPOGRAPHICAL SKETCH MAP OF THE MIDLANDS

Photo Algraphed by John Vail, Government Printer, Hobart, Tasmania.