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GEOLOGY AND MINERAL RESOURCES OF THE MURRAY VALLEY REGION

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REPORT NO. 1947/10

I. INTRODUCTION.

The region under review may be broadly subdivided into three distinct geological and physiographic areas which are here discussed as separate entities. This report is set out as follows :-

- I. Introduction
- II. Section A.
 - (a) Geology
 - (b) Physiography
 - (c) Mineral Resources.
- III. Section B.
 - (a) Geology and Physiography
 - (b) Mineral Resources.
- IV. Section C.
 - (a) Geology and Physiography
 - (b) Mineral Resources.
- V. Future Mineral Prospects of the Region.

Section A. comprises the area south of a line drawn through Charlton following the Palaeozoic-Post Tertiary boundary to Corowa (see geological plan) and east of the meridian through Corowa, in addition to a small area north of the Lachlan River and east of a line running northerly from Hillston. The section includes the headwaters of the Murray River, and the greater part of the north-flowing tributaries. The distinctive features of the section are that it is composed for the most part of older Palaeozoic sediments intruded by granitic masses, and that it has greater topographical relief than other sections of the Murray Valley region.

Section B. consists of the remainder of the Murray Valley region with the exception of a small area to the west of the Murray near its outlet to the sea. The whole of the section has low relief or is flat, and comprises Tertiary and post-Tertiary sediments with a few granitic inliers.

Section C. is the small area lying to the west of a line joining Murray Bridge, Strathalbyn, and Goolwa and including the peninsula between Gulf St. Vincent and the open sea at Victor Harbour. The topographic relief in this section is moderate and the rocks are of pre-Cambrian age overlain in part by Permo-Carboniferous glacial deposits.

The boundaries of these sections are shown on the accompanying geological plan of the Murray Valley region.

II. SECTION A.

(a) Geology

Cambrian. Apart from a small area of black and green cherts, shales and phosphate rock near Mansfield, the principal development of Cambrian rocks is in a belt trending northerly and south-easterly from Heathcote. The basal series (pre-Middle Cambrian) consists of diabasic rocks, foliated in part, with

a few bands of bedded cherts. Fine-grained black mudstones, ash beds, tuffs and breccias characterise the Middle Cambrian series, whilst the Upper Cambrian is somewhat similar to the Middle but lacks the interbedded volcanic rocks. All rocks of Cambrian age are highly folded and affected by faulting.

Ordovician. Beds of Ordovician age conformably overlie the Cambrian, from which they are distinguished by the incoming of graptolites. They consist of slates, shales, sandstones and mudstones, closely and sharply folded along north-south axes and extensively faulted. Ordovician beds occur in two distinct areas, one of which extends westerly from the Cambrian belt through Heathcote, and the other to the east of a line running south-east from Benalla. It is probable that the broad belt of metamorphic rocks (schists, gneiss, etc.) extending from Mt. Hotham to Wodonga includes beds of Upper Ordovician age which have been metamorphosed by "lit par lit" injection or granitic intrusion. The area near the source of the Murray is not very well known and the N.S.W. Mines Department has not differentiated the Elder Palaeozoic rocks on the N.S.W. side of the river. For convenience they have been shown on the accompanying plan as Silurian, but it is probable that they include some beds of Ordovician age.

Silurian. Sandstones, mudstones, shales, grits, conglomerates and limestones of Silurian age occur in the central portion of this section, extending from Heathcote Cambrian belt in the west to the vicinity of a line running south-easterly from Mansfield. They are conformable with the Ordovician and form the core of a broad synclinerium flanked by Lower Ordovician beds to the west and Upper Ordovician beds to the east. Some of the beds previously regarded as Upper Silurian in age are now regarded as Lower Devonian, but they are all shown as Silurian on the accompanying geological plan. On the New South Wales side of the Murray, to the west of Tumbarumba and north-east and north-west of Albury, the beds recognised as Silurian consist of slates, schists, phyllites, tuffs, quartzites and limestones. In the extreme north-east of the section, the beds shown as Silurian on the geological plan are mostly limestone.

Devonian. The Devonian period was one of extensive vulcanicity accompanied by some earth movements. The principal Devonian rocks in the section are dacites, porphyries, tuffs, agglomerates, and associated acid lavas outcropping to the south-west and south-east of Benalla, in the upper reaches of the Mitta Mitta River, and north-easterly of Hillston. Limestones, calcareous shales, sandstones and breccias of Middle Devonian age occur in a roughly triangular area of which the western boundary is about 20 miles east of Mansfield and 10 miles east of Woods Point. Devonian quartzites, sandstones, shales and conglomerates occur in a narrow belt running northerly from the northern-most point of the Hume Reservoir, in a small area about 15 miles east of Tumbarumba, and northerly of Hillston.

Towards the close of the Devonian period there was extensive outpouring of acid lavas followed by the epi-Devonian intrusions of granitic rocks which now outcrop at numerous localities in the section under review. Earth movements with extensive faulting and folding were associated with this post-Upper-Devonian period of activity, and were responsible for the wide-spread dynamic metamorphism and folding of the older sediments.

Carboniferous. Coarse-grained micaceous sandstones, shales and conglomerates of Lower Carboniferous age occupy an area to the north and east of Mansfield. Fish remains are common and the sediments are dominantly estuarine or terrestrial, but some marine intercalations are recorded. There is no angular uniformity between these beds and the underlying Upper Devonian beds.

Permo-Carboniferous. The Permo-Carboniferous period was one of glaciation, and remnants of what was probably a wide-spread sheet of glacial tillites and sandstones occur to the north-west of Heathcote and have been proved to underlie more recent deposits at a number of localities between Wangaratta, Beechworth and Bright.

Mesozoic. Bedded strata containing plant impressions of Triassic-Jurassic age have been recorded south easterly of Greta. The extent of these beds is not fully known and they have not been shown on the accompanying geological plan.

Tertiary. The Tertiary period is represented in this section by lava flows ranging from Oligocene to Pleistocene in age. The Older Basalt (?Oligocene to Miocene) occurs as residuals in the higher parts of the Eastern Highlands, e.g. south and east of Mount Hotham and northerly of Mansfield. The Younger Basalt (?Upper Pliocene) occurs along the Campaspe River east of Bendigo and east of the Loddon River. The exact age relationship of the Basalts in the Rosewood and Tumbumba region are not clear and, for convenience, they have been shown as Older Basalt on the geological plan.

Post Tertiary. Fluvial, lacustrine and aeolian deposits of post-Tertiary to Recent age occur along the northern and western margins of the section, where the arbitrary boundary of the section has included portions which correctly belong to Section B. Recent alluvium occurs along major stream courses.

(b) Physiography

That portion of the section lying easterly of a meridian through Seymour is included in the Eastern Highlands physiographic division. The dominant controls in this division are differential erosion, Tertiary warp movements, and Older Basalt lava flows, all of which have combined to produce an area of rugged topography characterised by dissected high level plateaus. These are of two types, viz: those which are remnants of a Mesozoic peneplain which has been subject to elevation and deep dissection; and those which are relatively flat-topped lava residuals. It is believed that peneplanation of the area was complete by the Cretaceous period and that the earliest uplift commenced in early Tertiary times. The dissection consequent upon this uplift was obliterated in part by the Older Basalt flows of the Oligocene and Miocene periods, following which further uplift took place and stream dissection was resumed in the Pliocene period. The later warp movements were more pronounced in the eastern portion, with the result that the general level of the present land surface slopes downward from about 5000 feet in the east to about 2000 feet in the west. The combined effect of uplift and dissection has been to leave Older Basalt which once occupied stream valleys as residuals at high elevations. (e.g. in the vicinity of Mt. Hotham).

Differential erosion has left some peaks of resistant rocks standing above the general plateau level, the principal examples being Mt. Kosciusko (7,305 feet) Mt. Bogong (6,508 feet), Mt. Feathertop (6,306 feet) and Mt. Hotham (6,100 feet). The main divide or water parting which traverses the central part of the Eastern Highlands is coincident, in general, with the southern boundary of the section under review. The full lengths of the main stream courses have been shown on the geological plan as an indication of the position of the divide, which has not altered to any marked extent since early Tertiary times.

The portion west of Seymour forms part of the Western Highlands province, in which differential erosion has been the dominant physiographic agent. Older Basalt does not occur in this province and the post Older Basaltic elevations which were of major importance in the Eastern Highlands were very minor or absent altogether, with the result that erosion proceeded almost without interruption until the Newer Basalt flows. These had the effect of smoothing out some

of the topographic relief, and the area is now one of moderate to low relief with the general level in the vicinity of 1,000 feet above sea level.

(c) Mineral Resources

(See map of Mineral Localities)

Most of the minerals of economic value obtained in the Murray Valley Region were contained in reefs and lodes associated with the Older Palaeozoic beds of section A, and in deep leads. Gold is of outstanding importance, and it is estimated that the total value of the yield from the section exceeds £200,000,000 whilst other minerals of lesser importance include those containing tin, antimony, molybdenum and tungsten, fluorspar, felspar, diatomite, kaolin, phosphates and building stones.

GOLD

Some very rich yields of gold have been obtained from the sub-basaltic deep leads at Laurel Hill and Tumbarumba, and alluvial deep leads have been proved by boring near Albury and Corowa. A low grade pyritic quartz reef was worked at Quartzville, near Tumbarumba, and at Ournie, 6 miles east of Jingellie, yields as high as 2 oz. of gold per ton were obtained from reefs up to 4 feet in width. Some silver, lead and zinc were associated with the latter reefs at shallow levels.

At Bethanga, several parallel narrow lodes carried persistent shoots of gold in a highly mineralised matrix containing arsenopyrite and copper sulphides, and the average yield exceeded 1 oz. per ton in spite of the refractory nature of the ore. The Chiltern - Rutherglen area was notable for an extensive series of deep leads as well as for good yields of gold from shallow workings on reefs.

Some of the gold obtained in alluvial workings was in a very finely divided state and the establishment of a modern cyanidation plant has enabled profitable recoveries from tailings in the district. This work has been in progress for some years and during 1946 the return of gold was 2,470 oz. of gold from 68,470 tons of tailings. The Woolshed Valley, Beechworth, was the scene of a great gold rush in the early 'fifties, and the area became one of the richest alluvial fields in the State. Only one company is now operating in the valley, and it is reported that recent returns from sluicing operations have continued to be satisfactory. West of Beechworth is Eldorado, which attracted the attention of surface alluvial miners in 1855 but was regarded as of little importance until shaft sinking and deep working were undertaken in 1859. Rich yields were obtained for some years, but the water problem caused some concern and it was not until dredging and sluicing became the vogue that regular and profitable yields were recorded. The only company working at Eldorado at present is Cocks Eldorado Gold Dredging Co., which has a modern electrically operated dredge in the valley of Reedy Creek, a tributary of the Ovens River. The dredge has been in continuous use since 1936, recovering highly profitable amounts of gold and tin to a depth of 90 feet below water level. It was recently estimated that the dredge has two years work in sight, during which time it is expected to treat about 4,000,000 cubic yards valued at £100,000.

The valley of the Ovens Valley from Myrtleford to Harrietsville has proved very rich in alluvial gold, which was obtained by dredging to a false bottom from 30 to 40 feet below water level.

The largest bucket dredge in the southern hemisphere recently commenced operations at Harrietteville, where it is anticipated that it will have a profitable life of about 20 years, treating about 4,000,000 cubic yards per annum to a depth of 130 feet. A small dredge at Freeburgh is being converted to electrical power and may be expected to resume operations at an early date.

Considerable amounts of gold have also been obtained from reefs in the watersheds of the Ovens River and tributaries, notably at Wandiligon, Bright, Myrtleford and Harrietteville. The Williams United and Hillsborough mines at Wandiligon and the New Liffey mine at Harrietteville are at present engaged in developmental work, whilst the Sambas mine at Harrietteville is at the producing stage, having a yield in 1946 of 232 oz. gold from 300 tons extracted from a saddle and inverted saddle reef. A reef discovered near Mt. Hotham a few years ago - the Red Robin reef - proved to be exceptionally rich and during 1946 produced 106 oz. of gold from 2 tons of quartz. The reef is in a very remote locality which can only be reached during summer months, but the opinion has been expressed that the discovery may be the forerunner of the development of a new field.

Some details of the yields obtained in the abovementioned districts are given hereunder :

District	Mine or Reef.	Years	Tons crushed	Gold ozs.	Dividends £.
Bethanga	Gift lode		53,104	60,879	
Chiltern	Golden Bar Chiltern Valley		25,230	13,697	
Rutherglen	Great Eastern		Alluvial 3,000	299,707 9,000	237,030
Eldorado	Cocks Eldorado	1940- 1942	Dredge	10,595	48,125
Myrtleford	Reform Reef		42,254	21,549	
Bright	Pioneer		25,752	11,050	
Harrietteville	Rose Shamrock & Thistle (Now Sambas) Mons Meg reef		101,234 45,000	69,929 25,000	

The Upper Goulburn district has proved to be very rich and two of the leading gold producers are situated within an auriferous belt about 60 miles in length. The belt is on the western limb of a synclinal fold in Silurian beds, and the gold-bearing reefs are associated with dykes intruded into the slates, and sandstones. The Morning Star dyke at Wood's Point was discovered in 1861, since when it has yielded gold to the value of more than £A1,000,000 and is still being exploited. During 1946 the present company obtained 10,042 oz. of gold from 12,240 tons of ore, and the total dividends paid from 1935 to February, 1947, amount to £220,000. The A.1 Consolidated mine at Gaffney's Creek headed the list of Victorian gold producers during 1946 with a yield of 23,815 oz. of gold from 11,440 tons crushed (an average of over 2 oz. per ton) and the company has now paid dividends totalling £427,500. Treatment methods at Wood's Point and Gaffney's Creek are by crushing and concentration only, as cyanidation of tailings is considered impracticable on account of the difficulties of stacking residues. The Lauraville mine at Gaffney's Creek is being re-opened at the present time. Details of some yields from the district are as follows :-

District	Mine	Years	Tons Crushed	Gold oz.	Remarks
Gaffney's Creek	Lyre Bird New Demsey	1860 1902- 1904	20 13,415	586 15,438	One Crushing
Wood's Point	Morning Star Dyke	1861	?	10,000	Stone broken in 10 days.
	" "	?1915	64,417	65,675	Not present Morning Star Co.

Some prospecting led to a few rich crushings from other localities in the Upper Goulburn Valley at Yea, Alexandra and Molesworth, but the yields were not persistent and only one mine, the Providence, at Yea, is at present in operation, having recently been re-opened and some prospecting undertaken at shallow levels. Between the Goulburn and Campaspe rivers, comparatively small amounts of gold have been obtained at Heathcote, Toolleen, Rushworth and Costerfield, both from reefs, and alluvial deposits. The gold at Costerfield was obtained in reefs bearing antimonial ore, and the value of antimony produced exceeds that of the gold.

The Bendigo field has had an unbroken record of gold production since 1851, during which time the value of the output has exceeded £65,000,000. During the peak years nearly 200 mines were working, but not all of the gold had to be won by reef mining as some alluvial deposits in the district proved to be very rich. About 20 nuggets larger than 100 oz. were discovered during the early days on the field, and the largest recorded weighed 573 oz. The field consists of a series of close folds in Lower Ordovician slates and sandstones, with auriferous saddle reefs occurring at the axes of the anticlines and recurring at depth. The eastern limit is marked by a major fault with downthrow to the east. More than 20 anticlinal axes have been mapped in a width of 3 miles and extending for a distance of 15 miles, but most of the mining has been on three main axes, known as the New Chum, Garden Gully and Hustlers lines, and about seven side lines or minor axes. Dykes of monchiquite occur in the centre country of all the folds and faulting is not uncommon. Mining operations have been carried to considerable depths, there being two shafts exceeding 4000 feet in depth, 19 others exceeding 3000 feet, and 53 others exceeding 2000 feet. Current operations are at higher levels.

The first five years were characterised by intense activity in surface alluvial mining, but the decreasing returns by these methods led to the establishment of reef mining in 1856. For the first ten years after the discovery of gold (1851-1861) the total yield was more than 4,500,000 oz. and the annual yield dropped below 200,000 oz. on only three occasions in the first 25 years. For the next 30 years (1877-1906) the yield fluctuated between 248,785 oz. and 148,701 oz. per year, since when it has gradually declined but continues to be significant. A few typical yields are listed below :

Mine	Tons crushed	Gold Ozs.	Dividends £
Garden Gully United	?	440,923	852,963
South New Moon	452,661	251,389	522,400
Great Extended Hustlers	?	296,770	479,150
New Moon	?	232,576	371,728
Johnson's Reef	?	323,316	334,020

Mining in Bendigo received a set-back during the war years, but companies are resuming operations as labour and material are available, and at the end of 1946 three were at the production stage and 11 were occupied in developmental work. The 1946 statistics for the operating mines are as follows :-

Mine	Tons crushed	Gold Oz.	Average Grade dwt. per ton	Dividends (1946)
Central Deborah	11,038	5,657	10.2	£18,000
Deborah	10,622	2,685	5.05	£ 3,050
North Deborah	14,644	9,531	13.01	£51,200

Bendigo ore is free milling and good recoveries are obtained by crushing, but some cyanidation of old tailings is being carried out with profitable results. The largest plant is operated by Gold Dumps Pty. Ltd., which recovered 1,269 oz. of gold from 48,090 tons of tailings during 1946. Eight hydraulic sluicing plants are also working in the district with moderate success.

Westerly of Bendigo, on the west side of the Loddon River, a broad belt of auriferous country has been of great economic importance as a gold producer. It extends in a rough triangle from Dunolly in the south to the vicinity of Inglewood in the north and Wedderburn in the north west. This area is notable for both alluvial and reef mining and within it was found the world's largest nugget of gold. This was discovered at Moliagul in 1869 and was aptly named "The Welcome Stranger", the net weight of gold being 2,284 oz. Numerous other nuggets were found in the district at Newbridge, Tarnagulla, Rheola, Kingower Dunolly and Wedderburn. Large amounts of gold were obtained from alluvial mines, but the phenomenal yields from the Poverty and other reefs at Tarnagulla overshadowed the results from alluvial workings. The Poverty reef was discovered in 1855 and gold worth £1,340,000 was obtained from 600 feet of reef to a depth of 420 feet. Other reefs at Tarnagulla were exceptionally rich, but they were soon worked out and only sporadic prospecting has been carried out in the last 50 years.

Reefs at Dunolly, Wedderburn and Inglewood were very rich near the surface and some good yields were obtained, as indicated below :-

District	Mine or Reef.	Tons crushed	Gold ozs.	Remarks
Tarnagulla	Poverty reef (claims)	24,369	59,257	3 claims on 141 ft. of reef.
Dunolly	Queens Birthday	?	100,504	Width of reef 5 ft. to 30 ft.
Inglewood	Columbian reef	4,435	26,127	
	Jersey	9,935	17,139	
Wedderburn	Shaws Indicator	55	1,586	

Some reefs and alluvial leads were worked at St. Arnaud from 1856 onwards. The leads were of limited extent but the reefs yielded gold to the value of about £1,500,000 in addition to a little silver.

TIN :

Alluvial tin deposits and many small reefs containing tin ore are recorded in the area from Holbrook through Lankey's Creek to the neighbourhood of Jingellic, and a considerable amount of work was done on some of the deposits near Jingellic. Tin ore has been obtained from the alluvium in the valley of the Ovens River and tributaries, notably at Eldorado, where it has proved a profitable side line from dredging and sluicing activities for gold. The yield of tin concentrates from the Cocks Eldorado dredge during 1946 was 64 tons valued at £14,917, bringing the total Victorian yield to 18,500 tons valued at approximately £1,250,000. The majority of this amount was obtained from Beechworth and Eldorado districts. Stanniferous greisen and pegmatite dykes occur in the schists at Tallandoon, Eskdale, Koetong, Burrowye, and other localities in the metamorphic and granitic belt of north-east Victoria.

ANTIMONY:

Antimonial ore has been produced at Costerfield and to a lesser extent at Redcastle, Baillieston and Tallandoon, but with the easing in demand following the end of the war and general depletion of supplies, the 1946 output was down to 7 tons of concentrates. The Costerfield occurrence is of interest insofar as the stibnite is auriferous, and appreciable amounts of gold have been recovered during treatment of the ore. Mining commenced in 1862 and continued intermittently until 1939, after which the ore was hand-picked from dumps. It is estimated that more than 20,000 tons of metallic antimony have been obtained from Costerfield, which was the leading producer in Australia. Most of the 1946 production was obtained from a mine at Kevinge, where it is reported that high grade ore is available and prospects of increased production are good.

MOLYBDENUM:

Some quartz veins containing molybdenite occur about 4 miles south-east of Holbrook, the veins varying in width from 8 ins. to 4 ft. The molybdenite is coarse and a little has been recovered by hand-picking, but the occurrence has little economic importance. The most important deposit is that near Everton, where a roughly circular pipe of ore containing about 2 per cent molybdenite was worked from 1922 to 1944. A second pipe or annular zone was opened in 1941 but the values at depth proved disappointing and work was suspended in 1944, after the total value of production from the mine had reached approximately £60,000. Minor amounts of molybdenite have also been obtained at Thologolong, Yackandandah, Eurea, Yea, Mt. Moliagul, and near Bright.

TUNGSTEN :

Ores containing tungsten have been recorded at Lankey's Creek and Wymah, but they have little economic importance. Considerable prospecting was recently carried out at Wymah, where the wolfram occurs in numerous low grade faulted lodes, but the results were very disappointing. Small amounts of wolfram have been obtained in quartz reefs at Koetong, and Thologolong, and it has also been recorded at Wedderburn and Chiltern. Small quantities of scheelite have also been found at other localities but there has been no commercial production.

FLUORSPAR :

A deposit of fluorspar occurs as the gangue of a silver-lead lode at Carboona, and the material was used by the B.H.P. Co. as a flux in smelting operations. From 1916 to 1920, when production ceased, the total recorded production was 5,339 tons of fluorspar valued at £17,242. At Pine Mountain, a steeply dipping fissure lode occupies the contact between schists and granite, and has an average width of from 3 to 4 feet for a length of 400 feet or more. The lode has been worked sporadically since 1918, and the production during 1946 amounted to 321 tons valued at £2,247. /o

FELSPAR :

Felspar is being obtained in scattered surface detritus at Keetong, where the production during 1945 reached 214 tons. Other deposits of felspar in vein form have been mined at Huon Hill (near Wodonga) and Beechworth, and in pegmatite dykes at Barnawartha and Tallangatta.

DIATOMITE :

A deposit of diatomite suitable for filtration purposes occurs at Moranding, near Kilmore, and the total production to the end of 1945 was 2,433 tons valued at £8,071. The material was deposited on an irregular surface of weathered basalt and underlies a later basalt flow not less than 25 feet in thickness. It was estimated (1946) that about 2,000 tons of diatomite were available for extraction at the present workings.

KAOLIN :

An important deposit of kaolin is being mined at Epsom, 4 miles north of Bendigo, and the production during 1945 amounted to 1,206 tons valued at £211.

PHOSPHATES :

Phosphatic rock was obtained for some years from Phosphate Hill, Mansfield, where it is associated with certs and slates. The production from 1916 to 1926 amounted to about 16,000 tons, but the processed material obtained from it was inferior to super-phosphate and was not entirely satisfactory.

BUILDING STONES :

Granites suitable for use as building facings and for other purposes have been quarried at Wangaratta, Trawool and Harcourt, the grey stone from the latter locality being very popular in Melbourne for monumental and general ornamental work. Wangaratta granite is a dark reddish stone and the Trawool granite is grey with large phenocrysts of felspar.

III. SECTION B.

(a) Geology and Physiography

With the exception of small granitic and Older Palaeozoic inliers in the neighbourhood of Echuca, Swan Hill and Murray Bridge, the surface deposits in Section B consist of estuarine, lacustrine or fluviatile sands, clays and alluvium of Pleistocene to Recent age. Easterly of a line through Swan Hill the surface beds form a comparatively thin veneer over Palaeozoic bedrock (the submerged northern continuation of the complex discussed in Section A), whilst to the west of Swan Hill they overlie marine limestones, marl and clay which in turn rest on lacustrine ligneous clays of Lower Tertiary age. The limestones were deposited in a broad bight which extended in Miocene and Pliocene times from the vicinity of Eyre's Peninsula in the west to Swan Hill in the east ("The Murray Gulf") and their existence over a very wide area has been proved by bores and by outcrops along the Murray cliffs from Overland Corner to near Murray Bridge. Sedimentation in the Murray Gulf continued until late Pliocene times, when major movements of uplift led to the draining of the gulf and establishment of the coast line nearer its present position. The total thickness of post-Palaeozoic sediments may be about 1,500 feet. A layer of impervious clays overlying the limestones has proved an effective seal, and limestones are now the principal aquifer in the Mallee artesian and sub-artesian basin.

North of the Murray the area is almost uniformly flat, with shallow depressions representing abandoned stream channels scattered fairly widely over the broad flood plains of the main tributaries, the Murrumbidgee, Lachlan and Darling Rivers. These streams and the Murray have reached an advanced stage of maturity and pursue meandering courses within their flood plains. South of the Murray and west of the Avoca River, the Mallee country is distinguished by the absence of flowing streams. Drainage of this area is into depressions which receive water only after floods, at other times the water being lost by downward percolation and evaporation. The surface is gently undulating with broad ridges and troughs trending in a north or north-westerly direction. These corrugations are distinct from the wind blown dunes which characterise the western part of the Mallee, and may possibly be due to faulting and warping in the Palaeozoic bedrock on which the Tertiary and post-Tertiary beds were deposited.

(b) Mineral Resources

GYPSUM.

Gypsum is the most important mineral in this section, in which it has a wide-spread distribution. The deposits are all at the surface, having been formed by evaporation of gypseous solutions under semi-arid climatic conditions. In some areas the material has been concentrated by wind action into dunes, whilst elsewhere it remains in situ as a layer a few inches to several feet in thickness. Although thick beds of crystalline gypsum do not occur within the Section, the deposits which have been worked have proved suitable for plaster making, cement manufacture and agricultural purposes, and are still being exploited.

The Trida - Canoble district is the most important in N.S.W. from the point of view of gypsum production, the total recorded to the end of 1945 being 65,116 tons. Gypsum occurs here as the impure earthy form gypsite, and the thickness of the deposits range from a few inches up to 8 feet, the best material being in the top 2 feet. At Beilpargerrie, 29 miles from Ivanhoe, gypsite occurs in three main deposits, the largest being up to 5 feet thick and containing material assaying up to 89% gypsum. The total recorded production from 1924 to 1945 is 35,705 tons. In 1928 it was estimated that the total amount available in the three deposits was 2,500,000 tons. The largest outcrop of gypsite in N.S.W. occurs in an area about $2\frac{1}{2}$ miles long by $1\frac{1}{2}$ miles wide near Gypsum Palace, and it was estimated in 1928 that 3,000,000 tons of good quality material were available. The remoteness of the locality, however, has reduced the commercial importance of the occurrence and no production has been recorded. From 3 to 5 feet of gypsite occurs in low ridges in the Gol Gol district, and to the end of 1945 the recorded production was 16,418 tons. The grade is suitable for agricultural purposes.

Gypsum deposits are common in the Mallee country south of the Murray from Renmark to Swan Hill, and commercial production has been continuous at one locality or another for nearly 50 years. The leading producing area is at Bolton, where the production to the end of 1946 had reached 72,221 tons. Other districts which have produced significant quantities are Nowingi (69,000 tons), Tempy (20,758 tons), Lake Boga (31,256 tons) Boort (26,202 tons) and Waitchie (24,347 tons).

Flour gypsum and gypsite have been recorded at Renmark, Ingalta Siding, Lake Bonney, Cookes Plains and Bonney. Some of the material in these deposits is of considerable purity and quantities in sight are fairly good, but the high-grade easily worked deposits elsewhere in South Australia reduce the commercial value of those in the Lower Murray Valley and with the exception of the Cooke's Plains deposit, they have been exploited for local agricultural needs only. Gypsum from Cooke's Plains has been used in cement manufacture.

SALT :

Common salt is obtained from the lake floors at Pink Lakes where it is deposited annually in layers up to $1\frac{1}{2}$ inches in thickness, but no production figures are available.

BUILDING STONES :

Limestones exposed on the banks of the river near Murray Bridge, Renmark, Waikerie and Overland Corner are quarried for use as a building stone. They are compact and fairly uniform in grain and have proved satisfactory in use. A large outcrop of red granite near Murray Bridge is being quarried for use as an ornamental facing stone.

FIRECLAY :

A fair quality fireclay occurs in Tertiary clays overlying a seam of coal at Coorabin, where it is mined and most of the output despatched to Victoria.

COAL :

Coal of Permian age occurs beneath Tertiary clays at Coorabin. There are about 30 feet of coal but only about 6 feet is being worked. Boring and outcrops show that the basin has limited areal extent, and as much of the coal is below water level the present output is very small. Hygroscopic moisture averages 15% or higher, ash 18%, volatile hydrocarbons 25%, fixed carbon 42% and the calorific value ranges from 9,500 to 10,000 B.T.U.

The brown coal deposits at Moorlands lie outside the Murray Valley region but may have an important bearing on its development. At present the known reserves of shallow coal are insufficient for any permanent industrial development based on open cut mining, but a drilling program is in progress to determine the nature and extent of deeper coal.

IV. SECTION C.

(a) Geology and Physiography

This section lies to the west of a line joining Murray Bridge, Strathalbyn and Goolwa and comprises the southern-most part of the Mount Lofty Ranges. It forms a broad peninsula between Gulf St. Vincent and the open sea (Southern Ocean), with the tip of the peninsula at Cape Jervis.

Crystalline quartzites, schists and limestones of pre-Cambrian and Cambrian age form the "backbone" of the area, with isolated outcrops of granite (of which the age is not stated, but may be older than the granites of section A) at Victor Harbour and near Murray Bridge. Permo-Carboniferous glaciation led to the deposition of tillites and sandstone over the higher ground in part of the section and along the Inman and Hindmarsh Valleys.

The topographic relief is moderate, with the general surface level lying between 800 feet to the south-east and 1200 feet on the north-western flank. Some points rise to 1400 and 1500 feet above sea level. Comparatively short streams have cut steep-sided valleys but the general profile of the hills is smooth and rounded rather than angular. The movements which were responsible for the sunkland of Gulf St. Vincent are believed to have occurred from middle Pliocene to Pleistocene times. These included subsidence of the sunkland and uplift of the highlands, the net effect being a differential movement amounting to about 2,000 feet along a line approximately coincident with the present coast of Gulf St. Vincent. The present cycle of erosion in the section was initiated by this movement.

(b) Mineral Resources

Only a few minerals of minor importance have been obtained in this section, although the occurrence of silver, lead, zinc, copper, bismuth, gold, and a few non metallic minerals has been recorded. Small quantities of monazite and rutile have been recovered from beach sands at Normanville, and about 500 tons of copper ore were mined in the Callington-Kammantoo district west of Murray Bridge. Limestone is obtained at Rapid Bay and used as a flux in smelting operations at Whyalla, the output from the commencement of production in 1942 until 30th June, 1946 being 680,617 tons.

V. FUTURE MINERAL PROSPECTS

The foregoing sections of this report will indicate that the mineral resources of the Murray Valley Region have been of considerable economic importance, but the fact cannot be escaped that they are a wasting asset and that the future is therefore unlikely to be as spectacular as the past. The easily won deposits of metallic minerals are exhausted, and hope for maintenance of output now lies in improvement of recovery methods and vigorous prospecting for new fields or deposits.

A rise in gold production may be confidently expected over the next few years as labour and materials become available and some mines pass from the developmental to the production stage. If estimates prove correct, the large dredge at Harrietville should recover payable quantities of gold for 15 or 20 years, whilst it is possible that a new field may be developed following the discovery of the Red Robin and other reefs near Mt. Hotham. In the Wood's Point - Gaffney's Creek area the two producing mines - the Morning Star and A.I. Consolidated - appear to have years of profitable life ahead of them and may even expand production within the near future. The Bendigo field has been a mainstay in the mining industry for nearly a century and there is no reason to suppose that a steady output will not be maintained for some time to come. Some companies now in the developmental stage will doubtless become producers and help to augment the total output of the field.

Significant production of antimony and tin concentrates may be anticipated from Kevington, and the Ovens Valley respectively, but there is little immediate prospect of the production of other metallic ores unless new discoveries are made.

The production of non-metallic minerals, which has been expanding in recent years, will be governed by demand rather than supply. The region includes deposits of fluorspar, felspar, diatomite, kaolin, limestone and gypsum which are not exhausted by any means, and from which useful production will continue.

Generally speaking, it seems likely that while industrial technology remains substantially as it is at present, the mineral industry of the region will not return to its former importance, but will make a useful contribution to the economic situation. However, there is always the possibility that new industrial processes will bring hitherto unused minerals into prominence, as the achievement of atomic fission has done for radio-active minerals, and advances of a similar nature may occur in the future.