SOUTH AUSTRALIA

Department of Mines

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

Bulletin No. 37

Geology and Mineral Resources of Southern Eyre Peninsula

By R. K. JOHNS, M.Sc., Senior Geologist

Issued under the authority of
THE HONOURABLE SIR A. LYELL MCEWIN, K.B.E., M.L.C.
MINISTER OF MINES

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LETTER OF TRANSMITTAL

Geological Survey Office, Department of Mines,
Adelaide, 5th August, 1960.

Sir,

I have the honour to submit a report by Senior Geologist R. K. Johns dealing with the geology and mineral resources of southern Eyre Peninsula. Following several years' study of the area, the information contained in this report represents a valuable addition to the understanding of an important mineral-bearing province. Arising from this work 15 one-mile scale and one four-mile scale geological maps have been published.

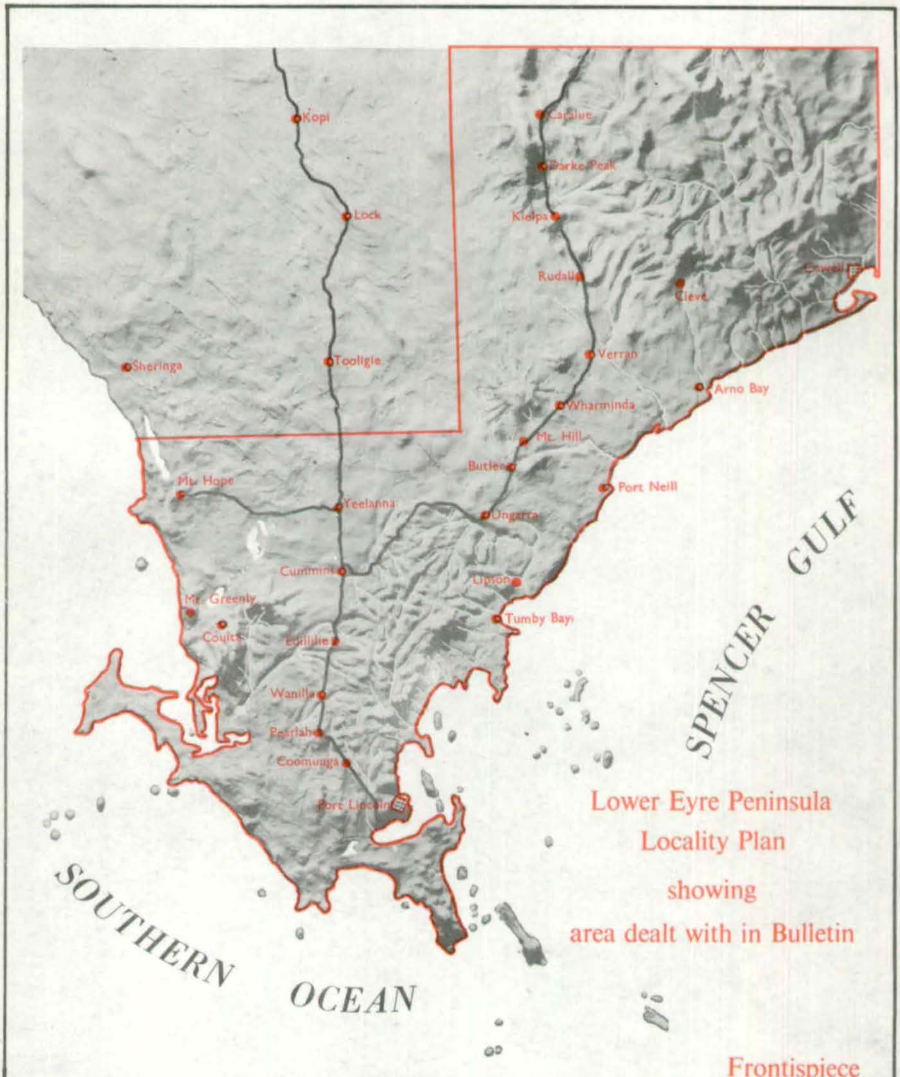
It is expected that the report will be of great interest to the mineral industry, and it is hoped that it will stimulate interest in prospecting on Eyre Peninsula.

I have, etc.,
T. A. BARNES,
Government Geologist.

To the Hon. Sir A. Lyell McEwin, K.B.E., M.L.C., Minister of Mines.

Submitted for approval to print as a Bulletin of the Geological Survey of South Australia.

Approved,
A. LYELL McEWIN,
Minister of Mines.



S.A. DEPARTMENT OF MINES

H. J. WALL, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE

CONTENTS

CHAPTER IX

PLANS AND ILLUSTRATIONS

PLATES

TEXT FIGURES

Geology and Mineral Resources of Southern Eyre Peninsula

Chapter 1

SUMMARY

A regional geological survey of southern Eyre Peninsula covering 15 standard 1-mile scale maps has been completed. These and one 4-mile scale map have been published.

The Province is underlain by Archaean metasediments of the West Australian Shield in which two broad lithologic groups have been recognized and defined. Detailed mapping has established a sequence of sedimentation within the Archaean comprising a diversity of gneissose, schistose and granitoid rocks, migmatites, quartzites, dolomites, amphibolites and hematitic quartzite which together make up a measured thickness in excess of 50,000ft. These rocks have undergone intense regional and additive metamorphism and have been deformed by compression and thrown into a system of folds. Repeated pitch reversals add complexity to the fold pattern.

Younger sediments include (?) Cambrian shelf deposits which have been correlated with the Corunna Group of the Middleback Range area. Shallow-water Tertiary marine limestones are preserved in a small embayment of the southern coast while Pleistocene calcareous aeolianites blanket large areas adjacent to the southern and western coast. The Recent mantle consists of alluvium and a prominent dune sand system which obscures large areas of the central and northernmost sections.

Economic mineral deposits are confined to the Archaean belts and include copper, silver, lead, manganese, talc, asbestos, graphite and magnesite. The ferruginous quartzites and cherts which are correlated with the Middleback formations are here thin and of low grade and offer no immediate source of iron ore.

The aeolianites are important aquifers and large supplies of potable water are drawn from an underground basin at Uley and delivered to the surface reticulation system. Other similar basins are potential sources of supply.

Chapter 2

INTRODUCTION

PRESENT INVESTIGATION

The present geological survey was undertaken as a special project to assess the mineral potential of the central and southern portion of Eyre Peninsula and in particular it was directed towards a search for further sources of iron ore. As an essential first step in the project, regional mapping was undertaken and this involved a stratigraphic and tectonic study of the region, the location and examination of mineral and rock deposits and an appraisal of those resources.

Reconnaissance mapping of the southernmost portion of the peninsula embraced by county Flinders was undertaken by the writer in 1950 when the hydrological data presented in the present report were collated, and some petrological work carried out on rocks of this area.

The present survey was initiated in July, 1955, and the field mapping was completed in May, 1957, while based at Port Lincoln. Fifteen standard 1 inch to the mile geological maps have been prepared for publication, namely Darke, Glynn, Rudall, Cowell, Verran, Arno, Kiana, Yeelanna, Neill, Coulta, Cummins, Tumby, Wangary, Lincoln and Sleaford (see fig. 1). From these the Lincoln 4-mile (plate I) and a special 4-mile map (plate II) of the Cowell region have been compiled.

The writer was assisted in the field by the following geologists—P. W. Bollen on Cowell, R. P. Coats on Glynn and R. D. C. Steel on Glynn. D. Thatcher was responsible for the greater part of the field mapping of Kiana, Yeelanna and Neill.

Mapping of the area was based on aerial photographs on scales of 60 chains, 40 chains and in some areas where greater detail was required on enlargements to a scale of 30 chains to the inch. In this area the photographs proved to be of only limited use in the delineation of geological features.

PREVIOUS INVESTIGATIONS

No previous workers have dealt with the geology of the area as a whole. Mawson (1907) published a generally descriptive paper on part of southern Eyre Peninsula. Ward (1913 and 1944) and Wade (1915) discussed the possibility of discovering oil in the region in South Australian Geological Survey *Bulletins.*

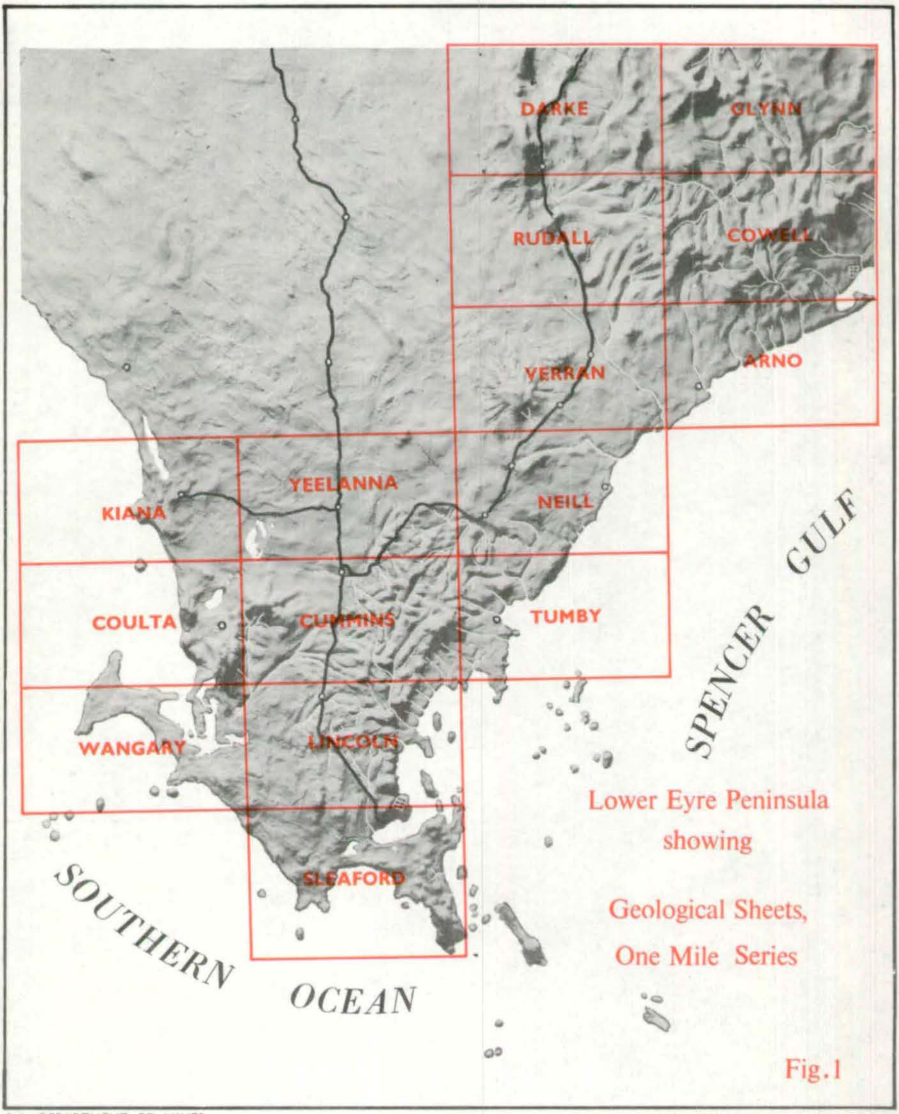
Jack (1914) published a geological map of county Jervois and parts of the adjoining counties in a report to the Government on underground-water supplies. His descriptions of the mineral deposits are particulary useful as at that time the workings were accessible.

Work of a petrological nature published by Tilley (1920 and 1921) is concerned with rocks of the southern part of the peninsula. A number of reports of local inspections by officers of the Department of Mines have been published dealing with specific problems or concerned with the various mineral deposits of the region. References to these reports are included where appropriate.

Prior to the present survey, large-scale geological State maps were dependent on Jack and Tilley for most of the Eyre Peninsula information shown thereon. Jack (1914) referred the basement rocks to the Precambrian complex and though he recognized the sedimentary character of much of the basement he interpreted granitoid types as younger intrusives. The sandstone of the Blue Range he referred to the Ordovician.

Tilley (1920, 1921) proposed the name Flinders Series for the granite gneisses which outcrop on the Port Lincoln foreshore; Hutchison Series for the obviously sedimentary formations which he believed to be intersected and partially engulfed by the Flinders Series; Warrow Series, for what he believed to be younger quartzitic sediments of the Marble Range locality; and Dutton Series for the granitic gneisses which enclose and isolate the Warrow rocks.

Mining has been sporadically carried out at a number of centres since the end of the last century. Prospectors were particularly active in the area during the period 1950-1955, chiefly in search of radioactive minerals, and several uranium deposits were located. An airborne scintillometer survey was subsequently made by the Department of Mines and this revealed a number of small and unimportant anomalies. In 1953 an airborne magnetometer survey was undertaken by the Commonwealth Bureau of Mineral Resources, Geology and Geophysics, and this was extended in 1955 by Adastra Hunting Geophysics Ltd. on behalf of the Department of Mines.



Lower Eyre Peninsula
showing

Geological Sheets,
One Mile Series

Fig. 1

S.A. DEPARTMENT OF MINES

H. J. WALL. GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE

ACCESS

Lincoln Highway extending southerly from Port Augusta is the main road connection between Port Lincoln and Adelaide. It skirts the western shores of Spencer Gulf and passes through Cowell and Arno Bay with short deviations into Port Neill and Tumby Bay.

The Flinders Highway extends from Port Lincoln along the western coast of the peninsula to Ceduna, where it makes connection with the Eyre Highway. Secondary roads are either of the bratten type or are formed from lateritic gravels. Access over large areas of Darke, Glynn, Verran, Kiana, Wangary and Sleaford is by way of unimproved bush tracks which are often little more than cleared lines through scrub, being narrow, rough and devious to avoid such obstructions as sandhills, rocky outcrops or swamps.

Construction of a narrow (3ft. 6in.) gauge railway network which connects Port Lincoln separately with Penong, Mount Hope and Buckleboo have served to open up large areas which would be otherwise undeveloped.

A bi-weekly passenger and cargo motor vessel ferry service operates between Port Lincoln and Port Adelaide while coastal steamers make periodical calls at Spencer Gulf ports including Tumby Bay, Port Neill, Arno Bay and Cowell.

Airport facilities exist at Port Lincoln, Cowell and Cleve and regular services operate.

HISTORICAL

The shores of Eyre Peninsula were charted and its principal geographical features named by Captain Matthew Flinders R.N. in his voyage of discovery in H.M.S. *Investigator* in 1802. After sailing down the western coast of Eyre Peninsula and rounding West Point tragedy struck off Cape Catastrophe and this is recorded on a tablet erected at Memory Cove (fig. 2).

Flinders named Port Lincoln after his native province and reported favourably on the harbour, surrounds and climate. Water was taken on from near the head of Proper Bay and his voyage continued on to Franklin Harbour and beyond.

Peron, the French navigator, visited these shores shortly after Flinders, though sailing in the opposite direction and several of his place names are recorded along the southern coast.

Whalers frequented the southern shores of the peninsula and Thistle Island prior to permanent settlement and remnants of their landings and boiling pots exist at Fishery Bay.

Permanent white settlement took place at Port Lincoln in 1839 when land was taken up and cleared for cultivation inland from the original settlement at Happy Valley and later at other centres on the West Coast.

The aborigines were generally amicable though there were occasions of open hostility. A youth, Hawson, was speared by natives at Kirton Point, the explorer John Darke was attacked at Waddikee Rocks and died and was buried at the foot of the peak which bears his name, and later a party droving stock overland from Adelaide disappeared without trace and is presumed to have been attacked by the natives near Cowell. Two tribes, the Nauo and Parnkalla, occupied the Port Lincoln region, and near Franklin Harbour, the Nukunnus, and in the north, the Ngannityiddis. An aboriginal mission was established at Poonindie but the native tribes rapidly became extinct.

It was from Port Lincoln that Edward John Eyre set out in 1841 to cross to Western Australia. Another early explorer, John McDouall Stuart, had associations with this region, having lived for some time in the Port Lincoln district.

CULTURAL

The better-soil areas of the plains have been mostly cleared of the ubiquitous mallee scrub and have been brought under cultivation for the growing of cereal crops, wheat, barley and oats, for raising of stock and wool production.

Still covered by virgin scrub are large areas of Darke, Glynn and Rudall where mallee and broombush have not been cleared from poor-soil areas or from rocky hill tops, though the alluviated gullies have in many places been brought into production. Poor sandy soils and extensive dune-ridged areas of Darke, Glynn, Rudall, Verran, Arno and Yeelanna are largely untouched as are large parts of Kiana, Coulta, Wangary, Lincoln and Sleaford which are underlain by aeolianite and covered by eucalypts ("mallee") and tea tree.

Closer settlement of many areas followed the placing of ex-war servicemen on newly developed lands at Wanilla which formerly carried sheoak and yacca on lateritic soils. This area joins on the north the Wanilla hardwood forest plantation.

Major developmental works on the peninsula include harbour facilities at a number of ports on the Spencer Gulf coast, a widespread water reticulation scheme and a growing network of electric power lines emanating from the generating station at Port Lincoln (Kirton Point).

Port Lincoln (fig. 3) is the principal township, being situated on a fine deep-water harbour at the terminal of three rail networks. The livelihood of the community is derived from the rich farmlands which centre on the town, an abattoirs, freezing works, fish cannery, superphosphate works, railways and coastal and overseas shipping. An equable climate and an abundance of fish in local waters attract holiday makers to this locality.

Coastal ports north of Port Lincoln include North Shields, Louth Bay, Tumby, Port Neill, Arno Bay, Port Gibbon and Cowell. Ketches and small coastal vessels trade between these and other gulf ports, out-cargo consisting principally of grain.

Cleve and Cummins are the principal inland centres and these serve mainly agricultural and pastoral communities.

CLIMATE

The southern Eyre Peninsula region enjoys an equable Mediterranean climate without experiencing extremes of heat or cold. Rain falls chiefly in winter (June to August) though summer storms of short duration contribute irregular and sometimes fairly large accessions. The average annual rainfall recorded at various stations is as below:

	in.		in.
Port Lincoln	18.24	Yeelanna	16.02
Greenpatch	24.19	Tumby Bay	13.89
Mount Hope	19.56	Arno Bay	12.43
Brimpton Lake	19.10	Cowell	10.07
Lipson	14.50	Coulta	19.20
Warratta Vale	11.93	Cummins	17.43
Port Neill	12.99	Ungarra	16.46
Cleve	15.67	Rudall	13.06
Darke Peak	14.99	Mangalo	13.11
The Fountain	20.30	Miltalie	18.89
Koppio	20.95		

Fig. 4 depicts the isohyets for the region and was compiled from figures from the above stations as supplied by the Weather Bureau to the end of 1957.

FIG. 2—COMMEMORATIVE PLAQUE

Erected at Memory Cove

FIG. 3—PORT LINCOLN FROM WINTER HILL

Happy Valley in foreground

AVERAGE MONTHLY REGISTRATIONS (COMMONWEALTH BUREAU OF METEOROLOGY, 1839-1950)

	Jan. in.	Feb. in.	Mar. in.	Apl. in.	May in.	June in.	July in.	Aug. in.	Sept. in.	Oct. in.	Nov. in.	Dec. in.
Arno Bay . . .	0.47	0.83	0.67	0.96	1.24	1.53	1.49	1.46	1.36	1.24	0.91	0.69
Brimpton Lake	0.35	0.72	0.58	0.97	2.23	3.14	3.33	2.69	1.99	1.39	0.95	0.76
Cleve	0.59	0.93	0.78	1.08	1.49	1.78	1.72	1.88	1.64	1.49	1.16	0.77
Coulta	0.39	0.59	0.66	1.37	2.44	3.72	3.40	2.77	1.94	1.37	0.86	0.57
Cowell	0.53	0.70	0.71	1.06	1.10	1.19	0.97	1.06	1.09	1.13	0.78	0.57
Darke Peak . .	0.62	0.98	0.52	0.84	1.43	1.97	1.82	2.11	1.65	1.36	1.01	0.81
Greenpatch . .	0.56	0.71	0.87	1.77	2.86	3.98	3.92	3.32	2.46	1.76	1.13	0.85
Koppio	0.58	0.63	0.69	1.42	2.26	3.51	3.25	2.99	2.19	1.67	0.98	0.78
Mangalo . . .	0.61	0.85	0.62	0.90	1.37	1.58	1.49	1.68	1.40	1.26	0.91	0.71
Miltalie	0.62	0.86	0.86	1.15	1.46	1.60	1.38	1.50	1.40	1.35	0.98	0.69
Port Lincoln .	0.54	0.57	0.79	1.37	2.27	3.00	3.02	2.63	1.95	1.41	0.94	0.69
Port Neill . .	0.37	0.85	0.52	0.84	1.25	1.62	1.58	1.50	1.36	1.27	0.96	0.73
Tumby Bay .	0.33	0.62	0.60	1.05	1.51	2.09	2.23	1.86	1.52	1.27	0.87	0.60
Ungarra . . .	0.42	0.88	0.62	0.88	1.75	2.18	2.48	2.17	1.90	1.51	1.03	0.85
Waratta Vale.	0.35	0.52	0.58	0.95	1.30	1.79	1.57	1.47	1.24	0.99	0.70	0.47
Yeelanna . . .	0.32	0.67	0.52	0.84	1.82	2.35	2.65	2.30	1.72	1.33	0.83	0.69

OUTCROP CONDITIONS

Outcrops of basement rock are generally discontinuous. In the hilly regions they are for the most part obscured by gravels and alluvium along drainage lines, and by talus and rock waste over those parts of the highlands which are remnants of an old peneplained surface. In the Lincoln Uplands a younger Tertiary mantle obscures the elevated partially dissected peneplain and bedrock outcrops are generally here confined to the deeply eroded gullies or to ridges on which erosion has been more advanced.

In the Cleve Uplands cultivation of alluviated gullies has been generally undertaken leaving the bedrock ridges in their virgin state while in the Lincoln Uplands the undissected interfluves have been cleared, the valleys being generally less productive.

Over Darke and Glynn, sand has often been blown up to high levels obscuring the bedrock over large areas. The Central Basin has an uneven bedrock floor with occasional small outcrops emerging at the surface while adjacent to the southern and western coastline aeolianites obscure all the underlying materials (fig. 5).

Quartzites and cherts give rise to bold rocky outcrops and prominent elongate meridional ridges. The elongate ridges of the Marble Range locality, Darke Peak Range (fig. 6) Caralue Bluff (fig. 7) Blue Range, Mount Olinthus, Mount Nield (fig. 8), etc., owe their elevation to resistant cores of quartzite. Schists generally outcrop strongly whereas the foliated gneisses and migmatites appear in subdued topographical relief. Even-grained granitoid rocks give rise in some places to bold features, *e.g.*, Carappee Hill (fig. 9), Mount Dutton, Elbow Hill, etc.

Chapter 3

PHYSIOGRAPHY

Eyre Peninsula is bounded on the east by Spencer Gulf and on the south and west by the waters of the Southern Ocean; it is triangular in shape with an irregular coastline and many off-shore islands. The area is one of subdued relief on which the mainland physiographic elements are the eastern coastal plains, eastern highlands, central basin and the western highlands (see fig. 10). These are described below. The drainage pattern is described separately in subsequent paragraphs.

EASTERN COASTAL PLAINS

Skirting the shores of Spencer Gulf is a gently undulating plain which extends from North Shields northerly to beyond Cowell. The plain is of variable width, being bounded on the west by a slightly arcuate fault scarp—the Cowell scarp (Miles; 1952)—and its southern prolongation, the Lincoln scarp. Faulting has stepped up the range block to the west to a height of about 700ft. above the general level of the plain. The Cowell scarp is traceable from a point northeast of Utera to a point seven miles southwest of Elbow Hill. Southerly from this point to near Lipson the fault is known only from airborne magnetometer traverses carried out in 1955 (fig. 11). The Lincoln scarp (fig. 12) which extends from near Lipson to Port Lincoln is a prominent feature.

The elevation of the plain above sea-level ranges from a few feet to 432ft. at Oswald trig. Sea erosion has given rise to an indented coast with a series of wide open bays backed by sandy beaches and separated by headlands which owe their preservation to platforms of basement gneiss. Coastal bedrock platforms are generally only a few feet above water level but may exceed 50ft. in some places.

Coastal samphire swamps with mangroves fringe the shores of Franklin Harbour while farther south, between this locality and North Shields, are a number of disconnected saline lagoons and samphire swamps separated from the sea by white sand dunes.

The shores of Boston Bay and Port Lincoln proper are almost coincident with the Lincoln Fault.

The peninsula forming the hundred of Flinders is on a general southerly prolongation of the eastern coastal plain, the main ridge attaining an elevation of 770ft. The eastern coast of this peninsula is quite rugged (fig. 13) though the cliffs are not as precipitous as those of Thistle Island, 5 miles offshore, where almost sheer walls of aeolianite overlying crystalline basement rocks rise in places to over 700ft. from the sea. The intervening islands and those elsewhere off the eastern coast are generally low and rounded having elevations similar to that of the mainland coast. Wedge Island rises to 662ft. abruptly from the sea and Boston Island rises to an elevation of 318 feet.

EASTERN HIGHLANDS

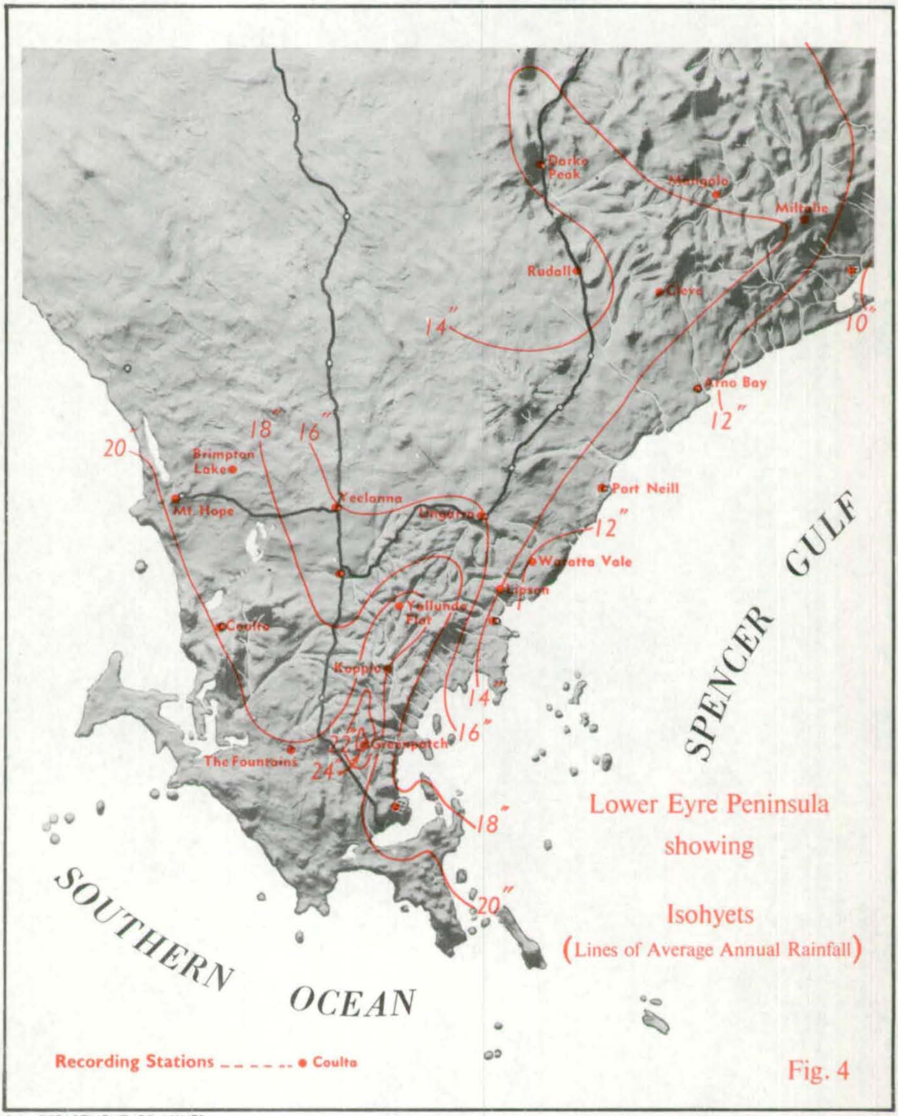
The uplifted belt flanking the coastal plains appears in skyline profile as a flat tableland. It is made up of three distinct units, the Cleve Uplands, the Blue Range and the Lincoln Uplands, the intervening terrain being generally flat, of lower elevation and covered with sand dunes, merging with the coastal plains to the east and westerly to the central basin.

Cleve Uplands

The physiography here reflects closely the geological structure. Resistant beds of quartzite form the most prominent ridges while the intervening lowlands are occupied by more readily eroded gneisses which appear in sporadic outcrop. The ridge features are exemplified in Darke Peak Range, Caralue Bluff, Plug Range and Mount Olinthus ridge. Mount Olinthus (fig. 14) rises to 1,443ft., Darke Peak to 1,564ft. and Carappee Hill to 1,625 feet.

On the eastern side of the ranges, Triple Hill, Benbuy, Elbow Hill, Mount Parapet, Minbrie Hill and Mount Geharty are prominent peaks in gneissose rocks.

The topography throughout is generally mature and large areas of these "uplands" are almost flat, relieved only by discontinuous low rock pediments and occasional ridges which are covered by sand dunes.



Lower Eyre Peninsula
showing
Isohyets
(Lines of Average Annual Rainfall)

Fig. 4

Uplift of this block has rejuvenated erosion and many of the creeks which empty on to the coastal plains have cut steep-sided gorges. The headwaters of Yabmana Creek and its tributaries draining the eastern Mount Miller divide have particularly steep gradients.

The uplands give way to the south to undulatory plains with superimposed sand dunes; bedrock outcrops are sparse in this locality and conspicuous only at Mount Priscilla (800 feet).

Blue Range

The Blue Range is a dissected plateau made up of flat-lying sandstone-quartzites. Its highest point is 854ft. above sea-level.

Lincoln Uplands

This belt comprises an elongated uplifted block (some 10 miles wide) and with a 700ft. elevation. It is bounded on the east by a prominent fault scarp, but to the west the margin is less well defined.

The physiography of these uplands shows two distinctive forms. Parts of the region comprise dissected rolling uplands with dendritic drainage which merge into areas of elongated ridges and valleys having rectilinear or trellis drainage. These different features reflect two stages in the sculpturing of the land surface by stream action. The rolling upland is a remnant of an old erosion surface or peneplain, where late Tertiary gravels and laterites have been preserved but which are dissected by the present-day drainage system. Where erosion has been sufficiently vigorous since uplift, linear ridges and valleys having northerly or northeasterly trends have been carved in the basement. Strong linear ridges and valleys along the eastern flanks of the ranges result from the differential erosion of interbedded soft schists and resistant quartzites and from the pronounced foliation in the gneisses.

Prominent hills such as Winter Hill (771ft.), Mount Gawler (806ft.), and Pillaworta Hill (about 1,200ft.) which stand out above the general level in this elevated region were probably monadnocks in what were aggraded plains prior to uplift.

WESTERN HIGHLANDS

Near the western coast the Marble Range stands out in lines of imposing meridional ridges which in association with the ridges of Mount Dutton, Mount Greenly, Mount Drummond, Mount Hope, the Frenchman and North Block impede drainage to the western coast of the peninsula.

The Marble Range is elevated 1,421ft. above sea-level, North Block 1,266ft. and Mount Greenly 1,001 feet.

These prominences stand out as isolated cuestas and hogbacks in an otherwise flat terrain (figs. 15 and 16). Their southerly prolongations (masked by a cover of aeolianite) give rise to the peninsula features about Coffins Bay where Recent drowning of broad expanses of flat country behind these high dune-covered ridges has resulted in the formation of shallow land-locked bays, joined by narrow channels, *e.g.,* Kellidie Bay, Mount Dutton Bay, Coffin Bay and Port Douglas (figs. 17 and 18).

Coffin Bay Peninsula is included within this province only for convenience as its surface is generally subdued and covered by fixed sand dunes except adjacent to the coast where "blowouts" of drifting sand occupy large areas.

CENTRAL BASIN

The area designated the Central Basin lies between the Lincoln Uplands and the Western Highlands. It is a broad stretch of gently undulating country with internal drainage and occupied by Tertiary paralic sediments which to the south are obscured by a blanket of aeolianite and migratory sand dunes. The basin is of undetermined extent to the north. Basement rocks form an irregular floor and outcrop at various points within the basin.

Along the southern and southwestern coasts precipitous cliffs exceeding 400ft. in height have been developed—the cliffs between Cape Wiles (fig. 19) and Point Avoid possibly being the most rugged on the mainland of lower Eyre Peninsula.

A high sand ridge elevated 748ft. parallels the coast near Shoal Point, but northwards on the basin proper the topography is subdued.

Chapter 4

DRAINAGE

A normal surface-drainage system has developed over the southern part of the Cleve Uplands, the Lincoln Uplands, on the eastern coastal plains and in the central-southern part of the Central Basin. These areas are underlain either by outcropping basement rocks or by impermeable Tertiary clays, laterites and their transported derivatives.

In the northern and western sections of the Cleve Uplands a poorly defined system of surface drainage exists as Recent windblown sands blanket the valley floors. Drainage channels issuing from these uplands in all but a few cases are soon lost beneath the sand a short distance from the point of discharge on to the plains.

The main drainage channel in the Cleve Uplands is that of Salt Creek and its tributaries which rise in the central part of the region and empty out on the coastal plain north of Cowell. Except when in flood, the water is highly saline and the course of Salt Creek (fig. 20) is marked by chains of brackish pools in the upper reaches and by brine in the lower reaches. The course of this creek generally cuts across the strike and foliation of the basement rocks though the channels of its tributaries and of other creeks draining these uplands are strongly controlled by the underlying rocks which impose a trellis-type drainage pattern. Salt Creek undoubtedly receives large accessions as underflow from its tributaries draining from the north and which are blanketed by sand.

Most of the creeks emptying on to the eastern coastal plains lose their identity on crossing the scarp terrace.

The River Driver rises 1 mile to 4 miles west of Taragoro railway siding as a prominent channel draining from a number of salt pans which tap the subsurface flow from creeks draining the western divide of the Cleve Uplands.

In the Lincoln Uplands a dendritic drainage system has developed in areas underlain by rocks having no pronounced foliation or covered by a lateritized surface. In the central eastern part of the region resistant beds of quartzite or chert confine major creek channels to fairly straight courses conforming to the trend of the strata (*e.g.*, Tod River, Pillaworta Creek and Rock Valley Creek) with the development of a trellis drainage system. Mine Creek and Waterfall Creek, Tod River and others draining into Spencer Gulf have cut steep gorges where they cross the underlying metasediments.

Creeks draining westerly from the Lincoln Uplands and easterly from the Marble Range divide are connected to swamps and lagoons. Much of the water which drains into Lake Wangary, Big Swamp, Little Swamp and other un-named marshes which fringe the aeolianite boundary ultimately reach the Southern Ocean by subsurface flow.

Except for Duck Creek and Minniribbie Creek there is an absence of any surface drainage in terrain underlain by aeolianite.

FIG. 5—TRAVERTINIZED AEOLIANITE (3FT. THICK) ON BASEMENT GNEISS AT COAST NEAR PORT LINCOLN

FIG. 6—DARKE PEAK RANGE

Quartzite dips to the east (right) at 40 degrees. Darke Peake is in the middle distance

To face page 14]

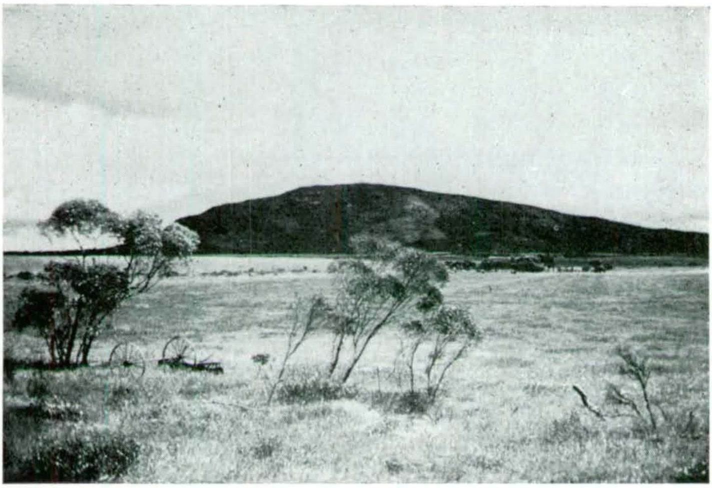


FIG. 7—CARALUE BLUFF—LOOKING WEST
Massive quartzite surrounded by flat sandy plain

FIG. 8—MOUNT NIELD

High ridges in background (Mount Nield on left) are composed of quartzites separated by felspar-quartz gneiss. The low rounded hills are of mica schists.

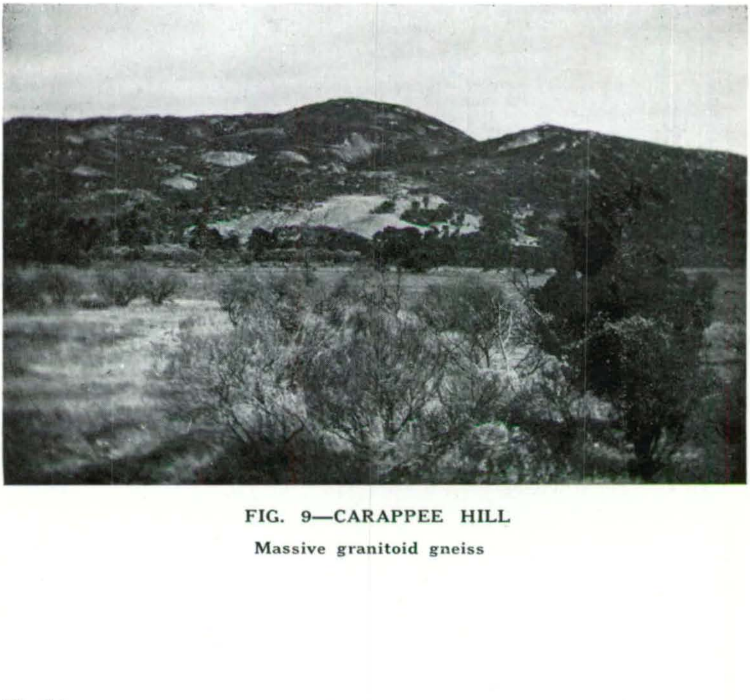


FIG. 9—CARAPPEE HILL

Massive granitoid gneiss

To face Fig. 7

The ridges near the western coast cause large areas of the Central Basin to have internal drainage. This combined with a high evaporation rate and an abundant supply of cyclic salt results in the development of salt lakes and playas, for example Lake Greenly, Lake Malata, Lake Baird and other nearby salinas. The underground waters of this region reflect a similar degree of salinity.

The sand dune covered plains abutting the various uplands are devoid of surface streams as they are sufficiently permeable to absorb all rainfall and outflow from the neighbouring highlands.

Lake Hamilton and Sleaford Mere are both completely surrounded by aeolianite and their water-level represents the exposed groundwater tables in these regions.

Chapter 5

GEOLOGY

GENERAL

The geological formations occurring in the region may be grouped into three main lithological and structural units which are widely separated in age. They comprise a crystalline basement or shield formation of Archaean age, a succession of sedimentary formations of (?) Cambrian age lying in marked unconformity upon the Archaean, and a younger surface mantle which masks the older formations over large areas. This last-named mantle is divisible into units of different ages and includes Tertiary marine limestones of limited extent, paralic Tertiary strata of the Central Basin, late Tertiary pisolitic clays, laterites and gravels, Pleistocene aeolianite and Recent developments of travertine, alluvium, sand, etc.

The region lies on the eastern side of the West Australian Shield and is one that has shown great stability over a long period of time. Apart from local transgressions by Proterozoic-Cambrian and later Tertiary seas the Shield rocks have been subjected to long periods of sub-aerial erosion. The overlapping sediments show slight tilting and are unmetamorphosed, indicating that the Archaean rocks had derived their present metamorphic state and structural deformation in orogenies prior to the Proterozoic Era.

ARCHAEAN SHIELD METASEDIMENTS

Stratigraphy

Early workers (Mawson 1907, Ward 1913, Wade 1915, Jack 1914 and Tilley 1920, 1921) compared the rocks of Eyre Peninsula to those of the Archaean which are exposed elsewhere in southern and western Australia. The basement is part of the West Australian Shield, with a rock succession not recognized elsewhere in the State. It is nowhere far below the present land surface and is exposed in discontinuous outcrops over the greater part of the region but which are best studied in the uplands and along the coastal platforms.

C. E. Tilley (1920) proposed the term Hutchison Series to embrace the oldest group of rocks that he recognized; . . . "only remnants of this terrain are now exposed to view, the series having been broken up by the great intrusions of igneous gneisses that have succeeded. To this group of igneous rocks, the name—Flinders Series—is given, from the hundred and county in which they attain a widespread and typical development. Fragments of the Hutchison Series have been engulfed in the Flinders Series, and these can be recognized at points remote from typical exposures of the Hutchison Series. There is abundant evidence that this sedimentary terrain has been invaded and intensely metamorphosed by the succeeding igneous intrusions."

Tilley (1921) described the Flinders Series as consisting of a "complex of igneous rocks; granites and gneisses with associated basic rocks, amphibolites, hornblende schists, and pyroxene-granulites . . . Its relation to the Hutchison Series is always of the intrusive kind, the Hutchison Series being invaded and metamorphosed by sills of the Flinders gneisses."

The Warrow Series he described as "a metamorphosed sequence of sediments principally developed in the hundreds of Warrow and Lake Wangary. The rocks are quartzites, slates and mica schists, the chief characteristics being a great thickness of massive quartzites, rocks which form inconspicuous members of the Hutchison Series."

The Dutton Series was proposed for the "later extrusion of granites, developed in the hundred of Warrow" which metamorphosed the Warrow sediments. "These granites are distinguished by the development of abundant tourmaline in their more acid differentiates. A zone of lit-par-lit injection along the contact has resulted in the development of injection gneisses from the Warrow schists.

"The serial sequence given above is one of decreasing geological antiquity, and the oldest group of rocks developed in the area is thus of sedimentary origin.

"There can be little doubt as to the Precambrian age of the Hutchison, Flinders, and Warrow Series, but the inclusion of the Dutton Series within the Precambrian is tentative only, and . . . it may be relegated to the Lower Palaeozoic."

From the foregoing it is clear that rocks which strongly resemble sediments Tilley regarded as Hutchison Series—granitoid types he referred to the Flinders Series.

During the present mapping programme two main subdivisions within the Archaean metasedimentary sequence were distinguished. The resultant concept necessitates redefinition of Tilley's terminology, of the Flinders and Hutchison Series and abandonment of the Dutton and Warrow Series which are now considered untenable. Under this new concept the Flinders Group comprises the oldest gneissose rocks of the region while the Hutchison Group embraces the youngest schistose rocks. It will be now shown that the so called Dutton Series is not a younger mass of intrusive granite but that the gneissose rocks of the Marble Range locality are but inliers of the Flinders Group. The Warrow Quartzites have been shown to be part of that metasedimentary sequence.

It is believed beyond reasonable doubt that all of the Archaean rocks represented in the region are metasediments which have responded to metasomatism on a regional scale to a degree dependent on the original composition of the sediments and with varying degrees of intensity in different parts. There is a great diversity of gneissose rocks present which range from undigested sediments such as quartzites and dolomites, through metasediments, schists, amphibolites and migmatites, and a variety of foliated and banded quartzo-felspathic gneisses to granitoid types. One of the main objectives of the present survey was to recognize mapping units and to group the formations in rock units of regional validity.

The rocks herein referred to the Flinders Group (Gneiss Group of the maps published earlier in the investigation, viz. Darke, Glynn, Rudall, Cowell, Verran and Arno) would fall into the Flinders Series classification of Tilley, and the Hutchison Group (Schist Group of earlier published maps) here comprise those relegated in part to the Hutchison Series. Detailed mapping has now shown that there is no basis for the supposed younger groupings—Dutton and Warrow—which are synonymous with the Flinders Group. The name Warrow, however, has been

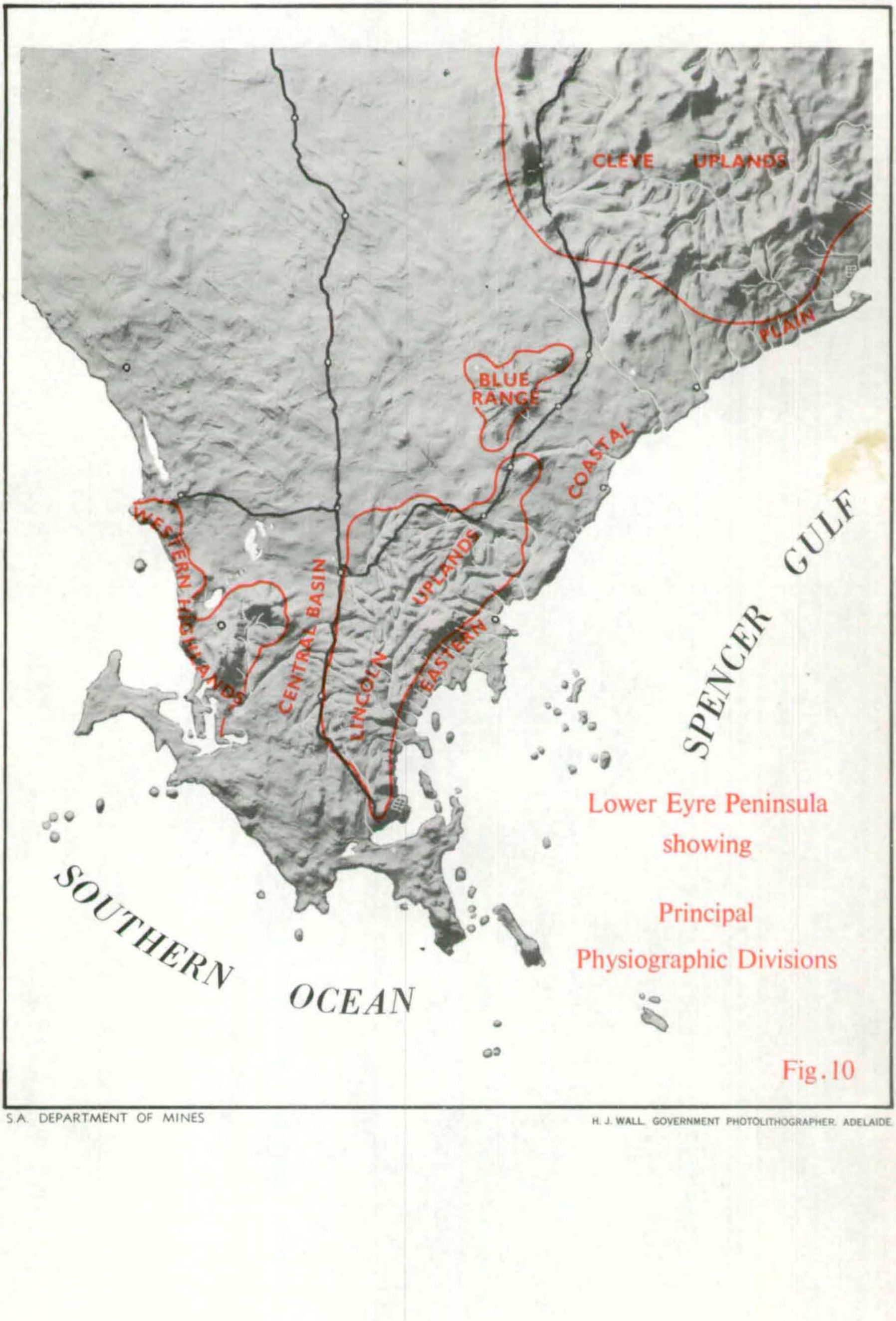


Fig. 10

S.A. DEPARTMENT OF MINES

H. J. WALL, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

retained and is applied to the major quartzite horizon developed within the Flinders Group and typically exposed in the hundred of Warrow in the Marble Range locality, Darke Peak Range, etc.

The contacts between the two groups are gradational and are therefore arbitrarily defined. The Flinders Group has a maximum measured thickness of 30,000ft. and the Hutchison Group 20,000ft., though neither the top nor the bottom of the section is exposed.

Further detailed geological mapping of the metamorphic rocks with supporting microscopic study would demonstrate perhaps a fuller stratigraphy and a greater complexity of structure.

Flinders Group

Gneisses

The domed anticlinal cores of the major fold structures are occupied by a group of metasediments, the chief components of which are quartz-felspar gneisses. These show varying degrees of alteration induced by regional metamorphism, the variations being thought to reflect the original composition of the sediments. As a result pure quartzite and dolomite beds have remained intact within a complex of highly foliated gneisses and migmatites.

The quartz-felspar gneisses are characterized by a foliation which generally approximates to the original bedding and the structural mapping of the area has been based on this assumption. The gneisses range from granitoid varieties through varying degress of banding and foliation, to zones of completely injected rocks, all of which enclose metamorphosed sediments and often beds of quartzite or dolomite, whose bedded sedimentary origin is obvious. The directional element within the gneisses may be imposed by a concentration of particular minerals in parallel bands, development of quartz and felspar augen, alignment of mica flakes, or by flattening and parallelism of felspar tablets and porphyroblasts.

In places the gneisses merge into migmatites consisting of amphibolite and schistose metasediments which contain quartzo-felspathic streaks and veinlets, felspar porphyroblasts, and incipient pegmatites (figs. 21 and 22). The unassimilated sediments are commonly fine grained whereas the pegmatitic phases are of medium to coarse grain. All gradations are observable between uncontaminated basic rock and quartzo-felspathic bands to give a series of mixed colour-banded gneisses. During the process of large-scale hybridization, the rocks achieved some measure of fluidity as is evidenced by the intense interfingering of basic and acidic phases and ptygmatic folding. Much of the felspar present is undoubtedly a product of metasomatic processes or granitization.

In the Cleve Uplands, Jack (1914) recognized that much of the gneiss had been "produced by the extreme alteration of sedimentary rocks, accompanied or followed by the introduction of felspathic minerals," but he considered that others were younger intrusives. The present writer believes that the granitoid rocks which show no foliation. *e.g.*, the large mass of Carappee Hill and that at Carpa, etc., are also products of the metasomatic processes which influenced the whole area. In composition and appearance they are granitic and consist of medium- to coarse-grained grey or pink felspars, quartz, biotite, muscovite, and accessory apatite.

In the Lincoln Uplands a complex of granitic gneisses outcrops in a narrow elongated belt along the eastern margin of the uplands from opposite Cape Euler to near North Side Hill. The same rocks occur in sporadic outcrop over the coastal plain and in low platforms at headlands along the coast from Port Neill southwards along the eastern coastline. Structurally the rocks of this group exhibit wide variations; the foliation planes generally dip at high angles and commonly an irregular wavy foliation has been developed (fig. 23). Heterogeneity in composition and mineral assemblage is a feature of this belt with gradational changes from gneisses and schists having a sedimentary appearance through banded and foliated gneisses to massive "porphyritic" granite. A separation of these different types on any but a very detailed scale is not possible. The granitoid rocks are typified by the development of large felspar ovoids, reminiscent of the "rapakivi" type of felspar set in a finer-grained matrix of quartz, biotite, hornblende, microcline and acid andesine, with accessory iron ore and orthite. Generally a markedly gneissose structure is displayed by the parallelism of the biotite and hornblende crystals as well as by alignment of the felspar ovoids. The massive non-foliated rock is also of common occurrence, the weathered surfaces are grey, and because of a tendency to exfoliate, large tors and rounded boulders are common. These rocks must have attained some measure of mobility during metamorphism as is evidenced by the wavy and ptygmatic structures which have been developed.

Along the coast east of Port Lincoln and on Boston Island charnockitic varieties occur. In these, pyroxene accompanies and takes the place of hornblende sometimes to its complete exclusion; the plagioclase is calcic andesine-anorthite and is accompanied by quartz and microcline with hypersthene and accessory apatite, sphene, zircon, orthite and magnetite.

In the Western Highlands and enclosing elongated masses of quartzite are developments of coarse gneissose granite which show smooth rounded features on weathering. They are "conformable" with the quartzites and are considered to have been produced by metasomatism from pre-existing arkosic sediments. The felspars in many cases attain porphyroblastic dimensions and form tablets up to 1in. by ¾in. Quartz, biotite and muscovite are essential constituents.

From a point ½ mile west of Winter Hill to a point 1 mile west of Poonindie, remnants of a narrow calc-silicate bed can be traced. It is a striking white- and green-banded rock consisting of quartz and microcline alternating in bands with epidote and hornblende with accessory iron ore and sphene. Microcline commonly occurs in porphyroblasts.

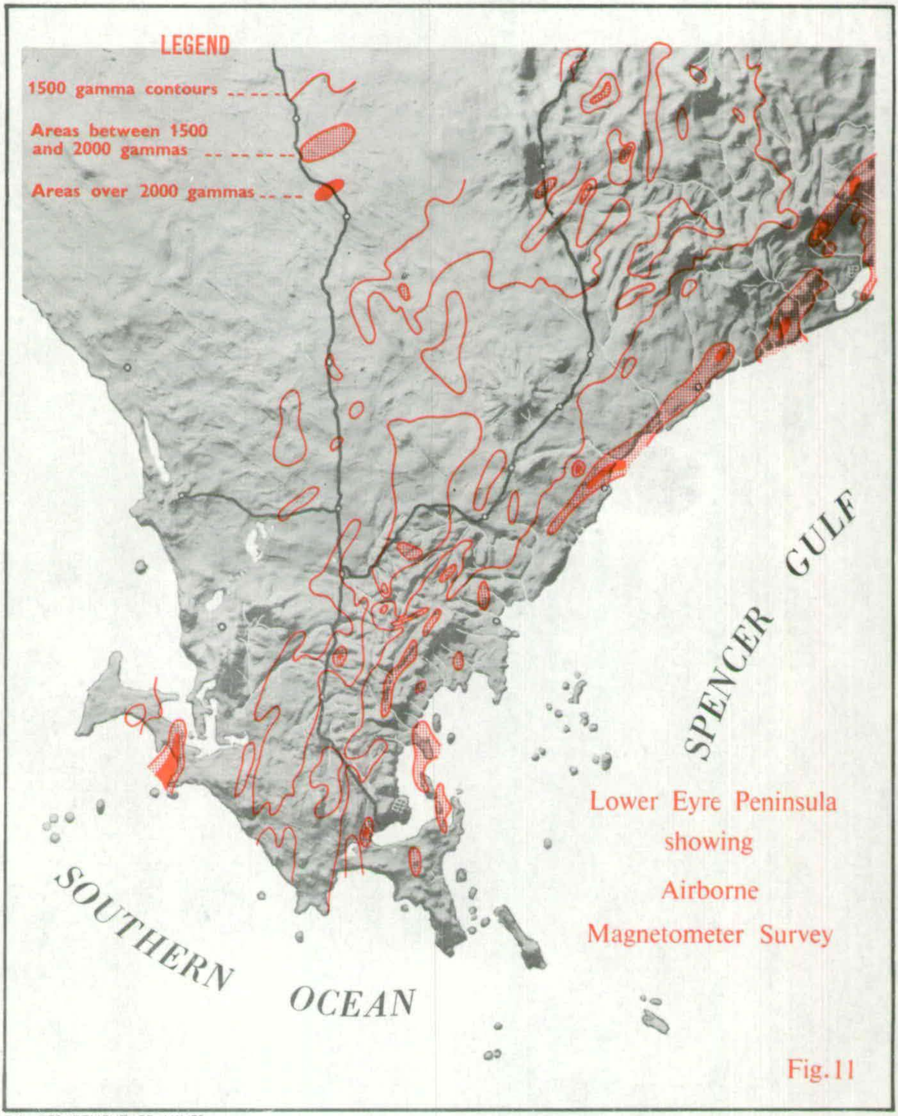
Quartzites

Quartzites are prominent members of the Flinders Group and though they occur at all levels within the exposed sequence, they are particularly well developed in certain regions, viz., Darke, Rudall, Glynn and Coulta, where outcrops of these beds serve to outline the tectonic structure. Thin siliceous beds are ubiquitous but have been distinguished on the maps only where they are traceable for some distance.

In the Cleve Uplands the quartzites are mostly thin and inconspicuous except north of Cleve in the Mount Nield locality where they make prominent ridges and also in the Carpie Puntha-Yalanda locality.

The longitudinal cuesta of Darke Peak Range, and, to the north, the Caralue Bluff ridge, are formed by a thick quartzite formation, the Warrow Quartzite. Here it is generally white, flaggy to massive, often strongly lineated and containing small flakes of sericitic mica (fig. 24). In the upper parts of the bed silvery and pearly mica is sufficiently abundant to constitute a sericite quartzite or quartz-sericite schist. Massive sections of the quartzite resemble quartz "blows" as they have been completely recrystallized. In some places they appear glassy, elsewhere milky white. Some weathered surfaces show knobby or occasional cigar-shaped lenticles which appear at first sight to be elongate milled-out pebbles or mylonitic structures, but are perhaps related to rod-like lineation.

Jack (1914) states that conglomerates are present in the Darke Peak Range and at Caralue Bluff, but the "conglomerates" are here considered to be of tectonic origin and not to lie at the base of a series although the formation in parts much resembles a sheared conglomerate, the fragments of which consist of siliceous material, rounded or elliptical in section, consisting of siliceous rock enclosed in a more micaceous matrix. Their elongated form is evidently a result of shearing movements.



S.A. DEPARTMENT OF MINES

H. J. WALL, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

The same quartzite formation outlines a domed structure in the southeast corner of Darke and occupies the overturned western limb of a major anticline in the Carpie Puntha ridge. In this vicinity the bed appears to have thickened considerably though this may be accounted for in part by poor outcrop conditions whereby quartzite fragments shed from this formation mask the enclosing gneisses. This horizon is traceable to the Plug Range (fig. 25) where it is represented by three discrete beds of quartzite varying from 30 to 100ft. in thickness and separated by quartz-felspar gneisses. To the north, through Roller Point and beyond, the three beds thicken considerably and ultimately appear to have coalesced.

The quartzite formation which makes up the prominent ridges in the Marble Range locality is correlated with the formation of Darke Peak as it occupies a similar stratigraphic position and it is strikingly similar in lithology and thickness. It is made up of massive and flaggy quartzites, sericitic quartzite and sericite schists. Near the base, knotted quartz-mica schists have been developed.

The quartzite of Mount Greenly and the Frenchman is dense and glassy and is interbedded with thin schistose bands, the whole dipping at 40°-70° E. The overall geological structure is partly inferred in this region because of paucity of outcrop. It is considered that the Warrow Quartzite of Mount Greenly and the elongate ridges of the Marble Range form complementary limbs of a syncline. The lowermost beds of the formation which are exposed at the base of North Block are quartz augen schists, the quartz knots attaining 1in. in diameter. The prominent cliff-forming dense glassy micaceous quartzites of the North Block locality alternate with flaggy bands.

Phyllitic slates which are seen only at the Lady Franklin and Moonlight mines on the flanks of the Marble Range occur on about the same stratigraphic level as the Warrow Quartzite.

Dolomites

Dolomites occur at several levels within the Flinders Group of metasediments and though they are too discontinuous to act as regional marker beds, they are sufficiently widespread in several localities to outline the geological structure. They have been recognized as mappable units only in the Cleve Uplands. They outcrop near the top of the group 4 miles south of Mangalo and near the contact from west of Mount Nield to near Cleve. There are also conspicuous developments of dolomite in a belt near the edge of the uplands west of Cowell where there are three main beds up to 200ft. in thickness.

At several other localities, viz., near Carpa, in the Plug Range locality, and in isolated exposures on Glynn and Rudall, dolomite has been mapped.

Thin impure calcareous bands within the gneisses have been noted at a number of localities in the Cleve Uplands, but they are not separable on the mapped scale.

The dolomites consist of crystalline white dolomitic marbles, in places siliceous and with local developments of felspathic gneiss, pegmatite, or siliceous and slaty rocks. In places thin alternating bands of impure marble and limey gneiss occur between the main bands of dolomite and gneiss indicating a gradational contact and a normal sedimentary sequence. The dolomite rocks are mostly white, sometimes grey, and in many places are yellow-green in colour, due to the development of serpentine. They range from fine- to coarse-grained rocks and though the various beds in different localities are physically similar, they vary in chemical composition. The magnesia content varies from low to that of a fairly pure dolomite.

Bedding persists as irregular colour streakings and relicts in even highly deformed marble beds. Microscopically few other minerals appear to be present.

Schists

The Flinders-Hutchison Groups boundary is an arbitrary one, the rocks at this contact are generally schistose, a felspathic quartz-mica schist being common. Within the Flinders Group proper, mica schists are subordinate and generally inconspicuous and they have not been differentiated on the geological maps.

Amphibolites

In the Cleve Uplands amphibolites are unimportant members of the group but they are common in the Lincoln Uplands. In places they are possibly remnants of calcareous sediments though many appear to have been derived from basic intrusives.

Hutchison Group

Though the Hutchison Group derives its name from the Tumby Bay region (hundred of Hutchison) it is best studied in the Cleve Uplands. Here the Hutchison (Schist) Group over 15,000ft. in thickness succeeds the Gneiss (Flinders) Group, and is characterized by the development of lustrous mica schists. The abundance of schist suggests that the original conditions of sedimentation progressively changed resulting in a predominance of argillaceous material.

Mica Schists

In the Cleve Uplands most of the sediments comprising the group are typically silvery green to grey felted crenulated mica schists, fine grained and very fissile. Micas present are both biotite and muscovite. Quartz commonly occurs as lenticles or elongate boudinage-type stringers parallel to the bedding. In some of the intensely crumpled schists the competent siliceous bands are gently folded, the "boudins" appearing as flattened lenticular masses or disrupted into elongate "pebbles". The proportions of quartz present are variable from place to place and there are all transitions present from mica schist to micaceous quartzite. Felspar is subordinate though near the base of the group, *e.g.,* in the Mount Millar region, felspar development is advanced and all gradations between mica schists to highly foliated augen-felspar gneisses are observable. In this same locality garnets were observed in dodecahedra up to ½in. across.

In the Lincoln Uplands mica schists with thin interbedded quartzites are exposed along the courses of Chinmina Creek and Salt Creek on the Neill sheet over a width of 1,000ft. and thence at intervals along creek channels and road cuttings southwards to the Tod Reservoir. They range from lustrous, fine-grained, highly schistose rocks through psammitic schists to fine-grained felspathic gneisses. The beds are closely puckered in some places and carry lenticles of quartz or ptygmatic veinlets of quartz and felspar. In Mine Creek (Tumby sheet) these veined schists attain a thickness of 2,500ft., the dominant components being biotite and quartz with variable amounts of felspar, muscovite and garnets.

Amphibolites

Bedded amphibolites which no doubt represent calcareous intercalations within the original strata have not been differentiated in the Cleve Uplands where they are thin and discontinuous and quite subordinate. In the Neill, Tumby and Cummins regions of the Lincoln Uplands, however, para-amphibolites outcrop for a distance of over 30 miles, over a width of up to 3,000ft. The amphibolites are usually well-banded rocks with amphibole or leucocrats predominating in alternating parallel bands. They are of fine to medium grain and are constituted or hornblende, quartz and plagioclase with accessory biotite, iron ore and apatite. The amounts of quartz and felspar (andesine) present vary considerably. In some specimens the amphibole takes up a radial or sheaf-like arrangement on the bedding planes.

The para-amphibolites are believed to represent metamorphosed dolomitic shales and in the Lincoln Uplands they make up the lowermost members of the group.

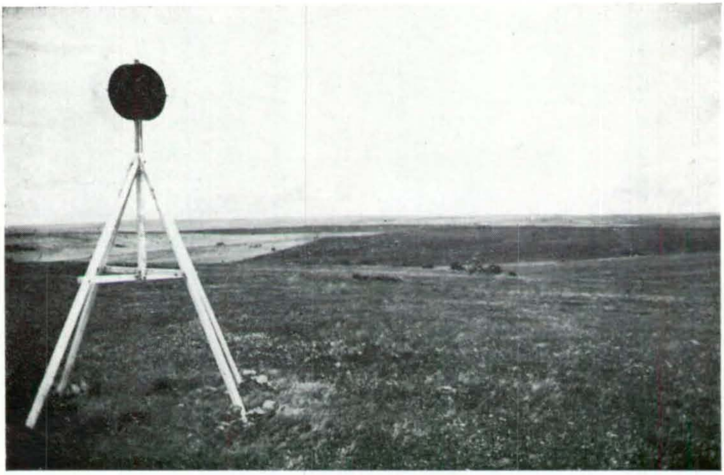


FIG. 12—OSWALD TRIG

Looking southwest across the coastal plains to the Lincoln Scarp and flat even profile of the uplands

FIG. 13—COASTAL AEOLIANITE CLIFFS NEAR CAPE CATASTROPHE

Basement gneisses form the headland platforms. The cliffs are about 200ft. high. Thistle Island is in the far distance.

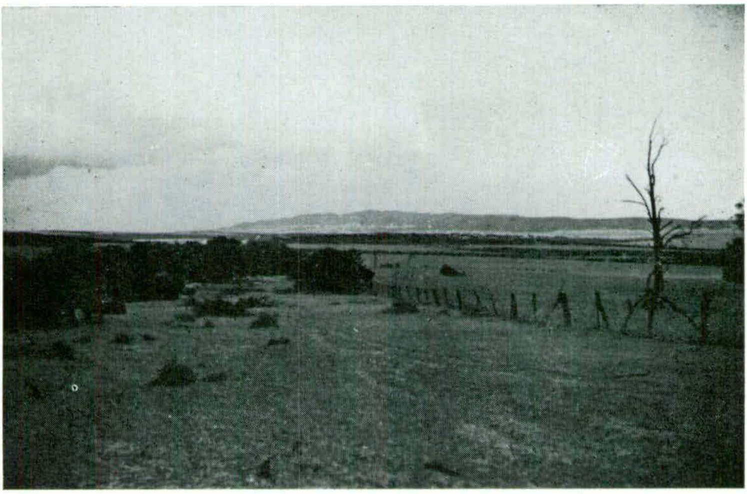


FIG. 14—MOUNT OLINTHUS RIDGE FROM NEAR MINBRIE HILL

The high range is composed of quartzites and the intervening flat terrain of easily eroded gneiss

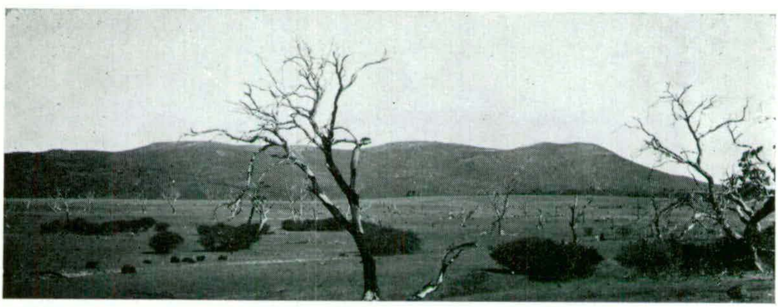


FIG. 15—MARBLE RANGE, LOOKING EAST

The highest ridges are composed of quartzite and the lower slopes of granite gneiss

FIG. 16—MARBLE RANGE, LOOKING NORTH FROM NEAR LAKE WANGARY

Sheoak (*Casuarina stricta*) and yacca (*Xanthorrea Tateana*) in foreground

FIG. 17—KELLIDIE BAY, A SHALLOW-WATER EMBAYMENT IN AEOLIANITE

Marble Range in left background

FIG. 18—PENINSULA FEATURES AT COFFIN BAY, FORMED BY OLD AEOLIANITE DUNES

Kellidie Bay on right; Port Douglas on left foreground and beyond

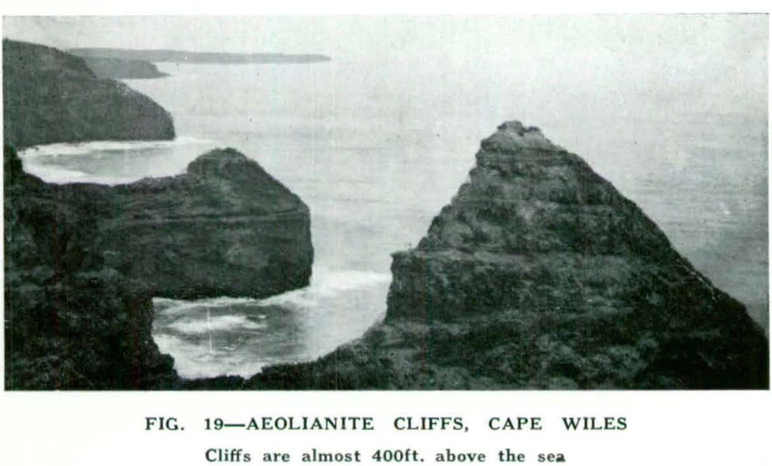


FIG. 19—AEOLIANITE CLIFFS, CAPE WILES

Cliffs are almost 400ft. above the sea

FIG. 20—SALT CREEK, NEAR MOUNT MESSENGER

Mica schists intruded by pegmatite; outcrop in creek bed

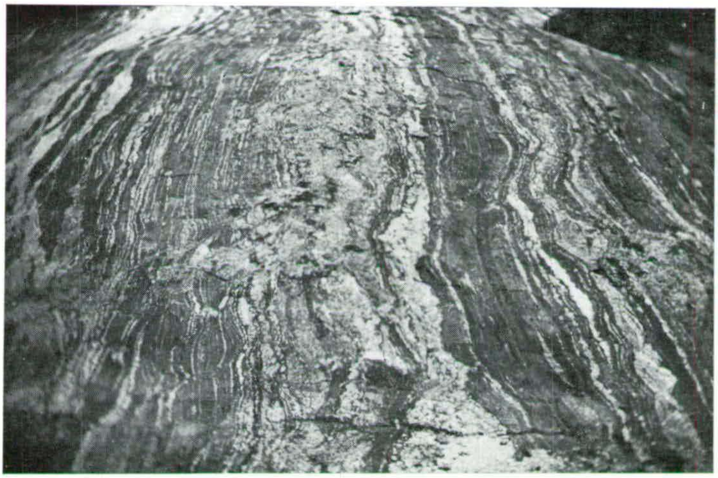


FIG. 21—METASEDIMENTS NEAR WINTER HILL

Amphibolitic bands separated by quartz-felspar veinlets and incipient pegmatites

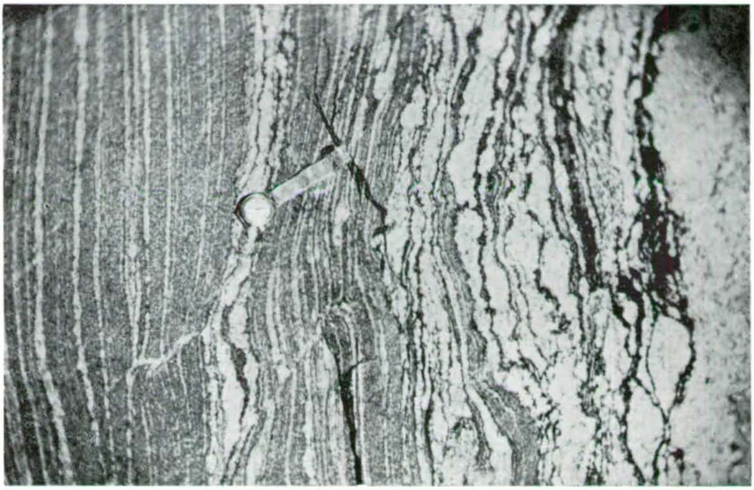


FIG. 22—MIGMATITES NEAR WINTER HILL
(Compare fig. 21)

FIG. 23—FINELY CONTORTED COARSE AUGEN GNEISS—KIRTON POINT

FIG. 24—FLAGGY AND MASSIVE QUARTZITES—
CARALUE BLUFF

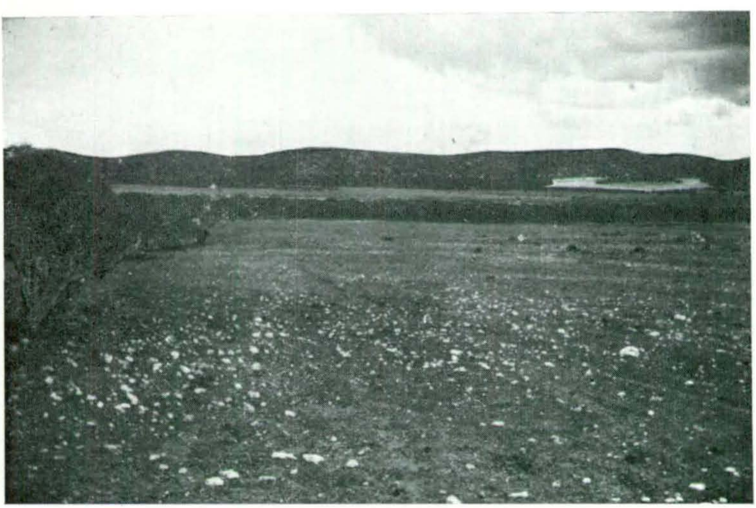


FIG. 25—PLUG RANGE, LOOKING WEST

Quartzites outcrop on the ridge and along the eastern flank of the range, separated by quartz-felspar gneisses; dolomites in foreground

On the eastern limb of a synclinal structure and outcropping in an elongate belt 1½ miles wide which extends southerly from near the Tumby Bay copper mines to the vicinity of Port Lincoln this formation bears the imprint of more intense migmatization. These migmatites are obviously modified amphibolite sediments, in which layers of granitic composition and consisting of quartz-felspar aggregates, alternate with hornblende-biotite gneisses; they carry discontinuous stringers of slightly coarser pegmatitic material of the same composition. The layers of different composition are sharply defined and have uniform thickness though there is heterogeneity in composition and structure and all gradations exist from unassimilated sediments to porphyroblastic gneisses. The sharp margins of individual layers and the conformable relations with the underlying sediments for a distance of over 30 miles suggests felspathization of sediments in place rather than earlier-held beliefs that the igneous-looking bands were concordant magmatic (lit-par-lit) injections.

Hematite Quartzites

Occurring at or near the base of the Hutchison Group is a formation which because of similar lithology is correlated with the Middleback Quartzite of the Middleback Range. The hematite quartzite formation is a persistent marker horizon though it displays a change in facies to quartzite or in other places to chert.

Reference to the plans (plates I and II) and cross-sections (fig. 27) shows that the schists below this hematite quartzite are markedly lenticular indicating a number of local facies changes within the group. In the Lincoln Uplands, though the outcrops of the horizon are discontinuous, they appear to occupy a position several thousand feet from the base of the group. In the Cleve Uplands the formation forms the base of the Hutchison Group on Glynn and also in the Mount Olinthus locality. In the Wangaraleednie vicinity and on the complementary limb on which Mount Shannan and Mount Desperate are located, however, over 5,000ft. of schist separate this formation from the base, while even farther to the west and north in complementary synclinal structures it again appears to be at the base of the group.

The lenticular facies changes within the group as a whole, the rapid changes of facies and intraformational breccias within the hematite quartzites and cherts all suggest shallow-water conditions with interrupted sedimentation. The bedded iron ores are believed to be chemically precipitated sediments dominantly of marine origin similar to Precambrian banded iron ores known elsewhere and typically showing a process of rhythmic deposition in alternating laminae of chert and hematite (fig. 28). On Rudall 2½ miles south of Poolalalie Hill, dolomite is closely associated with this formation.

The beds making up this formation on the Cowell sheet in the Mount Olinthus locality are about 500ft. wide. They consist here of flaggy to massive quartzite, white, often glassy and in places strongly lineated, the lineation being due to the preferred orientation of sericitic mica. The formation is hard and very resistant to erosion and gives rise to the prominent ridges between Wangaraleednie and Yalanda, and northwards forms a gentle arc. Close folding is involved to explain the great thickening of the formation in the region between Ulgera Gap and Miltalie (see fig. 26). The limbs of the folds are steep to vertical and in places overturned. This pounded keel structure is repeated in dual elongated synclines on Glynn, pitch reversals being common here. The quartzites occupying the limbs of these structures in the area covered by the Glynn sheet are similar both in lithology and thickness, but on the eastern limb of the structure, lying to the north of Miltalie, the quartzite is interbedded with ferruginous cherts. The ferruginous beds constitute low-grade iron ores which are highly siliceous and appear to have a high manganese content. The formation has been locally brecciated and the fragments cemented by iron and manganese oxides.

This same quartzite outcrops in prominent ridges which make up the western limb of a keel structure in the northeastern section of the Glynn sheet.

On the western side of the Cowell and on the Rudall and Darke sheets a number of thin and more or less continuous hematitic cherts outline the geological structure. The eastern limb which makes a gentle arc through Mount Desperate and Mount Shannan (fig. 29) is made up of a number of thin lenses of hematite quartzite or chert (in some places at least four separate beds), but generally there are two main beds present which are separated by mica schist. Further discontinuous outcrops of hematite quartzite have been located at Campoona Hill and still farther west near Cockabidnie Reservoir (Rudall sheet) where they extend into the Darke sheet.

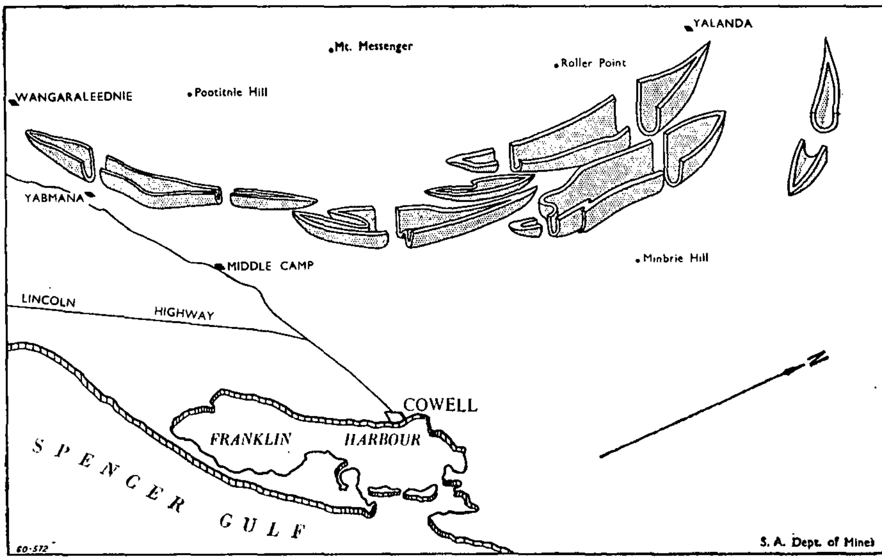


FIG. 26—STEREOGRAM ILLUSTRATING STRUCTURE OF QUARTZITE FORMATION

Between Wangaraleednie and Yalanda

Mount Priscilla (Verran sheet) is made up of this quartzite formation apparently on the keel of the major syncline traceable southwesterly from the Cleve Uplands. Farther south the quartzite makes a bold outcrop in Mount Hill (Neill sheet).

In the Lincoln Uplands hematite quartzites occupy a position several hundred feet above the base of the Hutchison Group and trace out an elongate pounded syncline from Curilla Spring (Tumby sheet), westwards beyond the Port Lincoln copper mines locality. Another elongated syncline extends southeasterly from the Tumby structure to near the Tod River Reservoir (Cummins sheet). The same formation is traceable in isolated exposures southwards through the Lincoln and Sleaford sheets to the coast at Sleaford Bay and on the western side of a major anticline from near Coomunga Springs (Lincoln sheet) at intervals to beyond the Three Brothers locality (Yeelanna sheet). The formation consists in this region of one or two separable beds of hematite quartzite lithologically similar to those of the Cleve Uplands and the Middleback Range. Assays of samples taken from near the Koppio graphite mine compared favourably with the hematite quartzites (taconitic ores) of the Middleback Range, with an average Fe content of 39.1 per cent.

Iron ore from the Iron Mount locality (Tumby sheet) was formerly mined for use as a flux in the Port Pirie smelters.

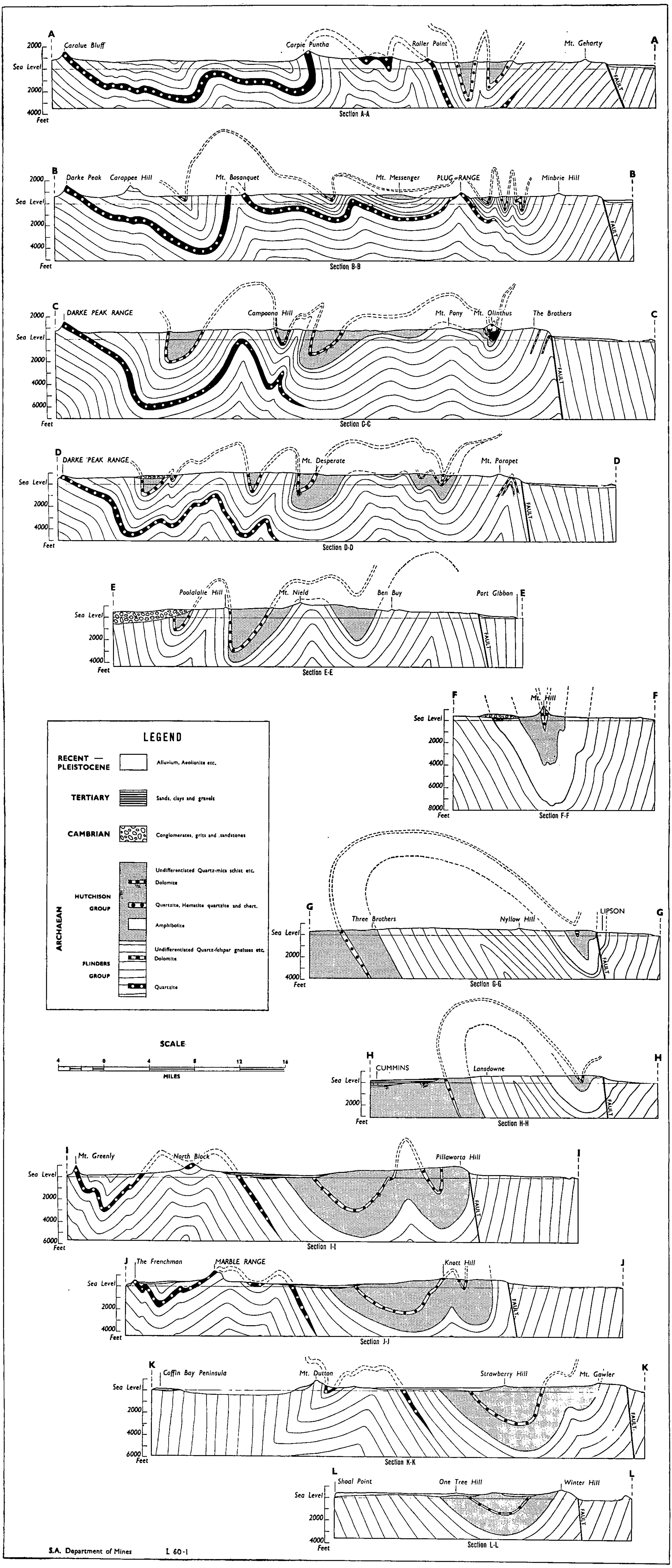


FIG. 27—GEOLOGICAL CROSS-SECTIONS

Along the course of Pillaworta Creek to Kapperna Creek on the Cummins sheet the formation displays a changed facies, being a flaggy and somewhat micaceous quartzite about 300ft. wide.

The iron minerals are represented by hematite but this is hydrated at the surface so that limonitic films and crusts have developed. Blue-black stains in some areas suggest the presence also of manganese oxides. The tonnage of even low-grade ore is low, as the iron-bearing beds are not only thin but in general they appear in subdued and interrupted outcrops.

Lithological differences within this formation over short distances suggest that the deposition of both clastic and chemical deposits took place at the same time in different parts of the basin. Banded iron ores were deposited in zones where no clastic material was brought in.

Quartzites

Thin discontinuous quartzites were noted at a number of localities within the Hutchison Group but were not separated during this survey. They are particularly numerous on the Tumby and Neill sheets in the region lying between Salt Creek and the talc mines. The quartzites are generally completely recrystallized glassy, white or blue rocks, and are in parts micaceous.

Dolomites

Dolomites are useful horizon markers at several levels within the group in the Cleve Uplands, but are inconspicuous in the Lincoln Uplands. On the Cowell sheet dolomites are prominent members in the Ulgera Gap-Wangaraleednie vicinity both above and below the quartzite of this locality. They have been mapped elsewhere as only thin local developments.

On the Tumby sheet, dolomites are locally well developed and are the host rocks to talc mineralization. They are traceable to the southwest for some distance where dolomite occurs on several horizons on or about the same stratigraphic level as the hematite quartzite.

In some localities the dolomites are somewhat siliceous and in Mine Creek and on the coast at Sleaford Bay they are notably so. A bed of dolomite-quartzite is exposed in the course of Mine Creek over a width of 200 feet.

At Sleaford Bay the interfingering dolomitic members are now represented by coarse diopside with rosettes of coarse hornblende and disseminated flakes of graphite. Weathering of the dolomitic quartzites results in characteristic etching of the carbonate component resulting in honeycombed and banded rocks.

Gneisses

As observed elsewhere the Hutchison Schists contain felspathic gneissose developments, and over large areas of the Lincoln Uplands felspathization of these beds is a conspicuous feature, possibly indicating a more complete "soaking" during the process of regional metamorphism and migmatization. Along the southern and southwestern coast, extending from Sleaford Bay to Redbanks and thence at intervals to Shoal Point, the gneisses are characterized by the presence of garnet. In this sector parallel-banded structures within the gneisses appear to result from initial differences in composition of the original sediments; light-coloured bands consist of quartz, microcline, oligoclase and garnet, while the darker bands are made up of quartz, biotite and garnet (fig. 30). Garnets occur up to 1in. in diameter; hypersthene and hornblende are sparse, and accessories include apatite, zircon, sphene, orthite, spinel and sillimanite. The gneisses have a regular north-south foliation.

Graphitic Rocks

Graphitic schists and gneisses seldom outcrop because of their soft nature, but they have been observed over a wide extent in the Cleve and the Lincoln Uplands. Graphite schists occur at or about the same horizon as does the hematite quartzite formation; they have been noted to lie above and below this formation and in some places to be interbedded. Graphite, quartz and biotite are common constituents with variable amounts of garnet and felspar and all transitions have been noted between graphite schists and graphite quartz-felspar-garnet-biotite gneisses. These schists form a distinct stratigraphic unit in the Hutchison Group and persist with variable width and character from the coast at Sleaford Bay northwards through the Lincoln Uplands and on a more-limited scale in the Cleve Uplands. These disseminated flake graphite deposits appear to be not far removed genetically from the "bedded" deposits arising from intense thermal metamorphism of carbonaceous sediments.

PEGMATITES

Throughout the region quartz-felspar pegmatites are numerous in the schistose and gneissose rocks. They are unevenly distributed and vary widely in size, shape, texture and in structural and geometric relations to their host rocks.

Pegmatites within gneissose rocks of the Flinders Group are generally transgressive bodies and vary from very thin veinlets or lenses showing ptygmatic folding and "pinch and swell" structures to large bodies which attain several yards in width and are in many cases some chains in length. The contacts with the host rock are either sharp or diffuse, and many are intimately intergrown. Some pegmatites are merely clusters of felspar porphyroblasts in gneisses and migmatic metasediments.

Conformable pegmatites are more common in the Hutchison Group of schistose rocks where they are controlled by the bedding or foliation.

Their mineralogy is variable though quartz and felspar are dominant constituents; both potash felspar and plagioclase are common. Micas are commonly present and tourmaline is especially common in several regions, viz., in the Marble Range locality and on the Cummins sheet in the domed gneiss core of the Flinders Group.

Coarse-grained hornblende-bearing pegmatites intrude the gneisses at Redbanks (Sleaford sheet). Hornblende, diopside and garnet are rare, while orthite has been noted. Beryl occurs in small crystals south of the Frenchman (Coulta sheet) and near Mount Geharty (Glynn sheet).

The pegmatites are more coarse grained and apparently younger than their host rocks, are without visible avenues of supply from conventional magma sources, and appear to have been formed rather by replacement or by dilation of their hosts during late stages of the migmatization process.

APLITES

Aplitic rocks are rare and appear to be variations of pegmatites wherein quartz, microcline, and acid plagioclase are the only constituents. The few aplite dykes noted are thin discordant bodies which postdate the basic intrusives.

INTRUSIVE BASIC ROCKS

Basic dykes intrude the Flinders gneiss complex in great profusion in the eastern coastal belt south of Tumby Bay and are best exposed for study in the Port Lincoln region (figs. 31, 32, 33, 34 and 35). They show great variations in width, shape and mineral structure and their mode of occurrence, texture, and composition indicate that they are basic hypabyssal intrusives. The dykes generally conform with the foliation of the gneisses, and are therefore for the most part steeply dipping and concordant. Where the gneisses have been intricately folded the dyke rocks have been folded with them, but retaining their separate identity. Widths of the various dykes range from inches to chains.

While some dykes show chilled borders others show contamination with the host rocks and ill-defined margins.

FIG. 28—HEMATITE-QUARTZITE FORMATION—MOUNT DESPERATE

Alternating bands consist of chert and hematite

FIG. 29—HEMATITE-QUARTZITE KNOLL—MOUNT SHANNAN

To face page 24]

FIG. 30—METASEDIMENTARY QUARTZ-GARNET GNEISSES INTRUDED BY BASIC DYKES—SLEAFORD BAY

FIG. 31—BASIC DYKE IN COARSE "RAPAKIVI" GRANITOID GNEISS —LOUTH BAY

Margins of dyke are irregular

Tilley (op. cit.) classified the dyke rocks into meta-dolerites, garnet amphibolites, and quartz-orthoclase amphibolites, depending on their composition and degree of metamorphism undergone since emplacement.

Microscopic study of thin sections prepared by the author illustrate that while some dykes show primary porphyritic or doleritic textures, others show varying degrees of metamorphism with the development of palimpsest and schistose structures. Plagioclase (oligoclase to calcic anorthite) is an essential constituent, while olivine, hypersthene, augite, hornblende, biotite and quartz are variable components. Garnet is rare, and magnetite and apatite are accessories.

AGE OF THE METAMORPHISM AND GRANITIZATION PROCESS

There have been no absolute age determinations made so far on any of the mineral components of the crystalline basement. The metasediments are thought to be pre-upper-Proterozoic in age by lithologic analogy with other terrains which underlie the upper Proterozoic (Adelaide System) and as with these terrains they are tentatively here assigned to the Archaean. However all that can be conclusively stated from the study of this region is that the ancient sediments reached their present metamorphic state and were folded into their present attitudes prior to the encroachment by (?)Cambrian seas and the deposition of conglomerates, grits and sandstones which are preserved in the Blue Range and on the south-western flanks of the Cleve Uplands.

The extreme changes induced in the shield rocks have been described above. The writer believes that though some rocks attained a certain measure of fluidity there was no mobilization or movement of "magma" in the area mapped with the exception of the Midgee massif which lies to the north of Cowell on the McGregor sheet and which represents a mobilized core. Evidence cited to support this belief includes concordance of gneissic rocks and structures over the whole region, and absence of phenomena normally attributed to magmatic intrusions. The process would appear to involve migmatic "soaking" or granitization of pre-existing sediments *in situ*.

THE SEDIMENTARY MANTLE

(?)Cambrian Series

In order of antiquity after the basement rocks are the strata which have been somewhat doubtfully referred to the Cambrian. The boulder and pebble beds (fig. 36) which overlap the Archaean basement northwest of Cleve (Rudall sheet) and are preserved farther to the southeast in the Blue Range (Verran sheet) have been equated with the Corunna Conglomerate which was regarded by Miles (1954) and Johns, Solomon and Miles (Corunna geological map, 1952) as being the basal formation of Cambrian overlap in that region. More recent work done in connection with the search for oil in the Wilkatana-Lake Torrens region, however, has suggested that these strata are even older and are of Marinoan age (upper Proterozoic). The lack of fossil evidence leaves the problem at the present time unsolved.

On the Rudall sheet the conglomerate makes a sharp contact with the basement in a profound unconformity (fig. 37). The basement rocks have a northeast-southwest strike with near vertical dip where they are overlapped by the younger strata whose strike is northwest-southeast.

The conglomerates are composed of well-rounded pebbles from 1in. to 3in. in diameter, chiefly white vein-type quartz, red jasper, quartzite and grey chert. Very rarely, pebbles of granitic rock types are found though the matrix is rich in felspar fragments. The main conglomerate occurs at the base of the series, but thin grits and quartzites occur a short distance above the basal beds. The upper limits of the conglomerate are not well defined but they grade upwards through grits and arkosic quartzites by pebble diminution.

In the Blue Range (Verran sheet) the sequence is made up almost wholly of fine-grained pink and white sandstone-quartzites. They are normally felspathic and fine grained, but towards the base they are somewhat gritty. The (?) Cambrian sedimentation was epicontinental and consisted of a shallow-water facies of arenaceous sediments. The true thickness of the series is unknown, but appears to be in excess of 8,000ft. on the Rudall sheet and approximately 500ft. in the Blue Range.

Tertiary Sediments

Subsequent to (?) Cambrian sedimentation the region appears to have been subjected to a long period of sub-aerial erosion, until the early Tertiary when erosion of Precambrian rock landmasses took place and deposition by river and aeolian agencies filled depressions in the old land surface. Deposition in ponded basins along the borders of the old land mass took place during the Eocene and is considered to have continued until such time as the whole region was reduced to base level.

A Tertiary basin lies between the Western Highlands and the Lincoln Uplands; its southern extent is undetermined because of the cover of younger sediments while to the north insufficient borehole information is available to determine its limits.

The sequence studied from bore-log data in the Wanilla-Cummins region shows great variations in lithology and thickness of strata indicating shallow-water conditions of sedimentation. The sediments consist of non-fossiliferous clays, sands, thin lignites and gravels whose overall thickness varies to a maximum of 445ft. penetrated in a Cummins bore. Bedrock gneisses outcrop in several places in the basin while drilling has shown that the basement floor is irregular and undulating.

The clays are multicoloured and range from white, yellow, orange and brown to bright red. Sands range from very fine well-sorted quartz grains through various grades of grit to coarse unsorted river gravels. Carbonaceous clays taken from a bore sunk in Cummins township contained planktonic foraminifera which have been described by N. H. Ludbrook (Palaeontologist) in a report, "A Widespread Pliocene Molluscan Fauna with *Anodontia* in South Australia". The presence of small planktonic foraminifera is taken as an indication of sedimentation under salt swamp or estuarine conditions. Pollen grains of *Proteacidites pachypolus* have been identified (Cookson) and these are characteristic of middle or upper Eocene deposits in South Australia.

Marine Miocene-Pliocene Strata

Fossiliferous buff-coloured gritty marine Miocene limestones containing abundant shell casts and boulders of bedrock gneisses are preserved in the cliffs at Fishery Bay on the south coast. These are overlain by littoral Pliocene limestones. The included species were identified by Ludbrook (loc. cit.). Fossils consist mainly of casts of large pelecypods; the fauna indicates a shallow-water bay head facies of Pliocene age widespread in South Australia and characterized particularly by a large species of *Anodontia.*

Laterites and Fossil Soil Development

Laterites, lateritic gravels and conglomerates have been preserved in many cases at high levels and mark the traces of widespread Tertiary peneplanation over large tracts of the central and southern parts of the region. The Central Basin is presumed to have been filled and the former highland areas reduced to the same level. Under humid pluvial conditions of the Pliocene, poorly drained soils were leached, leading to an accumulation of sesquioxides of iron and the formation of extensive areas of laterite.

FIG. 32—BASIC DYKE IN GNEISS—KIRTON POINT

Margins of dyke are sharp and regular

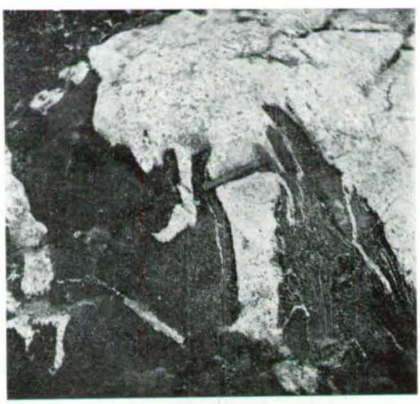


FIG. 33—IRREGULAR BASIC DYKE IN GRANITE GNEISS—KIRTON POINT

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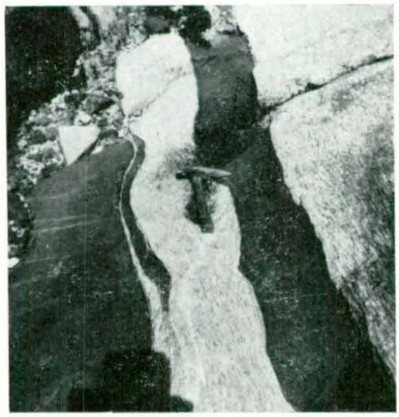

FIG. 34—BASIC DYKES IN AUGEN GNEISS—KIRTON POINT

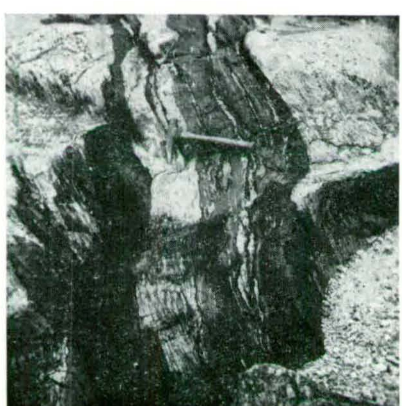

FIG. 35—BASIC DYKES IN AUGEN GNEISS—KIRTON POINT

Fossil lateritic soils have been preserved at high levels over the interfluves of the Lincoln Uplands where they were formed *in situ*. Similar soils covering the slopes of the uplifted and partially dissected plateau and much of the outwash material of the coastal plains and the Central Basin are resorted materials. The soils are shallow and light textured and are characterized by a considerable but variable proportion of pisolitic or massive ironstone gravel. Laterite conglomerates form thin hard cappings in many places, while elsewhere at high levels coarse river gravels and conglomerates have been preserved.

During the period of lateritization the peneplained basement rocks underwent deep weathering, ferruginization and kaolinization. Schists of the basement have been particularly prone to lateritization and sections in the weathered rock show a regular banding of purple, red and brown rocks which maintain their schist identity but which grade up into reddish-brown clayey rocks with pebbly concretions. These increase in size and merge with each other, until, at the top of the section, they form the familiar ironstone crust. The original composition of the underlying rocks appears to have had no effect on the final product, the conditions of low topographic relief and high tropical temperatures being favourable to the removal of silica with seasonal oscillations of water table and the concentration of iron oxide.

A large part of the solid geology is obscured in the Lincoln Uplands by the laterite formation which forms a continuous sheet. Regional uplift resulting in rejuvenation of drainage and subsequent erosion has partially stripped this cover.

Pleistocene Aeolianite

During the middle and late Pleistocene at the height of the Ice Age, broad expansions of continental shelf were exposed by a fall in sea-level which has been estimated by Daly (1934) to be in the vicinity of 250ft. As the coastline of the southern part of the State retreated shell fragments and calcareous sands were swept inland and formed the aeolianite deposits which now cover large tracts on areas embraced within the Sleaford, Lincoln, Wangary, Coulta and Kiana sheets.

The sand rapidly accumulating as a complex of slowly migrating transverse dunes (fig. 38), was piled up over the old erosion surface and filled the ancient river valleys. Under conditions favoured by an abundant supply of sand, moderate winds and deficient vegetation, a thickness in excess of 600ft. was built up in some places.

The deposits are made up of cross-bedded unconsolidated or loosely aggregated calcareous sands of low to very low silica content and characterized by fairly uniform particle size and the virtual absence of clays and pebble beds. The sands are white to buff and of fine to medium grain. Individual laminae are visible on coastal outcrops because of differential weathering which probably reflects differential wind packing, grain size and cementation.

The sands are well cemented by lime along the coast and at or near the surface of the inland exposures where solution and redeposition has developed a thin crust of kunkar. They have also been fixed by the growth of tea tree and mallee. Precipitous cliffs up to 400ft. high have been developed in aeolianite along the southern and western coast while on Thistle Island cliffs rise in excess of 600ft. from the sea.

Thin patches of these sands have been preserved at high levels on the flanks of Mount Dutton, Mount Greenly and Winters Hill. Thin kunkar developments noted elsewhere particularly on the Tumby, Neill, Verran and Arno sheets are probably related to this cycle.

N. H. Ludbrook has described an assemblage of small foraminifera, which occur in greenish-buff calcareous sandy clays underlying 104ft. of aeolianite and were penetrated in a bore sunk near the coast at Sleaford Bay. Below this strata the clay contained shell fragments, echinoid spines and brackish-water foraminiferal assemblage. Deposition is thus inferred to have been in shallow, sheltered water.

The occurrence of similar clays beneath the aeolianite has been reported in several bores elsewhere, but their occurrence appears to be very restricted.

Recent Cover

Sand Dunes

There are two distinct types, those of the interior and the coastal dunes.

The dunes of the interior are long narrow sub-parallel ridges of white and red siliceous sand which mantle the surface over the Central Basin, the area flanking the upland regions and also large areas of the Cleve Uplands themselves. The ridges consist of wind-deposited sand in dunes that rise to a single summit. Individual dunes are up to 5 miles though commonly 2-3 miles long tending 120-140 deg. About the southern and eastern flanks of the Cleve Uplands (Rudall, Cowell, Arno sheets) the dunes terminate against alluvial outwash from numerous drainage fans, but in the northern section (Darke, Glynn sheets) the sand has been blown to high levels (climbing dunes).

The interdune flats are occupied by brown sandy clays, the spacing between the dunes being about ¼ mile.

Streams are absent over nearly all of the sand-dune covered area of the lowlands, the chief exception here being the River Driver. In the Cleve Uplands where the drainage channels are choked with sand they are in many cases poorly defined, and the drainage is largely by subsurface flow.

The dunes are generally of the longitudinal type—long and narrow and extending in a direction parallel to that of the prevailing wind. The dunes are not now active and are fixed by vegetation, so it is apparent that they developed in an environment where conditions were different from those of the present day.

The prevailing more or less unidirectional wind responsible for this particular dune form was from the northwest as is indicated by the wind shadows in the lee of such prominences as Caralue Bluff, Darke Peak, etc. (see plate II). This also illustrates how the reflection of the wind has modified the dune structure on the western flanks of Darke Peak Range. Elsewhere in the Cleve Uplands prominent hills and valleys have obviously channelled and directed the winds resulting in discontinuous dunes and irregular crescentic mounds of a modified parabolic or transverse type.

Coastal dunes are located adjacent to the southern and western coasts and are of the transverse type which range in size and shape from small crescents to extensive elongated ridges whose crests are oriented parallel to the coast. The dunes are white and of variable composition ranging from dominantly siliceous to almost pure calcium carbonate. They have been blown into narrow elongate strips less than 1 mile wide on the Spencer Gulf coast south of Franklin Harbour, near Gibbon Point, in Tumby Bay, Peake Bay, and Louth Bay, or they may be in the nature of "blowouts" (fig. 39).

Blowouts have been derived from the Pleistocene aeolianites adjacent to the southern and western coasts under conditions characterized by little vegetation and an abundant supply of moving sand. The greatest blowout-development is in the area between Coffin Bay and Shoal Point where great mobile masses of sand elevated up to 738ft. above sea-level have moved inland from the coast a distance of 6 miles along a front 8 miles wide. Individual dunes are here 200ft. high and are composed almost entirely of calcium carbonate grains. The silica content of these sands is dependent on proximity to pre-Pleistocene rocks.

The coastal dunes are all of comparatively recent generation and most are still quite mobile.

FIG. 36—BASAL (?)CAMBRIAN CONGLOMERATES AND GRITS

Northwest of Cleve

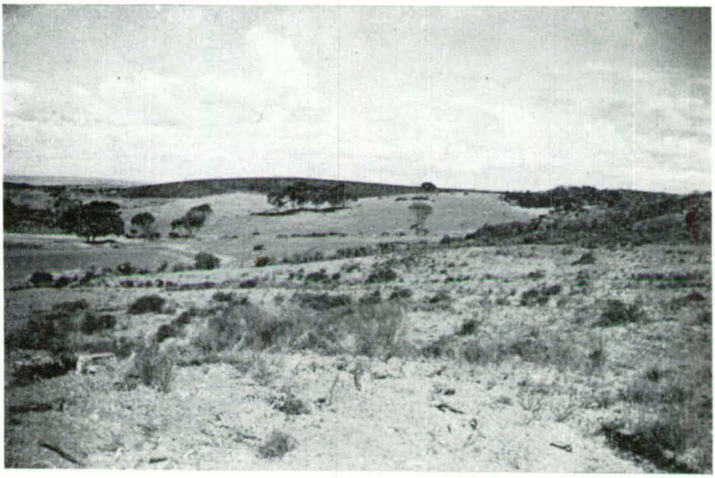

FIG. 37—The (?)CAMBRIAN UNCONFORMITY NORTHWEST OF CLEVE

Archaean schists outcrop on the low rounded hill in the background and are overlapped by conglomerates which outcrop on the right and in the foreground

FIG. 38—OLD SAND DUNE FORMATIONS—AEOLIANITE
(ONE TREE HILL)

FIG. 39—COASTAL SAND DUNES, "BLOWOUTS"—SLEAFORD BAY

The low cliffs and marine benches consist of aeolianite

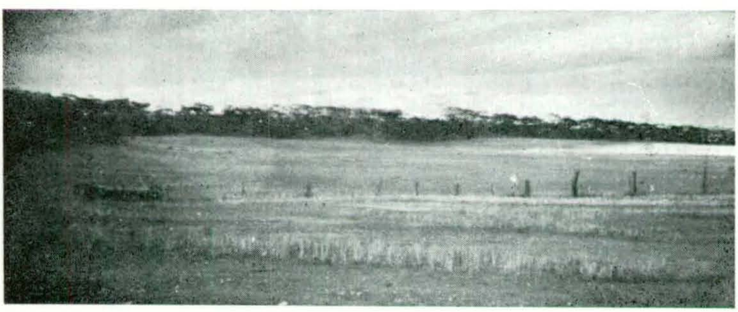

FIG. 40—THE COWELL FAULT SCARP

Near Cowell-Cleve road

Alluvium, Etc.

Freshwater clays, sands and gravels of the present erosion cycle mantle large tracts of the peninsula and to a large extent consist of resorted lateritic gravels. On the coastal plains and in the Central Basin where surface drainage is restricted, saline playas, lagoons and lakes are receiving basins for muds and evaporites.

Chapter 6

STRUCTURE

The strike and dip symbols and strike lines recorded on the published geological plans refer to bedding, schistosity or foliation depending on which of these structures is best developed in the rocks concerned. In those rocks in which traces of the original bedding are discernible, the bedding approximates closely to the foliation or schistosity which were later developments. In those areas in which all traces of the original bedding are obliterated or indiscernible, a similar relationship has been assumed. The concordance of the planar structure with lithological boundaries suggests that the original bedding was not extensively modified by metamorphism.

Bedding is particularly well preserved in the ferruginous cherts, some of the quartzites and in those gneisses that escaped intense metamorphism. In massive quartzites bedding has been generally obliterated by recrystallization and development of pronounced lineation, linear grooves or striations in a preferred orientation or by cigar-shaped lenticles resembling milled-out pebbles.

FOLDING

As the (?) Cambrian strata are unmetamorphosed and have been tilted only at low to moderate angles, it is apparent that the metasedimentary Archaean strata were folded to near their present attitudes, and reached their present metamorphic state prior to the (?) Cambrian overlap. The Archaean strata have been deformed by compression and thrown into a system of closely spaced synclines and anticlines whose axial lines lie approximately parallel to the present coastline. Folding is fairly intense. the limbs of the folds being inclined at moderate to high angles and occasionally overturned. Gentle reversals of pitch are common throughout the belt and give rise to domed and pounded structures.

Because of the poorer outcrop conditions in the Lincoln Uplands, the structural data are considered to be less reliable, but those known with some certainty follow the same pattern as the folding in the Cleve Uplands; here lateral compression directed from the northwest has involved great crustal shortening by the development of steep-limbed folds with broadly arcuate fold axes of a modified *en echelon* form.

Folding in the gneissose (Flinders Group) rocks is generally open whereas the overlying schists occupying synclinal positions have yielded to more intense squeezing by plastic flow and tight puckering. The absence of schists to the east of the Mount Olinthus Ridge (Cowell sheet) is attributed chiefly to great attenuation. In this locality the flaggy quartzite equivalent of the Middleback quartzite outcrops in three elongated and arcuate keels arranged *en echelon*. A stereogram illustrating the structural interpretation of the Mount Olinthus quartzite horizon is depicted in fig. 26. Similar structures are featured in the same formation on the Darke, Rudall, Neill, Tumby and Cummins sheets.

The mapped and inferred major fold axes are shown in fig. 42. The general fold pattern was first resolved in the Cleve Uplands and these principals were applied to solve the structures of the Lincoln Uplands.

Two periods of deformation are indicated in the area. The first involved the folding of the Archaean rocks and occurred prior to the deposition of the (?) Cambrian conglomerates, etc. The second deformation followed their deposition and involved gentle westward tilting of the northern part of the area, while the central and southern parts appear to have been undisturbed.

FAULTING

The only faults apparent in the area are those that now define the elevated blocks of the ranges adjacent to the Spencer Gulf coast. Prominent fault scarps are traceable from near Port Lincoln northwards beyond Lipson (the Lincoln scarp) and another (the Cowell scarp—fig. 40) from south of Elbow Hill northerly beyond the limits of the mapped area where they form an intricate fault block pattern as mapped and described by Miles (1952). He presents evidence that Plio-Pleistocene faulting on Eyre Peninsula resulted in the foundering of the Spencer Gulf sunklands. Comparison of the levels of the upland surfaces on southern Eyre Peninsula suggests that the net vertical movement is about 700 feet.

The Lincoln scarp separates crystalline rocks of the uplands from the alluviated coastal plain whereas the Cowell scarp is a "dirt" scarp wherein the last displacement is recorded in the younger outwash materials and is thus typical of the scarps in the Whyalla-Cowell region. The fault has no surface expression between a point 7 miles southwest of Elbow Hill and Lipson township, but lineal continuity can be inferred by reference to fig. 11, which shows a series of magnetic highs in that position.

Chapter 7

GEOLOGICAL HISTORY

The major geological events which have taken place on central and southern Eyre Peninsula may be interpreted in a somewhat limited way from the rocks, structure and physiographic forms now exposed for study.

During the Archaean, in what is considered to be a geosynclinal environment, there were deposited at least 50,000ft. of strata. The lowermost rocks now exposed (Flinders Group) were possibly impure arkosic sediments. Limey or dolomitic sediments are very thin and lenticular and are restricted to the eastern section of the Cleve Uplands. Normal quartzites occur at all levels throughout this sequence with one important member, the Warrow Quartzite reaching almost 1,000ft. in thickness along the western margin of the area in Darke Peak Range and in the Marble Range. It thins considerably towards the east and in the Plug Range (Glynn sheet) it is represented by three separate beds little more than 50ft. in thickness. This formation is apparently absent still farther east and has not been recognized at all in the Lincoln Uplands. This thinning of the quartzite in an easterly direction suggests that the source of this sediment was a land mass to the west of the area with greatest deposition of sand in the shallow-water shelf, tapering off eastwards into deeper zones of the geosyncline.

The succeeding sediments now represented by Hutchison Group schists were fine-grained argillites. Amphibolitic zones represent what were no doubt originally impure (siliceous and argillaceous) limestones. Dolomites are thin and lenticular and occur at several levels throughout the area.

At or near the base of these predominantly argillaceous sediments is a formation which, where originally deposited in a shallow-water or shelf environment, is now represented by hematite quartzites or cherts, and where deposited in deeper zones farther east, by quartzites. There is a fairly rapid change of facies from the one to the other. The taconitic sediments are thought to be derived from silica and iron hydrosols leached from a neighbouring land mass and transported to a shallow-water environment under anaerobic conditions which contributed to the

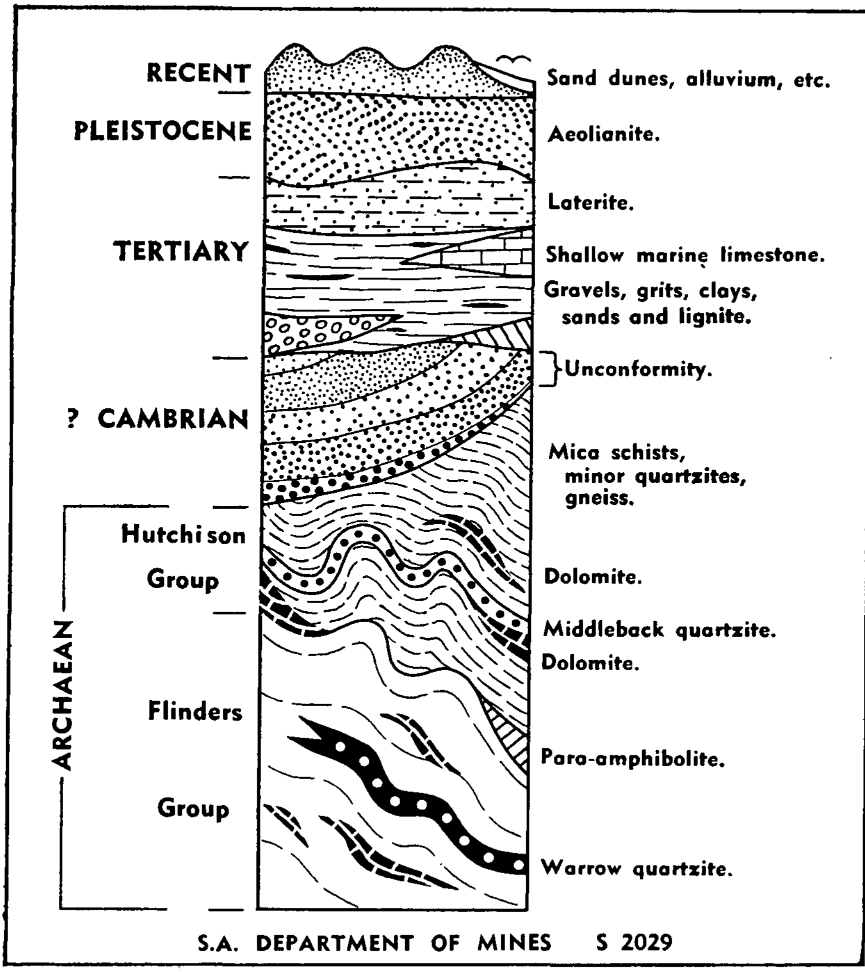

FIG. 41—DIAGRAM OF EXPOSED GEOLOGICAL COLUMN
Eyre Peninsula

stability of the colloidal gels. Rhythmic banding probably reflects seasonal changes—iron being deposited during the cool season, silica in the warm season. These chemical precipitates probably demand lagoonal or partially closed basin conditions.

The geosynclinal accumulation of sediments was subsequently subjected to compression directed from the northwest with consequent crustal shortening and high-angle folding; frequent changes in the plunge of the folds have resulted in domed and pounded structures. Folding was accompanied or succeeded by regional migmatization, metasomatism and granitization in the "impure" sediments and culminated in mobilization and granitic intrusion (Midgee Granite). "Pure" sediments, namely quartzite, chert and dolomite, meanwhile retained their identity throughout.

Following this deformation there followed a prolonged period of erosion until the (?) Cambrian period of shallow-sea transgression when conglomerates, grits and quartzites were deposited with sharp unconformity on the basement. These have been consolidated and are now tilted at low angles.

There is no further evidence in the geological record until Eocene times when clays, sands, gravels, etc., were deposited in a brackish-water lagoonal environment in the Central Basin. These sediments are markedly lenticular.

Encroachment of the sea is recorded in isolated deposits of Miocene and Pliocene limestones near the Southern Ocean coast; these incursions appear to have been local and brief.

Lateritization of the base-levelled surface of the peninsula took place during the Pliocene. During the Plio-Pleistocene, uplift of the eastern ranges block accompanied foundering of the gulf region. Contraction of sea-level during the Pleistocene Ice Age exposed large areas of the continental shelf and provided a source of calcareous sand which was blown up on the southern and western coasts and filled old river valleys. The system of parallel siliceous sand dunes which is developed over the inland parts of the area is undated, but is probably of Pleistocene-early Recent age. Subsequent sub-aerial erosion has given rise to the present relief while the sea has been actively reshaping the coastline.

A proposed stratigraphic sequence detailing the exposed geological column as outlined above has been prepared (fig. 41).

Chapter 8

MINERAL RESOURCES

The production of economic minerals from the area has been sporadic and dates from about 1863, when the Port Lincoln copper mines were opened. Other mines in this locality commenced production later (Tumby, 1867; Burrawing, 1871) and few were in production by 1900. In the Cleve-Cowell region the earliest report of mining concerns the Windittee copper mine (early 1870's). Other deposits were subsequently opened up but all prospects proved to be short lived, the economic mineralization being confined to near-surface enriched oxidized ores. Lead ores have been mined from several localities in the area, but the deposits were small and low grade except for small pockets of phenomenally rich silver ore at Atkinson's Find. Iron ore has been produced from one locality and shipped to smelters for use as a flux and a little manganese has been marketed.

Various non-metallic minerals have been produced, the most important deposits being the Tumby Bay talc and the Koppio and Uley graphite. Though these are now inoperative they are capable of further exploitation.

The demand for uranium in recent years created renewed interest in the area. Department of Mines prospectors systematically covered the area in the period 1949-1954 and discovered a number of points of anomalous radioactivity. The most interesting discoveries, however, were made in the Port Lincoln township area by private prospectors and these were subsequently drilled by the Department.

During 1954 an airborne scintillometer survey was undertaken for the Department of Mines and in 1955 an airborne magnetometer survey.

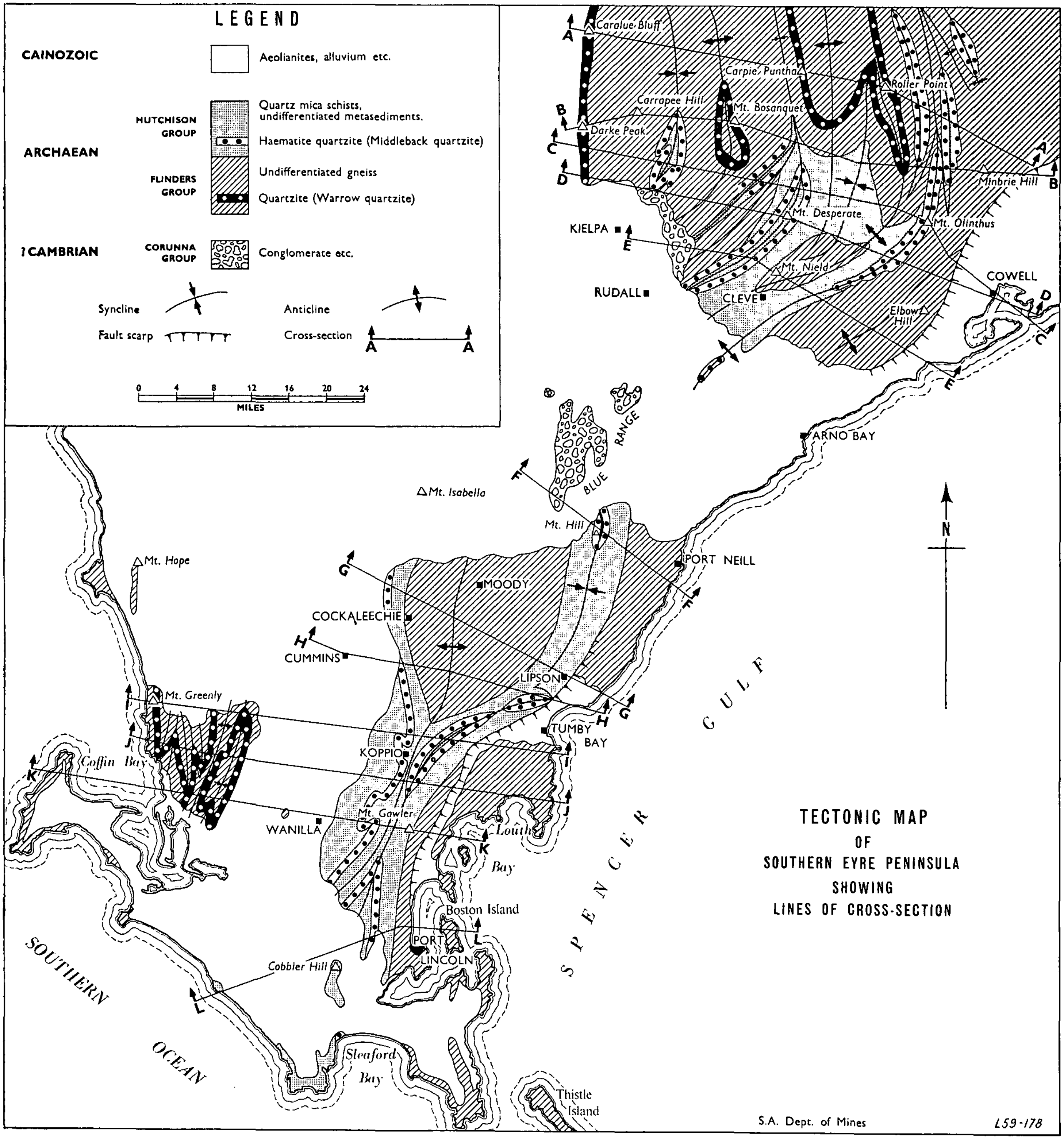

FIG. 42—TECTONIC MAP OF SOUTHERN EYRE PENINSULA
Showing lines of cross-section

To face page 32]

All of the mineral deposits are confined to the crystalline rocks of the basement. Graphite deposits are confined to a particular stratigraphic horizon within the Hutchison Group and have been noted throughout the region. The graphite content is thought to be determined by the nature of the original sedimentation and the belief is held that there has been no enrichment, the flake size being perhaps dependent on the intensity of metamorphism.

Talc bodies and asbestos mineralization within dolomite are related to magnesia metasomatism possibly as a late phase of the Archaean metamorphism and diastrophism. Though a number of the copper prospects appear to be of the confined fissure-lode type, it has been previously noted (Jack, 1914) that most of these are genetically related to pegmatites and are intimately associated with them.

Below are described the various deposits, but as most of the mine workings are now inaccessible the descriptions and plans are mostly taken from previous workers; due acknowledgement to the sources of information is made where appropriate.

Also described here are economic rock deposits including limestones, clays, road-making materials, etc.

General water supplies and underground resources are also described in some detail.

METALLIC DEPOSITS—CLEVE UPLANDS

Miltalie (Franklin Harbour) Mine (Pb, Ag, Cu)

Location.—Section 43N, hundred of Miltalie, county Jervois; 12 miles northwest of Cowell.

References

Review of Mining Operations 12, pp. 21-22, 1910 (H. Jones).
Review of Mining Operations 15, pp. 30-31, 1912 (H. Jones).
Review of Mining Operations 17, p. 38, 1913 (R. L. Jack).
Review of Mining Operations 18, p. 32, 1913 (H. Jones).
Review of Mining Operations 20, pp. 63-64, 1914 (H. Jones).
Review of Mining Operations 22, p. 21, 1915 (Boring).
Review of Mining Operations 22, p. 58, 1915 (H. Jones).
Review of Mining Operations 23, pp. 18-19, 1916 (Boring).
Review of Mining Operations 24, pp. 22, 29-32, 1916 (Boring).
Geol. Survey S. Aust. Bull 3, p. 34, 1914 (R. L. Jack).

Geology

The lead-silver-copper lode at the Miltalie mine strikes north-south and dips 50 deg. west. The lode is confined to a group of metasediments, augen gneisses, felspathic quartzite, and dolomite; it parallels the bedding foliation.

History, Workings, Lode

Mining operations had been carried out intermittently for a number of years prior to 1910, the principal workings—which are situated on the top of a low rise—consisting of three shafts sunk to depths of 45, 70 and 130ft. respectively.

No. 1 or Whip shaft was sunk vertically for 34ft. and for a further 36ft. on the underlie of the lode. No. 2 shaft situated 35ft. away was timbered for its 40ft. vertical extent and connection was made by a drive at the 45-ft. level and winze at the 70-ft. level to Whip shaft. Stoping operations were carried on over the drives southwest of Whip shaft, and from the 70-ft. level up to within 10ft. of the surface the orebody was stoped out for a length of 50ft. except for small pillars. The lode in this section was well defined and consisted of quartz and gossan from 3ft. to 5ft. wide and carried malachite, azurite, and galena which occurred in seams and pockets. The richest vein located near the hanging wall was 6in. to 8in. wide. At the extreme southwestern end of the stopes the formation was displaced on a fault and not disclosed beyond it. At the bottom of Whip shaft a sample showed a content of 40.8 per cent lead, 1oz./ton silver and nil copper.

The main vertical shaft situated 80ft. southwest of Whip shaft is 7ft. x 3½ft., is timbered, and is 120ft. deep. It was sunk with a view to intersecting the lode at an anticipated depth of 150ft.-160ft., but operations were suspended for lack of funds. It was equipped with poppet-head winder and pump shaft. At the 91-ft. level a crosscut was extended to the east for 40ft., and 22ft. of driving done on a barren quartz vein. From this level 88ft. of driving were carried on a formation 4in.-8in. wide to reach within 6ft. of Whip shaft, but 26ft. below the bottom of same. A drive at the 74-ft. level was connected to the 91-ft. level by means of a winze sunk on a seam 3in.-5in. wide which carried galena and cerussite.

The workings were unwatered several times during the period 1910-1914, but little mining done as the deepest workings from the main shaft disclosed only thin seams of low-grade ore.

In 1913 a concentrating plant was constructed so that the large dump of second-class ore at the surface could be treated. Six samples taken from this dump showed a lead content varying from 1.8 to 48.3 per cent, silver from 14 dwt. to 1oz. 4 dwt., and copper nil to 4.7 per cent.

In 1914 work on the property was confined to prospecting on the banks of Wilklow Creek, ½ mile northeast of the mine where in 1890 two shafts were reported to have been sunk.

The Government commenced diamond-drilling operations at the mine in 1915 and these were completed the following year. Three holes were drilled with discouraging results.

Drilling

The three bores were depressed at 78° 30′ in an easterly direction; the logs are as follows:

BOREHOLE No. 1

(Anticipated lode intersection 240ft.)

Depth From ft.	To ft.	Description
Surface	5	Travertine and clay.
5	141	Augen gneiss.
141	168	Felspathic quartzite.
168	231	Highly felspathic biotite schist.
231	235	Lode. Soft lode material charged with pyrite.
235	240	Soft broken "rock".
240	341	Augen gneiss, biotite schist.

BOREHOLE No. 2

(Anticipated lode intersection 300ft.)

Depth From ft.	To ft.	Description
Surface	8	Travertine, clay, mica schist.
8	151	Pink felspar gneiss.
151	162	Fine, medium-grained gneiss with pyrite.
162	217	Pink coarse-grained gneiss.
217	219	Mica schist.
219	303	Pale-grey, pink gneiss.
303	570	Medium-coarse pink, grey gneiss with sporadic pyrites.

BOREHOLE No. 3

(Anticipated lode intersection 200ft.)

Depth From ft.	To ft.	Description
Surface	2	Clay, travertine.
2	54	Pink, grey augen gneiss.
54	55	Mica schist.
55	82½	Felspar gneiss.
82½	84½	Mica schist.
84½	89½	Pink, grey gneiss.
89½	90	Mica schist.
90	140	Medium-grained grey gneiss.
140	145	Broken grey gneiss with pyrite.
145	200	Grey gneiss.

Plan

The plan (fig. 43) shows salient surface features.

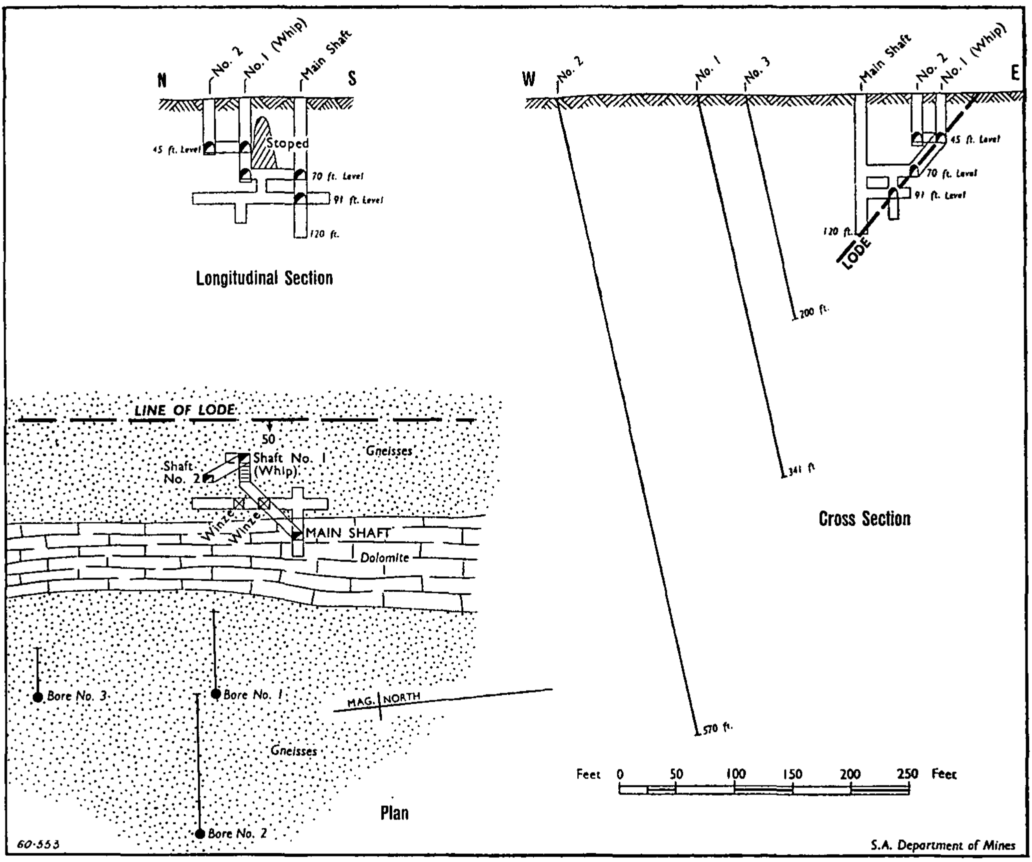

FIG. 43—MILTALIE MINE
Plan and sections

Morowie (Marowie) Mine (Cu)

Location.—Sections 20 and 21, hundred of Miltalie, county Jervois; 12 miles northwest of Cowell.

References

Record of the Mines of S. Aust. (4th Ed.), p. 79, 1908.
Review of Mining Operations 17, pp. 37-38, 1913 (R. L. Jack).
Review of Mining Operations 18, p. 31, 1913 (H. Jones).
Geol. Survey S. Aust. Bull. 3, p. 37, 1914 (R. L. Jack).

Geology

Morowie mine comprised several groups of prospects which included Morowie Blocks, Morowie South, Old Pauls and Porridge Pot. The lodes carried copper carbonates and were all reputed to have been associated with pegmatite or aplite dykes which are enclosed in mica schists.

History and Workings

Morowie shaft, reported to have been sunk about 1880 to 120ft. opened up a pegmatite 1ft. to 8ft. in width. Copper carbonates occurred in the dyke and in the adjacent walls of quartz-veined mica schists.

In 1908 it was reported that 7 tons of ore (containing 7 to 13 per cent copper) had been marketed and a further 4 tons of similar grade were ready for despatch. This ore had been mined from shallow shafts sunk on veins less than 2ft. thick.

When inspected in 1913 the Morowie shaft had collapsed and mining had been carried out on lodes situated ½ mile to the north by means of shallow shafts and stopes. South of Morowie shaft near the southern boundary of section 20 a number of shallow pits and costeans opened up showings of copper carbonates in micaceous quartzites and mica schist. One half mile to the west a 10-ft. shaft and a number of trenches exposed a pegmatite which carried a little copper.

In 1914 the old main shaft was cleaned out and timbered throughout to 137ft. with the intention of deepening the shaft and putting in crosscuts. The shaft was vertical for 30ft. and the remainder on a steep underlie. Samples taken at this time assayed up to 3oz. 16 dwt. of silver/ton.

Atkinson's Find (Ag, Pb)

(Cowell Consolidated silver-lead mine, McNamara's, Smith and Atkinson's, and Fairbanks)

Location.—Section 5, hundred of Miltalie, county Jervois; 12 miles WNW of Cowell.

References

Review of Mining Operations 17, p. 12, 1913 (General Notes).
Review of Mining Operations 17, pp. 34-36, 1913 (R. L. Jack).
Review of Mining Operations 18, p. 10, 1913 (General Notes).
Review of Mining Operations 18, pp. 29-31, 33, 1913 (H. Jones).
Review of Mining Operations 19, p. 10, 1914 (General Notes).
Review of Mining Operations 19, pp. 64-65, 1914 (H. Jones).
Review of Mining Operations 20, p. 9, 1914 (General Notes).
Review of Mining Operations 20, p. 62, 1914 (H. Jones).
Review of Mining Operations 21, pp. 34-35, 1915 (H. Jones).
Review of Mining Operations 22, pp. 18-19, 1915 (H. Jones).
Mining Review 46, pp. 56-57, 1927 (J. L. Pearson).
Geol. Survey S. Aust. Bull 3, p. 38, 1914 (R. L. Jack).

Geology

Rich silver ore was mined from a number of openings in steeply dipping schistose rocks at the interface of mica schists and dolomites. The strata strike north-south.

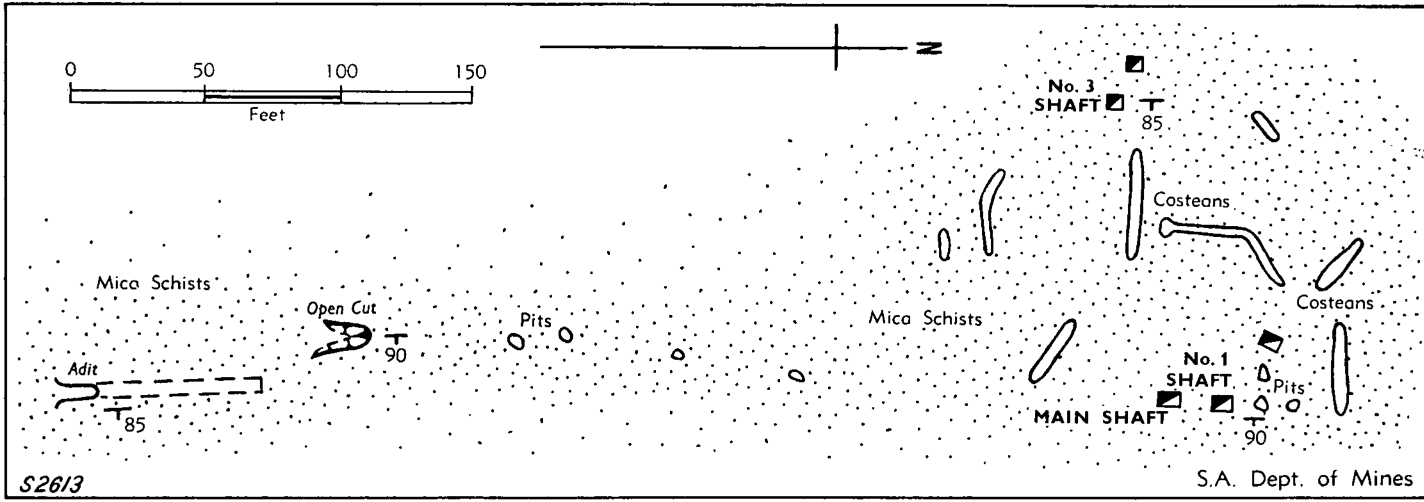

FIG. 44—ATKINSON'S FIND—HUNDRED OF MILTALIE

Surface Plan

History and Workings

The silver deposit was discovered in November, 1912. A specimen of silver chloride from the find weighing 195½ lb. was purchased by the Government and had an assay value of 6,800oz. fine silver/ton. The total silver content of the slug was 593.4oz. of fine silver. At the surface the lode was 2ft. 9in. wide and consisted of copper-stained gangue with a vein of extremely rich ore on the east side containing cerussite, cerargyrite, embolite, azurite, malachite and some native silver. A sample taken over a width of 12in. assayed 2,228oz. silver/ton, 3.4 per cent copper and 58.3 per cent lead.

While work was in progress in the years 1912-1915 a vertical shaft (the main shaft) was sunk to a depth of 101ft. and prospecting drives put in at the 25-ft. and 50-ft. levels and at the 100-ft. level a crosscut was driven for 38ft. to the west as well as driving to the south. At the site of the find No. 1 shaft was sunk and driving in various directions at the 14-ft. level carried out. Up to 1914, ½ ton of ore was treated for the recovery of 660oz. silver. No defined lode was disclosed in the workings, any values obtained being confined to small isolated patches of ferruginous material on what were described as fault walls. These patches were so limited in extent however, as to be of no commercial importance, and the rich ore recovered was all obtained at or near the surface.

The ground about these shafts was extensively trenched without disclosing ore. About 100yds. south of the original find and 100ft. below it on the side of the hill an open cut exposed a vertical well-defined lode formation. From this gully a tunnel was extended north into the hill for 60ft. On the adjoining northerly claim (McNamara's) a shaft was sunk in barren mica schist on what was the apparent line of lode. Still farther north (Smith and Atkinson's) open trenches and pits disclosed ore, a picked sample assaying 2oz. 4 dwt. silver/ton and 31.9 per cent copper. Adjoining the southern boundary of the silver find on Fairbanks claim a shaft 15ft. deep and several pits and deep trenches were excavated east-west across the apparent trend of a lode which showed a trace of silver and 0.6 per cent copper.

Mining on the property lapsed until 1927 when the No. 3 shaft was sunk vertically for 20ft. then on an underlie of 60 deg. to the east for a further 24ft. From the bottom of the shaft a crosscut had been driven for 50ft. in the direction of the original workings. All this work was in barren ground, mica schist and dolomite.

Plan

Figure 44 shows surface workings at the site of the silver find.

Calcookra Mine (Cu)

Location.—Sections 470 and 172, hundred of Hawker, county Jervois; 13 miles west-northwest of Cowell.

References

Review of Mining Operations 12, pp. 19-20, 1910 (H. Jones).
Review of Mining Operations 15, pp. 21-26, 1912 (H. Jones).
Review of Mining Operations 18, p. 33, 1913 (H. Jones).
Review of Mining Operations 19, p. 64, 1914 (H. Jones).
Review of Mining Operations 21, pp. 18-19, 1915 (Boring).
Review of Mining Operations 21, p. 35, 1915 (H. Jones).
Review of Mining Operations 22, pp. 20-21, 1915 (Boring).
Review of Mining Operations 24, pp. 24-28, 1916 (Boring).
Mining Review 97, pp. 30-32, 1954 (Boring).

Geology

The lode consisting of ferruginous quartz with azurite and malachite has been exposed in the upper oxidized zone above water-level by shallow workings over a length of 500ft. The lode strikes N65°E and dips in a southeasterly direction at 50 deg.; it is confined to mica schists.

History and Workings

Recorded production from the mine is 90 tons.

The principal workings situated on the slopes of a low hill 40ft. above creek level consist of two shafts, an underlay shaft 50ft. deep and the southwest shaft 80ft. deep. Much of the mining carried out was prior to 1910 and it was continued until 1915.

From the underlay shaft drives were put in at the 20-ft. and 43-ft. levels. The lode thinned to 3in. in the faces of the drives to the southwest but the lode between the drives to the northeast was completely stoped out over a width of 4ft. and for a length of 32ft. where connection was made with a vertical shaft. The ore raised from these workings in 1914—30 tons—assayed 15·19 per cent copper and contained a little silver.

Over 185ft. of driving was done in various directions from the southwest shaft but nothing of value was mined. A barren ferruginous formation was cut in the face of a drive 82ft. from the shaft.

The vertical shaft in section 470 in 1914 was down 35ft. and at the bottom a drive 10ft. in length showed a lode 2ft. in width, a sample of which carried 22.4 per cent copper and 16oz. 4 dwt. of silver/ton.

In 1914-15 four diamond-drill holes exposed the lode in the vicinity of the underlay shaft but the results were not encouraging.

Following the discovery by A. S. Giles (Departmental Prospector) in 1949 that samples of copper ore from the dumps near the underlay shaft were abnormally radioactive, two diamond-drill holes were sited to test the lode in the vicinity of the southwest shaft. These were drilled in 1952 but they failed to locate any underground extension of the lode or to record any significant occurrence of either copper or radioactive minerals. The first of these bores penetrated old mine workings. Radiometric logging failed to reveal any significant radioactivity which, in the specimens from the dump, was attributed to the presence of monazite and an unidentified uranium ochre in a finely divided state.

Drilling

Borehole No. 1

(Depressed at 78½ deg.; anticipated lode intersection 200ft.)

Depth From ft.	To ft.	Description
Surface	2	Clay.
2	60	Quartz-veined schist.
60	80	Hard broken quartzite.
80	151	Mica schist with quartz veining.
151	208	Micaceous quartzite.
208	213	Lode. Calcite, quartz and pyrite.
213	388	Quartz-veined mica schist.

Borehole No. 2

(Depressed at 73 deg.; anticipated lode intersection 100ft.)

Depth From ft.	To ft.	Description
Surface	60	Mica schists.
60	119	Quartz-veined mica schist, micaceous quartzite.
119	124	Lode. Friable lode heavily charged with pyrite.
124	275	Quartz-veined schists.

Borehole No. 3

(Depressed at 73 deg.; anticipated lode intersection 200ft.)

Depth From ft.	To ft.	Description
Surface	3	Clay.
3	310	Quartz-mica schist.

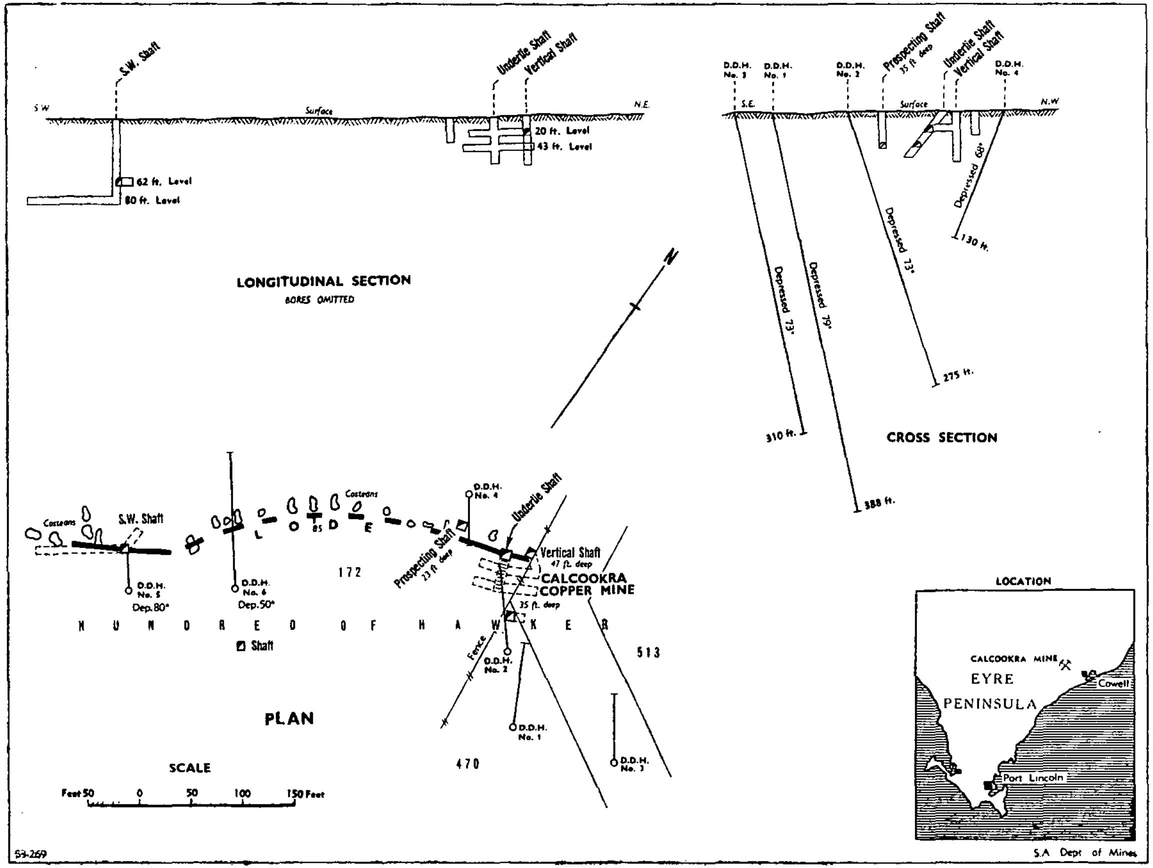

FIG. 45—CALCOOKRA MINE—HUNDRED OF HAWKER

Plan and sections

BOREHOLE No. 4

(Depressed at 68 deg.)

Depth From ft.	To ft.	Description
Surface	1	Clay.
1	130	Mica schists with hard pegmatite veins.

BOREHOLE No. 5

(Drilled 1952; depressed at 80 deg.)

Depth From ft.	To ft.	Description
Surface	2	Clay.
2	6	Pegmatite.
6	80	Mica schist.
80	86¼	Sand (old workings at 83-ft. level).
86¼	136	Contorted quartz-biotite gneiss.
136	160	Pegmatite.
160	191	Garnetiferous quartz-biotite schist.

BOREHOLE No. 6

(Drilled 1952; depressed at 50 deg.)

Depth From ft.	To ft.	Description
Surface	4	Clay.
4	57½	Mica schist.
57½	60	Aplite.
60	121½	Quartz-veined mica schists.
121½	142	Garnetiferous mica schist.
142	200	Mica schists with quartz-felspar veinlets.

Plan

Figure 45 shows the location of the boreholes, the line of lode and surface workings.

Yalpoudnie (Yalpoodnie) Mine (Cu, Pb)

Location.—Section 416, hundred of Hawker, county Jervois; 10 miles west-northwest of Cowell.

References

Record of the Mines of S. Aust. (4th Ed.), p. 155, 1908.
Review of Mining Operations 12, p. 24, 1910 (H. Jones).
Review of Mining Operations 17, p. 37, 1913 (R. L. Jack).
Review of Mining Operations 18, p. 32, 1913 (H. Jones).
Review of Mining Operations 24, pp. 22-23, 1916 (Boring).
Review of Mining Operations 24, p. 33, 1916 (Boring).
Geol. Survey S. Aust. Bull. 3, p. 36, 1914 (R. L. Jack).

History, Workings, and Geology

Mining began about 1880 when one shaft was sunk on the lode to a depth of 120ft. Prospecting operations were resumed in 1906 and thence spasmodically until 1913. A fairly well-defined lode formation up to 10ft. in width was exposed over a length of about 500ft. in the main underlay shaft (120ft. deep), the northern underlay shaft (30ft. deep) and a number of shallow pits.

The lode strikes north-south and dips westerly at 50 to 80 deg. and consists of ferruginous quartz with bunches of low-grade copper ores, malachite and azurite with some galena. A sample of dressed ore assayed 12.3 per cent copper, 0.8 per cent lead and 1oz. 8 dwt. silver/ton. The recorded production amounts to 4½ tons; 1 ton carried 12 per cent copper and the remainder assayed 21 per cent copper with 14 per cent lead.

The mineralized formation lies along the interface of mica schists (graphitic in part) and quartz-felspar gneiss.

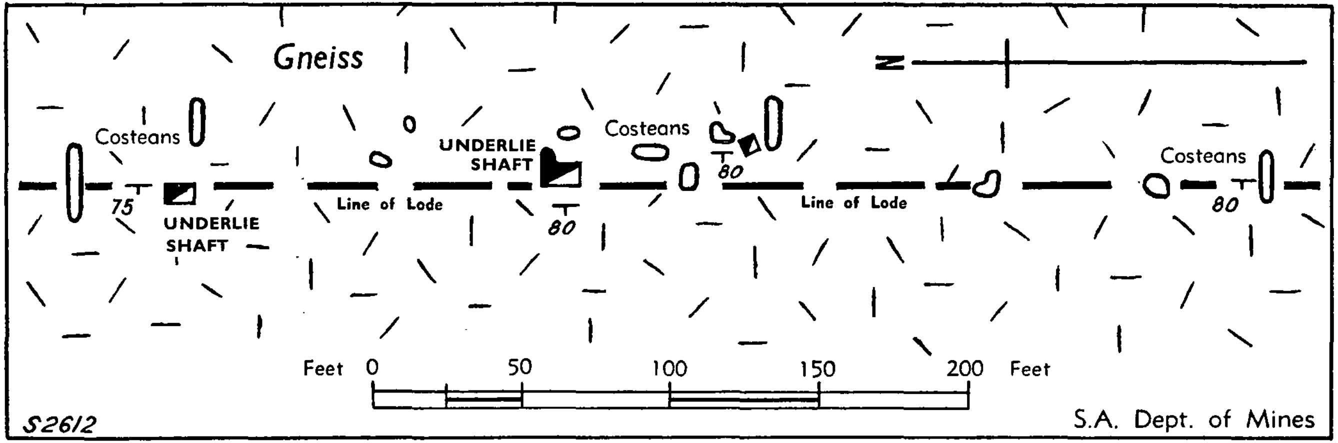

FIG. 46—YALPOUDNIE MINE—HUNDRED OF HAWKER

Surface plan

Drilling

In 1916 a borehole was drilled and was sited on the main road 300ft. west of the lode at a point 22ft. from northwest of the Cemetery Reserve. The hole was depressed at 75 deg. on a bearing east-southeast.

BOREHOLE NO. 1

Depth From ft.	To ft.	Description
Surface	32	Clays and gravels.
32	93	Weathered gneiss and schist.
93	267	Mica schists.
267	347	Coarse-grained gneiss with schist.
347	370	Mica schist.
370	372	Graphitic mica schist.
372	384	Lode (?). Felspathic mica schist with irregular seams of vein matter.
384	401	Gneiss.

Plan

Figure 46 shows surface workings along the line of lode.

Mount Miller (Millar) Mine (Ag, Pb)

Location.—Section 157, hundred of Hawker, county Jervois; 14 miles west of Cowell.

References

Review of Mining Operations 12, p. 22, 1910 (H. Jones).
Review of Mining Operations 17, p. 38, 1913 (R. L. Jack).
Review of Mining Operations 18, pp. 32-33, 1913 (H. Jones).
Geol. Survey S. Aust. Bull 3, pp. 37-38, 1914 (R. L. Jack).

History, Workings, and Geology

The shallow workings consist of a few shallow prospecting pits and a shaft sunk nearly vertically for 40ft. They are situated on a hill in quartzose gneisses and quartz-veined mica schists adjacent to the nose of a domed anticline, which is occupied by a thick bed of dolomite.

Jones in 1910 reported that no work appeared to have been done for a considerable time and the shaft had partly collapsed. Further work was carried out in the period 1910-1913 when the shaft was stripped and cleaned out and shallow prospecting pits were sunk.

Galena occurred as fairly high-grade bunches and in thin seams in an ill-defined lode formation up to 2ft. in width. The lode had a northeast-southwest trend and dipped to the northwest at 70 degrees.

A sample taken from 1 ton of dressed ore at the surface in 1910 assayed 77.4 per cent lead and 14 dwt. silver/ton.

Boards Mine (Cu)

Location.—Section 336, hundred of Hawker, county Jervois; 11 miles west-northwest of Cowell.

Reference

Mining Review 97, p. 39, 1954 (M. L. Wade).

Geology and Workings

A 14-ft. shaft was sunk in 1952 on a crush zone carrying copper stains and this was driven on to the northwest for 31ft. where jasper and clay in the end of the drive were barren.

Copper occurs as malachite in nodules adjacent to the shear and on the margin of a pegmatite dyke.

One half ton of ore was raised and estimated to contain 15 per cent copper. Picked ore assayed as much as 25 per cent copper and 19½oz. silver/ton. This ore was won from the shaft.

Plan

Figure 47 shows geological features and workings.

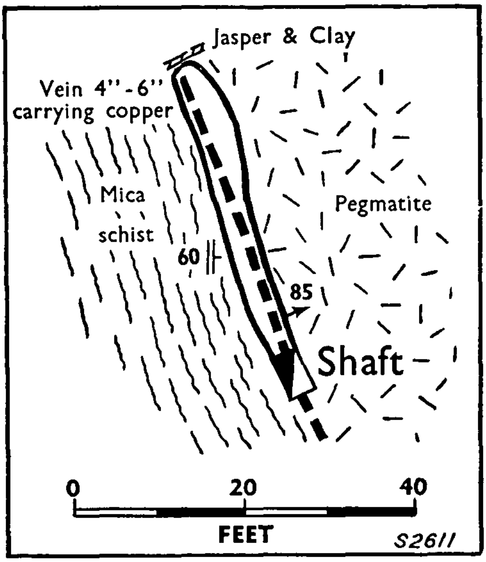

FIG. 47—BOARDS MINE
Sketch plan of 14-ft. level

Hawker Mine (Cu)

Location.—Section 75, hundred of Hawker, county Jervois.

Reference

Record of the Mines of S. Aust. (4th Ed.), p. 63, 1908.

Workings

A shaft was sunk to 25ft. prior to 1901 on lode matter 4ft. wide and containing malachite and azurite. It was a low-grade deposit, the best of several samples assayed showed a 2 per cent copper content.

The prospect was not located during the present survey.

Arno Bay (Windittie) Mine (Cu)

Location.—Sections 2115 and 1978, hundred of Mann, county Jervois; 4½ miles east of Cleve.

Reference

Record of the Mines of S. Aust. (4th Ed.), p. 152, 1908.

History

About 1870 a shaft was sunk on a lode carrying malachite and azurite. Details of workings are not recorded though a strong influx of water is reported. The shafts which were sunk in mica schist and lode material are now filled in. Recorded production amounted to 23 tons 16cwt. of over 15 per cent ore.

Cleve Mine (Pb, Ag)

Location.—Sections 216 and 229-232, hundred of Mann, county Jervois; ½ mile east of Cleve.

References

Mining Review 41, pp. 83-86, 1925 (J. L. Pearson).
Mining Review 50, pp. 84-86, 1929 (J. L. Pearson).
Mining Review 53, p. 92, 1931 (R. L. Jack).

Geology

A mineralized shear parallel to the bedding and striking N20°W. with dip 70° E. occurs in mica schists. Thin beds of dolomite outcrop above and below this zone. The lode consists of siliceous ironstone which carries cerussite and cerargyrite in veins up to 6in. thick.

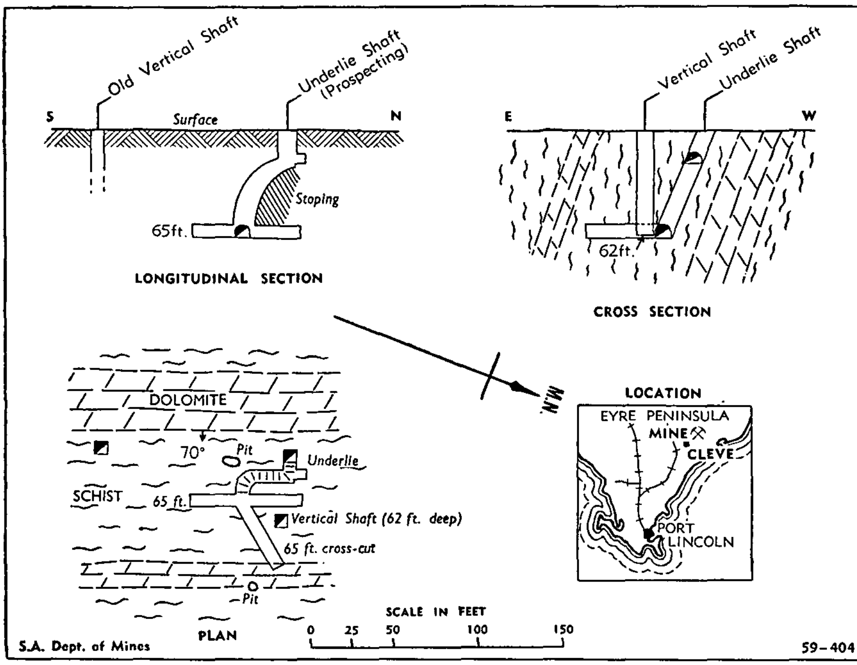

FIG. 48—CLEVE SILVER MINE

Plan and sections

History and Workings

The shaft which is vertical for the upper 16ft. then on an underlie for a further 32ft. was constructed in 1924 on a narrow vein carrying high silver values. Eight tons of ore were marketed which averaged 11.37 per cent lead and 133oz. silver/ton. A further 5 tons of ore were stacked at the surface when inspected in 1925.

The inclined portion of the shaft was subsequently extended to a depth of 65ft. and at this depth drives, 25ft. to the southeast and 30ft. to the northwest were completed in barren schist. A crosscut was extended for 40ft. in a northeasterly direction and showed no mineralization. Sampling of the northwest drive over an average width of 5in. showed average contents of lead 11.8 per cent and silver 56oz./ton.

A vertical shaft was sunk to a depth of 62ft. at a point 37ft. east of the main shaft in schist, prior to 1931 when mining at the property was abandoned.

Plan and Section

Figure 48 shows surface and underground workings and geological features.

Elson Mine (Ag, Pb)

Location.—Section 48, hundred of Mann, county Jervois; 1 mile east of Cleve.

References

Review of Mining Operations 19, pp. 65-66, 1914 (H. Jones).
Review of Mining Operations 20, p. 63, 1914 (H. Jones).

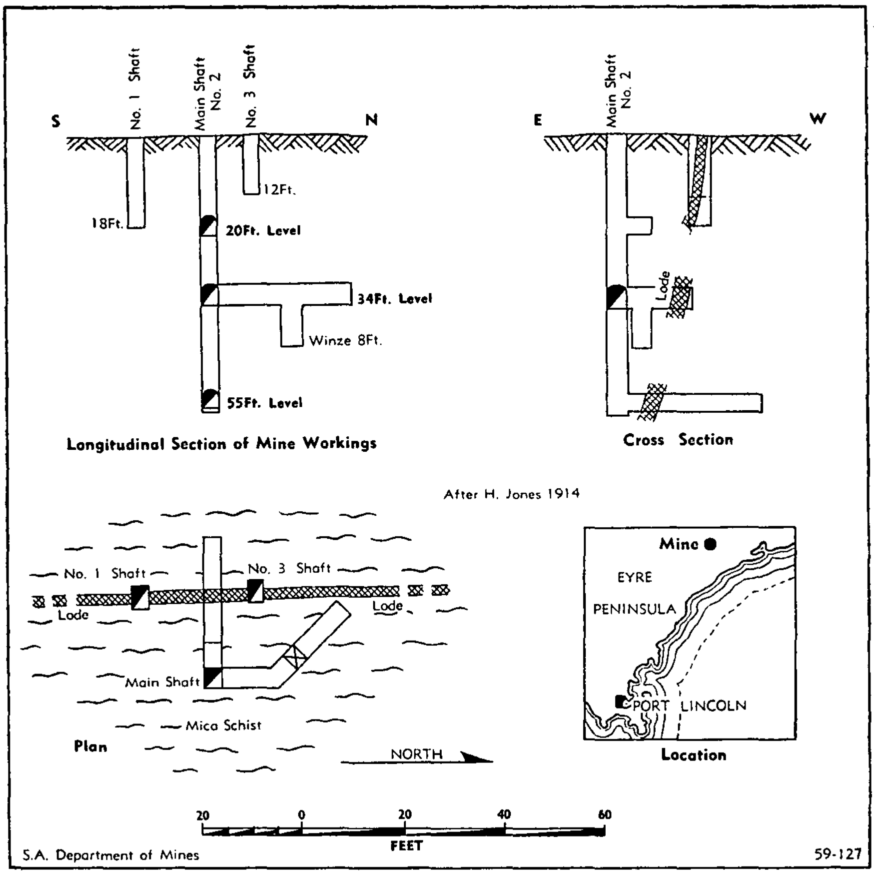

FIG. 49—ELSON MINE—HUNDRED OF MANN

Plan and sections

Geology

Mica schists striking about east-west and dipping steeply to the south are hosts to a siliceous lode formation up to 3ft. in width which carries thin veins of galena.

Workings

The workings on Star Hill consist of No. 1 shaft 12ft. in depth on the lode outcrop and No. 2 shaft which is 55ft. deep. From the main shaft short drives were carried into the lode at the 20-ft., 32-ft. and 55-ft. levels and some cross-cutting done from the bottom of the shaft.

A sample taken from a 12-in. vein in a winze at the 32-ft. level showed 34.8 per cent lead and 4oz. 4 dwt. silver/ton but the development was generally discouraging and work ceased in 1914.

Plan

Figure 49 shows surface features at the prospect.

Poonana Mine (Pb, Ag, Cu)

Location.—Sections 67, 68, 69, hundred of Mann, county Jervois; 2½ miles north-east of Cleve.

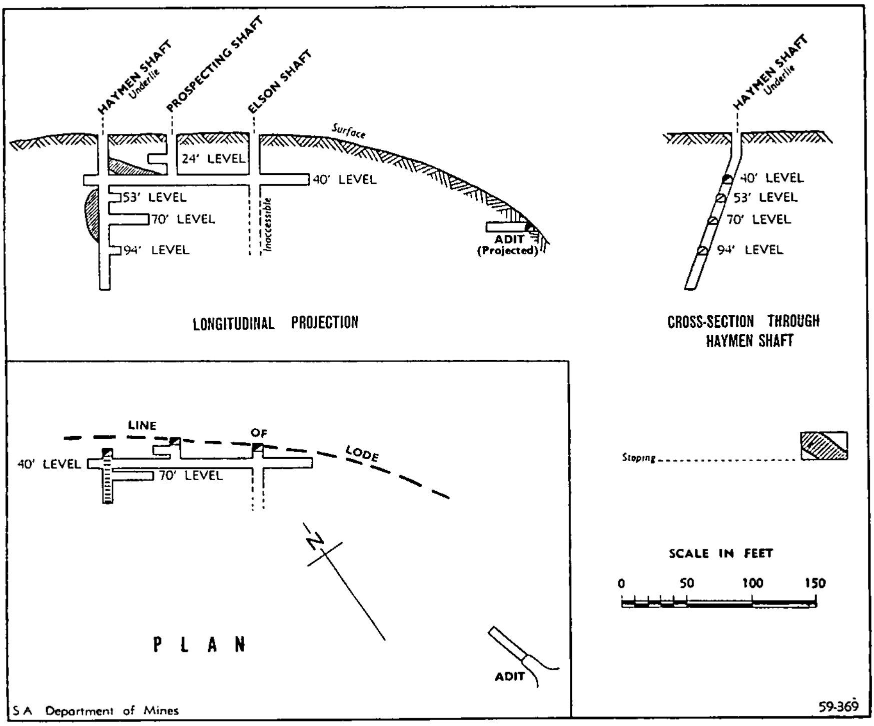

FIG. 50—POONANA MINE

Plan and sections

References

Review of Mining Operations 22, p. 13, 1915 (General Notes).
Review of Mining Operations 22, p. 58, 1915 (H. Jones).
Review of Mining Operations 23, pp. 59-60, 1916 (H. Jones).
Review of Mining Operations 25, pp. 77-78, 1917 (L. J. Winton).
Review of Mining Operations 26, p. 93, 1917 (L. J. Winton).
Mining Review 45, pp. 87-90, 1927 (J. L. Pearson).
Mining Review 66, p. 38, 1937 (General Notes).
Mining Review 66, pp. 71-73, 1937 (A. T. Armstrong).
Mining Review 92, pp. 57-59, 1952 (M. L. Wade).

Geology

A well-defined lode has been exposed for a length of 200ft. along the top of a hill on the interface of quartzite (on the footwall) and mica schist. The lode strikes northwest-southeast and dips at 60° SW., is 1-2ft. wide at the surface, and increases up to 5ft. in depth. It consists of quartz with malachite, azurite, chalcocite, covellite, cerussite and blende.

History and Workings

The deposit was discovered in 1914 and was then opened up along the outcrop and in three shafts, known as Elson, Prospecting and Haymen shafts and a level developed at a depth of 37ft. (40-ft. level). Samples from the shallow surface workings showed the following content: copper nil to 31.6 per cent, lead 11.1 per cent to 54.1 per cent, and silver 1oz. 6 dwt. to 2oz. 6 dwt./ton.

By 1917 Elson shaft had reached a depth of 120ft. When inspected in 1927 operations were confined to the sinking of Haymen shaft. Twelve representative samples taken over lode widths of 1ft.-5ft. from the 40-ft. level and Haymen shaft below this level gave an average assay value of 11.8 per cent lead, 1.4 per cent copper, 8 dwt. silver/ton and 0.3 per cent zinc, over an average 2ft. 9in. width. By 1937 a tunnel had been driven from the south side of the hill with the object of connecting with Elson shaft but it penetrated to 31ft. when the project was abandoned. Haymen shaft was down 128ft., the drive on the 40-ft. level had been connected with the other shafts, and some ore stoped out near Haymen shaft.

In 1949 A. S. Giles (Departmental Prospector) detected weakly anomalous radioactivity in ore on the surface dumps due to an unidentified secondary uranium mineral. A sample assayed 0.01 per cent U_3O_8.

The recorded production from the mine is 43 tons.

Plan and Section

Figure 50 shows underground workings in plan and section.

Emu Plain (W.G.) Mine (Cu)

Location.—Section 2B, hundred of Mangalo, county Jervois; 6 miles southwest of Mangalo.

References

Mining Review 72, p. 70, 1940 (L. K. Ward).
Mining Review 75, pp. 55-56, 1942 (A. T. Armstrong).
Mining Review 92, p. 11, 1952 (General Notes).
Mining Review 92, p. 59, 1952 (M. L. Wade).
Mining Review 99, p. 64, 1956 (L. W. Parkin).

Workings and Geology

Small bunches of copper ore occur in a fault zone within mica schists. The fault zone has a north-northeast trend and a steep easterly dip.

A shaft has been sunk to the east of the fault and continues on the footwall to 74ft. where a crosscut to the hanging wall shows a broken zone 21ft. in width. A thin seam has been explored on the eastern wall by means of a winze sunk to 15ft. in the end of the crosscut and by means of a 16-ft. drive. The ore was of low grade and rich patches were distributed too sparsely to enable the crush zone to be worked as a whole.

Radioactivity associated with the malachite has been ascribed to the mineral auerlite.

Plan and Section

Figure 51 shows the surface and underground workings.

Yadnarie Mine (Cu)

Location.—Sections 94 and 95, hundred of Yadnarie, county Jervois; 4 miles northwest of Cleve.

References

Review of Mining Operations 17, pp. 36-37, 1913 (R. L. Jack).
Geol. Survey S. Aust. Bull 3, p. 36, 1914 (R. L. Jack).

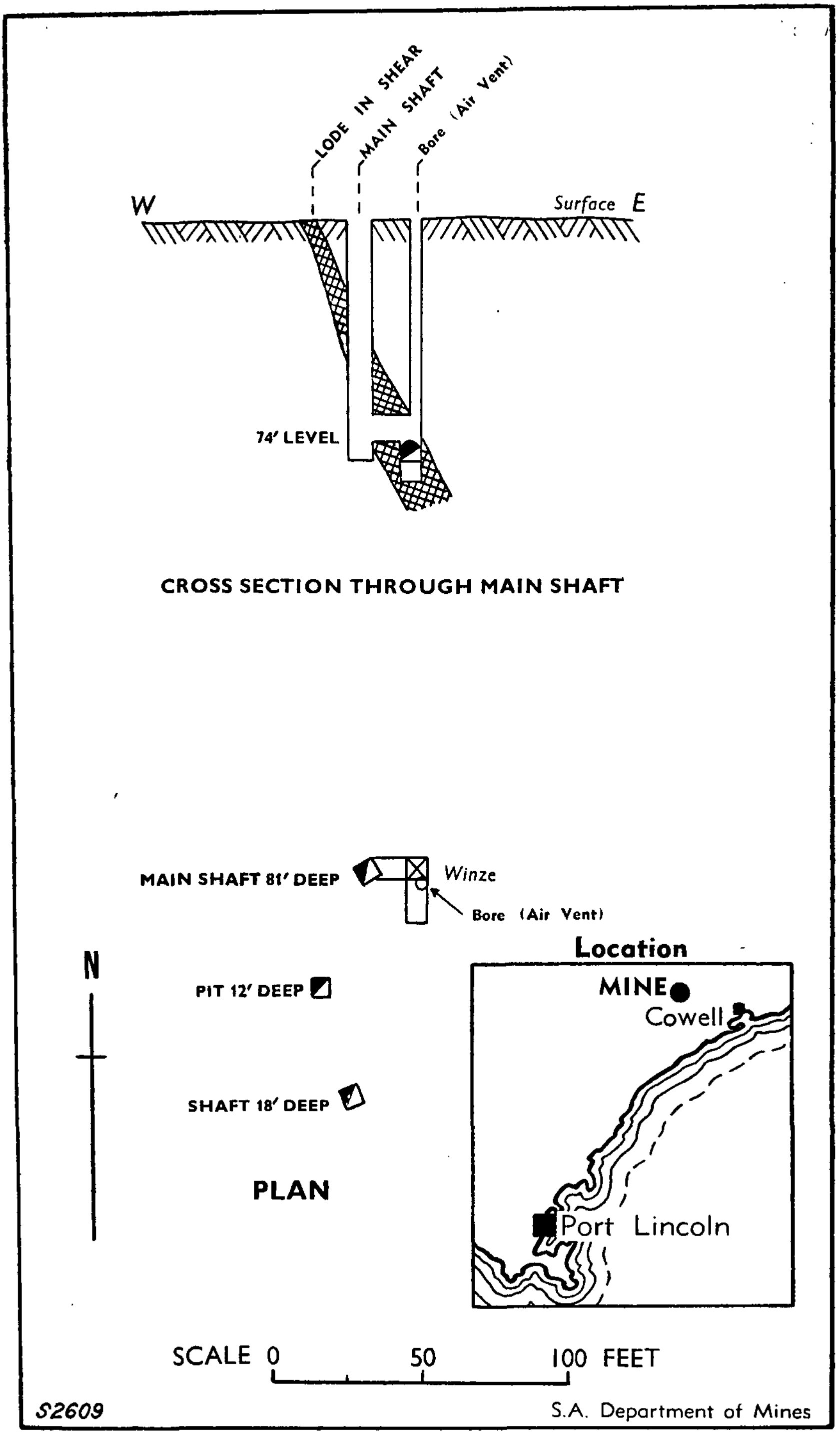

FIG. 51—EMU PLAIN MINE—HUNDRED OF MANGALO

Plan and cross-section

Workings

A lode 4ft in thickness consisting of quartz, malachite and azurite and confined to a mica schist host was explored by means of a shaft 34ft. deep on the dip of the lode.

No. 1 workings, situated 400yds. to the north-northwest, consisted of costeans and a shaft 28ft. deep in a formation of quartz and low-grade copper carbonate ore. At a distance of 50 chains to the west a shaft 14ft. deep was sunk on a vein 3in.-12in. thick carrying malachite and azurite.

Davey's Prospect (Ag, Pb)

Location.—Section 8, hundred of Miltalie, county Jervois; 10 miles west-northwest of Cowell.

Reference

Record of the Mines of S. Aust. (4th Ed.), p. 168, 1908.

Workings

Two shafts, 15ft. and 18ft. respectively were sunk on separate siliceous ironstone veins 18in. wide, and 10ft. apart. The veins are siliceous at the outcrop but at depth are ochreous and gossany and carried a little galena.

Copper Prospect, Miltalie (Cu)

Location.—Section 4, hundred of Miltalie, county Jervois; 14 miles northwest of Cowell.

References

Review of Mining Operations 17, p. 37, 1913 (R. L. Jack).
Geol. Survey S. Aust. Bull. 3, p. 37, 1914 (R. L. Jack).

Workings

A pit 8ft. deep has been sunk on a vein up to 12in. thick carrying copper carbonates on the interface of mica schist and gneiss adjacent to a pegmatite dyke.

Copper Prospect—Hundred of Campoona (Cu, Pb)

Location.—Section 2, hundred of Campoona, county Jervois; 11 miles northwest of Cleve.

Reference

Mining Review 107, pp. 100-101, 1957 (R. K. Johns).

Workings

A vertical shaft 21ft. deep has been excavated in pegmatite adjacent to the schist host rock. Copper carbonates occur as disseminations, small aggregations and as thin films along joints and along quartz and felspar boundaries, and also as rounded segregations within the schist.

Cerussite occurs over a width of 6in. on the western side of the shaft, but there is no defined lode.

A yellow mineral in several specimens taken from the shaft resembled carnotite and a radiometric assay showed the presence of 0.01 per cent U_3O_8.

A representative sample cut from the bottom of the shaft contained 2.3 per cent copper. A picked sample of ore from the dump assayed 7.6 per cent lead and 4.0 dwt./ton silver.

Other Deposits

Several mineral deposits which have been reported as occurring in the region and were not located in the present survey include the following.

Reachel Lease

Location.—Section 187, hundred of Hawker, county Jervois; 12 miles west of Cowell.

In the *Record of the Mines of S. Aust.* (4th Ed.), p. 125 (1908), a report of 1899 states that two small trial pits exposed 4ft. of lode material containing malachite assaying 6½ per cent copper.

Larkin's Find

Location.—Section 28, hundred of Hawker, county Jervois; 16 miles from Cowell.

H. Jones (*Review of Mining Operations* 20, p. 64, 1914) reports on prospecting operations in a formation of ferruginous quartz and exploration by means of an adit 60ft. in length and a crosscut.

The above location would place the find on the Cowell plains where there are no bedrocks exposed.

Wicklow Hut

Location.—Near Miltalie mine, hundred of Miltalie, county Jervois.

A shaft is reported to have been sunk (*Record of the Mines of S. Aust.*, 4th Ed., p. 193, 1908) on a decomposed pegmatite up to 4ft. wide and carrying veins of galena with silver contents of up to 1oz. 9 dwt./ton.

Yeldulknie Weir

Galena has been reported as occurring in small veins in a pegmatite where these have been exposed in a quarry. At the same locality torbernite occurs as thin scales (*Geol. Survey S. Aust. Bull.* 3, p. 39, 1914, R. L. Jack).

Simms and Bradleys Claim

Location.—Five miles from Cleve, hundreds of Yadnarie or Mann, county Jervois.

An old report describes a strong ferruginous outcrop from 4ft.-8ft. wide containing bunches of copper carbonates and which was worked from an open cut and a 40-ft. shaft. The recorded production is 22 tons of ore assaying 10 per cent copper. (*Record of the Mines of S. Aust.*, 4th Ed., p. 133, 1908.)

Mangalo Creek

Location.—Mangalo Creek, hundred of Yadnarie, county Jervois.

In 1887 a report was made of the occurrence of thin veins of galena with a little silver in mica schist. A trench exposed the lode in one place. (*Record of the Mines of S. Aust.*, 4th Ed., p. 18, 1908.)

Darke Peak

In 1895 a 40-ft. shaft sunk in this locality is reported to have exposed a silver-lead vein containing 33oz. silver/ton. (*Record of the Mines of S. Aust.*, 4th Ed., p. 168, 1908.)

Iron Ore

Hematite quartzite formations mapped in the area must be considered as possible sources of low-grade iron ore (taconite) though at the present time the grade and limited tonnage available suggest that further exploration is unwarranted.

These rocks are hard and cherty and give rise to prominent physiographic features especially in the Mount Shannan-Mount Desperate locality. They strongly resemble the Middleback Range taconites and have a similar iron content. Selected bands taken from Mount Desperate (Cowell sheet) and others from near Cockabidnie Reservoir (Darke sheet) assayed up to 61 per cent Fe, but the overall average would probably be about 30 per cent Fe.

There are generally two main beds of ferruginous chert present, separated and enclosed by mica schist, though in some places as many as four individual beds have been noted, the overall thickness of the "iron zone" being less than 1,000ft. and the individual iron-bearing beds seldom more than 100ft. wide and on an average about 50 feet.

The iron beds outcropping on the area included in the Glynn sheet appear to be more manganiferous than other exposures.

Some attention was paid to the possibility of there being concentrations of iron within suitable structures in these potentially favourable host rocks as is the case in the Middleback Range, but no such concentrations are apparent.

In section 5 (formerly A9), hundred of Campoona, a body of high-grade hematite occupying a shear zone in Corunna Quartzites has been exposed by prospectors in a number of trenches over a width of 10ft. (*Geol. Survey S. Aust. Bull.* 3, p. 39, 1914, R. L. Jack, and *Geol. Survey S. Aust. Bull.* 9, p. 28, 1922, R. L. Jack.) These deposits are quite small.

NON-METALLIC DEPOSITS—CLEVE UPLANDS

Graphite Deposits

Graphite occurs at a number of scattered localities included in the Cowell, Rudall, Darke and Verran sheets and the number would be considerably increased if better outcrop conditions obtained. The graphitic schists occur near the base of the Hutchison (Schist) Group, either immediately below or above the hematite quartzite horizon. The various known occurrences described below are shown on the locality plan (fig. 52).

*Hundreds of Pascoe, Campoona and Jamieson**

Locations.—Sections 15 and 28, hundred of Campoona, county Jervois, 8 miles east of Darke Peak; section 1, hundred of Pascoe, county Jervois, 7 miles east of Konanda R.S.; section 4, hundred of Jamieson, county Jervois; 8 miles east of Darke Peak; sections 7 and 15, hundred of Campoona, county Jervois, 8 miles east-northeast of Kielpa.

References

Review of Mining Operations 22, p. 57, 1915 (H. Jones).
Review of Mining Operations 26, p. 56, 1917 (R. L. Jack).
Review of Mining Operations 26, p. 61, 1917 (R. L. Jack).

Geology

Fine-grained graphite in schist occurs both above and below the main ferruginous chert horizon on both limbs of the major syncline in this locality. Magnesite is associated with the schists. The graphite flake is of fine grain and the occurrences are of generally too low grade to constitute economic deposits.

Workings

At the Sugarloaf mine two vertical shafts were sunk to depths of 63ft. and 80ft. on ferruginous graphite schist. At the bottom of the 80-ft. shaft a drive was put out 9ft. to the east. Samples taken by Jones (1915) contained up to 25.3 per cent graphite and 0.1 per cent copper; a 1-ton parcel of picked ore assayed 11.8 per cent copper.

Two samples taken by Jack (1917) yielded 15.37 per cent and 3.7 per cent of ferruginous concentrate which assayed 27.65 per cent and 31.72 per cent carbon respectively.

Campoona Hill Graphite†

Location.—Section 2D, hundred of Campoona, county Jervois; ½ mile northeast from Campoona Hill.

Reference

Review of Mining Operations 22, p. 57, 1915 (H. Jones).

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* See fig. 52, deposits Nos. 1, 2, and 3.

† See fig. 52, deposit No. 4.

The Deposits

A bed of fine-grained graphite schist about 70ft. wide has been exposed by means of two shallow pits. The graphitic zone is associated with decomposed mica schists and occurs in beds which enclose the hematite quartzite formation. A sample taken from the bottom of the 12ft. deep pit carried 6 per cent flake graphite assaying only 38 per cent carbon.

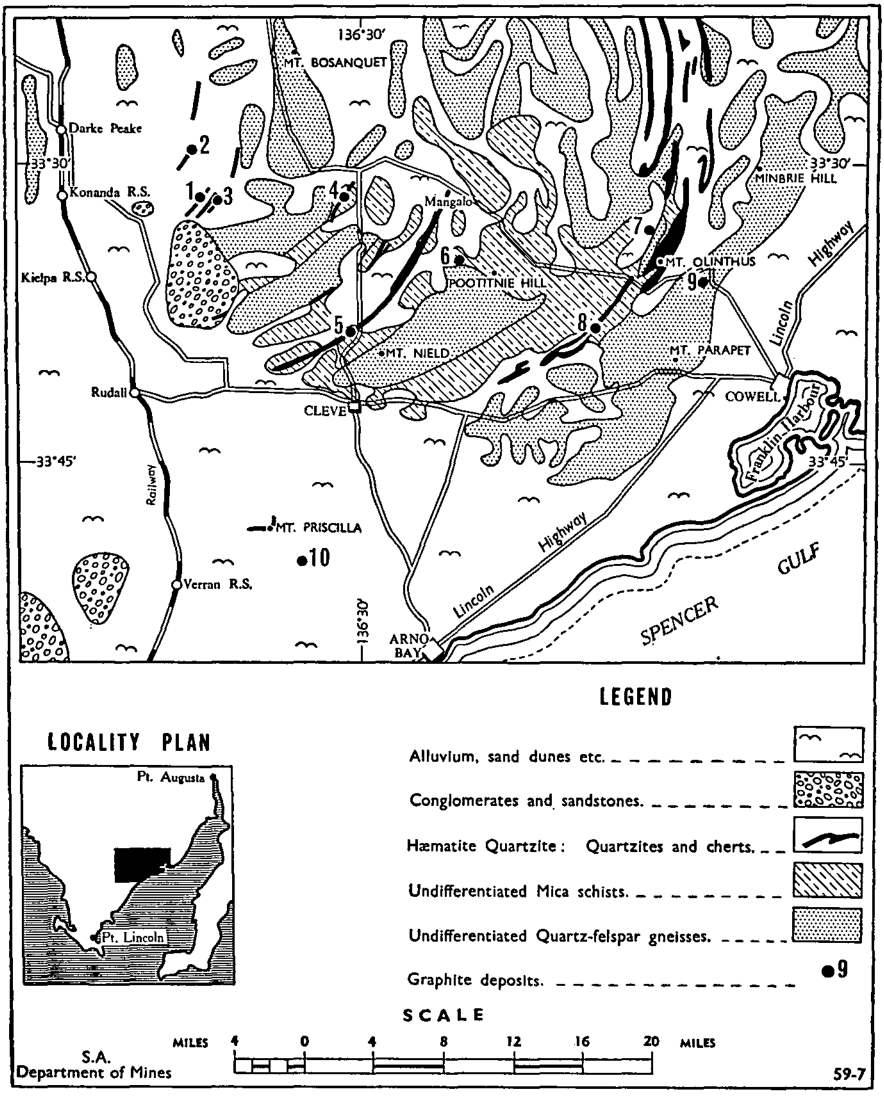

FIG. 52—CLEVE UPLANDS GRAPHITE DEPOSITS

Geological and locality plan

*Mount Shannan Graphite**

Location.—Section 106, hundred of Yadnarie, county Jervois; 4 miles north of Cleve.

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* See fig. 52, deposit No. 5.

The Deposit

Graphitic schists are exposed on the crest and upper slopes of a hill immediately above the hematite quartzite bed. The deposits have not been tested.

*Mangalo Locality**

Location.—Section 3, hundred of Mangalo, county Jervois; 4 miles south of Mangalo.

The Deposit

Graphite schist occurs near the base of the Schist Group and immediately above a thick conspicuous bed of dolomite in this locality. There are no workings but graphitic schist has been exposed in a shallow pit. (See fig. 54.)

Miltalie Graphite Deposits†

Location.—Sections 40, 43S, 43N, 48, 51 and 56, hundred of Miltalie, county Jervois; 12 miles northwest of Cowell.

References

Review of Mining Operations 27, pp. 54, 64-65, 1918 (R. L. Jack).
Mining Review 92, p. 11, 1952 (General Notes).
Mining Review 92, pp. 24-57, 1952 (M. L. Wade).
Mining Review 92, pp. 151-162, 1952 (F. N. Betheras).
Mining Review 92, pp. 199-203, 1952 (N. Jackson).

Geology

Graphitic schist occurs in a discontinuous belt on the western flanks of the Mount Olinthus ridge.

The most southerly deposit on section 40 has been exposed in a shallow pit over a width of 3ft. where it occurs as finely disseminated flake in a bed which dips easterly at 50 deg. The flake is small, bright but ironstained and occurs as composite particles with quartz, mica and felspar. The schist yielded 4.25 per cent of flake graphite which assayed 39.25 per cent carbon.

The deposit, which outcrops on section 51 over the top and eastern slopes of a prominent hill, consists of a bed of graphitic schist folded into an anticline plunging south at 40 deg. The graphite content of samples taken from trenches ranged from 15 to 23 per cent. The graphitic zone, which is from 10ft. to 40ft. in thickness, is flanked by banded quartzites and siliceous metasediments. Metallurgical tests of the surface material showed that the size of the flotation concentrate was too fine to make a commercial product, as grinding to minus 200 mesh was required to free the graphite from the gangue.

Drilling

Two diamond-drill holes were drilled in 1952 but the graphite intersections were disappointing. Core recovery was poor, the graphite was of fine particle size, of low grade and contained a large admixture of clay and silica.

BOREHOLE No. 1
(Depressed at 60 deg.)

Depth From ft.	To ft.	Description
Surface	51	Quartzite.
51	56	Quartzite with graphite and seams of graphitic schist.
56	62	Fine graphite.
62	68	Clay.
68	71	Quartzite.
71	90	Siliceous gneiss.

* See fig. 52, deposit No. 6

† See fig. 52, deposit No. 7.

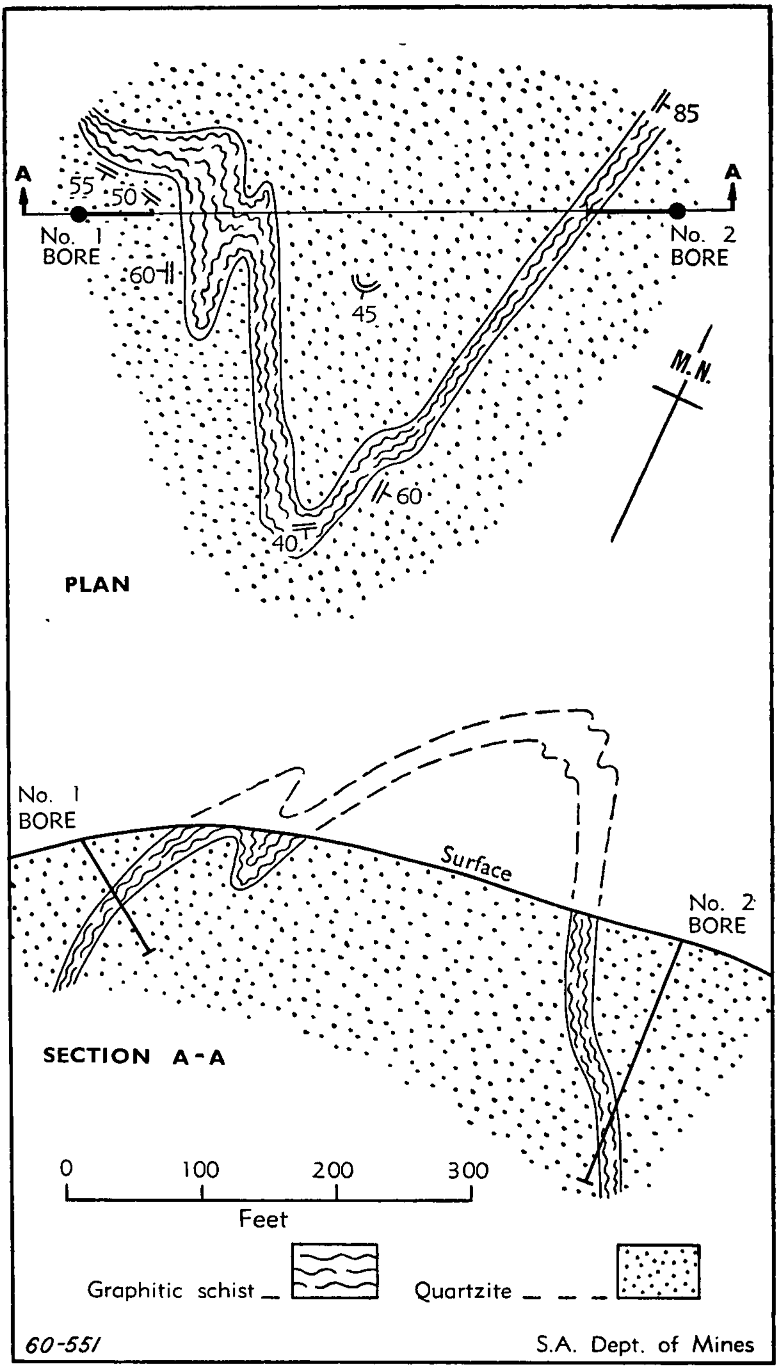

FIG. 53—MILTALIE GRAPHITE DEPOSIT

Plan and cross-section

BOREHOLE No. 2
(Depressed at 70 deg.)

Depth From ft.	To ft.	Description
Surface	45	Quartzite.
45	121	Clay.
121	130	Clay and graphite.
130	155	Clay.
155	176½	Clay and graphite.
176½	218	Quartzite.

Plan and Section

Figure 53, plan and section, shows geological features of the deposit and drill-hole locations.

Graphite Deposit—Section 367, *Hundred of Hawker**

Location.—Section 367, hundred of Hawker, county Jervois; 7 miles northeast of Yabmana.

The Deposit

Graphite has been exposed in a trench where it occurs below a bed of dolomite and in association with yellow ochre.

Graphite Deposit—Section 13, *hundred of Miltalie*†

Location.—Section 13, hundred of Miltalie, county Jervois.

The Deposit

Graphite schist has been reported from this locality (*Mining Review* 92, p. 11, 1952, General Notes), but it was not located during the present survey.

Mount Priscilla Area‡

Location.—Section 43, hundred of Roberts, county Jervois; 6 miles east of Mount Priscilla.

References

Review of Mining Operations 20, p. 64, 1914 (H. Jones).
Review of Mining Operations 26, pp. 55-56, 1917 (R. L. Jack).

The Deposits

Low-grade graphite schists which are associated with quartzites and mica schists have been exposed in several shafts and shallow pits over a distance of five chains on a low rise. Four shafts sunk to depths of 50ft., 30ft., 10ft., and 35ft. all showed graphite (greatest width 8ft.) in amounts ranging from 5 per cent to 12.5 per cent extractable flake, and containing 52-63 per cent carbon. The low grade of the material gave no encouragement for further work.

Dolomites and Associated Mineral Deposits

Though dolomitic marbles are relatively thin members of the Archaean succession, they are quite important, and have economic significance in that they have a potential usage in steelmaking and as ornamental or building stones as well as being host rocks to asbestos and talc mineralization.

The Mangalo and Carpa dolomites were prospected by The Broken Hill Proprietary Co. Ltd. prior to their acquisition of the Ardrossan deposits. Thicker and more extensive than these, however, are those that outcrop near Ulgera Gap and southwards therefrom. A number of thin beds of dolomite also outcrop in the domed core of gneisses near the eastern flanks of the hills west of Cowell.

Below are briefly described those dolomites which are mineralized or have been tested previously.

* See fig. 52, deposit No. 8.
† See fig. 52, deposit No. 9.
‡ See fig. 52, deposit No. 10.

Mangalo Dolomite

Location.—Section 3, hundred of Mangalo, county Jervois.

A bed of dolomite at least 200ft. wide occurs at the base of the Hutchison Schists and has been exposed in a number of deep costeans. The dolomite is underlain by a bed of graphitic schist.

Figure 54 shows the existing workings. Several shallow pits have been sunk on thin seams of asbestos which occur in the dolomite.

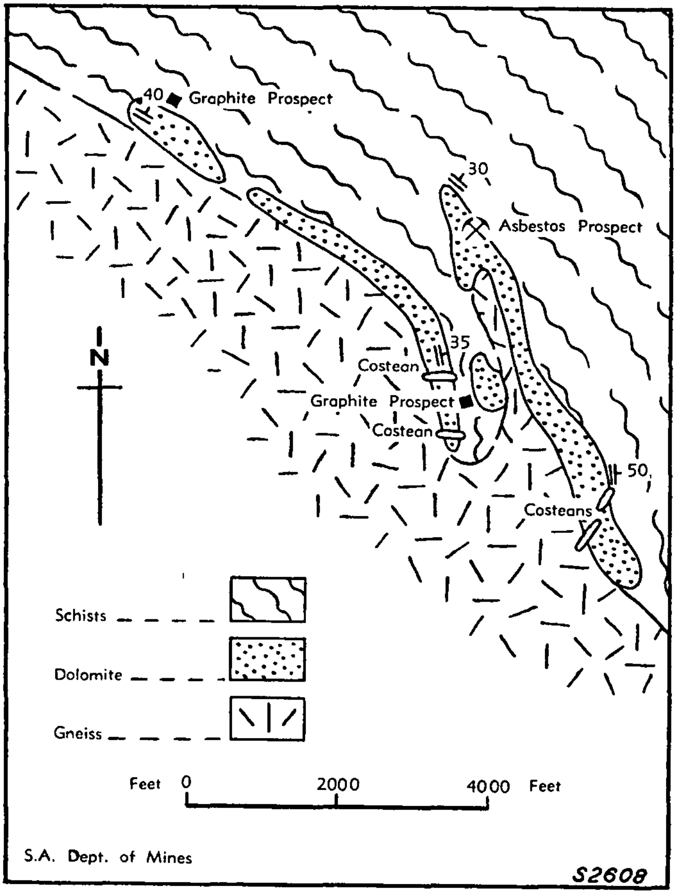

FIG. 54—MANGALO DOLOMITE DEPOSIT

Sketch plan

Carpa Dolomite

Location.—Section 229, hundred of Hawker, county Jervois; 3 miles southeast of Carpa.

Reference

Mining Review 71, pp. 98-99, 1940 (H. S. Cornelius).

The Deposit

A lenticular bed of dolomite enclosed by quartz-felspar gneisses has been exposed in a number of shallow costeans over an outcrop length of 2,500ft. The bed is up to 200ft. wide in the centre of the outcrop where a shaft has been sunk to 50ft. and crosscuts put out from the bottom for 12ft. to the northwest and 135ft. to the southeast.

A partial analysis is given below:

CaO per cent	MgO per cent	Fe_2O_3 per cent	Al_2O_3 per cent	Insolubles per cent	MnO	Loss on ignition per cent
28.2	22.7	1.1	1.5	3.2	trace	44.2

Figure 55 shows the deposit and workings.

Dolomite Deposit—Sections 114w, 115, 137 *and* 246, *Hundred of Hawker*

Location.—Sections 114w, 115, 137 and 246, hundred of Hawker, county Jervois; adjacent to Cowell-Cleve Road.

A bed of dolomite 200ft. wide occurring within quartz-felspar gneisses as a dense crystalline rock was partially analyzed, with results as below:

CaO per cent	MgO per cent	Fe_2O_3 per cent	Al_2O_3 per cent	Insolubles per cent	TiO_2 per cent
30.24	20.91	0.32	0.55	1.88	0.03

Ulgera Gap Dolomite

Location.—Sections 18 and 19, hundred of Miltalie; county Jervois.

The thickest of several beds of dolomite was sampled with the following results:*

CaO per cent	MgO per cent	Fe_2O_3 per cent	Al_2O_3 per cent	Insolubles per cent	TiO_2 per cent	MnO per cent
37.84	14.00	0.13	0.40	7.76	0.02	0.02

Dolomite Deposit—Section 110, *Hundred of Minbrie*

Location.—Section 110, hundred of Minbrie, county Jervois; 7 miles northwest of Cowell.

References

Review of Mining Operations 30, pp. 38-40, 1919 (R. L. Jack).
Review of Mining Operations 38, pp. 51-52, 1923 (R. L. Jack).
Mining Review 51, pp. 64-65, 1930 (R. L. Jack).
Mining Review 53, pp. 98-99, 1931 (R. L. Jack).
Mining Review 54, p. 125, 1931 (J. L. Pearson).
Mining Review 56, pp. 65-66, 1933 (J. L. Pearson).
Mining Review 68, pp. 60-62, 1938 (A. T. Armstrong).
Mining Review 82, p. 10, 1946 (General Notes).
Mining Review 92, pp. 18-25, 1952 (K. R. Miles).

The Deposit

A bed of dolomite 170ft. thick outcrops over two low rounded hills in this section and is traceable to the east where it is truncated on the fault scarp and for about 1½ miles to the south. This locality is the locus of magnesium-rich metasomatism by which the marble has been locally altered to greenish-yellow serpentine. This alteration has not been uniform so that the stone is mottled, streaked, or in places completely altered. Chrysotile asbestos occurs in thin discontinuous seams along narrow steeply dipping fractured zones in the serpentinized marble and has been mined from a number of shallow openings (fig. 59). An open cut and several shallow pits have been opened up on a development of green soapstone and a little carnotite also occurs near the margin of the dolomite bed.

The chrysotile asbestos was discovered in 1918 and the recorded production since that time amounts to only 12 tons. The veinlets of asbestos range from paper thickness to a maximum of about 2in., the bulk of the fibre being less than a ¼in. A number of small quarries has been opened up, trenches and costeans dug, and shafts sunk, and drives extended from the shafts on the asbestos seams.

* Jack, R. L., *Geol. Survey S. Aust. Bull* 10, p. 37, 1923.

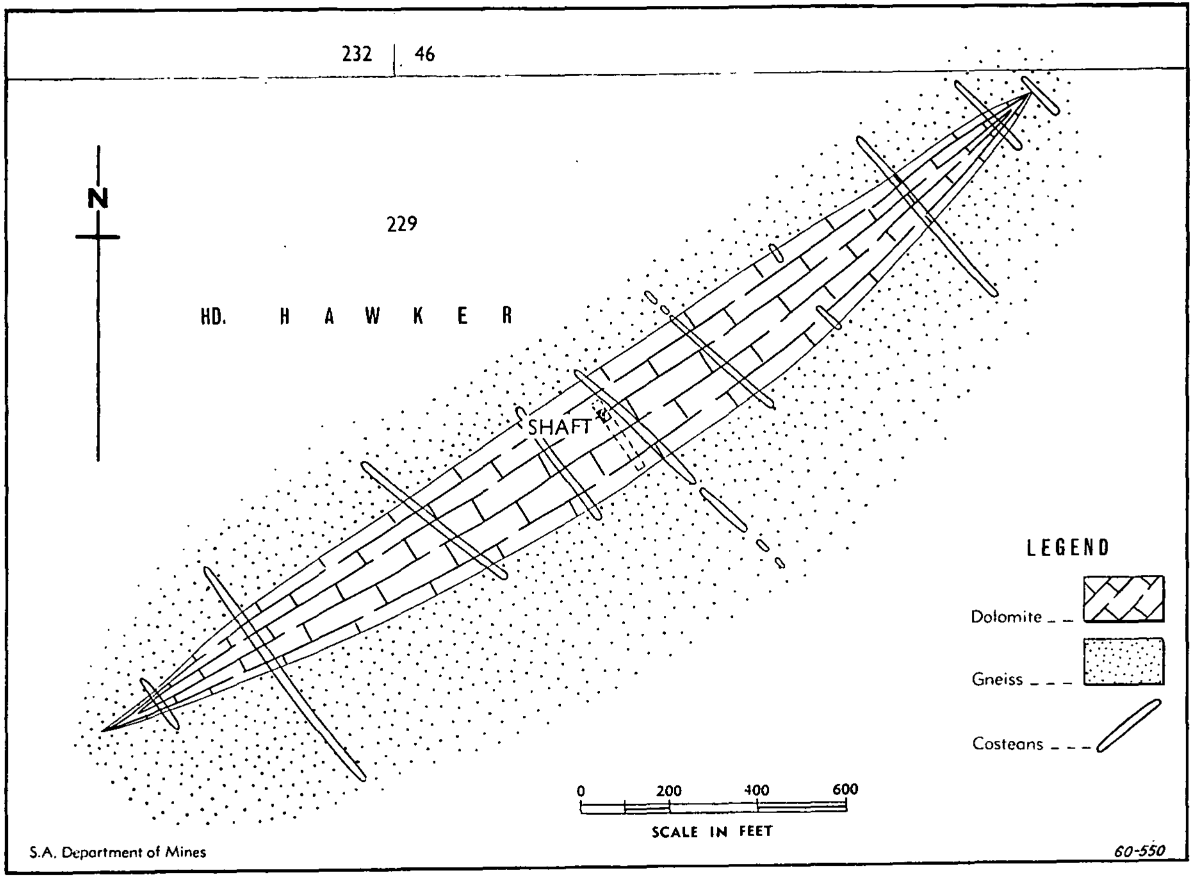

FIG. 55—CARPA DOLOMITE DEPOSIT
Geological plan

Schistose talc or soapstone which occurs within the bed of marble on the eastern hill is dark green in colour, fine grained and pulverizes readily to an off-white powder. Recorded production consists of a single parcel of 15 tons marketed for £45 in 1929.

Two shallow shafts have been sunk on schistose marble which carries carnotite staining on fracture surfaces over a width of about 3ft. Figure 56 shows the disposition of the various deposits at this locality.

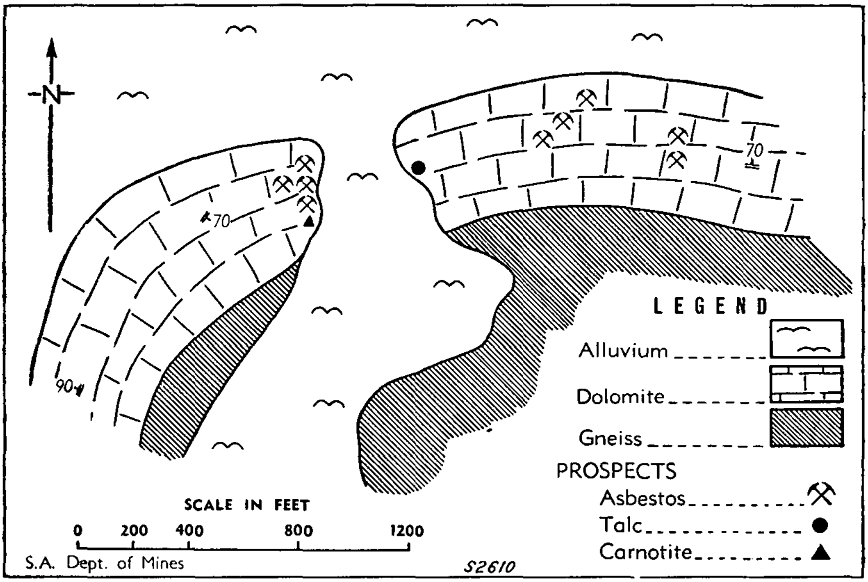

FIG. 56—GOLF COURSE DOLOMITE—SECTION 110, HUNDRED OF MINBRIE
Plan showing mineral deposits

Asbestos Deposit—Section 13, *Hundred of Miltalie*

Location.—Section 13, hundred of Miltalie, county Jervois; 7 miles northwest of Cowell.

Asbestos occurs in dolomite in a narrow crushed zone which has been to some extent serpentinized. This zone which averages about 3ft. in thickness, carries veinlets of asbestos ranging up to ½in. in width. The zone has been opened up by an open cut 43ft. in length and 21ft. deep. From the bottom of these workings a drive has been extended 35ft. on a northerly course in broken dolomite; but asbestos is absent.

Recorded production amounts to 8 tons.

Asbestos Deposit—Section 3A, *Hundred of Miltalie*

Location.—Section 3A, hundred of Miltalie, county Jervois; 20 miles northwest of Cowell.

Veinlets of good-quality asbestos are developed in a bed of dolomite where the serpentinization is most intense (Jack, R. L., 1929, unpublished). One half ton of fibre was produced. This prospect was not located.

Asbestos Deposit—Section 156, *Hundred of Hawker*

Location.—Section 156, hundred of Hawker, county Jervois; 14 miles west of Cowell.

Reference

Mining Review 77, pp. 74-77, 1943 (A. T. Armstrong).

The Deposits

Asbestos occurs in serpentinized patches in two adjacent beds of dolomite. Serpentinization is very irregular and appears as light- to dark-green patches up to 3ft. across, through which run veins of asbestos ranging from very fine threads to an inch in width.

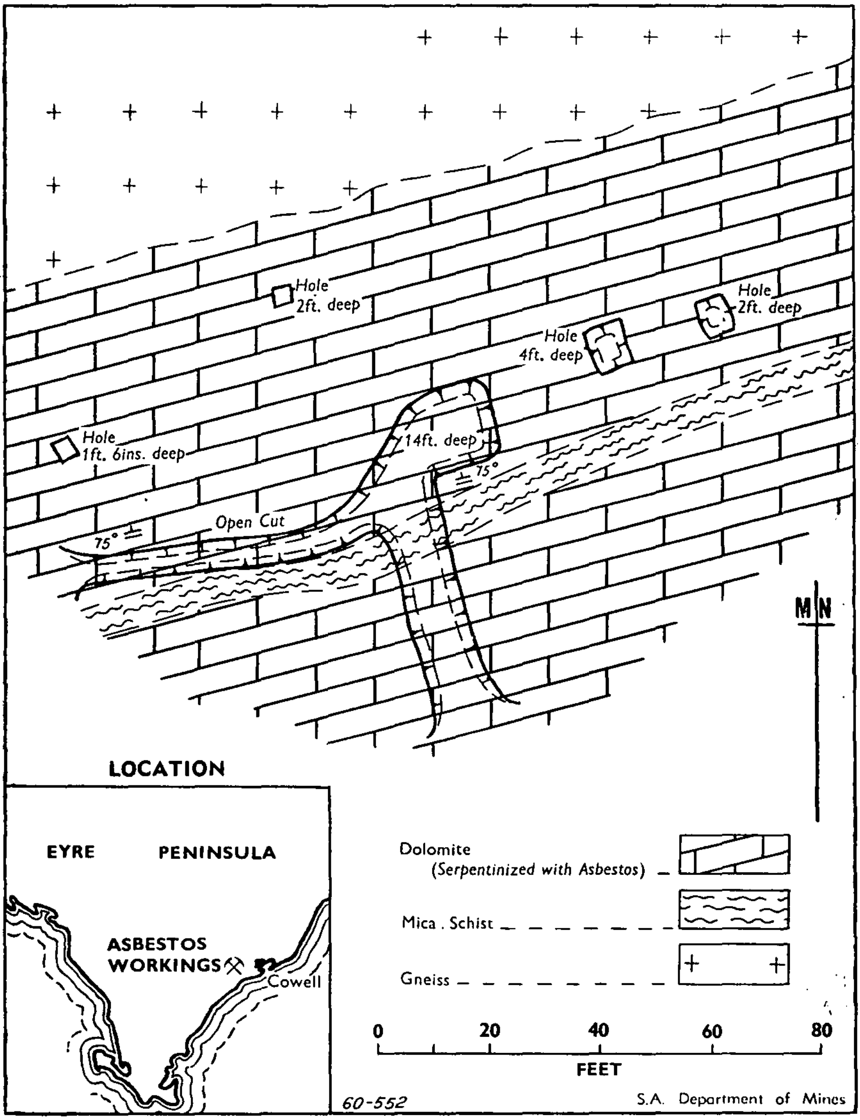

FIG. 57—ASBESTOS WORKINGS—SECTION 156, HUNDRED OF HAWKER
Geological and locality plan

The deposits have been worked from an open cut 80ft. long and from a cross trench 40ft. long connected to the open cut. Farther to the northeast, on the same dolomite formation, showings of asbestos have been opened up by means of trenches and shallow pits.

Throughout the workings the changes in the length of fibre and quantity are very rapid and there are many large barren masses of limestone present.

Figure 57 shows the workings on the dolomite bed.

Clays

Deep weathering of felspathic rocks has given rise in some places to white clays which might be suitable for china ware, paper manufacture, etc. The only deposit investigated for such a purpose is that situated in section 87, hundred of Miltalie, 18 miles northwest of Cowell and situated on the northern bank of Salt Creek. Samples from the deposit were submitted to the Ceramics Laboratory and the results of tests carried out are published.*

The deposit of clay has been exposed by stream erosion in the northern bank of Salt Creek where it consists of a bed of kaolinized felspar-quartz gneiss, poor in mica, approximately 35ft. in width and bounded above and below by beds of white flaggy quartzite each more than 100ft. in thickness (fig. 58). The lower quartzite bed encloses a number of thin bands of kaolinized gneiss. The kaolinized gneiss is a homogeneous, soft rock, free of iron staining and showing a weak lineation throughout.

In the laboratory the rock was crushed and washed to remove quartz and mica and the resultant clays were fired. A good recovery was achieved and the resultant materials showed it to have low contraction and a refractory nature. Ellerton (op. cit) compared its composition and firing behaviour to that of Cornish china clays.

Reserves are not established and the main factor against exploitation would appear to be its remote location.

Radioactive Mineral Deposits

Anomalous radioactivity has been detected by hand monitor and by using airborne prospecting techniques at a number of centres, though in each case the activity was due to finely divided secondary uranium compounds.

The airborne scintillometer indicated strong anomalies over the courses of the River Driver and River Dutton and in a number of the near-coastal salinas in the Arno Bay-Port Neill locality. These have been attributed to decomposition ("daughter") products (radon) of uranium compounds.

References

Poonana—*Mining Review* 92, pp. 57-59, 1952 (M. L. Wade).
Calcookra—*Mining Review* 97, pp. 30-32, 1954 (Boring).
Boards—*Mining Review* 97, p. 39, 1954 (M. L. Wade).
Emu Plain—*Mining Review* 99, p. 64, 1956 (L. W. Parkin).
Golf Course—*Mining Review* 38, pp. 51-52, 1923 (R. L. Jack). *Mining Review* 92, pp. 19-25, 1952 (K. R. Miles).
Yeldulknie Weir—*Geol. Survey S. Aust. Bull* 3, p. 39, 1914 (R. L. Jack). *Review of Mining Operations* 17, 1912 (L. K. Ward).
Section 31, hundred of Miltalie—*Mining Review* 92, p. 11, 1952 (General Notes).
"Airborne Scintillometer Survey of Eastern Eyre Peninsula"—*Mining Review* 101, pp. 72-78, 1956 (K. R. Seedsman and J. L. Harris).

Occurrences

At the Calcookra, Boards and Emu Plain mines the uranium is closely associated with copper mineralization. At the Poonana mine lead and silver are also associated. Torbernite has been reported in a quarry at Yeldulknie Weir and in section 110, hundred of Miltalie carnotite occurs in white shale.

In section 31, hundred of Miltalie, finely divided secondary uranium compounds occur with limonitic and manganiferous patches in dolomite.

The concentration of uranium at all centres is insignificant.

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* Ellerton. H., *Mining Review* 93, pp. 26-27, 1952.

FIG. 58—FIRECLAY DEPOSIT, SALT CREEK

Kaolinized gneiss bounded and interbedded with thin quartzites

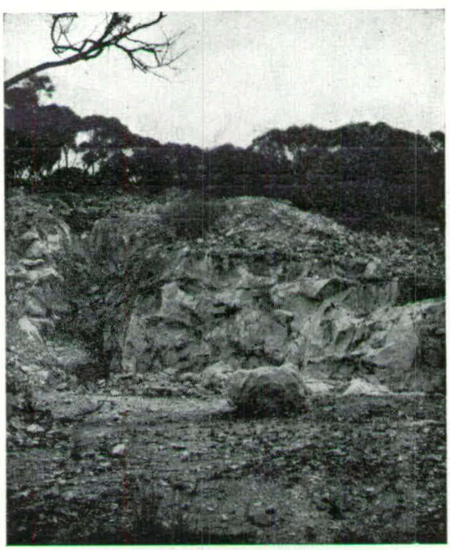

FIG. 59—OLD ASBESTOS WORKINGS IN SERPENTINIZED DOLOMITE

About 7 miles northwest of Cowell

To face page 62]

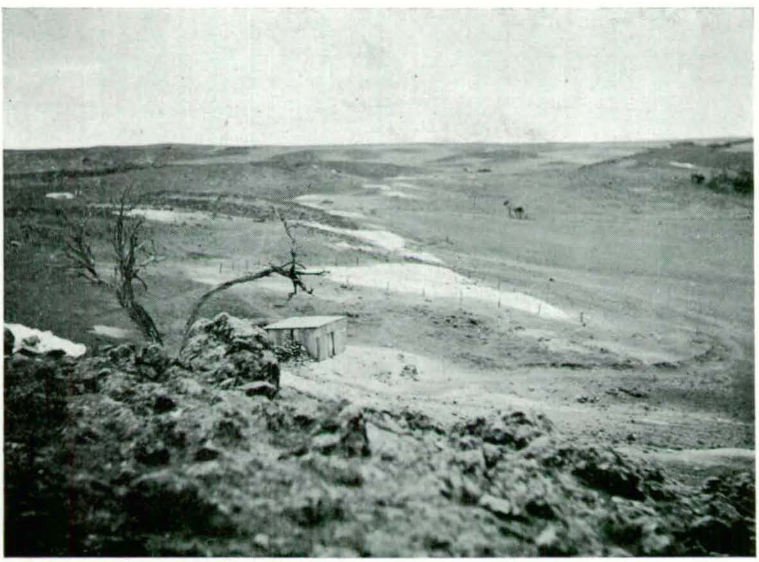

FIG 60—TUMBY BAY TALC DEPOSITS

Showing line of talc workings

Building and Ornamental Stones

Stones utilized locally for construction of farm houses and outbuildings include various gneisses, granites and kunkar while in Cleve and Cowell townships local dolomitic marbles have been used to some extent.

Granitic gneiss has been obtained from a deposit situated in section 114w, hundred of Hawker, near the Cowell-Cleve road where a small quarry has exposed dense, even-grained, dark-grey and pink-coloured granitoid gneiss. A number of large blocks were extracted and shipped to Adelaide for use as a monumental stone.

The only stone being currently exploited is the serpentinized dolomite in section 110, hundred of Miltalie. The stone is subjected to two-stage crushing at the site to produce green-yellow chips for use in terrazzo ware, panels, tiling and flooring. Production of large blocks for monumental ware might also be an economic proposition.*

Roadmaking Materials

Kunkar, quartzites and gneiss of many localities have been satisfactorily utilized for road building in the region—the biggest quarry being that located on the eastern slopes of Darke Peak Range in quartzite. This has been used as ballast, concrete aggregate and road building material.

Beryl

The only recorded occurrence of beryl in the Cleve Uplands is that which is confined to a coarsely crystalline felspar-quartz pegmatite dyke located in the hundred of Minbrie 1 mile south of Mount Geharty. Several crystals have been found and the occurrence is of academic interest only.†

METALLIC DEPOSITS—LINCOLN UPLANDS

Copper

Copper was mined from a number of centres west of Tumby Bay, but the mines are all now in disrepair, work having been abandoned in some cases over 50 years ago. The lodes were all confined to near-vertical narrow shears in banded augen gneisses. The workings appear to have been confined to oxidized ores which were associated with quartz. None of the prospects appears to be worth further exploration.

Burrawing Mine

Location.—Section 403, hundred of Yaranyacka, county Flinders; 2 miles north-west of Lipson.

Reference

Record of the Mines of S. Aust. (4th Ed.), p. 39, 1908.

The Mine

A copper-bearing lode which is about 2½ft. wide at the surface has been worked over a length of about 10 chains, the main shaft being 275ft. deep. The lode occupies a near-vertical fissure parallel to the bedding of micaceous quartzites and schists.

Opened in 1869 and wound up in 1874, the mine yielded ore to the value of £6,300. Copper assays showed up to 37 per cent copper while some showed about 1½ per cent bismuth.

Lipson Cove Mine

Location.—Section 833, hundred of Yaranyacka, county Flinders; near Lipson Cove jetty.

Reference

Record of the Mines of S. Aust. (4th Ed.), p. 77, 1908.

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* Johns, R. K., *Mining Review* 103, pp. 81-82, 1957.

† *Mining Review* 92, p. 11 (General Notes).

The Mine

The mine commenced operations in 1860 when several shallow shafts were sunk in lodes consisting of quartz and malachite. All that is now visible is a small opening in the cliffs near Lipson Island and some ruins.

Tumby Bay Mine

(Tumby, Wheal Bessie, Flinders.)

Location.—Sections 71, 142, hundred of Hutchison, county Flinders; 4 miles northwest of Tumby Bay.

References

Record of Mines of S. Aust. (4th Ed.), pp. 56, 136, 160, 1908.
Review of Mining Operations 11, pp. 19, 23, 1910 (General Notes).
Review of Mining Operations 14, p. 40, 1911 (H. Jones).
Review of Mining Operations 16, p. 7, 1912 (General Notes).
Review of Mining Operations 17, p. 8, 1913 (General Notes).
Review of Mining Operations 17, p. 36, 1913 (R. L. Jack).
Review of Mining Operations 18, p. 6, 1913 (General Notes).
Review of Mining Operations 19, p. 7, 1914 (General Notes).
Review of Mining Operations 20, p. 6, 1914 (General Notes).
Review of Mining Operations 24, pp. 61-62, 1916 (H. Jones).
Review of Mining Operations 25, p. 9, 1917 (General Notes).
Review of Mining Operations 25, pp. 73-77, 1917 (L. J. Winton).
Review of Mining Operations 27, p. 9, 1918 (General Notes).

The Mine

Work commenced in 1867 on two main lines of lode which strike east-west and dip at 70-80 deg. south. Most of the mining was carried out during the period 1910-1916 and by 1918 the property was abandoned.

The southernmost lode (Tumby lode) was exposed over a length of about 400yds., in three main shafts, Prisk, Vertical and Stephens shafts and by a number of shallow cuts and trenches.

Prisk shaft is reported to be 167ft. deep, sunk on the underlie of the lode (80-85 deg. south). At 88ft. it is connected by a drive to Stephens shaft which was 124ft. deep. The vertical shaft was connected to the drive on the lode from Stephens shaft at the 52-ft. level by a crosscut 25ft. long. Stoping operations were carried out between the 88-ft. level and the 52-ft. level where the lode formation is reported to have been up to 3ft. wide and to have consisted of quartz, chalcocite, covellite, cuprite, and copper carbonates. No chalcopyrite was encountered.

Twenty-five tons of ore (containing 19 per cent copper) were reported to have been extracted from these workings up to 1910. Winton (1917) noted that about 30-40 tons of marketable ore existed on the dumps and suggested further investigation of the eastern end of the lode beyond Prisk shaft.

One half mile north of the Tumby lode is the Flinders lode which was exposed in an underlie shaft (Flinders shaft) to a depth of 240ft. and in several other shallow shafts. On the western side of the shaft a stope was carried up from the 85-ft. level over a length of 65ft., almost to the surface. Some stoping was also undertaken from the eastern side of the shaft over a length of 25ft. The ore consisted of blue and green carbonates, and chalcocite. Chalcopyrite was penetrated in Flinders shaft at 210ft. and this appears to be the only record of primary sulphide ore in the region.

Flinders lode is the northernmost of three lode formations at this locality; the centre lode was prospected by several shallow pits showing traces of copper and the southern (No. 3 lode) was worked from two shafts, 25ft. and 59ft. deep.

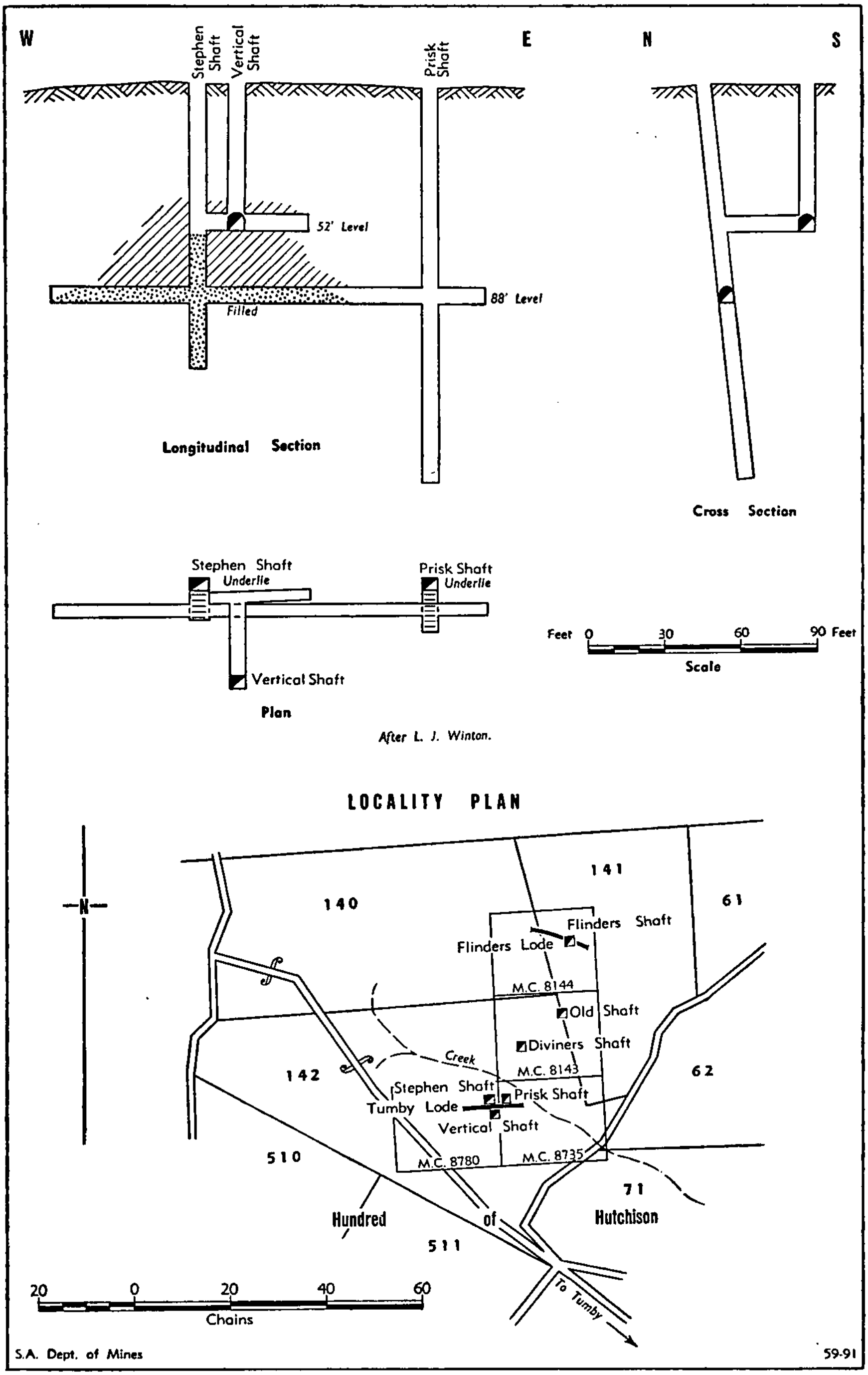


FIG. 61—TUMBY BAY COPPER MINE

Plan and sections

Twenty-five tons of ore (average 15 per cent copper) were reported to have been sold to smelters by 1899 while a further 10 tons of similar grade ore were awaiting shipment.

Another lode has been opened up in a shallow shaft between the Tumby and Flinders lodes. Hard (Diviner's) shaft sunk nearby is in barren gneiss throughout its depth of 167 feet.

Plan and Section

Figure 61 shows location of the Flinders and Tumby lodes and the underground workings on the Tumby lode (plan and section).

Port Lincoln Mine

Location.—Sections 800, 801, 804, 805, 806, 807, 812 and 813, hundred of Hutchison, county Flinders; 5 miles west of Tumby Bay.

Reference

Record of the Mines of S. Aust. (4th Ed.), pp. 113-114, 1908.

The Mines

Ore was produced intermittently from a number of shafts sunk on two main lode systems during the period 1849 and 1908. The recorded production amounts to 850 tons of which one parcel of 500 tons averaged 25-30 per cent copper.

The north and south lodes are 1,000ft. apart. On south lode, Painter shaft was 150ft. deep with drives at the 60-ft. level in chalcocite and copper carbonates. East shaft (¼ mile from Painter shaft) on the same line of lode was sunk to a depth of over 60ft. A tunnel and drives exposed the lode over a length of 150ft. to the west of Painter shaft.

The north lode was exposed in Engine shaft (over 200ft. deep) with drives at the 40-ft., 100-ft. and 200-ft. levels. Stoping was carried out over the 40-ft. level. On the same line of lode Whim shaft was sunk 120ft. and a "fair quantity of high-grade ore" was extracted prior to 1907.

Mount Liverpool Mines

Location.—Sections 824 and 827, hundred of Hutchison, county Flinders; 7 miles west of Tumby Bay.

Reference

Record of the Mines of S. Aust. (4th Ed.), p. 93, 1908.

The Mines

Good ore consisting of copper carbonates, chalcocite and chalcopyrite is reported to have been raised from the "old" and "new" Mount Liverpool mines. The narrow lodes were opened up by means of shallow shafts, open cuts and stopes over a length of about 240ft. prior to 1863.

Other Prospects

A number of workings are listed in the *Record of the Mines of S. Aust.* which were not located with certainty during the current survey. Their approximate locations and published general data are given below:

Mortlock Mine: Near Burrawing mine, hundred of Yaranyacka, county Flinders. *Record of the Mines of S. Aust.* (4th Ed.), p. 160, 1908.

Copperer: Hundred of Hutchison, county Flinders; 6 miles from Tumby Bay.

Copper King: Hundred of Hutchison, county Flinders; adjacent to the Copperer.

New Year's Gift: 4 miles from Tumby Bay.

When inspected in 1899 it was being worked from a 90-ft. shaft and an open cut on a lode 2ft. wide at the surface. Ore consisted of "good carbonates, grey ore and red oxide." Recorded production amounts to 2 tons of ore containing 15 per cent copper. (*Record of the Mines of S. Aust.,* 4th Ed., p. 102, 1908.)

Moorahnoo: Section 62, hundred of Hutchison, county Flinders; 4 miles northwest of Tumby Bay and adjoining old Montezuma mine.

It is reported (1899) that a shaft 43ft. deep had been sunk on a lode formation up to 12in. wide and consisting of carbonates. (*Record of the Mines of S. Aust.*, 4th Ed., p. 86, 1908.)

Great Montezuma: East of and adjoining the Flinders mine. (*Record of the Mines of S. Aust.*, 4th Ed., p. 59, 1908.)

W. Condell's Claim: On Flinders line of lode—prospecting is reported to have exposed some carbonates. (*Record of the Mines of S. Aust.*, 4th Ed., p. 43, 1908.)

Condell and Provis Claim: Adjoining the Flinders mine. The lode which was up to 2ft. wide was exposed in two shafts 37ft. and 82ft. and in shallow trenches. Green carbonate ore occurred in shoots and bunches. Six tons of 12 per cent ore are reported to have been sent to smelters. (*Record of the Mines of S. Aust.*, 4th Ed., p. 43, 1908.)

Copperenga Mine: "Near Tumby Bay".

Harris Hill: "Two miles north from Tumby". Several shallow shafts and a number of pits are reported to have been sunk on two well-defined lodes 27ft. apart. Ore consisted of green carbonates and cuprite. Production recorded amounts to ½ ton of ore. (*Record of the Mines of S. Aust.*, 4th Ed., p. 62, 1908.)

Koona: Adjoining Flinders mine. A lode parallel to the Flinders lode was exposed in three shafts which ranged from 15ft. to 85ft. in depth. The lode was up to 4ft. wide. "Large quantities" of malachite ore were despatched to the smelters. (*Record of the Mines of S. Aust.*, 4th Ed., p. 76, 1908.)

Heyward: Adjoining Flinders mine, section 802, hundred of Hutchison, county Flinders. A few trial pits and one shaft 30ft. deep were sunk on a lode 2ft. 6in. wide and showing blue and green carbonates. (*Record of the Mines of S. Aust.*, 4th Ed., p. 62. 1908.)

Mount Gawler Mine: Thirteen miles north of Port Lincoln—near Mount Gawler, hundred of Louth, county Flinders.

Silver—Lead—Gold

Lady Franklin Mine and Moonlight Mine

At the Lady Franklin mine and Moonlight mine situated near the eastern flanks of the Marble Range in sections 153 and 156, hundred of Warrow, a number of shallow shafts and costeans were sunk on formations carrying galena, blende and pyrite. In the Lady Franklin mine a sample taken at 55ft. assayed 5 dwt. 23 gr. to 12 dwt. of gold/ton. One parcel of ore smelted at Wallaroo was reported to have yielded 22 per cent lead, 1½oz. silver and 12 gr. of gold/ton, with traces of copper and zinc. A sample taken from the dump in 1899 assayed 1 per cent copper and gold, nil.

The main vertical shaft was 82ft. deep and at 47ft. a short crosscut was driven into phyllitic slates and schists. The lode strikes northeast and dips steeply southeast but the workings are now completely filled.

References

Record of the Mines of S. Aust. (4th Ed.), pp. 180-181 and 255, 1908.

Mining Review 32, pp. 55-56, 1920 (L. J. Winton).

Other Occurrences

In the *Record of Mines of S. Aust.*, 4th Ed., 1908, pp. 309 and 367 reference is made to the Port Lincoln syndicate which was concerned with gold but it obviously had little success. Gold, silver, and platinum were alleged to have been found in the upper reaches of the Tod River (unpublished report, Woodward, 1885) and gold in the hundred of Wanilla but none of these discoveries were confirmed.

A trace of gold has been reported from the face of the adit at the Iron Mount mine (*Review of Mining Operations* 11, p. 19, 1910, General Notes). An assay of arsenical pyrite from the Burrawing mine is alleged to have shown 5½ gr. gold per ton.

Iron

References

Review of Mining Operations 11, p. 19, 1910 (General Notes).
Review of Mining Operations 24, p. 61, 1916 (H. Jones).
Mining Review 103, pp. 79-81, 1957 (R. K. Johns).
Geol. Survey S. Aust. Bull. 9, pp. 21-22, 1922 (R. L. Jack).

Hematite quartzites are traceable as thin-bedded formations within the Archaean Hutchison metasediments from the Tumby region southwards to Sleaford Bay. The hematite quartzites are typically well bedded and the proportions of iron and silica variable from place to place, being such as to constitute a low-grade iron ore in some sections. Exposures of this horizon in the Lincoln Uplands are generally poor and discontinuous, being veneered by lateritic gravels and clays.

The formation ranges in different places from less than 50ft. to over 300ft. in width and is generally interbedded with schists and kaolinized gneisses. Enclosing beds consist of high-grade schists, often graphitic, and gneisses with minor quartzites, dolomites and amphibolites.

The best exposures of the highest-grade material extend northwards from the Tod Reservoir to Curilla Springs (Tumby sheet). These beds consist of alternating bands of glassy or cherty quartz and iron-rich bands, the bands being ⅛in. to ¼in. wide and often contorted. The iron minerals are steel grey when fresh; they are weakly magnetic and have a red streak. Martite is probably the chief iron mineral though on the weathered surfaces it is hydrated to brown limonite.

The only occurrence that has been worked commercially is that of the Iron Mount mine where leases were held over parts of sections 140 and 141, hundred of Hutchison. A tunnel was driven into the hill for a distance of 140ft. where the main formation is about 60ft. wide. Ore was mined from several shafts and from shallow pits and shipped for use as a flux to the Port Pirie smelters. The ore assayed up to 51 per cent Fe and up to ½ per cent manganese.

The formation which outcrops strongly along Rock Valley Creek was sampled in section 33, hundred of Koppio (Johns, 1957). The ferruginous zone as indicated by shoad material is about 200ft. wide though the actual outcrops of hematite quartzite are little more than 50ft. wide. Immediately west of the Koppio graphite mine two adits have been driven from the eastern side of the ridge, presumably to test the iron deposit, but both penetrated kaolinized gneiss to 50ft. from the portals and stopped short of the iron formation. Sampling of the bed was undertaken over a representative thickness the assays being as below:

	Surface-10ft.	10-20ft.	20-30ft.	30-40ft.	40-50ft.
Total H_2O	6.70	4.32	4.86	4.72	7.20
SiO_2	35.2	27.0	55.1	28.8	26.7
Total Fe	38.5	44.9	26.1	43.3	42.8
FeO	0.22	0.20	0.68	0.81	0.44
S	0.04	0.02	0.03	0.15	0.03
Mn	0.05	0.09	0.01	0.01	0.03
P	0.20	0.26	0.16	0.20	0.37
SiO_2	0.01	0.01	0.02	0.07	0.04

These assays compare favourably with those of the Iron Mount ore (Jack, 1922) and those of the Middleback Range (Miles, 1954, p. 121).

A small deposit of limonite ore has been quarried from the Wadella Springs locality. The ore resembles the bog-iron type (Mawson, 1907).

Manganese

Reference

Record of the Mines of S. Aust. (4th Ed.), p. 352, 1908.

General

Nodules of pyrolusite presumably derived from the weathering of hematite quartzites have been gathered by hand and taken from shallow pits in the Tumby locality and small tonnages have been marketed. A report of 1899 records the despatch of 40 tons and though assays are not available the ore appears to have been of high grade.

NON-METALLIC DEPOSITS—LINCOLN UPLANDS

Talc

References

Review of Mining Operations 14, p. 42, 1911 (H. Jones).
Review of Mining Operations 20, pp. 34-36, 1914 (L. K. Ward).
Review of Mining Operations 24, p. 63, 1916 (H. Jones).
Mining Review 45, p. 31, 1927 (General Notes).
Mining Review 78, pp. 86-88, 1943 (S. B. Dickinson).
Mining Review 80, p. 5, 1945 (General Notes).
Mining Review 83, pp. 26, 29, 1946 (Boring).
Mining Review 89, p. 141, 1950 (L. L. Mansfield).
Geol. Survey S. Aust. Bull. 13, p. 38, 1928 (R. L. Jack).
Geol. Survey S. Aust. Bull. 26, pp. 109-122, 1951 (E. Broadhurst).

General

The Tumby Bay talc deposits are situated in sections AN, AS, 28 and 46, hundred of Yaranyacka, about 2 miles west of Lipson township, where they are associated with a bed of dolomite.

The talc occurs as tabular crystals in schist or more commonly in dolomite and in irregular white pulverulent masses. The talc bodies are associated with jasper and occur in a zone near the margin of the dolomite, which itself occupies the keel position of a major synclinal fold.

The orebody has not been systematically mined and the amount which can be raised by the present system of mining is becoming limited and costly. Shafts have been sunk on the best makes of talc at the surface (fig. 60) and from these irregular narrow drives and tortuous rises are opened on the highest-grade material so as to leave masses of chalcedonic quartz and large pillars of good-quality talc.

Small pockets of talc were also observed in dolomite near Mine Creek but this occurrence is of no further interest.

Graphite

References

Record of the Mines of S. Aust. (4th Ed.), p. 370, 1908.
Review of Mining Operations 1, p. 12, 1904 (General Notes).
Review of Mining Operations 11, pp. 23-24, 1910 (General Notes).
Review of Mining Operations 20, p. 64, 1914 (H. Jones).
Review of Mining Operations 25, p. 11, 1917 (General Notes).
Review of Mining Operations 26, pp. 47-62, 1917 (R. L. Jack).
Mining Review 27, pp. 52-65, 1918 (R. L. Jack).
Mining Review 28, pp. 36-43, 1918 (R. L. Jack and L. K. Ward).
Mining Review 30, pp. 35-38, 1919 (R. L. Jack).
Mining Review 31, pp. 52-56, 1920 (R. L. Jack).
Mining Review 31, p. 15, 1920 (General Notes).
Mining Review 31, p. 18, 1920 (General Notes).

***Mining Review* 33, p. 62, 1921 (R. L. Jack).**
Mining Review 45, pp. 44-50, 1927 (Drilling).
Mining Review 45, p. 33, 1927 (General Notes).
Mining Review 45, pp. 65-72, 1927 (R. L. Jack).
Mining Review 45, pp. 72-74, 1927 (H. W. Gartrell).
Mining Review 46, p. 27, 1927 (General Notes).
Mining Review 47, p. 32, 1928 (General Notes).
Mining Review 48, p. 28, 1928 (General Notes).
Mining Review 49, p. 35, 1929 (General Notes).
Mining Review 50, p. 38, 1929 (General Notes).
Mining Review 51, p. 33, 1930 (General Notes).
Mining Review 52, p. 35, 1930 (General Notes).
Mining Review 57, p. 39, 1932 (General Notes).
Mining Review 73, pp. 47-53, 1941 (H. W. Gartrell and K. S. Blaskett).
Mining Review 74, p. 11, 1914 (General Notes).
Mining Review 75, pp. 45-50, 1942 (H. W. Gartrell and D. R. Blaskett).
Mining Review 75, pp. 58-61, 1942 (A. T. Armstrong).
Mining Review 76, pp. 42-54, 1943 (H. W. Gartrell and D. R. Blaskett).
Mining Review 76, pp. 64-65, 1943 (H. W. Gartrell and D. R. Blaskett).
Mining Review 76, pp. 66-71, 1943 (H. H. Dunkin and J. G. Hart).
Mining Review 76, pp. 90-91, 1943 (A. T. Armstrong).
Mining Review 77, p. 9, 1943 (General Notes).
Mining Review 77, pp. 71-72, 1943 (A. T. Armstrong).
Mining Review 79, pp. 90-94, 1944 (H. W. Gartrell and D. R. Blaskett).
Mining Review 79, pp. 109-114, 1944 (E. Broadhurst).
Mining Review 80, pp. 5-6, 1945 (General Notes).
Mining Review 80, pp. 113-118, 1945 (A. T. Armstrong).
Mining Review 81, pp. 92-111, 1945 (A. T. Armstrong).
Mining Review 81, p. 19, 1945 (General Notes).
Mining Review 82, pp. 93-109, 1946 (E. Broadhurst and A. T. Armstrong).
Mining Review 87, pp. 196-197, 1949 (A. T. Armstrong).
Mining Review 87, pp. 151-152, 1949 (L. K. Ward).
Mining Review 92, pp. 103-113, 1952 (N. W. Garwoli).
Mining Review 92, pp. 114-115, 1952 (D. McPharlin).
Mining Review 92, pp. 151-162, 1952 (F. N. Betheras).
Mining Review 93, pp. 110-111, 1952 (M. L. Wade).
Geol. Survey S. Aust. Bull. 13, p. 69, 1928 (R. L. Jack).

General

Graphite occurs as disseminated flake evenly distributed throughout schists and gneisses which occur at about the same stratigraphic level as the hematite quartzite formation within the Hutchison Group. The graphite schists form a distinct stratigraphic unit which persist with uniform trend but variable width and character from the coast at Sleaford Bay northwards through Koppio and beyond. They have not been differentiated as separate units on the published maps, however, because of the paucity of outcrop of this rather soft rock.

The graphite of the Lincoln Uplands region occurs in small folia or masses of aggregated scales, often with quartz, felspar, biotite, magnesite and hematite—the "graphitization" consisting of local enrichments grading off laterally into weak impregnations. The flake is noticeably coarser here than that seen in the Cleve Uplands where it occurs as an amorphous variety.

In a number of localities graphite is intimately associated with magnesite.

At the surface of the various deposits graphite usually persists even when mantled by soil or laterite and the fine flake is often discernible in clayey, gritty or ferruginized gangue arising from chemical decay of the host.

Most of the graphite schist outcrops observed have been superficially tested by prospectors by means of shallow pits or trenches though near the surface little can be judged of the economic worth of the deposits. The workable deposits have no sharp boundaries and from an economic viewpoint have been limited to ground carrying 8 per cent of flake graphite. Deposits have been mined at two localities (Uley and Koppio) and these have only been worked sporadically.

Uley Graphite Deposit

The Uley graphite mine is situated in section 2AE[2], hundred of Uley, about 14 miles by road from Port Lincoln. The deposits are situated over a low rounded hill covered by lateritic soil and surrounded by travertine. Graphite flakes persist in the laterite but the graphite schists do not outcrop.

The main bed has been exploited by means of a number of shafts connected to three main underground working levels and an open cut. It ranges in thickness from 5ft. to 30ft. This graphite schist formation is interbedded with graphitic quartz-felspar gneisses, the beds being folded into an open anticline which pitches northerly at 25 degrees.

Since 1866 over 550 tons of graphite have been mined and treated at Uley, the yearly recorded production being as below:

Year	Tons	Value £
1866-1940	146	—
1941	49	1,076
1942	70	2,239
1943	39	1,438
1944	207	5,413
1947	21	545
1948	10	266
1949	69	2,164
1950	83	2,436

Figure 62 has been compiled from the mine plans of F. H. Jones (1945) and shows the geology and underground workings at the mine.

Up to 1920 the principal workings were on No. 3 shaft where crosscuts were driven from the 37-ft., 45-ft., and 64-ft. levels. In 1920 stripping of overburden, over an area of about 140ft. square, was commenced to enable the body of graphite proven in No. 3 shaft crosscuts to be worked by means of open cut.

Seven vertical diamond-drill holes (total footage 850ft.) were sunk by the Department of Mines to prove and sample the orebody and from the results obtained it was calculated that there were 63,000 tons of ore "in sight" from which 7,000 tons of flake graphite could be recovered. A mill was erected at the mine and commenced operations in 1928.

The Imperial Geophysical Experimental Survey carried out investigations in 1930 when definite indications were given over bodies proven to exist by boring and mine development and extensions were indicated by the results obtained.

Ore was taken from the open cut down to the 39-ft. level by means of an incline which extended into the orebody as an inclined shaft to the 66-ft. level. Graphite was extracted from the underground workings by the room-and-pillar system of stoping. No. 1 winze was connected from the 66-ft. level to the No. 2 (115-ft.) level which had been driven from the main two-compartment shaft.

Operations were suspended at the mine in 1945 and resumed again in 1948 when the open cut was extended to the south. The underground workings have collapsed and are now inaccessible. Only desultory operations have been carried out on the surface since 1948.

Koppio Graphite Deposits

The Koppio mine was opened on a bed of graphite schist which can be traced discontinuously northwards from near Tod Reservoir, along the River Tod and

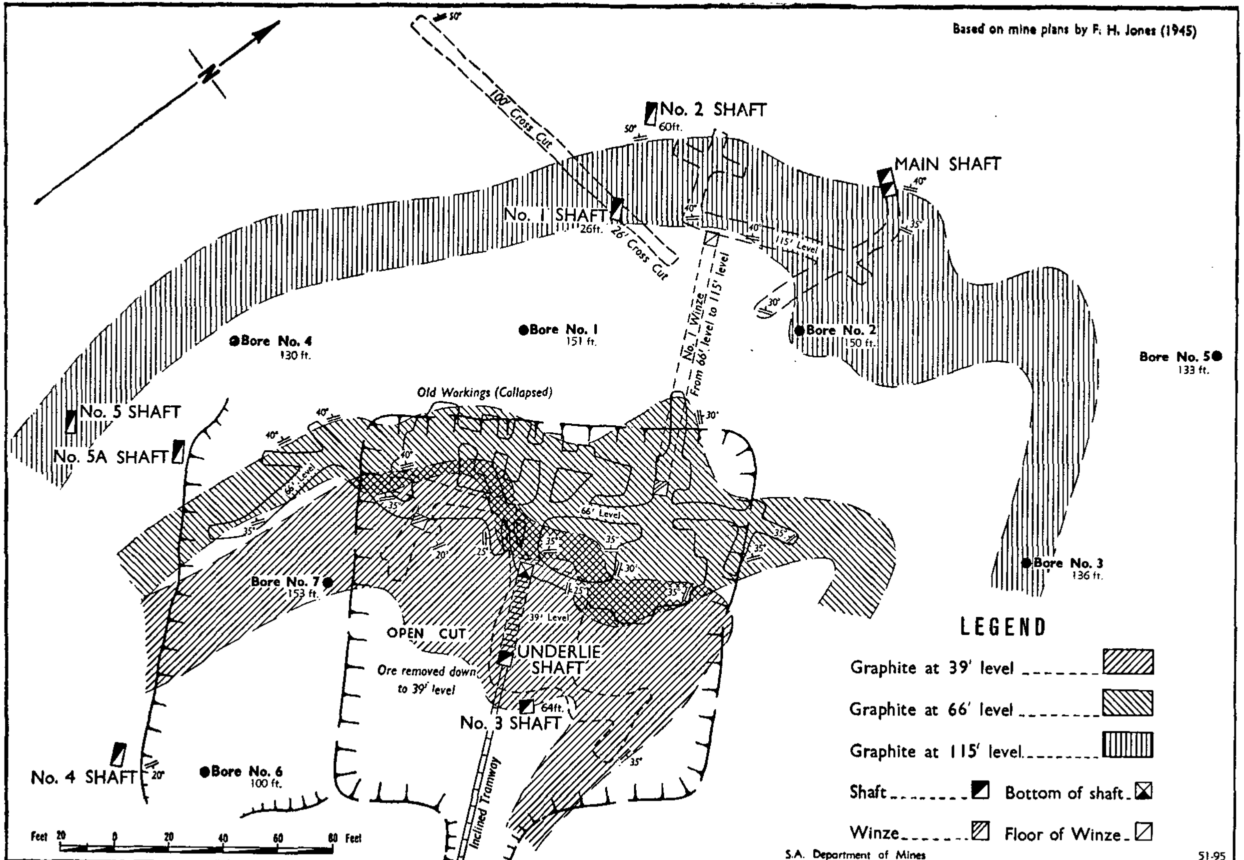


FIG. 62—ULEY GRAPHITE MINE

Geological plan of workings

Rock Valley Creek to section 31, hundred of Koppio, 20 miles north of Port Lincoln. The bed is about 40ft. wide at the surface and underlies a sequence of hematite quartzites, schists and para-gneisses which are here overturned to the east at angles varying between 35 deg. and 85 deg. Some folds seen underground are distorted isoclinal structures which do not maintain the general trend and plunge of the drag folds and are interpreted as being flow adjustments made by these incompetent beds during regional deformation of the metasediments.

Recorded production amounts to 97 tons and this is distributed as below:

Year	Tons	Value £
1943	48	2,800
1944	42	3,204
1945	5	350
1946	2	140

Figure 63 is a plan and section of the mine workings (after Broadhurst, 1944). Little mining was carried out prior to 1917 when the ore was worked by means of an open cut and several shafts. The mine was abandoned in 1917 and reopened in 1941 when an open trench 125ft. long and a tunnel of the same length were connected to the old shaft. Drives were put in near the walls in the best makes of graphite and connections were made to the drives by two short crosscuts. Shallow winzes have been sunk on the footwall and hanging wall.

One diamond-drill hole sunk at some distance to the east of the deposit disclosed a thinning of the graphite zone and a steepening in dip of the strata.

Other Deposits

Graphite schists outcrop on the shore at Sleaford Bay where they are interbedded with quartzites, gneisses and schists. This zone was tested and a 50-ft. shaft sunk at a site 50yds. inland, but was abandoned when tidal water was cut. The same zone has been tested by means of shallow shafts and trenches in sections 13M, 14D, 14B, 14E and 15, hundred of Sleaford, and in section 116^{S}, hundred of Lincoln where graphite shows in the surface laterite.

Graphite gneisses are exposed in a railway cutting in sections 470 and 472, hundred of Lincoln and just east of the railway line in section 82, hundred of Wanilla. A shaft is reported to have been sunk on kaolinized graphite gneisses in the northeastern corner of section 103, hundred of Wanilla.

Graphite shows in gneisses on the dump of One Tree Hill Well.

In the hundred of Louth graphite schists occur in section 308 and extend northwards into the hundred of Koppio, in sections 205, 206, 215 and 216 along the Tod Reservoir inlet channel to sections 33, 34, 35, 37 and also 122, 129, 194, 85, 88 and 178 of the same hundred. Similar deposits have been trenched and subsequently abandoned in section 63, hundred of Stokes, sections 28, 60 and 45, hundred of Yaranyacka, and section 27, hundred of Hutchison. All of these deposits have been examined but superficially in the upper weathered zones only. In all, the flake is fine but the size and grade might reasonably be expected to improve at depth.

Magnesite

References

Review of Mining Operations 19, p. 13, 1914 (General Notes).
Review of Mining Operations 20, pp. 30-33, 1914 (L. K. Ward).
Review of Mining Operations 24, pp. 62-63, 1916 (H. Jones).

The Deposit

Magnesite occurs at a number of separate localities usually in association with graphite, the main deposits being situated in sections 33 and 42, hundred of Stokes and section 178, hundred of Koppio.

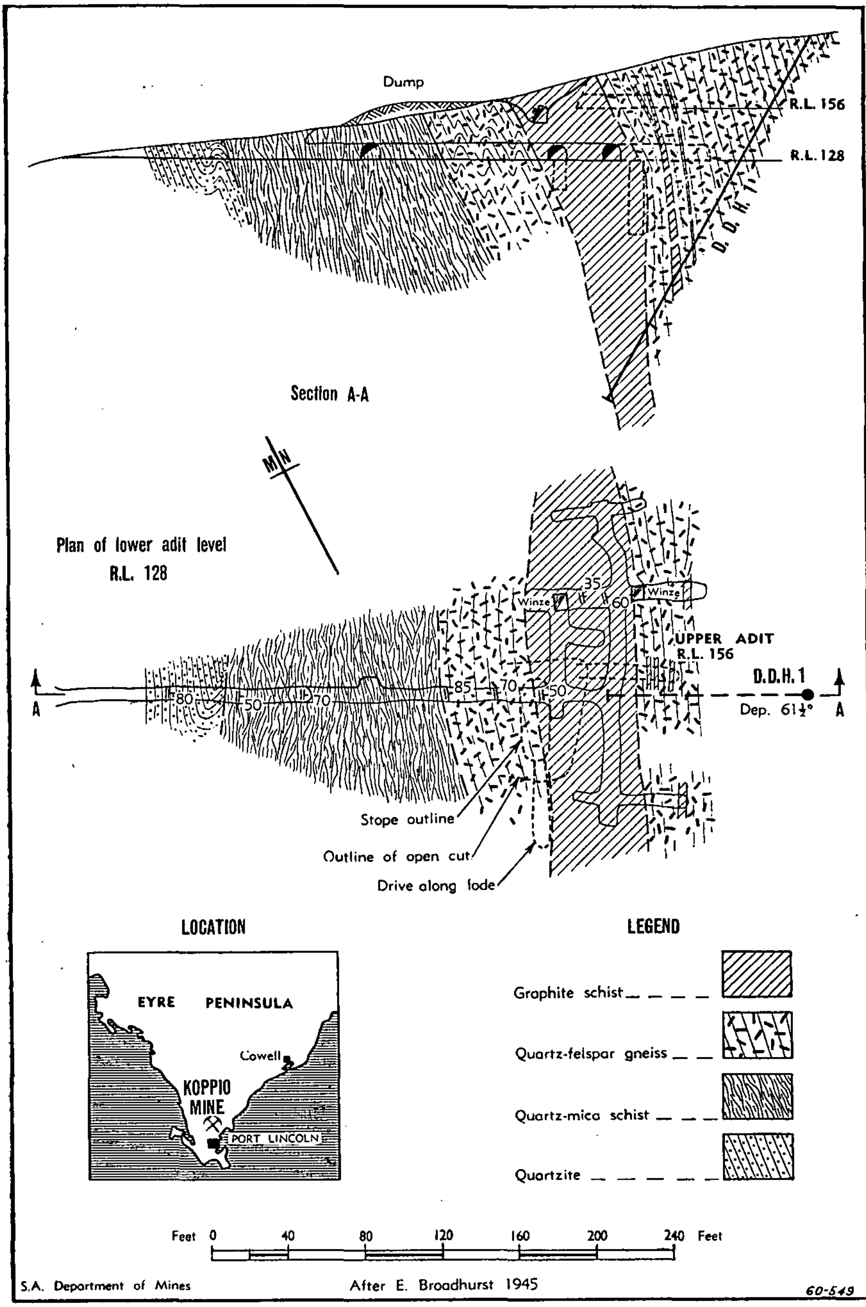


FIG. 63—KOPPIO GRAPHITE MINE

Geological plan and section

High-grade, snow-white, dense, cryptocrystalline magnesite (containing up to 99.50 per cent $MgCO_3$) occurs in narrow, elongate lenses up to 5ft. in width in schistose Hutchison rocks and in association with quartz, hematite and graphite.

Small tonnages have been mined by means of shallow shafts and trenches but they are all of limited size and quite unimportant.

Clays

White Clays

References

Review of Mining Operations 20, p. 34, 1914 (L. K. Ward).

Mining Review 87, pp. 106-107, 1949 (S. B. Dickinson).

The Deposits

White clay derived from the kaolinization of felspathic rocks in sections 6B and 90, hundred of Stokes, have been tested in the laboratory but were found to be unsuitable as fireclays. In each case the reserves appear to be limited.

Kaolinization of gneisses and granitoid rocks of this region is widespread though only in the northernmost parts of the uplands do the resultant clays appear generally white and free of iron staining.

Red Clays

Red clays are utilized as brickmaking materials near Poonindie, 9 miles north of Port Lincoln, by J. Hallett and Son Ltd. where pits have exposed red alluvial clays to a depth of about 20ft. Thin gravel lenses occur and have been exposed in several faces of the pit. Two downdraft kilns are in operation.

Asbestos

Weak asbestos mineralization is associated with serpentinization of dolomite in the gorge of Waterfall Creek west of Tumby Bay. A short adit has been driven on a prominent system of fractures carrying asbestos fibre less than 1in. long.

Whiting

References

Mining Review 30, pp. 40-45, 1919 (R. L. Jack).
Geol. Survey S. Aust. Bull. 13, pp. 44-50, 1928 (R. L. Jack).

The Deposits

A whiting deposit is situated near Wanna, 20 miles by road south of Port Lincoln.

The whiting occurs in the bed of a dry lagoon and has been exposed in a number of shallow pits to a depth of 3ft. in places. About 20,000 tons of various grades of material are reported to occur and though the first-grade material was of good white colour and in a finely divided state there has been no production since 1919 when 70 tons were taken. The whiting yielded the following on partial analysis:

	Per cent
$CaCO_3$	83.64
$MgCO_3$	8.00
Insolubles	1.18
Moisture (over 100°C.)	4.19

Lower-grade "whiting" also occurs in the bed of Lake Pillie which is situated about 5 miles north of Wanna. It is discoloured (cream to grey) and is rich in the remains of *coxiella* sp. On partial analysis this material showed:

	Per cent
$CaCO_3$	65.26
$MgCO_3$	26.08
Insolubles	3.92
Moisture (over 100°C.)	2.57

Limestone

Calcareous aeolianite deposits which flank the southern and western coasts are potential sources of lime and are utilized at the present time to a small degree.

Kunkar, which occurs as a surface layer over the loosely coherent limestone sand and also as derived boulders, is gathered locally and burned in an intermittent flare kiln by Miller's Lime Ltd. near Port Lincoln.

A large quantity of limestone is reported to have been quarried along the shore of Proper Bay and shipped away for flux. (*Review of Mining Operations* 11, p. 24, 1910, General Notes.)

They have far greater potential value however because of their high grade, ready availability, large reserves, and ease of mining. Samples taken from near Sleaford Bay, adjacent to outcropping pre-Pleistocene rocks, show a higher silica content than those more remotely situated. The mobile sand dunes of the Coffin Bay vicinity have sufficiently high calcium carbonate content to be suitable for the steel, lime, and cement industries. Representative samples taken from these deposits show uniformity of grade, composition, and grain size.

Partial analyses of several samples of representative materials are shown in the following table:

Sample No.	$CaCO_3$	$MgCO_3$	Al_2O_3	Fe_2O_3	SiO_2	SO_3	P_2O_5	NaCl
1 ..	95.2	2.2	0.37	0.26	1.05	0.15	0.10	0.01
2 ..	91.5	5.7	0.28	0.18	0.76	0.38	0.10	Nil
3 ..	93.0	4.0	0.27	0.19	0.60	0.30	0.09	0.02
4 ..	84.0	3.6	1.80	0.76	6.45	0.29	0.06	0.15

Sample No. 1—The Fountain; block 1, hundred of Wanilla.

Sample No. 2—Coffin Bay dune sand, section F, hundred of Lake Wangary.

Sample No. 3—Uley-Wanilla Basin; section 6, hundred of Uley.

Sample No. 4—Sleaford Bay; section 1, hundred of Flinders.

Beryl

The occurrence of beryl on the eastern coast of Coffins Bay, section 157, hundred of Warrow, about 1½ miles south of the Frenchman is of academic interest only. Beryl occurs in pale-green idiomorphs up to 1½in. long and $^3/_{16}$in. in diameter, in pegmatites with quartz, felspar, tourmaline and muscovite which intrude granite gneisses near the gneiss-quartzite contact.

Beach Sands

References

Mining Review 26, p. 52, 1917 (R. L. Jack).

Mining Review 92, p. 11, 1952 (General Notes).

Mining Review 92, pp. 164-166, 1952 (L. L. Mansfield).

The Deposits

Heavy mineral concentrations have been noted in a number of bays along the southern and eastern coastline of the peninsula though none of those seen were sufficiently extensive to justify further investigation.

At Sleaford Bay garnetiferous sands are concentrated in a crescentic embayment adjacent to section 14E, hundred of Sleaford, over a distance of about 300ft. and to a depth of less than 2ft. at the foot of low cliffs in garnetiferous gneisses. The deposit contains nearly 200 tons of sand of which about 25 per cent is composed of heavy minerals (Mansfield, 1952). The heavy fraction of the sand in various samples is composed of the following:

	Per cent
Garnet	49-57
Iron ores	21-36
Diopside	1½-12½
Spinel	1-4½
Hypersthene	½-5
Hornblende	1-8

About ½ mile to the east in section 15, hundred of Sleaford adjacent to a wrecked ketch, similar sand occurs on the beach and also in small dunes. The deposit on the beach was estimated to contain over 200 tons of heavy mineral sand while the dunes contain over 140 tons.

Black sands collected from near Curta Rocks contain 73 per cent of iron ores but rutile, zircon and monazite are absent.

Samples of black heavy sand taken from Porter Bay, section 110, hundred of Lincoln, showed 46 per cent hematite, 35 per cent ilmenite, 5 per cent garnet, 5 per cent zircon, 2 per cent rutile and 1 per cent monazite. Another sample taken from near Murray Point had a similar mineral content with spinel, corundum, hornblende, magnetite, tourmaline, diopside, andalusite and staurolite also present in the heavy fraction.

Sand taken from the beach in Boston Bay, 3 miles north of Port Lincoln contained 32 per cent of ilmenite; zircon, rutile and monazite were absent.

Black sands collected from the shore near Arno Bay are composed of hematite principally with subordinate ilmenite, monazite, and traces of zircon and rutile.

The heavy-mineral constituents of these sands are generally angular and of medium-size grain. The sands are strikingly dissimilar to those of the eastern Australian coast, where the garnet content is only about 0.7 per cent, monazite about 1 per cent, zircon 70 per cent and rutile up to 33 per cent.

Phosphate Deposits

References

Record of the Mines of S. Aust. (4th Ed.), p. 343, 1908.

Geol. Survey S. Aust. Bull. 7, pp. 43-45, 1919 (H. Jones).

Geol. Survey S. Aust. Bull. 7, pp. 45-46, 1919 (F. R. George).

The Deposits

On Marum Island in the Sir Joseph Banks Group, guano formerly occurred with soil and sand up to 3ft. in thickness over much of the island. It was reported that 7,000 tons of guano were available containing from 6.4 per cent to 46.8 per cent tricalcic phosphate. When inspected in 1909 about 80 tons (containing 30 per cent tricalcic phosphate) had been marketed and further quantities were being mined from trenches. Guano also occurred in two caves on the island.

Guano has also been mined from soft deposits up to 10ft. in thickness from Bickers Islets. The main workings were situated on the southeastern end of the northern islet. Samples taken showed a tricalcic phosphate content ranging between 2.6 per cent and 64.2 per cent. Recorded production amounts to 260 tons.

A report of 1902 describes a small deposit of fossil bones and bone breccia at the site of an old eroded cave in aeolianite on the western end of the larger of the Brothers Islands situated in Coffins Bay, 2½ miles west from the southwestern extremity of Horse Peninsula. The fragmentary animal and bird bones had consolidated into calcareous breccia while the adjacent limestone rock is phosphatic. The guano mixed with sand was removed for use as a manure which contained up to 68.3 per cent tricalcic phosphate.

Building Stones

Kunkar limestone finds widespread use on southern Eyre Peninsula as a building stone and rough dressed stone from this source would constitute the walls of most of the houses, public buildings and farm outbuildings in the region.

Some fine- to medium-grained granitoid rocks of the Flinders Group constitute potential sources of monumental stone though they have not been utilized.

Road-Building Materials, Aggregate, and Ballast.

Laterite and kunkar constitute the most readily available and most widely used roadmaking materials and have proved very satisfactory for the construction of secondary roads.

Nodular lateritic gravels require little more than occasional grading to maintain a smooth road surface. The use of kunkar as a road making material and its adaption by "brattenization" was first developed on Eyre Peninsula. The Bratten process involves laying a foundation of coarse blocky limestone which is succeeded by a finer material and this is "sealed" with fine rubble. Such roads however corrugate and develop pot-holes with heavy use, particularly in wet weather.

Aggregate used in bitumen road construction is generally derived from granitoid rocks in the locality. A number of surveys and some diamond drilling have been undertaken over a number of deposits of quartzite, chert, hornblendite and granite gneiss situated between Port Lincoln and Tumby Bay to test their suitability and availability for this purpose.

The supply of railway ballast constitutes no problem because of the ready availability of suitable rock throughout most of the uplands. A quartz reef situated about 6 miles north of Port Lincoln has been quarried, crushed and screened to furnish concrete aggregate.

Lignite

Soft black and grey lignites are reported (Woodward, unpublished report) to occur with earthy limestones under a thin cover of sand on the north shore of Coffins Bay Peninsula, a few miles west of Port Longnose. The lignitic matter constitutes less than 2in. of a 40ft. section. A proximate analysis is as below:

	Per cent
Water	1.75
Bituminous matter	25.57
Fixed carbon	48.55
Ash	24.00

Further analyses show water 64.34 per cent, ash 19.95 per cent, and combustible matter 15.71 per cent, while another, water at 212°C. = 9.77 per cent, ash 50.47 per cent and fixed carbon 6.71 per cent. The present leaseholder of Coffins Bay Peninsula states that he has seen specimens of lignite which were reputed to have been taken from this locality, but has been unsuccessful himself in locating the material. He is unaware of any occurrences elsewhere on the coast or in wells inland. The occurrences because of their low grade, remote location and limited size have no economic value.

Early Tertiary lignites and lignitic clays have been intersected in at least 12 bores in the Central Basin. In the deep bore near Cummins township five lignitic horizons were intersected, two of the seams being of insignificant thickness and the main seam being 14ft. thick.

The lignitic character of the strata is inconsistent and they are absent over much of the basin area explored by drilling for water supplies. No samples were taken for analysis. Further drilling in basin areas not already tested and the sampling of the known lignitic areas seems justified.

Uranium Prospects

The most promising discovery of radioactive deposits on the peninsula was made near Port Lincoln township by a local resident, Mr. P. J. Gibson in March, 1954. These occurrences, the first reported in the district, are similar in type with the ore mineral, pitchblende, occurring in sodic hornblende granitoid gneiss in a relatively narrow zone within Flinders metasediments. Secondary uranium minerals, uranophane and gummite, also occur as minute disseminations. The largest of these deposits is known as the Hospital Prospect and was tested by

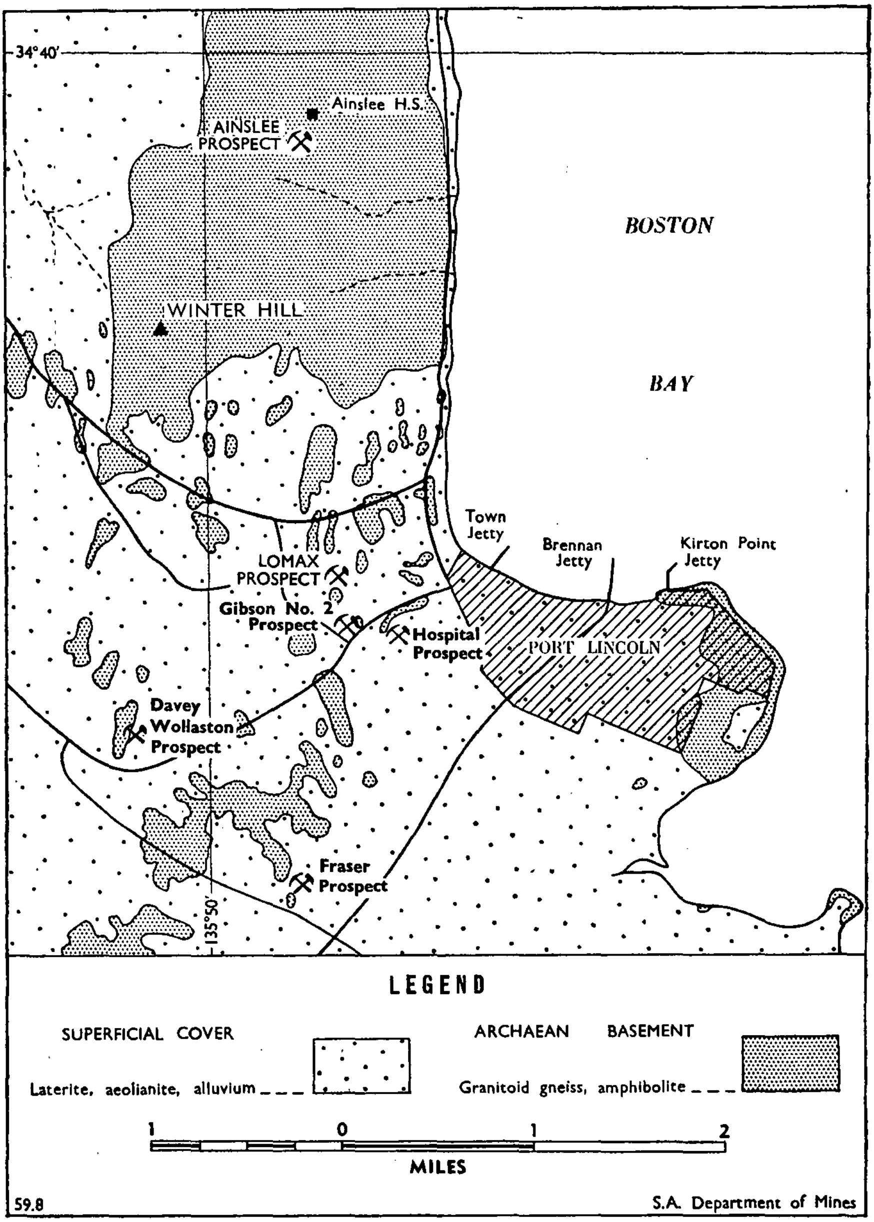


FIG. 64—PORT LINCOLN URANIUM PROSPECTS
Locality plan

diamond-drilling, and qualified for a Government discovery reward. Other discoveries include Hargistrom (Gibson No. 2 prospect) and Ainslee North and Ainslee South (Gibson No. 3 prospect); Ainslee South was subsequently tested by drilling.

In July 1954 Mr. G. Lomax made a further discovery in this region and this was followed by those of Frazer and Davey-Wollaston to make six separate sources of radioactivity, all within a distance of 3 miles of Port Lincoln township (fig. 64).

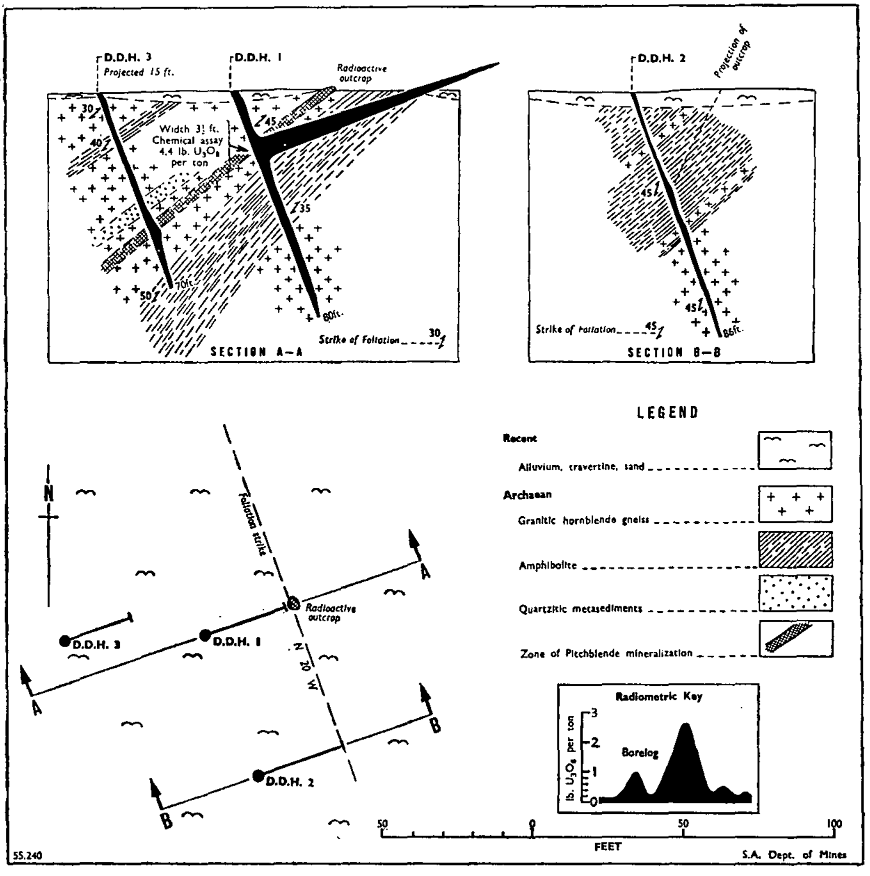


FIG. 65—LOMAX URANIUM PROSPECT

Geological plan and sections

Hospital Prospect

Location.—Section 348 (Government Reserve), hundred of Lincoln, county Flinders; at rear of Port Lincoln Hospital.

Reference

Mining Review 101, pp. 32-41, 1956 (D. King and W. Woodmansee).

The Deposit

Abnormal radioactivity is found at the surface in a number of small isolated exposures of hornblende granitoid gneiss which is part of a sequence of metasedimentary gneisses and amphibolite.

Uranium mineralization has been identified as pitchblende grains thinly disseminated throughout the steeply dipping concordant body of gneiss and as secondary minerals, uranophane and gummite, coating fractures and planes of foliation.

Diamond Drilling

Seven boreholes were completed comprising 866ft. of drilling, and these showed that the orebody persisted to a depth of 50ft. A total of 5,700 tons of uranium ore, averaging 2 to 3 lb. U_3O_8 per ton has been established.

Lomax Prospect

Location.—Town block 91, section 358, hundred of Lincoln, county Flinders.

Reference

Mining Review 103, pp. 24-25, 1957 (R. K. Johns).

The Deposit

A small exposure of granitic gneiss which is part of a sequence of partially altered metasediments, quartzite and amphibolite, shows abnormal radioactivity at the surface. Mineralization is similar in all respects to that noted at other nearby localities.

Diamond Drilling

Three diamond-drill holes sited to test the deposit below the outcrop and also laterally, confirmed the limited extensions of surface outcrop as a concordant mineralized tabular body.

The deposit contains a maximum of 400 tons of ore; only one intersection showed ore-grade material (4.4 lb./ton U_3O_8). Figure 65 shows a geological plan and cross-section along the boreholes.

Ainslee South Prospect

Location.—Section 33, hundred of Lincoln, county Flinders; 3 miles north of Port Lincoln.

Reference

Mining Review 103, pp. 25-26, 1957 (W. Woodmansee).

The Deposit

A small radioactive area in an outcrop of brecciated granitoid gneiss was found to contain small amounts of disseminated uraninite which yielded spot assays ranging from 4 lb. to 15 lb. U_3O_8/ton.

Diamond Drilling

Two shallow diamond-drill holes showed that the uranium mineralization is weak and spotty, being localized in small discontinuous centres, none of which would constitute an orebody. The centres of moderate to high radioactivity at the surface are the result of local concentration of secondary uranium minerals.

Figure 66 shows the location of drill sites and distribution of radioactivity along the boreholes in cross-sections.

Other Deposits

Reference

Mining Review 101, pp. 72-78, 1956 (Seedsman and Harris).

Prospecting

An airborne scintillometer survey of eastern Eyre Peninsula was commenced on 2nd December, 1953, and completed on 21st July, 1954. Those of the 42 major anomalies and 1,300 minor anomalies revealed, which were subsequently investigated on the ground were found to be caused by the mass effect of widespread, low-grade sources of radioactivity.

Reference to the map (*Mining Review* 101, p. 73) shows that the Gibson and other prospects at Port Lincoln were unrecorded.

Anomalous radioactivity detected in the Marble Range is attributed to thorium.

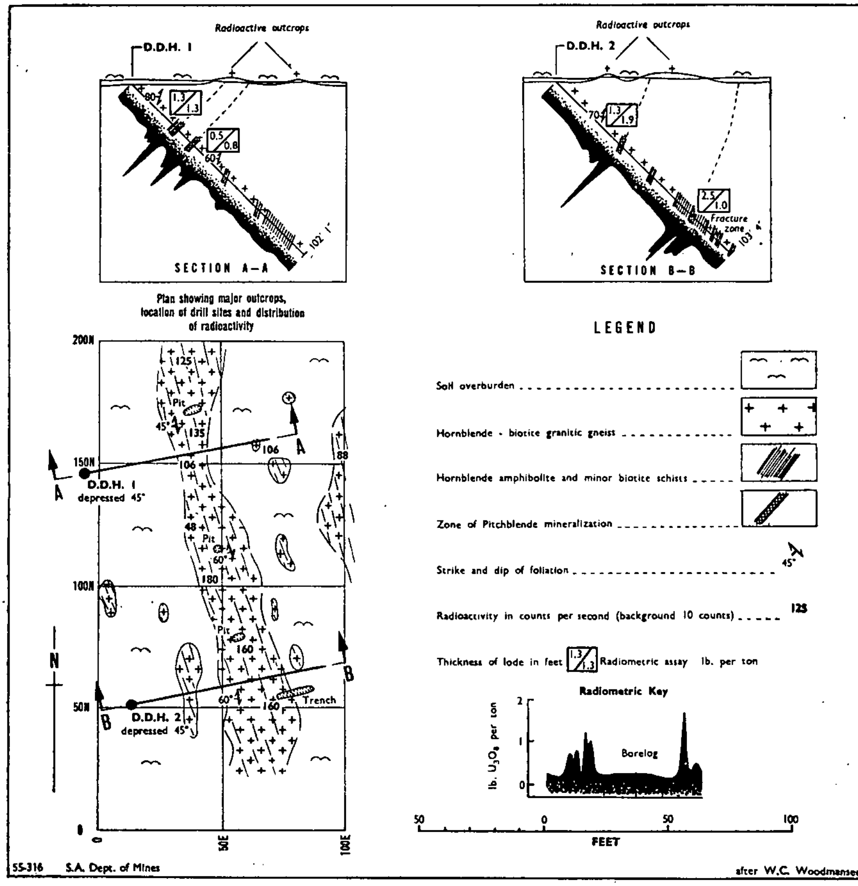


FIG. 66—AINSLEE SOUTH URANIUM PROSPECT

Geological plan and sections

WATER SUPPLIES

Surface

Conservation of surface water supplies by the construction of dams and reservoirs has been undertaken by Government authorities on a number of the larger drainage channels in the region. These waters are reticulated to many areas in which underground sources are unsuitable because of high salinity and/or poverty of supply. In these and in other areas landholders rely on dams for stock water supplies where suitable catchments exist.

As elsewhere in low-rainfall areas, all houses, sheds, etc., are equipped to catch and store in tanks rainfall runoff from rooftops. At one locality on the Cowell-Kimba road (Glynn sheet) Government sheds have been constructed for this purpose.

In the Lincoln Uplands the Tod Reservoir with a total storage capacity of 2,495,000 gallons was constructed by the Engineering and Water Supply Department. The dam is an earth-fill structure and was constructed on Toolillie Creek near its junction with the River Tod. The water covers an area of about 250 acres when the reservoir is full. Water enters the reservoir by a system of weirs and concreted channels which tap the surface flow of the Tod River, Pillaworta Creek and their tributaries. The Tod Reservoir is connected to Knott Hill Reservoir and a network of mains which constitute the Tod River scheme. The salinity of the reservoir water ranges from 40 to over 200 grains per gallon, depending on the seasonal intake from an unreliable rainfall over the catchment area.

Closer settlement of the southern parts of Eyre Peninsula and inadequacy of the reservoir to cope with the increased demand for water have led to the development of the Uley-Wanilla groundwater basin. This source is now coupled to that of the Tod and serves an area which extends to the north and connects with the Cleve and Cowell systems.

In the Cleve Uplands the Engineering and Water Supply Department has constructed vertical concrete walls to dam back the waters of Ulbana Creek (Minbrie Reservoir) and those of the Ullabidinie and the Yeldulknie Creeks and these are reticulated through a system of mains. Minbrie and Ullabidinie Reservoirs are located on the eastern scarp near Cowell and Yeldulknie on the southern flanks of the uplands east of Cleve.

A number of dams have been constructed by the Government on stock routes—these include the following: Eranie, Yalanda, Carroo Curtie, Heggarton, Carpie Puntha, Coolanie, Malgra, Bosanquet, Monument, Caralue Bluff, Lucroma, Poolgarra, Broombush and Wharminda.

Railway dams have been excavated at a number of localities adjacent to the railway lines for boiler use.

Underground

General

Underground water has played, and will continue to play, an important role in the settlement of Eyre Peninsula owing to the general low rainfall over large areas and the lack of suitable dam sites to impound surface waters in others. Much of the work of Jack (op. cit.) in the region was connected with a survey of the underground-water potential prior to railway construction and closer settlement. Others have been concerned with various projects, principally Segnit (1939) with the Uley-Wanilla Basin and Barnes (1950) with the Wanilla soldier settlement programme. The writer has collated the available data and located most of the underground-water points throughout the region. From this study a number of facts on the availability of useful underground-waters has become evident.

The area embraced by county Flinders has been studied in detail while the region extending to the north (parts of counties Jervois, Musgrave, York and Buxton) is less well known because of the lack of subsurface data and this may be due in part to the unavailability of suitable stock waters proved by earlier settlers, though large areas are still untested. Figure 67 shows the availability of underground waters on southern Eyre Peninsula.

Cleve Uplands

Landholders rely to only a small degree on underground supplies in this region and stock supplies are drawn principally from dams. The depths of bores and wells indicated on a plan prepared by L. K. Ward (1939, unpublished) ranged between 20 and 400ft. with an average depth of about 100ft. Salinities of water here are extremely variable and range from good stockwaters to saline. Supplies range from 100 to 3,000 gallons per day.

Generally the basement rocks are not favourable for the storage and supply of large supplies of water. Gneisses and granitoid rocks are mostly massive and not strongly jointed, mica schists appear to be almost impermeable and all quartzites completely recrystallized and lacking in pore spaces. Conditions are so variable that a specific geological inspection would appear to be warranted in every case prior to boring for underground supplies.

Most of the large drainage channels have saline courses and carry brackish or highly saline waters except after heavy rains, and the subsurface water adjacent to these channels is expected to reflect a like salinity.

Lincoln Uplands

Many of the creeks in the ranges to the north of Port Lincoln are fed by springs along their courses, and wells sunk in the shallow valley alluvium generally yield only small supplies of stock water. The springs yield surface supplies of water in some creeks for most of the year, and the creek underflow maintains water in discontinuous pools which only become dry after prolonged dry seasons.

Well and bore sites are generally confined in this belt to valley alluvium where bedrocks are obscured by sands, clays and gravels. Remarks applying to bedrock impermeability in the Cleve Uplands apply equally here, though in this region the higher rainfall and paucity of bedrock outcrop ensures more thorough "flushing" of the aquifers and better recharge so that most waters here are suitable for stock and yield generally better supplies.

Drilling for the Wanilla soldier settlement programme in 1949-50 proved a great thickness of alluvium in some channels. Here 35 bores were drilled in the elevated belt and, of these, 28 encountered bedrock. Water suitable for stock was cut in 30, and of these 11 yielded supplies of less than 30 gallons per hour.

Sites located high up in gullies proved to yield better quality water than those downstream and farther removed from their source of supply though a greater supply was generally assured at the lower sites. Variations in the salinity and supply from place to place are great and unpredictable.

On the depressed belt which lies between the Cleve Uplands and Lincoln Uplands the depths of existing bores and wells ranges between 50 and 135ft. with salinities ranging from 600 to 1,750 grains per gallon and most commonly 1,000-1,400 grains per gallon. Proven supplies in this region range from 1,000 to 10,000 gallons per day. The poor quality of the underground-waters in this area is a reflection of the poor surface drainage on a base-levelled terrain where bedrock is obscured by a thin mantle of clay and sand.

Eastern Coastal Plains

On the eastern coastal plains, bedrock, consisting principally of granitoid gneiss, forms a fairly even impervious platform. The overlying sediments are thin and consist principally of clays and sandy clays with some gravels. Groundwater occurs at shallow depth on this plain and it is of variable quality.

In those areas where bedrock outcrops or is covered by only a very thin mantle the groundwaters are mostly salinè—these conditions exist in the Port Neill-Tumby Bay-Louth Bay localities though shallow wells on the flanks of sand dunes adjacent to the coast tap a "cream" of rather better-quality water.

Near the fault scarp and along outwash fans between North Shields and Tumby Bay water cut in gravels is generally suitable for stock. Shallow wells have been sunk along the banks of the River Tod and many in the Tumby Bay vicinity where sands and gravels are the aquifers to good stock supplies. In the Tumby Bay vicinity the aquifers are recharged by the waters of Coonta Creek which empties hereabouts on to the coastal plain; south and east of this limited area where bedrock outcrops or has only a thin clay or kunkar cover the waters held in depressions are saline (see fig. 67).

North of Port Neill to Cowell and beyond, the underground-water conditions pertaining are unknown, but are suspected to be poor. Bedrocks outcrop at Point Gibbon and were encountered in a bore sunk in Cowell township at 109ft. so

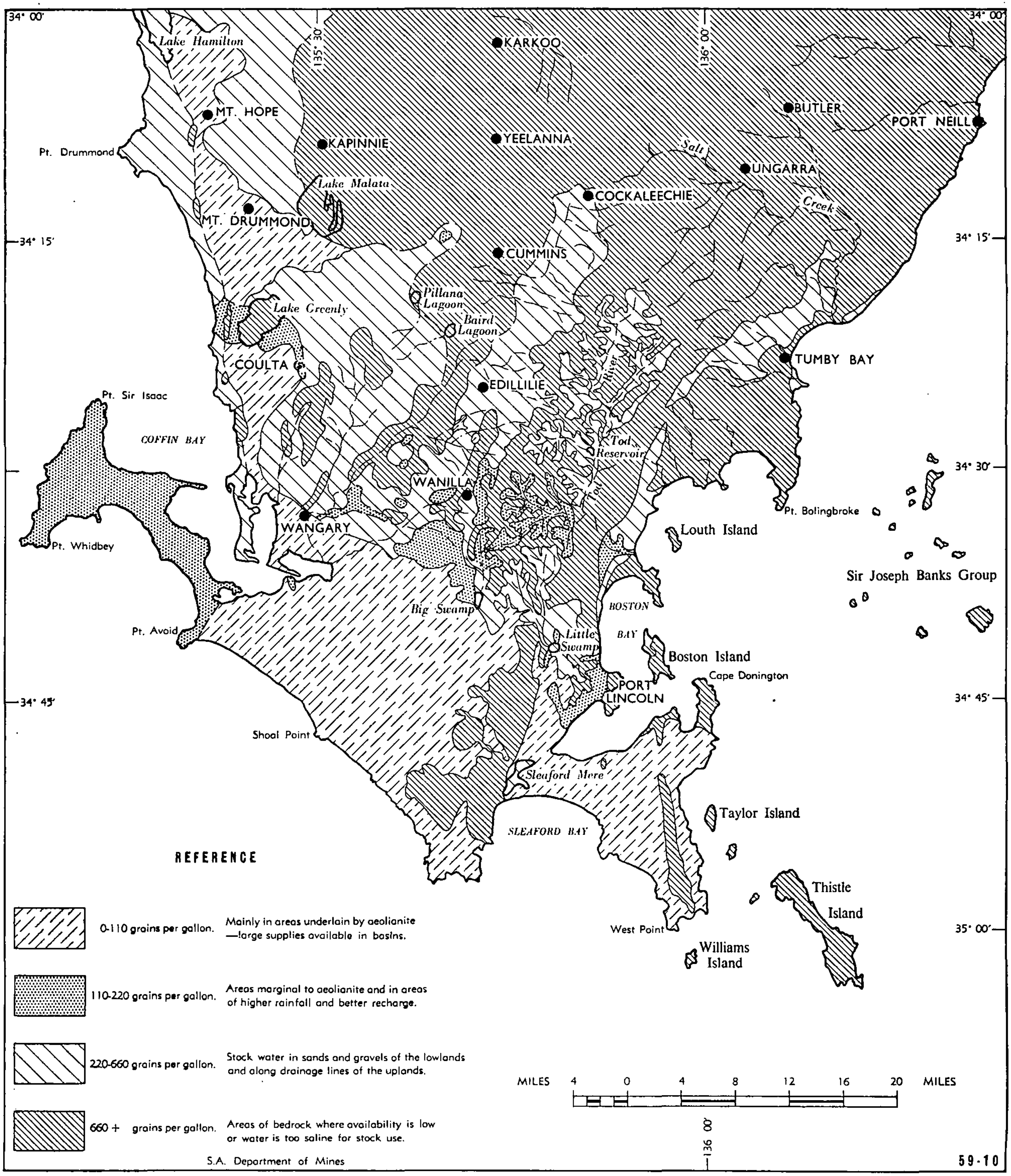


FIG. 67—PLAN SHOWING AVAILABILITY OF UNDERGROUND WATER

Southern Eyre Peninsula

To face page 84]

that the superficial cover would appear to be at least 150ft. near the fault scarp. The lack of information here suggests that early boring attempts were fruitless. Water penetrated in the Cowell bore rose to 17ft. and was saline.

Central Basin

Under a rehabilitation scheme for the settlement of ex-servicemen in parts of the hundreds of Wanilla and Mortlock, the Department of Mines in 1949-50, undertook drilling on behalf of the Lands Development Executive to supply a "house" and a "paddock" bore on each property. Of a total of 73 bores drilled in the Central Basin, 41 cut water suitable for stock and of these 37 yielded what was considered an adequate stock supply of more than 30 gallons/hour. Water too saline for stock use was penetrated in 23 bores, while 9 bores were abandoned as dry.

The waters generally rise in the boreholes when the aquifers are penetrated. In some bores, as many as five aquifers were cut, the salinities of the various waters ranging between 15 and 1,500 grains/gallon. The salinity and supply vary greatly from borehole to borehole and are quite unpredictable on surface indications (see fig. 67).

Impervious gneiss forms an undulatory and irregular floor to this basin and outcrops at a number of places. The aquifers are thin sand or gravel lenses which are separated by clays, lignitic clays and sands, all of Eocene age. The porous water-bearing lenses are discontinuous and separated and it was found impossible on the data available to satisfactorily correlate the various beds in adjacent bores.

In the northern part of the soldier settlement area and northwards towards Cummins township, groundwaters are generally saline and few farms depend on this source for supplies. Several wells have been sunk along the course of Peelina Creek and yield good stock water while several bores sunk in Cummins township for drainage purposes encountered saline water. Towards Yeelanna township and beyond, there are little data available but it is considered that in this direction poor underground waters would result as a consequence of lower rainfall, less well-defined drainage and poorer intake.

South of Wanilla and west of Port Lincoln township where the Central Basin merges with the Lincoln Uplands, shallow wells (10 to 40ft. deep) yield small supplies of stock water and many farms are here dependent on these for supplies.

Drilling at Wanilla proved that bedrock ridges are to be avoided when drilling as the outcropping and hidden basement proved to be impermeable except in several cases where there was a considerable thickness of weathered and porous rock.

Major creek channels and swamps in the lower reaches, proved to overlie saline waters. In cases where saline water was cut at a shallow depth it was found that the deeper-seated waters proved also saline.

Some aquifers were found to be difficult to develop because of the fine nature of the sand and these necessitated the fitting of sand screens.

Areas Covered by Aeolianite

Generally no difficulty is experienced in obtaining supplies of good-quality non-pressure underground water in areas underlain by aeolian sands. In these areas there is generally no surface drainage and rainwater percolates freely downwards to the water-table through porous, unconsolidated, calcareous sands. These conditions obtain over large tracts flanking the southern and western coastline in the hundreds of Flinders, Sleaford, Lincoln, Uley, Wanilla, Lake Wangary, Warrow and Ulipa. Here the thickness of water-bearing sands is variable from a few feet to over 200ft. and the depth to water, depending on surface elevation, ranges from surface to about 50ft. in the "basin" areas and somewhat deeper along the high-cliffed coasts.

Wells sunk in aeolianite in most cases require to be timbered throughout and bores need to be cased to prevent caving because the material is seldom consolidated sufficiently to stand open.

The salinity of aeolianite waters shows variations ranging from 15 to 200 grains per gallon, but it is generally less than 100 grains per gallon.

Because of their present and potential importance the Uley-Wanilla and the Lincoln groundwater basins are discussed below in more detail. Both basins are confined on three sides by outcropping or submerged bedrock ridges and in part represent concealed drainage channels fed by quite large catchment areas.

Uley-Wanilla Groundwater Basin

The basin, situated about 10 miles west of Port Lincoln, has been described in several reports by R. W. Segnit (1939, unpublished). The Department of Mines carried out test drilling over the most promising areas, to define the northern, eastern and western limits of the basin. Subsequently a number of permanent bores were drilled and these connected to the mains which allowed a connection to be made with the Tod scheme and considerable extensions thereto.

The Engineering and Water Supply Department has undertaken the selection of bore sites and determined surface levels and water-table levels in certain bores at regular intervals. Information on bench-mark levels, water-tables, and analyses were freely made available to the writer.

Geology: The aquifer of the basin is a loosely coherent cross-bedded, calcareous sand that was deposited during the Pleistocene period by wind over an uneven impervious floor of lateritic clays on granitic gneiss. The maximum thickness of aeolianite encountered during boring was 100 feet.

The basin is confined on the eastern and western sides by buried bedrock ridges and, except for several constrictions due to basement "highs", is open southwards to the Southern Ocean.

Lenticular clayey bands were penetrated in several places and appear to be discontinuous.

The ground surface is gently undulating and falls in elevation steadily towards the south. Elongate and irregular fixed dunes give rise to prominent features in some places.

Hydrology: Big Swamp, in the north-east corner of hundred of Uley, acts as a collecting basin for most of the surface runoff of an area of 5,400 acres north of the basin proper and replenishes the Basin water supply to a large degree.

Surface drainage is absent over the Basin—the whole of the rainfall being quickly absorbed into the porous sands.

Boring.—Twenty-four wells were in existence prior to testing of the basin in 1939. Subsequently 85 bores were drilled to probe the most suitable area for development and record depth of water-bearing strata and these were kept under observation to note changes of hydraulic surface and salinity. Nine large-diameter permanent bores were pump tested over a prolonged period and the draw down about the cone of influence of each noted in a number of nearby observation bores drilled for that purpose. During the past two years further exploratory drilling has been undertaken in the Fountain Springs locality. Fig. 68 shows the location of private wells, trial bores and permanent bores within the basin.

Reference to fig. 69 showing subsurface bedrock form lines shows the existence of a buried channel extending southerly from Big Swamp and a parallel one (separated by a low saddle) extending southerly from Fountain Springs. The superposition of surface form lines allows ready determination of the thickness of aeolianite and indicates that there is but a thin cover along the margins. The floor of the basin shows a maximum fall of 150ft. over the "proved" area of the basin.

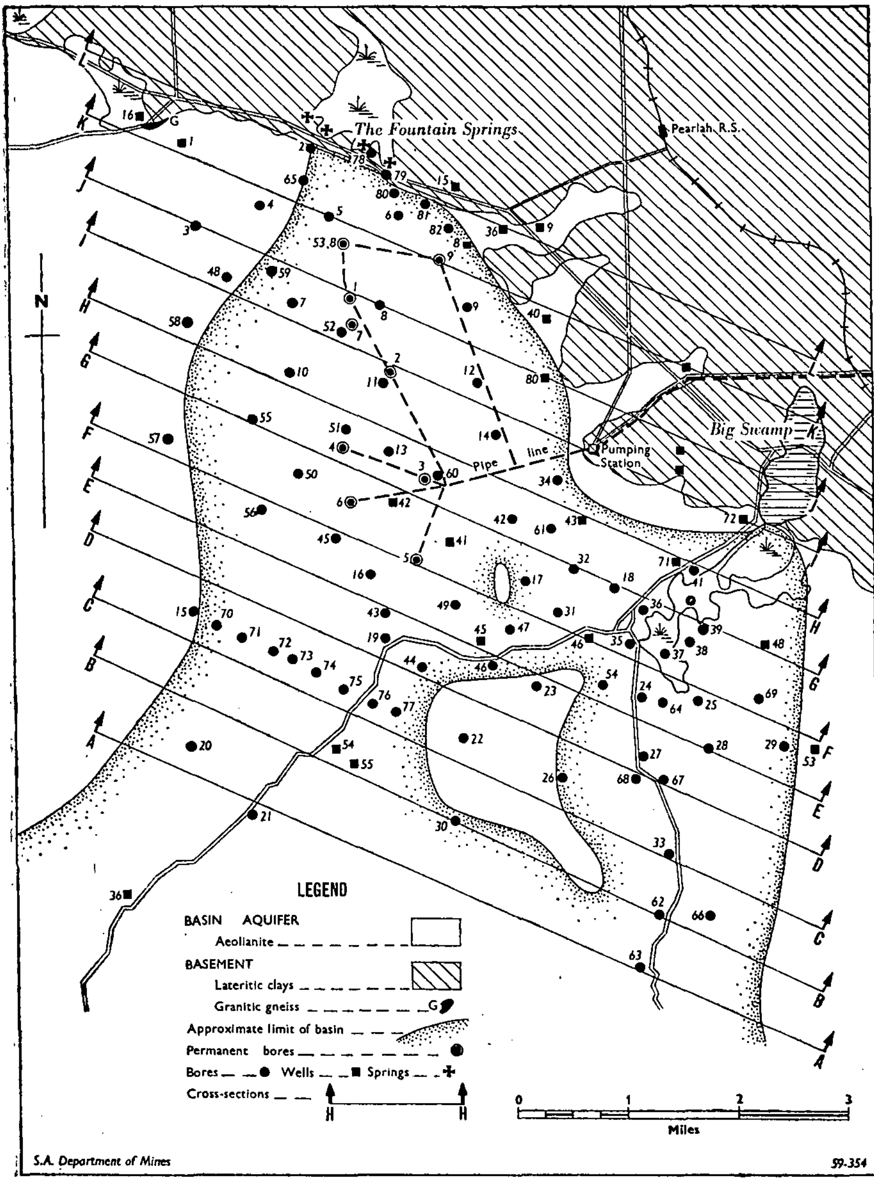


FIG. 68—ULEY-WANILLA BASIN

Geological plan and bore locations

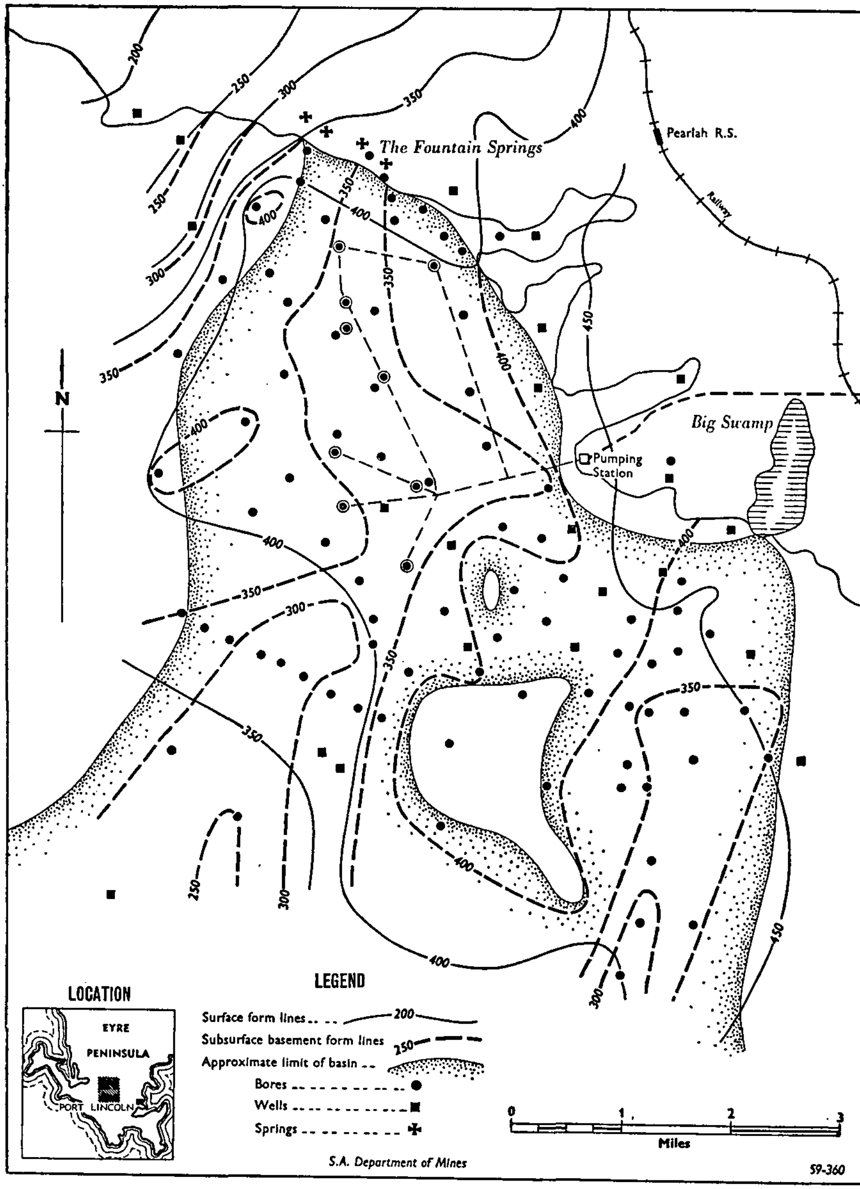


FIG. 69—ULEY-WANILLA BASIN

Surface and subsurface basement form lines

Contours of the Watertable.—Groundwater contours (isopotentials) have been plotted from readings taken regularly at monthly intervals by the Engineering and Water Supply Department since 1940 and from these it can be demonstrated that there has been no variation in the general movement of water though, since readings were first taken, there has been a steady lowering of the water-table.

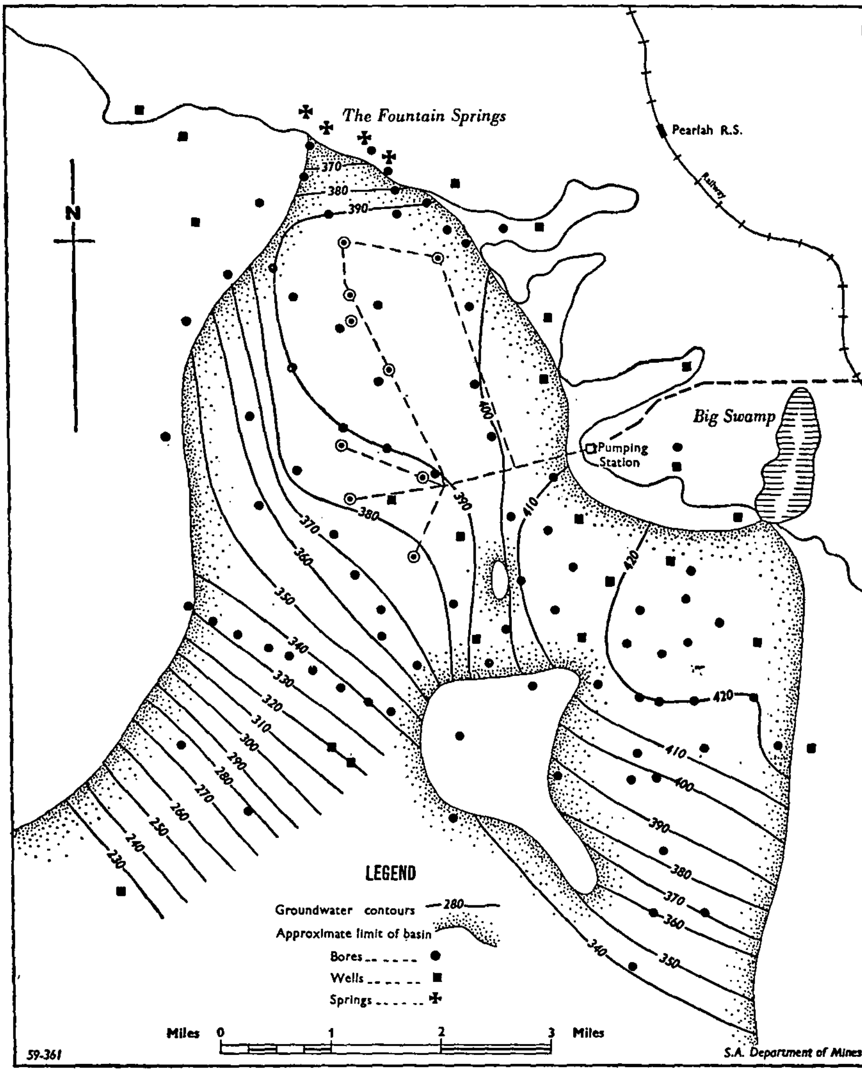


FIG. 70—ULEY-WANILLA BASIN

Plan showing isopotentials

This fall is attributed to the heavy drain-off through the nine bores which discharge into the Uley-Wanilla scheme. These bores were commissioned in 1948 and each now pump at the rate of about 8,000 gallons per hour.

Figure 70 indicates the isopotential surface as at October, 1950, and is typical of the water-table.

Water moving westwards from Big Swamp over the submerged saddle constitutes recharge to the utilized portion of the basin. From a R.L. of 420ft. immediately south of Big Swamp there is a steady fall in the groundwater surface to the west and south which clearly illustrates the general movement of water from the main intake area, towards the Fountain. At the Fountain Springs (fig. 72) the water-table coincides with the ground surface and basin floor at R.L. 370ft. resulting in leakage from the basin in a chain of springs—the "Fountain". Water issuing from here flows northwards into chains of swamps. A V-notch gauge was installed at the springs and though the recorded flow was only a fraction of the leakage the seasonal flow at this gauge ranged between 70 and 140 gallons/minute with an estimated annual flow over the gauge in excess of 51,000,000 gallons. Springs also have been noted at low tide on the Southern Ocean coast near Shoal Point.

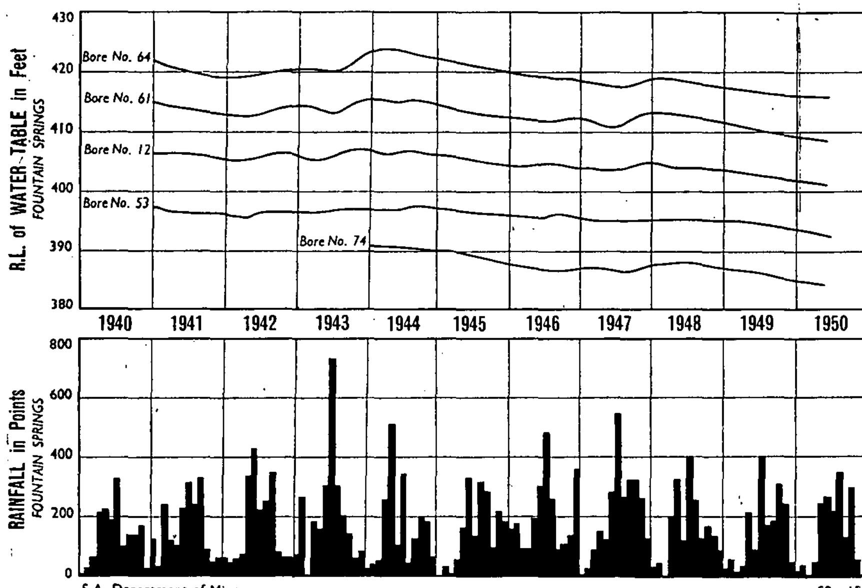


FIG. 71—ULEY-WANILLA BASIN

Seasonal variations of water-table

Segnit (1939, unpublished report) noted that heavy local falls of rain caused a quick response at the Fountain in an increased flow of water over the gauge which is indicative of the porosity of the aquifer.

A graph (fig. 71) has been prepared to show the seasonal variations of the water-table in several bores and the relation to rainfall.

Salinity of the Groundwater.—Over 200 samples of water were taken from test bores and wells and the samples were analyzed. These indicated that high-quality potable waters are present over the entire main-basin area. The saline matter present ranges from 15 to 50 grains per gallon and averages about 25 grains. In the southern part of the basin several bores penetrated poorer-quality water (up to 170 grains) under clays which prevent free movement of the waters and lead to incomplete scouring and thus a concentration of salts.

Water emerging at the Fountain has a fairly constant salt content of 35 grains/gallon—the lowest recorded is 25 grains/gallon and the highest about 45 grains.

FIG. 72—FOUNTAIN SPRINGS

Aeolianite dunes in foreground give way in background to the plains of the Central Basin. Springs extend for a distance of $\frac{1}{4}$ mile each way along the aeolianite boundary from the shed. The "fountain" is located near the large group of trees beyond the road

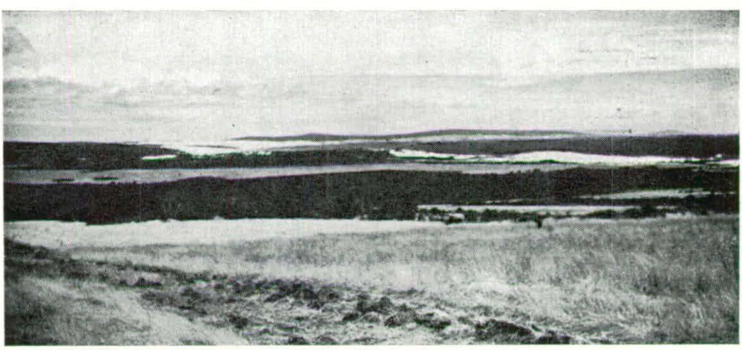


FIG. 73—SLEAFORD MERE

The mere (light-coloured body of water) is separated from the waters of Sleaford Bay by sand dunes. The grassy foreground is underlain by laterite gravels over gneisses

To face page 90]

A typical analysis of Fountain water is quoted below:

	Per cent
Cl	9.7
SO_4	3.4
CO_3	9.4
Ca	4.3
Mg	2.8
$CaCO_3$	12.4
$MgCO_3$	2.9
$MgSO_4$	4.1
$MgCl_2$	4.2
NaCl	10.9

34.5 grains/gallon.

	ppm.
Fluorine	0.9
Dissolved oxygen	8.3
Free CO_2	17.0
pH	7.4

Total hardness: 23.3 deg. English. Due to Ca: 13.1
Due to Mg: 10.2

Permanent hardness: 7.6
Temporary hardness: 15.7

Utilization of the Basin.—Small stock supplies are drawn from the basin while the annual draw-off from the permanent bores is about 500 million gallons. This water is drawn through Pomona pumps and delivered to storage tanks situated near the main pumping station. From here the water is connected by a network of mains to the Tod scheme. Approximately 51 million gallons are estimated to pass over the gauge at the Fountain annually—this is but a proportion of the water leaking from the basin in this vicinity. Consideration has been given by the Engineering and Water Supply Department to the construction of a retaining wall adjacent to the Fountain Springs to curtail this loss and present plans envisage construction of a trench across the main outlet at this point and the pumping of water from this trench into an extension of the surface mains.

Further exploitation of the basin southwards towards the Southern Ocean coast is expected to increase the output considerably.

An attempt has been made by the writer to calculate the average storage capacity of the tested area of the basin. Sections were drawn across the basin at half-mile intervals to aid in the calculation of volume of water held in the aquifer (see figs. 74 and 75).

The volume of water held in the main western part of the basin is estimated to be 11,250,000,000 cub. ft., and in the eastern part (separated by an impervious bedrock ridge) 7,250,000,000 cub. ft. The total volume of water is thus 18,500 million cub ft. A bulk sample of sand taken from a bore sunk in this basin and submitted to a porosity test yielded an absorption of 1.80 gallons of water per cubic foot of sand—the average storage capacity of the basin from Fountain Springs to line of section A-A is thus 30,000 million gallons.

The main sources of intake to the basin would appear to be by way of Big Swamp which is the collecting basin for a catchment of 5,400 acres. The swamp generally holds water and it may be assumed that its floor is impervious. Samples of water taken periodically from the swamp show wide variations in salinity, the northern part of the swamp holding water of higher salinity than the southern part due to incomplete flushing and hence a greater accumulation of salts. The northern area of the swamp attains salinities as high as 450 grains per gallon while the southern section (south of the Flinders Highway) less seldom dries up and generally holds water of salinity 50 to 150 grains per gallon depending on the intake.

The occurrence of such a large body of uniformly high-quality water suggests therefore that there is a large intake from rain falling over the basin itself (areas approximately 2,300 acres) and areas marginal to the basin proper (about 3,700 acres).

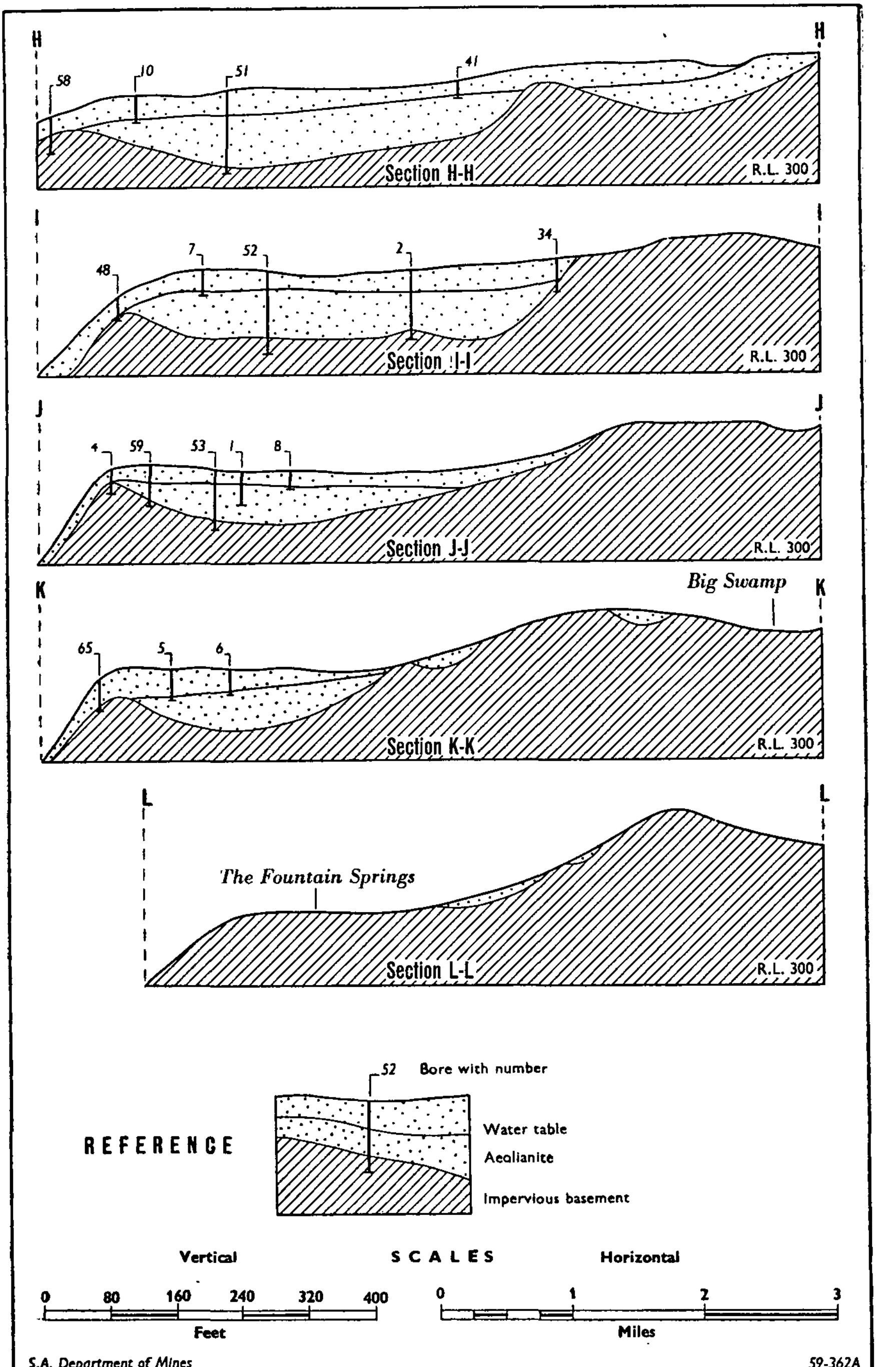


FIG. 74—ULEY-WANILLA BASIN

Geological cross-sections

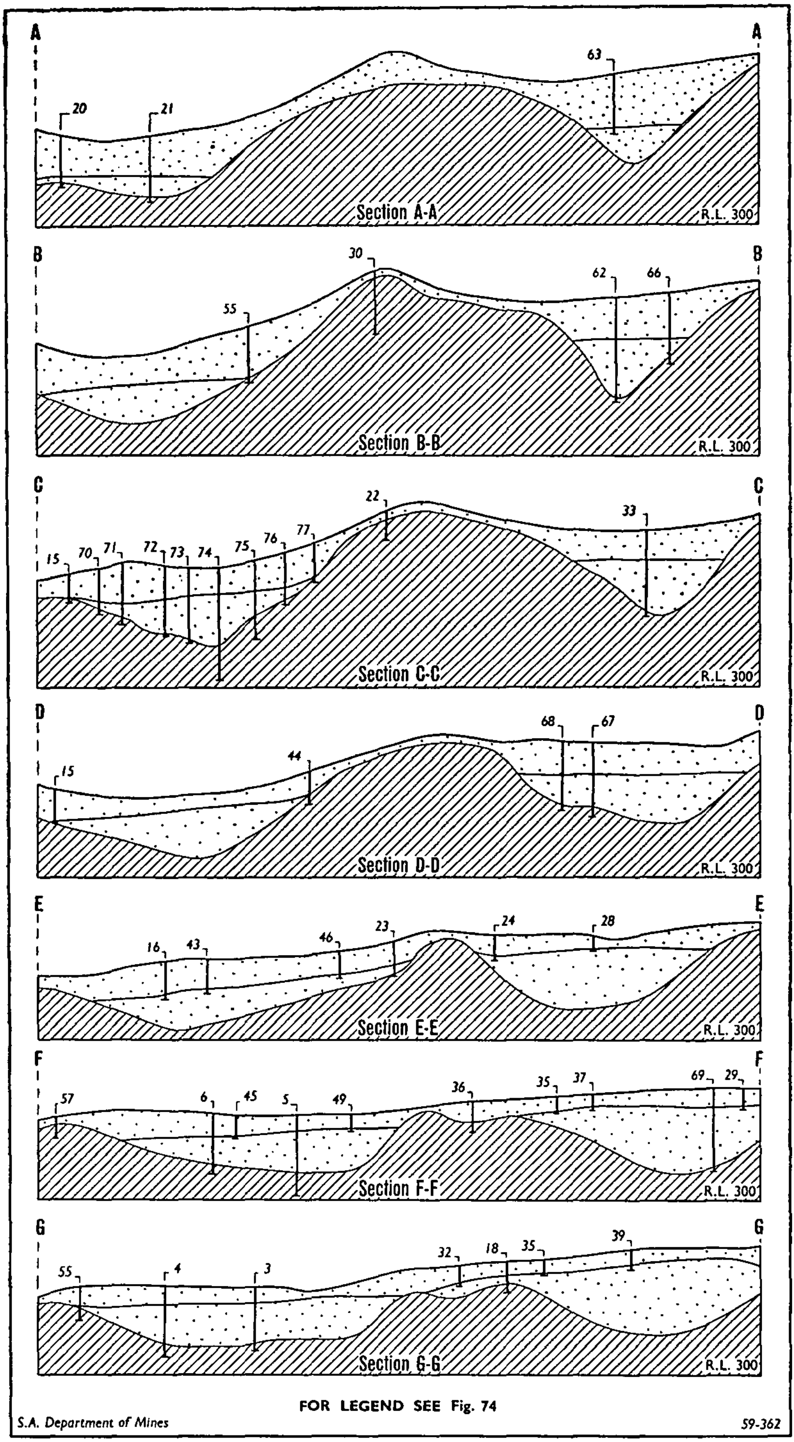


FIG. 75—ULEY-WANILLA BASIN

Geological cross-sections

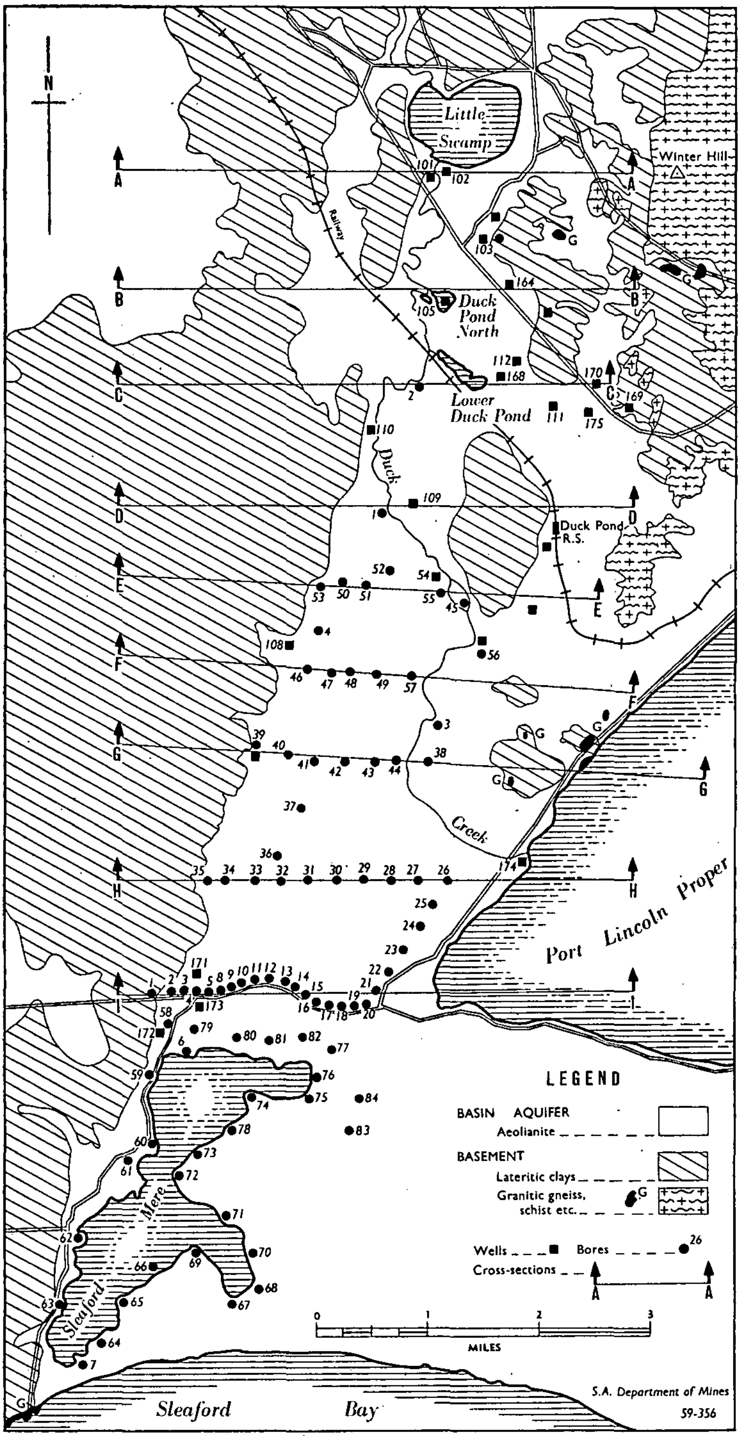


FIG. 76—LINCOLN BASIN

Geological plan

Lincoln Groundwater Basin

Private wells in the Lincoln Basin have been kept under observation by the Engineering and Water Supply Department since 1941 as it was realized even at that time that the Uley-Wanilla Basin might not be able to fully cope with increasing demands which were certain to be made of reticulated water on lower Eyre Peninsula. This basin could provide an augmentative supply. A detailed survey was undertaken in 1950 by the writer to map the limits of the basin and to select sites for trial boring and pump testing.

Further trial drilling was initiated in 1955 and is still in progress. Some 90 bores have now been drilled by the Department of Mines and the drilling has been extended beyond the limits of the basin proper. This report is confined to that portion of the basin extending in a narrow elongate depressed belt southerly from Little Swamp (about 3 miles west of Port Lincoln), southwards to Sleaford Mere.

Geology: Pleistocene wind-blown calcareous sands occupy the most depressed portion of a broad valley carved into the Archaean basement between the Winter Hill-North Side Hill ridge and the elevated belt of which Cobblers Hill is the highest point, to the west. Granite gneiss outcrops in these peaks (Cobblers Hill 640ft., North Side Hill 638ft. and Winter Hill 771ft.) and in subdued exposures at and near the shore of Port Lincoln Proper (see fig. 76). Hematite quartzites outcrop on the western and northern sides of Little Swamp.

Bedrock has been intersected in several of the private wells and in a number of the trial bores—basement rocks being either gneisses or schists. Figure 77 is a plan on which are superimposed surface form lines and bedrock form lines.

Cross-bedded aeolian sands which constitute the basin aquifer display a modified dune form at the surface, being fixed by a crust of kunkar and by a ubiquitous dense cover of low mallee scrub. The thickness of aeolianite is greatest near the basin centre where it is over 70ft. In several boreholes grey sandy clays with shell fragments have been penetrated below the windblown aeolianites.

There is generally a variable thickness of red-brown lateritic clays (late Tertiary) which separate the aquifer from basement gneisses. These clays are impermeable.

Cross-sections have been prepared from the available drilling data (fig. 78).

Hydrology: Little Swamp acts as a temporary collecting and storage basin for the drainage of an area in excess of that of Big Swamp catchment. The southern outlet connects with Port Lincoln Proper by way of a well-defined channel in Duck Creek and this undoubtedly provides a large proportion of the groundwater intake to the basin. Twenty-four private wells and bores are in existence over the basin proper besides a further 75 bores drilled by the Department of Mines in 1950 and 1955-1957; the localities of these are indicated on fig. 76.

Isopotentials.—Levels taken at monthly intervals since 1941 by the Engineering and Water Supply Department show that the hydraulic surface has shown only small variations in any particular well. The accompanying graph (fig. 79) in which the variable water-levels in a number of wells have been plotted illustrates that major fluctuations take place at the northern end of the basin while in the central and southern portions the levels are more or less static.

Figure 80 shows contours of the water-table as at May, 1957. The gradient and general disposition have varied little since observations were first made, there being a gradient of about 1 in 500 (a fall of 205ft.) from the southern end of Little Swamp to the head of Proper Bay and Sleaford Bay. Springs at the coast in Proper Bay represent points of leakage from the basin into the sea.

Sleaford Mere represents an area of about 1,700 acres over which the water-table is exposed at the surface. The level of the mere remains fairly constant and is only several feet above sea-level (fig. 73).

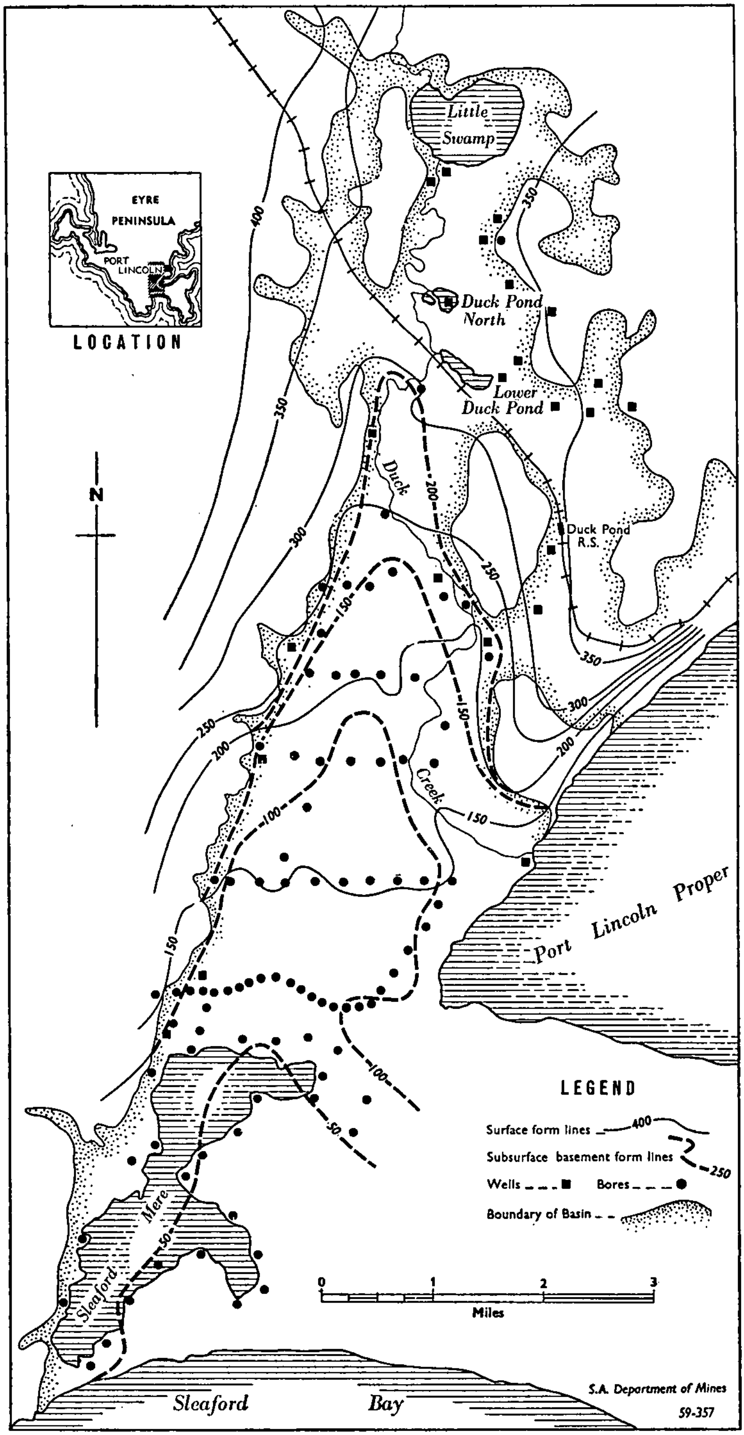


FIG. 77—LINCOLN BASIN

Plan showing surface and subsurface form lines

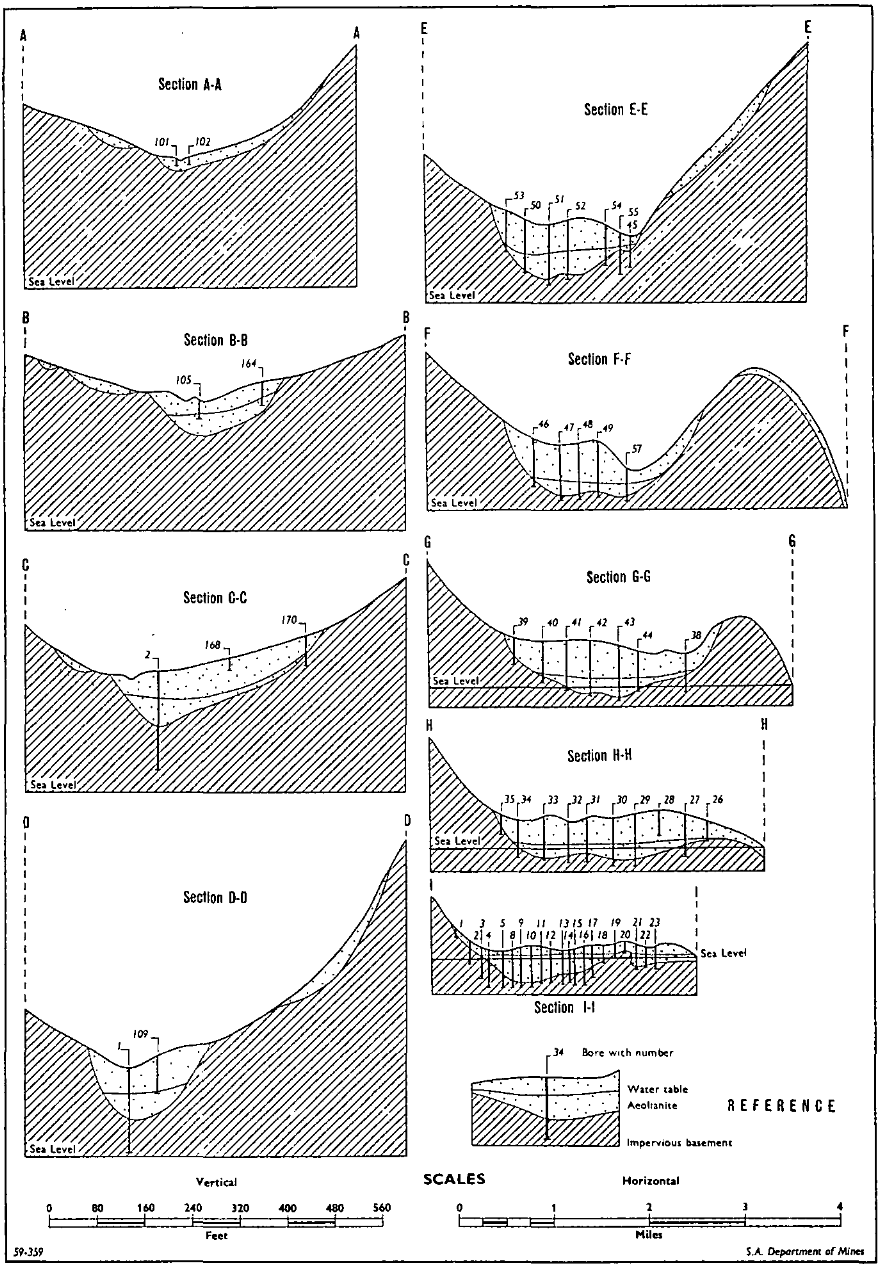


FIG. 78—LINCOLN BASIN
Geological cross-sections

Salinity of the Groundwater.—Samples of water were taken from all water points in the basin during the course of the survey and these were analyzed. Sleaford Mere water is brackish and contains 500 to 700 grains per gallon dissolved saline matter. Bores nearby yield water containing 40 to 50 grains/gallon. Several bores yield water containing 30 grains in the central and southern portions while the springs at the coast contain 80-90 grains. In the northernmost section of the basin salinities of up to 125 grains have been recorded.

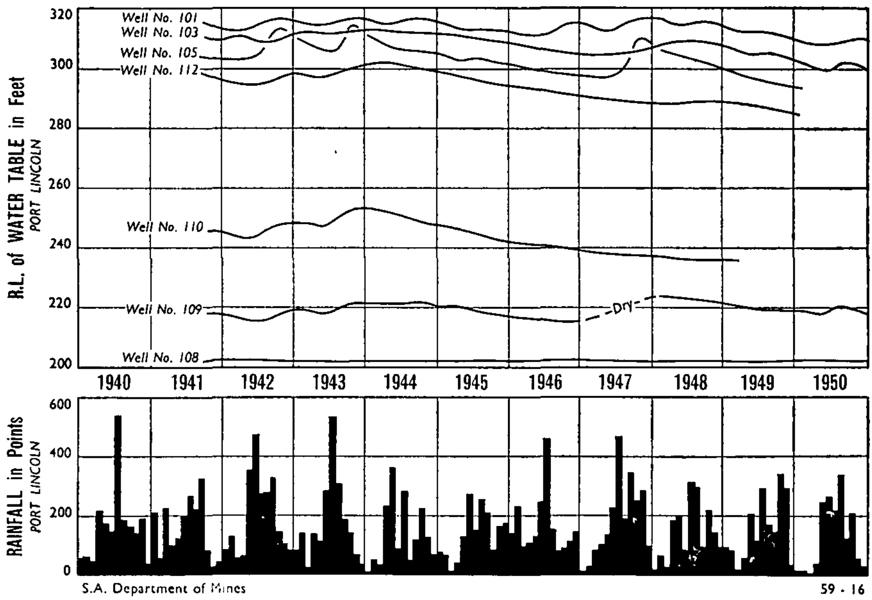


FIG. 79—LINCOLN BASIN

Seasonal variations of water-table and relation to rainfall

The writer assumed during the early part of the investigation that the main source of recharge was by way of Little Swamp and, in times of flooding, Duck Ponds North, Lower Duck Ponds and Gum Flat as well as accessions from the bed of Duck Creek. However, it will be shown below that a large proportion of the rainfall which falls over the basin itself percolates down to the water-table.

The graph (fig. 81) indicates seasonal variations in salinities of Little Swamp, Duck Ponds North and Lower Duck Ponds over a period of 6 years and the relation to rainfall (from figures supplied by the Port Lincoln Post Office). The direct relationship is obvious. During the summer months a salinity as high as 780 grains/gallon has been recorded in water from Little Swamp; the maximum recorded in Duck Ponds North is 280 grains/gallon while that of Lower Duck Ponds is 180 grains/gallon. The lowest salinity recorded in Little Swamp is 95 grains/gallon, Duck Ponds North 95 and Lower Duck Ponds 70 grains/gallon.

During the winter months when the basin would be recharged, the water taken into the basin via these lakes would contain about 120 grains per gallon. Little Swamp seldom completely dries up and obviously has an impermeable floor. The Duck Ponds often dry out during seasons of low rainfall while Gum Flat last received water by way of Duck Creek in 1942 after a particularly wet winter. That the Duck Ponds hold water for extended periods despite the apparently porous aeolianite floor suggests that silt partially seals pore spaces. It is obvious that water flowing along Duck Creek would find a ready entry to the water-table as its bed is entirely confined to porous loosely consolidated aeolianite.

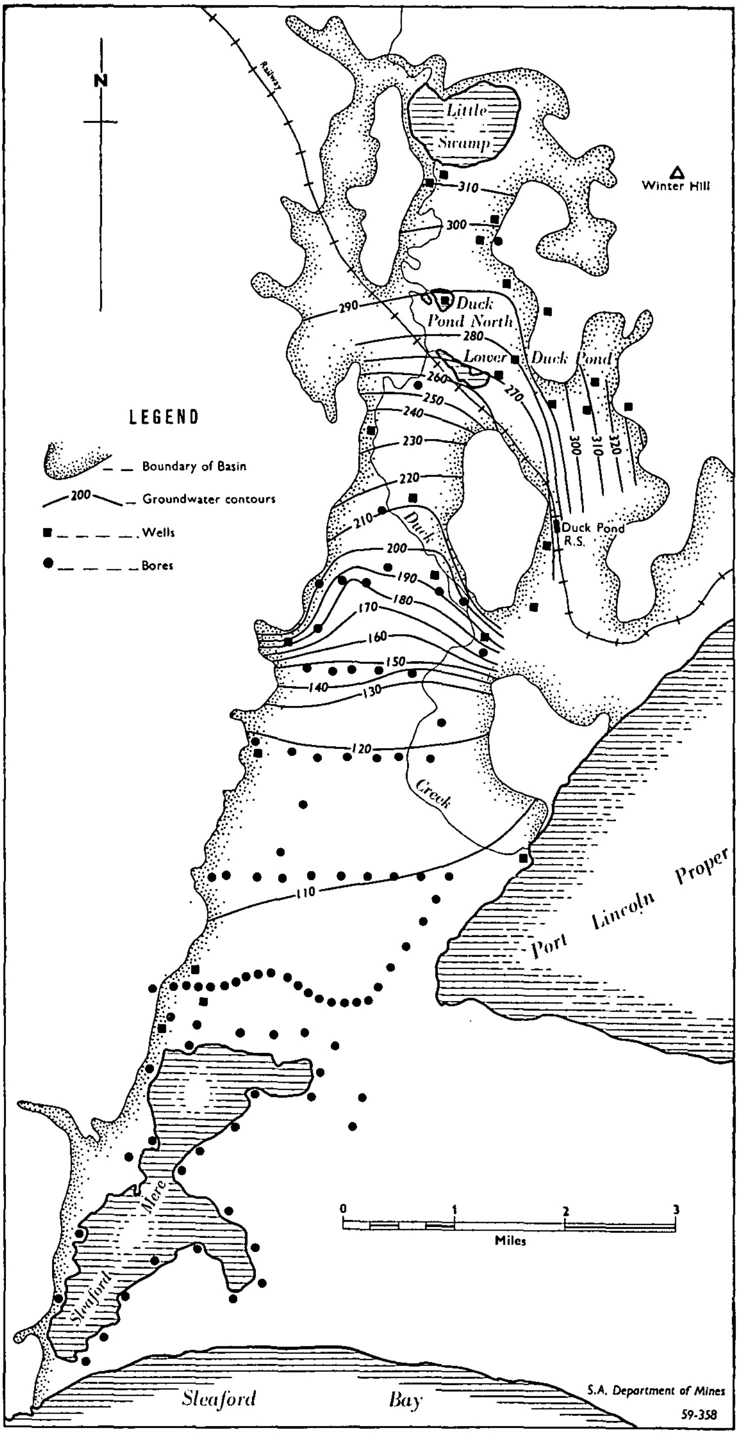


FIG. 80—LINCOLN BASIN

Plan showing isopotentials

Water pumped from wells in the area lying between Little Swamp and Duck Ponds contained saline matter in amounts variable from 75 to 350 grains per gallon while southward from Duck Ponds the salinities range from 100 to 350 grains. In the central and southern part of the basin the salinities are all less than 55 grains. As the water entering the basin via Little Swamp or ancillary Duck Ponds contains 120 grains per gallon, or 70 grains at best, it is immediately apparent that there must be very large contributions from rain falling over the basin proper and over the marginal areas which serve to "sweeten" the groundwater over a considerable area of the basin.

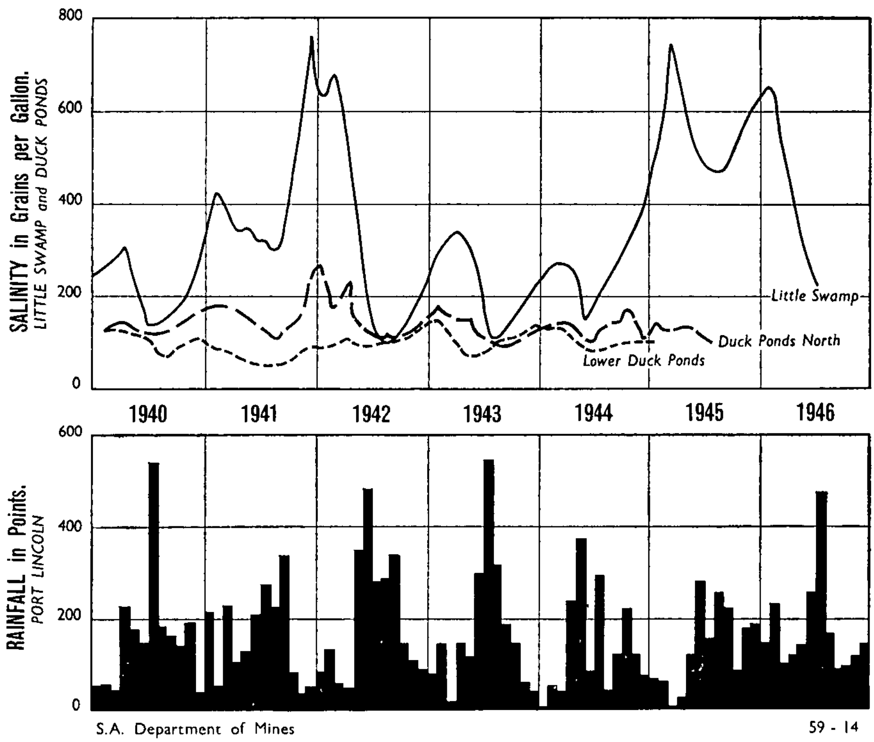


FIG. 81—LINCOLN BASIN

Seasonal variations in salinity of Little Swamp and Duck Ponds and relation to rainfall

Utilization of the Basin.—Only small supplies are at present drawn from the basin for watering of stock and in one place at least for garden irrigation. Recent drilling has shown that potentially large supplies of water are available to augment supplies at present being drawn from the Uley-Wanilla Basin. This drilling has also indicated extensions of the basin east of Sleaford Mere to Pillie Lake and to Point Warna.

Comparison between this and the adjoining Uley-Wanilla Basin shows that the catchment area for Little Swamp is in excess of that for Big Swamp while the area of catchment over the basins themselves are almost equal. From existing data it is apparent that there are great variations in the salinity of the groundwater from place to place in the Lincoln Basin which is in striking contrast to the proven Uley-Wanilla Basin where the waters have a remarkably constant salinity.

Chapter 9

ACKNOWLEDGEMENTS

The writer is particularly indebted to Mr. L. W. Parkin, formerly Chief Geologist and later Deputy Director of Mines, who supervised the project from its inception and also critically read the manuscript.

The ready assistance given by landholders in the region was appreciated and is here acknowledged.

Many of the data incorporated in those sections dealing with the Uley-Wanilla and Lincoln Basins are due to the Engineering and Water Supply Department and acknowledgement is here made to Mr. E. Wannon in particular.

REFERENCES

Alexandrov, E. A., 1955—''Contributions to Studies of Pre-Cambrian Banded Iron Ores.'' *Econ. Geol.* 50 (5), pp. 459-468.

Crocker, R. L., 1946—''An Introduction to the Soils and Vegetation of Eyre Peninsula.'' *Trans. Roy. Soc. S. Aust.* 70 (1), pp. 83-107.

Crocker, R. L., 1946—''Post Miocene Climatic and Geologic History and its Significance in Relation to the Genesis of Major Soil Types of South Australia.'' *Bull. Coun. Sci. Industr. Res. Aust.* 193.

Crocker, R. L. and Wood J. G., 1947—''Some Historical Influences on the Development of the South Australian Vegetation Communities and their Bearing on Concepts and Classification in Ecology.'' *Trans. Roy. Soc. S. Aust.* 71, pp. 91-136.

Daly, R. A., 1934—''The Changing World of the Ice Age.'' *Yale Univ. Press.*

Dewhurst, I. E., 1939—''The Sir Joseph Banks Islands.'' *Proc. Roy. Soc. Vict.* 51 (1), pp. 142-147.

Howchin, W., 1909—''Geological Observations on some of the Localities Visited by the Governor Musgrave Party in January, 1907.'' *Proc. R. Geogr. Soc. Aust., S. Aust. Br.* 10, pp. 204-219.

Jack, R. L., 1914—''The Geology of the county of Jervois, and of Portions of the Counties of Buxton and York, with Special Reference to Underground Water Supplies.'' *Geol. Survey S. Aust. Bull.* 3.

Jack, R. L., 1951—''The General Geology of Eyre Peninsula.'' *Proc. Aust. Inst. Min. Metall.* 162-163, pp. 199-215.

Johns, R. K., 1958—''The Geology of South Australia,'' Ed. by M. F. Glaessner and L. W. Parkin. *Jour. Geol. Soc. Aust.* 5 (2), chapter IV.

Ludbrook, N. H., 1959—''A Widespread Pliocene Molluscan Fauna with *Anodontia* in South Australia.'' *Trans. Roy. Soc. S. Aust.* 82, pp. 219-233.

Mawson, D., 1907—''Geological Features of Part of Eyre Peninsula.'' *Trans. Roy. Soc. S. Aust.* 31, pp. 71-76.

Mawson, D., 1907—''The Wadella Springs and Associated Bog Iron Ore Deposit.'' *Trans. Roy. Soc. S. Aust.* 31, pp. 77-78.

Mawson, D., 1928—''A Brief Resume of Present Knowledge Relating to the Igneous Rocks of South Australia.'' *Rep. Aust. Ass. Adv. Sci.* 18, pp. 230-274.

Mawson, D., 1944—''The Nature and Occurrence of Uraniferous Mineral Deposits in South Australia.'' *Trans. Roy. Soc. S. Aust.* 68 (2), pp. 334-357.

Miles, K. R., 1947—''Pre-Cambrian Granites and Granitization with Special Reference to Western Australia and South Australia.'' *Trans. Roy. Soc. S. Aust.* 71 (1), pp. 54-66.

Miles, K. R., 1952—''Tertiary Faulting in Northeastern Eyre Peninsula.'' *Trans. Roy. Soc. S. Aust.* 75, pp. 89-96.

Schurmann, C. W., 1879—''The Aboriginal Tribes of Port Lincoln in South Australia.'' (Reprinted in *The Native Tribes of South Australia* by J. D. Woods).

Tate, R., 1881—''Geology in its Relation to Mining and Subterranean Water Supply in South Australia.'' *Trans. Roy. Soc. S. Aust.* 4, pp. 113-134.

Tate, R., 1881—''Notes on the Geology about Franklin Harbour, West Side of Spencer's Gulf.'' *Trans. Roy. Soc. S. Aust.* 4, pp. 143-144.

Tilley, C. E., 1920—''The Metamorphism of the Pre-Cambrian Dolomites of Southern Eyre Peninsula, South Australia.'' *Geol. Mag.* 57 (10), pp. 449-462.

Tilley, C. E., 1921—''The Granite-Gneisses of Southern Eyre Peninsula (South Australia) and Their Associated Amphibolites.'' *Quart. Jour. Geol. Soc. Lond.* 77, pp. 75-134.

Tilley, C. E., 1921—"The Graphite Rocks of Sleaford Bay, South Australia." *Econ. Geol.* 16 (3), pp. 184-198.

Tilley, C. E., 1921—"Pre-Cambrian Para-Gneisses of Southern Eyre Peninsula." *Geol. Mag.* 58 (6), pp. 251-259.

Wade, A., 1915—"The Supposed Oil-Bearing Areas of South Australia." *Geol. Survey S. Aust. Bull.* 4.

Ward, L. K., 1913—"The Possibilities of the Discovery of Petroleum on Kangaroo Island and the Western Coast of Eyre Peninsula." *Geol. Survey S. Aust. Bull.* 2.

Ward, L. K., 1944—"The Search for Oil in South Australia." *Geol. Survey S. Aust. Bull.* 22.

Whitehouse, F. W., 1940—"Studies in the Late Geological History of Queensland." Queensland Univ. Paper, Dept. Geol. 2 (N.S.) (1).

Wilson, A. F., 1952—"The Charnockite Problem in Australia." Sir Douglas Mawson Anniv. Vol., Ed. by M. F. Glaessner and E. A. Rudd, pp. 203-224.

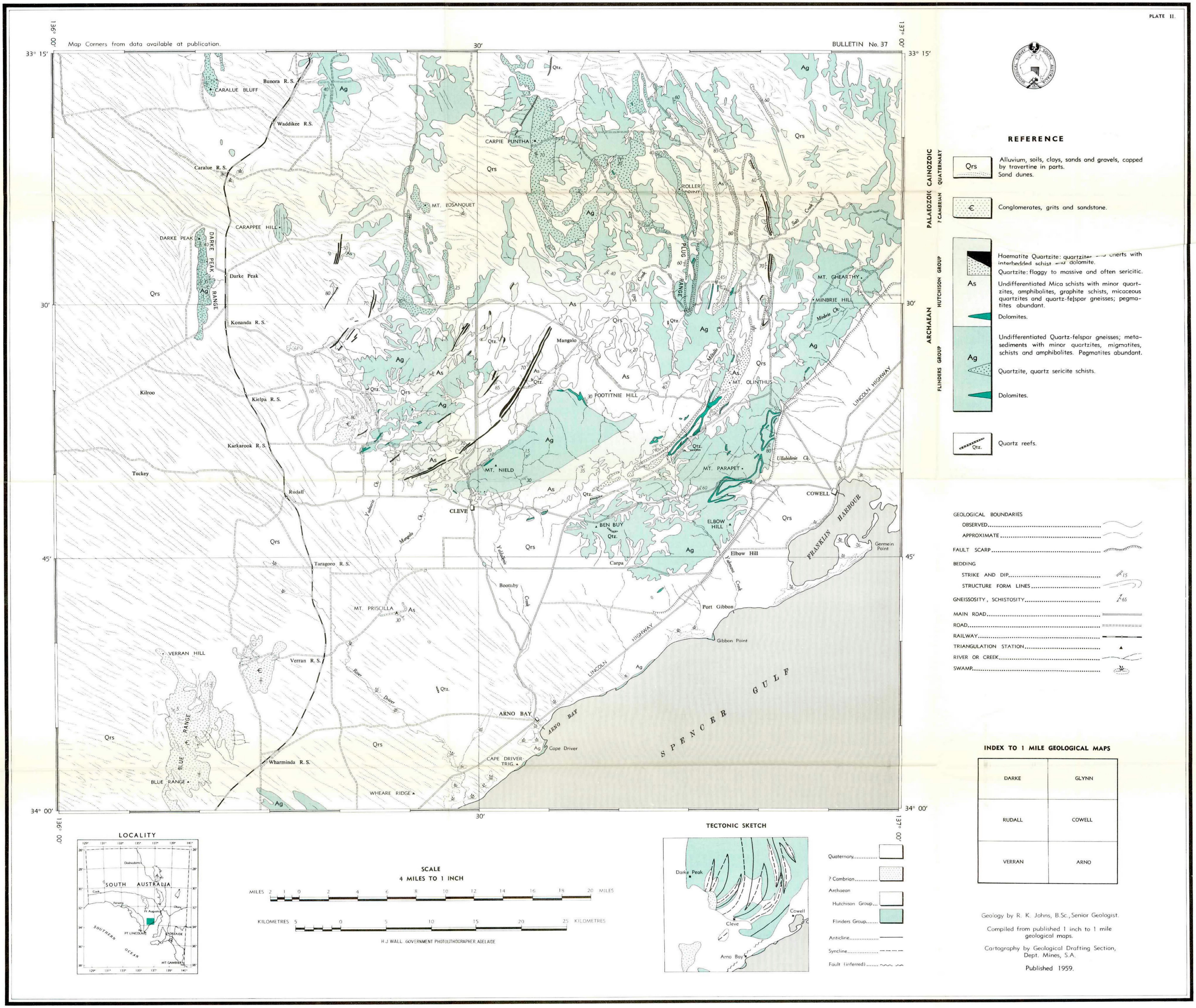
Woolnough, W. G., 1927—"The Chemical Criteria of Peneplanation." *Jour. and Proc. Roy. Soc. N.S.W.* 61, pp. 1-53.

Zeuner, F. E., 1945—"The Pleistocene Period." The Roy. Society, London.

Zeuner, F. E., 1945—"Dating the Past: An Introduction to Geochronology." London (Methuen).

PORTION OF

EYRE PENINSULA
GEOLOGICAL MAP



LINCOLN

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
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