



DEPARTMENT OF MINES
SOUTH AUSTRALIA
GEOLOGICAL SURVEY

**THE GEOLOGY OF THE JERVIS
AND
YANKALILLA MILITARY SHEETS**

Explanation of the Geological Maps

by

B. CAMPANA, D.Sc., Geologist

R. B. WILSON, B.Sc., Assistant Geologist

With contributions by

A. W. G. WHITTLE, M.Sc., Petrologist

REPORT OF INVESTIGATIONS No. 3

*Issued under the Authority of
The Hon. Sir A. Lyell McEwin, K.B.E., M.L.C., Minister of Mines*

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

Report of Investigations No.3

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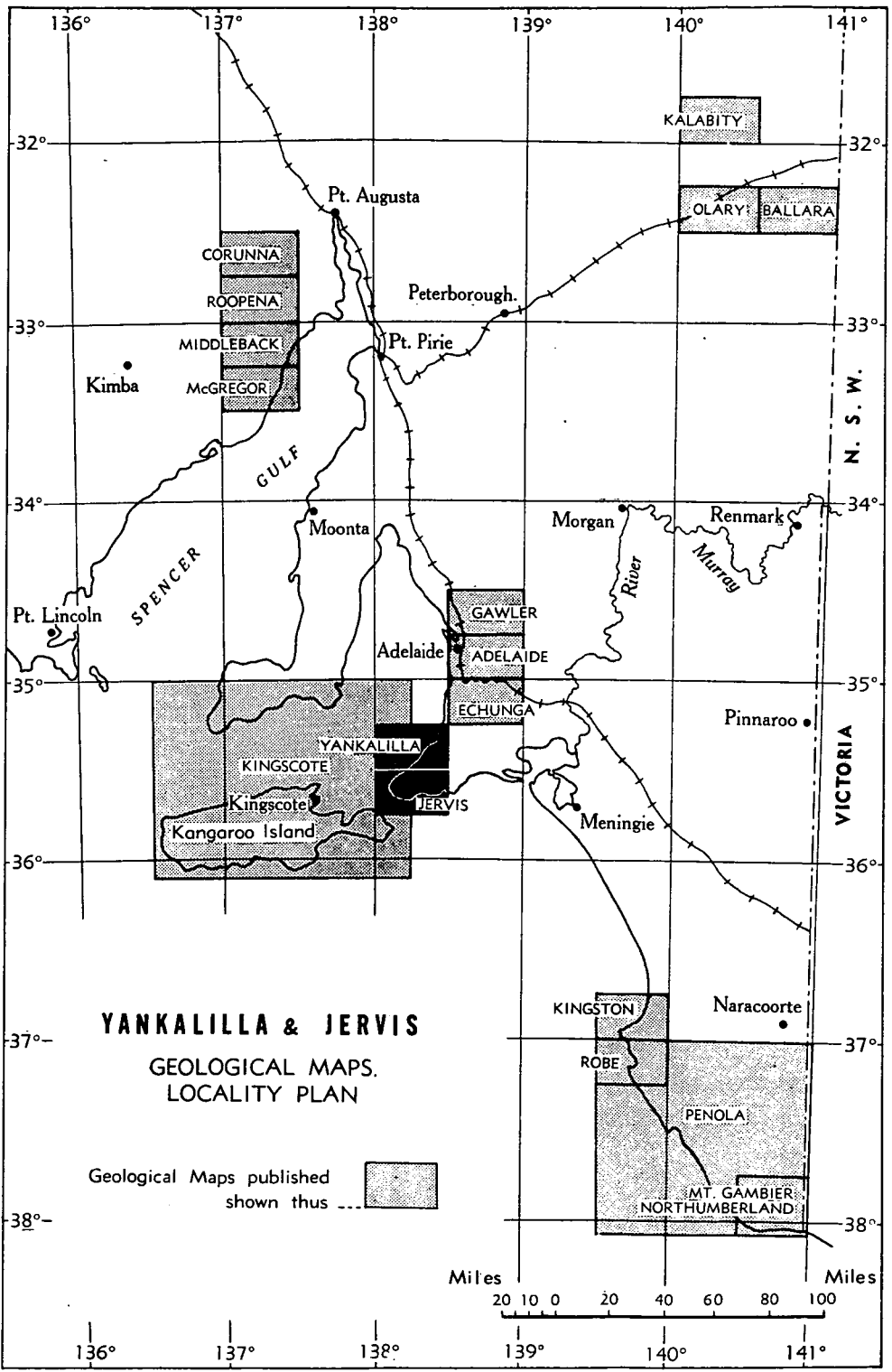
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YANKALILLA & JERVIS
GEOLOGICAL MAPS.
LOCALITY PLAN

Geological Maps published
 shown thus

Miles 20 10 0 20 40 60 80 100 Miles

LETTER OF TRANSMITTAL

Geological Survey Office,
Department of Mines,
Adelaide. 28th September, 1953.

Sir,

I have the honour to submit herewith, for publication, an account of the geology of the Cape Jervis and Yankalilla areas, by Dr. B. Campana, Geologist.

These notes cover descriptions of the general geology of the area, including the extent and nature of the known mineral occurrences and of underground water resources.

The notes describe the geological maps which are published on a scale of one mile to one inch. The notes and the maps have extremely useful application in the development of these areas for agricultural and industrial activities, in the planning of new land settlement, in the exploration and development of new mineral resources and in the provision of additional services, such as roads and water supply. In time the geological maps and the notes accompanying them will prove most valuable references for all developmental activities and it is one of the major functions of the Geological Survey to publish the results of the regional mapping work in this form.

I have, etc.

S. B. DICKINSON
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 Report of Investigations of the Geological Survey of South Australia.

Approved.

A. LYELL McEWIN
MINISTER OF MINES.

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INTRODUCTION

The geological maps of the Cape Jervis-Yankalilla area, at a scale of 1 inch to 1 mile, were prepared for publication in 1953. The related field work was carried out during the years 1952 and 1953, using "Adastra" aerial photographs at a scale of 4 inches to 1 mile. The final drawing was prepared using base-maps at a scale of 4 inches to 1 mile plotted from the photographs and controlled by the Army triangulation. In addition, many altimetric measurements were made for drawing form-lines of the area at intervals of 50 feet.

The systematic mapping of these areas has had a considerable bearing on the better understanding of the geology of the coastal districts, adjacent to Gulf St. Vincent and Kangaroo Island. It also clarifies the structural and stratigraphic relationships of the rocks of the eastern and western slopes of the Mt. Lofty Range; and of Permian glaciation in South Australia. The Cape Jervis and Yankalilla areas also contain important mineral deposits, and the mapping has disclosed localities which warrant more detailed mineral investigation.

Because of the wealth and range of geological data available in the Cape Jervis and Yankalilla areas, it is hoped that the published maps and these notes will form a valuable basis for future research on the geology of the coastal areas of the State.

PHYSIOGRAPHY

This area may be divided into the following physiographic units.

The Plateau Region

The plateau region forms the most southern segment of the Mt. Lofty Range and is made up of highly folded Archaean, Pre-Cambrian, and early Palaeozoic formations. The plateau corresponds to a pre-Tertiary peneplain, which has been uplifted during Tertiary and Quaternary times and deeply dissected by subsequent cycles of erosion. The old land surface in the Cape Jervis zone is circumscribed by Mt. Hayfield, Mt. Desert, Tapanappa Hill, and Bullaparinga Hill, its elevation being about 1,000 ft. above sea-level. In the north the old peneplain is marked by Myponga Hill, Clarke Hill, and Moon Hill, and reaches 1,400ft. above sea-level. These plateau remnants are

generally covered by a leached residual lateritic soil, supporting a dense scrubby vegetation. They are dissected by steep and narrow gullies through which numerous creeks with steep torrential gradients reach the sea.

The Glacial Depressions

The glacial depressions form Inman Valley, Back Valley, Torrens Vale, Yankalilla-Myponga lowland, and Backstairs Passage. They represent remnants of a Permian glacial topography in which the valleys were filled during the Mesozoic era with post-glacial drift. These valleys were reopened by differential erosion after the Tertiary uplift. The present-day depressions are plastered by the morainic material of the Permian era. They support fertile pastures.

The Aldinga Plain

The Aldinga Plain occupies the northern portion of the Yankalilla area. It is separated from the plateau region by the long and regular Willunga escarpment, and consists of Tertiary sub-horizontal formations overlain by a thick blanket of Quaternary alluvial deposits.

STRATIGRAPHY

Quaternary

Debris and Talus

A thin and very limited blanket of debris and waste occurs at the base of the coastal cliffs, especially along the southwestern coast from Normanville to Cape Jervis. The material is of some economic importance as a source of road metal.

Landslides

Landslides ranging from true landslides on elevated slopes to flowing clay and mud in the depressions and along watercourses are quite numerous in the areas occupied by unconsolidated glacial drift. They are also commonly developed near the contacts between sandy and clayish layers.

Coastal Sand and Dunes

Coastal sand-dunes occur at intervals along the coastlines from Waitpinga Beach to Port Willunga. They are of limited thickness and extension, and their maximum encroachment on to the land is of the order of some hundred yards.

Travertine

The map shows only the travertinised coverings which are not related to underlying calcareous beds. These blankets of travertine occur on the now dry sea terraces and platforms bordering the coastline. The best examples are those at Cape Jervis and Waitpinga Beach.

Valley-Trains and Thin Alluvial Deposits of Watercourses

Alluvial clay, sand, and silt of Recent age are present along the main lines of drainage, especially at or near the base level of erosion. In many

places they form the most valuable agricultural areas.

Lateritic Mantle of Uplifted Plateau

A red to brown clayish lateritic blanket covers the uplifted portion of the pre-Tertiary erosion surface. This material is also found on younger erosional slopes within 200 ft. of the plateau surface. It would appear that the age of this weathering process is (?) Pliocene to Recent in age and is still active.

(?) Upper Pliocene to Pleistocene Clays and Gravels (fig. 1 and 2, plate I fig. 1)

These formations comprise the subhorizontal alluvial formations of Sellick Beach and Myponga Plain. Along the cliffs south of Sellick Beach, three main horizons occur: a lower reddish to buff clay; a middle pink-coloured coarse gravel; and an upper mottled gravelly clay. They range up to 200 ft. in thickness. Their deposition is not related to the present cycle of erosion but to that of a late Pliocene to Pleistocene age. The gravels do not contain any pebbles of Cambrian limestone although these formations outcrop along the landward slope. Their absence indicates that the uplift of the basement rocks was continued during the post-Pleistocene time (see p.17). Plate I fig. 1 shows the relationship between (?) late Pliocene to Pleistocene clay and gravel and Oligocene to Miocene marine limestones at Sellick Beach.

At Snapper Point, mottled and grey clays up to 25 ft. in thickness are seen to rest on Pliocene marine beds.

In the Myponga Valley, a deep bore passed through 276 ft. of Recent to Pleistocene clays, gravels, and sands, which rest on Miocene limestone.

Tertiary

Pliocene Marine Beds (fig. 1)

Pliocene marine beds outcrop along the cliffs from Port Willunga to Snapper Point and thin out towards the south. They consist of two main horizons: a lower shelly limestone with numerous and well-preserved *Ostrea arenicola* specimens; and an upper white to buff sandy layer associated with a thin travertine horizon.

Late Oligocene-Lower Miocene

Polyzoal Limestones (plate I fig. 1, 2, 3) --- These beds comprise sandy and richly fossiliferous limestone layers alternating with calcareous sandstone. They outcrop from Snapper Point to Port Willunga, also at Sellick Beach, where they occupy a subhorizontal position in the gently folded northern zone (plate I fig. 1), but are warped-up to the vertical southerly of Mt. Terrible Gully (plate I fig. 2 and 3, and plate V fig. 1). Bores have proved their continuity beneath the Aldinga and Myponga Plains. A thickness of 385 ft. in the sequence was intersected by the deep Myponga bore. The fossils present in these beds are very numerous but usually much fragmented. They include Mollusca, Echinoids, Foraminifera (Lepidocyclus, Sherbonia, Gumbellina)

* Personal communication of Dr. M.F. Glaessner, University of Adelaide

Fig. 1

**STRATIGRAPHIC SECTION
OF MARINE MIOCENE-PLIOCENE BEDS
BETWEEN PORT WILLUNGA AND SNAPPER POINT**

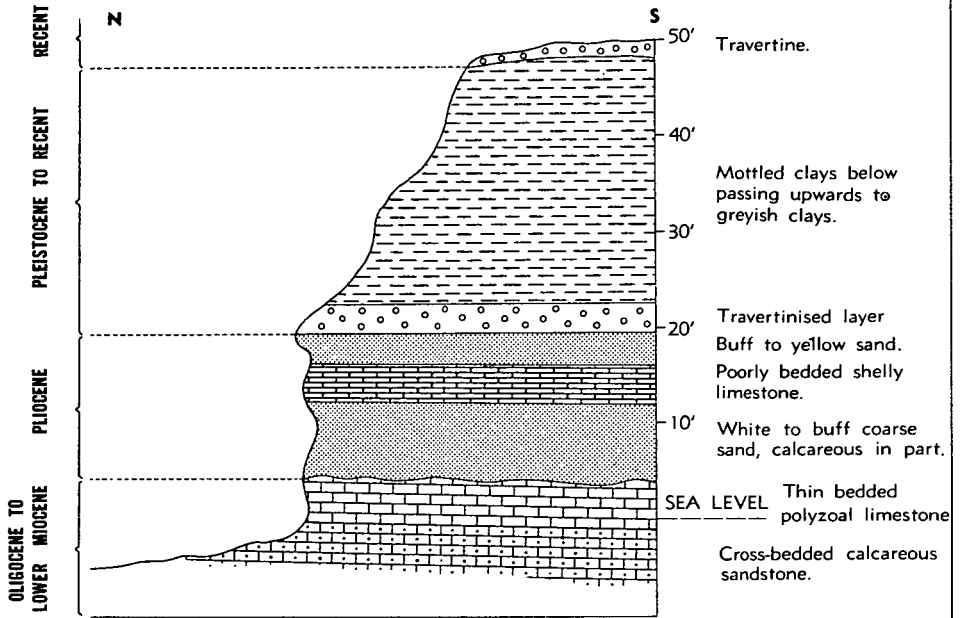
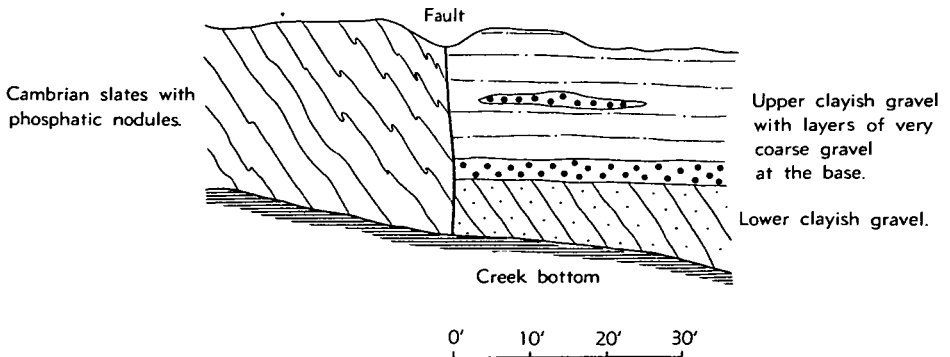


Fig. 2

**TILTED PLEISTOCENE LOWER GRAVEL
OVERLAIN UNCONFORMABLY BY HORIZONTAL UPPER GRAVEL,
BOTH IN CLEARCUT TECTONIC CONTACT WITH CAMBRIAN FORMATIONS.**

MOUNT TERRIBLE GULLY



Basal Conglomerate --- A basal conglomerate composed of unconsolidated manganeseiferous sand, in which are embedded well-worn pebbles up to a few inches in diameter, outcrops at the base of the warped polyzoal limestone of Sellick Beach at points 1,500 and 3,000 yds. south of Mt. Terrible Gully. It marks the surface of the Miocene marine transgression on Cambrian slates. The transgressional contact is evidenced also by the infilling of cracks in the Cambrian beds by Miocene material. Plate I figs. 1 and 2 show this relationship, as exposed at the mouth of a small creek some 3,000 yds. south of Sellick Beach.

Palaeozoic

Permian

The Permian rocks are represented by glacial, fluvioglacial, and glaciolacustrine (varved) deposits, which are found in the glacial depressions of the area. These beds consist mainly of unconsolidated sand and boulder clay. They represent old moraines, as shown by numerous erratics embedded in the drift and also by striated pavements. They rest unconformably and indiscriminately on folded Pre-Cambrian and Cambrian rocks forming the ancient glacial floor. Although occurring over a wide area, the old moraines are mostly covered by vegetation, alluvial drift, or material re-washed from the slopes. The best outcrops occur in Inman Valley and especially at Cape Jervis, some 2,000 yds. north of Lands End, where the moraines attain some 100 ft. in thickness and consist mainly of unsorted, unstratified boulder clay and sandy clay, containing erratics of all sizes and degree of angularity. In places, however, thin well-bedded layers occur, which consist of light-grey to buff sandy clay with well-defined lamination and extremely irregular grain size. In thin section, these thin 1 - 2 mm. laminae were found to be composed of silky felted sericite-chlorite of ultramicroscopic dimension. Alternating with these laminae are much wider bands up to 1 cm. thick, consisting of beautifully rounded quartz grit averaging 0.25 mm. diameter and enclosed in a base of fine quartz and ultra-fine sericite-chlorite. Numerous larger grains 1 cm. in size are dispersed irregularly as erratics, and it is noticeable that with increasing grain size there is increasing angularity. These rocks are clearly of the varve type, representing seasonal deposition.

The glacial deposits are almost everywhere in horizontal to sub-horizontal position. The nature and composition of these beds in relation to the remnants of the Permian glacial topography suggest a mountain-type glaciation. This feature is discussed in greater detail elsewhere.

Varved formations

The varved formations are present in a cutting along the road joining Torrens Vale and Mt. Hayfield, with a visible thickness of 15 ft. They are also exposed in a cliff face at Cape Jervis where they are interstratified with the coarse morainic material shown in plate II fig. 2.

A general order of stratigraphic succession has not been recognized, but in Inman Valley a top layer of sand overlies a more clayey horizon. One constant stratigraphic feature is the presence of coarse tillite, with boulders up to 12 ft. in diameter, at the contact of the glacial deposits with the bedrock. The tillite consists mainly of pebbles and cobbles of all sizes, well smoothed and rounded but having one predominant flat and well-polished surface (see plate II fig. 3).

This feature is evidence of a fluvioglacial smoothing and subsequent glacial polishing. The abundance of quartzitic pebbles and the paucity of pebbles of other rock types is undoubtedly due to selective resistance to erosion and weathering.

The age of these glacial deposits has been inferred by comparison with the fossiliferous tillite of New South Wales and Western Australia. Plant remains discovered in these deposits on Kangaroo Island have not yet been specifically determined.

Cambro-?Ordovician (Kanmantoo Group)

These rocks outcrop mainly round Cape Jervis, along the south coast, and in the Inman Valley region. They show significant lithological variations. Two major groups have been recognized, sufficiently distinctive for field differentiation.

Group 1 - Greywackes ^A

The greywackes form the major part of the Kanmantoo Series in the Jervis area, mostly in unbroken sequence but in places containing beds of Group 2.

A series of samples taken at intervals northwards along the cliffs from Cape Jervis proved to be largely massive or slightly schistose greywacke interspersed with quartz-mica schist or phyllite. The colour of the greywacke ranges from light grey or brown to dark colours and in places is mottled by white kaolin derived from feldspar decomposition. The grain size is regular throughout the series. The coarser detrital grains of quartz and feldspar are 0.05 mm. in size, and the enclosing matrix is an ultra-fine rock-flour of sericite, clay, etc. Quartz is always abundant; feldspar is present in variable but significant amounts and includes both potassic and sodic varieties. Both feldspar and quartz are in angular to rounded grains. A variable amount of biotite exists in the various rocks. It is always sufficient to colour the rocks darker or lighter greys and browns. Its disposition in the rocks also produces banding in an otherwise massive rock. Accessory detritals, such as apatite and opaque mineral, are unusually prominent but there are lesser amounts of zircon, tourmaline etc.

Features directly related to original conditions of deposition include current-bedded structures, localized fine banding in contrast to the usual massive structure, rare porphyroclastic structure due to the presence of accidental slate fragments and arkosic aggregate where the rock consists almost entirely of rounded quartz and feldspar. An example of the latter occurs 3 miles E. of Cape Jervis. In the more schistose members of this group of samples a predominance of biotite and muscovite is apparent both in the detritals and in the fine rock base.

^A Greywacke is essentially a feldspathic sandstone containing abundant impurities, such as grains of quartzite, slate, shale, limestone, and basic detrital minerals (amphibole, chlorite, plagioclase, etc.). The grains are of irregular size and angular shape, and are embedded in a matrix largely composed of clay, sericite, and very fine-grained quartz.

In another set of samples taken over a 4-mile strip northwards from Tunkalilla Beach, the rocks were likewise found to be almost exclusively greywacke similar to those already described. Near the beach, a type which in the field would readily be termed a basic porphyritic dyke, is, in fact, a porphyroclastic greywacke of unusual character, containing large pieces of granoblastic quartzite and large feldspars up to 0.5 cm. in size embedded in the usual groundmass. The size of quartz and feldspar detritals in all these rocks average 0.05 - 0.5 mm., and show no signs of important stress. This fact is remarkable in view of the intense folding in the underlying Adelaide System.

Some 4 miles N. of Tunkalilla Beach the greywacke contains irregular discontinuous lenses of interbedded quartzose material suggesting a change to the rocks of Group 2.

The Kanmantoo formations in the hills flanking the Inman Valley are variously greywacke, massive quartzite, and micaceous sandstone, of which sandstone is the most common.

Group 2 - Phyllites, Quartz - Mica Schists and Quartzites

These are the non-feldspathic rocks of the Kanmantoo Series as distinct from the greywacke which are notably feldspathic. They may be further subdivided into micaceous and non-micaceous. The non-micaceous types are either friable bedded sandstones or massive well-indurated quartzites, with no structure except a blocky jointing.

In a suite of rocks - consisting of greywackes and fine-grained quartz with schist - obtained some 3 miles S.E. of Second Valley, the schists are non-feldspathic, or just slightly so, and consist largely of irregularly rounded quartz of 0.05 - 0.25 mm. sizing with abundant well-oriented biotite flakes and minor muscovite and fine sericite. Apatite and opaque mineral are abundant and there is a little zircon and tourmaline.

Although the metamorphic grade of the Kanmantoo rocks is low, i.e., at or below the biotite zone, there is at least one instance where locally the grade is much higher. Two miles southeast of Cape Jervis there is a development of quartz-actinolite-garnet schists. They are grey-coloured banded rocks composed of fine-grained quartz with bands rich in actinolite and yellow chlorite. Small garnets of 0.1 mm. size are disseminated through them.

At Carrickalinga Head this group is represented by siltstones. They consist of highly angular quartz grains in a base of clay-sericite-chlorite rock-flour, suggesting sediments derived from an outwash plain. The coarser varieties contain angular quartz as well as feldspars of 0.1 mm. size, dispersed in a clay-micaceous matrix. On the basis of stratigraphic, petrological, and structural evidence, it is accepted that these siltstones occur near the base of the Kanmantoo Series whose total thickness may exceed 30,000 feet.

The age of the Kanmantoo succession has been determined solely from its position in the stratigraphic sequence (plate VI). In the Rapid Bay-Cape Jervis region, the Kanmantoo beds form the top horizon of both limbs of an overturned anticline, the core of which consists of metamorphosed Cambrian slates and limestones (Rapid Bay marble), the latter overlying rocks of the Adelaide System. At Carrickalinga Head, the siltstones conformably overlie fossiliferous beds of Lower to Middle Cambrian age.

Cambrian

Upper Slates with Phosphatic Nodules: --- These beds comprise multicoloured argillaceous slates and siltstones containing numerous black phosphatic and carbonaceous nodules generally arranged in parallel rows along the bedding planes. The slates are laminated and usually well-bedded, each layer being up to a few inches in thickness. These beds show a characteristic ribbon pattern, especially along the cliffs from Sellick Beach to Carrickalinga Head. At this latter locality, spheric bodies up to 15 in. across simulate a conglomerate. However, they consist of the same material as the host slates, (i.e. sericite, muscovite, and biotite, with disseminated quartz and black opaque carbonaceous matter) and are therefore considered to be intraformational nodules.

No fossils have been found in these beds, which rest conformably on fossiliferous Archaeocyathinae limestones, without any apparent break of sedimentation.

In the Rapid Bay-Cape Jervis region the metamorphic equivalent of these beds is present as a dark carbonaceous phyllite which, at the mouth of Campbell Creek, also contains dark nodules.

The observable thickness of these beds is 700 feet.

Upper Archaeocyathinae Limestone (and Rapid Bay Marble): --- These distinctive rocks comprise massive coralline limestone with abundant Archaeocyathinae. Grey to bluish when fresh, yellowish to buff coloured when weathered, they are commonly covered by a travertinised crust. They outcrop along the coast and in the gullies from Sellick Hill to Carrickalinga Head, where they disappear beneath the alluvial flats bordering Yankalilla Bay. These limestones are frequently recrystallized, the rock becoming thus an ultra-fine Archaeocyathinae marble traversed by secondary calcite veinlets and segregations. In places large Archaeocyathinae are metamorphosed to form crystalline calcite nodules.

No Archaeocyathinae fossils have been found in the Rapid Bay region, where coarse white to blue banded marbles are mined for limestone flux.

The assignment of Cambrian age to these Rapid Bay marbles is based on their relationship to adjacent typical members of the Adelaide System and their position in the anticlinal fold structure previously described (plate VI). It must be noted, however, that in this zone the upper members of the Adelaide System are not clearly differentiated from the Lower Cambrian. It is therefore not excluded that part of the Rapid Bay-Second Valley marbles, shown on the map as Cambrian, may in fact belong to the Brighton horizon of the Upper Adelaide System. The approximate thickness of Archaeocyathinae limestone is 700 - 1,000 feet.

Mottled Limestones and Calcareous Slates: --- Below the massive Archaeocyathinae limestones and Rapid Bay marbles are alternating mottled and banded limestones and calcareous slates with minor gritty layers. The mottled limestone consists of bluish calcareous layers alternating with siliceous silty bands, each layer being up to 2 in. thick. This structure may be interpreted as organic (algal limestone) or possibly that of irregularly shaped calcareous mud pellets. No definite fossils have been found in these beds.

Lower Archaeocyathinae Limestone: --- This bed comprises a blue siliceous, somewhat dolomitic limestone, finely recrystallized and becoming buff to brownish coloured when weathered. It has a distinctive appearance due to differential weathering, which brings into prominence narrow closely siliceous inclusions in an otherwise fine-grained calcareous rock. Under the microscope numerous small Archaeocyathinae are recognizable, averaging 0.25 mm. in size. It forms a continuous band near the base of the Cambrian calcareous beds, and is about 100 ft. in thickness.

Proterozoic (Adelaide System)

Marinoan Series

Upper Quartzites and Slates:--- Grey to purplish argillaceous and sandy slates with thin felspathic sandstones and quartzites form a transitional series between the purple slates below and the fossiliferous Cambrian above. They are possibly the equivalent of the Pound quartzite horizon, which is regarded as the basal member of the Cambrian Series in the Flinders Range. In this area, however, while this horizon is clearly differentiable in the Sellick Hill region, it rapidly loses its individuality to the south. In the field mapping it was therefore more convenient to regard the base of the Cambrian formations as the base of the calcareous series described above. The maximum thickness of these beds is approximately 800 feet.

Purple Slates: --- Purplish to green and grey slates, with few minor sandy layers, are well represented in the Sellick Hill region. They thin out rapidly to the south, and in the Rapid Bay area this horizon is much reduced. The thickness near Sellick Hill is in the order of 2,000 feet.

Sturtian Series

Brighton Limestone: --- This distinctive formation is present as a thin lenticular blue siliceous limestone, grading in places to buff-coloured dolomite. Its maximum thickness is 100 feet.

Tapley Hill Slates: --- These beds comprise a uniform succession of grey to blue, usually well-laminated slates having a thickness of approximately 2,500 ft. to the north of Sellick Hill and thinning out in a southerly direction.

Near Second Valley, in the Congeratinga Gully, this horizon is represented by grey to blue phyllites and slates, calcareous in part.

Sturt Tillite: (plate III fig.1) --- Two bands of tillite have been recognized in the Myponga-Yankalilla area. Each band has a thickness of 30 - 100 ft. and is associated with whitish dense quartzite and grey-blue to dark slaty layers. This tillite horizon has been identified also in the Second Valley to Poole Flat area where it is represented by a conglomerate with boulders up to 2 ft. in diameter embedded in a dark schistose unstratified slaty matrix. Fine outcrops may be observed at the mouth of Congeratinga River and in the coastal cliffs some 1,000 yds. N.E. of the jetty at Second Valley.

Mitcham and Glen Osmond Quartzite Group: --- This group, comprising dense highly siliceous whitish quartzite bands with interbedded bluish and phyllitic slates, underlies the tillite and is a sub-glacial facies, as evidenced by arkosic sandstones and boulder sandstones. Six principal beds may be distinguished in the Myponga area, while in the Second Valley region only three

quite thin bands have been recognized. The maximum thickness is of the order of 1,000 feet.

Torrensian Series

Grey to Blue Slates: --- These consist of laminated slates and phyllitic slates with occasional dolomitic lenses. They may be broadly correlated with the upper phyllites of the Adelaide area.

Stonyfell Quartzite Group: --- A group of two to five quartzite bands separated by grey to blue slates has been assigned to this group. They form a prominent range of hills in the Yankalilla-Myponga depression flanking the main Archaean ridge. They consist of alternating yellow to grey massive fine-grained micaceous sandstones and harder fine-grained micaceous quartzite. The average grain size of these rocks is 0.05mm., and they contain small amounts of opaque minerals, tourmaline, and zircon 0.02 mm. in size. This group has also been recognized near Grey Spur, not far above the basal members of the Adelaide System. Their approximate thickness is 600 feet.

Grey to Blue Slates with Dolomitic Lenses: --- These beds overlie the basal grits and are probably to be correlated with the lower phyllites of the Adelaide region.

Basal Grit and Conglomerate (Aldgate Sandstone) (plate III fig. 2): --- A thin but persistent conglomeratic horizon outcrops in the Grey Spur-Illohra area in the form of a coarse conglomerate, with elongated quartzitic pebbles up to 12 in. across. This horizon has also been traced near Myponga (on the west limb of the overturned regional anticline) as a feldspathized schistose conglomerate rich in quartz and with squeezed and elongated pebbles. It outcrops again farther south, from Little Gorge to the mouth of the Congeratinga River where it rests unconformably on Archaean mica schists and may be followed around the nose of the major anticlinal fold. Some distance back from the unconformity the rock is a well-banded one, in which thin layers - rich in rounded detrital hematite and ilmenite - alternate with wider arkosic bands up to 1 in. in thickness. The arkosic lamellae consist of rounded quartz, orthoclase, microcline, perthite, and albite up to 0.5 mm. in diameter, set in an interstitial matrix of fine quartz feldspar, and sericite. Towards the contact with the Archaean basement the rock passes to a micro-augen gneiss. Shearing along the contact has transformed the feldspar to fine felted sericite, muscovite, and biotite. Mica-rich bands alternate with quartzose ones, the latter consisting of fine granular quartz, interrupted at intervals by lenticular augen of recrystallized quartz. Large quantities of fine subhedral tourmaline, averaging 0.05 mm. in size, occur mainly along the micaceous bands.

The basal conglomerate frequently shows a distinct schistosity and carries ovoid pebbles up to 12 in. across, which are in places elongated with their longest axis parallel to the dip of the beds. Microscopic examination of sections cut across the stretched pebbles indicates that these have been subjected to extreme stress. The sections show undulose extinction, and parallel strain cracks across at an angle to the lineation in the surrounding matrix. These cracks are filled with epigenetic silica in the form of fresh unstrained fine-textured quartz. In the Illohra region it has been observed that the coarse basal conglomerate grades, in places, to a gneissic or migmatic rock type which in the hand specimen can hardly be distinguished from the underlying Archaean gneisses. However, the field relationship and microscopic examination allow, as a rule, a fair differentiation.

Archaean Complex

The following units have been distinguished on the map:

Archaean Undifferentiated

This group consists mostly of schists, gneisses, and stressed granites. Gneisses range in variety from quartz-mica to sillimanite-garnet gneisses, all with strong schistosity, and frequently, also, well-defined foliation.

The fine-grained quartz-felspar-biotite gneisses contain an assortment of feldspars and strongly strained quartz. Much of the felspar is pseudo-morphed in sericite, and there is abundant oriented biotite and coarse opaque mineral. Re-crystallized original argillaceous sandstones produced well-banded gneiss in which quartz, sericite, and biotite are segregated into individual foliae, respectively rich in one or other mineral. Dark-grey finely banded gneisses are composed of fine quartz, mica, and chlorite, and contain quartz lenticles several millimetres in size, severely strained and broken. There is no felspar in these rocks but abundant coarse opaque mineral and blue tourmaline. Zircon and apatite occur in some samples.

Many of these gneisses contain bands of aplitic material, composed of quartz, potassic felspar, and a little oligoclase, which lie along the planes of schistosity.

Higher-grade gneisses may be either simple quartz-biotite-garnet types or more complex, with the addition of sillimanite and felspar. Quartz forms highly strained lenticles; biotite forms bands in which graphic quartz is sometimes intergrown. Garnet is dispersed through the rock as small euhedra, whereas sillimanite is well crystallized as prisms lying along the cleavage of the rock. Sphene is a common accessory.

Various granitoid rocks occur amongst the gneisses. There are strongly kaolinized, almost pegmatitic albitic leucogranites containing zircon, opaque minerals, and a little deep red-brown mica. Normal potassic granite is also found. It is usually severely stressed with optically anomalous quartz and felspar and carries opaque minerals, zircon, apatite, and traces of monazite. The sodic leucogranites vary - by increasing biotite and muscovite and decreasing quartz - to granodiorites. The schists comprise quartz-sericite, quartz-chlorite, plagioclase-quartz-chlorite-sericite, and pyritic biotite varieties with also subordinated bands of kyanite and sillimanite schists. Quartz is always present, frequently in the form of augens.

The mica schists are commonly feldspathized and grade into the adjoining gneisses.

Phyllitic Slates and Quartzites of Illowra

These rocks are seen at the margin of the Archaean crystalline core, as a zone less affected by metamorphism and granitization. Their appearance and composition differ little from the slates and quartzites of the Adelaide System, but they must be considered as a part of the ancient Archaean Series as they underlie the basal conglomerates of the Adelaide System. A thin layer of blue and finely crystalline marble is associated with similar slates and quartzites some 100 yds. W. of Kemmie Hill trig station where they occur amidst highly injected schists and gneisses.

The maximum thickness of this group in the Illowra region is 1,200 feet.

Microdiorites

Bands of this amphibolitic rock are intercalated in schists and gneisses usually along the schistosity planes. Careful mapping has revealed their great continuity. They are fine grained and dark coloured, mostly consisting of dark-green to blue hornblende which show a parallel alignment. Quartz is also present in variable amounts, associated with plagioclase (andesine). Microscopically these rocks appear to be igneous types but their field relationship suggests, in places, derivation from calcareous sediments.

Their pattern indicates that they are more intensely folded than the overlying Proterozoic sediments, which fact points to their Archaean age. Their thickness is up to 30 feet.

Epidotized Gneissic Bands of the "Houghton Type"

These rocks comprise bands of green and pink mottled gneissic rock, intercalated in schists and gneisses similarly to the microdiorites. They have previously been referred to as epidote-syenite but it would now appear that they are in fact altered sediments.

A specimen, taken 2 miles S.E. of Yankalilla, shows under the microscope that the three main constituents of the rock, namely, feldspar, amphibole, and epidote, are present in about equal proportions. The accessory minerals are titanite and zircon. The directional structure of the rock results from partial parallelism of the amphibole crystals. The major minerals of the rock have developed in place, thus the rock is an entirely reconstituted one. Epidote, with minor clinozoisite, has developed into large crystals and the actinolite has absorbed minor rock constituents which appear as inclusions. The feldspar, which is mainly microcline with lesser microperthite, is practically free from inclusions and is usually subhedral. This rock is not igneous but represents a stage in the feldspathization of a former sediment of a rather basic nature, such as a greywacke or shale in which chlorite, epidote, and ferruginous material were abundant.

This same rock-type is prominent in and round Wild Dog Creek, where it varies from a banded gneiss to a structureless granulite. The feldspar may be entirely albitic or mainly potassic. In some cases a granulitic aggregate of albite makes up to 70 per cent of the rock, while xenomorphic actinolite and green-brown biotite form interstitial material. Coarse apatite is quite a feature of these rocks, and there is usually some zircon, sphene, rutile, and opaque mineral. The amount of epidote is highly variable but commonly it becomes a major constituent. To a lesser degree the same may be said of the sphene content.

In specimens which may be called albite-pyroxene-granulites some idea of the origin of the rock may be gained. These are evenly granular medium-grained mottled green and pink rocks, with a granulo-se structure. Highly albitic plagioclase, the major rock constituent, forms a granoblastic mosaic of interlocking interpenetrant crystals amongst which quartz, as smaller grains, is interstitial. The feldspars have formed in places producing the peculiar texture by mutual intergrowth. Quartz, of which mere remnants remain, was replaced by the feldspars. The green-blue hornblende of the rock is derived from earlier diopside, a few relics of which remain enclosed in amphibole. Coarse and fine epidote is associated with the pyroxene aggregates and is

apparently a product of uralitization. Coarse ilmenite (usually surrounded by leucoxene), aggregates of titanite, and large 1-2 mm. apatites are accessory constituents.

Much the same data were obtained from a study of specimens from the smaller Archaean core south of Yankalilla. Here too are various strongly foliated and schistose Archaean rocks penetrated by sills of altered microdiorite and of granulitic albite-epidote-pyroxene rock rich in sphene, ilmenite, and apatite. At the Little Gorge, potassic pegmatite is closely associated with shears in the gneiss and schist, in which there are deposits of monazite and rutile. Some 1-2 miles N.E. are various small copper deposits associated with massive actinolite rock and an albitic pegmatite carrying small amounts of pyrochlore, chalcopyrite, pyrite, and molybdenite.

Both occurrences of Archaean rocks, north and south of Yankalilla, have affinities with the Houghton Complex near Adelaide. The main differences lie in the absence of microdiorite at Houghton and the coarser grain of the albite-pyroxene rocks of Yankalilla. The genesis seems to be comparable, but soda metasomatism is more complete and more widespread at Houghton, where recent petrographic investigations have shown the connexion between feldspathization of basic sediments and ilmenite-rutile-uranium mineralization. In brief, the evidence suggests that the original rocks of the Archaean Complex were sandy argillaceous sediments with zones of greywacke and impure magnesian limestone. General metamorphism produced the various gneissic types, while the subsequent soda metasomatism selectively affected the calcareous horizons and produced an albitic calc-magnesian silicate rock, namely, an albite-diopside rock with accessory sphene, apatite, etc. The latter has since degenerated to an albite-actinolite rock.

Intrusive Rocks of Uncertain Age

Quartz Reefs

These are abundant in the Archaean schists and gneisses but are also present in the Proterozoic and early Palaeozoic formations. The quartz is not uncommonly associated with titaniferous hematite.

At the Talisker mine, important quartz reefs intruding Cambrian phyllites carry galena and arsenopyrite. Tungsten mineralization is associated with another group of quartz reefs, intruding the Kanmantoo formations at Callawonga Creek.

Pegmatites

Intense pegmatization has affected the Archaean formations and also in places the basal beds of the Adelaide System. The pegmatites consist mostly of quartz and pink microcline, and they are, on the whole, not mineralized. One exception is a small occurrence of monazite in a pegmatite at Little Gorge.

Basic Dykes

A basic dyke, with a maximum thickness of 10 ft. and maximum length of approximately 400 yds., occurs together with a few smaller irregular intrusions about 1 mile S.E. of Arthur Hill.

These are of a peculiar scapolitic dolerite type and intrude sandy schists of the Kanmantoo Series. A limited zone of contact alteration has taken place with these intrusions, and indurated recrystallized and spotted quartzites and schists may be seen.

TECTONICS (Plate VIII)

The tectonic movements which have affected this area may be grouped into three major orogenic periods, namely, the intense Archaean and early Palaeozoic orogeny, and the mild Cainozoic movements.

The Archaean Orogeny

The Archaean orogeny may comprise more than one orogenic cycle, but the intensity of folding and metamorphism has obscured the structural elements to such an extent that only some of the major patterns and trends are now to be seen. These formations were intensely folded, metamorphosed, and injected before the deposition of the Adelaide System. This is evidenced by the fact that the basal conglomerate of the Adelaide System rests on the Archaean with strong unconformity and contains pebbles of granite, gneisses, and schists as well as layers of titaniferous hematite, which represent reworked erosion products of the Archaean Complex. The structural trends of this complex have been recognized by a careful mapping of the persistent microdioritic beds, which show best the difference of intensity and trends between the folding of the Archaean and the subsequent orogenetic cycles.

The Early Palaeozoic Orogeny

The most apparent effect of this orogeny is the folding of the Proterozoic, Cambrian, and Cambro-Ordovician formations, (Fig. 3). The underlying Archaean basement was also strongly affected by this orogenetic cycle. Because of the difference of plasticity the former show intense but fairly regular folding, whereas the rigid Archaean Complex has been broadly domed and sometimes split and overthrust at low angle on the younger formations.

The regional tectonics is dominated by Myponga Hill - Little Gorge anticline, a broad fold overturned to the west and forming the most southerly arc of the Mt. Lofty Range.

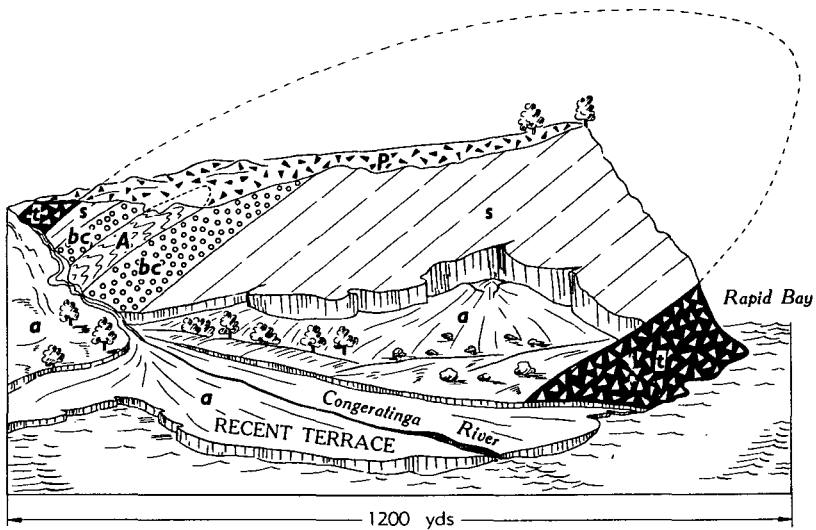
The overturned limb of the anticline, consisting of Adelaide System (basal grit to purple slates) and Cambrian formations, dips at a lower angle beneath the Archaean core, the axial pitch being flat to the southwest. The south pitch of the structure is shown by the nosing of the Adelaide System around the Archaean core in the Poole Flat - Second Valley area. In this region the overlying Cambrian formations, intensely dragged (See plate VIII), form the Rapid Bay Complex anticline and remain observable up to Campbell Creek, where they show a stretched sharply overturned and sheared anticlinal fold.

In the Little Gorge Creek, formations of the Kanmantoo Group may be seen to rest directly upon the Archaean schists, the Adelaide System being absent. This anomaly would appear to be tectonic rather than stratigraphic in origin, as evidenced by the extremely sheared nature of the rocks in the vicinity of this contact. It has been related to a major low-dipping thrust affecting the normal east limb of the anticline. The lateral extension of the thrust is masked by Permian glacial drift, but it may be assumed to continue up to Inman Valley - for a distance of some 10 miles - where it would cause the sudden lateral disappearance of the members of the Adelaide System to be found at

Fig. 3

PANORAMIC SECTION OF THE LEFT BANK OF THE
CONGERATINGA RIVER MOUTH

showing Archaean and Adelaide System Formations in overturned
anticlinal position, capped by Permian glacial drift.



- | | |
|--|--|
| a Alluvial and debris. | s Slates, quartzites and dolomitic beds |
| A Archaean micaschists | t Sturt tillite |
| bc Adelaide System basal conglomerate | P Permian boulder clay and sand |

Illowra.

Subsidiary minor folds and dragfolds are common features, and account for the locally abnormal thickness of the Adelaide System series and Kanmantoo Group. The dominant structural pattern is that of overturned and frequently acute folding, the best examples of which are revealed by aerial photograph in the Kanmantoo Group, near Cape Jervis, Campbell Creek, and Tapanappa Hill.

Longitudinal Faults

Longitudinal faults of Palaeozoic age have also been recognized, the major one being along the Willunga escarpment. The formation of this will be discussed later.

Transverse Faults

No transverse faults of any significance have been observed.

The Tertiary Tectonic Movements

Special attention has been paid to the age, succession, and importance of the Tertiary tectonic movements. The following facts have been established: (1) The outcropping Miocene of Myponga Valley and Hindmarsh Valley both lie at about the same height above sea-level - 790 ft. and 695 ft. respectively. (2) Both outcrops are lying some 700 ft. below the surrounding plateau remnants - bounded by Myponga Hill (1,445 ft.), Mt. Cone (1,362 ft.) and Spring Mount (1,373 ft.).

The difference of level between these Miocene inliers and the uplifted plateau cannot be ascribed to tectonic movements. No differential faulting affects this area and the general structural picture, as well as the geological data, show that the pre-Tertiary erosion surface was uplifted before the lower Miocene (or upper Oligocene) marine transgression. Thus the Tertiary orogeny comprises the following phases (see plate XI).

Pre-Miocene phase

Marked by an uplift of the old peneplain along the line of the old Palaeozoic fault of the Willunga escarpment.

Lower Miocene (or upper Oligocene) phase

Marked by subsidence and subsequent marine transgression, with deposition of polyzoal limestones in depressed areas, i.e. in portions of the old peneplain which had not previously been uplifted (e.g. Aldinga Plain), or in rejuvenated glacial valleys and basins (Myponga and Hindmarsh Valley Miocene inliers). The Miocene sea did not transgress on the uplifted portions of the pre-Miocene erosion surface.

Post-Miocene phase

This phase is admirably recorded at Sellick Beach (see fig. 2, plate I, fig. 1, plate V fig. 1 and 2).

The major fault line is marked topographically by the Willunga escarpment. On the western side of this, gently folded Miocene beds outcrop along the beach and are unconformably overlain by horizontal Pleistocene clays and

gravels. Along the fault zone - marked by strong brecciation - the Miocene polyzoal beds occupy a steep to overturned position and rest with strong angular unconformity upon brecciated Cambrian slates. Pleistocene gravels there rest horizontally on the Miocene as well as the Cambrian formations (plate V fig. 1) but near the fault zone the gravels are faulted too, and displaced from a few feet to a maximum of 80 ft. (see plate V fig. 2). In Mt. Terrible Gully - at about $\frac{1}{2}$ mile from its mouth - horizontal gravel layers overlie unconformably tilted gravel beds and both the tilted and horizontal gravels may be seen to abut with a clear-cut mechanical contact, against the Cambrian formations (see fig. 2). Thus, the post-Miocene movements in this area may be classified as follows:

Late Miocene movements

Marked by the angular unconformity separating the domed and faulted Miocene beds from the overlying Pliocene marine deposits.

Late Pliocene movements

Recorded by the unconformity between the Pliocene formations and the Pleistocene alluvial gravel and clay.

Late Pleistocene movements

Responsible for the faulting of the lower Pleistocene gravel and subsequent deposition of the upper gravel, the latter resting unconformably on the former (see fig. 2).

Post Pleistocene movements

Faulting and tilting of the upper gravel (fig. 2, plate V fig. 1) and formation of river and sea terraces.

The cumulative effect of the Tertiary tectonic movements is an uplift of the old peneplain of some 1,500 ft., half of which at least must be ascribed to the pre-Miocene tectonic phase.

Rather than by purely epeirogenic movements, the Tertiary orogeny has been marked by tangential stresses acting upon the thick set of Proterozoic, Palaeozoic, and Tertiary sediments. The first stage would have been a broad doming, followed by cracking, block-faulting, or thrust phenomena, according to the degree of plasticity of the formations involved.

PHYSIOGRAPHICAL EVOLUTION

Pre-Permian Times

During Pre-Cambrian times, the area under review was part of the Adelaide Geosyncline. This is testified by the identity of the facies in this area, where almost every member of the typical Adelaide System sequence has been recognized. But, as pointed out previously, the Proterozoic formations thin rapidly in a southerly direction and it must be assumed that the region formed the southern limits of the sedimentation trough. This assumption is substantiated by the fact that, on the eastern side of the core of the range - near Inman Valley - only the lower members of the Adelaide System have been recognized. A gap in sedimentation is probably responsible for the absence of the Marinoan and the Sturtian Series in this area.

At the beginning of Cambrian time, the terrigenous, paralic, azoic, and partly glaciogene sedimentation of the Adelaide Geosyncline, was followed by deposits of epicontinental facies, represented by coralline limestones and calcareous or phosphatic slates, attesting a warm climate and a mature relief around the Cambrian sea. At a later stage - in the upper Cambrian and perhaps to Ordovician times - geosynclinal conditions reappeared in the southern and eastern portions of the area with deposition of Flysch-type sediments of the Kanmantoo Group. This group may have a thickness of over 30,000 ft. Important subsidences and rejuvenations of the surrounding relief must thus be assumed. These would be forerunners of the orogeny which finally uplifted, folded and partly metamorphosed these geosynclinal sediments during early Palaeozoic times. Little is known about the physiographical conditions prevailing in this region during the middle Palaeozoic, as no deposits of this age have been recognized. However, it may be assumed that this area, like most of the Mt. Lofty Range and Flinders Range, has never been covered by the sea since early Palaeozoic times.

The Permian Glaciation

The remnants of glacial topography and the nature of the glacial deposits leave little doubt that the elevated mountain chains built up by the Palaeozoic orogeny, were still present in Fleurieu Peninsula in Permian time. The glacial relief of this area is characteristic of a mountain glaciation, as evidenced by strongly over-deepened glacial basins, glacial bars, and remnants of cirques. (See plates IX, X and XI).

Basins

Back Valley: --- This corresponds to an old glacial basin at present partially filled by reworked glacial drift. Its depth reaches 700 ft. below sea-level, but in order to assess the magnitude of the original overdeepening^A it is necessary to refer to a pre-existing land surface. Considering that the pre-Miocene peneplain - although not dating back to Permian time - gives the minimum value, an original overdeepening of 1,700 to 1,800 ft. is found (difference of level between the plateau and the bottom of the basin intersected by Back Valley deep bores.)

Myponga Basin: --- This basin is occupied by the Myponga Plain, with an apparent overdeepening of 700 - 800 ft. and an original one of 1,800 ft. at least (difference of level between the bedrock intersected by the deep Myponga bore and the surrounding plateau ridge).

Amphitheatres

The most important of these have been gouged in the Kanmantoo Series south of Back Valley. Other remnants have been observed south of Torrens Vale, Inman Valley, and the Yankalilla - Myponga lowland.

^A . Glacial overdeepening is defined in these notes as the depth of erosion of the old glacial floor below the pre-Miocene peneplain.

Glacial bars (see plate X)

The Physiographic Evolution after Recession of the Permian Glaciers-
Preservation of the Glacial Records (plate XI)

During the Mesozoic Era the Permian relief was reduced to a peneplain, and the absence of marine deposits of Mesozoic age suggests permanent emersion of the area as a stable land table.

The preservation of the Permian glacial records during such a long interval is due to the fact that these records were part of a negative relief, i.e. of overdeepened depressions lying beneath the Mesozoic base level of erosion. After the pre-Miocene uplift, the glacial depressions have been reopened by differential erosion, thus enabling the sea to invade them during the Miocene subsidence and transgression. The Polyzoal limestone of Myponga and Hindmarsh Valley basins has been deposited therefore in gulfs comparable to the present Backstairs Passage. This interpretation would explain all the observed facts, including the presence of Permian tillite at a level above the Miocene limestone.

The Present Morphology and Drainage

The post-Miocene tectonic movements and related erosional cycles are responsible for the present morphology and drainage system of the area. The uplift has repeatedly rejuvenated the relief and stimulated the erosional process. As the soft unconsolidated glacial drift filling the ancient valleys is easily removed, the main watercourses of the area flow along these glacial troughs (Inman River, Back Valley Creek, Yankalilla River, Bungala River, Carrickalinga Creek, and Myponga River). In the middle part of their course these rivers have built up limited and shallow alluvial flats, while in their lower reaches they flow to the sea in steep "gorges de raccordement". No important alluvial fans are observable at their mouths. This is clearly due to the still active uplifting movements which stimulate removal rather than accumulation. The coastal creeks commonly enter the sea by way of waterfalls or steep rapids.

River and sea terraces are abundant. At the mouth of Carrickalinga Creek, three terraces are discernible, which succeed as follows:

- (1) Older - 35 ft. terrace
- (2) Middle - 15 ft. terrace
- (3) Younger - 5 ft. terrace

This order appears to be of a more than local significance as it has been observed in other localities within this area, and also by one of the writers (Campana) along the Gawler River, north of Adelaide.

Notwithstanding the high rainfall in the Fleurieu Peninsula, most of the water courses have a seasonal flow. The most persistent and regular flow occurs in the Myponga River and to a lesser extent in the Inman River.

ECONOMIC GEOLOGY

Mineralization and Mineral DepositsMineralization in the Archaean Terrains

The intensely intruded gneisses, mica schists and migmatites which form the bulk of the Archaean terrain appear to be the most promising formations for mineral searches in this area. Quartz reefs, pegmatites, and hematitic and titaniferous veins are abundant; and of special significance is the presence of the calc-magnesian silicate rocks (rich in albite, diopside, sphene, apatite, and epidote) which form the host-rock of the uranium minerals found at Houghton, near Adelaide. These tough and beautiful formations may be easily distinguished in the field owing to their uncommon aspect. The freshly broken surfaces have a grey colour with characteristic dark-green and pink shades, and the outcrops are unusually well marked owing to a great resistance to weathering and erosion. Significant findings of radioactive minerals associated with these beds have already been located at Little Gorge (monazite pegmatite) and near the Little Gorge farm, where a sodic albite pegmatite carries uraniumiferous minerals as accessory constituents. Nearby, copper mineralization occurs in epidote-quartzite beds, suggesting mineralization controls comparable to those which have been recently recognized in other parts of the State. The calc-magnesian silicate rocks (epidiorite or epidote syenite of earlier writers) have been mapped with accuracy throughout the area as a guide for uranium prospecting.

The importance of these Archaean formations as a potential source of uranium has been confirmed by the pitchblende deposits discovered in October, 1953, in the Wild Dog Creek area, near Myponga. The country-rocks comprise perthitic gneisses, orthoclase gneisses, and sillimanite-garnet gneisses, which grade in places to albitized rocks of metasomatic origin and contain bands of epidotized gneisses of the Houghton type.

The lodes are known to contain pitchblende, gummite, curite, kasolite, beta-uranotil, urano-spinite, and possibly meta-autunite. Albite occurs in direct association with pitchblende and its alteration products. Two distinct occurrences have been located so far. One would appear to be controlled by a shear, marked by abundant flaky mica (phlogopite), biotite, and muscovite. In the other one, the minerals occur in the hinge of a local anticlinal fold, where it seems to be due to metasomatic processes. As the lateral extension of the lodes is marked by soil and vegetation, their geological control is still obscure. It may, however, be accepted that both albitization by metasomatism and structural features played a role in the emplacement of the ore.

Mineralization in the Adelaide System Beds

Though frequently intersected by quartz veins, the Adelaide System sediments have not yielded minerals of economic value in this area, except dimension stone and crushed rock for building purposes. They are not mineralized to any significant extent, and mineral prospecting in these beds appears likely to be discouraging.

Mineral Deposits in the Cambrian Formations

Numerous but small and scattered patches of silver-lead minerals have been found at Carrickalinga Head, associated with the Cambrian Archaeocyathinae limestones, and in the Rapid Bay zone where they occur in the same stratigraphic

horizon, i.e. in the Rapid Bay marble. The main ore mineral is galena, replacing the limestone in the most irregular manner. A few hundred tons of mineral has been won from the Wheal Coglin and the Olivaster mines near Rapid Bay, averaging 50 per cent lead and 25 oz./ton silver. But the weak and irregular mineralization and the absence of a definite geological control made the occurrence unattractive for further exploration.

Copper has been won at intervals at Yattagolinga, easterly of the Rapid Bay quarry, apparently from a crush zone in the limestone. The minerals are chalcopyrite, malachite, and azurite replacing the country-rock along the bedding planes. The mineralization is manifestly too poor for development, and the deposit has been abandoned after unsuccessful drilling in depth.

Alunite deposits also occur at Carrickalinga Head and near Rapid Bay in the form of nodules disseminated in reddish-brown shaly or slaty rocks of the "multi-coloured slates horizon", near the contact with the underlying Archaeocyathinae limestones. They appear to be due to the action of water rich in hydrogen sulphide, which took clay from the country-rock. Their excessive dissemination and irregularity is responsible for unsuccessful attempts at exploitation.

The marble of Rapid Bay forms the most valuable material of the Cambrian formation. It is worked on a large scale by The Broken Hill Proprietary Co. Ltd., which uses it as flux for steel furnaces at a rate of over 500,000 tons yearly. The rock is a rather coarse one, usually fairly massive, but intersected by jointing planes, fissures, and crush lines, which facilitate the mining operations. Particular attention has been paid by the writers to the geological conditions of this marble which has been previously described as an enormous but isolated lens. Its shape is, truly, a lenticular one, but in no sense does it form an isolated stratigraphic body. To the southwest, at about 1,000 yds. from the quarry, this marble rapidly becomes thin without, however, losing its continuity. At some 1,000 yds. westerly of Mt. Rapid it is seen nosing sharply in an overturned anticline and then continuing in an easterly direction, towards Second Valley. To the east of the quarry the worked marble beds are soon covered by glacial and alluvial drift of the Yattagolinga River. But they reappear soon on the east bank of this river, forming the upper edge of the coastal cliff between Second Valley and Rapid Bay. In brief, the Rapid Bay marble belongs to a unique stratigraphic horizon, which is formed as a whole by limestone and broken in places by layers of more argillaceous beds. The great variations of thickness and local break of its continuity is principally due to folding, shearing, or thrust in a highly incompetent and plastic material. In particular the great thickness of the marble horizon worked at the quarry is the result of tectonic repetitions along the axis of the major anticline which dominates the structural pattern of the area. It is the intense and minute folding which makes this deposit relatively easy to operate and of a practically inexhaustible supply.

Mineral Deposits in the Kanmantoo Group

Although younger, the formations of the Kanmantoo Group are more interesting as mineral-bearing strata than the underlying Cambrian and Adelaide System beds. This is due to the position of the Kanmantoo Group in the Mt. Lofty Range arc system. They belong to an internal portion of the geosynclinal area which has been intruded by plutons of granite (Victor Harbour granite) during or just after the early Palaeozoic orogeny. In relation with this magmatic activity, regional metamorphism developed locally and mineral-bearing solutions injected the country-rock in various places.

The Callawonga Creek wolfram deposit (Queen Mary wolfram mine) discovered in 1911, worked till 1918, and re-opened in 1952, is associated with quartz veins of pneumatolitic origin which intruded the Kanmantoo beds over an area of 1 sq. mile at least. One of these quartz-felspar-tourmaline veins carried ferberite and to a lesser degree gold and yttrium. In recent petrological investigations one of the writers (Whittle) recognized traces of xenotime and zircon.

In a 140 ft. long, 15 ft. deep and 2 to 12 ft. wide open cut, 312 tons of 0.8 per cent ferberite ore had been won up to 1918. As the deposit is expected to extend along the strike and dip, it is of economic significance depending on the price of wolfram. The surrounding and extensively developed quartz veins appear also of potential economic interest and are worthy of closer prospecting.

Another fairly important deposit associated with the Kanmantoo beds is the silver-lead lode of the Talisker mine, 3 miles N. of Cape Jervis. It was exploited from 1862 to 1872, and five lodes have been recognized, only one of which, however, was worked. The lodes occur in the Cambrian (or possibly upper Proterozoic) slates, phyllites, or schistose slates, forming an acute sheared and overturned anticline, which pitches toward the southeast and is flanked by a great thickness of Kanmantoo beds. This important structural element, which has not been recognized during previous local investigations, plays presumably a major role in the general mineralization control of the deposit. The lode is composed of quartz, arsenical pyrite, and argentiferous galena, the mineral won having a general average of 40 oz. silver per ton, the ratio of silver to lead being one ounce of silver to one unit of lead. The mine is an interesting prospect and there are indications of potential reserves which may justify developmental work in depth.

Hydrology and Water Supply

The Cape Jervis - Yankalilla area is one of the wettest in the State. Precipitations up to 40 in. are registered on the elevated plateau region, whereas the lower lands average an annual rainfall of 25 to 30 in. and over. However, the precipitations take place in autumn, winter, and spring only, the summer being a dry and warm one. Thus problems of water supply for irrigation purposes and for stock arise, a good deal of the area being admirably suitable for dairy farming, lucerne, and vegetable growing. Attention has therefore been paid in the field to the general hydrogeology of the region, with special regard to springs, underground water systems, and water conservation schemes.

Springs

In the portions of the elevated plateau areas now in process of being cleared for agricultural development, numerous springs have been recognized and observed by the writers at different periods of the year. Their hydrogeological conditions are quite clear and fairly uniform throughout the area. They form soaks at the head of the creeks which drain and dissect the plateau slope, at the edge of the old flat surface. The water-bearing stratum is an argillaceous deeply weathered and frequently lateritized material formed in situ at the expense of the underlying Kanmantoo formations, the soaks occurring at or near the contact of the unweathered country-rocks. It has been observed that the flow is ordinarily small (of the order of 500 - 5,000 gall. daily, at most, during the summer season), but it is generally permanent depending on the extent and retentive power of the water-bearing blanket. The good drainage conditions allow the free movement of the water in store and are responsible for

a low degree of salinity. Thus the permanence of flow, and the frequency and low salinity of these springs are of great value for grazing and dairy farms. The supply may be increased by adequate traps, such as underground drainage trenches or pipes, or open channels in the swamps which form downstream; but they can not be expected to provide supplies great enough for irrigation purposes.

Underground Water Supply

Well defined aquifer horizons do not occur in the zones occupied by Archaean, Proterozoic, or Kanmantoo Group formations. The presence of fissured quartzites, faulting, or brecciation may assist underground water storage in these beds, but the difficulty of locating such traps is great and the results are always uncertain.

The most favourable formations for underground water supply are the Miocene limestones, the Pleistocene gravelly beds, the Recent alluvial deposits, the Permian glacial material, and the Cambrian limestones and marbles.

Aquifers in the Miocene Polyzoal Limestones:--- These may be expected in the Myponga Plain at a depth of 200 to 600 ft., as well as at Sellick Beach from 150 ft. downwards, according to the topographic location of the bore. A good supply may be reasonably expected in both localities. In the Myponga Plain at least the water should be of good quality and suitable for vegetables or lucerne growing.

Aquifers in the Pliocene Gravels: --- Aquifers are also present in these zones, up to 250 ft. or so in depth. Their location is however more difficult, owing to rapid lateral changes in the composition of these beds and their high content of impervious clay.

Alluvial Deposits: --- The alluvial deposits along watercourses contain shallow-water sheets which are quite important for farming and limited gardening purposes. Especially at the contact with impervious country-rock, reasonable supplies may be obtained in many instances, but the flow will be limited and variable according to the season.

Permian Glacigene Beds: --- These beds are another potential source of underground water supply. The geological disposition of these deposits is illustrated by plates IX and X. Aquifers may be struck by bores at the contact of an upper sandy layer with a lower clayish one, as is the case, for instance, in the Robinson Hill region (Inman Valley) and elsewhere. The contact of the glacial beds with the country-rock is another favourable surface, owing to the fact that near the basement the glacial material is frequently coarse, and rich in pebbles, cobbles, or blocks embedded in a sandy matrix. But it should be remembered, before starting a costly bore, that aquifers in these beds are not easy to locate owing to the variable nature of the deposits, so rich in compact, impervious, and thick layers of clay. Another element of uncertainty is the depth at which the bedrock will be intersected; from a few feet to 1,000 ft. and possibly more in some cases, as evidenced by the bores sunk in Back Valley (see plates IX and X). Briefly, the glacial and fluvioglacial terrains may carry significant underground water sheets, but the search is frequently difficult and expensive. Detailed geological and geophysical investigations may be of great assistance in determining the depth of the bedrock and the probability of intersecting water-bearing formations in the overlying glacial beds.

Cambrian Limestones and Marbles: --- These may also be considered as a potential source of underground water. Well developed jointing and fissures, frequent brecciation, and dissolution channels, facilitate the percolation of water through these beds; their intense dragging and folding, and the impervious nature of the slates wrapping them, suggest underground water traps in synclines or along faults and thrust planes. The difficulty of locating such traps has not, however, to be overlooked, as the required geological details are frequently obscured by travertine, debris, or vegetation or by too severe tectonic deformations.

Water Conservation

If springs, groundwater supply, and small earthdams cover the ordinary needs of domestic and stock water, and allow occasional and limited irrigation, it is only by more important water conservation works that irrigation on a large scale can be carried out. Only one permanent watercourse drains the area, i.e., the Myponga Creek, the damming of which is already under consideration.

The Myponga dam is therefore a work of major interest for the economy of the State as a whole. It would appear to be the only possible scheme of such a magnitude in the area concerned, as the other watercourses have smaller catchment areas and only seasonal flow. Other minor irrigation schemes may however be based on the damming of seasonal creeks with a high winter flow. In places, narrow gorges and a relatively low stream gradient would allow good storages at a cost which does not appear uneconomical for groups of holdings favourably located and potentially fertile. This may not be of an immediate interest, but it has possibly to be considered when closer settlement and intensive agricultural developments become paramount.

Soil Erosion and Erosion Control

A most disturbing factor in the rural development of the area concerned is the widespread soil erosion.

The process started as a result of clearing, stocking, and the activity of rabbits, and is going on rapidly as no erosion control has been seriously attempted. It mainly affects the low land occupied by the glacial sand and clay of the Inman Valley - Myponga - Yankalilla - Second Valley area where many prosperous holdings show extensive development of furrows, gullies, top soil abrasion, and landslides. Field surveys and computation from aerial photographs have shown that some 20 per cent of the area covered by the map is severely damaged, the soil in some localities being attacked throughout the whole property. As the erosion develops in a geometric progression, it would appear that some of the best agricultural holdings will be of little value in a few decades.

As stated, the erosion is more severe in the glacial terrain (or reworked derivatives), as they are as a rule unconsolidated and therefore easily attacked and removed. An apparently insignificant furrow, open at first in the clayish or sandy soil on a line of drainage, a crack or a rabbit hole, in the wet season develops a channel, one of which has been seen by the writers to reach 120 yds. in length and 4 ft. in depth in a few weeks time. A deep and narrow gully is soon established, which ramifies rapidly at its head, stimulating a process which culminates finally in a landslide.

It is out of the scope of these notes to discuss methods of erosion control to be applied in the area. It suffices to mention that in the milder cases limited afforestation along the drainage channel would be an easy, inexpensive, and quite adequate way of healing existing soil wounds and preventing potential ones from developing. Light civil engineering works are necessary in other cases.

It would also seem desirable to study the consequences of clearing the large areas of the lateritic plateau formerly considered as unsuitable for rural development and left therefore uncleared. As a result of the discovery of the trace element theory, these leached tablelands are now usable, and clearing work is proceeding on a large scale. This will undoubtedly bring new holdings into production, but it may be questioned whether the applied methods of destroying all the existing arborescent vegetation, without growing a new one, is, in the long run, really sound. A careful planning of the clearing process appears to be important. It should be remembered that the total deforestation of the elevated plateau between Myponga and Inman Valley and southerly of Back Valley will greatly stimulate the erosion in the lower glacial depressions, which, as stated, are extremely sensitive to any disturbance of the natural drainage conditions.

It is estimated that the total clearing of the plateau area will increase up to 3 times the winter run-off of main watercourses. This increase will add strength to the erosion process which is already powerfully at work. At the same time a greater tendency for drying up of soaks in the dry seasons is to be expected.

It would appear to be of great scientific and economic interest to study, in the course of time, the hydrologic behaviour and changes related to the clearing of these extensive areas of elevated land. (28/2/54).

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PLATE I



Fig. 1

? Late Pliocene to Pleistocene clay and gravel (P) resting unconformably on Miocene polyzoal limestone (M) at Sellick Beach.

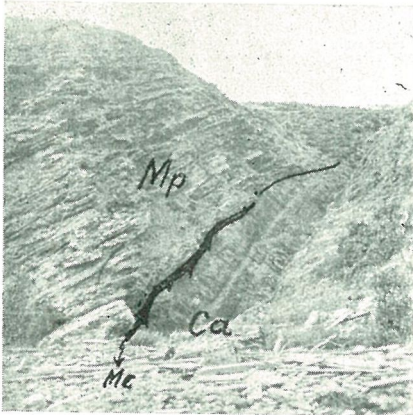


Fig. 2

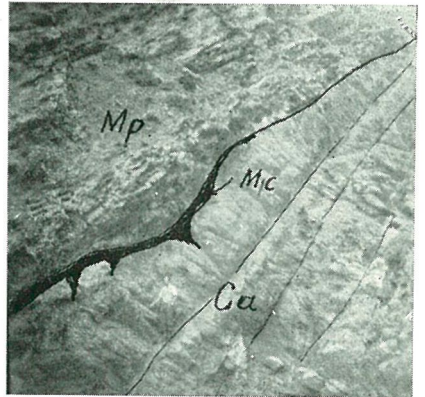


Fig. 3

Tilted Miocene beds, transgressing with angular unconformity on Cambrian slates. Cliff one mile S.W. of the mouth of Mount Terrible Gully, Sellick Beach. Mp = Polyzoal limestone, Mc = Miocene basal conglomerate, Ca = Cambrian slates with phosphate nodules.



Fig. 1

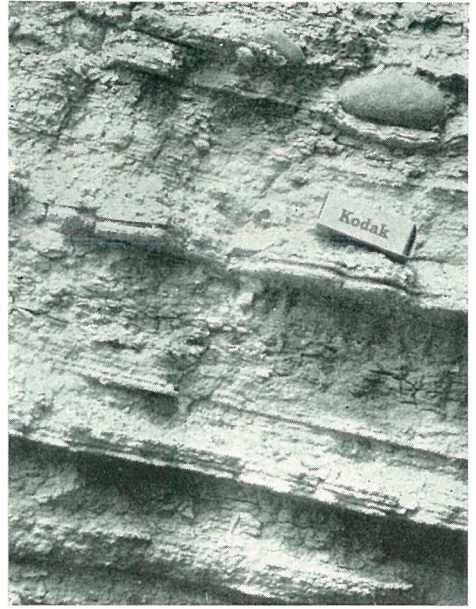


Fig. 2

Fig. 1.—Permian boulder clay (Cl) resting unconformably on Cambro-? Ordovician greywacke of the Kanmantoo Group (K). Gr = Victor Harbour granite as erratic. Cape Jervis, along the cliff north of the jetty.

Fig. 2.—Varved formations interbedded in the boulder clay at Cape Jervis.



Fig. 3

Well worn pebbles of the Permian tillite, showing one prominent polished surface.

PLATE III



Fig. 1

Sturt tillite, at the mouth of the Congeratinga River.

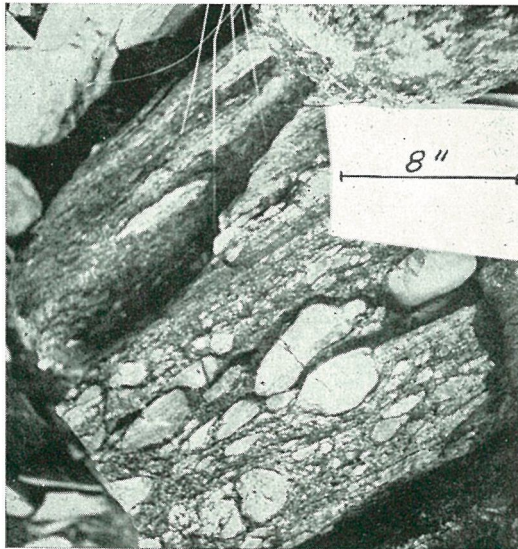


Fig. 2

Basal conglomerate of the Adelaide System showing voluminous pebbles stretched and elongated along the formation dip.

PLATE IV



Oblique aerial view of the coast north of Cape Jarvis, showing east dipping greywackes of the Kanmantoo Group. Patches of Permian glacial deposits rest on the greywacke, near the shore. C = Cambro-? Ordovician greywacke; Pt = Permian tillite.

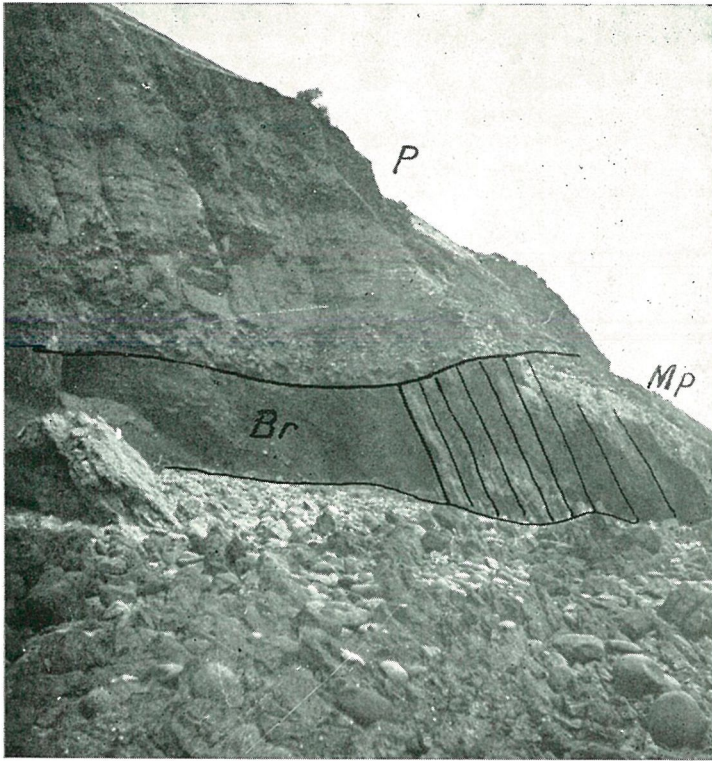


Fig. 1

Orogenic movements as recorded at Sellick Beach.

- Br = Brecciated Cambrian slates.
- Mp = Miocene polyzoal limestone resting unconformably on Br.
- P = Pleistocene clay and gravel resting unconformably on Mp and Br.

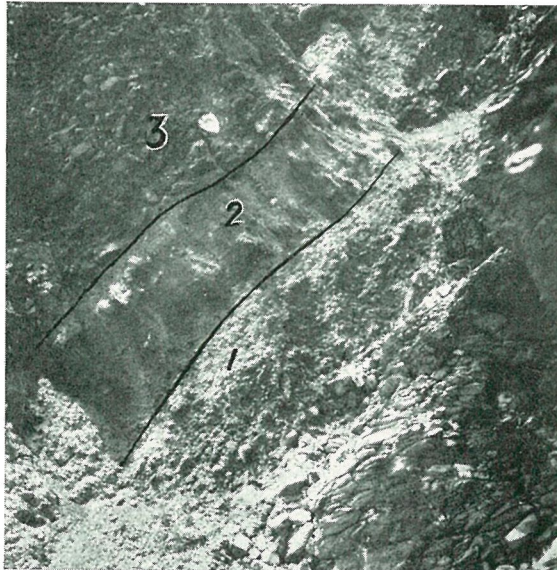
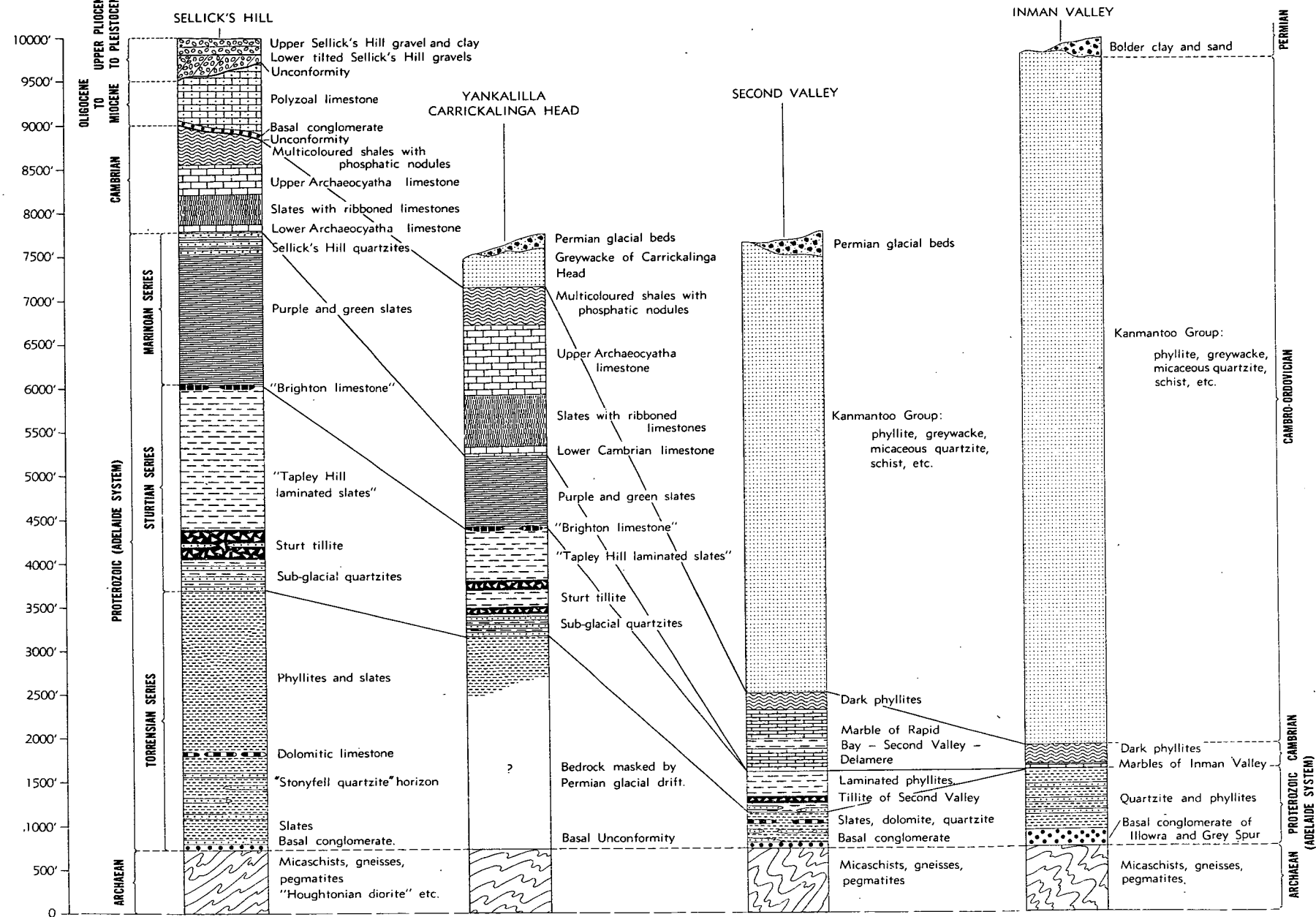


Fig. 2

Tilted Pleistocene upper gravel at Sellick Beach, near the mouth of Mount Terrible Gully. (Post Pleistocene movements).

- 1 = Gravelly clay.
- 2 = Clayey sand with scattered pebbles.
- 3 = Coarse gravel.

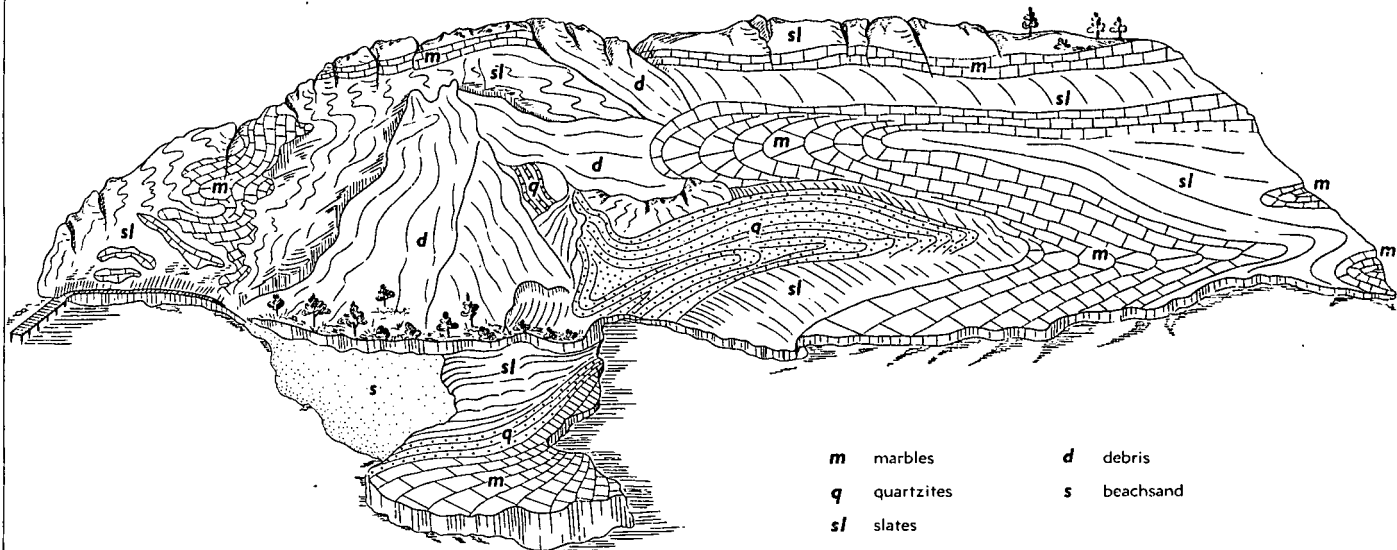
STRATIGRAPHIC SEQUENCES AND THEIR CORRELATIONS IN THE SELICK'S HILL, YANKALILLA, SECOND VALLEY AND INMAN VALLEY AREAS



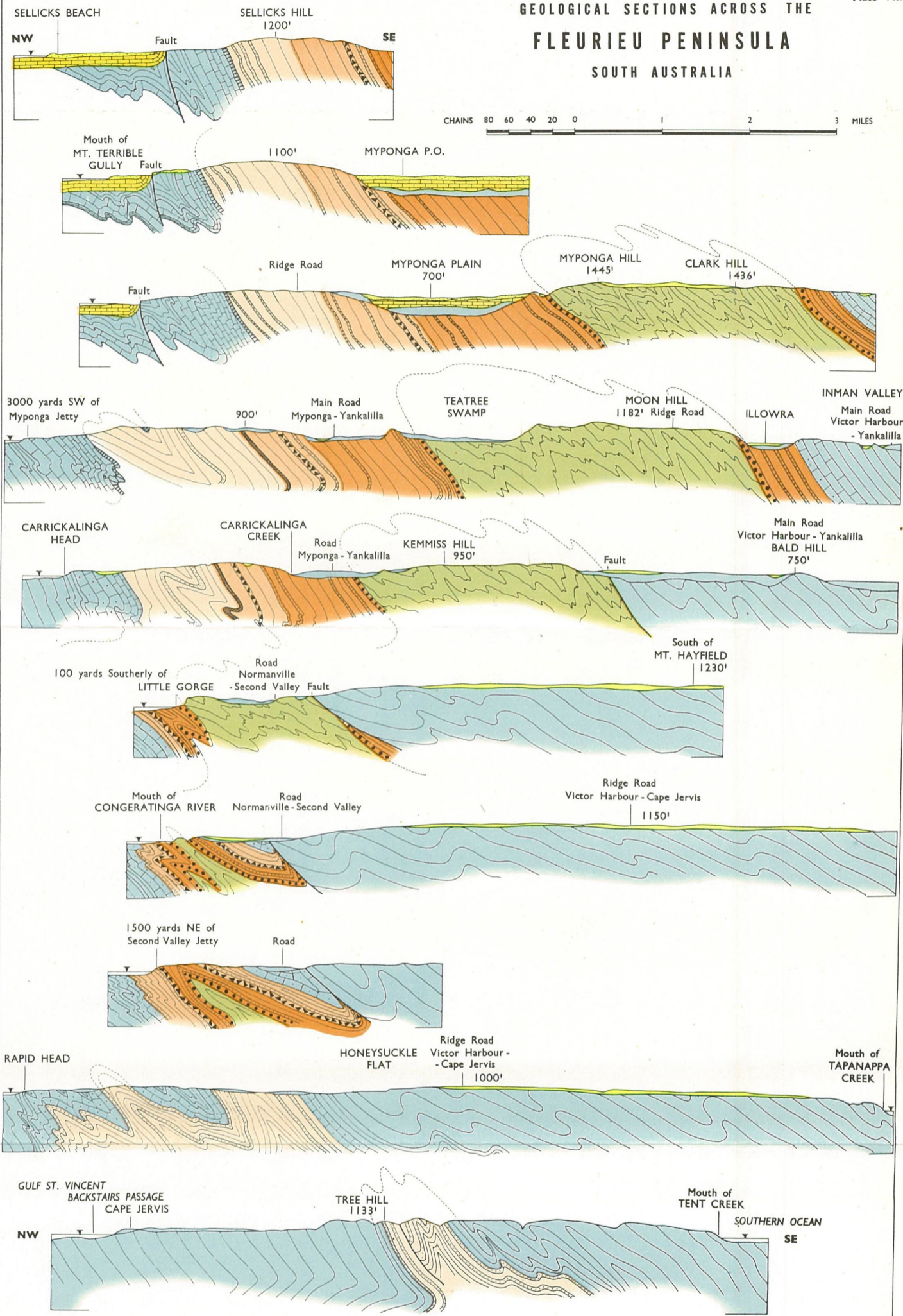
B. Wilson, B.Sc., B. Campana, D.Sc., 1953.

CLIFFS AT SECOND VALLEY JETTY

SHOWING FOLDING AND DRAGS IN CAMBRIAN
MARBLES, QUARTZITES AND SLATES



GEOLOGICAL SECTIONS ACROSS THE FLEURIEU PENINSULA SOUTH AUSTRALIA



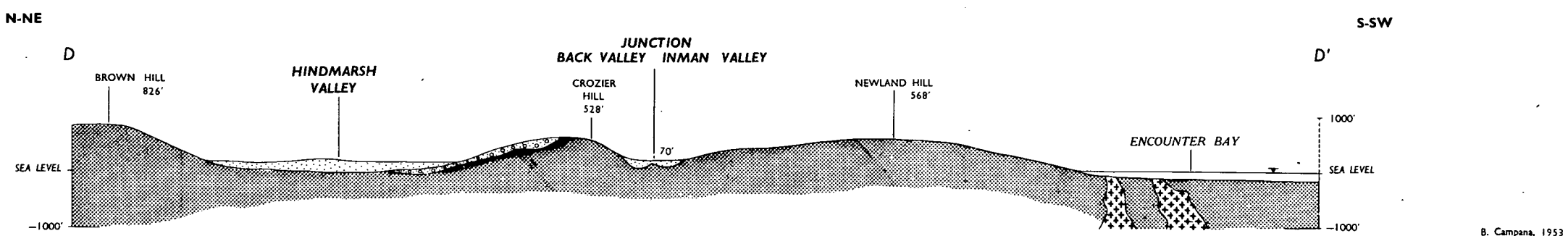
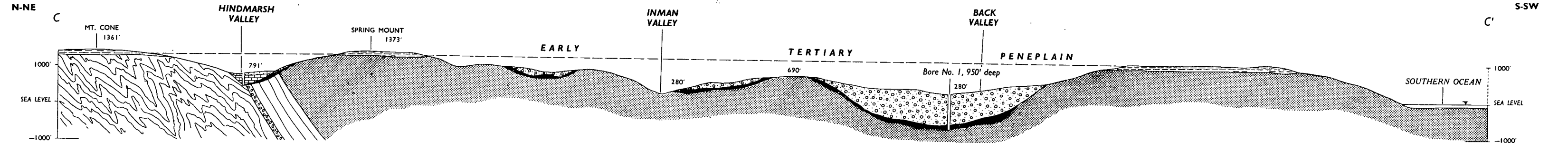
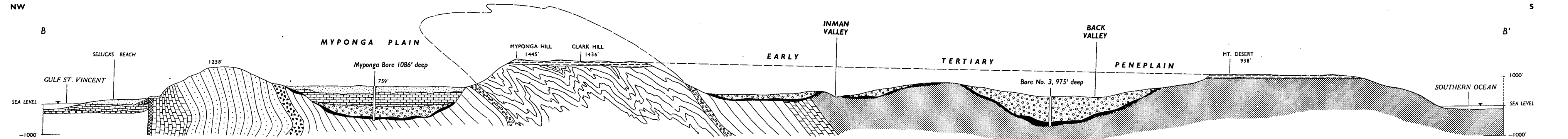
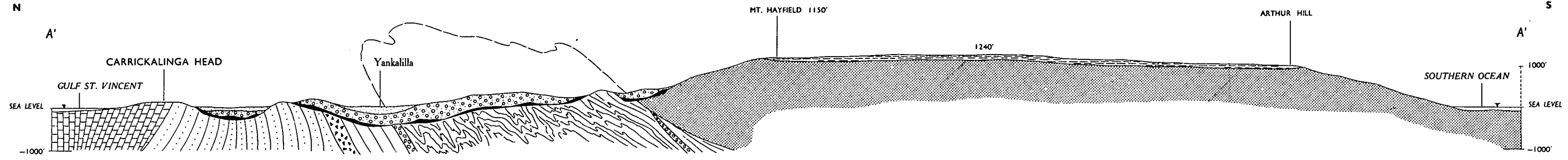
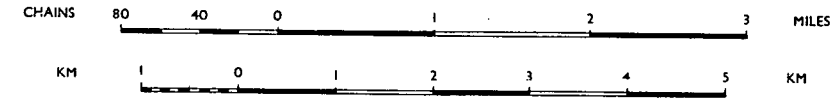
- QUATERNARY**
 - Yellow box: Quaternary undifferentiated (and lateritic capping of plateau).
 - Yellow box with dots: Pleistocene clays and gravel of Selicks Beach and Myponga.
- LOWER MIOCENE**
 - Yellow box with horizontal lines: Polyzoal limestone.
- PERMIAN**
 - Blue box: Moraines and reworked derivatives.

- CAMBRO-ORDOVICIAN**
 - Blue box with horizontal lines: Kanmantoo Group: greywacke, micaceous quartzites, phyllites, etc.
- CAMBRIAN**
 - Blue box with horizontal lines: Multicoloured slates with phosphatic nodules.
 - Blue box with horizontal lines: Upper Archæocyatha limestones and marbles.
 - Blue box with horizontal lines: Rapid Bay and Delamere marble.
 - Blue box with horizontal lines: Calcareous slates, grits and mottled limestone.
 - Blue box with horizontal lines: Lower Archæocyatha limestone.

- ARCHAEOZOIC**
 - ADELAIDE SYSTEM**
 - Orange box with horizontal lines: Upper quartzites and sandy slates.
 - Orange box with horizontal lines: Purple slates with minor gritty layers.
 - Orange box with horizontal lines: "Brighton limestone".
 - Orange box with horizontal lines: "Tapley Hill laminated slates" in the Rapid Bay area.
 - Orange box with horizontal lines: Sturtian and Marinoan Series undifferentiated.
 - Orange box with horizontal lines: Sturtian tillite with quartzites and slates.
 - Orange box with horizontal lines: Slates.
 - Orange box with horizontal lines: Quartzites.
 - Orange box with horizontal lines: Basal conglomerate.
 - ARCHAEO**
 - Green box with horizontal lines: Archæan complex: micaschists, gneisses, pegmatites, etc.



GEOLOGICAL SECTIONS ACROSS
PERMIAN GLACIAL VALLEYS
 OF FLEURIEU PENINSULA
 SOUTH AUSTRALIA



- REFERENCE**
- PLEISTOCENE - RECENT: Upper alluvial clay, sand and gravel; Lower gravel
 - OLIGOCENE - PLEISTOCENE: Lateritic crust of the Pre-Miocene peneplain
 - PERMIAN: Marine limestone and sand with basal conglomerate (local)
 - PERMIAN: Mainly reworked glacial and fluvioglacial deposits; Clayish or sandy boulder till
 - CAMBRO-ORDOVICIAN: Micaceous quartzites, phyllites, greywacke and schists
 - CAMBRIAN: Fossiliferous limestones, slates and marbles

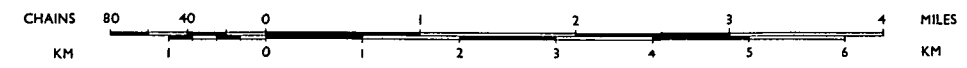
- PROTEROZOIC (ADELAIDE SYSTEM)**
- Slates, quartzites, dolomitic limestone
 - Sturt tillite
 - Slates and quartzites
 - Basal conglomerate
 - Schists, injection gneisses and migmatites
- Tectonic breccia**
- Victor Harbour granite**

LONGITUDINAL SECTIONS ALONG PERMIAN GLACIAL VALLEYS OF SOUTH AUSTRALIA

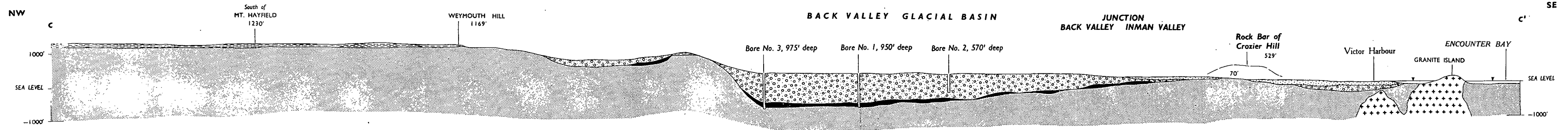
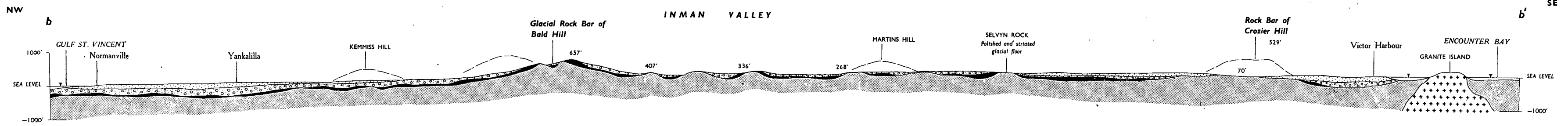
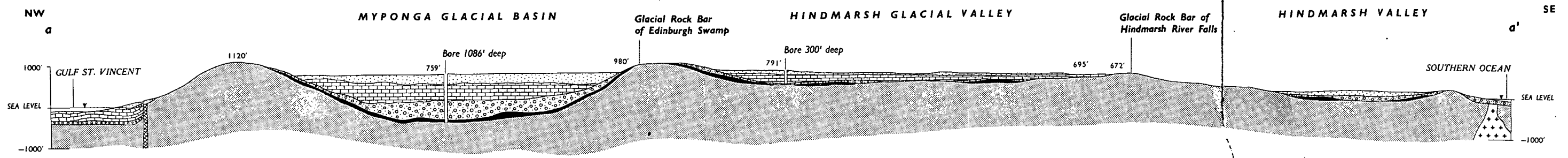


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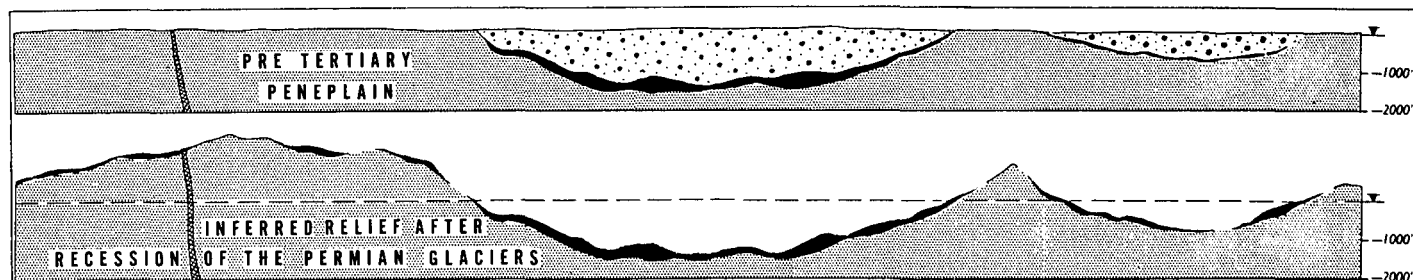
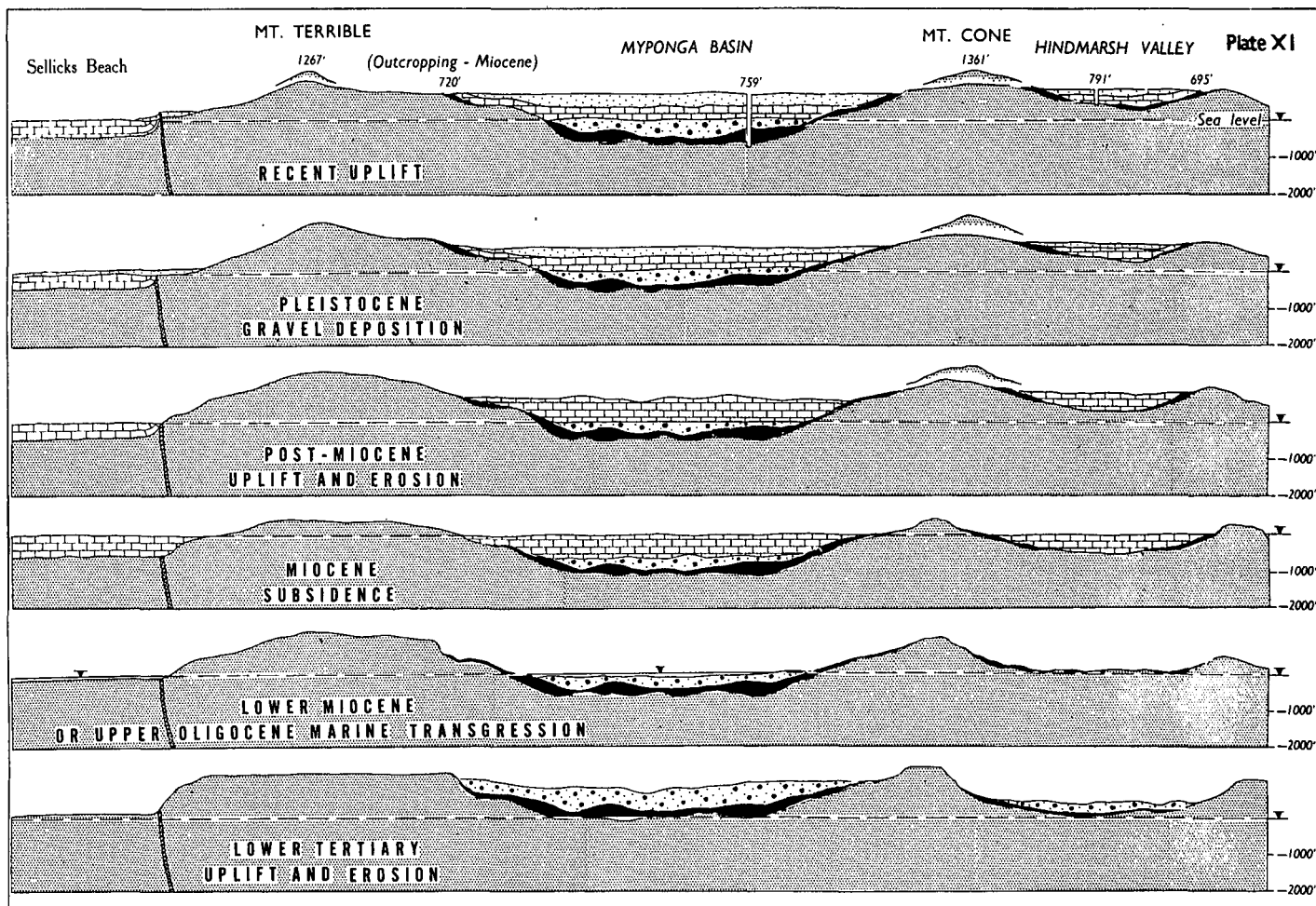
- PLEISTOCENE RECENT**
 - Upper alluvial clay, sand and gravel
 - Lower gravel
- QUATERNARY - MIOCENE**
 - Lateritic crust of the Pre-Miocene peneplain
- PERMIAN**
 - Marine limestone with basal conglomerate
 - Fluvioglacial and reworked glacial drift
 - Clayish or sandy boulder till
 - Undifferentiated Pre-Carboniferous sediments with intruded Victor Harbour granites
 - Tectonic breccia



← General direction of Permian glaciers



EVOLUTION OF THE FLEURIEU PENINSULA AFTER RECESSION OF PERMIAN GLACIERS



Pleistocene, alluvial



Fluvio-glacial and post glacial beds.



Pre-Carboniferous basement.



Miocene, marine beds.



Permian glacial beds.



Fault with tectonic breccia.