DEPARTMENT OF MINES

SOUTH AUSTRALIA

BRIEF EXPLANATORY NOTES TO ACCOMPANY THE GEOLOGICAL MAP, THE SOIL-SUBSOIL MAP AND THE PROSPECTING MAP OF THE TIPARRA-MOONTA AREA.

by

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INTRODUCTION:

The area of the Tiparra-Moonta Military sheet (scale ½ mile to the inch) has been mapped by the writer during 1954-55.

Aerial photographs on the same scale have been used as a topographic base for the plotting of the geological data in the field.

Unlike many other mapping terrains in which outcrops provide a reasonable basis for the identification of the rock formation and their structural features, the area surveyed is a plain mantled by Recent-Pleistocene deposits which conceal the rock formations.

For this reason the numerous excavations (dams, underground tanks, road metal quarries, prospecting pits, shafts and so on) were the chief sources of geological information.

The primary purpose of the present survey was to establish criteria for the geological classification of the area with special reference to the search for copper.

From this view point the soil and subsoil were formations of special interest.

A series of maps covering the subject has been compiled.

LOCATION AND TOPOGRAPHY:

The area surveyed is located in the south-western portion of County Daly and covers Hd. Tiparra, the southern portions of Hds. Wallaroo and Kadina and the western portions of Hds. Kulpara and Clinton extending from north to south about 20 miles and from west to east about 30 miles.

Three main physiographic units canbe recognized in this area:

1. The Kadina Plain (plateau) is characterized by a gentle slope to the north-west. The elevation is limited approximately by the 400-500 ft. surface contour above mean sea level in the south-eastern portion and by the coastal line with the 100-150 feet at the north-west with gradients ranging from about 0.005 to 0.001.

While the surface drainage is generally limited and there is no defined drainage system, a number of depressions, swamps

Fig. 1. Moonta Bay cliff (General view)
Cambrian rock in the foreground "Basal" clag and loessial silt with the travertine layers in the upper section of the outcrop.

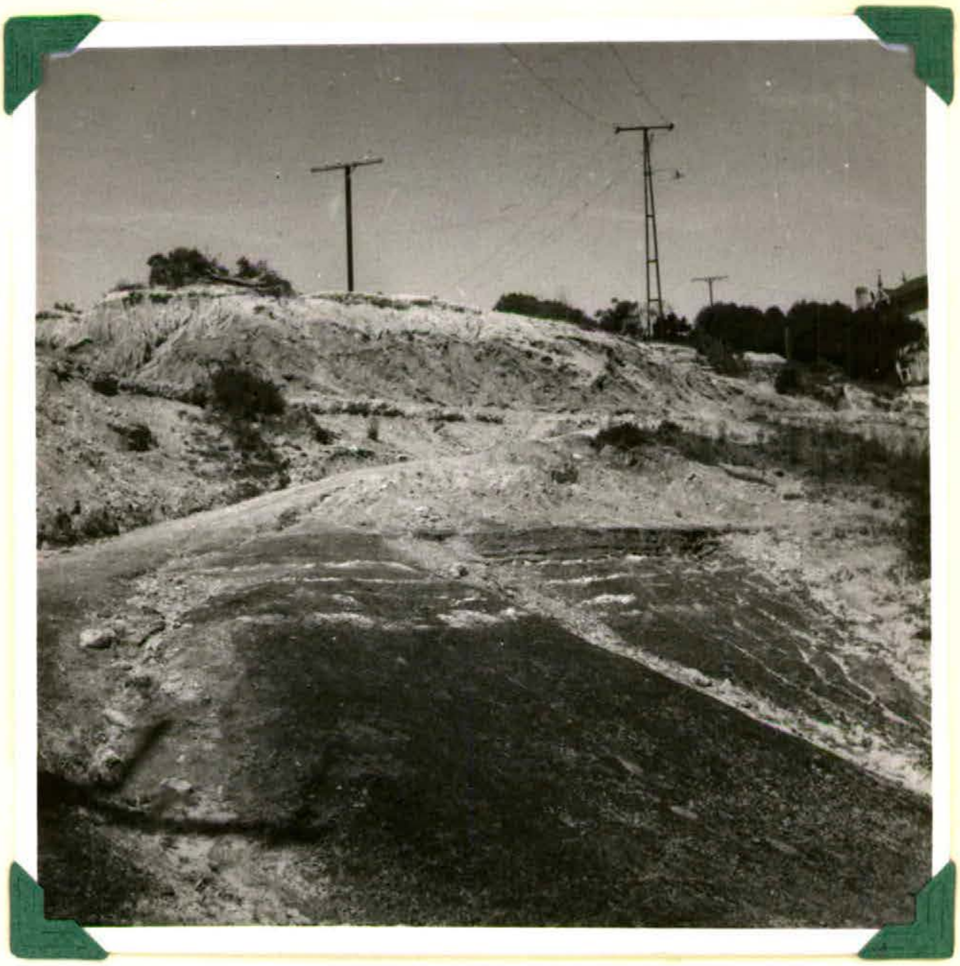

Fig. 2. Moonta Bay cliff (close view)
"Basal clay (in the foreground) and overlying loessial silt with travertine.

and seasonal lakes accumulating local run-off have been recognised and mapped (see maps).

2. The Tiparra Loessial Plain is undulating country with well-developed aeolian sand-silt ridges alternating with intradune depressions, the ridges sometimes rising 30-40 feet.

The trend of these sandridges is generally uniform being chiefly in a WNW-ESE direction.

The surface contours at 500 feet at the south-east portion of the area and 50-100 feet near the shore line determine the range of the elevation.

Extending westwards the Tiparra Plain gradually changes into the back shore dunes.

3. The Hill Country is in the Arthurton area and the eastern portion of the sheet.

This is a reasonably well drained area with the numerous salients indicating its complex physiographical development.

The highest elevation is found in the vicinity of Arthurton township where the surface contours of 700 feet, 800 feet and 850 feet are concentric in shape.

It is notable that while Quaternary alluvial deposits cover all of these three areas the type of soil and subsoil formation of each is quite distinctive.

STRATIGRAPHY:

Quaternary

Recent

1. Beach sand and related back shore dunes:

1. White-grey coarse siliceous sand usually with comminuted marine shell fragments; wind blown sand up to 30 feet in thickness forms back shore dunes nearly all along the coastal line; a travertine bed occurs in this sand in places.

2. Grey-whitish highly consolidated calcareous (travertine) crust often porous is well developed in many portions of the modern beach.

11. Swamp, marsh and lagoon deposits.

1. Grey saline loam often associated with travertine.

Fig. 3. Section showing the relationship of the travertine crust to underlying loessial silt and "basal" clay (Moonta B

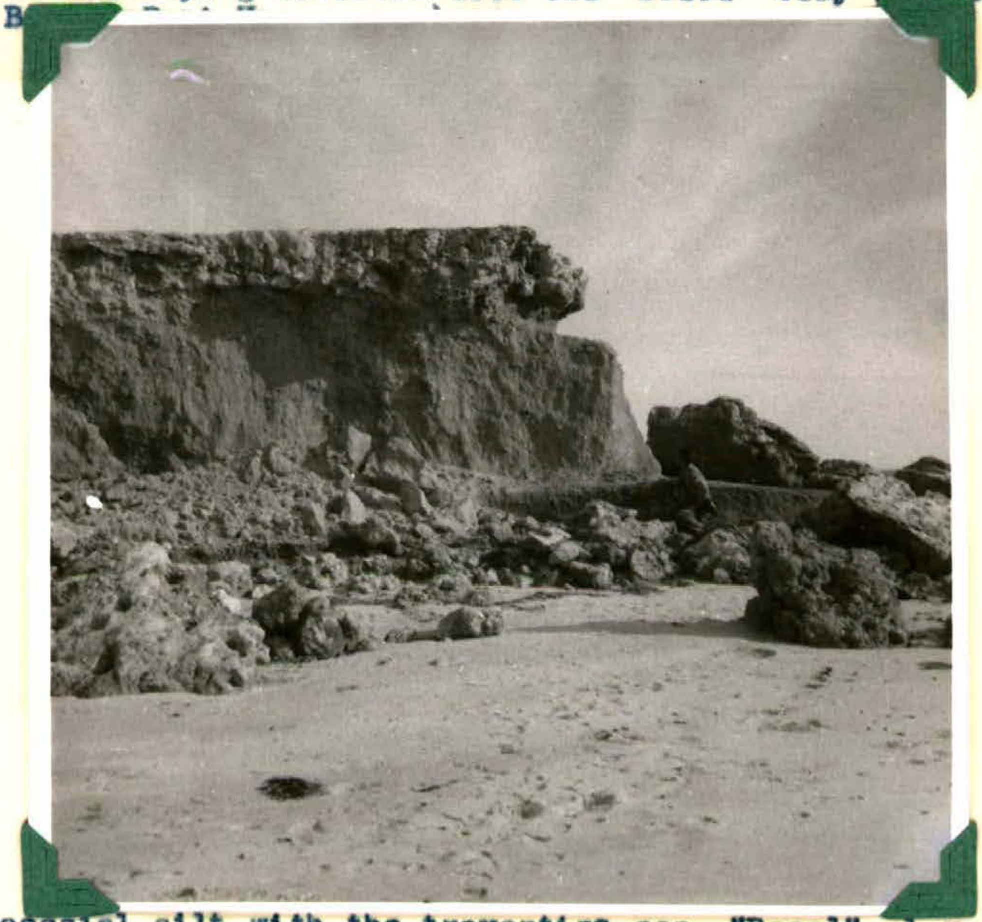

Fig. 4. Loessial silt with the travertine cap. "Basal" clay outcrops in the lower section of the profile.

2. Alluvial clay accumulated along the creek beds and the local depressions in the hilly portion of the country.

Recent-Pleistocene

1. Buff calcareous silt (loessial drift) often capped with nodular and tabular travertine. The latter is not uniform: it varies from round limey fairly loose calcareous accumulations a few millimeters in diameter dispersed throughout silt layers to highly consolidated agregates still round in shape (nodules) often many inches in diameter and further to a massive consolidated layer of travertine limestone.

The illuvial travertine horizons are very common in calcareous silt as frequently observed in numerous road cuttings

The colour of the travertine is generally uniform, chiefly greyish-white but darkish blue and black nodules often occur also.

The thickness of the travertine varies considerably from a few inches to 4-5 feet.

Downwards, the buff calcareous silt is substituted in places for reddish-brown calcareous silt, that can be termed "terra rossa". The section observable in the sea cliffs at Wallaroo where "terra rossa" overlies Tertiary limestone is most instructive in this respect.

Figs. 9-14 show the structure of the travertine bed and its relationship to the underlying silt.

2. Calcareous fine-grained sand and sand dunes comprising upper ("recent") grey sand up to 5-6 feet in thickness and lower ("old") reddish-yellow sand usually 4-5 feet in thickness.

Fig. 15 shows the succession as observed in the road cutting along the main Moonta-Maitland road.

3. Greyish-white "shelly" travertine is associated with lagoon deposits in places the thickness of which is usually as much as 3-4 feet.

This bed consists of marine shells cemented by travertine in solid mass.

It is assumed that this area has been encroached by the

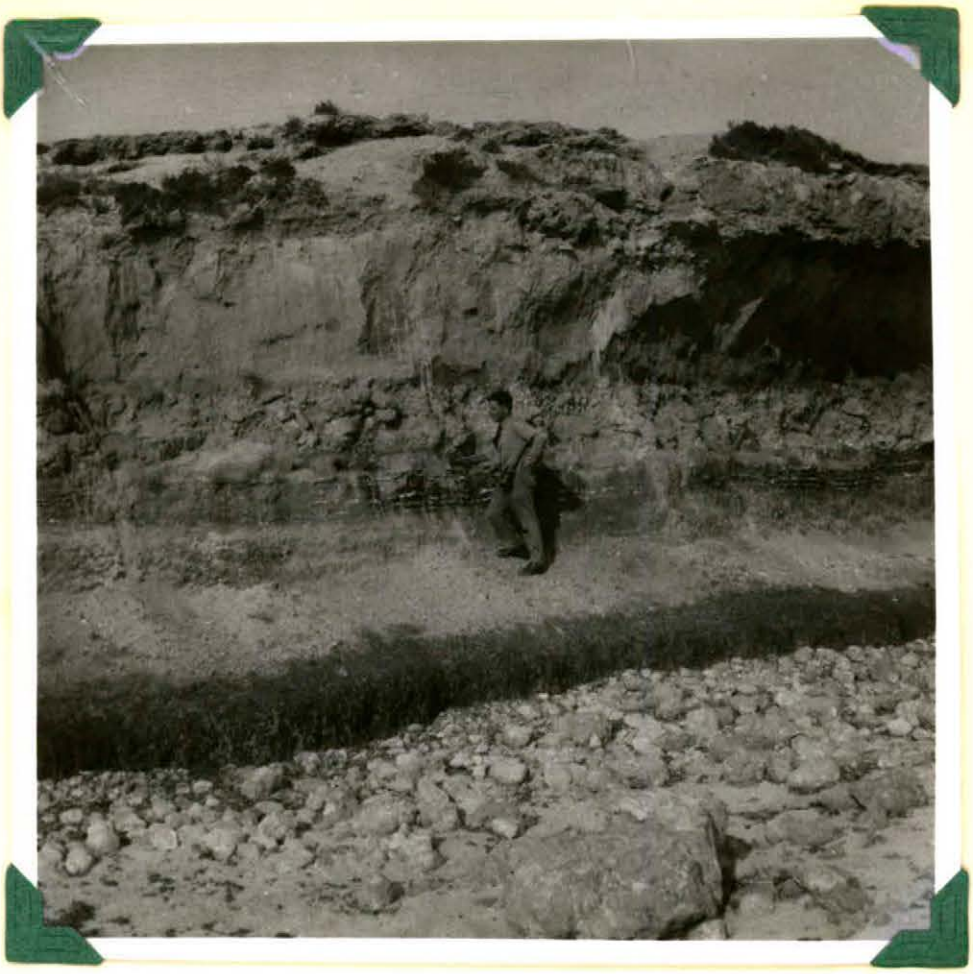

Fig. 5. Section showing the contact between "basal" clay and the overlying travertine bed. Granite - aplite outcrops just below "basal" clay (granite in association with the blocks of travertine is seen in the foreground).

Fig. 6. Calcareous seams in the upper section of "basal" clay underlying the lower travertine bed (Moonta Bay) (close view of Fig. 5.)

sea (?Osborne sea coast).

Tertiary

(?) Pliocene

"Basal" clay. This is red (ferruginous) compact plastic clay with some greyish-green patches in places gradually passing into an ochreous, reddish-brown and yellowish clay.

The thickness of "basal" clay varies from 5 feet (Moonta Bay - Port Hughes area) up to 8-10 feet (Mineral lease No. 1046, Moonta mines).

This clay is generally widespread in the Kadina-Moonta area, but it seems that its morphology and probably genesis are different in the various sections of the area surveyed.

Figs. 1-6 illustrate the occurrence of "basal" clay and its relationship to overlying formations in Moonta area.

(?) Miocene

Limestone. This is a yellowish-buff and white consolidated bed and is highly fossiliferous. One of the most important sections illustrating the texture of the limestone bed and its relationship to the overlying Quarternary succession is exposed in the Wallaroo cliffs.

Nodular concretions alternating with clay material form the upper section of this formation which overlies massive layers of fossiliferous limestone.

In the quarry located at Sect. 68, Hd. Kadina, the Tertiary limestone is massive and is widely used for building purposes although relatively soft clayey patches are not unusual.

Generally the Tertiary limestone occurs in the area surveyed only as remnants capping the underlying Cambrian formation.

This fact must be taken into account when the compiled maps are considered.

The thickness of Tertiary limestone is unknown but it is presumed to be about 12 feet at maximum.

Fig.8 shows the Tertiary limestone and overlying "terra rossa" loessial silt and travertine cap as observed in the

Fig. 7. Section showing brown calcareous soil, nodular and tabular travertine and Cambrian quartzite (Hd. Kulpara).

Fig. 8. Section showing 1.travertine cap, 2.loessial silt, 3 "Terra Rosa", 4. Tertiary limestone (Wallaroo cliff)

Wallaroo cliffs.

Cambrian

Limestone forms the upper section of this system being well exposed in the Wallaroo cliffs and elsewhere on the eastern margin of the area surveyed.

This is medium to dark grey highly consolidated finely crystalline dolomitic limestone and buff coloured cryptocrystalline and clayey limestone, which is often ferruginous.

In places finely crystalline limestone is in contact with quartz-felspathic sandstone.

Fig.16 shows a section of Cambrian limestone as observed in the railway cutting at Wallaroo.

There are no more outcrops in the area surveyed, but the chips of limestone from the numerous excavations have been indentified in the field and by subsequent petrological examination.

Quartzite. This is a highly ferruginous (when weathered) gritty felspar quartzitic sandstone traversed in places by finely crystalline calcareous veins. In outcrop (Port Hughes and elsewhere) the quartzite bed of brownish-yellow colour is characterized by current bedding and the presence of pebbles and other coarse-grained material

Conglomerate (quartzite-conglomerate) is the lowest formation of the Cambrian system. Well rounded and subangular pebbles of various rock types (granite, slate, quartzite, quartz) and of different sizes (the biggest are 3-4 inches in diameter) are numerous in a groundmass of the quartzite-conglomerate layers. Numerous joints traverse the conglomerate bed.

At Port Hughes conglomerate unconformably overlies Pre-Cambrian rock.

Pre-Cambrian Complex.

Sediments and Meta-Sediments

These are represented by slate, quartzite, quartz schist, mica schist, phyllite and altered limestone which form the

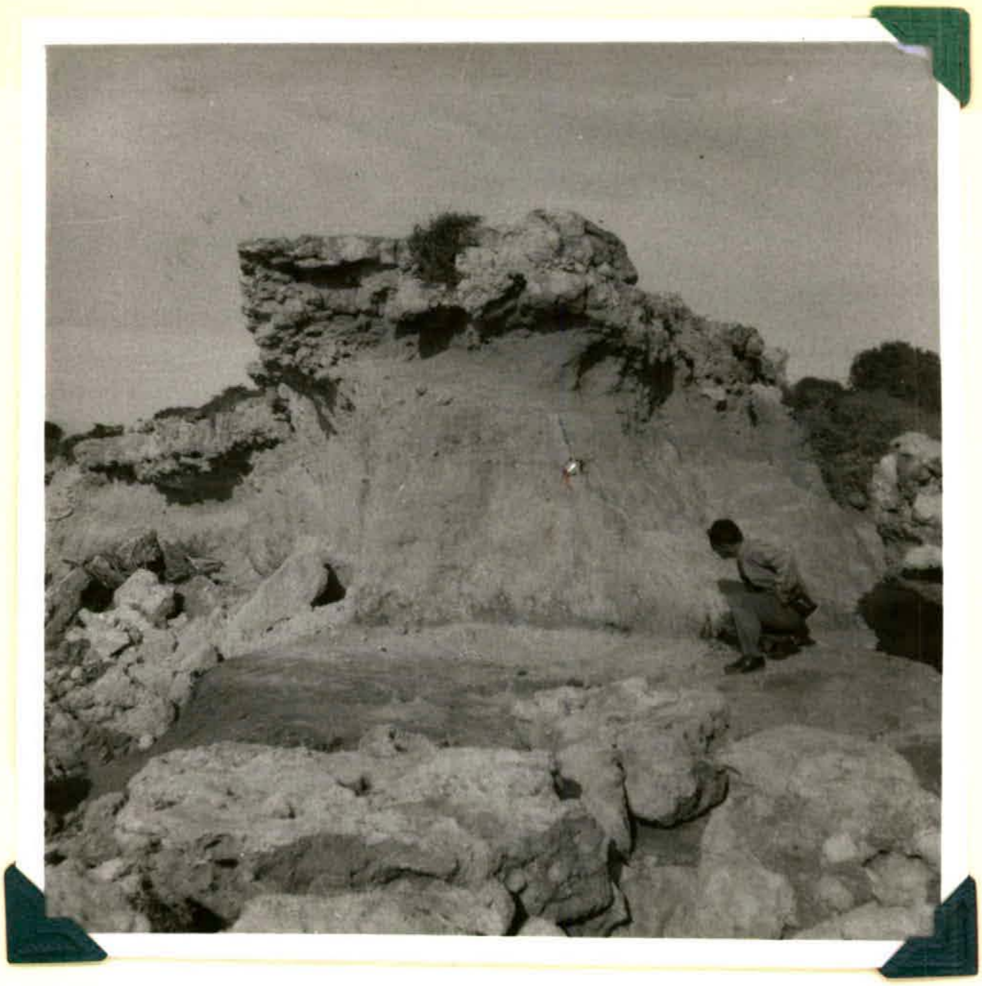

Fig. 9. Travertine cap and underlying loessial silt. Huge blocks of travertine in the foreground.

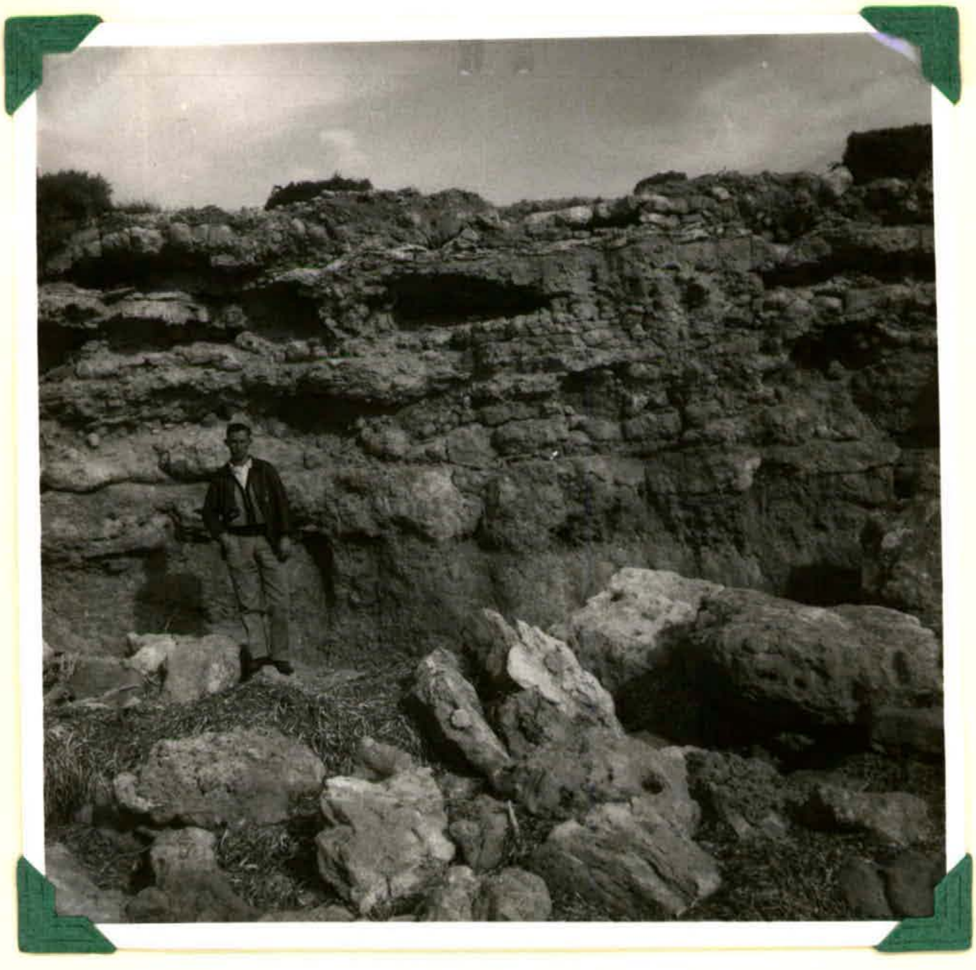

Fig. 10. Section showing a variation in morphology of the travertine bed. (Cape Elizabeth, Hd. Tiparra)

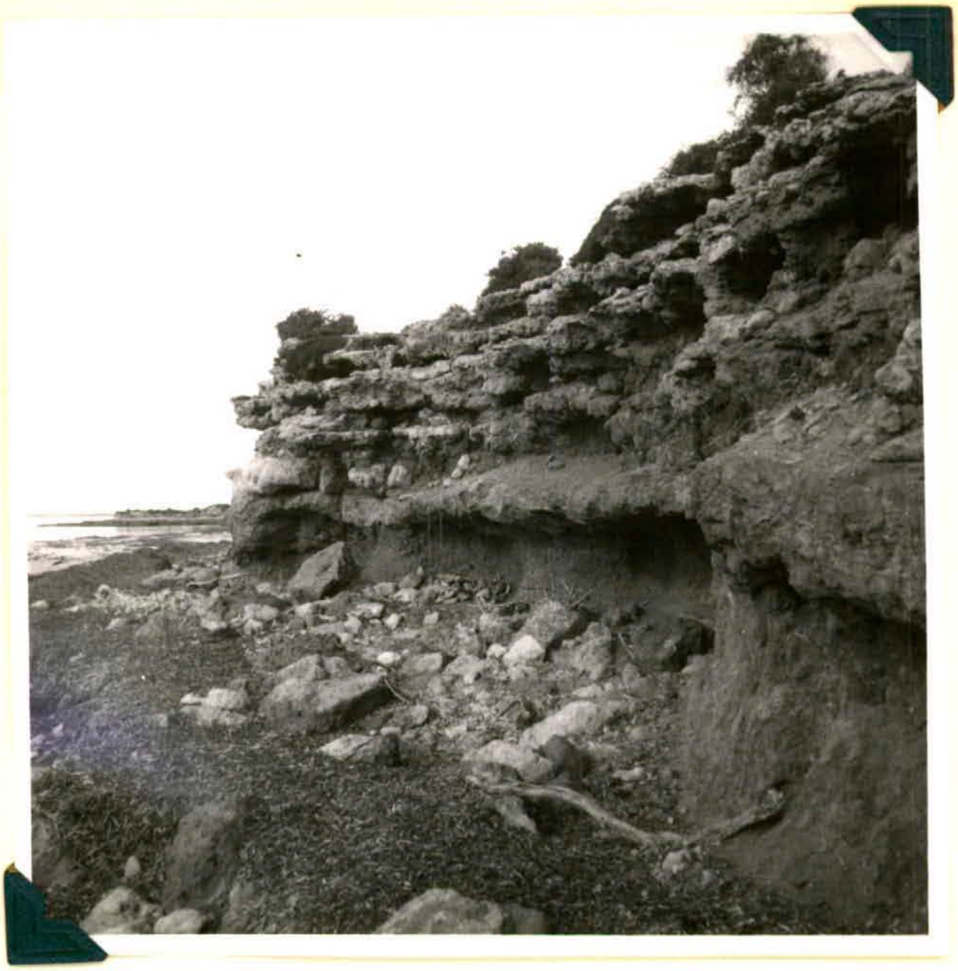

Fig. 11. Tabular travertine upon loessial silt (Cape Elizabeth, Hd. Tiparra)

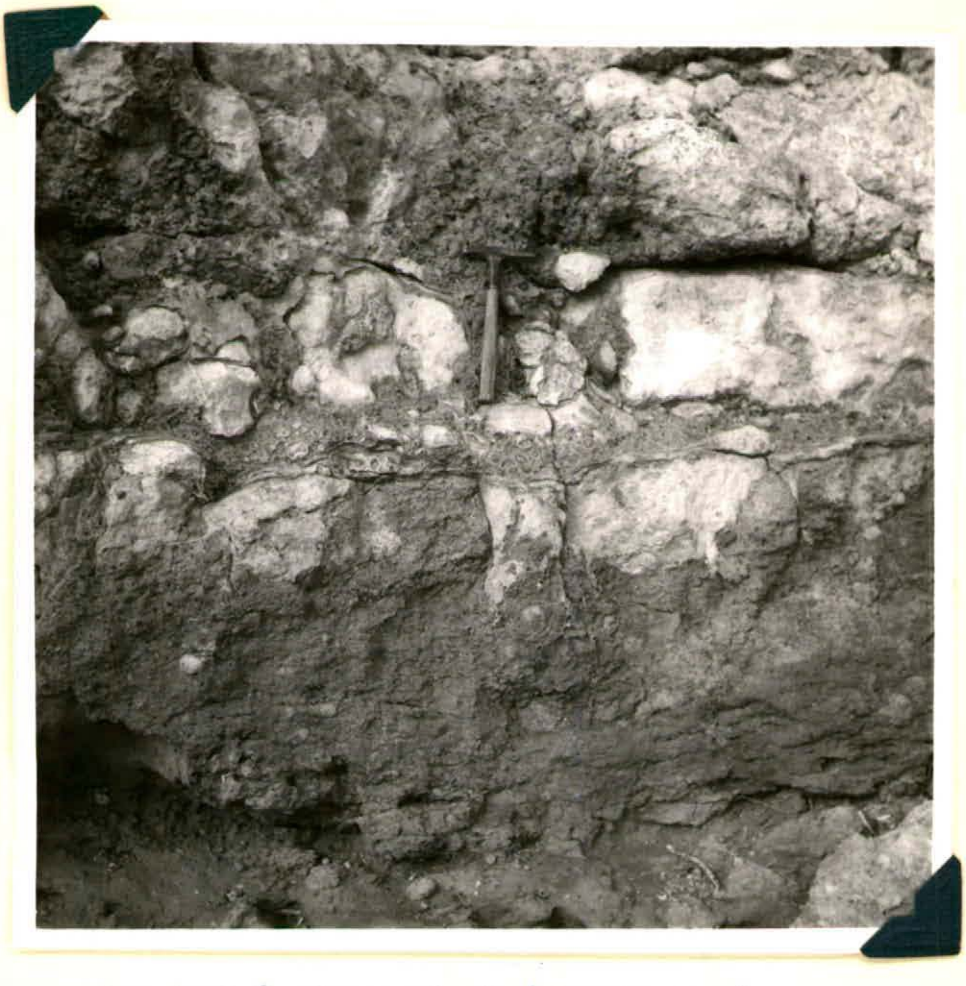

Fig. 12. Travertine bed (close view) (Moonta Bay)

basement rock of the area surveyed. So far can be judged from the examination of the specimens collected from excavations the rocks are dense, ferruginous, and grey in colour, often of quartzitic texture, but also sometime a finely divided sericitic shale, or siliceous clay slate.

Pre-Cambrian meta-sediments are intersected in the southern portion of the area by numerous granite-aplite and pegmatite dykes. A granite intrusion has caused the formation of gneiss in places.

Igneous (intrusive) Rock - porphyry and granite.

In the Moonta area there occurs a dark-brown to reddish-brown dense porphyry. According to R.L.Jack[x] who studied this rock in detail there are both: felsitic and porphyritic types present. In the latter feldspar phenocrysts are present.

Granite-aplite is found in the Moonta Bay-Port Hughes area along the beach. The dominant constituents of this rock are alkali-felspar (microcline, orthoclase) and to a lesse extent albite, when weathered, grains of feldspar are completely converted into alumino-silicate material mingled with hydrated oxide of iron. Sericitic material derived from former ferro-magnesium minerals occurs as interstitial patches to felspar and quartz.

Coarse-grained microcline granite consisting of microcline orthoclase, albite, quartz, bluish-green hornblende and biotite is found among the chips from the excavation near Angery.

STRUCTURE

As has been mentioned the area surveyed does not provide sufficient geological data for the interpretation of the structural features.

It can only be said the Pre-Cambrian highly weathered schist which outcrops at Port Hughes strikes NW-SE and dips 60° to the NE.

Cambrian rock at the same point lies horizontally while at Warburto Point a gentle folding in this rock (strike NE-SW. dip 150 E) can be indentified.

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[x] R.L.Jack The Geology of the Moonta and Wallaroo Mining District S.A.Geol.Survey Bull.No.6.1917.

Fig. 13. Nodular travertine typical for the road metal quarries in the area (Hd. Wallaroo)

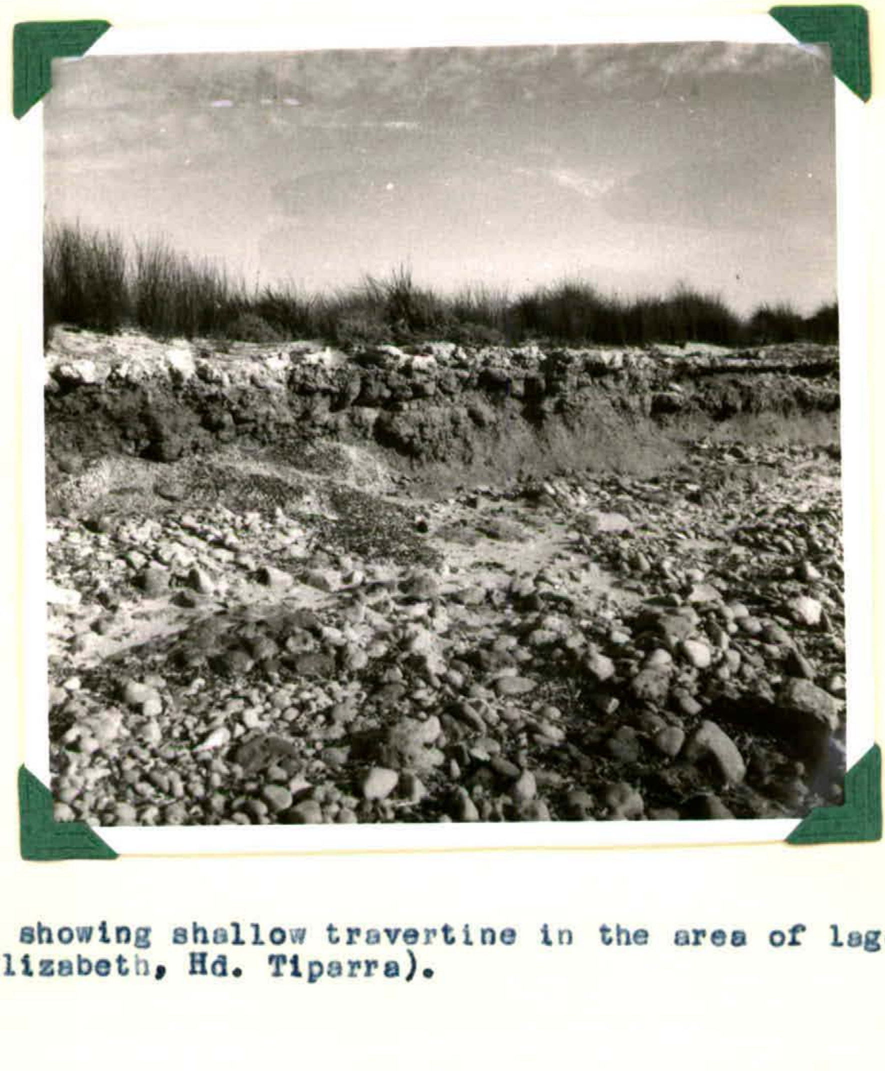

Fig. 14. Section showing shallow travertine in the area of lagoon deposits (Cape Elizabeth, Hd. Tiparra).

THE PROBLEM OF SOIL GENESIS

The most representative soil-subsoil section recorded at the Moonta Bay - Port Hughes cliff provides the following data (from the top to the bottom):

1. Travertine Cap. This is a compact and partly nodule-structured sediment consisting of accumulations of fine-grained calcium-carbonate, limonite and clay with a subordinate amount of detrital quartz.

The rock has evidently been formed by the precipitation of lime in situ. Thickness - 7 feet.

2. Buff loessial silt. This consists of a fine mixture of calcite, clay material and limonite, throughout which occur rather well-rounded grains of quartz and small amounts of feldspar.

The heavy medium separation of this sample has shown a great variety of accessory minerals. In order of abundance these are: green amphiboles (hornblende, actinolite), garnet, tourmaline, zircon, rutile, iron minerals, andalusite, staurolite, sillimanite, kyanite, hypersthene, diopside, spinel, epidote, zoisite, titanite, biotite and chlorite. Thickness-8 feet.

3. Travertine bed. This is a friable highly ferruginous clay-calcareous-quartz-sandstone. The heavy mineral constituents are similar to those mentioned for layer 2. Thickness-2 feet.

4. Clay bed. This is ferruginous, and in places highly calcareous clay enclosing a gret deal of clastic material. The latter can be seen as well rounded or subangular grains of quartz effected by strain and in less amount, felspar.

5. "Basal" clay. This is a completely weathered and highly ferruginous rock consisting of clay minerals (montmorillonite group), quartz and small amounts of alkali-felspar with a few grains of plagioclase. Some grains of detrital material have rounded outlines and irregular extinction due to stress. The minerals observed in an heavy fraction of this sediment

Fig. 15. Section showing relationship of aeolian (grey and yellow-reddish) sand to underlying "soil" travertine and loessial silt (Road cutting, Moonta - Maitland Main Road).

are identical with those mentioned under 2. above although there is slight variation in the percentage content of some constituents. Thickness - 5 feet.

6. Granite-aplite. This is a weathered and oxidized rock consisting largely of alkali-felspar (microcline-microperthite, orthoclase) and in less amount-albite, minerals forming approximately 65 per cent of the rock. The grains of felspar are cloudy or nearly opaque due to the high state of alteration (kaolinization). Some grains of felspar are completely converted into alumino-silicate material, mingled with hydrated oxide of iron. Quartz is in subordinate amount, the grains being visibly effected by strain and stretched out in a roughly parallel direction, occurs in smaller quantities.
Sericite material, derived from former ferro-magnesium minerals, occurs as interstitial patches.

The heavy mineral constitnents of this rock are quite distinctive from those previously described. The principal accessory of the granite-aplite is a very altered dark-greyish variety of zircon, associated with crystals of cyrtolite. Other accessory minerals are limonite, hematite, barite and biotite.

Mr. A. W. Whittle, the Departmental Chief Petrologist, suggests[x] that a comparison of the result of the examination of accessories of the sedimentary rocks with those of the granite-aplite indicates that the latter is not the source of the overlying sedimentary material, from which it is implied that the sandy-clayey formations are allogenic in origin. The amphiboles, biotite, garnet, andalusite, sillimanite kyanite, staurolite, spinel, diopside, corundum etc., identified in them are derivatives of contact-metamorphic rocks or crystalline schists which must be considered as source of the subsequent sediments.

The travertine or calcareous clay contains the same association of heavy minerals as the sandy clay so that it

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[x] Petrological Report (11/1/55)

may be suggested that the two sediments have been laid down in a similar environment.

SOME NOTES ON THE FURTHER INVESTIGATION

Field work

It seems reasonable to believe that "basal" clay has a direct bearing on the problem of the search for copper in the area surveyed.

As the data presented in this report indicate a very complex relationship of soil and subsoil to the underlying rock formation, it appears necessary to carry out a detailed soil study from the view point of its morphology, physical properties and chemical composition.

The area of this investigation has been outlined on the "Prospecting Map" as the "approximate limit of the area of interest".

The field work and associated laboratory study must comprise:

1. A description of the relief and micro-relief of the area: the gradients, length and shape of slopes (if any) and their pattern.

2. The water regime of the area and the features caused by erosion and accumulation of the soil material.

3. The occurrence of the travertine crust, its thickness, texture, relation to the underlying and overlying members of soil profile and the relation to the local relief.

4. The sinking of soil pits and auger holes in a grid-like pattern for the purpose of obtaining soil profiles. The depth of soil pits sould be between 10-15 feet.

5. Sampling and description of soil units.

6. The laboratory investigation of physical properties (binocular examination, clay fractions, uniformity coefficient etc.,) petrology of the travertine formation, light and heavy mineral, and chemical properties of soil (loss on ignition, loss on acid treatment, exchangeable metal ions, X-ray examination,chemical composition).

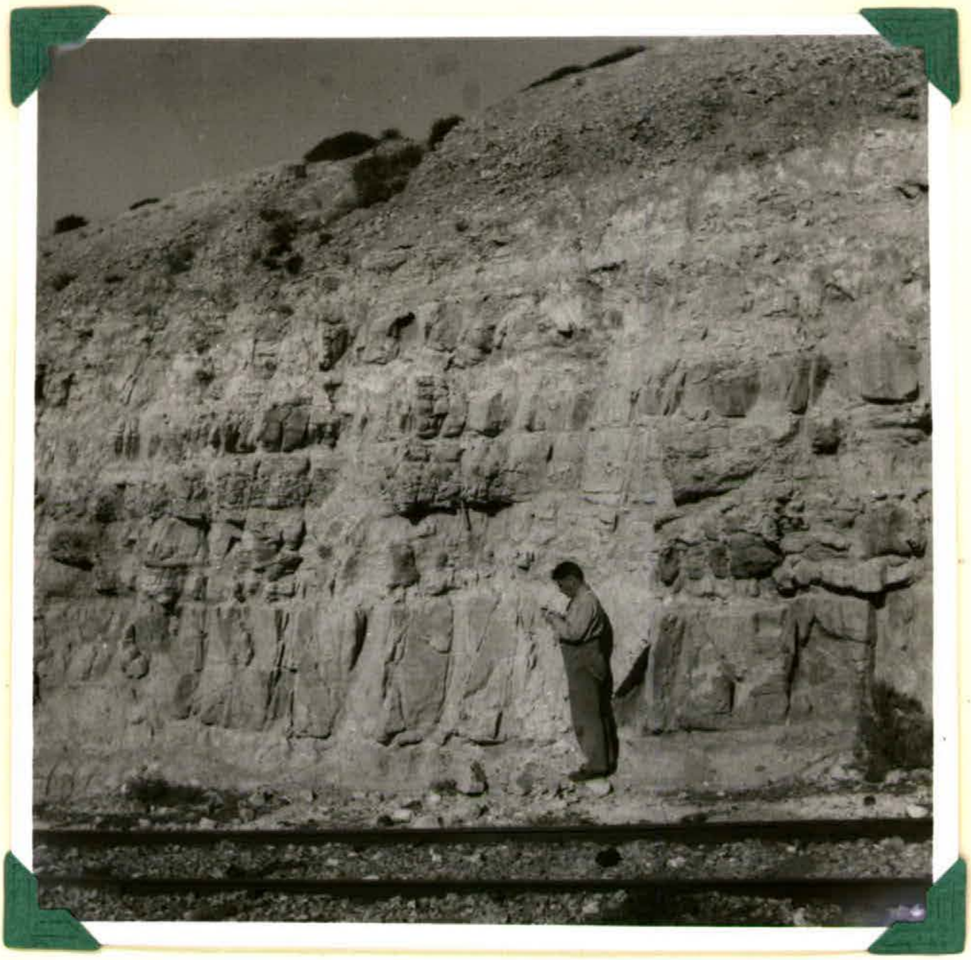

Fig. 16. Cambrian Limestone at Wallaroo.

GEOCHEMICAL INVESTIGATION:

It is suggested that the cobalt, nickel and copper content of the soil and subsoil and the ratio of these elements must be taken as a leading criterion in the search for copper in this area.

As it has been well established (Fersman's geochemical school) there are the following ratios of Co : Ni : Cu in some typical soil formations:

1. Light-chestnut soil			Co : Ni : Cu
0-5 cm	horizon	A_1	1 : 5 : 1.2
30-35cm	"	A_2	1 : 3 ; 1.6
60-65cm	"	B	1 : 2.7:1
110-115cm	"	C	1 : 3 : 2.2
2. Red-brown soil			
0-5 cm	horizon	A_1	1 : 9 : 0.3
45-50cm	"	A_2	1 : 9 : 0.7
100-105cm	"	B_1	L : 8 : 0.8
3. Krasnozems (the type somewhat similar to our "basal" clay)			
0-10 cm	horizon	A	1 : 2.7. : 2.7.
40-50 cm	"	B	1 : 4.6 : 8.0.
90-100cm	"	C	1 : 4.3 :11.3

From these figures it appears that "krasnozems", which is morphologically identical to Kadina-Moonta "basal" clay is the most favourable soil formation for the accumulation of copper particularly in its lower horizons.

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(I.I. CHEBOTAREV)

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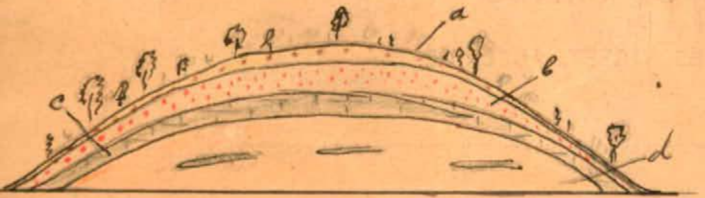
Road cutting ⑱



㉕ Road cutting: Grey fine-grained sand (dune) under vegetation cover about 5'; b) yellow-reddish fine sand (old dune) 3'; c) "sand" tabular (soft) travertine about 2'; gradualy merges into d) buff calcareous silt partly travertinized about 6';

㉖ Road metal pit excavation: a) Brown sandy soil with nodular travertine 1'; b) "upper" tabular travertine over 2';

㉗ Road cutting: a) Grey fine grained sand under the vegetation cover (dune sand) 2; b) yellow-reddish fine grained calcareous sand 1'; c) "sand" travertine gradualy merging into underlying silt - about 1', d) buff calcareous silt partly travertinized about 6-7';

㉘ Road cutting about 16' deep: a) Grey fine sand (dune) under the vegetation cover 3-5'; b) yellow-reddish (Brown) fine sand 3'; c) "sand" tabular travertine (soft) about 1'; d) buff calcareous silt partly travertinized 7-8';

㉙ Road cutting about 12' deep: a) Grey fine sand 2'; b) yellow-reddish (Brown) fine sand 4'; c) "sand" tabular travertine 1'; d) buff calcareous silt partly travertinized 6';

Alan Gibson's notes on Moonta.

TOPOGRAPHY

The landform is very mature, but modified by a widespread aeolian veneer. Relief is gently undulatory and the surface is smooth (no micro-relief). On aerial photographs the major topographical features of the area are seen to be ancient fixed sand dunes trending in an E.S.E. direction from the coast. However, these calcareous sand dunes are so subdued in form that few are recognisable from ground level. The elevation at Moonta railway station is 89 ft above Low Water Mark, Port Adelaide, and few features in the area rise more than 30 feet above this.

Surface drainage is not confined to any regular channels, but water does tend to accumulate in shallow depressions during the rainy season. Subsoil drainage is impeded vertically beneath the aeolian mantle, but it is unrestricted laterally.

Originally the vegetation was predominantly mallee, but only roadside remnants are left, most of the area having been cleared to provide fuel for boilers during mining activities and now sown to crops or pasture.

SOIL PROFILE - in dune, or interdune?

The soil profile is complex and can be divided into at least four genetically and morphologically distinct units.

Qrk not all, [Test.]

(a) The upper unit comprises a layer of travertine limestone rubble and marl 2 ft to 7ft thick, overlying terra rossa clay 1ft to 4ft thick with sometimes a sandy base up to 16 inches thick. This unit is of aeolian origin.

? Qrc ? Qpm or Qpa ↗

(b) The next lower unit is a plastic red-brown clay with a high sheen and a coarsely prismatic structure containing well rounded to sub-angular pebbles and grains. This is considered to be of mixed fluviatile - lagoonal origin.

? pisolites

? Qpm or Cat.

(c) This next unit consists of red-brown clay with a finely prismatic structure and frequently containing small bunchy nodules of iron ore and sub-angular fragments of ferruginous rock (weathered porphyry?) The top section of this unit often contains angular fragments of rock, mostly of Moonta porphyry. It is thought that this unit represents colluvial material superimposed on one or more remnant fossil lateritic soil "B" horizons.

? Qpm w A [dec A]

(d) The final unit, intimately associated with bedrock, is an irregularly prismatic red-brown and grey particoloured clay. This is a residual soil derived directly from bedrock, the acid Moonta porphyry and kindred rocks.

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If anything can be resolved from the controversial state of pedological opinion as to the nature of a typical lateritic soil profile it would appear that units (c) and (d) could be considered together as one such profile with a colluvial overlay.

PROBABLE ORIGIN AND AGE OF SOIL UNITS

A study of pedological literature indicates a general acceptance of the idea that lateritic soils are formed in humid climates on peneplain areas under conditions of excess soil moisture, thus indicating poor drainage and an elevated water table. The ironstone nodules associated with such soils seem to require periods of intense dehydration alternating with the humid conditions for their best development and whilst they are common to many laterites, their absence or sparseness does not invalidate the diagnosis of a soil as lateritic. The typical lateritic soil is formed by intense and prolonged chemical weathering during which organic constituents are reduced to carbon dioxide, silica is leached and iron and aluminium become concentrated in the form of hydroxides and clay minerals. The characteristic colour is red-brown.

There is also general agreement among pedologists that mottled clays, such as unit (d) above, are formed in the zone of a fluctuating water table. Since the present water table is some 50 feet below the surface a depression of about 40 feet is indicated since the lateritic soil was formed.

The alluvial material represented by unit (b) has undoubtedly resulted from prolonged and repeated water erosion and preliminary heavy mineral studies suggest a distan~~c~~t source for at least some of the material.

A stereoscopic study of aerial photographs of the Moonta area coupled with in situ examination of the ridged areas so indicated leaves little doubt that the travertine limestone of this area is of aeolian origin. When the desert-type dunes of Yorke Peninsula (as distinct from the littoral dunes) are plotted and compared with those on Eyre Peninsula it is seen that they have the same general bearing, configuration, and spacing and therefore are likely to be contemporaneous. This plotting also reveals that the southward limit of these dunes is a little south of Cape Elizabeth and this limit is seen to coincide with the southern limit of a broad shallow submarine sandbank in Spencer Gulf delineated by the 11 fathom (20 metre) contour, projecting as a salient from the eastern shore. It is therefore suggested that the principal source of the calcareous sand of which the dunes were formed was the bed of Spencer Gulf, exposed during a eustatic change in sea level resulting from one of the Pleistocene glacial cycles.

NO

A study of Admiralty chart soundings reveals the presence of a submarine bench at a depth of 14 to 15 fthms (25-27 metres) below present sea level, a bench which coincides in depth with similar benches throughout the world. A still-stand at this level during a cycle of eustatic variation in sea-level would have exposed a land-bridge across the Gulf. Since the prevailing wind at the time of dune formation is clearly indicated on aerial photographs of Eyre Peninsula as having come from a W.N.W. direction it is highly probable that the sandbank referred to previously was itself derived from a source further west and that the dunes on Yorke Peninsula were not only contemporaneous with those on Eyre Peninsula, but also were once continuous with them.

Finally, an inspection of the low cliffs of Moonta Bay and a close study of the contours of Yorke Peninsula both indicate that these dunes are younger than the 60ft.(18 metre) emerged beach of Zeuner (65ft Reedy Terrace of Tindale. See accompanying subdivision of Upper Pleistocene and Recent), since they cover it, but they are truncated by the 30ft beach (29ft Woakwine Terrace of Tindale) and are therefore older than this. This places the dunes as post-Monastirian and pre-Ouljian in age by Northern Hemisphere nomenclature, or post-Reedy and pre-Woakwine in the Southern Hemisphere.

It is here postulated that the older lateritic soil profile was developed on the peneplain remnant that is now the northern half of Yorke Peninsula under the influence of tropical to sub-tropical climate and an elevated water table at a time when sea-level stood about 60 feet or so higher than at present. Whilst it is recognised that an elevated water-table does not necessarily require a comparable rise in sea-level, the converse does apply. The Monastirian interglacial stage which reached its maximum around 150,000 years before present (B.P.) fits these conditions in every particular, as well as predating the period of dune formation.

It is highly probably that intense pluvial conditions preceded the onset of the subsequent Würm I (Margaret 1) glacial period. This would have resulted in the regeneration of ancient river systems, scouring of lateritic clays in many places and widespread flood deposit over peneplains and low-lying areas. The alluvial clay horizon (unit " ") probably originated in this way and at this time.

?=Qrc

The Würm I glaciation reached its maximum development around 150,000 years B.P. and was accompanied by a fall in sea level of the order of 330 ft. Thus much of the continental shelves of the world was exposed and climatic zones retreated towards the equator. The Moonta area then experienced cold, inland climatic conditions since it was some 120 miles from the sea and much of the coastal influence on climate was lost. It is possible that not all of the fall in sea level was due to extraction of water by glaciation. It has been suggested by Fairbridge (1953) that there was a discontinuous major downwarping of ocean basins, particularly the Pacific, during the Quaternary. If part of such ocean basin subsidence occurred during and/or after the Würm I glaciation, the recovery of sea-level would have lagged behind the warming of the land mass of the Australian continent. The eventual combination of conditions of warm, dry land mass, partly exposed and dessicated continental shelf and the strong wind conditions inevitably resulting from a warm land mass in much closer proximity to Antarctic ice than at present, would have been ideal for the development of the desert type dunes. It is postulated that some such combination of conditions occurred with the approach of the Ouljian (WoakwineI) interstadial stage, the period of dune formation culminating in the formation of the Yorke Peninsula dunes. Since the rate of melting of ice caps could be expected to increase with the diminution in their masses (assuming a fairly uniform amelioration of climate), and sea-level had recovered about 5/6ths of its former height at the time of dune formation, a reasonable estimate of the age of this occurrence can be made. This is estimated at 90,000 years B.P.

DUNE FIXATION AND SOIL FORMATION

The primary and most important factor in the fixation of the dunes in the Moonta area is considered to be the lixiviation of lime from the topmost calcareous sand by rainwater and precipitation at a lower horizon to form the travertine rubble layer. The leached and predominantly siliceous residual veneer so formed was subsequently wholly or partly removed and carried eastward by wind action, probably the final phase of the dune-forming period. The most easterly of these dunes still retain their siliceous sand veneer, or are buried by sand and further eastward again there is evidence of fairly widespread sand sheets.

On Yorke Peninsula, as elsewhere, the dunes encroached over pre-existing clayey soils and in addition to what remained of their own fine fraction they acquired clay and silt from local sources. Much of this finer material was not winnowed out, but remained within the dunes. During and after the fixation of the dunes the clay, fraction was leached downward to form a marked illuvial horizon (the terra rossa) due to solonization under the influence of cyclic salt.

(Illuviation is the pedogenic process of adding material to a soil either by mechanical or chemical means, or both. By this process clayey material is characteristically added to the subsoil horizon.

Solonization is a particular case of illuviation. When the clay complex of a soil becomes enriched in sodium it is rendered readily dispersable in water, or peptized. Thus leaching of the clay fraction be-comes possible under conditions which otherwise do not allow this to occur and the soil is then said to be solonized.)

The clayey sand which sometimes occurs at the base of the terra rossa represents the winnowed sand that was swept ahead of the dunes and was subsequently buried by their progress. The clay content here is also illuvial.

SUBDIVISION OF UPPER PLEISTOCENE AND RECENT

Modified after Rhodes W. Fairbridge (Australian Stratigraphy, 2nd Ed.1953)
to incorporate the correlation of N.B. Tindale (Rec.S. Aust. Mus.Vol.VIII,No 4,1947)

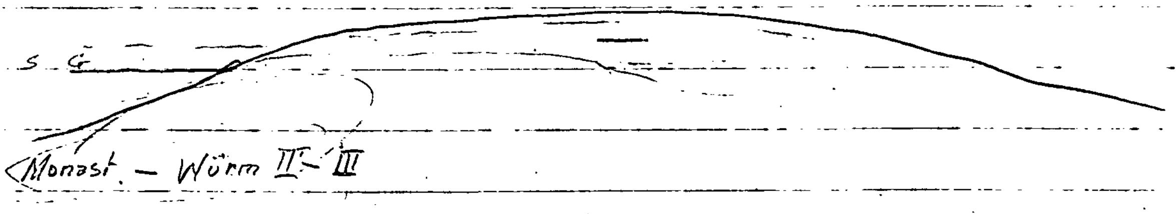
	Northern Hemisphere Stratigraphic Stage	Climatic Stage (Scandinavia)	Equivalent N. European Stage	Equivalent North American Stage	Equivalent Southern Hemisphere State (Tindale)	Sea Level		Chronology
						N.H'sph.	S.H'sph	
RECENT	Present)	"Subatlantic" (Oceanic)				0	0	2000 AD 1000 AD 0
	Dunkirkian)					+2'-3'		0 1000BP
	Calaisian	"Sub-boreal" (continental)				+5'-6'		2300BC 3300BP
	Flandrian	"Atlantic" (warm oceanic)				Still stand		4000BC 5000BP
		"Climatic optimum"				+10'-11'	+10'	5000BC 6000BP
	(Early Flandrian)	"Boreal" (continental)				low		7000BC 8000BP
	Finiglacial	"Pre-boreal" (Cool continental)	WEICHSEL	WISCONSIN		low		9000BC 10000BP
UPPER PLEISTOCENE		"Younger Dyas" (sub-artic)				low		
	Gotiglacial	"Allerőd" (warmer)	Fennoscandian	Mankato		low		12000BP
		"Older Dyas" (sub-artic)				low		
	Daniglacial	(artic)				low		20000BP
	Würm III	Glacial	Pomeranian	Carey	Margaret 3	? -100		25000BP
	(unnamed)	Würm II/III						
	Monastirian II alt.?	Interstadial			*Woakwine II	?+25	+25'	44000BP
	Würm II	Glacial	Brandenburg	Tazewell	Margaret 2	?-230'		72000BP
	Ouljian (Morocco)	Würm I/II Interstadial			*Woakwine I	+30'	+29'	83000BP
	Würm I	Glacial	Warthe	Lowan	Margaret 1	?-330'		115000BP
	Monastirian II (Zeuner 1945)	Interglacial				? +25'		?125000BP
	unnamed	Cold phase				-		?
	Monastirian I	Interglacial		Sangamon	Reedy	+60'	+65'	150000BP

* The Woakwine dunes are adjacent and partly eroded and superimposed on at least two truncated dunes at the same position and their age is therefore in doubt.

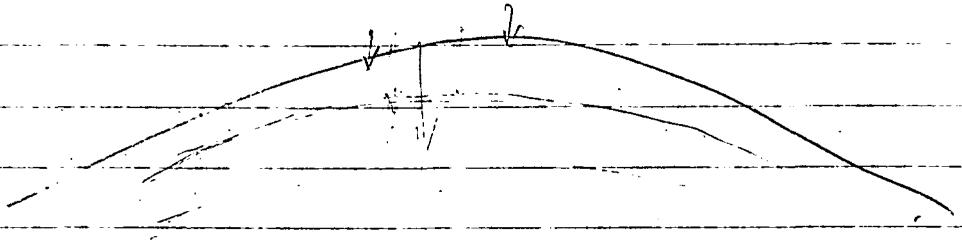
MAITLAND 4-Ml.

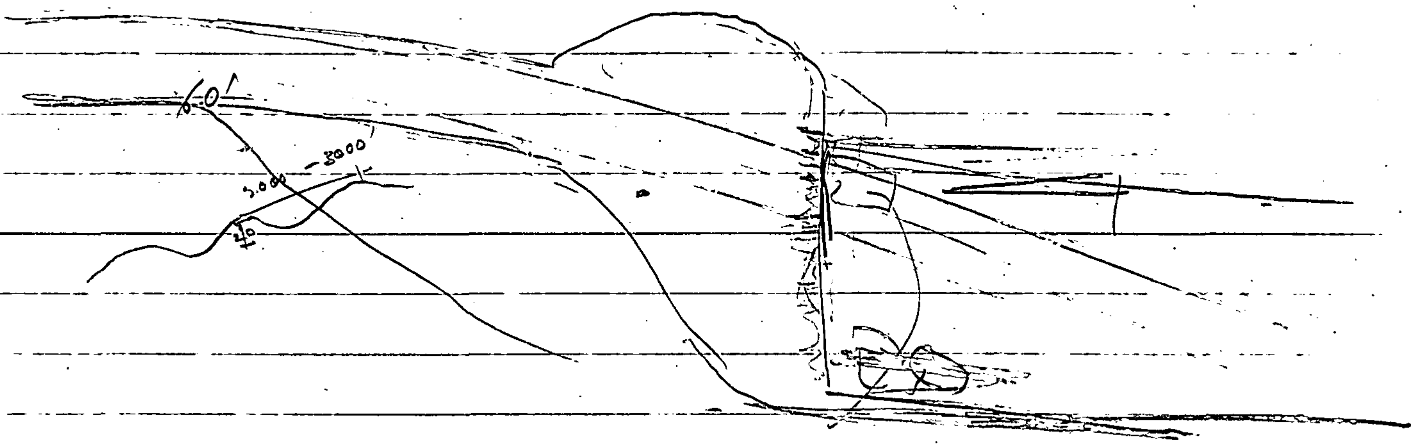
Me | Alan

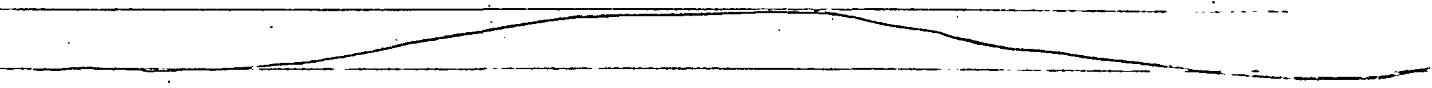
Qrk		9.5		0 – (1 to 6')	Terr. rubble.
Qrk		~~9.5~~ 9.0	Aeolian	(1'-6) – (3'6"-8'6)	Aeol.
Qpa	NOT Terra rossa	8.4		(3'6'-9'6) – (5'-10')	Terra rossa.
'Qpa-m'		7·8	Alluvial	(5'-10) – (7'6"-13)	R.b. clay. ~~[illegible]~~ rounded gravels.
Qpm		6.7	Lateritic.	(7'6-13) – (10'-20)	R-b. clay (lat.)
Qpm		6	Residual	(10'-20') – (12'-26)	RB & Grey [illegible]
A			Basement.		

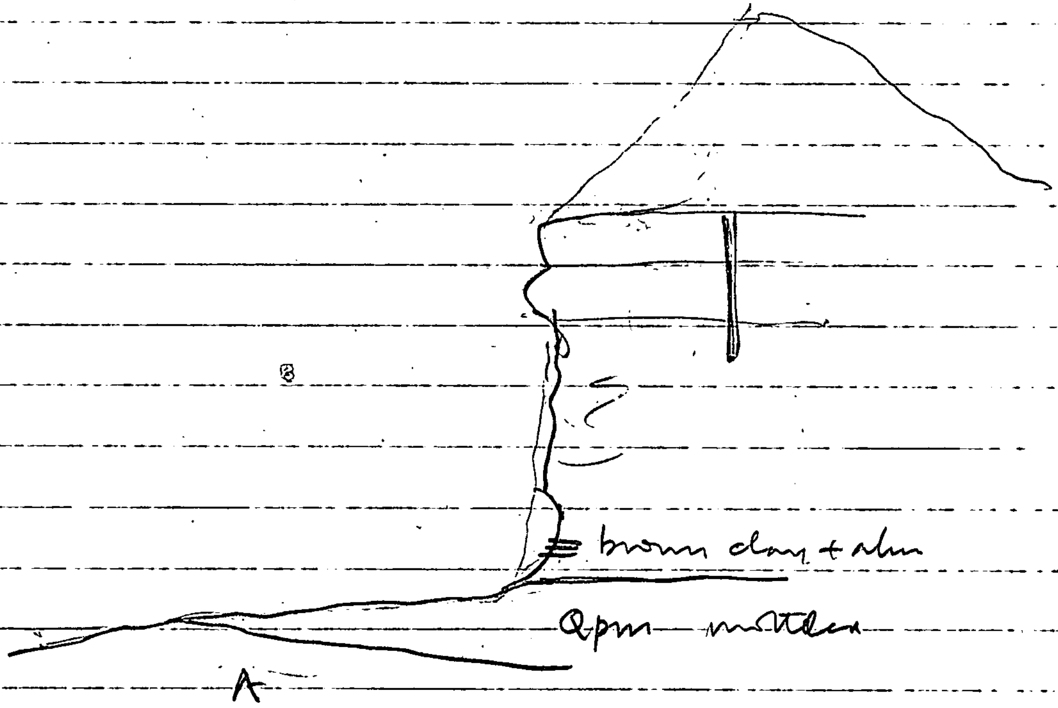


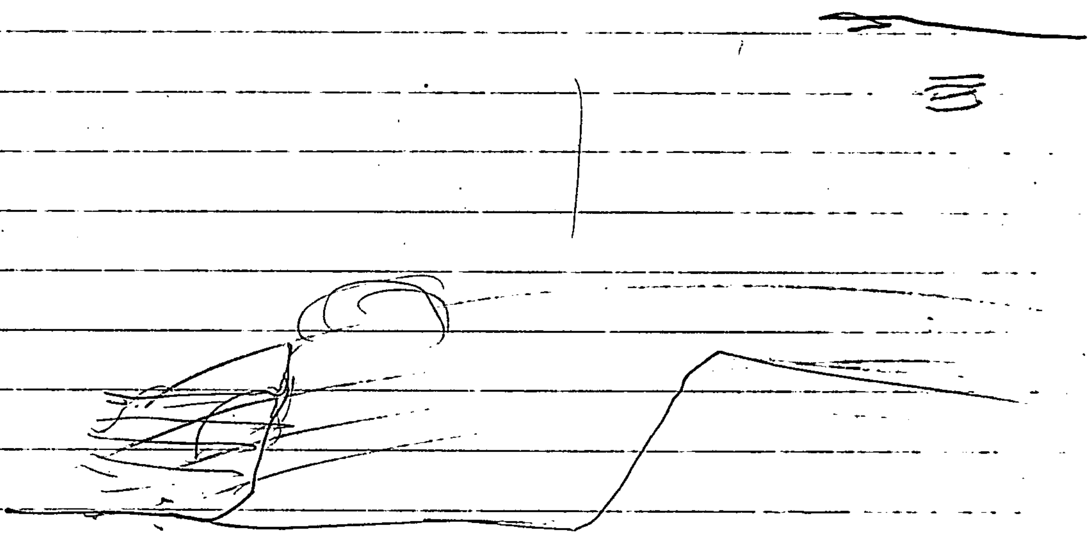
<Monast. – Würm II-III

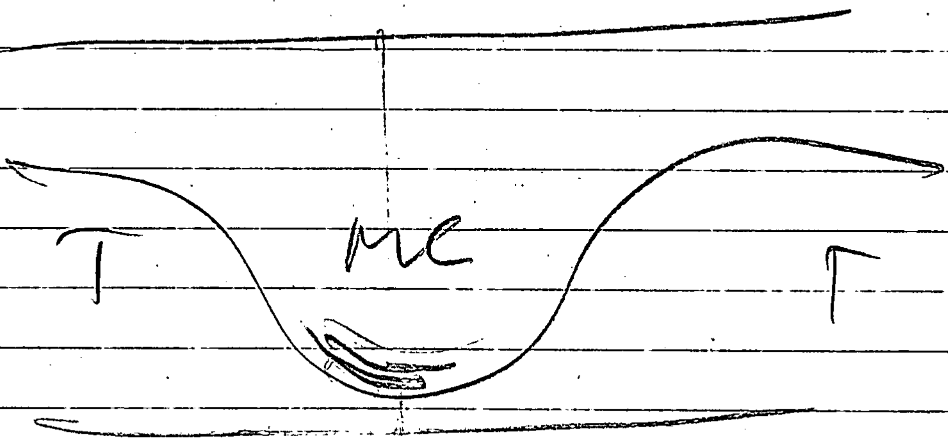







brown clay + alluv
Qpm mottled
A

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