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INVESTIGATION OF POTTERY CLAY RESOURCES, DARWIN AREA, NORTHERN TERRITORY.

by

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INVESTIGATION OF POTTERY CLAY RESOURCES, DARWIN AREA, NORTHERN TERRITORY.

SUMMARY

Investigations of occurrences of potential pottery clays were carried out intermittently between November 1962 and September 1963. Three main occurrences were investigated; Tertiary clay on Melville Island, Tertiary clay at Nightcliff and Cretaceous claystone at Gunn Point. Testing of samples of these materials was done by C.S.I.R.O. Division of Building Research. The Melville Island clay proved to be unsuitable as a raw material. The Nightcliff clay gives some promise; however, the deposit lies within the Greater Darwin residential area and is not available for exploitation. The Gunn Point Cretaceous claystone proved to be of two types, one light coloured and kaolinitic, the other dark grey and montmorillonitic; both are valuable raw materials in the ceramic, refractory and whiteware industries. The reserves of claystone at Gunn Point are expected to be large and recommendations are made for drilling in this area, both to substantiate the available reserves and to provide stratigraphic information.

INTRODUCTION

A search for suitable raw material for pottery-making was initiated in 1962 by a proposal from Dr. P.S. Hossfeld that pottery-making should be taught in native schools in the Northern Territory. Between November 1962 and September 1963, a number of investigations of possible sources of suitable clay were carried out; this report contains details of the investigations, together with results of tests done on the raw materials by the C.S.I.R.O., Division of Building Research, Highett, Victoria.

GENERAL

A detailed investigation of the heavy clayware resources of the Darwin area was carried out during 1962 (Gardner and Rix, 1963). However, the clays investigated as potential raw materials for heavy clayware are unsuitable as pottery clay, because of the presence of siliceous impurities, the relatively low plasticity of most of them, and their undesirable colour.

The raw material for good pottery consists of pure clay, preferably kaolin, with a high plasticity and a light colour, preferably white. It is particularly important that the clay should not contain any silt. If instructional work or a "cottage" industry is contemplated, it is also important that satisfactory strength and appearance should be attained in articles fired at relatively low firing temperatures (not more than 1050°C), as higher firing temperatures would involve more costly kilns and higher burning costs.

SOURCES OF RAW MATERIAL INVESTIGATED

NIGHTCLIFF

Introduction

In 1956, a number of boreholes were drilled in the Nightcliff area to locate strong foundation rock for a water tank. These holes showed that the Cretaceous porcellanite in this area appeared to be overlain by white, kaolinitic clay, the thickness of which varies from 14 to 19 feet (Moore, 1956).

Geology

The cliffs at Nightcliff were examined in February, 1963. White, but iron-stained, kaolinitic clay rests on an irregular surface of Cretaceous porcellanite (Plate 1), indicating a possible Tertiary age for the clay. The clay crops out in the cliffs over a distance of about 800 yards; the deposit is lenticular and reaches a maximum thickness of about 15 feet.

The underlying porcellanite is visible as a projecting platform, as a result of differential erosion of the two rock types; seepage of water occurs along the contact between them. The white clay in the cliffs is stained with iron oxide, carried in by water that has percolated along compaction faults and shrinkage cracks, from the six foot thick superficial deposit of red, ferruginous soil and ferricrete that overlies the clay.

These clays may have formed in lagoons or lakes, during the Tertiary period, on an irregular land surface of Cretaceous rocks. It is probable that other shallow basins containing similar clays occur in the Darwin region, but most of them are concealed by soil and ferricrete.

Investigations

An auger drill hole was put down to a depth of 18 feet on a site about 20 feet behind the cliff at Nightcliff Esplanade (Plate 1), to ascertain whether the iron staining occurs throughout the clays or whether it is merely a surface feature on the face of the cliffs. The auger hole encountered only iron-stained clay and it seems likely that the clay is iron-stained throughout. The material obtained from the auger hole was useless as a sample of the clay because of contamination by overlying soil and ferricrete. Consequently, a 50 lb sample of the clay was taken from the cliff exposures and sent to the Division of Building Research for evaluation.

Evaluation of Material

The testing (see Appendix) showed that the material is a plastic kaolinitic clay that could be used for pottery but it would require a firing temperature of at least 1050°C. For thin-walled articles and articles requiring appreciable mechanical strength, it was recommended that a lower firing clay with a higher plasticity be found.

Although this material has some promise, investigations were abandoned because the deposit is located within the Greater Darwin area and is therefore not available for exploitation.

NORTH-WEST PENINSULA OF MELVILLE ISLAND (PLATE 2)

Introduction

A brief visit was made to the north-western part of Melville Island on 19th and 20th November, 1962, to examine occurrences of Tertiary clays there. The localities visited were Goolumbini Creek, 7 miles east of Garden Point Mission, and Wulawungna, 10 miles north-north-west of the mission, where prominent cliffs form the coastline for almost 1½ miles, (Plate 2, Fig.1). These cliffs are referred to as Piper Head cliffs on the naval charts of the area.

Both localities are accessible by track from Garden Point Mission and Wulawungna is accessible by boat, preferably at high tide because of the presence of shallow offshore reefs in this area.

Geological Background

The north-west peninsula of Melville Island is formed by a platform of pre-Cretaceous ferruginous sandstones overlain by unconsolidated Tertiary sands within which are lenses of white clay. The platform is below beach level at Wulawungna, with the exception of one small beach outcrop of ferruginous sandstone. However, it is well exposed further south at Luxmore Head, where a gentle north dip is evident.

At Wulawungna, the Tertiary sands are clean, angular, extensively current-bedded, and variable in grade from medium sand to coarse, angular, poorly-sorted sand. These features indicate deposition in very shallow water. The lenses of white, compacted clay within the sands form small projections from the cliffs owing to their higher resistance to erosion. The contacts between the clay lenses and the sands are sharp and it is thought that the clays were deposited in small, possibly fresh water, coastal swamps or lagoons in an area of very shallow water that was being rapidly infilled with sand. The clay lenses show undulations within the sands, dips of 10° and 25° being observed, and some of them show current bedding, slumping and a few small compaction faults. Fossil leaves were found at one of the clay localities.

The Piper Head or Wulawungna cliffs are a striking feature from the seaward side, standing out as white cliffs with a red capping. A scale profile of the cliffs is shown in Plate 2, Fig. 2.

Economic Clay Deposits

Wulawungna. There are three large clay lenses and four small ones in the Tertiary deposits at this locality. The small lenses are uneconomic because a disproportionately large amount of overburden would have to be removed during extraction of the clay.

Details of the larger lenses are as follows:

Locality 1 is at the northern end of the cliffs. The clay lens is 210 feet long and was estimated to have an average thickness of 5 feet.

Locality 2 is about ¾ mile south of locality 1; the clay lens is 105 feet long and has an average thickness of 4 feet. The leaf fossils were obtained from rubble at this locality.

Locality 3 is ¼ mile from the south end of the cliffs and ½ mile south of locality 2. The lens is 360 feet long and has an average thickness of 4 feet.

A 20-30 lb representative sample of clay was taken from each of the three localities.

Two of the small uneconomic lenses occur between localities 1 and 2 and two between locality 3 and the south end of the cliffs.

The reserves of clay within the three larger lenses are calculated on the basis of an assumed 30 feet extension of the lenses into the cliffs with no diminution in the estimated average thickness.

Reserves:

Locality 1	- 1150	cu. yds.
" 2	- 450	cu. yds.
" 3	- 1600	cu. yds.
Total:	3200	cu. yds.

This would probably be sufficient to supply the needs of a small local pottery industry on the Island.

Other cliffs composed of Tertiary deposits were noted at Cape Fourcroy in the south-west of Bathurst Island and it is likely that clay lenses similar to those at Wulawungna occur there.

Goolumbini. White, silty clays of alluvial origin occur in a waterhole on Goolumbini Creek. A bulk sample was taken but the material appeared to be too sandy to make a good pottery clay.

Evaluation of Material

Small samples of clay from Goolumbini and Wulawungna were forwarded to the Mines Branch in 1957 by the Superintendent of Bathurst Island Mission. They were then sent to the Commonwealth Scientific and Industrial Research Organization, Division of Building Research, for testing.

The tests showed that the Goolumbini clay would be useless for any kind of pottery work because of its high sand content and low plasticity, which make the clay very difficult to mould.

The Wulawungna clay was described as a white, plastic, kaolinitic clay and was stated to be satisfactory for moudling and probably for slip casting, and could be burnt at 900° to 1100°C. The product was white, free from cracks or deformation and showed a shrinkage of about 4%. It also took a transparent commercial glaze well, showing no crazing after two to three months.

The samples submitted were too small to allow any large scale testing to be done and further tests were recommended to establish the best mixture of clay and additives.

Consequently, after the 1962 investigation, a 50 lb composite sample, representative of the three main clay lenses at Wulawungna, was sent to the Division of Building Research for detailed evaluation. These results showed that the Wulawungna clay has a low plasticity and is a mechanically weak material. The maximum temperature in the firing range tested (800°- 1050°C)

was not sufficient to give it the mechanical strength necessary for a cottage industry or for small pottery items. The Wulawungna clay was therefore rejected as a raw material for pottery making. In view of the favourable results on the earlier small sample, it can only be concluded that the earlier sample was not representative of the material.

The report by C.S.I.R.O., Division of Building Research, on the testing of this material is quoted in the Appendix.

GUNN POINT (PLATE 3)

Introduction

Exposures of Cretaceous rocks were known in the Gunn Point area and the presence of Tertiary clays, similar to those at Nightcliff, was suspected. The initial visit was made to the area in August, 1963.

The locality is situated about 50 road miles north-east of Darwin (Plate 1). It can be reached by a track that turns off the sealed road at Howard Springs, 20 miles south-east of Darwin, and connects, by way of Koolpinyah Homestead with the old Coconut Grove on the coast about 6 miles south of Gunn Point. Outcrops of Cretaceous claystone are located about half a mile south of the Coconut Grove.

Geology

At the Coconut Grove locality (Plate 3), a cliff 25 feet high has been cut into laterite that overlies soft Cretaceous strata which have been dated tentatively as Albian on the evidence of cephalopod fauna (Skwarko, 1960). The top of the cliff is about 80 feet above sea level and has retreated to its present position, about 450 feet behind the sand beach, by a process of successive landslips. The cliff forms the edge of a laterite plateau, about 100 feet above sea level, that extends north-west from Koolpinyah Homestead. In the sloping area between the cliff and the beach the Cretaceous strata are obscured by fallen blocks of laterite.

At beach level, soft dark grey claystone crops out and forms an impervious base to percolating water in the loose overlying material; consequently fresh water springs emerge at beach level and form small pools on the dark grey claystone. A small bank just behind the beach exposes landslip material composed mainly of fossiliferous, white and light grey, claystone. It appears that the white claystone is a bleached variety of the light grey claystone.

The relationship between the dark grey claystone and white or light grey, material is not clear in outcrop. The only material known to occur in situ is the dark grey claystone which, when exposed to the sun, shows shrinkage cracks, whereas the claystone in the landslip material does not show this feature. Tests carried out by C.S.I.R.O. show that they are two different types of clay - the white or light grey clay is kaolinitic and the dark grey clay montmorillonitic. Possibly the white or light grey claystone, which occurs above the dark grey claystone but beneath the laterite, is a result of the kaolinisation of the montmorillonite clays during the processes of lateritisation. Chemically, the main difference between the two clay minerals are the lower silica content and the much higher alumina content of kaolinite, as opposed to montmorillonite. This feature is compatible with the chemical changes that would be expected to occur during lateritisation. Alternatively, of course, the explanation could be that these differences are due to original variations within the Cretaceous claystone succession.

Drilling and Costeaning

An auger hole, which was sited 100 feet behind the small beach bank and 20 feet vertically above it, was drilled to a depth of 21 feet. The hole encountered a few feet of consolidated laterite rubble and then passed through light grey claystone. The claystone was not proved to be in place.

Three costeans were then bulldozed, at right angles to the beach, to remove loose material and expose the bedrock. The costeans exposed laterite rubble and soil with light grey claystone, probably all landslip material, overlying the dark grey claystone. The landslip material was thicker than expected and no clear section through the strata was obtained.

Thus, the auger drill hole and the bulldozed costeans provided no new information on the relationship between the different types of claystone.

Sampling and Evaluation of Materials

Initially, a 50 lb sample of the white claystone was obtained from the landslip material; representative samples of the dark grey claystone and the light grey claystone were subsequently obtained from the costeans and a further bulk sample of the white claystone was taken from the loose material in the small cliff exposures.

A representative 50 lb sample of the white claystone was sent to the Division of Building Research for testing. Their report (see Appendix) states that the claystone is kaolinitic and is a valuable raw material for the ceramic, refractory and whiteware industry.

Later, representative 10 lb samples of the dark grey and light grey claystones were sent for testing. The results were not expected to be significantly different from those for the white claystone. However, the report on the dark grey claystone (see Appendix) states that it is a montmorillonitic rock of high plasticity and very strong mechanical properties in the green state. Its drying shrinkage was more than three times that of the kaolinitic claystone. The sample of light grey claystone was not tested because it was considered to be similar to the white claystone which had already been tested.

Economic Geology

Reserves. Reserves of the kaolinite and montmorillonite claystones are not known but could reasonably be expected to be very large. Recommendations for further work to establish the stratigraphical succession and to prove large reserves of raw material are made at the end of this report. Sufficient raw material for a "cottage" pottery industry or instructional work in native schools could be obtained from the loose material close to the beach. Reserves of light grey and white claystone occurring in this way are probably of the order of a few thousand cubic yards, and probably would be sufficient to supply small pottery kilns for a number of years.

Exploitation. The small quantities of kaolinitic claystone that would be required for a "cottage" industry or instruction in native schools could easily be obtained from landslip material by pick and shovel methods.

Any future commercial development of these deposits, assuming the reserves are large enough, would entail the stripping of at least 25 feet of laterite overburden before the claystone could be excavated.

CONCLUSIONS

The Tertiary clays of Melville Island proved to be unsuitable for pottery manufacture. The Tertiary clays at Nightcliff are suitable pottery clays, but their occurrence with the Greater Darwin residential area precludes them from being exploited.

The Gunn Point Cretaceous claystones have been proved to be valuable raw materials for the ceramic, refractory and whiteware industries.

RECOMMENDATIONS

It is recommended that, initially, two cored diamond drill holes be put down in the Gunn Point area to determine the Cretaceous stratigraphy beneath the laterite cover (Plate 3), and, if possible, to establish the relationship between the montmorillonite and kaolinite claystones. Diamond drill holes are recommended in place of auger drill holes because the maximum drilling depth of most available auger drills is not sufficient to penetrate the anticipated thickness of these deposits.

To establish the presence of industrial-scale deposits of raw material, pattern drilling at suitably spaced centres would be required, but no programme can be laid out for this until the results of the first two holes are available.

REFERENCES

GARDNER, D.E., and RIX, P., 1963 - Investigation of heavy clayware resources, Darwin area, Northern Territory. Bur.Min.Resour.Aust.Rec. 1963/57.

MOORE, D., 1956 - Reports on exploratory drilling at Nightcliff and Darwin. Unpublished report, Resident Geological Section Darwin.

SKWARKO, S.K., 1960 - Mesozoic strata and fossils of the Northern Territory. Bur.Min.Resour. Aust.Rec. 1960/29.

APPENDIX

RESULTS OF TESTS CARRIED OUT BY C.S.I.R.O., DIVISION OF BUILDING RESEARCH ON MATERIALS SUBMITTED BY THE RESIDENT GEOLOGICAL OFFICE, DARWIN, N.T.

1. TERTIARY CLAY, WULAWUNGNA, MELVILLE ISLAND, N.T.

Sample Number	Burning Temp.	Total Shrinkage	Colour	Hardness
4 & 5	800	4.3%	Pale Pink	Soft
6 & 7	850	4.2%	Pale Pink	Soft
8 & 9	900	4.2%	Pale Pink	Soft
10 &11	950	4.5%	Pale Pink	Soft
12	1050	4.6%	Pale Pink	Soft

Samples were made into 4½" x ¾" x ¾" briquettes from crushed clay (-20 B.S.S.) by adding 24% of water. Shrinkage at 105°C was 4.5%. A plasticity test indicated a workability range between 21 (low) and 33 (high). The figures correspond to amounts of water added to 100 g of clay.

Conclusions

The test made proves that Wulawungna clay has low plasticity and is mechanically weak. The firing range tested (800° - 1050°C) was not sufficient to give it enough mechanical strength. A clay for "cottage" industry or small pottery items should have enough strength in a similar firing range. Higher firing temperatures are not practical for this type of production because of the higher cost of kilns, cost of burning and maintenance problems for the installations.

Summarising

We would reject Wulawungna clay as a material for teaching pottery making.

2. TERTIARY CLAY, NIGHTCLIFF, N.T.

The 50 lb bag of clay was homogenized and quartered to give a representative sample for the following tests:

Sample Number	Burning Temp.	Total Shrinkage	Colour	Hardness
1 - 2	850°C	4.52%	Pale Cream	Soft
3 - 4	900°C	4.91%	Pale Cream	Soft
5 - 6	950°C	5.4%	Pale Cream	Soft
7 - 8	1000°C	5.62%	Slight Cream	Soft
9 -10	1050°C	5.46%	White	Reasonably Strong
11 -12	1100°C	6.75%	White	Reasonably Strong

Samples were made into $4\frac{1}{2}$ x $\frac{3}{4}$" x $\frac{3}{4}$" briquettes from crushed clay (-20 B.S.S.) by adding 34.5% of water. Shrinkage at 105°C was 3.53%. A plasticity test indicated a workability range between 34 (low) and 48 (high). These figures correspond to amounts of water added to 100 g. of clay. A test with a specific deflocculant (Darvan) promises the possible use of the material as an ingredient for a casting slip. A differential thermal analysis of the clay gives a characteristic curve of a kaolin.

Conclusions

Nightcliff clay is a plastic kaolinitic clay. The use of it for pottery is possible but the firing of the articles should be at least 1050°C. To make thin walled articles and strong enough mechanically it is advisable to find a lower firing clay with a higher plasticity to improve its green strength. We suggest to take note of this clay deposit as a possible raw material for whiteware for the ceramic industry.

3. CRETACEOUS WHITE CLAYSTONE, GUNN POINT, N.T.

The sample received was quartered to give an average representative sample for the following test:

Sample Number	Burning Temp.	Total Shrinkage	Colour	Hardness
1 - 2	900°C	3.9%	Pale Cream	Reasonably Hard
3 - 4	950	5%	Pale Cream	Reasonably Hard
5 - 6	1000	5%	Pale Cream	Reasonably Hard
7 - 8	1050	5.7%	White	Hard
9 -10	1100	6.7%	White	Hard
11 -12	1200	9.9%	White	Hard

Drying shrinkage at 105°C was 3.5%

Samples tested were the usual 4" x $\frac{3}{4}$" x $\frac{3}{4}$" hand-made briquettes, from crushed clay passing -20 B.S.S. sieve. Water added was 47 parts to 100 parts of clay. Loss of ignition determined was 8.98%. A differential thermal analysis was typical of a kaolinitic type mineral. The clay was deflocculated easily.

Conclusions

The Gunn Point material is a valuable raw material for the ceramic refractory and whiteware industry. To be used for a native pottery industry it will need good grinding to bring it down to a grain size suitable for easy soaking. Such clay to develop a good plasticity should be kept wet for long periods.

4. CRETACEOUS DARK GREY CLAYSTONE, GUNN POINT N.T.

Samples tested were the usual 4" x ¾" x ¾" hand-made briquettes from clay passing -20 B.S.S. sieve. Water added for forming was 25 parts per 100 of clay. A plasticity test indicated a workability range of 49.5 (low) and 61.5. These figures correspond to amounts of water added to 100 g of fine ball-milled sample (-60 B.S.S.).

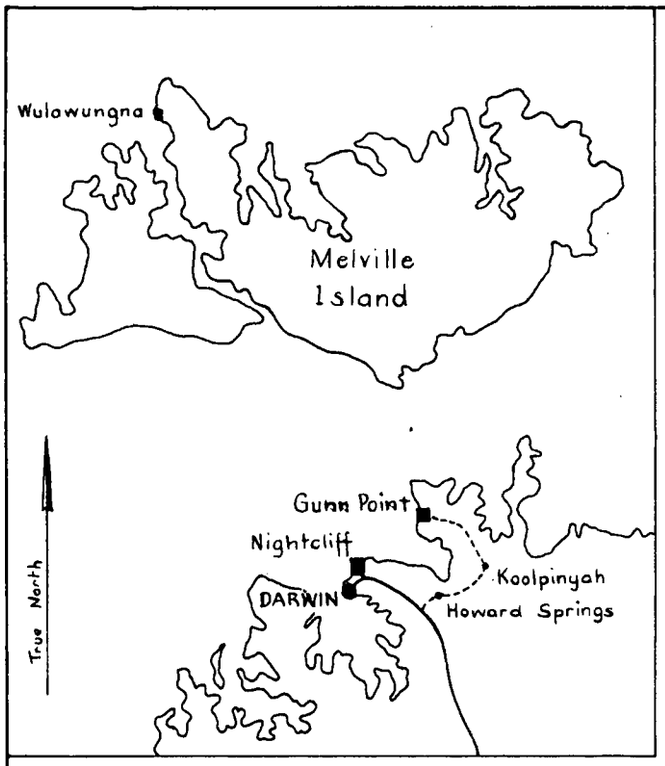
Shrinkage at 105°C was 11.5%. A differential thermal analysis and an X-ray diffraction test indicate a predominance of montmorillonite in the clay. The total firing shrinkage is indicated by the following table:

Sample Number	Burning Temp.	Total Shrinkage	Colour
1 - 2	900°C	12.75%	Cream
3 - 4	950	13.1	Cream
5 - 6	1000	13.1	Cream
7 - 8	1100	12.75	Dark Cream
9 -10	1200	12.5	Grey Cream

Conclusions

The dark grey claystone is a montmorillonitic rock of high plasticity and very strong mechanical properties in the green state. This type of clay is often used in small quantities for improving extrusion or moulding in the ceramic industry. It would also help to increase the green strength of cast products. It is used as a binder for foundry sands and refractory mortars. The clay did not deform or melt in the firing tests. At 1200°C the appearance was of a pronounced sintering.

PLATE 1



Scale
0 50 MILES

FIG. 1 LOCALITY MAP : DARWIN AREA N.T.

Showing potential pottery clay localities.

(Deposits shown by black squares)

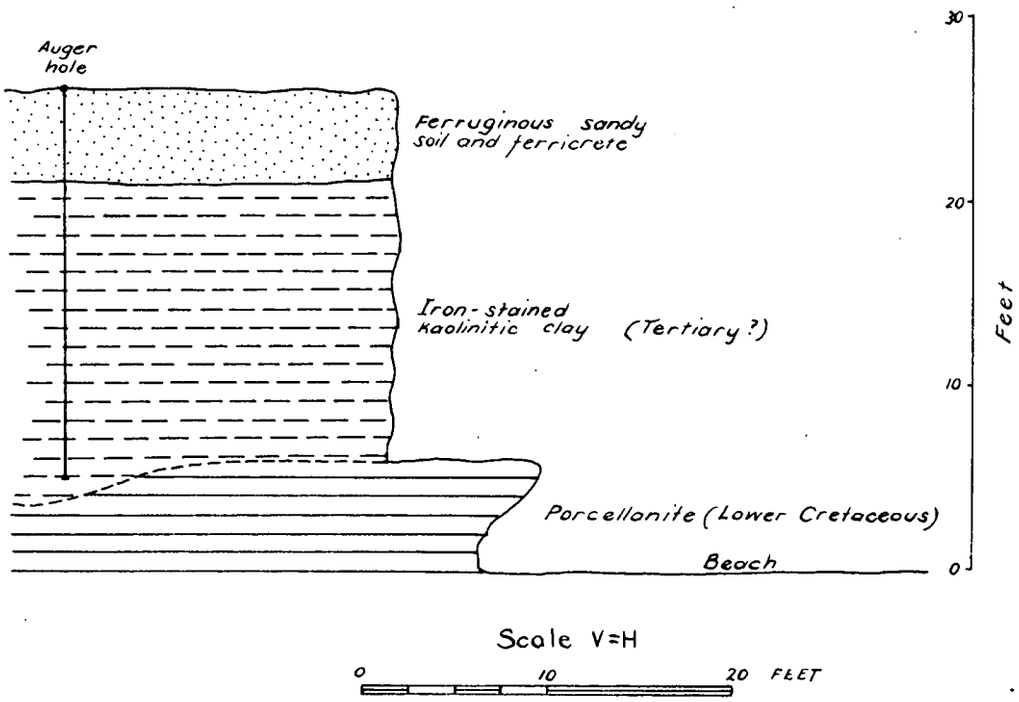


FIG. 2 CLIFF SECTION : ESPLANADE, NIGHTCLIFF.

To accompany Record 1964/94.

Resident Geologists Office, Darwin N.T. December 1963

D52/A4/25

D52/4/DG14

Fig. 1 Locality Map North west Peninsula of Melville Island, N.T.

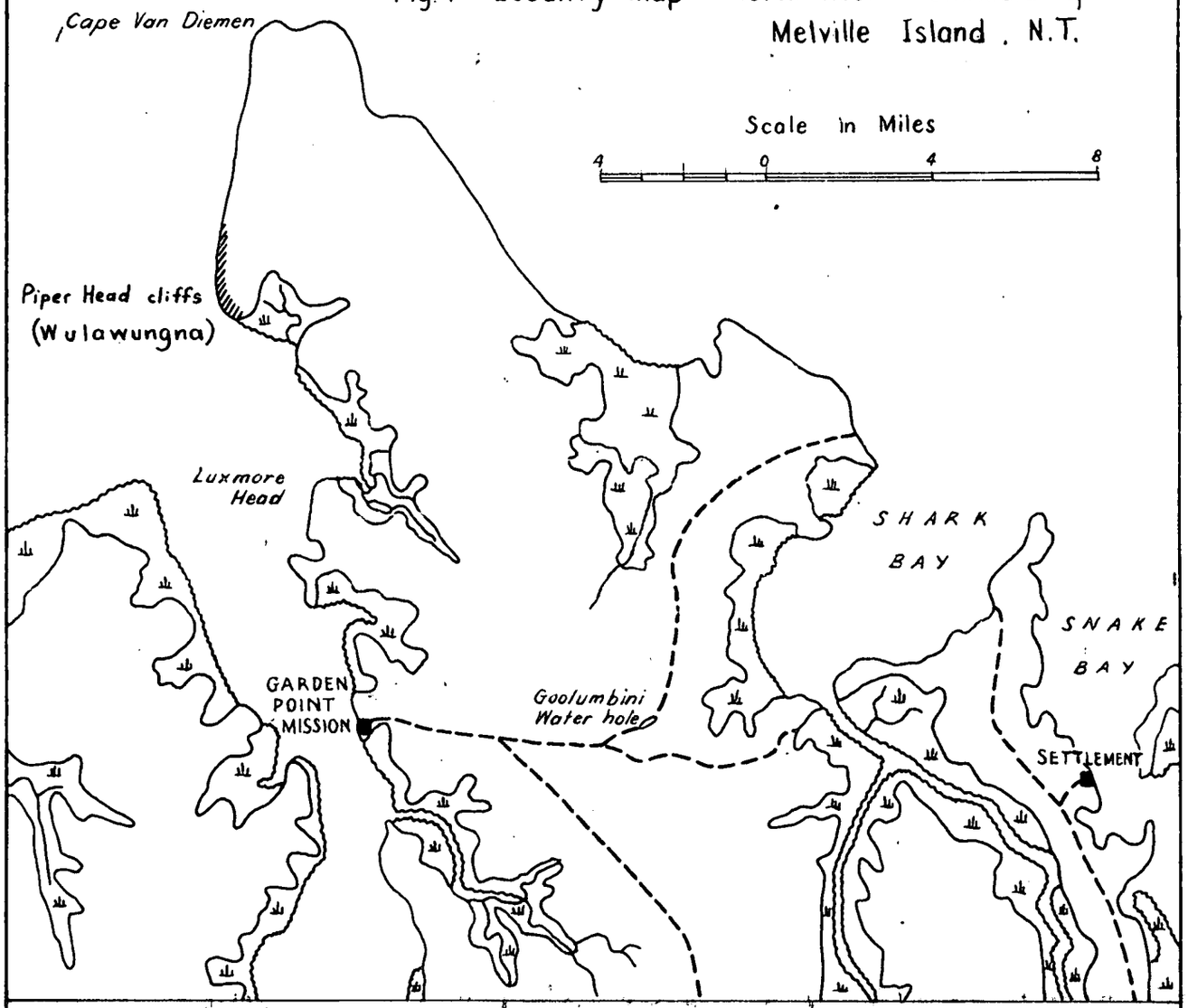
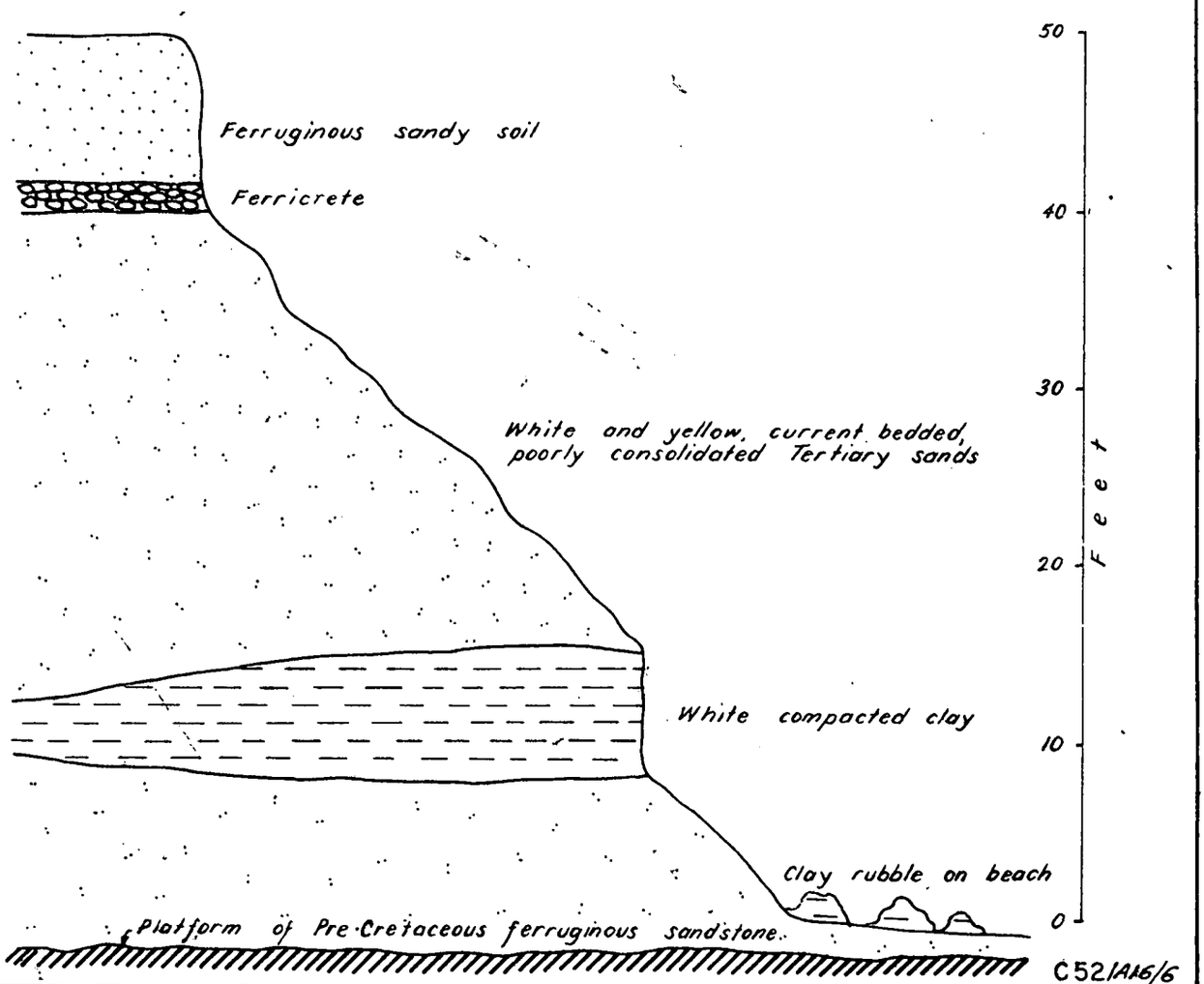


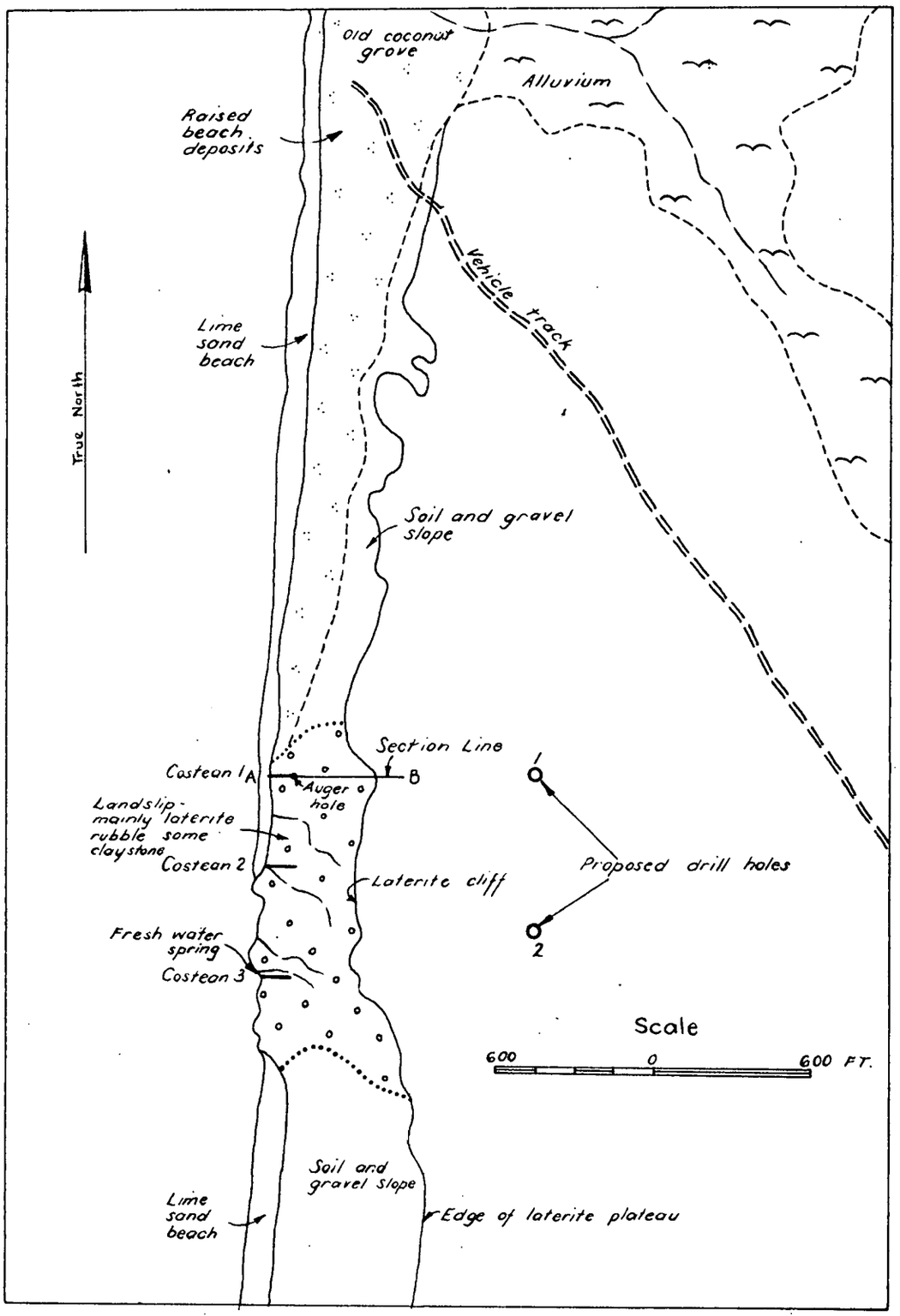
Fig. 2 Scale section of cliff, locality one, Wulawungna.



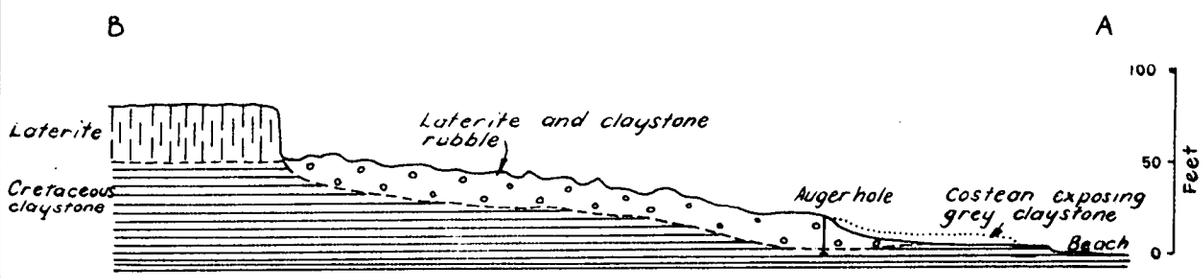
C52/A16/6

To accompany Record 1964/94.

C52/5/DG1



AREA NEAR OLD COCONUT GROVE, GUNN POINT N.T.



SECTION ALONG LINE A·B

Scale

100 0 100 200 FT.

To accompany Record 1964/94.

Resident Geologists Office, Darwin N.T. December 1963

D52/A4/26

D52/4/DG15