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INVESTIGATION OF HEAVY CLAY-WARE RESOURCES, DARWIN AREA, NORTHERN TERRITORY.

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by

D.E. Gardner* and P. Rix.+

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INTRODUCTION

GENERAL

During the last few years, several samples of prospective brickmaking materials have been obtained by Resident Geologists from locations between Katherine and Darwin; others have been submitted by private individuals for examination or for testing by C.S.I.R.O. Division of Building Research, Melbourne, and Australian Mineral Development Laboratories, Adelaide. In 1962, it was decided that a more comprehensive survey would be made of the resources of heavy clayware materials in the Darwin area.

Heavy clayware products include bricks, tiles, earthenware pipes, solar screens and similar articles. They are produced from clays of various types, principally sedimentary clays and those formed in situ by weathering of argillitic rocks. A suitable clay needs fairly small amounts of water for tempering, dries readily without excessive shrinking and accompanying cracking and deformation, and burns to a hard, non-porous product of satisfactory colour over a firing range of about 1000 to 1100°C without excessive shrinking, cracking and deformation. A very plastic clay commonly needs much tempering water, and shrinks excessively both in drying and burning. A less plastic clay or a weathered shale needs less tempering water and has a lower shrinkage, but it commonly lacks bonding material to give hardness on burning. Two clays or a clay and a weathered shale may be blended to give a material that has satisfactory properties.

White clays usually need a high temperature for burning, and yield an article that is too pale in colour to be pleasing as an exterior building material. Blending of a clay or weathered shale that contains disseminated iron oxide may yield a product that is satisfactory in colour, hardness, and shrinkage.

Bricks and tiles may be formed both by pressing and by extrusion, pipes by extrusion. An extrusion plant is the more versatile in the range of articles that can be produced, and in the ease with which modifications can be made in the shape and surface texture of the products.

PROSPECTIVE LOCALITIES, AND SAMPLING METHODS

Potential brick clays had been sampled by P. Rix and P.W. Crohn in pits down to depths of 3 feet at Noogoo Swamp, Milner Swamp, Elizabeth River, and near the 32-Mile peg and at Berry Flat, approximately 32 miles and 35 miles, respectively, from Darwin along the North Australian Railway. Additional samples from these localities and from Leanyer Swamp had been submitted by Mr. N.A. Densley, of Darwin, but the exact localities and depth of sampling are in doubt.

In the present investigation, a search was made for alternative sources of shale in Lower Proterozoic beds near Darwin and sources of clay in the weathered Cretaceous sediments

that cover much of the Darwin area. Clays of this type intersected in water bores had already been noted by P. Rix. To facilitate sampling, arrangements were made with the Department of Works, Electric Supply, to hire a truck-mounted power auger capable of operating to depths of 7 feet.

LABORATORY TESTING

Arrangements were made with Australian Mineral Development Laboratories Ceramics Section for preliminary testing of samples to ascertain the firing range and the general characteristics of each. Cylindrical test pieces about 1 inch diameter and ¾ inch thick, formed both by pressing and extrusion are dried and fired over the range 800°C to 1200°C in 50°C steps. From the general behaviour of the material tested and the appearance of the fired specimen, the suitability for more detailed testing and for blending is determined.

GEOLOGICAL BACKGROUND

DARWIN AREA (Plate 1)

General

The greater part of the Darwin area is capped by Cretaceous sediments, the Mullaman Beds, beneath a thin cover of alluvium and cemented ferruginous buckshot and gravel (the ferricrete of Hays 1960). Outcrops of Lower Proterozoic sediments are found mainly around the margins of the Cretaceous.

Extensive low-lying swamps form coastal fringes to the mainland, and extend inland as embayments for several miles. They are filled by sediment that is presumably Recent in age.

The exposed Cretaceous beds consist of sandstone, siltstone and conglomerate, with hard, siliceous "porcellanite" near the top of the sequence. Erosion and undercutting of the beds beneath the durable porcellanite gives rise to vertical or steep scarps at the seashore and at the margins of low-lying coastal swamps. Water bores near Darwin have intersected plastic clay and silty clay, commonly white in colour, through thicknesses of up to 65 feet. Similar clayey material is exposed in creek banks north of Darwin, both east and west of Lee Point Road. It probably represents weathered and decomposed siltstone, shale and silty mudstone, and is regarded as a potential material for heavy clayware.

Clay

Clay occurs in the coastal swamps, where it is probably Recent in age, and in the Mullaman Beds, where it has formed in situ through sub-aerial weathering, possibly before the deposition of the ferruginous gravel that now forms the ferricrete.

In the lower-lying parts of the swampy areas within the zone of tidal influence the dried surface is encrusted with salt, and presumably the clay would be too saline for burned clayware. Farther inland in the swampy embayments the surface or sub-surface water is fresh, and the clay, where examined to a depth of 7 feet from the surface, is highly plastic and tenacious. From the surface down to depths of a few feet, it contains various proportions of ferruginous pisolites or buckshot. For use in heavy clayware, it could be anticipated that the swamp clay would need to be blended with a material of lower plasticity, and lower drying and firing shrinkage.

The weathered Cretaceous beds intersected in water bores and exposed in creek banks yield clays that range in

colour from pale buff, pinkish-red, and reddish-brown, within the upper six feet, to grey and white at greater depths. The clays are less plastic than the swamp clays, and fragments of less-weathered mudstone and silty mudstone that persist within the clay would reduce the plasticity further, if they are amenable to fine grinding.

As is the case with the swamp clays, the clay derived from weathering of the Cretaceous beds, where exposed at the surface, contains ferruginous pisolites or buckshot to depths ranging to 4 feet. In addition, it is characterised by an irregular ferruginous mottling.

Shale

Cretaceous. Useful shaly beds were not found in the outcrops of Cretaceous sediments. Discontinuous or lenticular bands of silty shale and mudstone are interbedded with siltstone and fine sandstone in outcrops around the margin of Leanyer Swamp; they are too small to be economically worked. Possibly a pit opened for clay in the weathered Cretaceous beds would expose suitable argillitic materials - shale and mudstone - below the clay. Shale is recorded in water bores west and east of Lee Point road at depths ranging from 30 to 55 feet.

Lower Proterozoic. The Noltenius Formation contains fairly thick argillitic members consisting of well-weathered shale, commonly slightly silty, and sericitic and unctuous along bedding planes. The outcrops form cliffs capped by Mesozoic beds at Stokes Hill and Fort Hill in Darwin Harbour, along the western side of the railway line up to about half a mile north of Stokes Hill, where a width of at least 300 feet is exposed, and at Bullocky Point in Fanny Bay.

About 5 miles east of Darwin, east and west of the road that runs southwards from Berrimah through the Leprosarium to the Quarantine Station, a sequence of arkosic beds contains an argillitic member, arkosic silty shale, that has a known width of about 60 feet. It is exposed in a cutting in a hill just inside the boundary of the Leprosarium, about 1½ miles south of Stuart Highway.

Elsewhere east of Darwin, within the area shown on Plate 1, the Lower Proterozoic rocks seen in outcrops are arenitic and unsuitable for clayware.

BERRY CREEK AREA

The Berry Creek area is situated in the south-west portion of the Humpty Doo 1-Mile Sheet and the north-west portion of the Marrakai 1-Mile Sheet, in an area of low relief. The country is very gently undulating, and the slightly higher areas are separated by broad drainage belts which are under water for a considerable period during the wet season.

The higher areas are capped by ferruginous deposits, sand, and cemented ferruginous detritus.

The broad flats where intersected by auger holes consist of Quaternary alluvium - soil, and alluvial clay, sandy clay, sand and pebbly bands.

A few outcrops of Noltenius Formation have been mapped in the higher ground. One such outcrop, at the locality of the 32-Mile clay and shale prospect, is 2½ miles southwards along the North Australian Railway from the Berry Springs road. Decomposed shale is exposed in a drain at a culvert beneath the railway line. At a locality 2½ miles farther south, where the railway line crosses a broad, treeless flat, termed Berry Flat

in this report, clay is exposed in a drain along the eastern side of the railway. It has traces of horizontal banding which suggests a sedimentary origin; this was confirmed by augering.

INDIVIDUAL LOCALITIES

CLAY

Rapid Creek (Plate 1)

Rapid Creek drains a basin-shaped area of partly swampy land about a square mile in area at the north-western edge of the Darwin Aerodrome within the R.A.A.F. Defence Reserve; the swamp and environs are at an elevation of 50-75 feet above sea level.

Auger sampling to depths of 7 feet was done at localities 0.35 and 0.5 mile upstream from McMillans Road, access being gained along an old gravel road that follows the south-western side of the creek up to the aerodrome fence.

Clay is exposed in a gully cut by the creek for a distance of 1000 feet upstream from McMillans Road, at an elevation of 25 to 50 feet, above mean sea level. Further upstream the creek flows in a broad shallow channel, over soil, humus, and detrital fragments of ferruginous gravel and of Cretaceous sedimentary rocks.

Augering was restricted to the south-western side of the creek; it showed that clay occurs from the surface down to depths of at least 7 feet over a width of about 120 feet. The upper 6 inches to 1 foot contains black humus and was discarded. Farther from the creek, where the ground surface rises at a gradient of a few degrees, ferricrete and porcellanite were encountered at depths of 6 inches to 3 feet and were too hard to be penetrated by the auger.

Assuming that a similar width of clay occurs on the north eastern side of the creek, possible reserves of clay down to a depth of 7 feet, from McMillans Road upstream for half a mile amount to about 50,000 cubic yards. Testing at greater depths might substantially increase the figure of reserves.

The clay is buff, red, pink and grey in colour, is slightly silty, and does not seem to be highly plastic. In places, it contains fragments of firm to hard silty mudstone, and apparently was derived by weathering *in situ* of argillaceous Mullaman beds; it may, however, be an alluvial clay, filling an earlier, deeper channel of the creek.

A composite sample, No. 197019, from auger holes RC1, RC5, and RC6 was despatched to A.M.D.L. for testing (see Appendix 4 for results). Logs of the auger holes are given in Appendix 1.

Casuarina Beach Area (Plates 1 and 3)

Clay similar to that exposed in Rapid Creek occurs in the banks of a creek that runs west-north-west to Casuarina Beach from a locality near Lee Point road, about 2 miles south of Lee Point, near the entrance to the R.A.A.F. Firing Range. In this general area, the higher ground into which the creek channels have been cut consists of hard, silty, probably siliceous Mullaman beds, covered by ironstone gravel and locally by cemented ironstone. Erosion by the creek system shown on Plate 1 presumably has removed the hard, upper beds and exposed a fairly large area of clayey material derived by weathering of Cretaceous silty mudstone and shale. So far as is known, this

clayey material had not previously been examined.

The area examined is outside the boundaries of Defence Reserves and north of the planned residential areas. Auger holes (Plate 3) were put down to depths of 7 feet near the creek (holes CC1, CC4 and CC6) and in the somewhat higher ground between creek channels (holes CC3, CC5, CC7).

Near the creek, the upper 6 inches to 1 foot contains black humus and was discarded. Below this the clay is grey, white, buff, pinkish-grey and pink-red, and, as is the case at Rapid Creek, it contains scattered fragments of firm to hard Cretaceous silty mudstones.

Holes CC3 and CC5 between the creek channels intersected clay and ferruginous buckshot down to about 4 feet, and at greater depths, white, red and grey clay, and red clay with a small white mottling or speckling that imparts a granular appearance. This clay, too, contains fragments of Cretaceous silty mudstone and presumably has been formed through weathering in situ of Cretaceous Mullaman Beds.

Three samples were obtained. The first, No. 197021, is from holes CC1, CC4 and CC6 near the creek. The second, No. 197023, is from the lower part of holes CC3 and CC5 in the slightly elevated area between creek channels. Some clay containing a small proportion of buckshot ironstone was inadvertently included in this sample. These two samples were sent to A.M.D.L. for testing. (See Appendix 4 for results). The third sample, No. 197025, contains buckshot and red clay from the upper part of hole CC2; it has not been sent to A.M.D.L.

Hole CC7, on high ground beyond the creek system, intersected sandy clay and numerous fragments of fairly hard Cretaceous beds.

Reserves of clay are probably very large, but the area needs testing to greater depths than the 7 feet attainable by the auger.

Deeper drilling would probably locate weathered shale of the Noltenius Formation which could be useful for blending with plastic clays. Water bores in the area show probable Lower Proterozoic shales at depths ranging from 55 to 80 feet. These boreholes are in higher ground - about 75 feet above mean sea level; it is possible that in the area augered, which has an elevation between 25 and 50 feet, Lower Proterozoic beds would be encountered at depths of about 15 to 40 feet, or making the most optimistic use of the data at depths of 5 to 25 feet.

Milner Swamp (Plate 1)

Milner Swamp drains into the sea at Hope Inlet and is tidal in its lower parts; its upper portions are less than 25 feet above mean sea level, and are under water during the wet season.

At its margin, and probably within the swamp, the surface consists of very plastic clay, black with humus down to a depth of about one foot. The terrain rises gently at the edge of the swamp to a few feet above swamp level, where a cemented ferruginous capping occurs beneath the surface soil.

Access to the sample locality is by way of a road that runs north-east for a mile from just past the 10-mile peg on Stuart Highway to Department of Civil Aviation Transmitting Station, and thence by track for three miles east-north-east to

an old rice garden near the edge of the swamp.

An auger hole put down to a depth of 7 feet at a point 80 feet north-west from an earth bank that formed the edge of the rice garden, encountered clay, ferruginous buckshot and rock fragments down to 3 feet 6 inches, and pink-red and green, very plastic and tenacious clay from 3 feet 6 inches to 7 feet. A sample of the tenacious clay, No. 197052, was sent to A.M.D.L. for testing.

Reserves around the margin of the swamp are probably very large; if the clay is suitable for clayware it should be sampled to greater depths.

Two clay samples taken in 1961 by the Resident Geological Section are probably very similar to the Milner Swamp clay. One sample (field No. II) was obtained near Kings Creek in the lower part of Noogoo Swamp, which is subject to tidal waters; the other (field No. III) was obtained in the upper part of Noogoo Swamp probably in a similar position, with respect to ground water salinity conditions, to the auger sample from Milner Swamp. Both samples were tested by C.S.I.R.O., Division of Building Research. Sample No. II (Laboratory Code No. DNT6) showed very heavy surface scumming after oven drying, and sample No. III (Laboratory Code No. DNT7) was slightly scummed. DNT6 burned hard over a firing range of 850°C to 1150°C, at 50° intervals, and was cracked and warped at 1150°C. To avoid bursting during burning it had to be carefully dried at 110°C and after burning had an unsightly scum and tended to glaze at the higher temperatures. The colour was red-brown. DNT7 burned hard from 900°C to 1200°C, was orange-red in colour, and had one or two small cracks, but no deformation at 1200°C. It was almost free of scum and had low total shrinkage but suffered from a somewhat low fired strength, probably due to lack of bond.

The auger sample from Milner Swamp is more likely to resemble DNT7 than DNT6. However, DNT7 (Sample No. III) was taken from a shallow depth, vix. from 6 inches to 1 foot 6 inches, and could represent, in part, the leached A-horizon of a soil profile; the Milner Swamp auger sample was taken from a depth of 3 feet 6 inches to 7 feet; it consisted of very tenacious clay and probably has better bonding than the clay of DNT7. Should the plasticity and shrinkage be excessive, as well may be the case, the clay could be modified by blending with a material of lower plasticity. Such a material - the shale of the Noltenius Formation near Darwin Harbour is discussed later under Shales, where the firing range and characteristics of a sample of it (Laboratory Code No. DNT8) are given.

<u>13-Mile Turn-Off</u> (Plate 1)

At a point on the Suart Highway 13-1/3 miles from Darwin a road runs north-east across the railway line and continues as a track to Milner Creek and Milner Swamp. About 300 feet pas the railway, 50 feet south-east of the track, deeply cracked clay forms the bottom of a pit three to four feet deep, 60 feet long and 40 feet wide, that was excavated for ferruginous gravel. Within a radius of about a mile from the pit the country is flat lying, covered by buckshot and cemented ferruginous gravel, and contains scattered outcrops of Mullaman beds.

An auger hole put down in the bottom of the pit passed through grey and buff-brown clay, with buckshot ironstone from the surface to a depth of 1 foot and scattered carbonate concretions from 1 foot 6 inches to 7 feet 6 inches. The clay

contained fragments of shale, siltstone and mudstone, and presumably is derived by weathering from Cretaceous beds beneath the ferruginous capping.

A sample, No. 197054, was sent to A.M.D.L. for testing (see Appendix 4 for results).

32-Mile (Plate 1)

The 32-mile clay and shale locality is situated near the 32-mile mark on the North Australian Railway, about 2½ miles south of the Berry Springs road. Access is by the Stuart Highway to the Berry Springs turn-off, 30 miles south of Darwin, thence by the Berry Springs road to the railway crossing and finally by the track alongside the railway for 2½ miles in a southerly direction.

At this locality a few exposures of brown and yellow clay occur in a small creek that runs along the west side of the railway line. Shale is exposed in a cutting some distance south of the 32-mile peg.

Pits put down early in 1962 to a depth of 3 feet, in an area 400 feet long, and 50 to 250 feet east of the railway, exposed clay beneath surface soil and gravel; the colour of the clay ranged from red-brown to yellow. At the bottom of two pits weathered shale, mottled grey and brown, was exposed, and it was concluded that the overlying clay is a product of in situ weathering of the shale.

In the present investigation, auger holes were put down beside two of the earlier pits to obtain samples of weathered shale down to depths of 7 feet, the limit of augering. Two auger holes put down 600 feet east of the railway show that the weathered shale and the clay derived from it pass beneath alluvium that consists of silty, sandy and pebbly clay more than 7 feet thick.

The area that could be worked for clay derived by weathering of shale in situ, and hence free from sand and pebbles, was not ascertained. Humpty Doo 1-Mile Geological Sheet shows small areas of Noltenius Formation at the locality; possibly the workable area is of the order of 1000 feet long and 200 to 400 feet wide.

Two samples were sent to A.M.D.L. for testing:-

Sample No. 197048: A composite sample of clay from auger holes 1 to 4.

Sample No. 197050: A composite sample of weathered and decomposed shale from auger holes 5 and 6.

Logs of the auger holes are given in Appendix 1 and results of the A.M.D.L. tests in Appendix 4.

Berry Flat (Plate 1)

Berry Flat is situated 2½ miles southwards along the railway line from the 32-Mile locality and is reached by following the track alongside the line.

A pit dug early in 1962 to a depth of 2 feet 6 inches exposed dark red and grey mottled clay similar in appearance to that at the 32-Mile Deposit. The clay was thought to be underlain by weathered shale, and to be derived from weathering of the shale in situ. Shale is exposed in a cutting north of the flat.

In the present investigation, four auger holes were put down to depths of 7 feet on the south-eastern side of the railway line, two holes 50 feet from the line and two holes 600 feet from it. The north-eastern hole, 600 feet from the line, entered alluvial sandy clay at a depth of 5 feet; the other three holes passed through about 9 inches of surface silt and then through clay that was slightly silty in places. Logs of the auger holes are given in Appendix 1.

The augering suggests that the clay is sedimentary in origin, although possibly as at the 32-Mile locality, it is in part derived by weathering of shale in situ.

Probable reserves in the area augered amount to 40,000 cubic yards, but testing to greater depths over a more extended area would almost certainly prove that the deposit contains very large reserves.

One sample, No. 197056, from auger holes 1, 3 and 4 was sent to A.M.D.L. for testing (see Appendix 4).

OTHER LOCALITIES

Clay similar to that in Rapid Creek and in the Casuarina Beach area is exposed in minor gullies between Lee Point Road and Leanyer Swamp. However, this area is at present reserved for defence purposes and for the Australian Broadcasting Commission; it was not sampled.

Swamp clay similar to that obtained at the edge of Milner Swamp probably occurs in Leanyer and Noogoo Swamps, above the reach of tidal waters.

Clay similar to that sampled near the 13-Mile turn-off probably occurs at shallow depths at other localities beneath the broad cover of Quaternary alluvium and ferruginous gravel between the 13-Mile and Darwin. It is unlikely that the carbonate concretions are of widespread occurrence.

A deposit of alluvial clay and silt of low plasticity that might be somewhat refractory and a useful blending material for highly plastic clays occurs in a Forestry Reserve about a mile south of Berrimah (Plate 1). The surface is covered by sandy outwash material, a foot or less thick. A sample of the alluvial clay and silt, No. 197083, dug from a drain, was sent to A.M.D.L. (see Appendix 4).

SHALE

Darwin Harbour (Plate 1)

Stokes Hill. Stokes Hill rises about 50 feet above the general level of the roads and buildings at Darwin Harbour, and restricts the area available for access and storage; water storage tanks for fire fighting were constructed on it some years ago.

The hill is capped by Mullaman beds, probably less than 20 feet thick and these are underlain by shale of the Noltenius Formation interbedded with minor beds of silty shale and fine-grained sandstone.

A sample of Stokes Hill shale sent to C.S.I.R.O., Division of Building Research by P.W. Crohn in September, 1961, was burned as briquettes at temperatures of 1100°C, 1150°C, and 1200°C. The Laboratory Code No. is DNT8. Total shrinkage on drying and firing was - 1.0% at 1100°C and 1.9% at 1200°C. At 1200°C the briquettes were hard, but cracked and warped; at

the lower temperatures they were fairly soft, but not deformed. Small amounts of the weathered shale might be useful for blending with a clay that is too plastic, perhaps the Milner Swamp Clay.

One channel sample, No. 197042 was sent to A.M.D.L. for testing (see Appendix 4).

A car parking area excavated into Stokes Hill a few years ago could be extended by quarrying a block of shale about 120 feet long, 60 feet wide and 30 feet thick; in this way 8000 cubic yards of the shale might become available for use in heavy clayware. If the water tanks on the hill were removed at some future date to extend the area behind Darwin Harbour much greater quantities would be available.

Fort Hill (Plates 1 and 2). Fort Hill limits the area available for storage on the western side of Darwin Harbour, and at present proposals that the hill be removed are being considered. The western part of the hill (Plate 2) consists of shale of the Noltenius Formation and the eastern half of sandy shale and impure sandstone. The hill is capped by Mullaman Beds.

The shale is similar to that at Stokes Hill and presumably would have similar properties if used for heavy clayware. The quantity that would become available if the hill were removed is approximately 50,000 cubic yards.

One channel sample of Fort Hill shale, No. 197040 has been sent to A.M.D.L. for testing (see Appendix 4).

Leprosarium Reserve (Plate 1).

Silty, arkosic shale is exposed in a road cutting a short distance inside the boundary of the Leprosarium Reserve, on a low flat-topped hill about 400 feet east of the road to the Leprosarium and Quarantine Station.

The shale forms the western end of the low hill, which is capped by Mullaman Beds. Boundaries are obscured by rubble; probably the block of shale that could be excavated from the hill is about 300 feet long, 90 feet wide, and has an average thickness of about 15 feet. A rough estimate gives reserves of 15,000 cubic yards above plain level.

A channel sample, No. 197082, was sent to A.M.D.L. (see Appendix 4).

32-Mile (Plate 1)

The weathered and decomposed shale of the Noltenius Formation at the 32-Mile Locality is described above, under Clay.

The area that might be available for winning shale close to the surface is estimated, by reference to the Humpty Doo 1-Mile Geological Sheet, to be of the order of 1000 feet long by 200 to 400 feet wide. This would need to be checked by augering, preferably to greater depths than the 7 feet attained in the present investigation.

Shale sample No. 197050, from auger holes 5 and 6, was sent to A.M.D.L. for testing (see Appendix 4 for results).

OTHER LOCALITIES

Small quantities of shale of the Noltenius Formation could probably be excavated at selected localities on the western side of the railway up to a half a mile north of Darwin Harbour. This occurrence is mentioned under Geological Background, Darwin Harbour.

Probably shale of the Noltenius Formation would be found by deeper augering or drilling beneath the clay in the Casuarina Beach area. This is discussed under Clay, Casuarina Beach area.

Fairly hard silty shale occurs at the northern boundary of the quartzite in an old quarry on the north-eastern side of Stuart Highway about 17½ miles from Darwin. A search in this area might locate more deeply weathered, less silty shale, possibly in the lower-lying country a short distance north of the exposed shale.

Excepting the 32-Mile Locality, no search has been made for shale farther east than Milner Creek and the Lower Proterozoic outcrops south of Stuart Highway, at about the meridian of the 13-Mile peg.

Access and Working Conditions

Access to localities that are at some distance from made roads becomes difficult or impossible during and for some time after, the wet season, which generally extends from December to April. Flat country becomes covered by broad sheets of water, and even if access were practicable, draining of a working pit would be costly.

Clay pits at Rapid Creek and the Casuarina Beach area could be reached during the wet season without much preparatory expenditure in road-making. The terrain has low relief; any substantial pit would be below the level of the surrounding ground and become flooded; it could be kept workable by pumping into the creeks.

Milner Swamp, the 32-Mile locality and Berry Flat would be inaccessible and unworkable during the wet season; the two last-named deposits could be reached by rail to remove stockpiled material. The clay deposit at the 13-Mile Turn-Off could be made accessible at a reasonable cost but a pit could be kept dry only at considerable cost in pumping.

The shale localities within Darwin Harbour and in the Leprosarium Reserve would be accessible throughout the year, and each could be worked in a free-draining pit. At the Leprosarium Reserve, the quantities of shale above the level of the surrounding flat country are not large; probably it would be desirable to work a pit in two benches, the upper bench being reserved for the wet season.

PRELIMINARY LABORATORY TESTING

Method of Testing

Samples were finely ground, tempered with water and extruded without de-airing to form cylindrical specimens 1 inch in diameter and $\frac{3}{4}$ inch thick. The specimens were fired at temperatures ranging in 50 degree steps, from 800°C to 1200°C.

Results of Testing

The results of preliminary testing are summarized in Table 1.

Conclusions from Preliminary Testing

The following materials are recommended by the Australian Mineral Development Laboratories for full-scale testing:

Shale from 32-Mile
Clay from Berry Flat
Clay from Milner Swamp
Shale from Fort Hill
Shale from Stokes Hill
Shale from the Leprosarium Reserve
Forestry Reserve alluvial clay and silt.

The clay from the 32-Mile locality is regarded as a border-line material, not recommended for use if better materials are available.

Materials not recommended for use are:-

Clay from Rapid Creek

Clay from Casuarina Beach area

Clay from 13-Mile Turn-off.

TABLE 1. PRELIMINARY TESTING OF HEAVY CLAY-WARE SAMPLES, DARWIN AREA

Material Tested and Sample No.	Ease of Grinding	Extrud-ability	Shrinkage (Approximate)	Colour after firing	Hardness	Summary of Remarks by A.M.D.L. Ceramics Section
32-Mile (Shale) No. 197050	Ground easily	Extrudes well	Low wet to dry Fired: 5% at 1009°C 9% at 1050°C 10% at 1100°C 13% at 1150°C 15% at 1200°C	800°C to 1050°C Pink to pale red 1100°, red 1150°C, deep red. 1200°C, brown	Hard at 1000°C (not easily scratched with knife)	Although somewhat weak and short in the plastic state, it would probably make good de-aired bricks and also be useful in de-aired pipe and tile blends.
Berry Flat (Clay) No. 197056	Ground easily	Extrudes well	Wet to dry: low Fired: 4% at 1000°C 5% at 1100°C 5% at 1200°C	Pale red to orange from 800°C to 1050°C Red from 1100°C to 1200°C	Hard at 1050°C (not easily scratched with knife)	The material appears to be promising for red brick manufacture and may also be useful in pipe and tile blends.
Milner Swamp (Clay) No. 197052	Rather difficult to grind; required drying.	Extrudes well	Wet to dry and firing shrink-ages excessive	Red from 800°C to 1150°C Deep red at 1200°C	Hard at 850°C (not easily scratched with knife)	The extruded material was extremely tough, strong and plastic. It appears to be very promising for use as a bond clay in pipe, tile and brick blends.
Fort Hill (Shale) No. 197040 Stokes Hill (Shale) No. 197042	Ground easily	Extrudes satisfact-orily.	Wet to dry: very low Firing: Very low to 1050°C 3% at 1100°C 6% at 1150°C 12% at 1200°C	Pink or pale red up to 1050°C Red at 1100°C Deep red at 1150°C. Red-brown at 1200°C	Very soft from 800°C to 1050°C. Hard at 1200°C (not easily scratched with knife)	After extrusion, this material was extremely weak and de-watered readily. It appears promising for mixing with a strong bond clay in brick, pipe and tile blends.
Leprosarium (Shale) No. 197082	Ground easily	Extrudes satisfact-orily	Wet to dry: very low. Fired: very low to 1100°C. 5% at 1150°C 8% at 1200°C	Pink to 1050°C Pale red at 1100°C. Red at 1150°C. Deep red at 1200°C.	Very soft to 1050°C. Hard at 1200°C (not easily scratched with knife)	During extrusion this material was weak and de-watered readily. It appears to be promising and may find a use in blending with a strong bond clay for brick, pipe and tile manufacture.
Forestry Reserve (Alluvial Clay and Silt) No. 197083	Ground easily but was extremely gritty (siliceous)	It was not poss-ible to extrude this mat-erial, but specimens were pressed satisfact-orily.	After-firing shrinkage extremely low	Off-white from 800°C to 1200°C	Not very hard at 1200°C. Apparently needs high temperature for incipient vitrification.	Promising for use in refractories; it may also be suitable for use in blends to produce light-coloured bricks.
32-Mile (Clay) No. 197048	Ground easily	Extrudes satisfact-orily	Wet to dry: low Fired: 3% at 950°C 4% at 1000°C 5% at 1050°C 6% at 1100°C 7% at 1150°C 6% at 1200°C	Salmon-pink from 800°C to 1050°C. Pale red at 1100°C Red at 1150°C Deep red at 1200°C	Hard at 1050°C (not easily scratched with knife)	The amount of grit present is somewhat excessive. The material is not very promising but may possibly be used for brick-making if blended with a soft grit-free shale and de-aired.

TABLE 1. (Contd.)

Material Tested and Sample No.	Ease of Grinding	Extrud-ability	Shrinkage (Approximate)	Colour after firing	Hardness	Summary of Remarks by A.M.D.L. Ceramics Section
Rapid Creek (Clay) No. 197019	Contained some very hard small rock fragments and was somewhat diffcult to grind	Excessive gritty fragments; the extruded material displayed excessive dog-ears and cracks	Wet to dry: low Fired: 4% at 950°C 5% at 1000°C 6% at 1050°C 8% at 1150°C Other test pieces cracked, and measurement inaccurate.	Pale buff-red to pale buff-brown	Fairly hard at 1150°C but chips when scratched with knife.	The material is not very promising and is not recommended for use.
Clay from Casuarina Beach Area In creek gully No. 197021	Bulk of material ground easily; a few small ferruginous pisolites were hard to crush.	Excessive gritty fragments; the extruded column dog-eared	Total shrinkage 4% at 800°C 5% at 950°C 7% at 1050°C 8% at 1100°C 10% at 1200°C	Pale buff-brown to 1050°C Pale buff-pink at 1100°C Pale buff-brown at 1150-1200°C	Hard at 1100°C (not easily scratched with knife)	Material not very promising and not recommended for use.
In flat between creek gullies No. 197023	Ground easily			Pale red to red		The amount of grit present is somewhat excessive. May possibly be used in brick-making if blended with a soft grit-free shale and de-aired.
Clay from 13-Mile Turn-Off No. 197054	Ground easily	Extruded well	Total shrinkage: 10% at 800 to 1000°C 12% at 1050°C 15% at 1150°C-1200°C	Pale buff-brown from 800°C to 1050°C Pale buff 1100-1150°C Olive at 1200°C.	Hard at 850°C Speckled with calcined $CaCO_3$, from 1000-1200°C; this tends to decrepitate when scratched with knife.	The clay contains concretionary calcium carbonate, and hence is not recommended. It would be worth while trying to find similar clay free from calcium carbonate.

RECOMMENDATIONS FOR ADDITIONAL FIELD WORK

GENERAL

The results of the preliminary laboratory work indicate the materials that appear to be satisfactory and worthy of full-scale testing. However, the dimensions of the deposits have not yet been ascertained; to justify full-scale laboratory testing it will be necessary to ensure that reserves in each deposit are sufficient for exploitation on a commercial scale. This will entail additional mapping and sampling.

Localities Recommended by A.M.D.L.

32-Mile - Shale: The Shale has been exposed in only two auger holes. It is recommended that the area be systematically tested by augering or drilling to a depth of 30 feet to establish reserves of 200,000 cubic yards, if possible.

Berry Flat - Clay: It is reasonable to expect that the reserves here are far greater than are likely to be needed. However, the original augering was to a depth of only 7 feet, and the probable reserves estimated on the basis of the four auger holes is 40,000 cubic yards.

It is suggested that additional augering or drilling be done to a depth of 15 to 20 feet, with the object of establishing reserves of 200,000 cubic yards.

Milner Swamp - Clay: Probably it can be taken for granted that the clay resources here are far in excess of any possible demand. However, only one hole was put down, to a depth of 7 feet.

It is recommended that additional holes be augered or drilled to depths of 15 feet in the vicinity of the old rice garden to establish reserves of 50,000 cubic yards.

Fort Hill and Stokes Hill - Shale: The known shale reserves are very limited and action should be taken to ensure that these deposits are conserved. If the hills are to be removed, the shale should be stock-piled.

Leprosarium Reserve - Shale: It is recommended that the deposit be mapped and pitted or augered to establish its dimensions, so that an estimate of reserves can be made.

Forestry Reserve - Alluvial Clay and Silt: The sample obtained was rather silty and has a small proportion of fine sand. Possibly finergrained, refractory, white-burning material occurs in the low-lying flats a short distance south-west of the locality that was sampled.

It is recommended that augering or drilling be done to depths of 15 to 20 feet in an area extending to 1500 feet south-west from the Leprosarium Road, with the aim of locating a deposit of white, fine, silty clay free from fine sand. If such a deposit is located, it should be augered systematically to establish reserves of 50,000 cubic yards.

OTHER LOCALITIES

Clay in Casuarina Beach Area. A.M.D.L. report on sample No. 197023 states that the amount of grit present was somewhat excessive; the material is not very promising, but may possibly be used for brick-making if blended with a soft grit-free shale and de-aired. As noted earlier this sample was inadvertently contaminated with clay containing a small proportion of buckshot ironstone. Had the sample been free from ironstone, the laboratory report would probably have been favourable, and therefore the Casuarina Beach area cannot be entirely rejected at this stage. Further the possibility exists of obtaining at a greater depth than the 7 feet augered, the fine white plastic clay recovered from water bores in the Mullaman Beds, and weathered shale from the Noltenius Formation below the Cretaceous beds.

Considering the ease of access to the Casuarina Beach area, and the short distance from Darwin it is recommended that drilling and sampling be done to depths of 30 feet at the localities of auger hole Nos. CC1, CC3, CC4, CC5 and CC6.

13-Mile Clay Locality: The sample from this locality was favourably regarded by A.M.D.L., but it contains nodular calcium carbonate, which practically rules it out as a brick clay. In view of the ease of access to the locality and the short distance to Darwin, it should be worth while ascertaining whether the clay at greater depth is free from lime nodules, or whether similar lime-free clay can be found nearby.

It is recommended that the original sample locality be augered or drilled to a depth of 30 feet. A half-day of augering to a depth of 7 to 10 feet should also be done in the vicinity to try to find similar clay free from limy nodules. If this work is successful, systematic augering or drilling should be done to establish reserves of 50,000 cubic yards.

SAMPLING

General. It is intended that the proposed additional field work will finalize the heavy clayware investigation at each locality. The selection of sites for brick pits will be guided and in part controlled by the results of the full-scale laboratory testing, and hence adequate and representative sampling is essential.

When sampling and calculating reserves the following points should be borne in mind:

Hard fragments, of sand size and larger, are undesirable during grinding and extrusion of the material; "gritty" material should not be introduced into a sample that could be free from it; most localities are covered by superficial soil, sand and rock fragments; clay and shale that is otherwise satisfactory commonly contains hard ferruginous buckshot within 3 or 4 feet of the surface; alluvial clay and silty clay may grade laterally and vertically into sandy clay; and argillitic strata commonly grade into arenitic.

If the quality of the material changes with depth in regard to colour, particle size, plasticity and hardness, a separate sample should be taken. When the augering is

completed, it may be practicable to provide representative samples of two or more types of material that could be mined selectively, as desired.

The sample submitted for full-scale testing should be about 200 lb in weight.

REFERENCE

HAYS, J., 1960 - The geology of the Mount Harris Tin-Field, Northern Territory. Bur.Min.Resour.Aust.Rec. 1960/2.

APPENDIX I

LOGS OF AUGER HOLES

LOCALITY	HOLE NO.	DEPTH IN FEET From	DEPTH IN FEET To	DESCRIPTION	SAMPLE NO.
RAPID CREEK					
0.35 miles upstream from McMillans Road 30 feet south-west from creek	RC1	0	1	Dark organic soil, changing to buff coloured clay	RC1
		1	4	Buff clay	
		4	5	Pale buff clay	
		5	7	Pale buff and red clay. Water at 6 feet	
80 feet south-west from creek	RC2	0	0'9"	Soil	RC2
		0'9"	3	Buff yellow clay	
		3	5	Buff and red clay. Hard at 5 feet. Water at 5 feet	
170 feet south-west from creek	RC3	0	0'6"	Organic clayey soil	No sample
		0'6"	0'9"	Ferricrete detritus. Ferricrete at 0'9"	
144 feet south-west from creek	RC4	0	0'6"	Black organic soil	RC4
		0'6"	3	Grey clay. At 3 feet hard (porcellanite)	
0.5 miles upstream from McMillans Road 35 feet south-west from creek	RC5	0	0'6"	Black organic soil	RC5
		0'6"	5	Grey and red mottled clay. At 5 feet fragments of Cretaceous. Water at 3 feet	
		5	7	Pink and red clay, with small fragments of Cretaceous.	
115 feet south-west from creek	RC6	0	0'6"	Black organic soil	RC6
		0'6"	4	Pale grey clay with occasional fragments of porcellanite	
		4	5	Grey and buff yellow clay with buckshot and small fragments of Cretaceous.	
		5	7	Grey and pinkish clay; fragments up to 2" of Cretaceous.	
207 feet south-west from creek	RC7	0	0'6"	Soil. At 0'6" ferruginous porcellanite (?)	No sample
CASUARINA BEACH AREA					
Shown on Plate 3 (from W, 15feet51.5°M)	CC1	0	0'6"	Clayey soil	CC1
		0'6"	3	Grey clay	
		3	5	Grey clay with buckshot and fragments of Cretaceous. Water at 5 feet	
		5	6	Grey-white clay, yellow mottling; occasional small fragments of Cretaceous	
		6	7	White clay	
Shown on Plate 3 (from V, 54feet145°M)	CC2	0	2	Sand and buckshot; some clay	CC2
		2	4	Buckshot and red clay	
		4	5	Buckshot, more ferruginous at 5 feet	
Shown on Plate 3 (from AB, 22feet289°M)	CC3	0	2	Sand, clay and buckshot	CC3
		2	4	Red clay and buckshot	
		4	7	Red clay speckled white, and fragments of Cretaceous.	
Shown on Plate 3 (from BC, 168feet335°M)	CC4	0	1	Sandy Soil	CC4
		1	2	Buff-grey clay	
		2	3	Grey clay, fragments of charcoal, and ½ inch fragments of Cretaceous.	
		3	5	Pink-grey clay. Water at 5 feet	
		5	7	Grey-white and pink-grey clay. Ferruginous layer from 6' to 6'6"	

APPENDIX I

LOCALITY	HOLE NO.	DEPTH IN FEET From	DEPTH IN FEET To	DESCRIPTION	SAMPLE NO.
CASUARINA BEACH AREA (Continued)					
Shown on Plate 3 (from EF, 10feet292°M)	CC5	0	1	Soil (sand, silt, clay)	
		1	3	Red clay, with a small proportion of buckshot	
		3	5	Red clay, speckled white, with a small proportion of buckshot	CC5
		5	6	White and red mottled clay; a stiffer clay	
		6	7	Grey or pink-grey clay	
Shown on Plate 3 (from HI, 73feet003°M)	CC6	0	1	Sandy, silty and clayey soil	
		1	4	Red, white and grey mottled clay, similar to lower part of hole CC5. Dry	
		4	5'6"	Clay, damper, more greyish, but probably pale red	CC6
		5'6"	7	Pale red and pink-red clay	
Shown on Plate 3 (from LM, 40feet 271°M)	CC7	0	1	Silty soil	
		1	4	Yellow clay, slightly silty and sandy	No sample
		4	5'6"	Sandy clay and numerous ferruginous fragments of Cretaceous, up to 2" dimension	
32-MILE					
100 feet south of culvert, 200 feet east of rail	32M1	0	1'6"	Sand	
		1'6"	2	Red-yellow clay and rock fragments	
		2	3	Purple-red clay, with buckshot	
		3	5	Pink, pale purple and grey clay; some quartz fragments	32M1/1
		5	7	Yellow clay with occasional quartz fragments	32M1/2
100 feet south of culvert, 500 feet east of rail	32M2	0	1'6"	Grey silt	
		1'6"	3	Clay, sand and buckshot	
		3	4	Red and grey clay and buckshot	
		4	6	Red clay	32M2/1
		6	7	Brown clay, sand, some buckshot, some semi-rounded quartz to 1 inch	
700 feet south of culvert, 500 feet east of rail	32M3	0	1'6"	Grey silt	
		1'6"	2	Silt and clay	
		2	5	Red and yellow clay, silty and fine sandy	
		5	6	Fine sandy red clay	32M3/1
		6	7	Red and pale brown clay; a few quartz fragments to ½ inch	
700 feet south of culvert, 200 feet east of rail	32M4	0	2'6"	Fine sand, silt, and detrital vein quartz	
		2'6"	4	Red clay, buckshot, and some detrital quartz of granule size	No sample
		4	6	Ditto, red and yellow	
		6	7	Ditto, with rock fragments to 1½ inches	
250 feet north of culvert, 250 feet east of rail	32M5	0	1	Silt	
		1	2	Silt, rubble and buckshot	
		2	4	Yellow clay	32M5/1
		4	5	Yellow, decomposed shale	
		5	7	Yellow, decomposed shale	32M5/2
400 feet north of culvert, 100 feet east of rail	32M6	0	0'6"	Grey silt	
		0'6"	2	Red clay and buckshot	
		2	3	Yellow clay	
		3	7	Decomposed shale	32M6/1

APPENDIX I

LOCALITY	HOLE NO.	DEPTH IN FEET From	DEPTH IN FEET To	DESCRIPTION	SAMPLE NO.
BERRY FLAT					
300 feet south of vegetation at northern end of flat, 50 feet south-east of rail	BF1	0	0'9"	White silt	
		0'9"	2	Red clay and yellow-brown clay	BF1
		2	7	Yellow-brown clay	
100 feet south of vegetation at northern end of flat, 650 feet south-east of rail	BF2	0	0'9"	White silt	
		0'9"	2	Red clay	
		2	5	Pale yellow-brown clay	BF2
		5	6	Brown sandy clay	
600 feet south-west of hole BF1, 50 feet south-east of rail	BF3	0	0'6"	White silt	
		0'6"	1	Clay and silt	
		1	2	Red, yellow and brown clay	
		2	4	Pale brown clay)	
		4	5	Buff-brown clay)	BF3
		5	7	Pale brown clay, mottled grey; moist)	
600 feet south-west of hole BF2, 50 feet south-east of rail	BF4	0	0'9"	White silt	
		0'9"	2	Red clay	
		2	5	Pale brown, yellow-brown, and red mottled clay)	BF4
		5	7	Ditto, slightly silty, and moist)	
13-MILE TURN-OFF					
In floor of pit	13M	0	1	Red clay and buckshot	
		1	3	Grey clay)	
		3	5	Grey clay and carbonate concretions to ¾ inch)	
		5	6	Pale buff-brown clay and carbonate)	13M/1
				concretions to 1½ inches)	
		6	7'6"	Pale buff-brown clay with fragments of shale,)	
				siltstone and mudstone)	
MILNER SWAMP					
400 feet from point where track enters treeless swamp-margin; 80 feet from earth wall of old rice garden	MS1	0	0'9"	Black organic clay	
		0'9"	2'6"	Red and grey mottled clay	
		2'6"	3'6"	Red clay, buckshot and rock fragments	
		3'6"	5'6"	Pink-red clay; plastic, tenacious)	
		5'6"	7	Pink and green clay; very plastic and)	MS1
				tenacious	

APPENDIX 2 FIELD SAMPLE RECORD

CLAY AND SHALE SAMPLES

(Sample has been sent to A.M.D.L. for testing, unless stated otherwise).

LOCALITY	FIELD SAMPLE NO.	DESCRIPTION	SURPLUS MATERIAL SAMPLE NUMBER
Rapid Creek	197019	Rapid Creek, 0.35 to 0.5 mile from McMillans Road. Composite sample from auger holes RC1, RC5 and RC6.	197027
Casuarina Area	197021	Between Lee Point and Casuarina Beach, 2 miles from Lee Point, in and between creek gullies. Composite sample from auger holes CC1, CC4, CC6.	197022
Casuarina Area	197023	Between creek gullies, in flat area; Composite sample from auger holes CC3, CC5.	197024
Casuarina Area	197025	Buckshot ironstone and red clay (possible cement material). Not sent to A.M.D.L.	197026
32-Mile	197048	Composite sample of clay from auger holes 1 to 4.	197049
32-Mile	197050	Composite sample of weathered shale from auger holes 5 and 6.	197051
32-Mile	197079	Not sent to A.M.D.L. Auger Hole No.5, sample 1. 2' - 4' yellow clay 4' - 5' yellow decomposed shale.	-----
Berry Flat	197056	Clay sample from auger holes 1, 3, and 4.	197057
Milner Swamp	197052	Clay sample from auger hole	197053
13-Mile Turn-off	197054	Clay sample from auger hole	197055
Forestry Bureau Area, near Berrimah, on road to Quarantine Station, 300' from road, in drain.	197083	Alluvial silt and clay (a possible refractory material in brickmaking).	197087
Fort Hill	197040	Weathered shale from Fort Hill, Darwin Harbour. Channel sample.	197041
Stokes Hill	197042	Weathered shale from Stokes Hill, Darwin Harbour. Channel sample.	197043
Leprosarium Reserve near Berrimah Hillside about 400' from Quarantine Road.	197082	Silty arkosic shale in old	197086

APPENDIX 3.

Preliminary Laboratory Testing: Appraisal of Raw Materials

(by Australian Mineral Development Laboratories)

EVALUTATION OF RAW MATERIALS FOR BRICK MANUFACTURE NEAR DARWIN.

STAGE I INVESTIGATION

APPRAISAL OF RAW MATERIALS EXAMINED

Introduction

The following is a brief appraisal of the results obtained in the stage I Preliminary Investigation of all the twelve (12) materials submitted.

These results are listed numerically under each of the following headings and are not in any order of preference.

Group I Materials Recommended

These materials are recommended for full scale investigation, subject to favourable results being obtained from the boring programme suggested in previous progress reports.

Sponsor's Mark	A.M.D.L. Sample No.
197050	CM 1642
197056	CM 1643
197052	CM 1644
197040	CM 1646
197042	CM 1647
197082	CM 1654
197083	CM 1655

Group II Borderline Materials

These materials are not recommended for use if any better materials are available.

Sponsor's Mark	A.M.D.L. Sample No.
197048	CM 1641

Group III. These materials are not recommended.

Sponsor's Mark	A.M.D.L. Sample No.
197019	CM 1638
197021	CM 1639
197023	CM 1640
197054	CM 1645

Investigated by: G.R. Tilley

Officer-in-Charge, Ceramics Section: H. Ellerton.

APPENDIX 4

PRELIMINARY LABORATORY TESTING: DETAILED RESULTS OF TESTING

by Australian Mineral Development Laboratories

Locality and Field Sample No.	Laboratory No.	Results
32-Mile (Shale) 197050	CM 1642	The material ground easily and was extruded not de-aired to form specimens for firing tests. Although this material is somewhat weak and short in the plastic state, it would probably make good de-aired bricks and also be useful in de-aired pipe and tile blends.
Berry Flat (Clay) 197056	CM 1643	The material ground easily and was extruded not de-aired to form specimens for firing tests. At this stage the material appears to be promising for red brick manufacture and may also be useful in pipe and tile blends.
Milner Swamp (Clay) 197052	CM 1644	The material was rather difficult to grind; it required drying. A ground sample was extruded not de-aired to form specimens for firing tests. The extruded material was extremely tough, strong and plastic. The wet to dry and firing shrinkages were found to be excessive. At this stage the material appears to be very promising for use as a bond clay in pipe, tile and brick blends.
Fort Hill (Shale) 197040	CM 1646	The material ground easily and was extruded not de-aired to form specimens for firing tests. After extrusion this material was found to be extremely weak and de-watered readily. At this stage this material appears promising for mixing with a strong bond clay, in brick, pipe and tile blends.
Stokes Hill (Shale) 197042	CM 1647	The material ground easily and was extruded not de-aired to form specimens for firing tests. After extrusion this material was found to be extremely weak and de-watered readily. At this stage this material appears promising for mixing with a strong bond clay, in brick, pipe and tile blends.
Leprosarium Reserve (Shale) 197082	CM 1654	The material ground easily and was extruded not de-aired to form specimens for firing tests. During extrusion this material was found to be weak and de-watered readily. At this stage the material appears to be promising and may find a use in blending with a strong bond clay, for brick, pipe and tile manufacture.
Forestry Reserve (alluvial clay and silt) 197083	CM 1655	The material ground easily, however it was extremely gritty (siliceous?). It was not possible to extrude the material but specimens were pressed in a satisfactory manner. The after-firing shrinkage was extremely low and the colour off-white. At this stage the material appears to be promising for use in refractories. It may also be suitable for use in blends to produce light coloured bricks.
32-Mile (Clay) 197048	CM 1641	The material ground easily and was extruded not de-aired to form specimens for firing tests. There was some grit present. At this stage the material is somewhat promising for use in de-aired brick and pipe blends.
Rapid Creek (Clay) 197019	CM 1638	The material was somewhat difficult to grind as there were a number of very hard small stones. A ground sample was extruded not de-aired to form specimens for firing tests. However, the grit was excessive and the extruded material displayed excessive dog ears/cracks. At this stage the material is not very promising and is not recommended for use.
Casuarina Beach Area: (Clay in creek gullies) 197021	CM 1639	The bulk of the material was easy to grind, but there was a number of small stones (ironstone?) present which were difficult to crush. After the grinding, a sample was extruded not de-aired to form specimens for firing tests. The amount of grit present was somewhat excessive, and the extruded column dog-eared. At this stage the material is not very promising and is not recommended for use.
Casuarina Beach Area: (clay in flat between creek gullies) 197023	CM 1640	The material ground easily and was extruded not de-aired to form specimens for firing tests. The amount of grit present was somewhat excessive. At this stage the material is not very promising, but may possibly be used in brick-making if blended with a soft grit free shale and de-aired.
13-Mile Turn-Off (Clay) 197054	CM 1645	The material ground easily and was extruded not de-aired to form specimens for firing tests. Although this material appeared to be very good with respect to extrusion, drying and after-firing colour, acid tests indicated a possible high percentage of lime. The specimens fired to 950 and 1000°C appear to be cracking, due to hydration of quicklime. Consequently this material is not recommended; however attempts should be made to locate a deposit of similar material containing little or no lime and magnesia.

PLATE 1

GEOLOGICAL MAP
SHOWING
CLAY AND SHALE LOCALITIES
DARWIN DISTRICT N.T.

SCALE

1 0 1 2 3
Miles

REFERENCE

QUATERNARY
- Qa — Alluvium, soil cover
- Qf — Ferruginous deposits

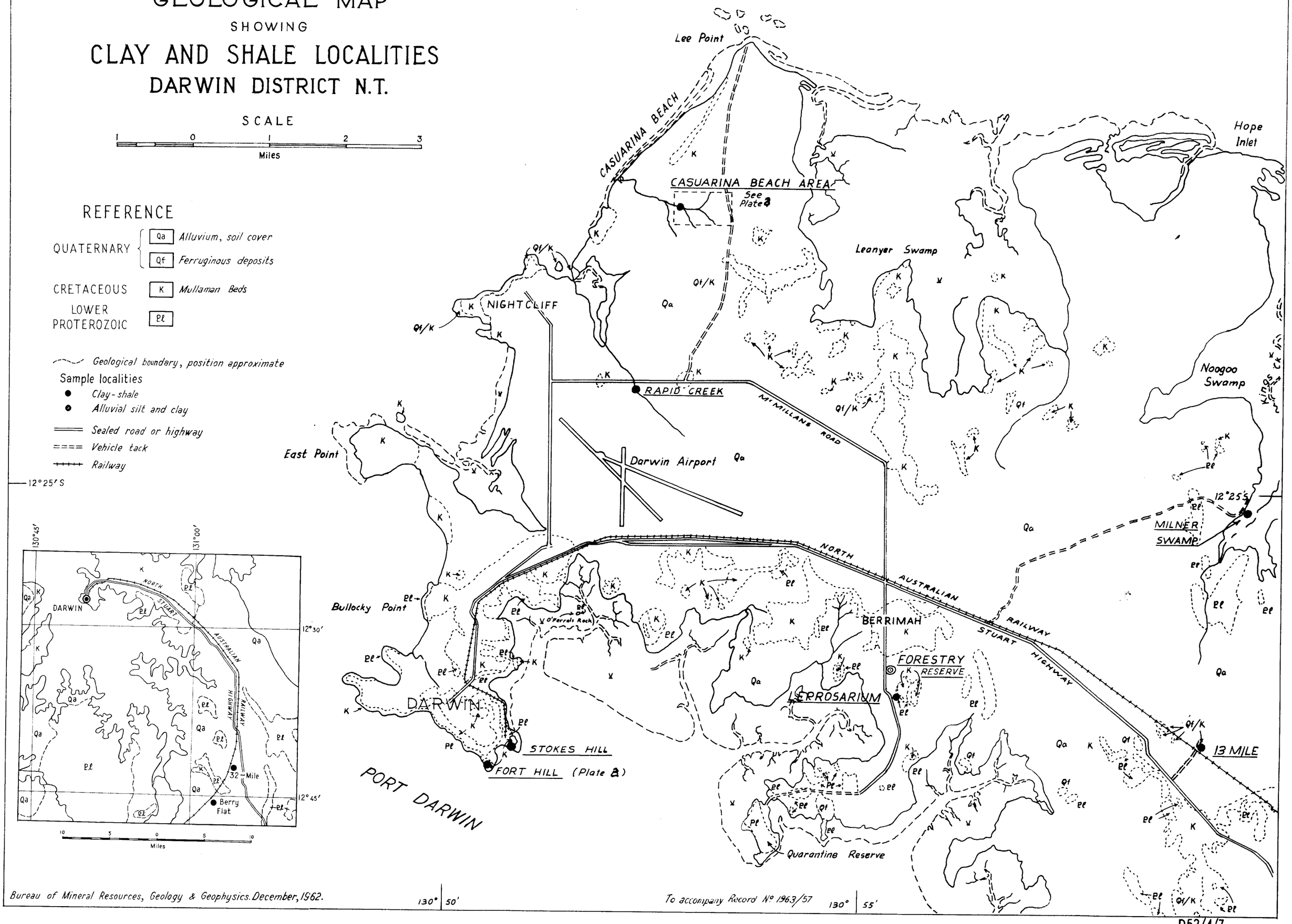
CRETACEOUS
- K — Mullaman Beds

LOWER PROTEROZOIC
- Pl

Geological boundary, position approximate

Sample localities
- Clay-shale
- Alluvial silt and clay

Sealed road or highway
Vehicle tack
Railway



Bureau of Mineral Resources, Geology & Geophysics. December, 1962.

To accompany Record No. 1963/57

D52/4/7

GEOLOGICAL MAP, FORT HILL, DARWIN, N.T.

Based on plane table survey by J. Waugh, June 1962.

(For location see Plate 1)

SCALE

feet 40 0 40 80 120 160 feet

REFERENCE

Cretaceous - Mullaman Beds

Lower Proterozoic (Noltenius Formation) — Shale; Sandy shale

△s Plane table station

DATUM

Assumed height at △1 is 20 feet

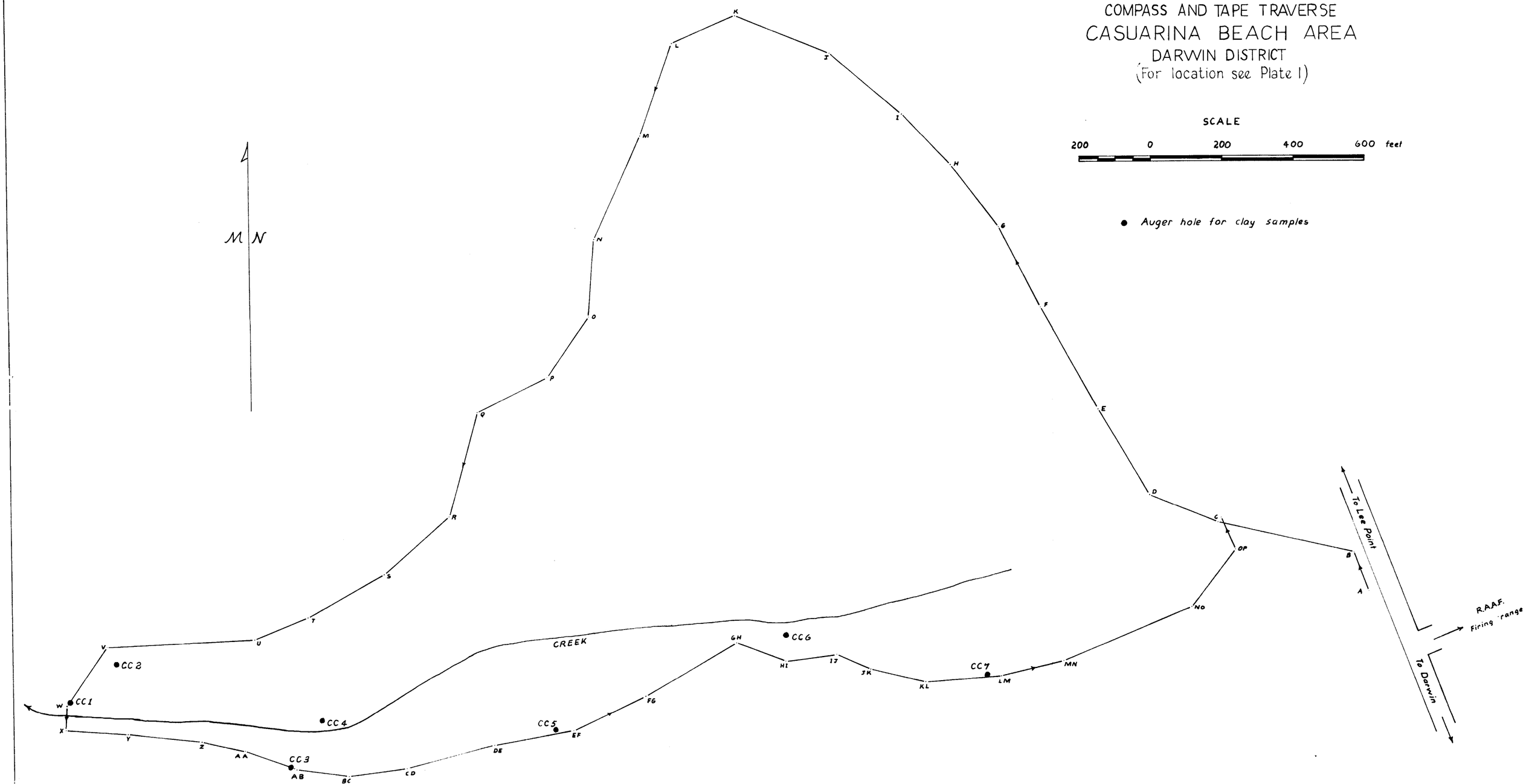
Bureau of Mineral Resources June 1962

To accompany Record No. 1963/57

D52/4/8

PLATE 3

COMPASS AND TAPE TRAVERSE
CASUARINA BEACH AREA
DARWIN DISTRICT
(For location see Plate 1)



D52/4/9

Bureau of Mineral Resources, Geology & Geophysics. June 1962

To accompany Record No. 1963/57