DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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PRELIMINARY INVESTIGATION OF A BRICK SHALE DEPOSIT AT GUNGAHLIN, A.C.T.

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CONTENTS

SUMMARY

Geological mapping and augering of brick shale at Block 2, Gungahlin, A.C.T. was carried out to determine the potential of the site for brick making. Standard laboratory tests were carried out on test bricks made at the Commonwealth Brickworks and on grab samples collected from disturbed augering. Results of the tests indicate that the weathered shale is satisfactory, and reserves are probably large. Additional drilling is recommended to adequately test the deposit, particularly the harder, less weathered, material.

INTRODUCTION

The potential of the Gungahlin area to support a brickworks has been commented on by Gardner (1960) and Hohnen (1974). At the request of the Commonwealth Brickworks, a brick shale deposit at Block 2, Gungahlin was inspected and sampled by Hohnen in early 1974 and an auger drilling program was designed. The location of the deposit is shown in Figure 1.

In September-October 1974, the area was geologically mapped, three backhoe pits were excavated and three disturbed-aguer holes were drilled. A batch of 9000 test bricks was made by the Brickworks from material excavated from one of the backhoe pits, P1, to a depth of 0-2 m (Fig. 2). Standard tests carried out on a selection from these bricks proved very satisfactory. The three auger holes penetrated shale to depth greater than 12 m but were not drilled to refusal. Grab samples were collected over 1.5- m intervals and standard laboratory tests were carried out.

GEOLOGY

The distribution of rock types is shown in Figure 2.

The shale occurs mainly beneath gently sloping, poorly drained terrain bounded to the east by dacite and to the west by porphyritic rocks both of which form higher ground. The shale has a well developed vertical cleavage striking 010°. The bedding dips about 40°E.

Three types of shale distinguished in the mapping correspond to those intersected in the auger holes. The relations and houndaries of the shale types are difficult to determine because of lack of outcrop but are probably representative of varying degrees of weathering of the olive-grey silty shale.

(a) Olive-grey silty shale.

Olive-grey silty shale crops out in the west of the area and forms low ridges; it is more resistant to erosion than the other shale types, being harder and more indurated. It is slaty in some zones and is slightly to moderately weathered at the surface.

FIG: 1

LOCALITY MAP

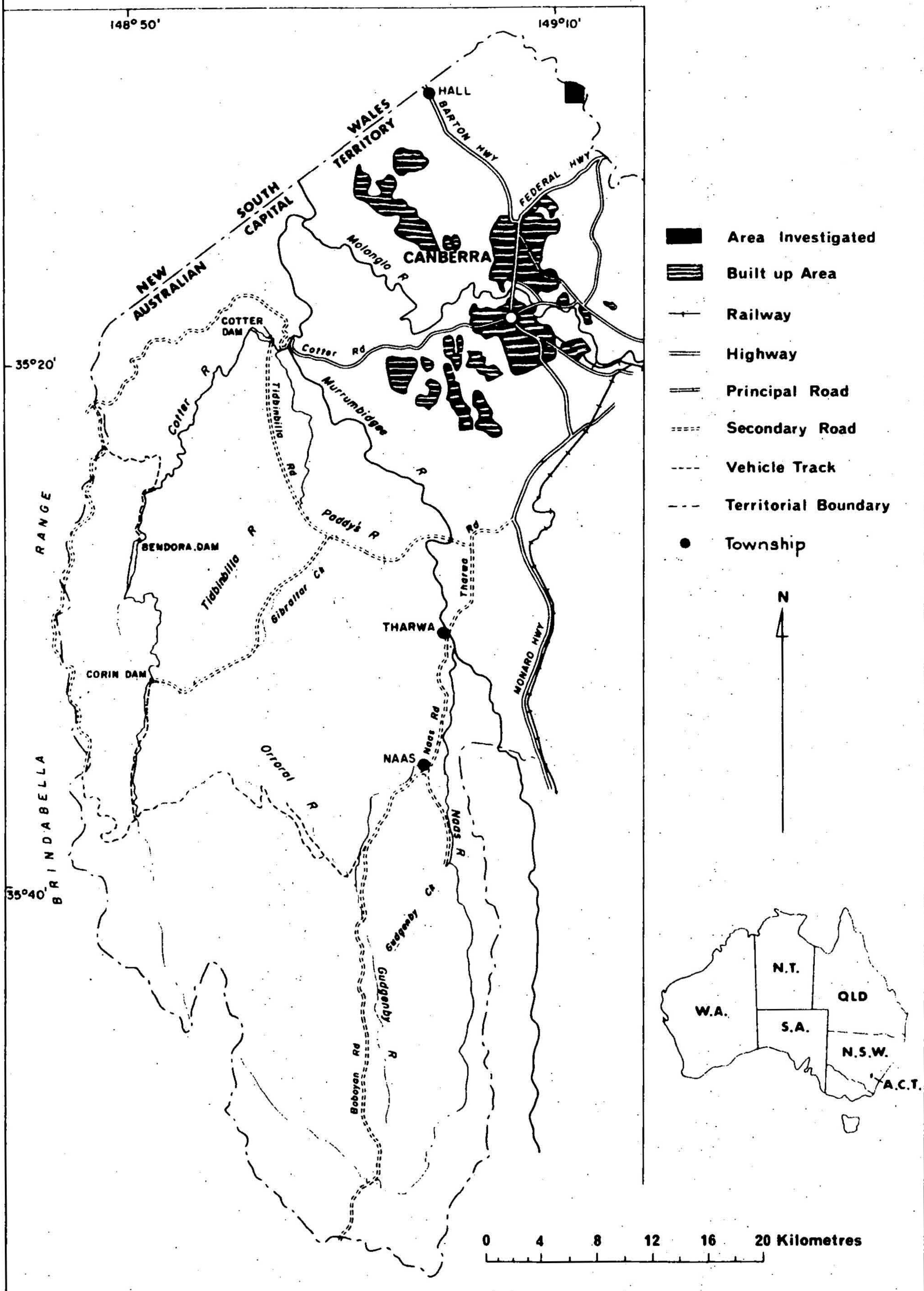

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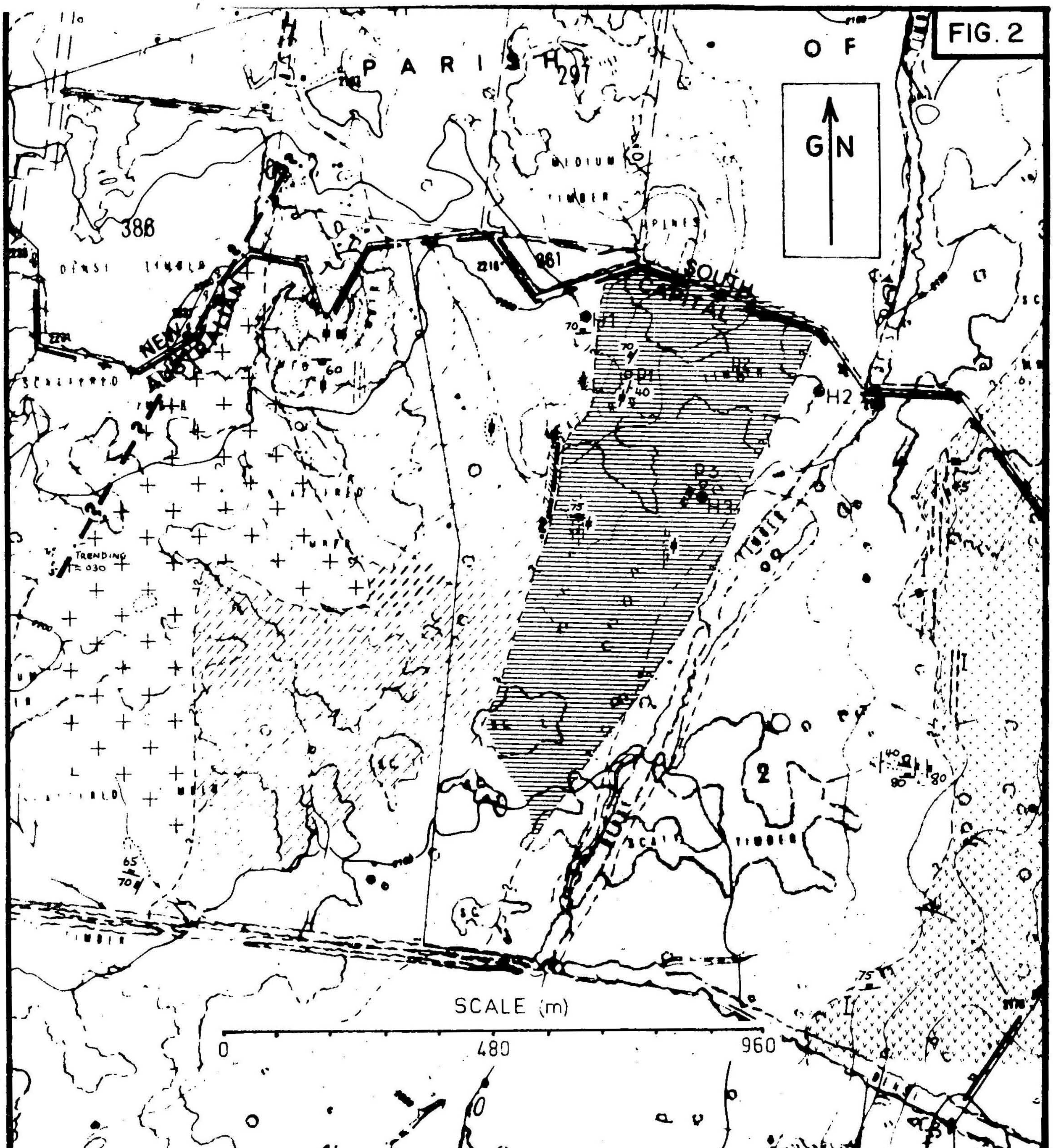
FIG. 2



GEOLOGY OF BRICK SHALE DEPOSIT — GUNGAHLIN.

- Inferred geological boundary.
- Inferred position of fault.
- Outcrop boundary.
- Quartz vein, fault-orientated.
- H 3 Auger holes; disturbed samples taken.
- P2 Backhoe pits.
- 40 Dip and strike of strata.
- 60 Dip and strike of joints.
- Vertical joint.
- Dip and strike of cleavage.
- Vertical cleavage.
- Trend lines. (cleavage)
- Acidic porphyry and volcanics.
- Shale; olive-grey, with ferruginous shale shown by hatching.
- Shale; yellow-brown.
- Shale; grey-white.
- Dacite; blue-grey.

Calcareous sandstone and siltstone, and some limestone are present elsewhere in the sequence, and pyrite has been found in a tectonically shattered zone to the south of the area. Although calcite and pyrite were not observed in the outcrops, they may be present and would be detrimental to brick making. The shale should be adequately sampled and tested to ensure its suitability.

(b) Yellow to yellow-brown clayey shale.

Yellow to yellow-brown clayey shale occurs in the central part of the area. It is soft, highly weathered, and closely cleaved.

(c) Pale grey to grey-white silty shale.

Pale grey silty shale weathers to a grey-white clay, and similar leached shale in the region have been found to contain a higher percentage of koalinite than the other shale. Bedding dips 30° to 40° E and a well developed joint set dips steeply to the north.

Shattered ferruginous shale crops out along a minor fault (Fig. 2) within the olive-grey shale. Limonite is present in the matrix and small veinlets of goethite and hematite are present. The veinlets are probably a secondary feature and may only occur near the surface. Several bands about 5 cm thick consisting of quartz gravel cemented with iron oxide minerals were also observed, and appear to be remnants of a ferricrete deposit.

The dacite to the east has a near vertical foliation striking 010°, and a joint set which trends east-west and dips steeply to the north.

An outcrop of porphyry occurs to the west of the shale, but its relation to, and the nature of the contact with, the shale are uncertain.

A quartz vein in the northwest of the area, ranging in width to 1m crops out for 200 m and represents the northeasterly extension of the Gungahlin Fault, mapped by Hohnen (1974). Probably most of the angulary quartz gravel that lies on the shale is derived from this fault zone.

Minerals such as pyrite and calcite are partly or completely removed during the weathering process and would not necessarily show in weathered material (b) and (c) but may be present in the less weathered material (a).

INVESTIGATION OF THE DEPOSIT

AUGERING AND BACKHOE PITS

Three backhoe pits were excavated to allow a quick appraisal of the site (Fig. 2), and were filled in immediately after excavation and sampling. The log of P1 is as follows, and is typical of the upper part of the yellow-brown shale.

Depth (m)	Description
0–0.1	Topsoil
0.1–0.6	Yellow-brown silty clay of high plasticity
0.6–1.5	Yellow-brown completely weathered shale with steeply dipping cleavage striking north.

Yellow-brown shale was removed from pit P1 for brick-making tests.

Three disturbed auger holes were drilled in highly to completely weathered shale to at least 12 m below ground surface and no hole reached the point of refusal i.e. a depth below which the auger would not penetrate. The holes were drilled in each of the different shale types shown in Figure 2 and illustrate the uniformity of the weathering profile in the different shales. The logs are as follows:

Logs of auger holes

Hole 1	Depth	: 0–12+m
	Lithology	: Light olive-grey, highly to completely weathered silty shale
Hole 2	Depth	: 0–12 m
	Lithology	: Pale grey, highly to completely weathered silty shale
Hole 3	Depth	: 0–12 m
	Lithology	: Yellow-brown, highly to completely weathered clayey shale.

SAMPLING

Because the auger cuttings indicated homogeneous material, samples for testing were collected from 6.0 to 7.5 m, approximately the mid-section of each hole.

Nine-thousand test bricks were fired from backhoe pit P1, and were formed from plastic clay and highly to completely weathered shale at the Commonwealth Brickworks, Canberra. The shale was yellow-brown (Fig. 2), and produced reddish brown bricks that were dense and strong (see Table 2). Bricks have not been made from the other two shale types mapped, but it is expected that they will give bricks of equal grade with some colour variations.

LABORATORY TESTING

TESTING OF SHALES

Grainsize, plasticity, and shrinkage

Plasticity index and shrinkage measurements were made on the samples (less than 0.5 mm fraction) from each auger hole. The sand-size and silt-size particles of the disturbed samples were examined under a binocular microscope and a grain count was made. The sand and silt fractions of the disturbed sample (no further crushing used) were separated by sieving (less than 0.074 mm) and decantation respectively. The results are presented in Table 1.

Linear shrinkages (oven drying at 110^{o}C) are minimal (less than 3.5%) and corresponding small shrinkages were recorded when the test bricks were fired. The grey shale from hole 2 has the greatest percentage of quartz in the sand fraction but this does not exceed 2 percent by volume of the total rock (estimate based on grain count).

X-ray diffraction analysis

A sample from each hole was analysed by X-ray diffraction.

Samples were prepared as follows:

(a) untreated whole sample

(b) less than 2 µm fraction, untreated

(c) less than 2 µm fraction, glycolated

(d) less than 2 µm, glycolated fraction heated to 300°C

(e) less than 2 µm, glycolated fraction heated to 550°C

The minerals present are as follows:

Hole 1

Quartz, muscovite, kaolinite

Minor* orthoclase and possibly minor goethite

Hole 2

Quartz, muscovite, kaolinite

Minor orthoclase

Hole 3

Quartz, muscovite, kaolinite, mixed-layer clay

Minor goethite, minor orthoclase

Discussion

The following aspects of the mineralogy of the shales are important in regard to their brick-making qualities.

(i) The X-ray diffraction analysis did not detect any high-shrinkage clays, and this is confirmed by the small linear shrinkages of oven-dried clay samples (Table 1) and by measurements of the test bricks (Table 2).

(ii) Carbonate was not detected in the X-ray diffraction analysis or in acid tests. Lime, which is usually present as carbonate, will slake and produce swelling in bricks and decrease the vitrification range during firing, particularly if it occurs in lumps, i.e.

$$CaCO_3 \xrightarrow{\Delta} CaO \quad H_2O \text{ (slaking)} \longrightarrow Ca(OH)_2$$

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* Minor means less than 5 percent by volume.

TABLE 1

PLASTICITY INDEX, LINEAR SHRINKAGE, AND GRAIN COUNT OF DISTURBED AUGER SAMPLES.

	Plasticity index	Linear shrinkage (%) on oven drying
Hole 1	5	2.5
Hole 2	2 - 5	2.6
Hole 3	8 - 10	3.4

	% Sand fraction in auger cuttings	Grain Count of Sand Fraction		
		% Rock fragments	% Goethite &limonite (iron oxides)	% Quartz
Hole 1 (Olive grey)	48	96 (46)*	-	4
Hole 2 (Light grey)	15	87 (13)	0.6 (0.1)	13 (2)
Hole 3 (yellow brown)	18	87 (16)	6.5 (1)	6.5 (1)

	% Silt fraction in auger cuttings	Predominant mineral constituents of silt fraction
Hole 1	40	more than 95% quartz (38)*
Hole 2	71	more than 90% quartz (64)*
Hole 3	62	more than 95% quartz (59)*

* Figure in brackets represent percentage of whole sample

TABLE 2

DIMENSIONS, COMPRESSIVE STRENGTH, EFFLORESCENCE, SPALLING, AND WATER ABSORPTION OF THE GUNGAHLIN TEST BRICKS

Grade: 'A' Extruded red clay building bricks

Brand: Red Comtex bricks

Dimensions

	Required dimensions		
	Single bricks - (cm)	24-brick sample (cm)	Range in dimensions for 24-brick samples (bricks laid side by side)
Length	22.9 ± 0.3	549.6±7.2	541 -556.3
Width	10.9±0.15	261.6±3.6	259.4 - 268
Depth	7.6±0.1	182.4±2.4	179.1 - 188

Compressive strength

Sample No.	Length (cm)	Width (cm)	Area (sq cm)	Total compressive strength (kg)	Compressive strength (kg cm^{-2})
1	22.35	10.67	238.47	250,056	1048.6
2	22.10	10.41	230.06	265,366	1153.5
3	22.10	10.67	235.80	265,366	1125.4
4	22.35	10.67	238.47	260,263	1091.4
5	22.35	10.67	238.47	265,366	1112.8
6	22.35	10.67	238.47	232,705	975.8
7	22.35	10.67	238.47	222,499	933.0
8	22.35	10.67	238.47	258,221	1082.8
9	22.35	10.67	238.47	254,139	1065.7
10	21.84	10.41	227.35	265,366	1167.2
11	22.60	10.67	241.14	254,139	1053.9
12	21.84	10.41	227.35	248,019	1090.9
Average compressive strength kg cm^{-2} =					1075.1

$\frac{X - C}{R}$ (AS. A21-1964 Clause 6.4.2) ± 2.84

Table (cont'd)

Efflorescence, spalling, water absorption

Sample No	1	2	3
Efflorescence	Nil	Nil	Nil
Spalling	Nil	Nil	Nil
Water absorption (%)	0.17	0.16	0.18

Dimensions and compressive strength measurements were made at the Materials Testing Laboratory of the Dept of Housing and Construction, October 1974. Efflorescence, spalling, and water absorption tests were made at the Bureau of Mineral Resources, October 1974.

(iii) Although some goethite was detected by X-ray diffraction, it is in a finely divided condition. No nodular or aggregate goethite, hematite, or pyrite, which can result in 'iron spots' in the bricks, was observed in any of the auger cuttings. The ferruginous shale with the goethite veinlets was observed at only one locality (Fig. 2) and will not be significant if this fault zone can be avoided during quarrying operations.

(iv) The highest grain count (percentage of total rock) obtained for quartz in the sand fraction was 1.9 percent. No gravel-sized quartz fraction was detected in any of the auger samples.

TESTING OF BRICKS

Twelve bricks were tested for compressive strength at the Materials Testing Laboratory of the Department of Housing and Construction, Canberra. Efflorescence[1], spalling[2], and water-absorption tests were made on 3 bricks in the BMR laboratory. All testing was in accordance with the procedures specified in Australian Standards A21-1964 and A140-1964. The results, listed in Table 2, indicate that the bricks made are satisfactory i.e. comply with the requirements of the Standard for A-grade bricks.

Australian Standard A21-1964 requires that A-grade bricks (facing bricks) have a minimum compressive strength of 492 kg cm^{-2} and the value of the expression

$$\frac{\bar{x} - C}{R}$$ must be greater than or equal to 0.38

where,

$\bar{x}$ = average compressive strength (kg cm^{-2});

C = the specified minimum compressive strength (492.1 kg cm^{-2});

R = the group range i.e. the difference between the average of the two highest strengths and the average of the two lowest strengths.

Table 2 shows that the lowest compressive strength obtained in the

1 Degree of precipitation of soluble salts on the surface of the brick

2 Propensity to fragment on exposure to air.

tests was 933 kg cm^{-2}, $\frac{\bar{x} - C}{R}$ was 2.84 and efflorescence and spalling were nil. This attests to the suitability of the yellow to yellow brown clayey shales at Block 2, Gungahlin for brickmaking. The water absorption of the bricks, which was calculated on a 24-hour immersion test (Australian Standard A140-1964, Clause 8.2), was negligible, and indicates high density and frost resistance of the bricks.

RESERVES

Inferred reserves for three different areas at Block 2, shown in Fig. 3, are given below. Reserves have been calculated on the basis of working the deposit to depths of 12 m, 15 m, and 18 m, because no auger hole reached refusal after drilling to 12 m.

Area (Fig. 3)	Inferred reserves in cubic metres with excavation to various depths		
	12 m	15 m	18 m
Triangular area XYZ	1 100 000	1 400 000	1 700 000
Rectangular area ABCF	4 500 000	5 600 000	6 800 000
Rectangular area ABDE	11 000 000	13 800 000	16 600 000

ENGINEERING GEOLOGY

Angular boulders of vein quartz are scattered over much of the area and were probably derived from the large quartz vein cropping out along the fault to the west of the area or from smaller unexposed quartz in the area. The quartz gravel lies near the surface and can be removed by scraping, but quartz from veins in the shale will have to be separated out during quarrying operations.

Because of the thickness of completely weathered and highly weathered shale (greater than 12 m), ripping of the material by bulldozer should be possible

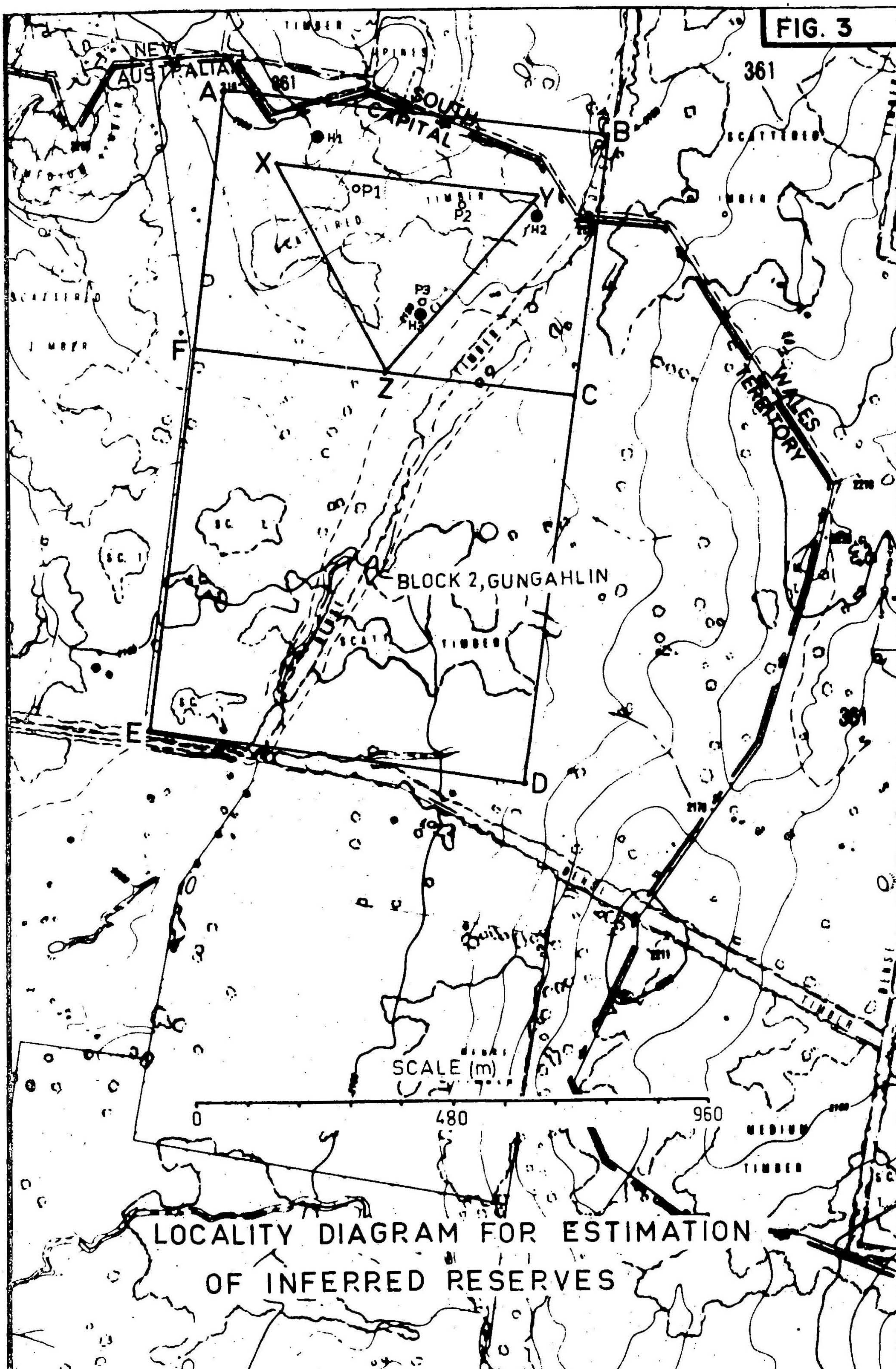
FIG. 3
NEW SOUTH WALES
AUSTRALIAN CAPITAL TERRITORY
361
A
B
C
D
E
F
X
Y
Z
P1
P2
P3
H1
H2
H3
BLOCK 2, GUNGAHLIN
SCALE (m)
0
480
960
TIMBER
SCATTERED
MEDIUM
LOCALITY DIAGRAM FOR ESTIMATION OF INFERRED RESERVES
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Minor perched water tables may be present in the soil profile, but are not expected to be a problem in quarrying operations down to depths of 15 m. Free drainage for surface water will be possible in the higher parts of the deposit but pumping of water may be necessary on the flat area in the east of the proposed site. Runoff could probably be diverted by drains around the quarry margin and a number of sumps may be required on the floor of the quarry. The catchment to the area is small and large-catch drains will not be necessary; however conservation measures to contain erosion will be required, and sediment traps will be necessary to handle all water drained from the pits.

CONCLUSIONS AND RECOMMENDATIONS

The scope of the present report does not extend to a site investigation for a brick pit, but results indicate that large reserves of high-quality brick shale occur beneath part of Block 2.

Before firm plans are made to open a brick pit, a detailed site investigation should be carried out to measure reserves and test all types of shale in various states of weathering and to assess ease of excavation. At least 20 cored holes should be drilled to maximum depths of quarry operations, and cored samples should be taken for testing.

The drilling program should be prepared with reference to the planned method of quarry operation and development for the entire deposit.

REFERENCES

GARDNER, D.E., 1960 - Brick shale resources of Canberra. Bur. Miner. Resour. Aust. Rec.1960/1 (unpubl.).

HOHNEN, P.D., 1974 - Engineering geology of Gungahlin urban development area, A.C.T. Bur. Miner. Resour. Aust. Rec.1974/186 (unpubl.).

AUSTRALIAN STANDARD A21-1964. Burnt clay and shale building bricks. Sydney, Standards Ass. Aust. 1964.

AUSTRALIAN STANDARD A140-1964. Methods of test for burnt clay and shale building bricks. Sydney, Standards Ass. Aust. 1964.