

1982/7. Geological investigation at Linden sandstone quarry, New Norfolk

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Abstract

A sufficient quantity of sandstone of suitable quality for cladding the new High Court of Australia building, Hobart could be obtained from Linden Quarry, New Norfolk.

INTRODUCTION

A geological investigation of Linden Quarry has been requested by the Commonwealth Government for the purpose of ensuring a sufficient reserve of stone of acceptable quality for the cladding of the new High Court of Australia building in Davey Street, Hobart.

REQUIREMENTS

An estimated 2000 m² of 100 mm thick panels measuring 900 mm x 300 mm is required and the specification states that the stone should be: hard, durable, sound and of uniform colour, quality, texture and strength.

LOCATION

The quarry is situated in the 'Linden' property owned by A.A. Ashbolt who holds the mineral lease (861P/M).

The quarry site is on a ridge of sandstone above and to the south of the Glenora Road approximately five kilometres west of New Norfolk [EN001650].

THE INVESTIGATION

The quarry was plane table surveyed and four diamond drill holes were put down ahead of the face. A geological map and sections through the drill holes are presented as Figures 1 and 2 included in this report. Samples from the drill core were tested and microscopically examined and the results are given in Appendix 1.

GEOLOGY

The rock type is Triassic freshwater sandstone of fine to medium grain size and light to dark brown colour. It is underlain by about two metres of thinly bedded or laminated sandstone and then by coarse-grained sandstone which, presumably is close to the base of the Triassic System.

The quarry face is about 75 m long and from 1 to 5 m high. The last 15 m on the eastern end of the quarry face is severely fractured and quite useless for the extraction of dimension stone. Beyond this point is an outcrop of sandstone and an old track which leads eastwards to an abandoned quarry which was worked last century and from which stone used for the building of 'Bryn Estyn' was quarried.

Bedding planes are not clearly evident in the quarry face but the area for ten metres ahead of the face has been stripped to prepare the ground for drilling. This area is a bedding surface over the entire length of the face. The strike was measured as 095° (true) and the dip 8° north. Bedding is virtually absent in the upper 6-8 m of sandstone in the core but is clearly evident in the laminated sandstone at the bottom

of the holes.

Jointing in two directions - north-south and east-west with a near vertical dip and a spacing of 2-3 m is utilised in quarrying as can be seen from the geological map (fig. 1). Minor jointing between master joints is present but is only serious at the eastern end of the quarry where structural evidence from the drilling suggests the presence of faulting. The presence of clay infilling and/or manganese dioxide (black) on joint planes was noted in both the quarry face and the drill core. The manganese dioxide staining was noted mainly on the north-south joints.

The geological sections (fig. 2) attempt to depict the structural continuity of the sandstone in the quarry. It is noted that there are discrepancies in both sections when beds are projected along the dip at angles appropriate to the surface measurements. The true dip is 8° north and this corresponds to a 6° dip in the north-south section and 4° dip in the east-west section.

In the north-south section there is eight metres difference between the top of the laminated sandstone in borehole 4 and the outcrop in the northern part of the area.

In the east-west section there is four metres difference between the levels of this bed in boreholes 2 and 3. In addition borehole 2 was weathered to a deep brown colour due to broken ground giving access to surface water, the hole lost drilling water at 10-11 m indicating an underground channel, probably a fault plane and finally the coarse-grained sandstone which occurs below the laminated sandstone was intersected in this hole which indicates a fault displacement. The displacements in these two sections are unlikely to have been caused by the same fault. The evidence of the directions of strike of these faults has been lost by quarrying. It is assumed in this analysis that the correlation of beds is correct. This aspect emphasises the need for geological mapping during quarrying so that the geological facts are recorded as they are exposed and before they are obliterated.

SANDSTONE QUALITY

The lengths of individual pieces of core were recorded as a measure of the likely sizes of blocks which would be won from the quarry. It is possible however to read too much from these data because stone is won in 2 m x 2 m x 1 m blocks whereas the diamond drill core is subjected to severe stresses both in drilling and in extracting the 45 mm diameter core from the core barrel. What did clearly emerge from this was that the top two metres of stone is very friable, due to the effects of weathering. Below this is a 6-10 m thickness of fine- to medium-grained brown sandstone which is the quarry product. The samples for testing and microscopic examination were taken from this bed in holes 3 and 4. In holes 1, 3, and 4 it was noted that the bottom 2-4 m of this bed contains clay pellets or cavities from which they have been removed. This is an undesirable feature and can be seen in some of the sandstone blocks in the Supreme Court building in Salamanca Place which also utilised this stone. This can be avoided by keeping to the upper layers.

COLOUR

The stone is normally light brown, but colour banding (liesegang rings) is common. This is apparently acceptable in moderation as there is about 50% of stone in the prototype panel which is lightly banded

Table 1. LOGS OF DRILL HOLES 1 TO 4

Bore-hole No.	Depth		Thickness (m)	Recovery		Core length (mm)	Log
	From (m)	To (m)		(m)	(%)		
1	0	2.75	2.75	2.69	98	170, 150, 180, 540, 110, 80, 810, 140, 510	0-8.58 massive fine-to medium-grained brown sandstone with numerous joints.
	2.75	4.12	1.37	1.33	97)		
	4.12	5.65	1.83	1.53	100)	770, 860, 1080, 1190, 400	Longitudinal joint with 10 mm clay filling
	5.65	7.12	1.47	1.44	98)		
	7.12	8.00	1.46	1.46	100	970, 150, 340	Scattered 5 to 10 mm clay pellets and some voids where clay pellets have been washed out. Bottom 50 mm laminated ironstained and silty layers.
	8.00	11.10	2.52	2.50	99		Laminated and cross-bedded sandstone
2	0	1.50	1.50	0.75	50	Numerous fragments, largest 100 mm.	0-8.68 massive, fine-to medium-grained dark brown sandstone 10 mm thick clay infilling of joint plane
	1.50	3.07	1.57	1.57	100	600, 520, 450	
	3.07	4.22	1.15	1.14	99	540, 400, 200	
	4.22	5.67	1.45	1.38	95)	70, 300, 80, 1440, 880,	Longitudinal clay filled joint
	5.67	7.22	1.55	1.54	99)	70, 80	
	7.22	8.68	1.46	1.43	98	80, 140, 340, 230, 130, 130, 100, 90, 190	First core length ends on joint plane with black staining (manganese oxide) all other core fragments terminate on bedding surfaces indicating a change to thin bedding.
	8.68	10.16	1.48	1.46	98	430, 300, 730	Laminated sandstone.
	10.16	13.26	3.10	2.99	94	1100, 370, 100, 1520	Coarse-grained with scattered clay pellets broken core (lost drilling water) coarse-grained with scattered clay pellets.
	13.26	14.80	1.54	1.48	96		Coarse-grained.

7-3

Table 1 (continued)

Bore-hole No.	Depth		Thickness (m)	Recovery		Core length (mm)	Log
	From (m)	To (m)		(m)	(%)		
3	0	2.42	2.42	2.40	99	80, 10, 130, 100, 20, 230, 40, 40, 55, 25, 50, 150, 50, 160, 670, 170, 420	0-12.00 fine-to medium-grained brown sandstone near longitudinal joint over 340 mm near bottom.
	2.42	3.62	1.20	1.20	100)	870, 1350, 675, 240, 560,	
	3.62	4.92	1.30	1.25	96)	130	Near longitudinal joint over 400 mm Scattered clay pellets.
	*4.92	6.33	1.61	1.28	79)		
	6.33	7.86	1.53	1.53	100)		
	7.86	9.39	1.53	1.50	98)	2240, 370, 880, 560, 440	Near longitudinal joint. Scattered clay pellets (near bottom).
	9.39	10.89	1.50	1.46	97)		
	*10.89	12.00	1.11	1.54	97	830, 350, 170, 190	Laminated sandstone.
	12.00	12.47	0.47)		
	12.47	14.12	1.65	1.55	94)	13 core lengths, longest 200 mm	
4	0	1.50	1.50	1.49	99	310, 110, 85, 105, 90, 30, 65, 230, 35, 315, 120	0-11.20 fine-to medium-grained brown sandstone.
	1.50	2.76	1.26	1.22	97)		
	*2.76	4.21	1.45	1.42	98)	180, 150, 160, 1580, 1380,)	Black staining (manganese oxide) on joints at 4.02, 6.62, and 7.0-8.0.
	4.21	5.31	1.10	1.10	100)	270, 200	
	5.31	6.87	1.56	1.56	100		
	6.87	8.44	1.57	1.55	99	160, 130, 1260	Scattered clay pellets. Laminated sandstone.
	*8.44	11.20	2.76	2.75	99		
	11.20	11.59	0.39	0.39	100		

* Samples taken for physical tests and mineralogical examination.

7-4

4/10

in this manner. Black staining on joint planes is easily avoided but black aggregates within the stone which may be weathered pyrite or marcasite are not because they are unpredictable.

DURABILITY

There is no satisfactory test for this quality except by trial and error. The 'Bryn Estyn' homestead was constructed of this stone last century and is reputed to be in good condition.

A common failing of Tasmanian Triassic sandstone is exfoliation which has been ascribed to the proportion of clay in the matrix of the sandstone and more particularly, the type of clay. Swelling clay minerals, if present, cause disruption of the stone fabric and lead to rapid deterioration. The mineralogical composition (see Appendix 2) of three of the samples is roughly 86% quartz, 10% clay matrix and the remainder accessory minerals. Sample 2 had a slightly different composition being lower in quartz and higher in matrix. The significance of this is not apparent but it would be of interest to investigate this aspect further as a possible marker horizon if further geological work is intended.

Physical testing, consisting of bulk density, water absorption, uniaxial compression, modulus of rupture and soundness tests were carried out on this stone in 1980 (Appendix 1). The results of physical tests on core samples taken during this investigation are given in Appendix 3.

RESERVES

No attempt has been made to determine reserves of dimension stone as the drilling programme was restricted to the immediate area of the quarry face.

An area of about 30 m x 15 m shown on the geological map and 6 m thick would contain 2700 m³ which is many times the required amount of stone for this contract after allowing for reasonable wastage.

It is anticipated that stone of the required dimensions and free of undesirable blemishes can be won from this quarry but it would result in considerable wastage. Obviously a balance between what is acceptable and what is economic will have to be determined.

[15 March 1982]

7-6

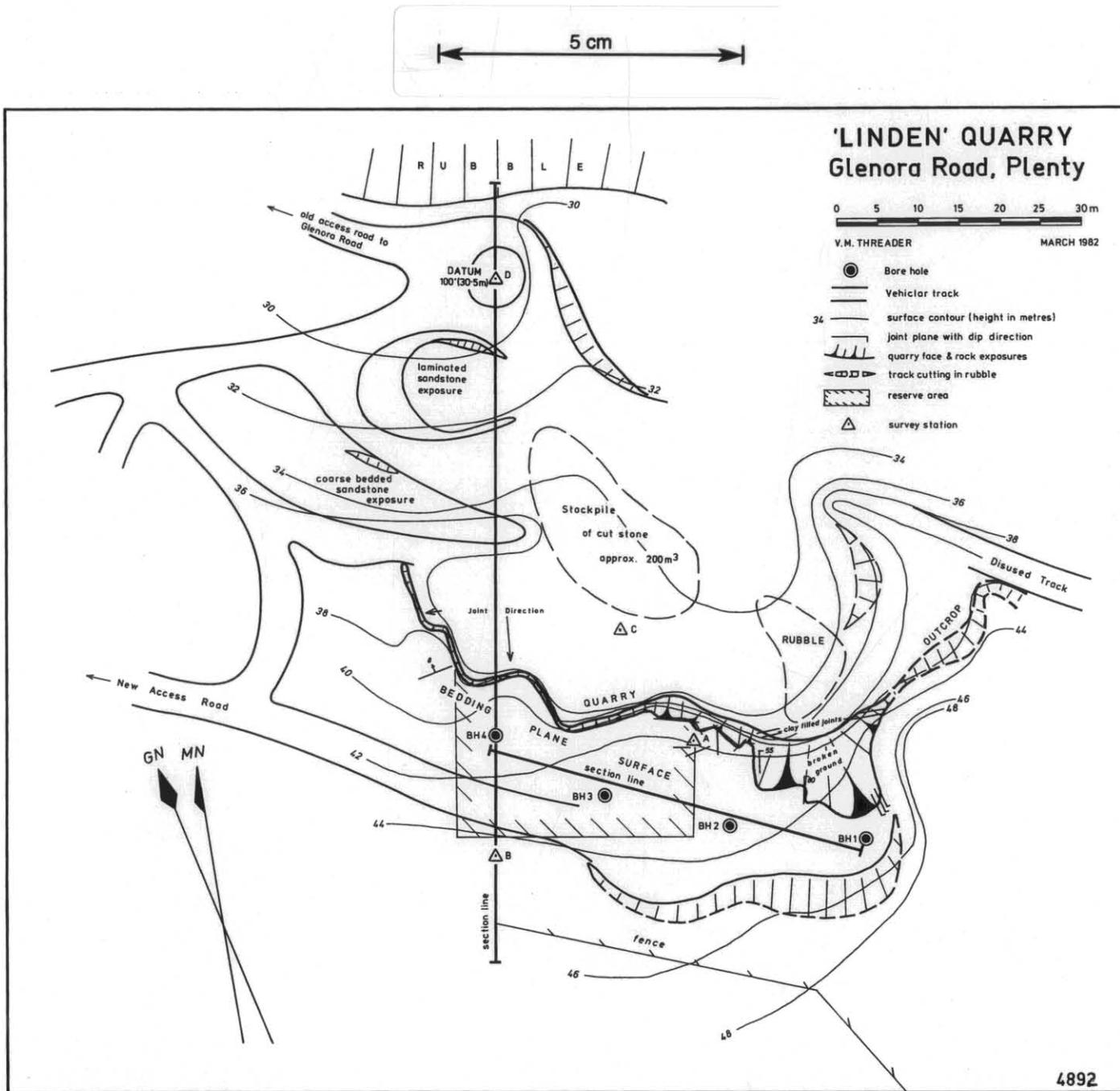


Figure 1.

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6/10

7-7

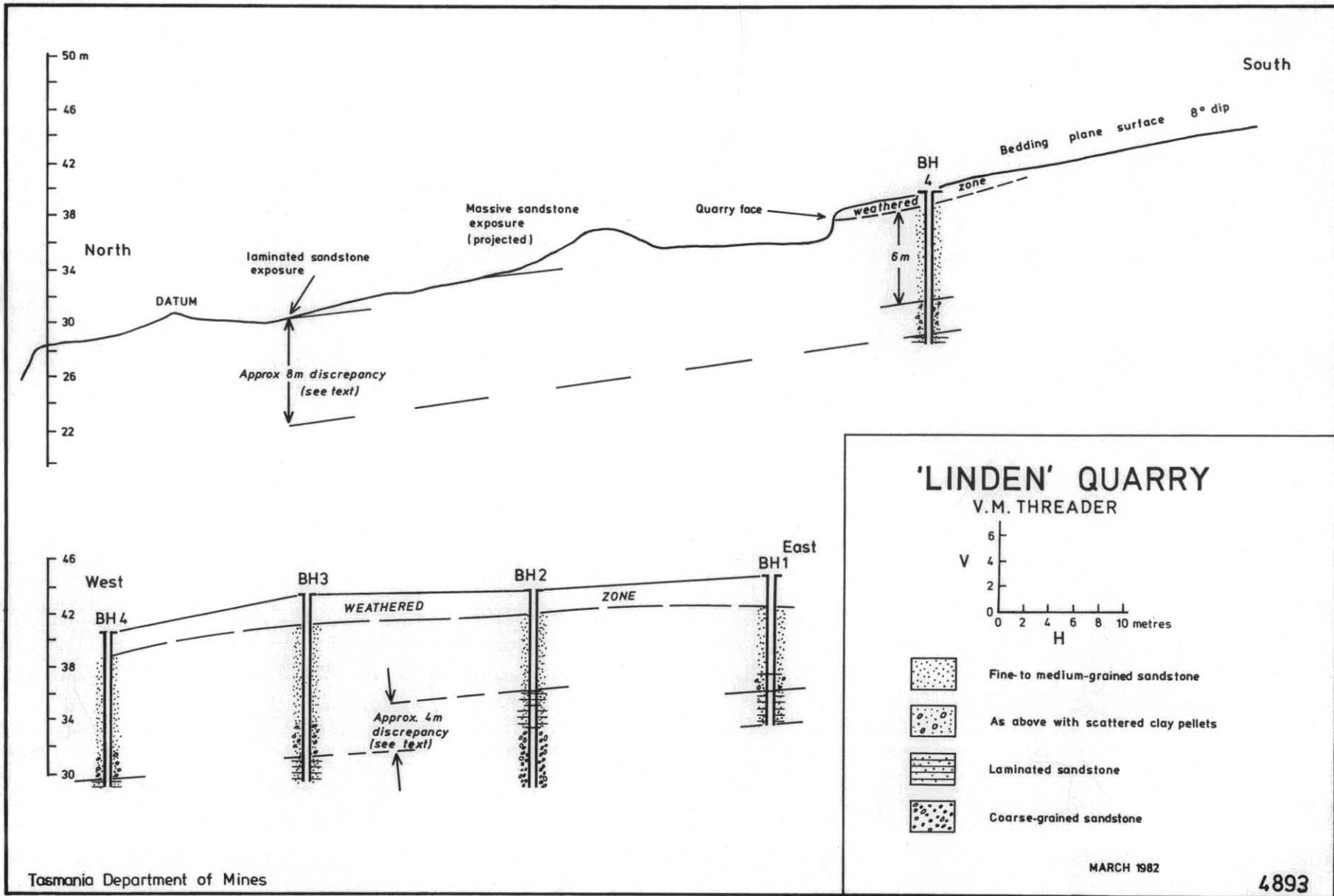


Figure 2.

5 cm

7/10

APPENDIX 1

Physical testing

Property	ASTM standard (C616-68)		Linden stone	Standard
	Sandstone	Quartzitic sandstone		
Quartz (min)	60	90	80-88	-
Bulk density			2.16)	
Water absorption - % (max)	20	3	4.8)	ASTM C97-47
Compressive strength (min) mPa (weakest direction)	14	69	70	ASTM C170-50
Modulus of rupture - (min) mPa	2	7	9	ASTM C99-52
Soundness test (% loss of mass after 6 cycle wetting and drying)	--	--	7.6	AS 1141 Sect. 24

These results were obtained from samples supplied by Rizzolo Stone and Concrete Pty Ltd in May 1980. Strength testing was done by the University of Tasmania Civil Engineering Laboratory and the remainder in the Department of Mines Laboratory in Launceston.

The samples were random samples and are not meant to indicate a statistical average. Nevertheless the samples collected did appear representative of the better type of stone available from the quarry.

APPENDIX 2

Petrological report on thin sections 1 to 4
Linden Quarry

D.C. Green

Samples 1, 3, 4 (The three samples are essentially identical)

Sandstone-quartz arenite, predominantly subangular-subrounded quartz (85-88%), minor feldspar (microcline), lithic fragments, trace muscovite and biotite. The accessory minerals form 2-5% of the rock. Diameter of quartz grains average ~200 μm, fine-medium grained sandstone. Matrix is of clay minerals, probably mixed layer illite-montmorillonite, often iron stained and forming between 8 and 10% of the rock. The matrix also contains small plates of hematite-goethite and occasional zircons. Quartz types are largely of recycled igneous origin, very minor chert, some metamorphic quartz, or opaline quartz was seen. Many quartz grains are in contact with the development of overgrowths. The rock would have fair to good porosity and appears rather friable.

Sample 2

Sandstone-quartz arenite, predominantly subangular quartz (80%) with minor feldspar, lithic fragments. The accessory minerals form 2-5% of the rock. Diameter of quartz grains average ~175 μm, fine-medium grained sandstone. Matrix (about 15%) generally of iron stained clay minerals with small fragments of goethite. Quartz types are largely of metamorphic origin with composite, strained extinction on individual domains of ~20 μm diameter, commonly outlined by trains of <1 μm material (probably an iron oxide). The rock is distinctive in this property which may be a means of correlation within the quarry. A few small rounded zircons were seen. The rock is of fair porosity and is somewhat friable in character.

APPENDIX 3

Physical tests on core samples

The following results on testing of bore core from holes 3 and 4 are available. Durability (wet and dry cycles) tests take several weeks to complete and results are not yet available.

Hole No.	Depth (m)	Sample ⁺ No.	Compressive strength* (mPa)	Bulk density† (kg/m ³)	Water absorption† (%)
3	5.0	3	49.7, 59.7, 56.1	2280, 2210	4.3, 5.0
	11.0	4	59.0, 49.2, 50.4	2260, 2220	4.5, 5.0
4	3.5	1	55.4, 44.9, 56.6	2200, 2270	5.3, 4.3
	8.5	2	63.4, 57.1, 58.7	2280, 2290	4.2, 4.2

+ Sample numbering corresponds to that used in the petrological report (Appendix 2).

* University of Tasmania Civil Engineering Laboratory.

† Department of Main Roads Materials and Research Laboratory, Hobart.

These results are comparable with those from earlier testing (Appendix 1) and indicate that the sandstone quality lies within acceptable limits.

Sample 2 was the best quality sandstone according to those results and this confirms the petrological report (Appendix 2).

[22 March 1982]