1985/46. Slope stability and site investigation of land at Sophie Place, West Launceston

W.R. Moore

Abstract

Steep slopes of 14°-15° occur on two large blocks, with steeper 19° slopes in the south-east corner. Regional mapping and a previous seismic survey indicated a considerable depth to 'bedrock' of unweathered dolerite with a thick surface layer of clay. This gave the blocks a high potential for slope failure.

Eight test pits were dug and two auger holes were drilled on the site. These showed clay present to a minimum depth of eight metres. A thin, moist surface zone in the clay is underlain by dry, massive, dolerite-derived clay. Most of the clay, depending on degree of weathering, was highly plastic, expansive and with a low shear strength. If the clay became water saturated to any depth, the steep slopes at the site would become prone to failure. This has not occurred and is thought to be prevented by unweathered dolerite capping the ridge above the site.

Building appears feasible and is recommended, provided that buildings have piled foundations into the harder, highly weathered dolerite-derived clay, and provided that water is prevented from penetrating deeper into the dry clay on the site.

INTRODUCTION

The Department of Mines was requested by Mr G. Charnley to investigate the foundation conditions likely to be encountered on Blocks 1 and 9 at Sophie Place, West Launceston [EQ106114]. Mr Charnley plans to build a series of two or three-storied town houses in blocks of four on this large area. These units will be at varying levels following the contours around the slope and overlooking the First Basin of the Cataract Gorge of the South Esk River. In order to obtain council approval for this project, a subsurface investigation was required.

PREVIOUS INVESTIGATION

The first Department inspection of the site was by P.C. Stevenson in 1984. No rocks crop out on the blocks, but large outcrops or blocks of dolerite occur on the neighbouring developed areas to the north-east and east. The crown of the slope at Sophie Place appears to be *in situ* dolerite and on the Launceston geological map (Longman *et al.*, 1964) the boundary between dolerite and the Launceston Beds of Tertiary age is placed here. Blocks 1 and 9 were thought to be underlain by Tertiary age sediments, probably clay, which were considered to have been deposited in one of the minor sedimentary basins of the Launceston Trough (Longman, 1966).

With the possibility that clay of the Launceston Beds laps on to dolerite, and with slopes averaging 14°-15°, the possibility of slope failure was considered to be potentially high on these blocks. Stevenson recommended a refraction seismic survey to Mr Charnley to try to establish the presence of any of these sediments and the depth to 'bedrock', which in this area, is considered to be unweathered dolerite.

Two refraction seismic spreads were fired on the blocks (fig. 1).

Both spreads showed two upper layers of low velocity rock (V_0 = 500-800 m/sec and V_1 = 1000-1300 m/sec). Only in the longer N-S spread (Spread no. 1) was a third high velocity layer seen (V_2 = 2400-2900 m/sec; the velocity range of unweathered dolerite). The calculated depth to this unweathered, probably tightly jointed dolerite was 16-23 m, with a suggestion of shallowing upslope to the east to 9-11 m (Table 1, Moore, 1984). The upper two velocity layers were interpreted as Tertiary age sediments overlying deeply weathered dolerite. It was also concluded that the surface layer (V_0 = 500-800 m/sec) was clay which could be up to nine metres thick in the middle and lower section of the block.

As a result of the seismic survey, a backhoe trenching programme with confirmatory auger drilling and possibly a follow-up with diamond drilling, was recommended to Mr Charnley (Moore, 1984).

SUBSURFACE INVESTIGATION

Trenching

Eight pits were dug using a light backhoe. These pits were surveyed and their locations, together with the previous investigation seismic lines and later auger holes, are shown on Figure 1.

The trenches were logged and samples collected for soil testing; the sampling results are given in Tables 1 and 2 and the logs of the pits in Appendix 1.

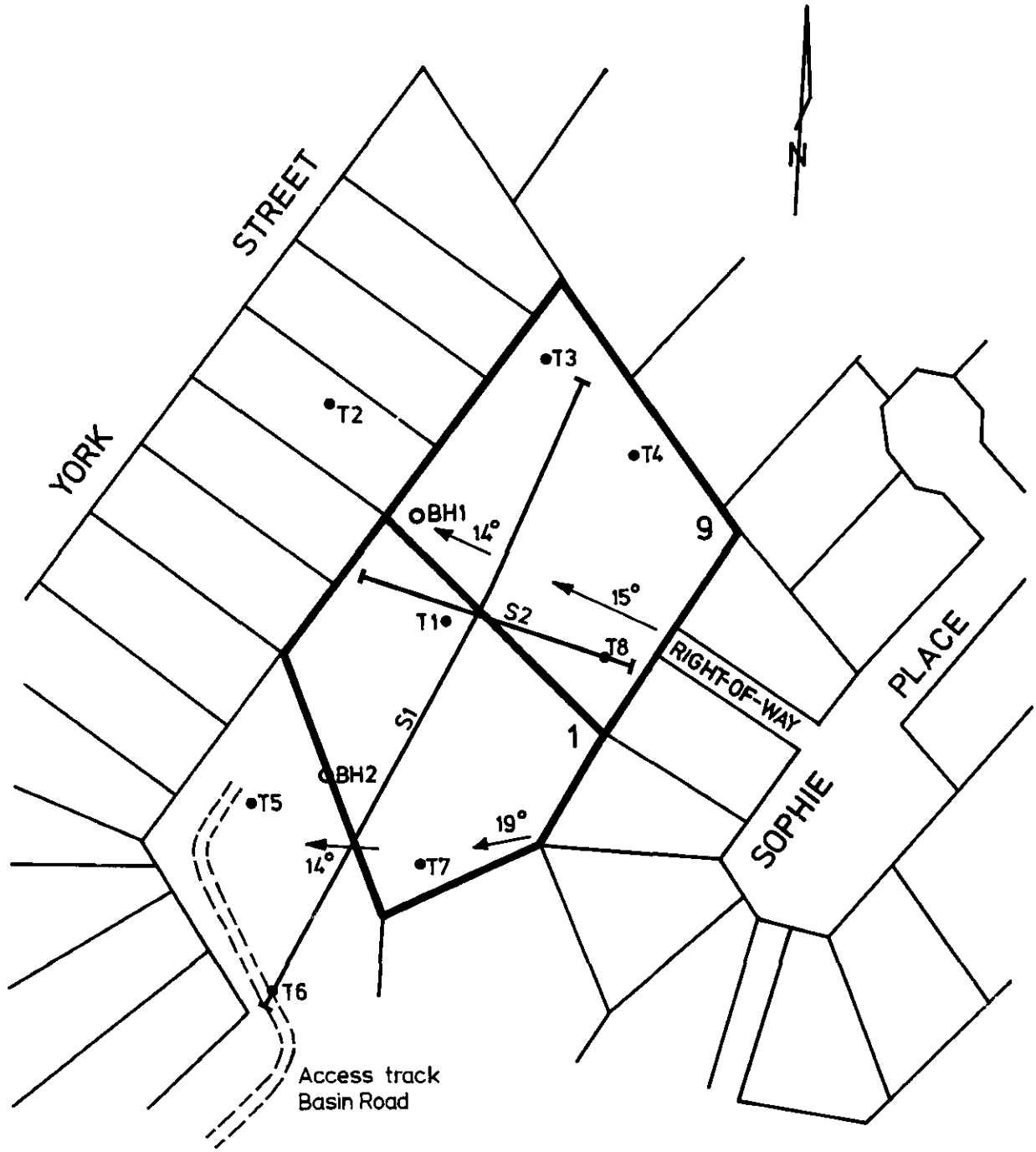
The depths to which the pits were dug varied from 1.5-2.5 m. Digging became difficult in some pits because the backhoe kept creeping down the slope, and the pits were stopped before their planned depth was reached.

A surface layer of black, moist clay soil, sometimes with dolerite boulders, was present in all the pits. This surface clay soil was underlain by brown and yellow white flecked clay which gradually changed to having the recognisable igneous rock texture of dolerite. This clay sometimes became slightly harder and was logged as highly weathered dolerite.

There was a marked change in all the trenches between the moist surface layer and the drier compact yellow flecked clay. Although this material is without doubt a clay, as for example Sample 3 collected at depth of 1.8 m from Pit 1, it is derived from the *in situ* weathering of dolerite. All of this material dug is considered to be in the surface slow seismic layer (velocities of 500-800 m/sec).

When dry and freshly exposed in the side of the trenches the clay and deeply weathered dolerite-derived clay appear to be a competent foundation rock. On wetting, the high plasticity of the clay is apparent. This was confirmed by the laboratory tests when only one of the clay samples tested gave a low liquid limit. This was Sample 3 from 0.7 m depth in Pit 3; in this pit, the clay rapidly changed to harder, highly weathered dolerite. Similar low to medium plastic clay was collected from Pits 2, 4 and 8, but was not tested.

The remainder of the samples were less rubbly and were weathered completely to a clay, even though some still retained an igneous texture. The samples had high liquid limits and covered a wide range in the high plasticity classification (fig. 2). The X-ray diffraction results of the fine fraction of these samples showed the dominant clay family present was montmorillonite, which gives the clay the high linear shrinkage.



T1 TRENCH
S1 SEISMIC SPREAD
BH1 BOREHOLE

Figure 1. *Location of investigations.*

5 cm

Table 1. RESULTS OF SOIL TESTING

Trench	Sample	Depth (m)	Field classification	Laboratory classification	Laboratory result					
					MC%	PL	LL	PI	LS(%)	XRD <2 μm (%)
1	1	0.2	OH	CH	25	27	94	67	25	
	2	0.6	CL		25					
	3	1.8	CL	CH	22	26	95	69	27	Mont 80-85 Kaol 15-20
2	1	0.4	OH							
	2	2.0	CL							
3	1	0.2	CH	CH	-	28	105	77	26	Mont 85-90 Kaol 10-15
	2	0.5	CL-CM	CH		29	108	79	25	
	3	0.7	CL	CL			45			
4	1	0.3	CL							
	2	0.5	CL							
5	1	0.4	OH	CH	27	32	117	85	21	
	2	1.0	CH	CH	24	25	83	58	22	Mont 80-85 Kaol 15-20
6	1	0.2	CH	CH	36	28	104	76	24	Mont 90-95 Kaol 5-10
	2	0.4	CH	CH	22		106			
	3	0.7	CL-CM	CH	25	27	91	64	23	Mont 85-90 Kaol 10-15
7	1	0.3	OH	CH	20	29	71	42	18	Mont 80-85 Kaol 15-20
	2	0.6	CH	CH	28		127			Mont 90-95 Kaol 5-10
	3	1.5	CL-CM	CH	30	25	60	35	-	
8	1	0.4	OH							
	2	1.0	CL							
	3	1.5	Jdl							

Mont = montmorillonite
Kaol = Kaolinite

No clay of the Launceston Beds of Tertiary age was seen in any of the trenches and no dolerite talus deposits were encountered, even though Trenches 7 and 8 were dug close to what appeared to be dolerite outcrops capping the ridge at Sophie Place. The trenches show that the dolerite, depending on the degree of weathering, breaks down to a low plasticity clay, then to a highly plastic clay. If the seismic calculations were correct, there appears to be a considerable depth of clay with harder but still very weathered dolerite, as exposed in the bottom of some of the pits. The calculated depth for this surface material could be as much as 9-11 m and to the unweathered dolerite 16-23 m.

If such material continued to this depth, some deep type of piled foundation becomes conceivable on the block. If concentric weathering of the dolerite occurred, this may produce unweathered dolerite horizons or kernels, too thin to be seismically detected but a good foundation layer.

In spite of the mounting costs for this site investigation, some drilling appeared to be required to test the material at depths greater than reached by the backhoe trenching.

Drilling

A light, trailer-mounted Treifus auger drill was used on the site. Even though not ideal for site investigation, as it produces no core, two holes were drilled within four hours to depths of 8.2 m and 5.0 m. Though not precisely on the seismic lines, these holes were adequate to indicate that the top seismic layer (clay) was very thick, because neither hole appeared to reach a harder, higher seismic velocity layer. The lithological logs of the two drill holes are given in Appendix 1, and their location is shown on Figure 1.

Hole 1 was stopped at 8.2 m, but not because the rock became harder or it had changed its lithology. The hole was in compact and very dry clay derived from extremely weathered dolerite, with two harder bands of highly weathered dolerite. This material was so fine that it compacted on the augers, causing them to become very difficult to lift. A depth of five metres was reached in Hole 2 in similar clay derived from extremely weathered dolerite. No harder bands were encountered. No softer or wet zones occurred below the surface clay layer in either drill hole.

INVESTIGATION RESULTS

The slow surface velocity layer of 500-800 m/sec has a proven minimum depth of 8.2 m and probably is in the order of 9-11 m deep as indicated by the seismic survey.

This surface layer is dominantly clay. It comprises a layer of black organic clay soil underlain by brown and then flecked yellow clay. This clay changes texture over a transitional zone of varying thickness to show the igneous structure of dolerite, which was logged as extremely weathered dolerite. This clay becomes harder at the bottom of some pits and is considered to be derived from a highly weathered dolerite. Two similar hard bands of highly weathered dolerite were encountered in one of the bore holes. No unweathered or slightly weathered dolerite was seen in any of the pits or encountered in the drilling.

A surface moist clay layer with a sharp transition to dry, massive stiff clay was present in all the pits. No soft or moist zones other than

Table 2. RESULTS OF SLOW SHEAR BOX TESTS

Trench	Sample	Residual angle of friction ($\phi'r$)	Effective cohesion c'r (kPa)
1	3	17	8.3
5	2	15	6.0
6	1	16	11.6

Shear box testing by R.N. Woolley, Department of Mines

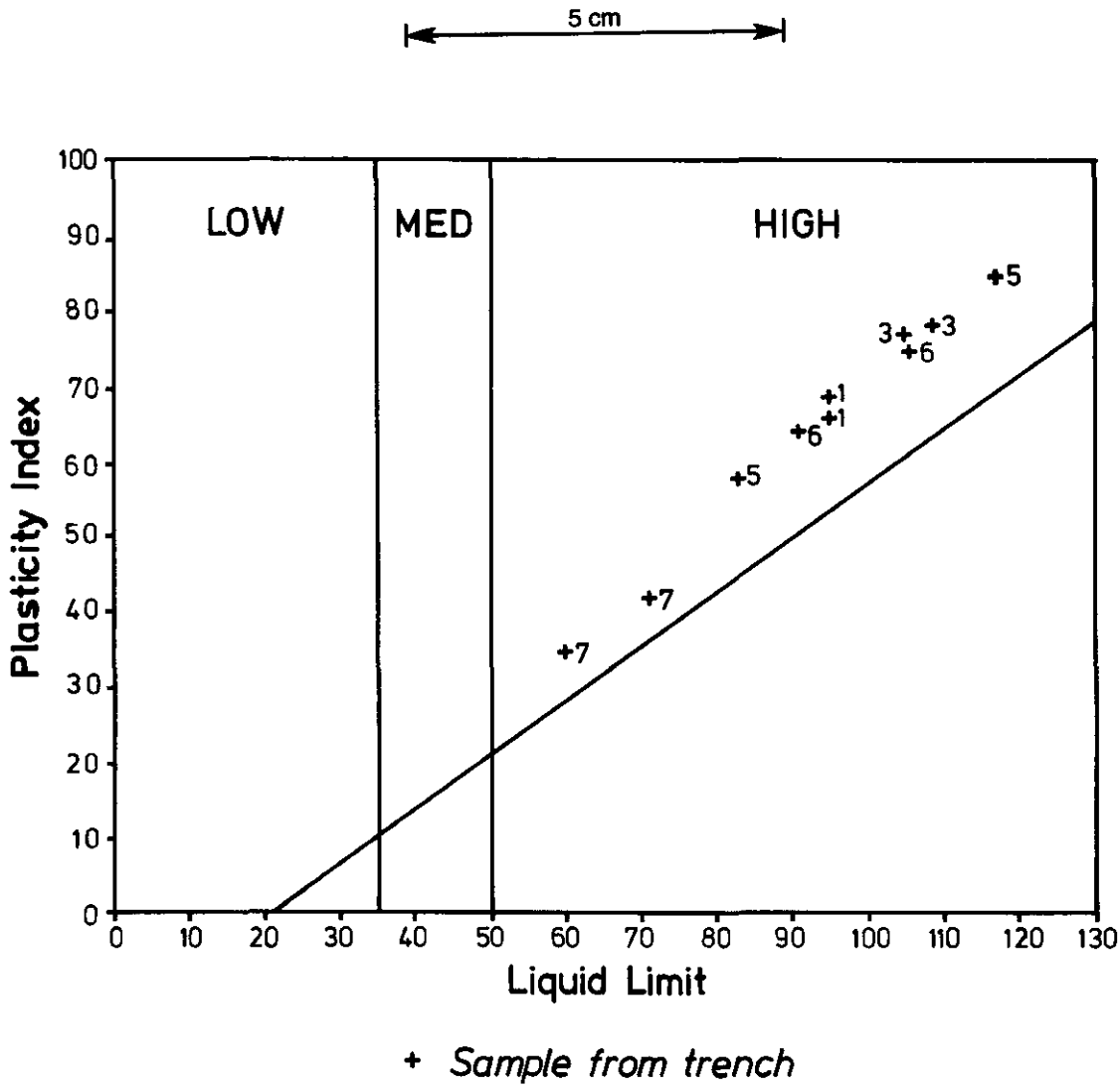


Figure 2. *Plasticity range of samples.*

this surface layer occurred in the pits or was encountered in the drill holes.

The moisture content of all clay samples (except one) was not greater than 30%. The exception was a sample from a pit located at the base of slope in a very moist area, near the Basin Road access track.

Both the surface black clay and the brown and yellow flecked clay with the igneous rock texture were highly plastic, but the range of plasticity is wide with plastic indices ranging from 35 to 79 (fig. 2). Some low plasticity clay was present in the harder and more rubbly clays.

X-ray diffraction showed that the composition of the fine fractions of the clay samples is dominantly montmorillonite, with a content above 80% for all the samples tested. The minor component is kaolinite, with no quartz recorded. With such a composition the clay is highly expansive with linear shrinkages varying between 17 and 25%.

Three samples were shear box tested. The angle of friction was found to be low at 15°-17° and the effective cohesion was from 8.3 kPa to 11.6 kPa.

Blocks 1 and 9 at Sophie Place have steep uniform slopes of 15°, flattening to 14° towards York Street. A very steep section occurs at the south-east corner of the block with slopes of 19° measured. Even though underlain by highly plastic clay with low friction angles, no evidence of any downslope translational movements was seen on the blocks or neighbouring lots.

CONCLUSIONS

(1) The degree of weathering of the dolerite, and the intensity and depth of weathering are exceptional, and are not considered by the writer to be related to the present day landscape and recent weathering processes.

The dolerite is decomposed to a clay to a depth known to be in excess of eight metres in one borehole and with the depth to unweathered dolerite estimated to be possibly in excess of 16 m. It appears to the writer that this is a residual area or pocket of very old weathering, considered tentatively to be Tertiary age. This pocket of soft clay is considered to have been protected by the capping of unweathered dolerite forming the ridge at Sophie Place. Similar deep residual weathering occurs in dolerite at Devonport (Moore, 1968*a*, *b*) and in Triassic sediments at Whitewater Creek (Moore, 1979) and granite at Scottsdale.

(2) With slope angles varying from 14°-19° and with an angle of friction of the clay of 15°-17°, the question is why has the slope not failed at Sophie Place? The moist layer is confined to a shallow surface zone and little moisture reaches the greater part of the clay sequence. In nearly all the pits dug on the slope, the moist layer was less than one metre deep and in some holes as little as 0.5 m. The only pit with a moist surface layer greater than one metre deep was Pit 5, which is situated at the foot of the slope.

This shallow, moist surface zone in the clay is thought to be the result of the local geology at Sophie Place. The dolerite acts as an impervious layer which causes the water to run off on the surface down the slope. The surface clay absorbs the water because of its

high plasticity. If the capping layer had been basalt, which because of its porosity and permeability would act as a leaky aquifer, water would penetrate to a greater depth in the clay, and the potential for slope failure would have been far greater. Such failures in the clay of the Launceston Beds of Tertiary age below the basalt are common in the Tamar Valley (*e.g.* Bradys Lookout).

RECOMMENDATIONS

(1) Provided that water can be restricted to the existing depth in the moist zone in the surface clay layer and it does not penetrate deeply to reach the highly weathered dolerite-derived clay, building appears feasible on Blocks 1 and 9 at Sophie Place.

(2) Any building on the areas with slopes of 14°-15° should have bored or piled foundations penetrating into the clay derived from the highly weathered dolerite. This type of foundation should be deep enough into this hard clay so that water cannot reach such depth.

(3) In the south-east corner of Blocks 1 and 9, where slopes are up to 19°, the foundations should be in the 'bedrock' of unweathered or slightly weathered dolerite, not the clay.

(4) A competent foundation engineer should design the building foundations, all of the drainage of the site, and the underground servicing, particularly the plumbing. With drainage so critical at this site, all of these should be the engineer's responsibility. The foundation engineer should also ensure during construction that the foundations are located to an adequate depth in the hard, massive, highly weathered dolerite-derived clay.

It should be noted that no slope stability analyses were undertaken, because without knowing the downslope dimension of the clay pocket and its depth above the rock, such calculations could be misleading at this stage of the investigation. If they are required by the foundation engineer, reliable depth information can only be obtained by diamond drilling and should not be based on seismic calculations, particularly on one spread. The seismic velocity interface does not generally coincide with the geological boundary in weathered dolerite, and the dolerite boundary between the clay and dolerite will vary greatly on the site, particularly if concentric weathering occurs as is suspected from the auger drilling.

REFERENCES

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[7 August 1985]

APPENDIX 1

Engineering logs of trenches

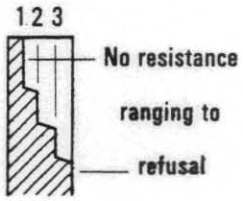
TASMANIA DEPARTMENT OF MINES

10/16

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

Notes - samples and tests

U50	Undisturbed sample 50mm diameter.
D	Disturbed sample.
N	Standard penetrometer blow count for 300mm.
N*	SPT + sample.

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feel dry.
M	Moist, no free water on hand when remoulding.
W	Wet, free water on hand when remoulding.
LL	Liquid limit.
PL	Plastic limit.
PI	Plasticity Index.

eg. M > PL – Moist, moisture content greater then the plastic limit.

Consistency

		hand penetrometer (kPa)
VS	Very soft.	< 25
S	Soft.	25 – 50
F	Firm.	50 – 100
St	Stiff.	100 – 200
VSt	Very stiff.	200 – 400
H	Hard.	> 400
Fb	Friable.	

Notes: X on log is test result

— is range of results.

Density index

		%
VL	Very loose.	0 – 15
L	Loose.	15 – 35
MD	Medium dense.	35 – 65
D	Dense.	65 – 85
VD	Very Dense	85 – 100

Cored borehole log

Case - lift

Casing used.

Barrel withdrawn.

Fluid loss

No loss

50% loss

100% loss.

Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm/sec.

Graphic log

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh.
SW	Slightly weathered.
HW	Highly weathered.
EW	Extremely weathered.

Strength

		point load strength index $I_{s\,(50)}$ (MPa)
EL	Extremely low.	< 0·03
VL	Very low.	0·03 – 0·1
L	Low.	0·1 – 0·3
M	Medium.	0·3 – 1
H	High	1 – 3
VH	Very high.	3 – 10
EH	Extremely high.	> 10

Note: X on log is test result.

Significant defects

Significant defects shown graphically.

Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

5 cm

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TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 1

sheet 1 of 1

project Foundation investigation, Sophie Place, Launceston

location see Figure 1

co-ordinates EQ106114

R.L. 96 m

excavation dimensions 1.5 x 1.0 x 2.5 m

exposure type Pit

equipment Backhoe

operator M. Campbell

pit commenced 19.3.85

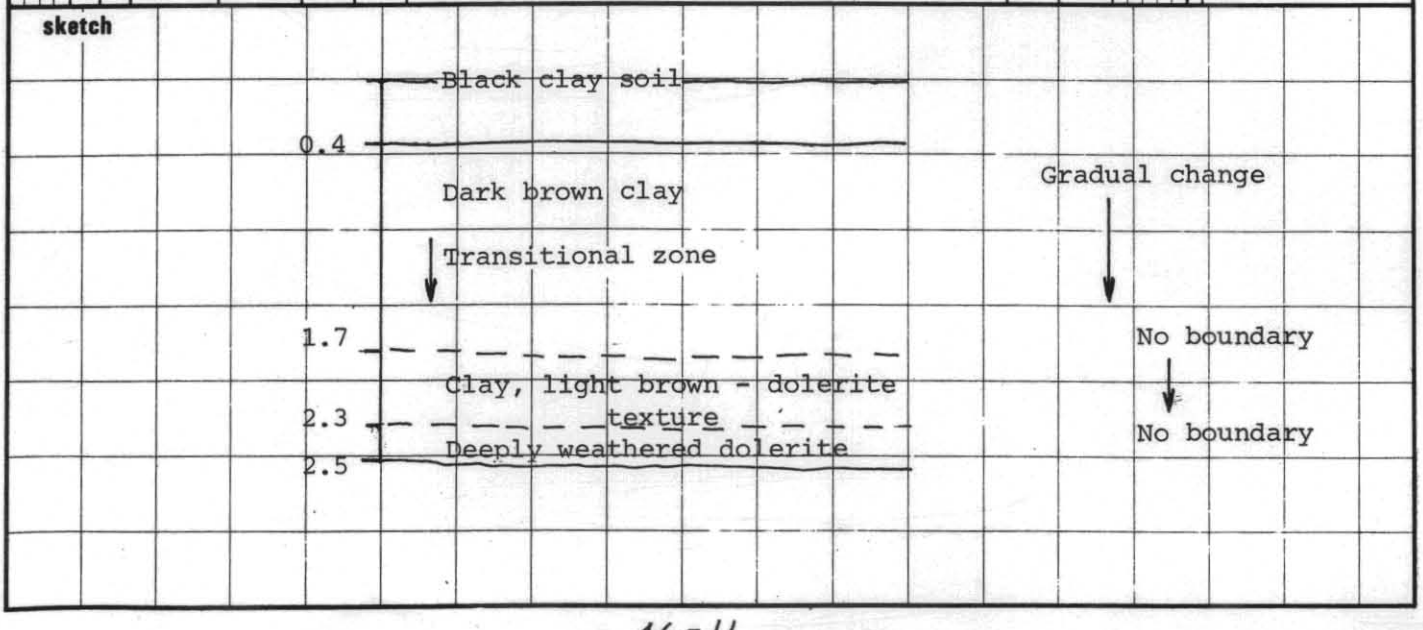
pit completed 19.3.85

logged by WRM

checked by RCD

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
	None	None	S1			OH	*Clay* - Black, organic. High plasticity, with roots	M	V St.		Surface soil
			S2	0.5		CH	*Clay* - Dark brown, medium to high plasticity. Flecked appearance which becomes igneous dolerite texture at base. Limonite staining. Massive and compact, + 500 kPa.	M / D	H		Transition zone
			S3	1.0 / 1.5 / 2.0		CH	*Clay* - Brown, spotted, high plasticity. Massive, almost rock - definite dolerite texture, + 800 kPa	D	H		Extremely weathered and decomposed dolerite
				2.5		CH	*Clay* - Yellow, high plasticity. Massive - extremely weathered dolerite.	D	H		Dolerite
							Backhoe had difficulty penetrating, trench stopped.				

sketch



46-11

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5 cm

ENGINEERING LOG – EXCAVATION

excavation no. 2

sheet 1 of 1

project: Foundation investigation, Sophie Place, Launceston — location: see Figure 1

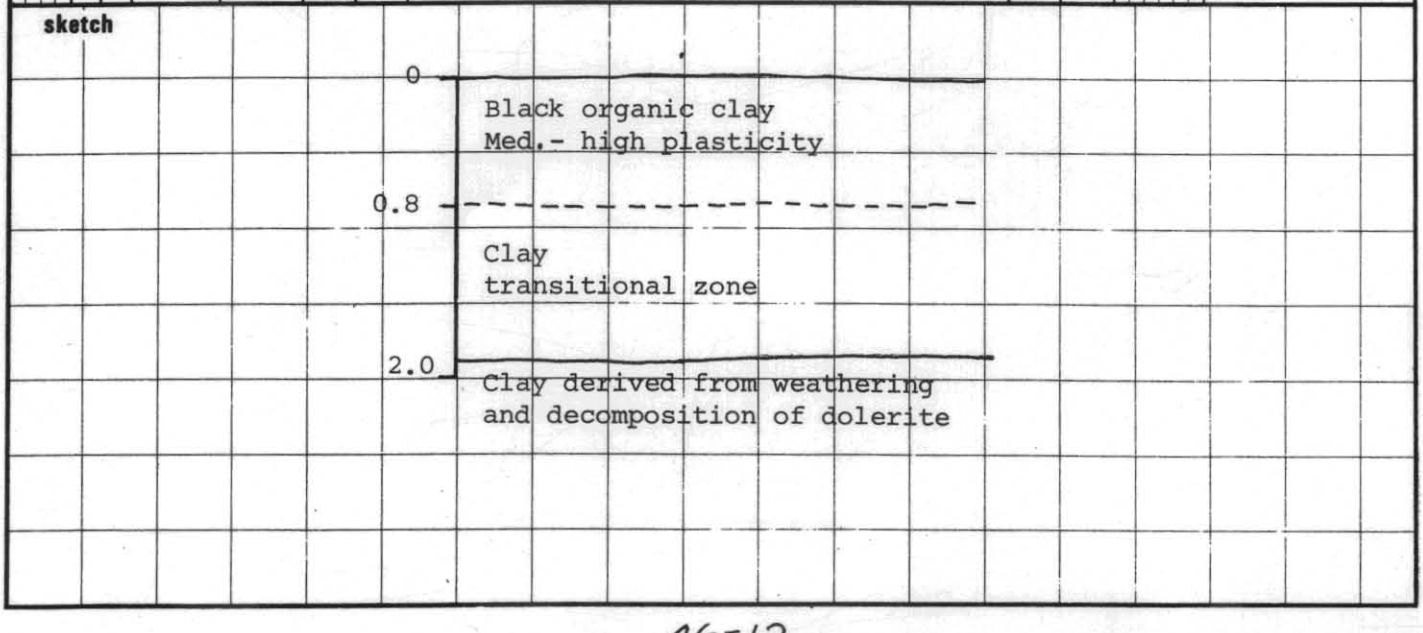
co-ordinates: EQ105114 — exposure type: Pit — pit commenced: 19.3.85

R.L.: 80 m — equipment: Backhoe — pit completed: 19.3.85

excavation dimensions: 1.5 x 1.0 x 2.0 m — operator: M. Campbell — logged by: WRM — checked by:

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material (soil type: plasticity or particle characteristics, colour secondary and minor components)	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
	None	None	S1	0.5		OH	*Clay* - Black organic. Med. - high plasticity with roots.	M	V St		Surface soil
				1.0		CL ↓ CH	*Clay* - Yellow, flecked. Med. - high plasticity. Massive but igneous texture becoming apparent at depth.	D	H		Transitional zone to decomposed and extremely weathered dolerite
				1.5							
			S2	2.0		CL - CH	*Clay* - Yellow, decomposed and extremely weathered dolerite.	D	H		Weathered dolerite
							Backhoe stopped. Penetration becoming difficult.				

sketch



46-12

13/16

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 3

sheet 1 of 1

project: Foundation investigation, Sophie Place, Launceston

location: N.E. corner, see Figure 1

co-ordinates: EQ106115

R.L.: 90 m

excavation dimensions: 1.5 x 1.0 x 1.7 m

exposure type: Pit

equipment: Backhoe

operator: M. Campbell

pit commenced: 19.3.85

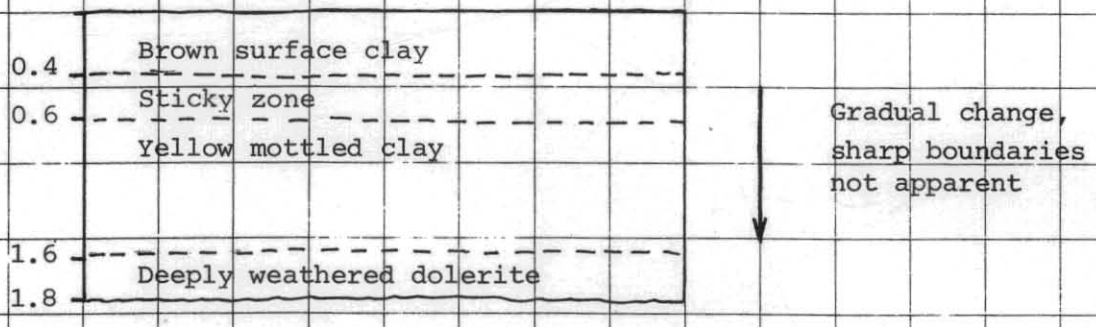
pit completed: 19.3.85

logged by: WRM

checked by: RCD

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
	None	None	S1			CH	*Clay* - Brown, high plasticity with roots, 550 kPa	D	H		Surface clay soil
			S2	0.5		CL CH	*Clay* - Brown, freckled, with roots & weathered feldspar flakes. + 500 kPa	M	H		Sticky zone
			S3	1.0		CL	*Clay* - Yellow, mottled with feldspar. Med. - low plasticity, igneous texture not developed.	D	H		Mottled clay
				1.5		CL	*Clay* - Extremely weathered. Dolerite igneous texture present.	D	H		Dolerite
				2.0			Backhoe sliding on slope. Difficult position to dig rather than hard to penetrate				

sketch



46-13

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

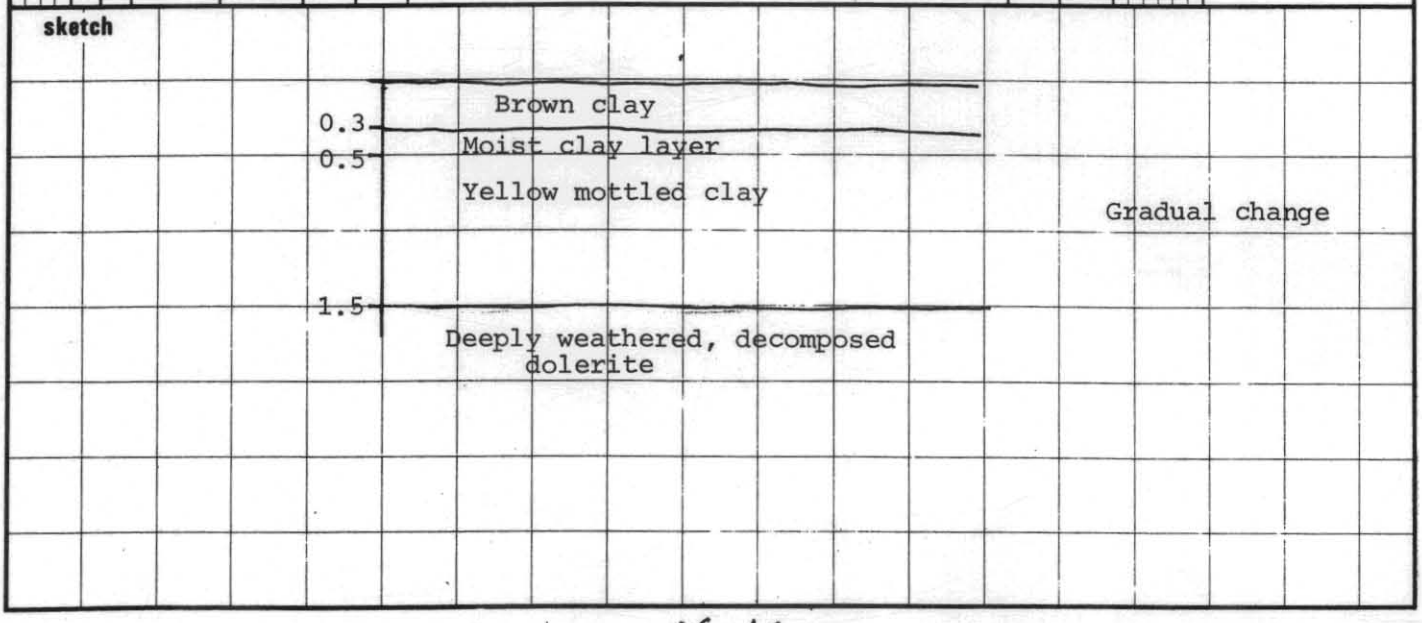
excavation no. 4
sheet 1 of 1

project: Foundation investigation, Sophie Place, Launceston
location: see Figure 1

co-ordinates: EQ106115
R.L.: 100 m
excavation dimensions: 1.5 x 1.0 x 1.6
exposure type: Pit
equipment: Backhoe
operator: M. Campbell
pit commenced: 19.3.85
pit completed: 19.3.85
logged by: W.R.M.
checked by: R.C.D.

penetration 1 2 3	support	water	notes samples, tests	metres R.L / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
			S1			CL / CH	*Clay* - Brown, med. - high plasticity with roots and dolerite boulders	D	H		Surface clay soil
			S2	0.5		CL	*Clay* - Brown, white flecked carbonates, low - med. plasticity	M	H		Moist zone
	None	None		1.0		CL	*Clay* - Yellow - brown - low to medium plasticity. Massive. 1500 kPa. Grades down to show igneous dolerite texture	D	H		Mottled clay
				1.5		CL	*Clay* - Yellow, extremely weathered dolerite. Backhoe sliding on slope. Difficult position to dig rather than unable to penetrate.				Dolerite

sketch



5 cm

15/16

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 5

sheet 1 of 1

project: Foundation investigation, Sophie Place, Launceston

location: see Figure 1

co-ordinates: EQ105114

R.L.: 70 m

excavation dimensions: 1.5 x 1.0 x 1.7 m

exposure type: Pit

equipment: Backhoe

operator: M. Campbell

pit commenced: 19.3.85

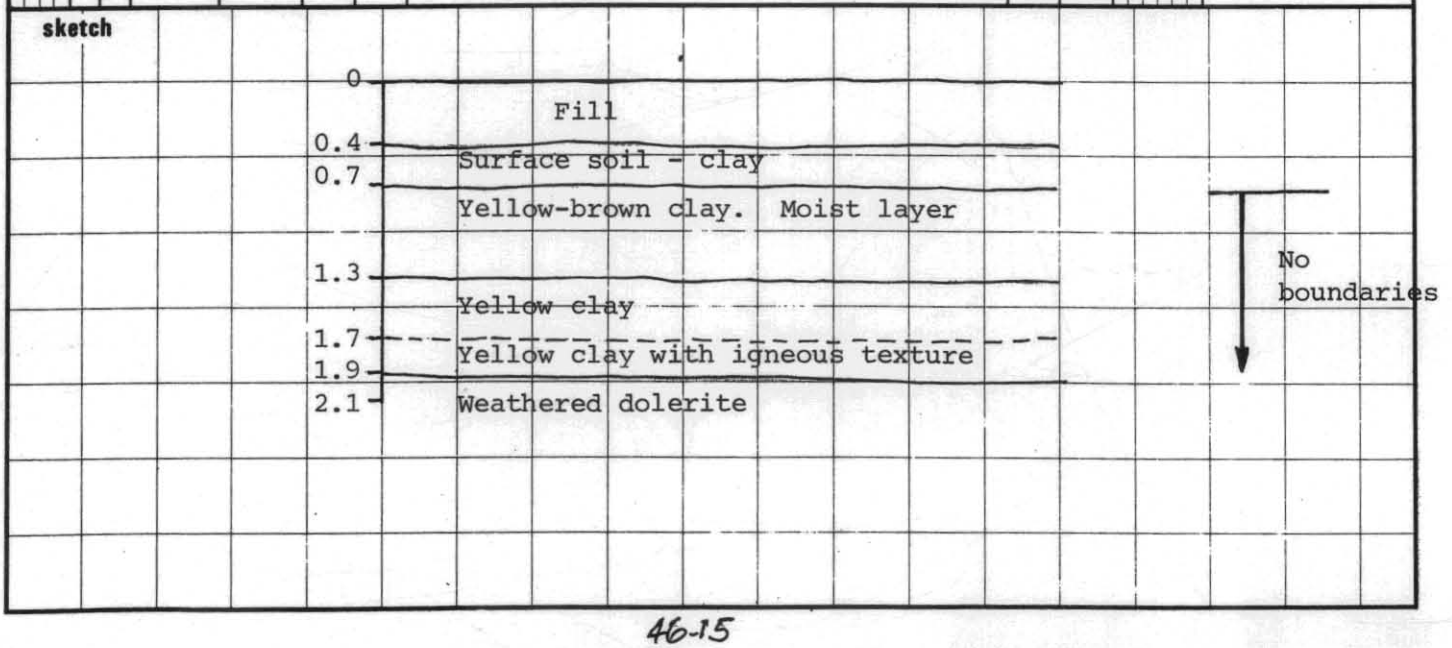
pit completed: 19.3.85

logged by: W.R.M.

checked by: R.C.D.

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
							GW SW OH	Sand, soil and boulders - soil, clay organic. Boulders dolerite, 30-60 mm. Sand wellgraded, fine - med., white	M	St		Fill
			S1		0.5		OH	*Clay* - Dark brown, high plasticity with roots and white zeolite? carb.? spots and roots.	M	V St		Surface soil
	None	None	S2		1.0		CH	*Clay* - Yellow-brown with white flecks High plasticity.	M			Subsurface clay
					1.5		CL | CH	*Clay* - Yellow, fine, medium to high plasticity. No igneous texture	D	H		Transition zone
							CL	*Clay* - Yellow, with harder, presumed ironstone band. Igneous texture	D	H		Extremely weathered
					2.0			*Clay* - Extremely weathered dolerite	D	H		Dolerite
								Backhoe stopped by a hard layer.				

sketch



46-15

16/16

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 6

sheet 1 of 1

project: Foundation Investigation
Sophie Place, Launceston

location: see Figure 1.

co-ordinates: EQ105113

R.L.: 80 m

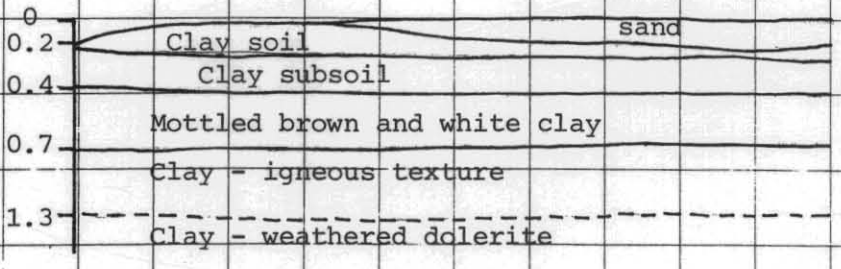
excavation dimensions: 1.5 x 1.0 x 1.5 m

exposure type: Pit
equipment: Backhoe
operator: M. Campbell

pit commenced: 19.3.85
pit completed: 19.3.85
logged by: W.R.M.
checked by: R.C.D.

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
			S1			SP CH	*Sand and clay* - Builders sand. Clay, dark brown, highly plastic.	M	S		Fill soil
			S2			CH	*Clay* - Brown with white spots and flakes. Highly plastic.	M	V St		Subsoil
				0.5		CH	*Clay* - Mottled brown and white. High plasticity. Remnant igneous texture.	D	H		Transitional zone
			S3			CL | CH	*Clay* - Yellow, plasticity low to med. Igneous texture and gritty feel.	D	H		
				1.0		CH	*Clay* - Extremely weathered, low plasticity, dolerite.	D	H		Weathered dolerite
				1.5			Backhoe stopped because of weathered dolerite and slow digging.				Dolerite

sketch



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