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14. Use of deep resistivity probes in basalt covered Tertiary basins.

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The problem of geological exploration in areas where Tertiary basins or leads are capped by basalt is seldom encountered. Drilling is the simple but costly solution which has been generally employed to overcome this problem.

In Tasmania, however, few holes have been drilled through basalt caps. In such an environment geological methods are inapplicable and many geophysical methods cannot be usefully applied without drilling control or the control of another method. For example, refraction seismic and magnetic methods are of no use and although gravity methods may yield some results, there are too many ambiguities present for these results to be directly useful. In those situations where drilling controls are absent, resistivity probing might provide the necessary vertical control for a gravity survey. Future groundwater surveys are to be aimed at Tertiary basins, most of which have a basalt capping, and therefore a method must be devised to overcome this problem. An approach is needed which would initially guide the drilling programme and later, when some drilling results are available, allow an extension of derived conclusions across the area surveyed.

RESISTIVITY SURVEY

Two areas were selected for examination; the Winnaleah-Branxholm lead, and the Port Sorell basin.

A small number of trial probes, using the Schlumberger configuration to a half-spacing of 600 m, were undertaken in selected locations in each area (fig. 15) to determine:

(1) The scale of spacings required to give sufficient detail near surface in the basalt or of the basement at depth.
(2) The effective depth of penetration with large half-spacings in an insulating and, or, highly conductive environment.
(3) Whether the depth to the water table, basalt thickness, and depth to basement could be reliably determined.
(4) The amount of input power required.
(5) Whether surface effects such as relief or lateral soil variations cause significant problems.
(6) The effect of electrode earthing problems.
(7) The practicality of regular use of large spacings.

All the results have been interpreted using the method outlined by Leaman (1973*b*).

AREA 1: WINNALEAH-BRANXHOLM

The location of the five test probes is shown in Figure 15. Probes 1, 3, 4 and 5 were situated in gently undulating areas whereas Probe 2 straddled a rounded hilltop. The form of the trial probes is shown in Figure 15, and the possible interpretations are given below. Due to very heavy rains immediately preceding the survey the water table is expected to be near surface.

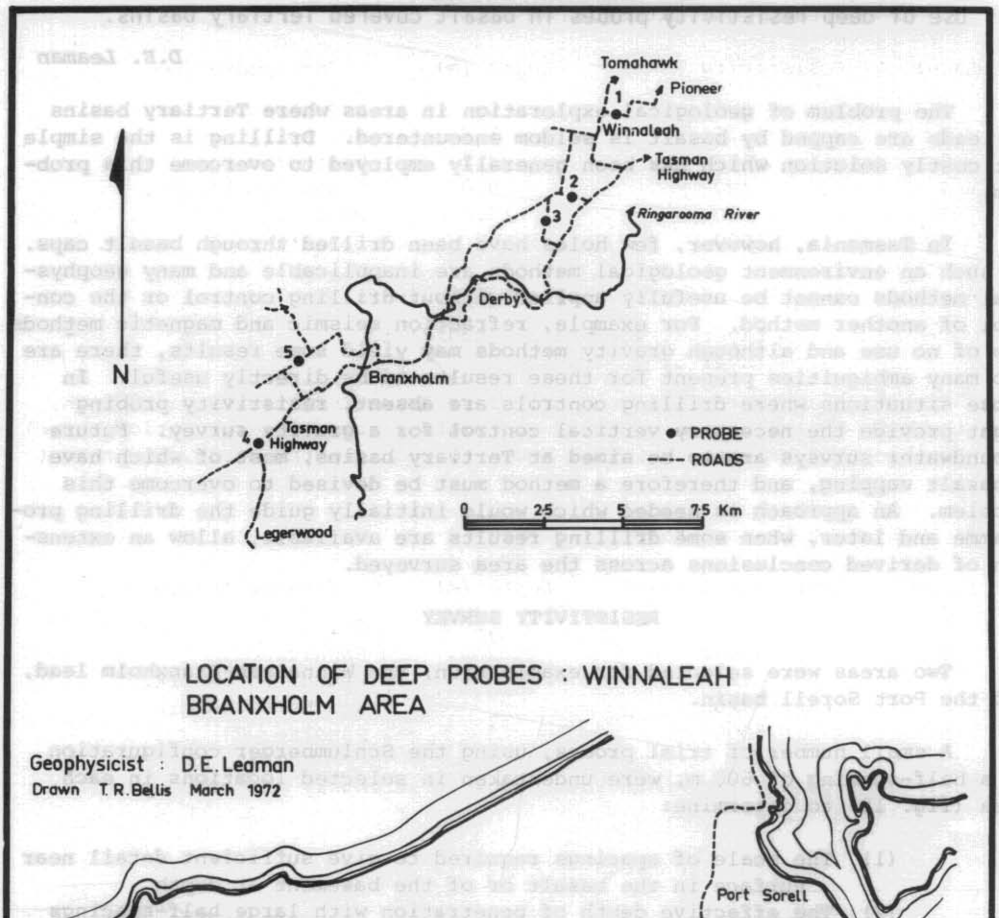
Tomahawk
Pioneer
1
Winnaleah
Tasman Highway
2
3
Ringarooma River
Derby
N
5
Branxholm
Tasman Highway
4
PROBE
ROADS
0 2·5 5 7·5 Km
Legerwood
LOCATION OF DEEP PROBES : WINNALEAH BRANXHOLM AREA
Geophysicist : D.E. Leaman
Drawn T.R. Bellis March 1972
Port Sorell
Devonport Airport
Northdown
Parkers Ford
3
6
Wesleyvale
7
4
2
PROBE
ROADS
Moriarty
0 1 2 3 Km
1
5
LOCATION OF DEEP PROBES DEVONPORT – PORT SORELL AREA
DEPARTMENT OF MINES 3593-29,32

Figure 15.

Probe 1: Pioneer back road, Winnaleah

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	200		Dry basaltic soil.
2	15	1.2	Wet soil.
3	150	2.7	Weathered basalt.
4	180	9.0	Weathered basalt.
5	800	15.0	Basalt.
6	1000	?	Basalt.

A second possible interpretation is as follows:

Layer 3, 4 Tertiary sediments
Layer 5, 6 Granite

Figure 16 shows that there is a regularly increasing resistivity with depth, and as there is no indication of thick sediments (second interpretation above) it is possible that granite, which is known to occur to the north, is present at shallow depth.

Probe 2: Winnaleah by-pass road.

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	300		Soil.
2	5000?	7	Basalt.
3	125	7.5	Weathered basalt.
4	20	8	Weathered basalt.
5	5000	15	Basalt.

There is a possibility that this probe is seriously affected by relief and local surface variations.

Probe 3: Raltray's road, Winnaleah

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	700		Dry basalt soil.
2	350	2	Wet basalt soil.
3	2000	8	Massive basalt.
4	100	17	Tertiary sediments.
5	2000	110	Slate or granite? (Probably granite)

Probe 4: Tasman Highway, Legerwood junction

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	1000		Dry soil.
2	50	1	Wet soil.
3	2000	2	Massive basalt.
4	20 000	20	Massive basalt.
5	100 000	30	Massive basalt
6	300	60	Tertiary sediments.

An alternative interpretation for Probe 4 is given below:

Layers 1, 2, 3 As above
Layers 4, 5 Granite

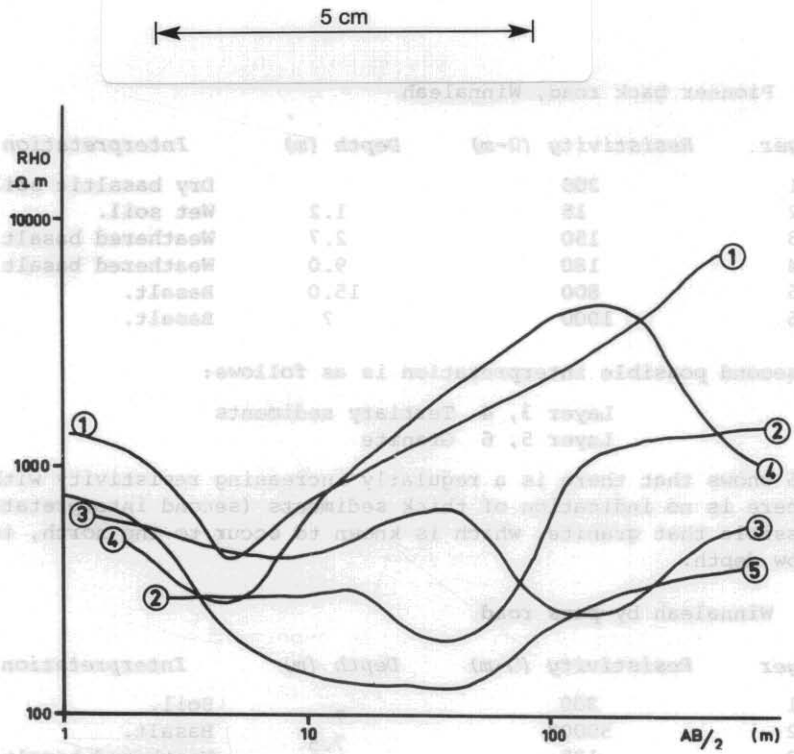

Figure 16. *Form of trial probes, Winnaleah-Branxholm area.*

Figure 17. *Form of trial probes, Port Sorell-Devonport area.*

Probe 5: Branxholm back road

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	750	1	Dry basaltic soil.
2	200	5	Wet soil.
3	100	40	Tertiary sediments.
4	1000	90	Slate(?)
5	500	120	Slate.
6	2000		Slate.

It is possible that layers 3 and 4 represent weathered massive basalt and that layers 5 and 6 represent sediments and slate respectively.

AREA 2: PORT SORELL

The location of the seven test probes in this area is shown in Figure 15. Probes 1, 4 and 7 were located in undulating country while the remaining probes were on level ground. The form of the trial probes is shown in Figure 17, and possible interpretations are presented below.

Probe 1: Parsons bore (Burns, 1965). Devonport 12 mile post, Exeter Highway

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	650	1	Dry soil.
2	100	1.5	Soil?
3	200	3	Soil?
4	60	9	Clay.
5	300	12	Gravel.
6	1000	15	Weathered basalt.
7	>10 000		Basalt.

This interpretation is based on the bore log given in Burns (1965), where it is reported that several metres of clay overlie gravel and basalt. The continuously rising, although fragmented profile (fig. 17), confirmed the presence of basalt to a considerable depth and no materials below the basalt have been detected. The very high resistivity value for the basalt suggests that it is quite massive and hard.

Probe 2: Frankford Highway east of Northdown Road, Moriarty

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	115	8	Soil.
2	400	18	Weathered basalt.
3	40	70	Tertiary clay.
4	70		Clay.

Probe 2a: The same location as Probe 2.

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	115	8	Soil.
2	400	14	Weathered basalt.
3	40	120	Clay.
4	1000		Basalt.

Probes 2 and 2a are based on observations made at the same spacings but in very different ground conditions. Probe 2 was observed at a time of soil water saturation. In view of the variation in the condition of the surface it is surprising to note that the curves differ at depth. No simple explanation for this condition can be found. Nevertheless both probes are in agreement for the top 70 m but Probe 2a implies a further high resistivity material, probably basalt or possibly dolerite (Leaman, 1973*a*), at about 120 m.

Probe 3: Northdown

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	65		Basaltic soil.
		2	
2	90		Basaltic soil(?)
		10	
3	10		Clay.
		28	
4	1000		Basalt?

The Devonport geological map (Burns, 1963) shows surface basalt in the area. However the resistivity values are so low they suggest that only soil and rubble is present.

Probe 4: Northdown road, Moriarty

Due to the great scatter of readings it was not possible to deduce a definitive curve for the probe. However the first layer has a resistivity of 100 Ω-m and is about 7 m in thickness. The 'second layer' has a lower resistivity and a thickness of approximately 100 m. A 'third layer' has very high resistivity. These observations are based on a trend predominance in the result scatter and if correct, the profile may be dry soil or gravel overlying clays and basalt or dolerite.

Probe 5: Thirlstane Road

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpretation*
1	150		Soil.
		1.5	
2	25		Wet soil, clay.
		9	
3	60		Clay.
		35	
4	200		Sandy clay.

The Beaconsfield geological map (Gee and Legge, 1971) shows surface basalt in the area. The results suggest that only a basaltic soil could be present and that Tertiary clays extend to a depth of at least 100 m.

Probe 6: Parkers Ford. Sulzberger bore hole 1 (Leaman, 1973*a*)

Interpretation of a continuously reducing curve is difficult using the computer based method of Leaman (1973*b*). However, using the zero thickness artifice to aid series convergence the following result was obtained. There was good agreement with the Schlumberger 3-layer curves in this case.

Layer	*Resistivity (Ω-m)*	*Depth (m)*
1	330	
		8
2	40	
		56
3	10	

Interpetation of this probe is of little significance as it is a purely Tertiary clay profile. The resistivity of the third layer is implied to be less than 5 in the Schlumberger master curves.

Probe 7: Road cutting, Frankford Highway, West Moriarty

Layer	*Resistivity (Ω-m)*	*Depth (m)*	*Interpetation*
1	400	1	Weathered basalt.
2	200	7	Sand, gravel.
3	600	44	Weathered basalt.
4	10		Clay.

The depth probe correlates very well with the geology of the area (Burns, 1964) and the interpretation of the layers is based on the geologic units mapped.

DISCUSSION

All probes were undertaken with AB/2 increments measured to provide regular intervals on a logarithmic plot. Initially 5 m steps were used, from 5 to 15 m. The maximum spacing used was 600 m. Adequate detail has been provided to a maximum depth of about 100 m. In order to detect basement, especially at Port Sorell where bore holes indicate a cover of up to 350 m of Tertiary sand and clay, a spacing of at least 1.5 to 2 km would be necessary. Such spacings would be difficult to lay out in the two areas examined and would introduce serious effects due to relief and geological variation. The locations of the twelve probes presented here were selected carefully with regard to geological uniformity and relief but even this selection was imperfect (see below).

The power output of the Yew 3244, battery powered resistivity meter, was adequate to reach spacings of 600 m in all but two cases (Probes 6 and 7, Port Sorell). The maximum output is about 100 W. The presence of a thick, very low resistivity layer in Probes 6 and 7 was responsible for power dissipation. It appears that resistivities less than 10 Ω-m produce this effect especially if underlying layers have relatively high resistivity. In the case of Probes 6 and 7 the resistivity is suspected to be less than 5 Ω-m.

Ground contact problems were not encountered during the surveys, which were undertaken in late winter and spring. However it is possible that in late summer, in those areas where clays are exposed, that this problem might arise. This problem was faced several years ago at Longford where dry dessicated soils overlay moist clays. The resistivity contrast was about 1000:1 and the penetration depth was commonly less than 5 m. In this situation use of mesh, stake or pot electrodes caused no improvement while they were surface based and also extensive wetting of the surrounding ground made little difference. It was found that excavation of a small hole to a depth of 50-75 cm with the electrode stake pushed into the hole bottom its full length, that is 30-50 cm, that excellent contacts could be made without wetting. Close examination of the soil dryness profile revealed a distinct dessication above 50 cm.

Relief effects appear to be important, such as the case of Winnaleah Probe 2, but the nature of the error introduced is unknown. Lateral soil variations are also significant (Probe 1, Port Sorell). Whether the effects of these two variables could be tolerated in a non-selective general survey is unknown. Lateral variations are revealed with changes of inner electrode spacing in the Schlumberger method but would remain an unknown factor if the Wenner configuration were used. Relief effects can only be assessed by comparing profile, interpretation and drilling results.

These trials have shown that it is practical to regularly undertake probes with regular spacings up to 600 m. It is necessary to pre-peg the measuring intervals desired and for all crew members to carry two-way radios. Larger spacings will cause difficulties in most areas.

The interpretations presented are uncontrolled and therefore there is room for ambiguity in each case; especially with reference to layer depths. In addition all interpretations are undoubtedly simple and many thin layers have probably been omitted in accord with the principles of suppression and equivalence.

The reliability of the results presented in this report is unknown and drilling at many of these locations is therefore recommended. Only then can a full assessment be made of the field and interpretative techniques. A library of controlled probes is necessary in areas of difficult relief in order to assess relief effects.

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