



Mineral Resources Tasmania

REPORT 1994/18

Drilling investigation of a magnetic anomaly and post-Jurassic deposits at Inside Plain, near Fingal

by J. L. Everard

Abstract

Drilling has shown that a negative magnetic anomaly at Inside Plain, 4 km north of Fingal, is attributable to sub-surface Tertiary(?) basalt, probably basanite. A feeder may exist in the vicinity.

In the drill hole [at EP81989303], the post-Jurassic (Tertiary?) sequence is 84 m thick and rests on a basement of Mathinna Beds arenite and lutite. A lower section (37–84 m depth) is dominated by pebble-cobble to boulder conglomerate containing clasts of mainly Jurassic dolerite and Mathinna Beds lithologies, and is interpreted as lithified river gravels deposited in probably well-defined channels. The basalt occurs as an interval (55–75 m) within the conglomerate and consists of probably two petrographically-similar flows, separated by a narrow interval of perperitic breccia.

The upper section (5–37 m) of the post-Jurassic sequence consists mainly of Tertiary(?) clay, silty clay and sandy clay, with minor intervals of lateritic(?) ironstone, coal and unlithified pebbly river gravel.

INTRODUCTION

An airborne geophysical survey flown over part of northeastern Tasmania by the Department of Mines in 1989 showed an unexplained large, negative magnetic anomaly located about 4 km north of Fingal (fig. 1, 2).

The aeromagnetic contours show a main anomaly centre of about 61 710 nT located at EP819930, and a subsidiary centre of about 61 715 nT about 500 m to the NNE at EP822935; the regional field in adjacent magnetically flat areas is about 61 755 nT. The east-west extent of the anomaly is less than one kilometre. These values and locations are only approximate, as the survey was of regional standard with a 500 m line spacing. In particular, the apparent double nature of the anomaly may be an artefact of the contouring process, as both centres lie on flight lines. Survey details are printed on the reverse side of the Alberton map sheet (McClenaghan *et al.*, 1993), and results and problems of interpretation are discussed by Richardson (1989a, b).

The anomaly coincides with broad river flats on the "Malahide" property, and is centred on the right (west) bank of the South Esk River just above its confluence with

the Break O'Day. On the Ben Lomond map sheet (Calver *et al.*, 1988) the area was mapped as "Qha — Holocene stream alluvium and swamp deposits". Higher ground one kilometre or more away to the west, northeast and northwest was mapped as "Qqa — older alluvium of river terraces". The nearest mapped exposures of bedrock are outcrops of Permian mudstone, siltstone and sandstone about 1.5 km to the SSE (Calver *et al.*, 1988) and 1.5 km to the east on the adjacent St Marys map sheet (Turner *et al.*, 1984). Siluro-Devonian Mathinna Beds crop out on hills 2 km to the west, and 2.5 km to the NNW, where they are overlain by Permian sedimentary rocks.

An east-west line of percussion holes (E1 to E7), passing just north of the anomaly, was drilled by the Anglo American Corporation (Mellor, 1982). East of the river, Mathinna Beds basement was reached at depths of 35–38 m, but west of the river, close to the nose of the anomaly, the holes bottomed in "carbonaceous grey clay, gravel including dolerite boulder beds, and minor conglomerate and lithic sandstone", assigned to the Tertiary system, at depths of up to 50 metres.

All these units are generally non-magnetic and none is considered capable of generating the anomaly. The nearest known magnetic bedrock type is Jurassic dolerite, at the base of Fingal Tier, about 4 km SSE of the anomaly centre. The nearest mapped Tertiary basalt at Beauty Flat, 10 km to the north (Calver *et al.*, 1988) is a strongly magnetic olivine nephelinite (J. L. Everard, unpublished data). Just east of Beauty Flat is a larger area of Tertiary tholeiitic basalt, which was probably erupted at EQ853045, the centre of a small intense magnetic anomaly (Everard, 1987, 1992).

Small areas of Jurassic dolerite talus (Qptd) were mapped within the terrace deposits (Qqa) and are associated, in places, with relatively weak positive magnetic anomalies.

The fact that the anomaly is small and relatively intense implies that it is caused by a strongly magnetic body of limited extent at shallow depth. The negative sign requires that the body possess significant magnetic remanence, acquired during an epoch of reversed geomagnetic polarity; a high susceptibility, merely locally enhancing the magnetic field, would produce a positive anomaly. Dolerite lag or talus is likely to consist of magnetically disoriented

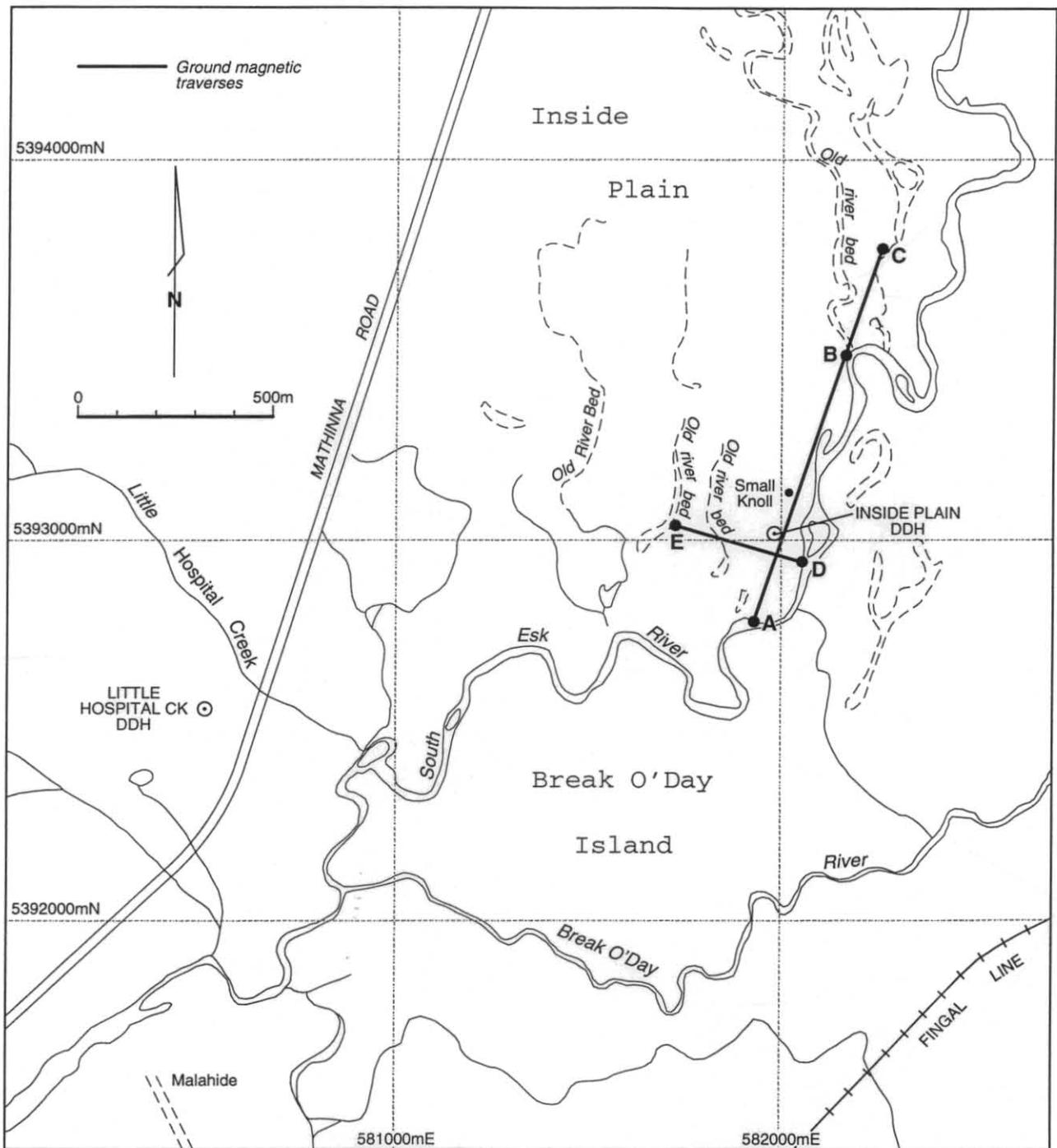
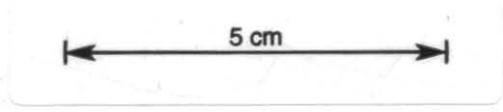


Figure 1
Location of drill hole and ground magnetic traverses



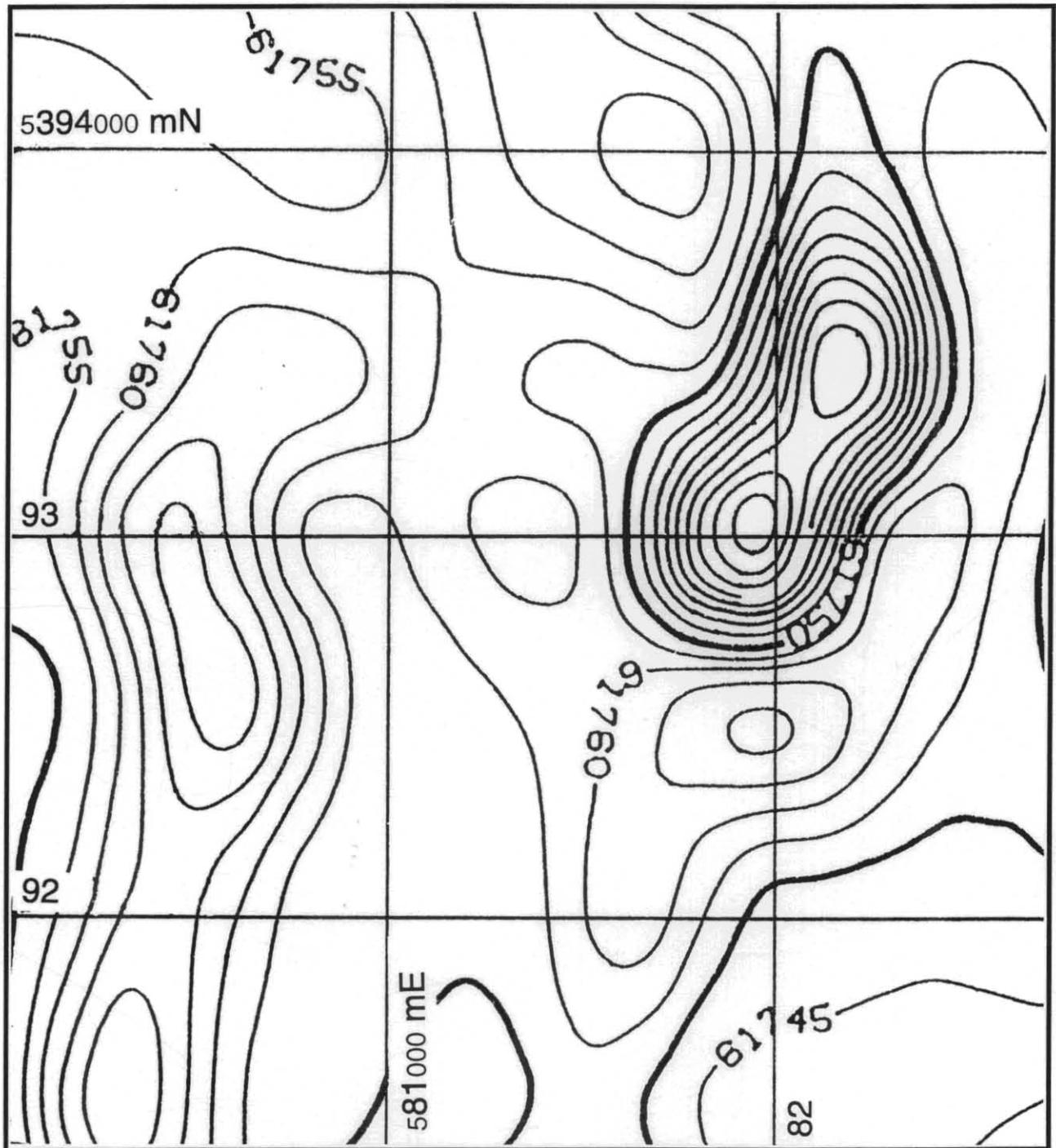


Figure 2

Aeromagnetic contours (5 nT) for area of Figure 1, showing the negative Inside Plain anomaly (right), and the less intense positive anomaly near Little Hospital Creek (left).
 Extract from Department of Mines 1989 survey, northeast Tasmania (plan 5292A).

5 cm

boulders, and is therefore unlikely to possess significant remanence.

It was concluded, therefore, that none of the mapped rock units in the area could account for the anomaly.

GROUND INSPECTION

In January 1990, at a time of low river level, the South Esk River was followed on foot from a bridge on a private road at EP823965, southward past the anomaly to about EP818927. Bedrock exposure was seen in only two localities, both well to the north of the anomaly. At a bend in the river at EP827954, a small outcrop of fine-grained, grey to orange-brown weathering siltstone occurs on the left (east) bank, about 2 m above low water level.

The outcrop displays bedding with strike and dip of $165^{\circ}\text{E}80^{\circ}$ and cleavage at $169^{\circ}\text{W}63^{\circ}$ (true bearings) and is assigned to the Mathinna Beds, which are mapped a short distance to the east on the Ben Lomond map sheet (Calver *et al.*, 1988). About one kilometre to the south, at a similar river bend at EP825947, a cream-to-fawn-coloured mudstone (lutite), cleaved at $165^{\circ}\text{W}60^{\circ}$, forms small cliffs on the left bank, and is overlain by cobble-pebble alluvium of a river terrace. This outcrop, which is not shown on the Ben Lomond map sheet, is also assigned to the Mathinna Beds on lithological and structural grounds.

Quaternary alluvium is well exposed in small, unstable cliffs up to three or four metres high at numerous localities along the river banks. Typically it consists of well-rounded to sub-rounded, ellipsoidal to tabular, subhorizontally aligned cobbles and pebbles (mostly 40–100 mm) of mostly Mathinna Beds lithologies and subordinate vein quartz, in a sandy, sometimes almost lithified matrix, in turn overlain by two to three metres of brown sand and silt.

GROUND MAGNETIC TRAVERSES

To assist in siting the drill hole, a hand-held proton precession magnetometer was used to measure the total magnetic field at ground level, with readings taken approximately every ten metres. Two traverses were measured roughly through the anomaly centre: a NNE-SSW line about 1 km long, and an approximately perpendicular WNW-ESE line of about 350 metres. These were not surveyed, but could be fairly accurately located (± 50 m) on the St Marys 1:25 000 scale topographic map (fig. 1).

The NNE-SSW line (fig. 3) shows a broad, undulating negative magnetic anomaly extending from near EP82199358 southward at least as far as the river bank at EP81939278. The minimum field recorded was 61 645 nT at approximately EP82119335, approximately 230 nT below the average field outside the anomaly.

The WNW-ESE line (fig. 4) shows that the anomaly extends only about 200 m west of the river bank at EP82059294.

DRILLING RESULTS

A vertical diamond-drill hole was sited at EP81989303, about 50 m west of the river bank, 70 m SSW of a low knoll, and 70 m north of the intersection of the two ground

magnetic traverse lines. The hole was drilled in late 1991 by drillers C. Mitchell and L. Newman.

A summary log is:

0 – 0.7 m	Soil, clayey, light brown.
0.7 – 5.5 m	River pebbles, mostly quartzarenite and vein quartz.
5.5 – 8.5 m	Clay and silty clay, pale grey.
8.5 – 11.4 m	Clay and sandy clay, medium grey.
11.4 – 17.5 m	No core except for 150 mm ironstone (?laterite)
17.5 – 34.2 m	Sandy clay and clay, pale grey-green, slightly micaceous, locally almost lithified. Fragments and minor intervals (≤ 15 mm) of coal.
34.2 – 37.2 m	Pebbles and cobbles of quartz arenite, vein quartz and conglomerate.
37.2 – 55.2 m	Conglomerate, clast supported, pebble to boulder-sized clasts of dolerite, quartzarenite and Mathinna Beds lithologies, subordinate vein quartz, rare granitoid, rare basalt.
55.2 – 61.7 m	Basalt, massive or slightly vesicular/amygdaloidal, fine grained.
61.7 – 64.7 m	Basaltic breccia, with about 30% intermixed clayey to silty sediment.
64.7 – 75.0 m	Basalt, as above.
75.0 – 84.2 m	Conglomerate, as above, but with a higher proportion of dolerite clasts, subordinate Mathinna Beds lithologies, basalt, vein quartz.
84.2 – 90.9 m	Mathinna Beds: dominantly lutite; steeply dipping with overturned bedding at about 20° to core axis.
90.9 – 94.4 m	Dominantly arenite.
94.4 – 96.0 m	Dominantly lutite.
96.0 – 106.6 m	Dominantly arenite.
106.6 – 108.8 m	Interbedded lutite and arenite, bedding subhorizontal to 45° to core axis, right way up.

These data are illustrated graphically in Figure 5 and a detailed log is included as Appendix 1.

The bottom of the hole penetrated 25 m into a generally steeply-bedded (in places overturned) and steeply-cleaved sequence of interbedded lutite and arenite. Flame structures, scours and rip-up clasts were noted. On lithological and sedimentological grounds, the sequence undoubtedly belongs to the Middle Palaeozoic quartzwacke turbidite Mathinna Beds, widespread in northeastern Tasmania.

Permo-Triassic rocks were absent in the drill hole, and a probably largely Tertiary sequence about 80 m thick rests directly on the Mathinna Beds basement. The lowermost unit is a 9 m thick interval of clast-supported, pebble, cobble, to boulder-conglomerate, the clast size of which

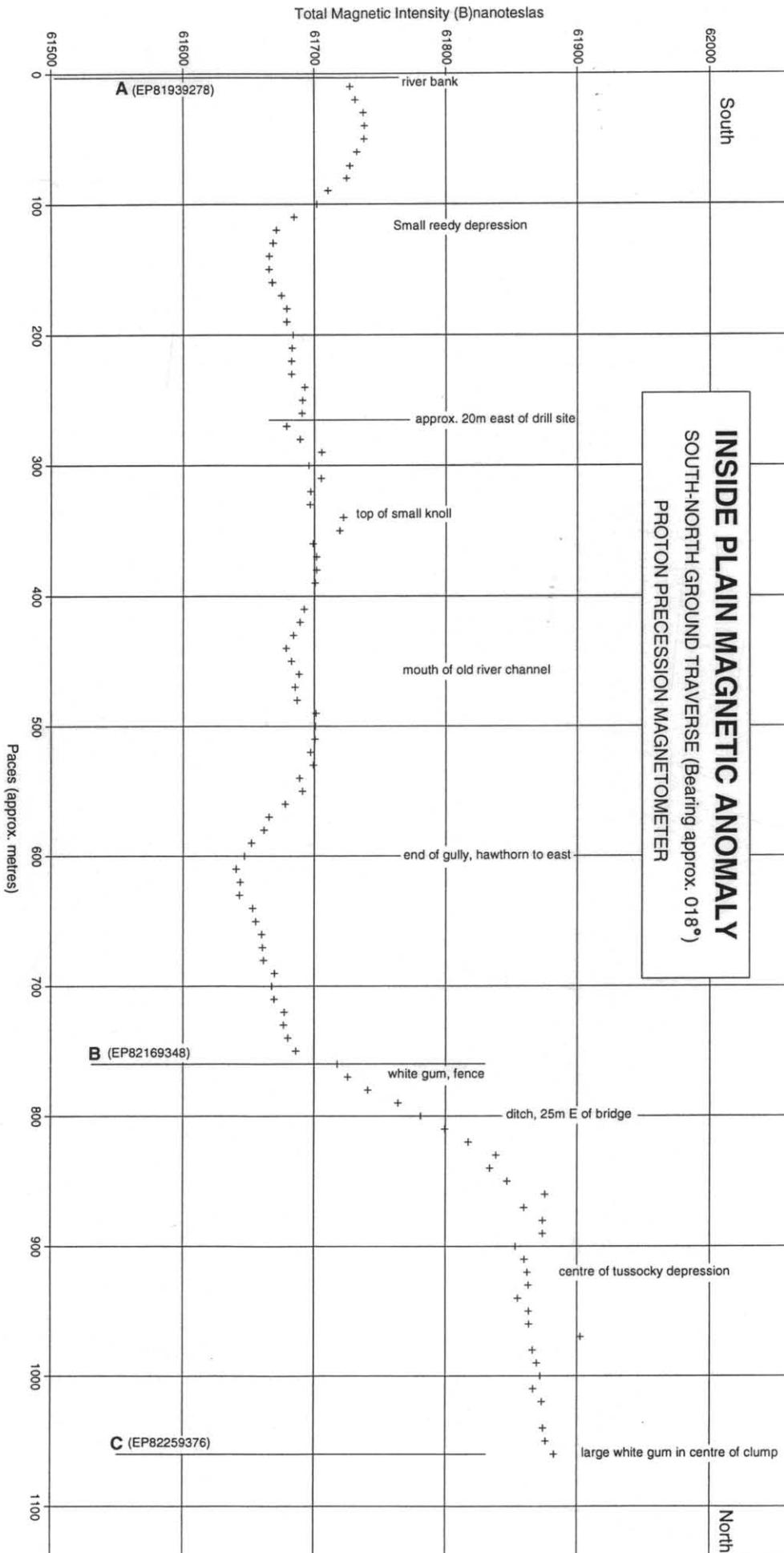


Figure 3

INSIDE PLAIN MAGNETIC ANOMALY
WEST-EAST GROUND TRAVERSE (BEARING APPROX. 105°)
PROTON PRECESSION MAGNETOMETER

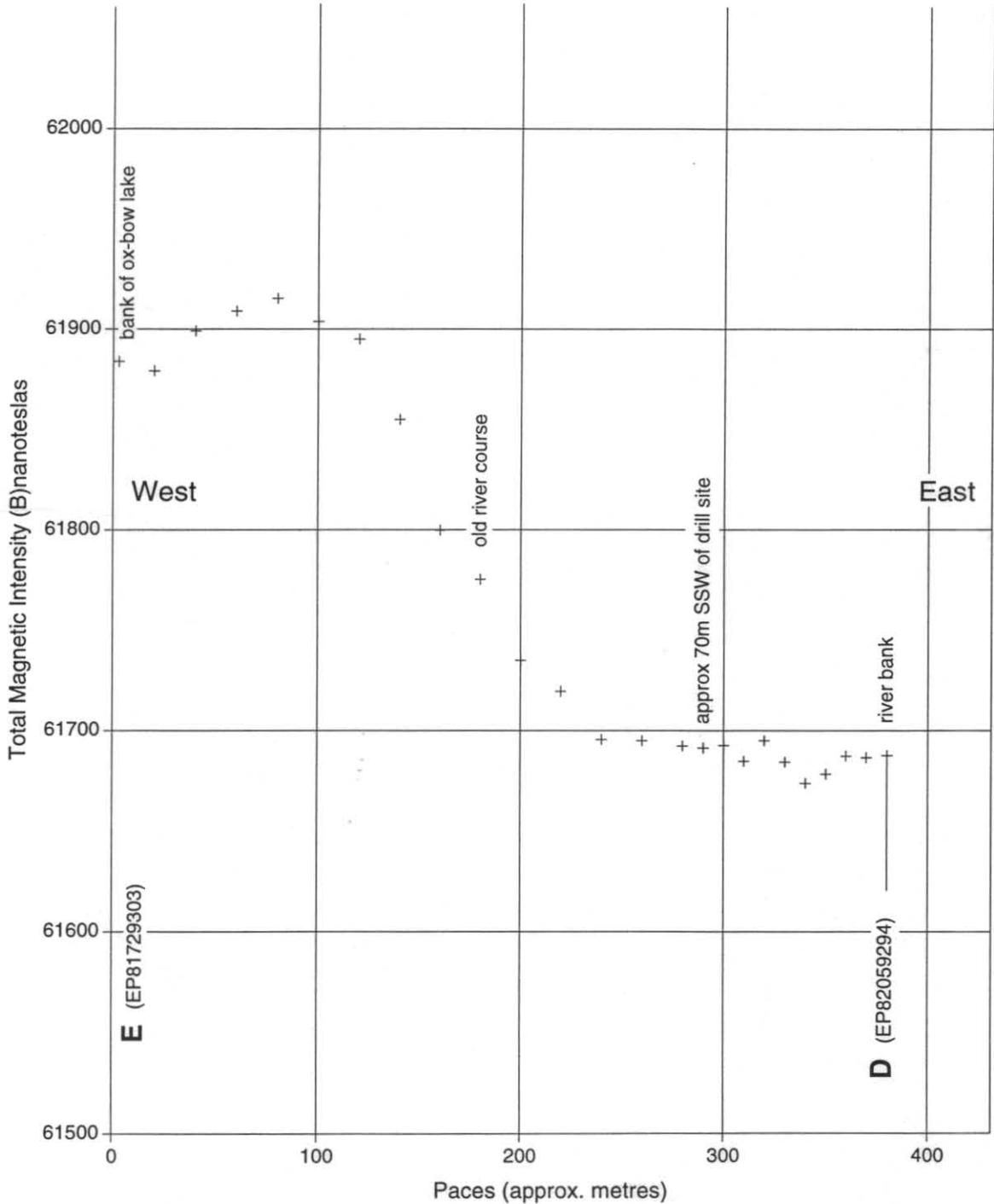
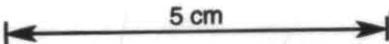
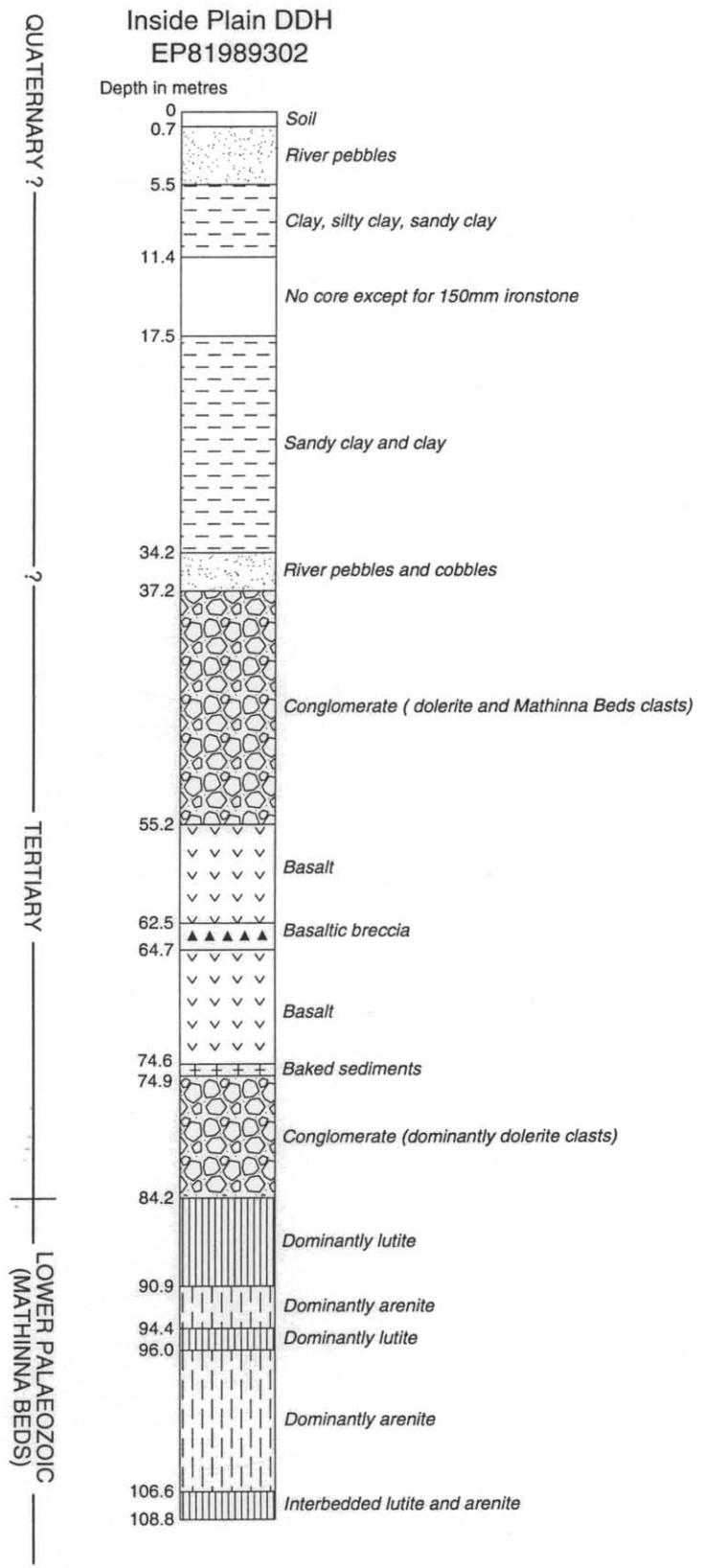


Figure 4





tends to increase upwards. The clasts are generally well-rounded and ellipsoidal, and typically of Jurassic dolerite, with Mathinna Beds lithologies (including vein quartz) subordinate and granitoid and basalt rare. The gritty to sandy, poorly-sorted matrix is probably also largely derived from dolerite. The conglomerate is interpreted as an ancient (post-Jurassic) lithified river gravel deposit.

Overlying the conglomerate is an interval, nearly 20 m thick, of generally massive to sparsely amygdaloidal or vesicular, dark grey, fine-grained basalt. Calcite and zeolite minerals (including finely fibrous white natrolite, identified by x-ray diffraction) line vesicles and fill amygdaloids and veinlets.

Near the middle of the basalt interval is a brecciated zone, about 2.2 m thick, consisting of very irregularly shaped, bulbous to globular clasts and/or lobes of weathered vesicular to amygdaloidal basalt, between which is clayey to silty fine-grained sediment, or void. The breccia has the characteristics of a globular peperite, and is interpreted as the result of interaction between the base of a lava flow and wet unconsolidated sediment, which may have been partly entrained into the flow. This implies that at least two basalt flows have been intersected in the drill hole. However, as the basalt is similar above and below the breccia, and there is no non-peperitised sediment, the time interval between the flows was probably short, with perhaps only thin discontinuous lenses of mud accumulating in pools in depressions in the top surface of the lower flow before being over-ridden by the upper flow.

Petrographically the basalt, both above and below the inferred peperitic breccia, contains abundant euhedral olivine, pinkish titanite and relatively sparse plagioclase with much intersertal glass (Appendix 2). It is a strongly undersaturated rock, probably basanite transitional to olivine nephelinite. Two samples have been submitted for chemical analysis, but results are not yet available.

Overlying the basalt is another interval of conglomerate, about 18 m thick. This is similar to the lower conglomerate interval, apart from containing a higher proportion of Mathinna Beds clasts, which are about as abundant as dolerite clasts. Rare granitoid clasts are also present. Clasts are mostly pebble to cobble sized, with few boulders. This conglomerate is also interpreted as lithified river gravel.

There may be an appreciable non-depositional or erosional break in the sequence at the top of the upper conglomerate unit. Over an interval of about three metres (34.2–37.2 m) core recovery was poor, consisting mainly of loose pebbles of Mathinna Beds, vein quartz and conglomerate, perhaps representing younger, unconsolidated river gravel.

A clay-dominated interval from 5.5–34.2 m corresponds to the carbonaceous grey clay intersected by the Anglo American percussion drilling (Mellor, 1982) and included in the subsurface unit Tc on the Ben Lomond map sheet (Calver *et al.*, 1988). The presence of minor intervals of coal, and probable laterite, suggests a Tertiary age. An abrupt colour change near the top of the interval at about 8.5 m may indicate a break in deposition, or merely be a weathering effect. A low energy depositional environment is likely for the whole of the clay-dominated interval,

which possibly represents overbank deposits on flood plains, riverine marshes and in ox-bow lakes, left by the receding waters of periodic floods. This environment is envisaged to be similar to that of the modern flood plains of the Break O'Day and South Esk rivers.

The topmost 5.5 m of the hole consists mainly of river gravels, similar to those being deposited a few metres away at the present day, and are of probable Quaternary, possibly Holocene, age.

GEOPHYSICAL INTERPRETATION

A hand-held susceptibility data meter was used to obtain magnetic susceptibility data from the core. Results are plotted in Figure 6. Because of the small physical size of the core and its curvature, the numerical results will be consistently lower than the true values by an unknown factor, and should be considered semi-quantitative only. However, it is clear that both the Mathinna Beds basement (average susceptibility 0.19×10^{-3} SI units) and the bulk of the upper clay-dominated interval are essentially non-magnetic. The relatively magnetic units are the lateritic(?) ironstone within the clay-dominated interval, both conglomerate intervals, and the basalt.

The magnetic character of the conglomerate is attributed to the presence of clasts of Jurassic dolerite, which itself typically has a susceptibility of $5\text{--}10 \times 10^{-3}$ SI units. The conglomerate has a rather variable susceptibility, due no doubt to the variable proportions of dolerite and Mathinna Beds clasts, and matrix. It is noteworthy that the lower conglomerate unit, containing a greater proportion of dolerite clasts, has a higher average susceptibility (4.3×10^{-3}) than the upper unit (2.6×10^{-3}). Because the dolerite clasts are highly likely to be magnetically disoriented, the conglomerate is unlikely to possess significant remanence, and therefore cannot account for the negative character of the anomaly. However, a series of less intense, elongate, north-trending positive magnetic anomalies extend along the western side of the South Esk valley north of Fingal for about 13 kilometres. These, although apparent on the 1989 survey, are clearer on the more closely spaced and better controlled aeromagnetic survey flown in 1993 for the NETGOLD project. On the latter survey, these anomalies have a narrow, sinuous, locally branching appearance suggestive of a meandering river system, and are therefore attributed to dolerite-clast conglomerates in Tertiary(?) river channels. Drill holes at Little Hospital Creek [EP80529256] and Pig Road [EP80639832] have proved this interpretation, as discussed briefly by Everard (1994), which will be elaborated upon in a later report.

The possibly lateritic ironstone within the clay-dominated interval, somewhere between 11 and 17 m depth, has a susceptibility of about 2×10^{-3} SI units. Its thickness is poorly constrained due to drilling problems, and only about 150 mm of ironstone core was recovered. The unit is probably too thin to account for the main negative anomaly, and it is doubtful whether such a unit could possess sufficient, negatively-oriented remanence.

The basalt interval, between 55.2 and 75.0 m depth, has an average susceptibility of 3.8×10^{-3} SI units, although very variable. Assuming that extrusion and solidification took place during an epoch of reversed geomagnetic polarity,

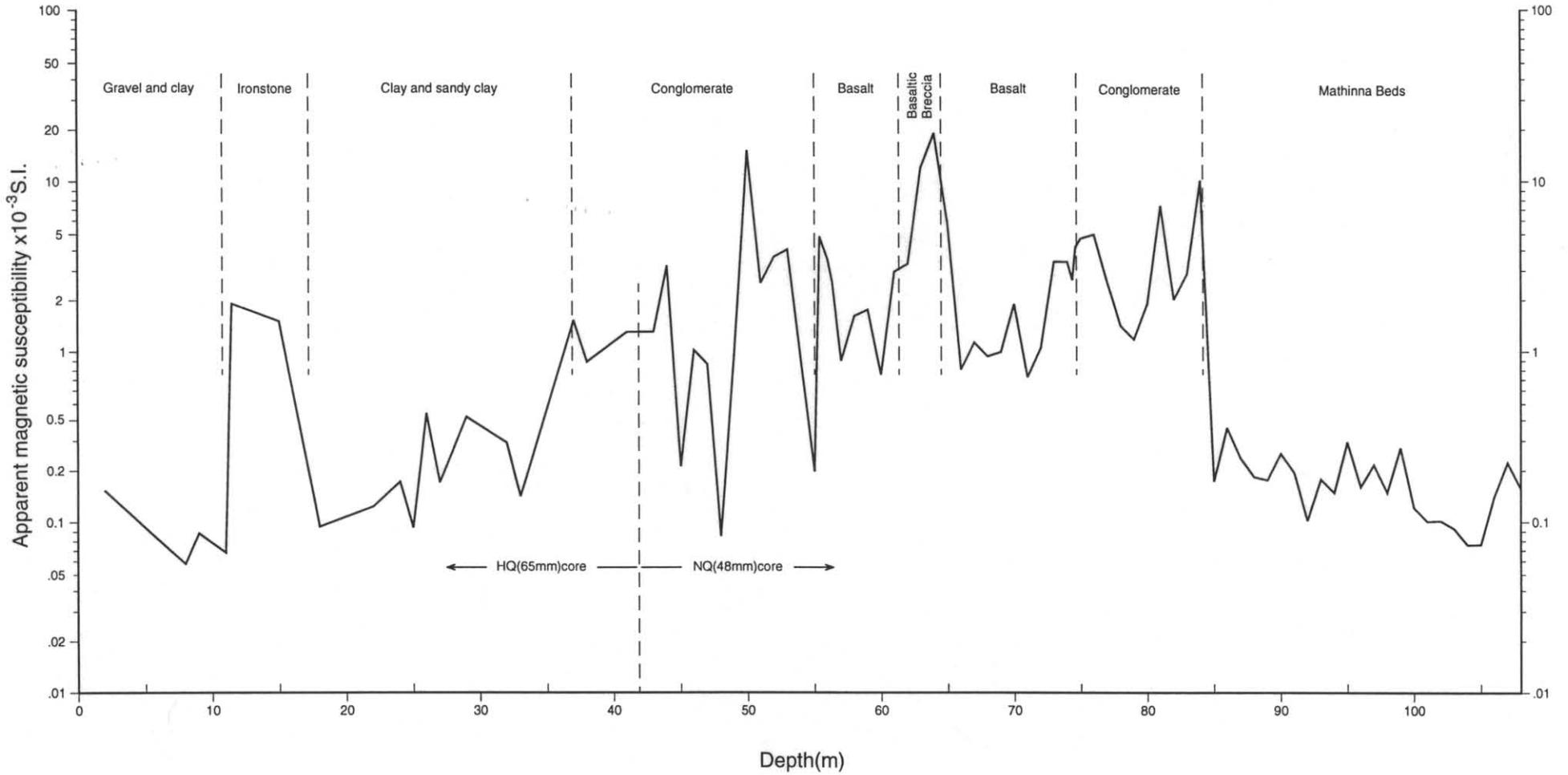


Figure 6. Magnetic susceptibility of core, Inside Plain borehole.

tblb

the basalt could well possess sufficient negative remanence to account for the anomaly, and this is the preferred explanation.

The shape and extent of the anomaly suggests a possible feeder. It is noteworthy that petrographically similar basalt, also accompanied by a negative magnetic anomaly, crops out 10 km to the north, on the left (east) bank of the South Esk River near the old Beauty Flat bridge site (Calver *et al.*, 1988; J. L. Everard, unpublished data). This outcrop may represent the remnant of a flow which extended northward (upstream but at a very low gradient in terms of present topography) from the inferred feeder at Inside Plain.

CONCLUSIONS

If suitable samples can be obtained, palynological dating of the clay-dominated interval and the conglomerate intervals, and radiometric dating of the basalt, could considerably improve our understanding of the timing of post-Jurassic processes and landform development in northeastern Tasmania.

The conglomerate units are thought to represent ancient river gravels and may be worth exploring for fossil placer deposits, particularly of gold.

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[13 July 1994]

APPENDIX 1

Detailed log of hole

0–2.53 m

Recovery only 0.7 metres. Light brown clayey soil, few pebbles. Coarsens towards bottom of interval to a pale orange-brown granule-rich sand, containing well-rounded pebbles (mostly ≤ 50 mm) of tough, silicified (hornfelsed?) quartzarenite.

2.53–5.53 m

Well-rounded to subrounded loose river pebbles (≤ 50 mm), mostly of tough medium-grey quartzarenite, but also subordinate, more angular pebbles of vein quartz. Only a little, pale-brown silty to sandy interstitial material recovered.

5.53–8.53 m

Recovery about 1.5 metres. Pale grey clay, silty in parts.

8.53–11.53 m

Recovery about 1.4 metres. Abrupt change to medium grey clay, in places slightly fissile with suggestion of horizontal bedding (perpendicular to core axis). Some zones of sandy clay with traces of white mica and carbonaceous material. Last 100 mm is massive dense red-brown ironstone (laterite?). Sample for palynology 9.8–11.1 metres.

11.53–14.53 m

No core

14.53–17.53 m

Recovery only 50 mm. Hard, massive, dense red-brown ironstone as above — laterite?

17.53–22.17 m

Pale grey-green, soft, poorly-sorted, slightly micaceous sandy clay, almost lithified to a friable sandstone. Contains occasional black (coalified) woody fragments. Recovery about 1.6 metres. Last 0.6 m of core is mainly grey-green clay with little sandy material, except at base of interval.

22.17–25.17

Pale grey-green, poorly-sorted sandy clay and clay, as above. Recovery about 2.1 metres.

25.17–28.17 m

Nearly complete recovery. Mostly pale grey-green clay and sandy clay, as above. At 25.3 m, impression 8 mm wide of coalified twig. Near 26.7 m is a 50 mm thick interval of fissile to flaky flaser coal, parting horizontal (perpendicular to core axis). At 27.2 m is a 15 mm interval of vitreous black coal. Sample for palynology at 27.2 metres.

28.17–31.17 m

Recovery only 0.7 metres. Pale grey-green clay and sandy to silty clay, as above.

31.17–33.72 m

Recovery only 0.6 metres. Pale grey-green clay, more sandy towards base of interval. Rare coalified woody fragments present.

33.72–34.17 m

Pale grey green sandy clay, as above. Upper part of interval is competent core, lower part is broken.

34.17–37.17 m

Loose pebbles and broken core, recovery about one metre. At top and bottom of interval are well-rounded, tough, (silicified or hornfelsed?) quartzarenite pebbles ≤ 50 mm, and subordinate, generally smaller and more angular pebbles of vein quartz. In middle of interval is about 0.3 m of broken core, including quartzarenite (boulder?) and pebble-cobble conglomerate (see below).

37.17–38.5 m

Conglomerate, clast supported or nearly so. Consists of well rounded pebble sized clasts, < 5 mm to 60 mm or more, in a lithified dark green-brown sandy matrix. Clasts often ellipsoidal to elongate, long axes have a preferred subhorizontal orientation. Clast lithologies include medium-grained dolerite, dark grey cleaved fine-grained sandstone/siltstone or quartzarenite, and vein quartz (generally smaller, more angular). Overall, poorly sorted.

(?)38.5–40.17 m

Only 10–15 well-rounded pebbles of dolerite, siltstone, and vein quartz recovered.

40.17– 42.00 m

Broken core, recovery < 1 metre. Broken pieces of weathered conglomerate, and well-rounded pebbles, as above.

42.00–46.00 m

Recovery nearly 100%, mostly competent core; broken zones 42.1–42.4 m and near 44.7 metres. Conglomerate as above, well lithified. Clast supported. Well-rounded pebble to cobble-sized clasts, some up to 130 mm, mostly 25–50 mm. Clast lithologies include medium to coarse-grained dolerite, tough dark grey siltstone, pale grey-green quartzite, white to pink vein quartz, rare medium-grained granite. Vein quartz fragments generally smaller and more angular; overall clast provenance about equally Jurassic dolerite and Mathinna Beds with only minor granite. Matrix green-brown, gritty, poorly sorted, probably also contains much dolerite-derived material. Voids between clasts common.

Conglomerate coarsens a little below about 45 m to a pebble-cobble clast size.

46.00–48.76 m

Pebble-cobble conglomerate, as above. Notable ellipsoidal clast, 60 × 40 mm, well rounded, of medium-grained granite at 48.0 metres.

48.76–52.06 m

Dominantly cobble-pebble conglomerate, as above. Some intervals (e.g. 50.8–51.1 m) with fewer clasts, supported by a coarse-grained (1–2 mm) ruditic, gritty, green-brown matrix. Some calcite in matrix; e.g. pale brown to off white calcite between dolerite clasts at 51.15 m; narrow (1 mm) calcite veinlets at 50.5 metres.

52.06–53.3 m

Cobble-pebble conglomerate as above. Core broken around 52.5 m with small (<1 mm) sugary quartz crystals lining voids between clasts.

53.3–55.06 m

Conglomerate, weathered. Pale-medium brown-green ('khaki') coloured mostly pebble-sized clasts of weathered dolerite, siltstone (sometimes fairly fresh, grey), rare vein quartz. At 54.1 m is a possible clast of weathered vesicular basalt. Matrix coarsens to a granule conglomerate towards base of interval.

55.06–55.25 m

Granule-pebble conglomerate, clasts mostly 3–30 mm, subrounded, long axes generally subhorizontal, mostly of cleaved siltstone, in dark brown-green matrix.

55.25–56.7 m

Weathered basalt. Dark green to black, greasy lustre, massive or with occasional small (≤ 20 mm) vesicles. Narrow (<1 mm) calcite veinlets present. Core broken near 55.6 m and 56.6 m, otherwise competent. Grades into ...

56.7–58.06 m

Basalt, more or less fresh. Dark grey to black, fine-grained nearly massive, with only sparse, small (≤ 10 mm) amygdaloids filled with greenish clayey alteration products.

58.06–61.07 m

Basalt, as above. Rare amygdaloids.

61.07–61.70 m

Basalt, as above. Near 61.2 m, pale green calcareous veinlet 1 mm wide at 25° to core axis. Calcite veinlet 3 mm wide at high angle to core axis at 61.4 m; also 1 mm wide calcite veinlet at 70° to core axis at 61.6 metres.

61.70–62.45 m

Basalt, as above. Rounded amygdaloids <5 mm locally present, filled with white ?zeolite. Near 62.3 m, irregular 1 mm wide calcite veinlet at about 30° to core axis. Grades into ...

62.45–64.65 m

Basaltic breccia. Weathered dark grey to brownish amygdaloidal to vesicular basalt clasts, between which is pale brown clay or dark green-brown silt. Clasts very irregular in shape; size probably typically 20–100 mm.

Also voids, partially filled with finely acicular growths of white natrolite, around margins of some clasts. Overall, core is about 70% basalt and 30% sediments. Grades to ...

64.65–67.11 m

Basalt, dark grey, massive to sparsely amygdaloidal, with fillings of calcite, zeolite. Large vesicles at 65.2 m, 66.1 m, 66.2 m up to 50 mm across, filled with inward growing, finely acicular natrolite. Scattered veinlets of calcite also present.

67.11–68.04 m

Basalt, as above. Sparse narrow veinlets, amygdaloids and vesicles filled or lined with white zeolite (including fibrous natrolite, identity confirmed by x-ray diffraction).

68.04–70.08 m

Basalt, as above. Fine-grained, dark grey, nearly massive, with sparse small vesicles and amygdaloids (few mm) and narrow veinlets of zeolite.

70.08–74.52 m

Basalt, as above. Nearly completely massive. Sample, 70.8–71.1 m, for petrography and chemical analysis.

74.52–74.65 m

Basalt, weathered, dark grey-brown to black, very fine-grained to glassy. Hackly to cuboidal fracture, greasy lustre. Towards base of interval, dark purplish-grey, slightly vesicular to amygdaloidal, with fillings of carbonate. Possible brecciation present at base of interval. Lower contact at 45° to core axis.

74.65–74.87

Baked sediment, grey-brown to grey-green, tough. X-ray diffraction shows smectite, quartz, calcite, possibly feldspar present. Suggestion of subhorizontal, diffuse, wavy, thin bedding. Lower contact at circa 35° to core axis.

74.87–76.07 m

Conglomerate, cobble-pebble sized well-rounded clasts, clast supported. Clasts 20–200 mm across, mainly dolerite, but some dark grey tough siltstone and pale quartzite, also vein quartz, present particularly in pebble-sized clasts. Some calcite present in gritty matrix, e.g. at 75.7 metres.

76.07–79.07 m

Conglomerate, as above. Probably boulder-sized clasts, as there are intervals of dolerite up to 300 mm. At 76.5 m is a fine-grained black, relatively magnetic clast of probable basalt; also basalt clasts elsewhere. Some smaller pebble-sized clasts of Mathinna Beds lithologies, and vein quartz.

79.07–80.86 m

Conglomerate, as above. Mostly cobble-pebble, some boulder-sized clasts.

80.86–82.07 m

Conglomerate, dominantly cobble to pebble-sized clasts, mainly dolerite, subordinate Mathinna Beds lithologies and vein quartz.

82.07–84.2 m

Conglomerate, as above. Mostly pebble-sized, well rounded clasts of dolerite, but also subordinate Mathinna Beds and vein quartz. At 83.2 m is a subrounded, 50 mm clast of pinkish ?microgranite; at 83.9 m is a fine-grained dark grey clast of probable basalt.

84.2–84.4 m

Broken core. Medium grey, well-cleaved lutite. Mathinna Beds.

84.4–84.97 m

Nearly competent core. Dull grey lutite, probable diffuse bedding at 20° to core axis.

84.97–86.54 m

Dull grey lutite as above. At 85.4 m definite, diffuse but thinly laminated bedding at 20° to core axis. Last 0.5 m of interval is broken core.

86.54–88.00 m

Dull grey lutite as above. At 86.7 m, streaky laminated to flaser bedding at 15° to core axis. At 87.8 m bedding at 20° to core axis.

88.00–90.89 m

Similar dull medium-grey lutite, inter laminated with paler grey fine-grained arenite. At 88.6 m bedding at 20° to core axis, scouring and flame structures indicates overturning. At 90.8 m calcite on joint developed parallel to bedding, at 15° to core axis, scouring indicated overturning; passes down hole to arenite.

90.89–93.07 m

Dull medium grey-green arenite, generally thick bedded. Near 91.6 m, diffuse faint bedding lamination at 30° to core axis. From 91.9 to 92.1 m, some diffusely interlaminated lutite. From 92.1 to 93.07 m, similar dull grey arenite. At 92.9 m, bedding at 25–30° to core axis, contains a few apparent dark grey rip-up clasts of lutite, 10–20 mm.

93.07–93.97 m

Similar dull medium grey-green arenite, with some diffuse lutite laminae. Near 93.6 m bedding at 45° to core axis.

93.97–c.94.4 m

Arenite as above. From 94.25 to 94.6 m is contact with lutite at 10° to core axis.

c.94.4–96.0 m

First lutite bed, about 10 mm thick, is very pale olive green in colour; thereafter lutite is dark grey to dark grey-green,

with diffuse thin, to streaky lamination. Near 95.6 m bedding at 10° to core axis. At 96.0 m passes down into arenite, contact at 15–20° to core axis.

96.0–97.04 m

Dull grey-green arenite. Near 96.5 m some interlaminated lutite, bedding at about 20° to core axis.

97.04–99.42 m

Pale grey-green arenite; hard; faint diffuse lamination, to massive. At 98.3 m contains a 70 mm long, ellipsoidal clast of dark grey lutite, with slightly wavy, sharp margins. Veinlets 0.5–2 mm wide of calcite also present; typically two per metre of core.

99.42–103.08 m

Massive, hard, tough, pale-medium grey-green to grey arenite, as above. Scattered narrow (<1 mm) calcite veinlets present.

103.08–c.105.4 m

Massive arenite as above. Near 103.7 m is suggestion of bedding at 45° to core axis.

c.105.4 m–c.105.8 m

Thinly interlaminated dark grey lutite and paler arenite. Bedding at about 10° to core axis.

c.105.8–c.106.6 m

Massive pale grey-green arenite.

c.106.6–107.5 m

Interlaminated dark lutite and pale arenite; bedding subhorizontal. Near 106.8 m flame structures suggest facing is up hole (right way up). At 108.4 m, bedding at 45° to core axis; another 10 mm thick bed of olive green lutite present.

c.107.5–c.108.5 m

Dominantly massive pale grey to grey-green arenite.

108.5–108.6 m

Interlaminated dark lutite and paler grey arenite. Bedding at 45° to core axis.

108.6–108.80 m

Massive medium-grey arenite; broken lutite in last few centimetres of hole.

END OF HOLE

APPENDIX 2

Petrography of basalt samples

Thin section, depth 70.95 m

The rock consists of mostly euhedral microphenocrysts of olivine, which grade in size downward to an intersertal groundmass of titanaugite, olivine, opaque minerals, relatively minor plagioclase, and much interstitial orange-brown glass.

The olivine microphenocrysts are typically euhedral or sometimes subhedral, equant to elongate polygons typically 300–600 μm across, ranging to stubby laths up to 1.5 mm long. A few larger, equant subhedral to anhedral olivine grains up to 2 mm across are present; these are often deeply embayed and may represent partly resolved xenocrysts.

In the groundmass, olivine occurs as scattered polygonal euhedra, generally 200 μm across. Faintly mauve to pink, very weakly pleochroic titanaugite ranges in size from granules of 20 μm to elongate euhedra up to 300 μm long. Plagioclase, which is less abundant than in most basalts, characteristically occurs as narrow laths, 100–250 μm long and 10–20 μm wide; extinction angles indicate that at least some is as calcic as bytownite (An₈₀). Interstitial glass is abundant, but under high magnification can be resolved into tiny acicular splinters and needles of an opaque mineral and an orange-brown, low birefringence alteration product. An opaque iron-titanium oxide mineral, probably titanomagnetite, is abundantly disseminated through the

groundmass as equant, squarish to polygonal grains, 10–50 μm across.

A small (500 \times 300 μm) crudely ovoid inclusion of a finely crystalline (10–25 μm) mosaic of colourless clinopyroxene and/or olivine is probably the reaction product of a xenocryst or high-pressure phenocryst, possibly of orthopyroxene.

The abundance of olivine and the presence of titanaugite indicate that the rock is an undersaturated basalt with alkaline affinities. The relative paucity of plagioclase suggests that it is a basanite, perhaps transitional to olivine nephelinite.

Thin section, depth 59.3 m

The rock closely resembles the sample from 70.95 m, but is a little more altered. Olivine microphenocrysts are perhaps a little less abundant, and many are partly or wholly altered to a colourless to very pale yellow, fibrous, low birefringence serpentine. A yellow-green fibrous mineral with higher birefringence, possibly anthophyllite, occurs as an intermediate product. The groundmass contains only rare orange-brown glass. In addition to granules of olivine and titanaugite, relatively sparsely distributed plagioclase laths and opaque minerals, there is a poorly crystalline, turbid mesostasis of indeterminate low birefringence material, possibly alkali feldspar and/or nepheline, and finely acicular opaque minerals.