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A re-interpretation of the previous drilling and seismic survey in the western section of the Great Northern Plain, Gladstone

by W. R. Moore

Introduction

This seismic work is a continuation of the investigation undertaken by D. E. Leaman and W. R. Moore in the Great Northern Plain area at the request of the Supervising Geologist, Economic Section.

An east–west seismic traverse was undertaken by Longman in 1967 across the Great Northern Plain from the Ringarooma River to the Cape Portland Road (Longman, 1969). These seismic spreads were fired along a Department of Mines series of percussion holes known as Line 14 (fig. 1).

Leaman (1973) could not reconcile his gravity interpretation of Longman's 1968 gravity survey of the Great Northern Plain with Longman's earlier seismic interpretation along Line 14. Nor would Leaman's gravity interpretation fit with drilling results obtained along this line in 1967, particularly west of BH30 (fig. 1).

As Longman's seismic records were no longer available it was decided to re-fire along part of this drill line where the drilling had reported encountering dolerite and the actual drill holes could be relocated. Four spreads of varying lengths were fired between BH18 and BH30 to try and confirm if the dolerite present in these bore holes was boulders or in situ.

A further spread was fired along the Boobyalla Road between BH2, 3a and 4, a N-S line of percussion bore holes drilled in 1970 (fig. 1). This spread was south of the rotary drill hole and the one spread fired for the Delta mine investigation (Moore and Leaman, 1974).

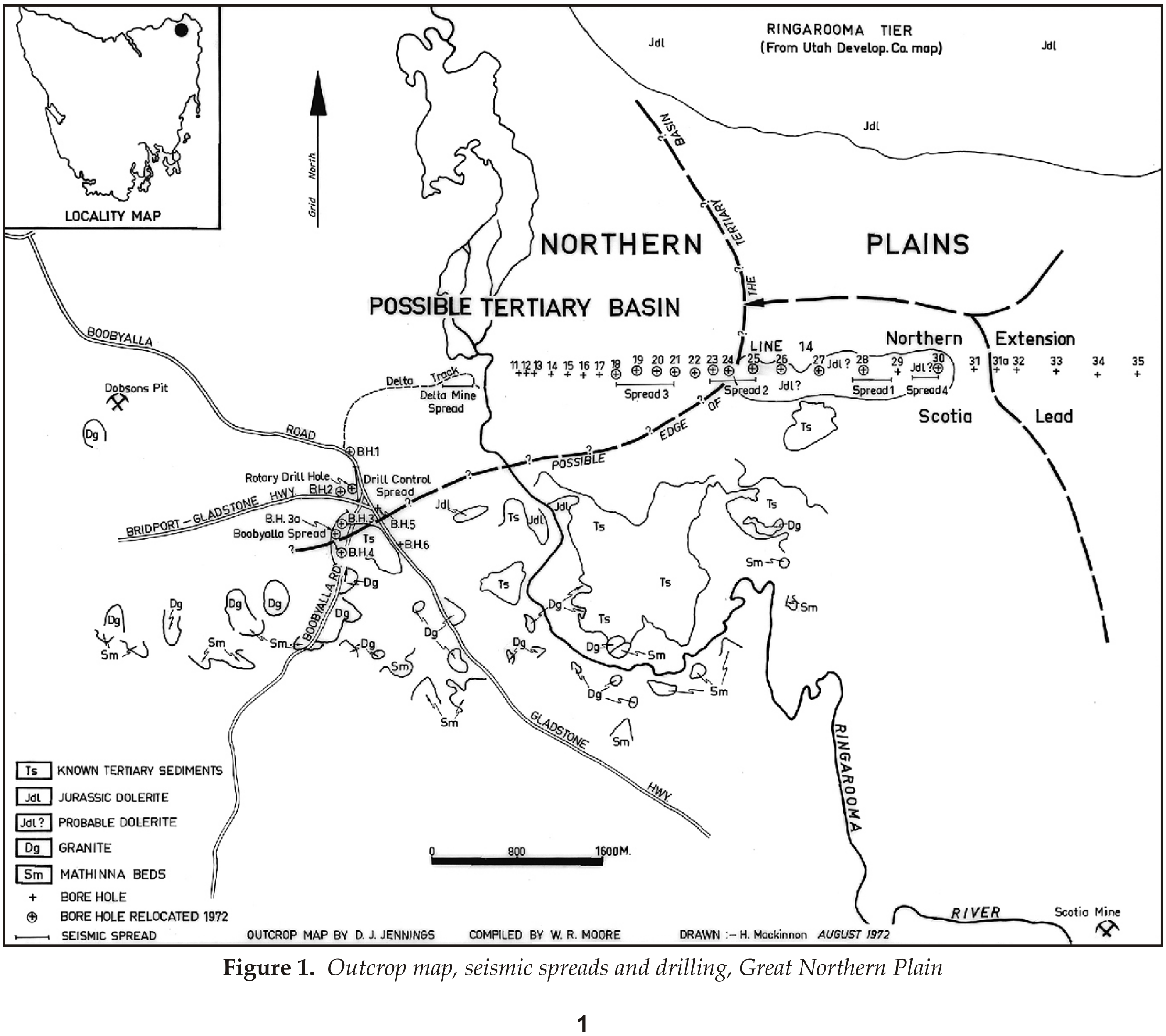


Figure 1. *Outcrop map, seismic spreads and drilling, Great Northern Plain*

Seismic velocities along Line 14

The results shown in Table 1 indicate that there is no great difference in the velocities found in 1972 compared with those in 1967.

Spread 4

Spread 4, the easternmost spread, was immediately west of what Longman considered to be the northern extension of the Scotia Lead. The eastern shot point for Spread 4 was BH30 (fig. 1). The high velocities found in this area indicate the presence of dolerite close to the ground surface. There is a reasonable correlation between the drill results and the calculated interface depths for the surface layer of clay and sand, the intermediate layer of weathered dolerite, and the third layer of unweathered but well jointed dolerite.

Spread 1

Spread 1 was fired at BH28 and recorded similar high velocities to Spread 3. A third layer with velocities of 12,000 to 15,000 feet/second and an intermediate layer with velocities of 5,500 to 7,000 feet/second were present. The surface layer of 2,500 feet/second has a calculated depth of 20–34 feet. Twenty-five feet of sand and clay were encountered above dolerite in BH28 when the hole was drilled.

The intermediate and third layers are interpreted as weathered dolerite and unweathered but well jointed dolerite. The depth of the interface between the second and third layer is calculated at 128 to 150 feet, which is surprisingly deep. This interface has a strong slope to the west, therefore this depth figure is not considered reliable.

Spread 2

Spread 2 was located 3,000 feet west of Spread 1 between BH23 and BH25. This spread produced a different velocity combination to the above two spreads.

From firing in the middle of the spread a surface layer with a velocity of 2,500 feet/second was apparent, with a calculated thickness of 10 to 15 feet. At the western end of the spread an intermediate layer of 5000 to 6000 feet/second overlies a third layer of 8000 feet/second. In contrast, at the eastern end of this spread an intermediate layer of 5000 to 6000 feet/second overlies a third layer with a much faster velocity of 12,500 feet/second. Even when the shot point was extended 650 feet in a westerly direction from the geophone line only a velocity layer of 8000 feet/second persisted with no sign of a 12,500 feet/second velocity. If such a fast velocity of 12,500 feet/second is present at the western end of Spread 2 it must be very deep with a steep slope from the eastern end. Alternatively the faster layer has lensed out between the two ends of the spread.

The correlation between drilling and interface depths are of little use in deciding which of the above explanations is correct. The velocity curves are so symmetrical that only the critical distance formulae can be used for each end of the spread, and this method is considered unreliable.

It should be noted that Longman has stopped his 12,500 feet/second layer in the region of Spread 2 between BH23 and BH24 and he shows no higher velocities than 7,000 feet/second west of this point (fig. 2). A difference of geological interpretation between that of Longman and the writer occurs west of BH24.

Spread 3

Spread 3 was the longest spread fired and was located between BH18 and BH21. Even though the shot point was extended out 1,050 feet in a westerly direction no fast layer was reached. All the shots fired in this spread gave constant velocities of 5,000 to 7,000 feet/second.

Longman's two deep lead interpretation for the western half of Line 14

Longman (1969) explained the absence of any high velocities west of BH24 as the result of deep weathering in dolerite basement. After completing his seismic traverse across the Great Northern Plain, Longman fired two extra, very long spreads between BH13 and BH18 to obtain further information about 'dolerite basement'.

Each of these spreads covered a distance of 2300 feet and the highest velocity that appears to have been recorded was 7000 feet/second. This V_2 velocity layer only appeared between BH15 and BH16 at a calculated depth of 150 feet. If the 7000 feet/second velocity layer is weathered dolerite then its depth must be considerable between BH15 and BH16, as well as between BH18 and BH24.

The absence of the 7000 feet/second V_2 layer between BH13–15 and BH16–8 was explained by Longman as being due to the presence of two deep leads separated by a dolerite basement high between BH15 and BH16. These two western leads were separated from the Scotia lead by the existence of another, more extensive dolerite basement high between BH19 and BH30 (fig. 2). This explanation was forced upon Longman by the drilling reports of dolerite being encountered in nearly all the drill holes east of BH19 to BH30.

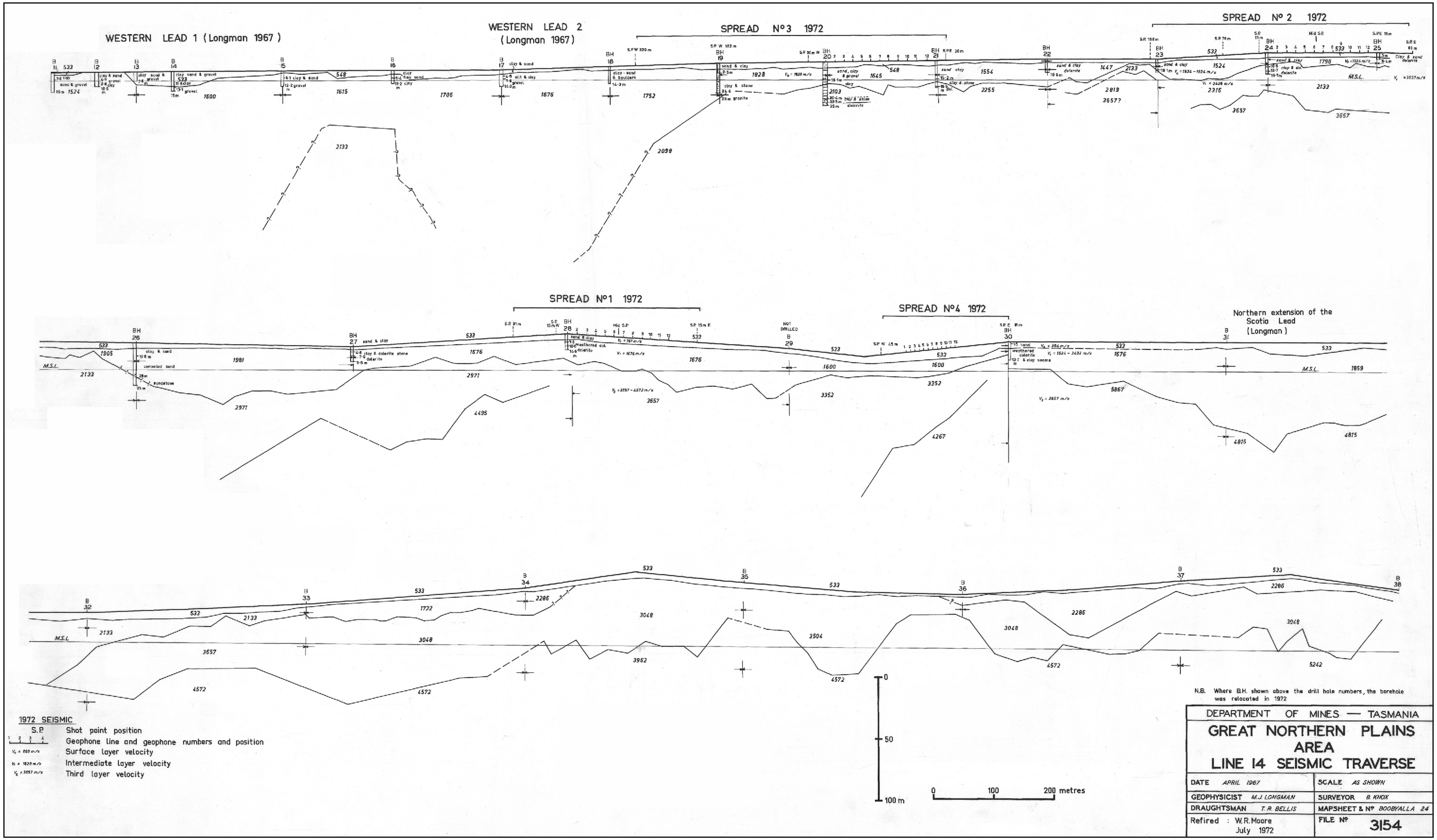


Figure 2

Seismic interpretation of Longman (1969)

Boobyalla Road seismic and drilling results

At the junction of Boobyalla Road and the Gladstone–Bridport (Waterhouse) road the Department's rotary drill penetrated 1000 feet of what appears to be Tertiary sediments without bottoming. Leaman estimates from reflection seismic shots fired in this drill hole that there is a minimum thickness of 550 to 610 metres (1800 to 2010 feet) and a possible maximum of 1100 metres (3610 feet) of sediments at this locality.

From the rotary drill chips and the driller's logs the sediments appear to be the same in the rotary drill hole as those in the series of percussion holes drilled along Boobyalla Road (Table 2).These sediments appear to be clay with a high percentage of boulders of dolerite, Mathinna slate, greywacke sandstone and quartzite plus possible aplite and Permian sandstone. No definite granite chips have been found to date.

A seismic spread fired at the rotary drill site gave very high constant velocities, with V_0 of 6000 to 8000 feet/second for the above sediments. Similar velocities were recorded at the Delta mine one mile to the northeast (Table 2).

The seismic spread fired between BH3 and BH4 on Boobyalla Road gave different velocity layers at either end of the spread. At the southern end a surface layer of 6000 feet/second overlay a second layer of 12,000 feet/second. The calculated depth of this interface is 86 to 90 feet, a depth which approximates closely to the Tertiary/granite contact in BH4 which bottomed in granite from 97 to 112 feet (fig. 3).

At the northern end of the spread only a surface layer of 6000 feet/second was recorded even though the shot point was extended north near the southern shot point of the rotary drill spread. This end of the spread appears to be underlain by a very thick layer of Tertiary boulder sediments, with a very steep slope on the southern margin of this Tertiary basin along Boobyalla Road.

Geological interpretation of the Boobyalla Road area

The Bouguer anomaly contours, the drilling and refraction seismic survey all indicate that the margin of the Tertiary basin is very steep at this locality. The most simple geological explanation is that the granite is faulted upwards and the slope is a fault scarp. It appears likely that similar fault scarps border the basin, making it a narrow wedge-shaped down-faulted block or trough. This trough was continuously filled with coarse boulder material as the trough deepened intermittently but continuously over an unknown period of Tertiary time. This theory offers no explanation for the apparent lack of any granite boulders in these sediments unless the granite was not then exposed. This appears difficult to visualise with the close proximity of the Mount Cameron granite block to the south.

Alternative interpretation for the western half of Line 14

If it is accepted that the type of Tertiary sediments with velocities extending from 5000 to 8000 feet/second in the Boobyalla Road area may extend to Line 14, all the 7000 feet/second layer of Longman's seismic traverse may be either Tertiary sediment or weathered dolerite. The presence of dolerite can only be presumed seismically by the existence of a deeper layer with a higher velocity (12,000 feet/second).

It appears very likely that all of Line 14 west of BH24 is part of the same trough found west of the Ringarooma River. No dolerite basement is present in the western half of Line 14 and no two leads have been cut into this basement as interpreted by Longman. The 1967 drilling in BH20, 21 and 22 does not appear to have bottomed in dolerite boulders.

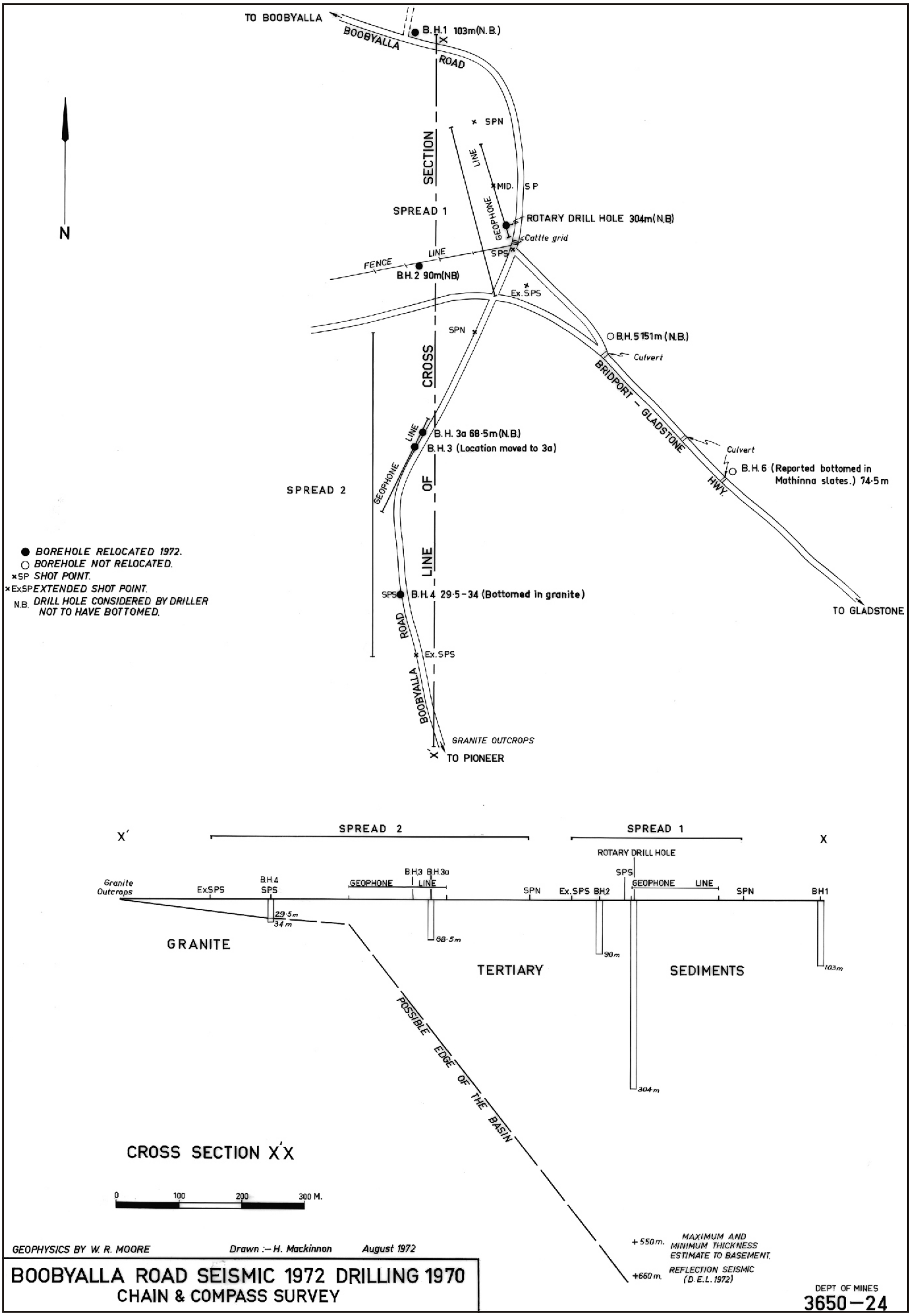
In situ dolerite occurs only west of BH24 to BH30 as indicated by the presence of the faster 12,000 feet/second velocity layer. This dolerite is possibly only a thin sheet with an irregular outline because in Spread 1 at BH28 this fast layer has a significant slope to the west. Longman's high velocity layer also cuts out at BH26 which is reported to have bottomed in sandstone from 95 to 115 feet.

The above interpretation (fig. 4) allows for a closer correlation of the seismic, gravity and magnetic profiles than Longman's interpretation. (See also Appendix 1).

The Scotia Lead

The dolerite between BH24 and BH30 appears to separate the Tertiary basin in the western section of Line 14 from the Scotia lead found between BH30 and BH33 (fig. 1). If this dolerite is an isolated mass and not connected to the extensive areas of dolerite known to outcrop to the north, then the Scotia lead may swing to an east–west direction between these two dolerite masses. The Scotia lead would then drain from an east and south-easterly direction into the Tertiary trough of the western half of Line 14. This east–west lead would account for the east–west indent of the Bouguer anomaly contours in this area (Leaman, 1973). Another lead may join this east–west extension of the Scotia lead from the north-east.

Such a lead pattern appears to explain the gravity and magnetic low pattern of Leaman as well as offering an explanation for the presence of Tertiary sediments with high tin values found by drilling north and northwest of the northern extension of the Scotia lead at Line 14.



TO BOOBYALLA
B.H.1 103m(N.B.)
BOOBYALLA ROAD
X
N
SECTION
SPN
LINE
MID. SP
GEOPHONE
ROTARY DRILL HOLE 304m(N.B)
Cattle grid
SPREAD 1
FENCE LINE
SPS
B.H.2 90m(NB)
Ex.SPS
SPN
CROSS
B.H.5 151m (N.B.)
Culvert
BRIDPORT - GLADSTONE HWY.
B.H. 3a 68·5m(N.B.)
B.H.3 (Location moved to 3a)
LINE
GEOPHONE
Culvert
B.H.6 (Reported bottomed in Mathinna slates.) 74·5m
SPREAD 2
OF
LINE
● BOREHOLE RELOCATED 1972.
○ BOREHOLE NOT RELOCATED.
×SP SHOT POINT.
×ExSP EXTENDED SHOT POINT.
N.B. DRILL HOLE CONSIDERED BY DRILLER NOT TO HAVE BOTTOMED.
SPS
B.H.4 29·5-34 (Bottomed in granite)
TO GLADSTONE
ROAD
Ex.SPS
BOOBYALLA
GRANITE OUTCROPS
X'
TO PIONEER
X'
SPREAD 2
SPREAD 1
X
ROTARY DRILL HOLE
Granite Outcrops
ExSPS
B.H.4 SPS
GEOPHONE
B.H.3 B.H.3a LINE
SPN
Ex.SPS
BH2
SPS
GEOPHONE
LINE
SPN
BH1
29·5m
34m
58·5m
90m
103m
304m
GRANITE
TERTIARY
SEDIMENTS
POSSIBLE EDGE OF THE BASIN
CROSS SECTION X'X
0 100 200 300 M.
+550m. MAXIMUM AND MINIMUM THICKNESS ESTIMATE TO BASEMENT.
+660m. REFLECTION SEISMIC (D.E.L. 1972)
GEOPHYSICS BY W. R. MOORE
Drawn :- H. Mackinnon
August 1972
BOOBYALLA ROAD SEISMIC 1972 DRILLING 1970
CHAIN & COMPASS SURVEY
DEPT OF MINES
3650-24

Figure 3

Further exploration recommendations

The writer considers that an attempt must be made to obtain core of the high velocity Tertiary sediments existing in the Boobyalla Road area before any further exploration is undertaken. Rotary drill chips are a most unsatisfactory method of logging such a drill hole with such jagged and unstable sides. The contamination from higher levels is considered to have been very high and almost continuous in this hole.

Coring with the rotary plant was not attempted because the constant jarring associated with drilling boulders in clay and the high mud pressures maintained on the bit would have made recovery of any core unlikely.

As the percussion plants have been unable to penetrate those sediments it is recommended that a heavy diamond drill be used to drill a hole to basement in the centre of the gravity basin. A further hole should be drilled near BH24 on Line 14.

Three or four north–south magnetometer traverses with stations at ten feet intervals should be undertaken from the Dorset Dredge road across the dolerite between BH24 and BH30 to the dolerite ridge to the north.

A north–south seismic traverse should be run along one of these magnetometer traverses.

References

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[26 July 1972]

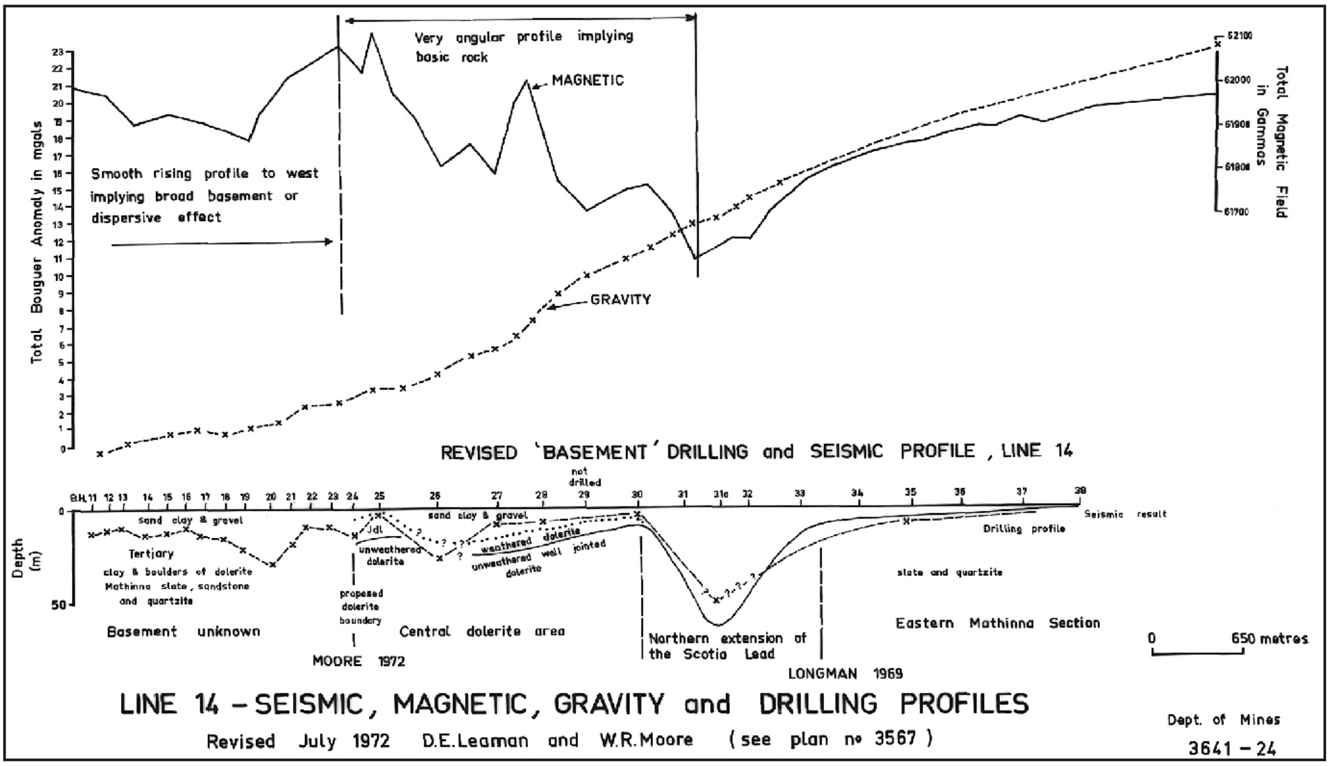

Figure 4

Table 1

Seismic spreads, Line 14

Location	Length (ft)	Geophone spacing (ft)	Velocity (ft/sec) (1967)	Velocity (ft/sec) (1972)	Calculated depth to interface (feet)	Geological interpretation (1972)	Drilling control 1967		
Spread 1									
BH28	950	50	V_0 – 1750	V_0 – 2500	20–34	V_0 – Sand and clay	BH28	0' – 25'	Sand and clay
			V_1 – 5500	V_1 – 5500–7000	128–150	V_1 – Weathered dolerite		25' – 35'	Weathered dolerite
			V_2 – 9750–12,000	V_2 – 12,000–15,000	Slope to the west	V_2 – Unweathered dolerite		35' – 48'	Dolerite & dolerite boulders
			V_3 – 14,750						
Spread 2									
BH23–25	1400	50	V_0 – 1750	V_0 – 2500	10–15	V_0 – Surface sand and clay	BH23	0' – 30'	Sand and clay
			V_1 – 5000–5900	V_1 – 5000–6000		V_1 – Tertiary clay and sand (west end)	BH24	0' – 35'	Sand and clay
			V_2 – 7000–7600	V_2 – 8000 (west end)	west end 82'	V_1 – Weathered dolerite (east end)		35' – 45'	Clay and dolerite
			V_3 – 12,000	V_2 – 12,500 (east end)	east end 57'	V_2 – Tertiary boulders (west end)		45' – 55'	Dolerite
						V_2 – Unweathered well jointed dolerite	BH25	3' – 12'	Dolerite
Spread 3									
BH19–21	1650	50	V_0 – 1800	V_0 – 6000–7000	No interface to basement reached	V_0 – Tertiary sand, clay and boulder beds	BH19	0' – 28'	Sand, clay and gravel
			V_1 – 5400–6000					28' – 79'	Clay & decomposed stone
			V_2 – 6900				BH20	0' – 53'	Sand, clay and gravel
								53' – 100'	Clay
								100' – 110'	Clay and stone
								110' – 115'	Dolerite
							BH21	0' – 50'	Sand, clay and gravel
								50' – 63'	Clay and stone
								63' – 64'	Dolerite
Spread 4									
BH30	700	25	V_0 – 750	V_0 – 1000		V_0 – Sand and clay	BH30	0' – 3'	Sand and clay
			V_1 – 5250–5500	V_1 – 5000–7000	10'–12'	V_1 – Weathered dolerite		3' – 25'	Weathered dolerite
			V_2 – 10,000	V_2 – 12,000	49'–52'	V_2 – Jointed dolerite		25' –45'	Dolerite with clay seams
			V_3 – 14,000–19,250						

Drilling control from K. Harper drilling records, Department of Mines, 1967

Table 2

Seismic spreads, Boobyalla Road and Delta mine

Location	Length (ft)	Geophone spacing (ft)	Velocity (ft/sec)	Calculated depth to interface (feet)	Geological interpretation	Drilling control 1970		
Delta mine spread								
Delta mine	1175	25	V_0 – 5000–6000		V_0 Tertiary sand, clay and boulders	None		
	(E–W)		V_1 – 8000	85–102	V_1 Tertiary boulder beds			
			V_2 – 16,000	140–160	V_2 Granite			
Spread 1 (control spread on the deep drill hole)								
Boobyalla Road BH2	1050	50	V_0 – 1000–3000		V_0 Grey sand and soil	BH2	0 – 4	Sand
& rotary drill hole	(N–S)		V_1 – 6000–8000	6–8	V_1 Tertiary boulder beds		4 – 50	Clay and broken stone
							50 – 70	Dolerite and clay
							70 – 120	Stone, slate & clay bands
							120 –195	Dolerite and clay bands
							195 – 220	Gravel, clay and stone
							220 – 287	Mainly slate
							287 – 295	Quartzite
						Rotary drill hole	0– 1000	Boulders of dolerite, slate, sandstone, vein quartz and possible aplite
Spread 2								
Boobyalla Road	1750	50	V_0 – 6000 (south end)	86–90 (south end)	V_0 Sand, clay and gravel	BH3a	0 – 3	Sand
BH3a and BH4	(N–S)		V_1 – 10,000–12,000		V_1 Granite (south end)		3 – 20	Clay and stone
			V_0 – 7000 (north end)	Interface not reached	V_0 Tertiary boulder bed (north end)		20 – 45	Clay and quartzite
							45 – 135	Gravel beds & quartzite
							135 – 180	Mainly quartzite
							180 – 225	Mainly clay & quartzite
						BH4	0 – 10	Clay and quartzite gravel
							10 – 65	Clay seams & quartzite
							65 – 77	Clay
							77 – 97	Quartzite
							97 – 112	Granite

Drilling control from K. Harper drilling records, Department of Mines, 1970
South end of Spread 2 calculated on critical distance formula

APPENDIX I

As outlined earlier in this report further seismic refraction work in the region of Line 14 (see also Longman, 1969 and Leaman, 1973) confirms the deductions of Leaman (1973) that the apparent double lead at the west end of Line 14 (Longman, 1969) is in fact part of a boulder-filled fault block and the slightly higher velocity quoted in the earlier report on the supposed interfluves is within the velocity range for the Tertiary materials (see Moore, above; Moore and Leaman, 1974). In view of the revised seismic results it appears certain that only boulders were encountered in the drilling of holes 15 to 24.

These observations also reinforce the presumptions of Leaman (1973) that there was less dolerite present than appeared from Longman's original seismic survey and the drilling. Figure 3 presents the revised interpretation of the three methods used in the area (compare figures, Leaman, 1973). The angular portion of the magnetic profile is due to dolerite at shallow depth and the subdued rising anomaly to the west is related to the dolerite boulders in a clay matrix which occupy much of the fault trough. Until this year the Tertiary sediments were believed to be clay and consequently the magnetic profile was anomalous west of borehole 22.

The gravity profile is not yet completely explained in its overall shape and the inference must be that the Tertiary trough wraps around the dolerite outlier revealed between boreholes 24 and 31. The original gravity interpretation used a density contrast of -0.60 g/cm^3 for the Tertiary materials. This presumed clays. The boulder bed present would have a contrast of not more than -0.45 g/cm^3 and the basin would therefore be some 200 metres deeper than estimated.

Thus rechecking of the seismic profile and further work has explained two of the three enigmas noted by Leaman (1973). Further work should be undertaken north and south of Line 14 in the region of boreholes 26 and 27.

[D. E. Leaman]