

TR17-88-98

17. Further geophysical work, Gladstone.

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At the request of the Supervising Geologist, Economic Section, a further seismic survey of the western section of the Northern Plains, Gladstone was undertaken.

PART 1. REFRACTION AND REFLECTION SEISMIC SURVEY OF THE DELTA MINE AREA

One reflection and two refraction spreads were fired near the Ringarooma River, 9.5 km north-west of Gladstone. One refraction spread was located at the Delta tin mine and a refraction and reflection spread was located at a stratigraphic drill hole near the junction of the Port Boobyalla Road and the Gladstone-Bridport Highway (fig. 22).

The stratigraphic drill hole was sited on the margins of a gravity basin extending over much of the Ringarooma and Boobyalla River delta areas (Leaman, 1973). At completion of drilling 304 m of Tertiary gravel and boulder beds with a small percentage of clay had been penetrated. The drill logs indicated that the boulders were composed of dolerite, slate and sandstone. The refraction spread using the drill hole as a seismic velocity control consisted of twelve geophones, 15 m apart, laid in a N-S direction parallel with Port Boobyalla Road (fig. 22). The southern end of the geophone line was located near the drill hole. Shots were fired 61 m to the north, 91 m to the south and at the mid-point of the geophone line. A weathering spread of 24 m was also fired.

The reflection spread consisted of geophones placed in pairs at 45, 60, 75, 90 and 105 m from the bore hole using a Geospace GT2A refraction unit and 14 Hz geophones. This equipment is not well suited to reflection work and has no automatic gain control or filtering; sufficient recording time is gained by adjustment of the motor mechanism. Shots were fired in the bore hole, but unfortunately thick mud in the hole allowed only shallow shots, the deepest being 15 m.

The Delta mine is located approximately 1.5 km to the north-east of the drill hole towards the centre of the gravity basin, yet is credited with bottoming on dolerite when production ceased in 1938. Since production began in 1934, 16.3 t of tin had been sluiced from the mine (Department of Mines records). The old mine extends in a narrow shallow irregular open-cut some 198 m into the bank of the terrace which is 4-6 m above the flood plain of the Ringarooma River.

The geophone line was laid in an approximate E-W direction on the floor of the mine with a geophone spacing of 7.5 m. Shots were fired 15 m west below the working face of the old mine, in the middle of the geophone line and 91 m to the east, at the end of the tail race cut. Two further shots were fired at distances of 61 m and 183 m from the geophone line at the western end of the river terrace in an attempt to elucidate any fast horizon that might be present at depth.

INTERPRETATION

*Drill hole refraction spread*

In the bore hole spread, a constant velocity of 1800-2400 m/s was found on all shots fired. This velocity is very high for Tertiary sediments but appears to confirm the driller's opinion that the sediments are very tight

gravels composed of very large interlocking boulders and cobbles with little or no sand present. The clay present forms a packing between the boulders in the gravel and is not a separate horizon. This type of sediment makes drilling very difficult even with a heavy rotary plant and almost impossible for light percussion rigs with 5-6 inch tools used by the Department of Mines and mining companies previously in this region.

#### *Weathering spread*

In the weathering spread a surface layer 1.8-2.4 m in thickness with a velocity of 300-900 m/s overlies a second layer with a velocity of 1500 m/s which increased to 2400 m/s. The upper layer is thought to be the grey superficial sands and soils overlying the Tertiary sediments.

#### *Reflection spread*

In the reflection spread a definite reflection was recorded at 900 m/s. It is not possible to give a definite value for the vertical component of the velocity as no deep shots were fired. Shallow tests show it to be in excess of 1200-1400 m/s but such tests could be influenced by the weathering layers. From the results it can be concluded that the depth to the basement is a minimum of about 550-610 m and a maximum of 1100 m.

#### *Delta mine spread*

The results from the spread fired at the Delta mine indicate a continuous surface layer with a seismic velocity of 1500-1800 m/s. This layer may overlie a  $V_1$  layer with a seismic velocity of 2400 m/s. In all shots fired at the eastern end of the spread the nearest two or three geophones recorded seismic velocities of 2400 m/s, whereas velocities of 1800 m/s were recorded from the remaining geophones. The geophones which recorded the higher velocities may be fast geophones situated above slightly faster material in the upper layer rather than a continuous second layer. If the second layer is present, the depth to the velocity layer interface is calculated to be 26-31 m.

Only from the shot fired on the eastern end of the spread, with a shot point distance of 91 m, was a high velocity third layer of 4200 m/s recorded. This third velocity layer was not reached at a western shot point distance of 61 m or even when the shot point was extended to 183 m. It can only be concluded that this fast layer has a considerable slope to the west and its depth, from this limited information is calculated to be 42-48 m.

The seismic spread at the Delta mine suggests that there is little evidence of dolerite forming the floor of the mine. If there is any true dolerite outcrop, rather than derived boulders, it must be very deeply weathered to depths of the order of 30-45 m to give 1800 m/s and 2400 m/s velocity layers. The third velocity layer with a velocity of 4200 m/s can also be considered low for unweathered dolerite.

The velocities recorded at the Delta mine spread appear more likely to represent those materials found at the control spread at the drill site, both the 1800 m/s and 2400 m/s velocity layers being Tertiary sediments. The higher velocity layer corresponds to the compact gravels and dolerite boulders found at the drill site. The deeper material present at the eastern end of the Delta mine spread, with a 4200 m/s velocity, appears more likely to be granite rather than dolerite.

# REFRACTION SEISMIC SURVEY DELTA MINE - GLADSTONE

0 10 20 30 KM

Fired & Calculated May 1971  
Drilled March May 1972

GEOLOGIST : W.R. MOORE  
Drawn : P.J. Donnelly

MINES DEPT DRILL NO. 14

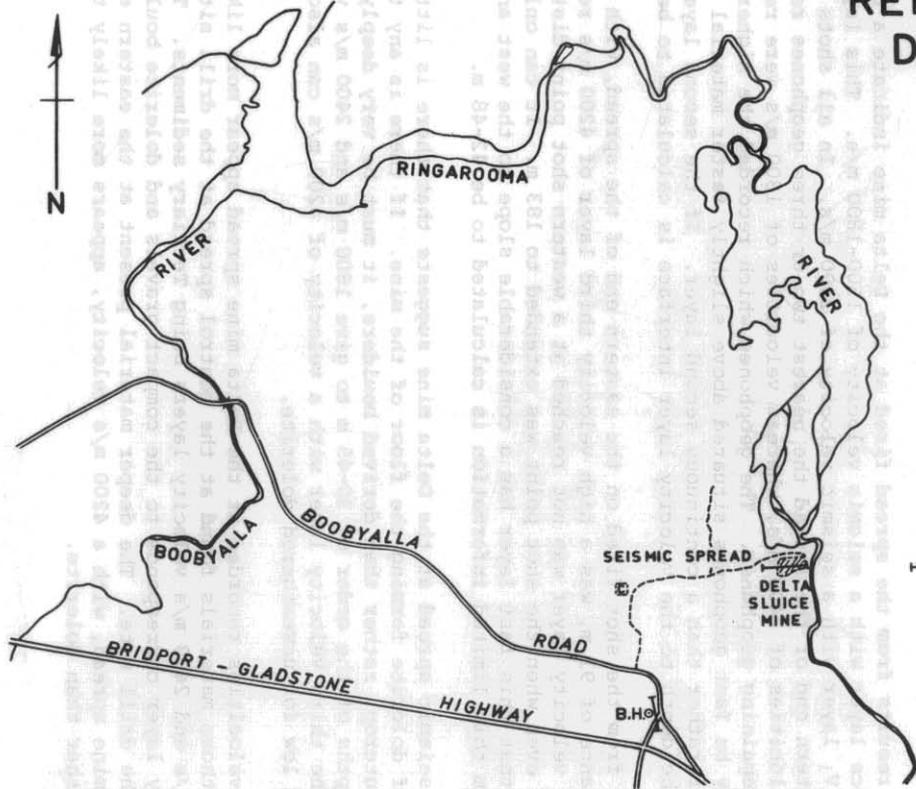


Figure 22.

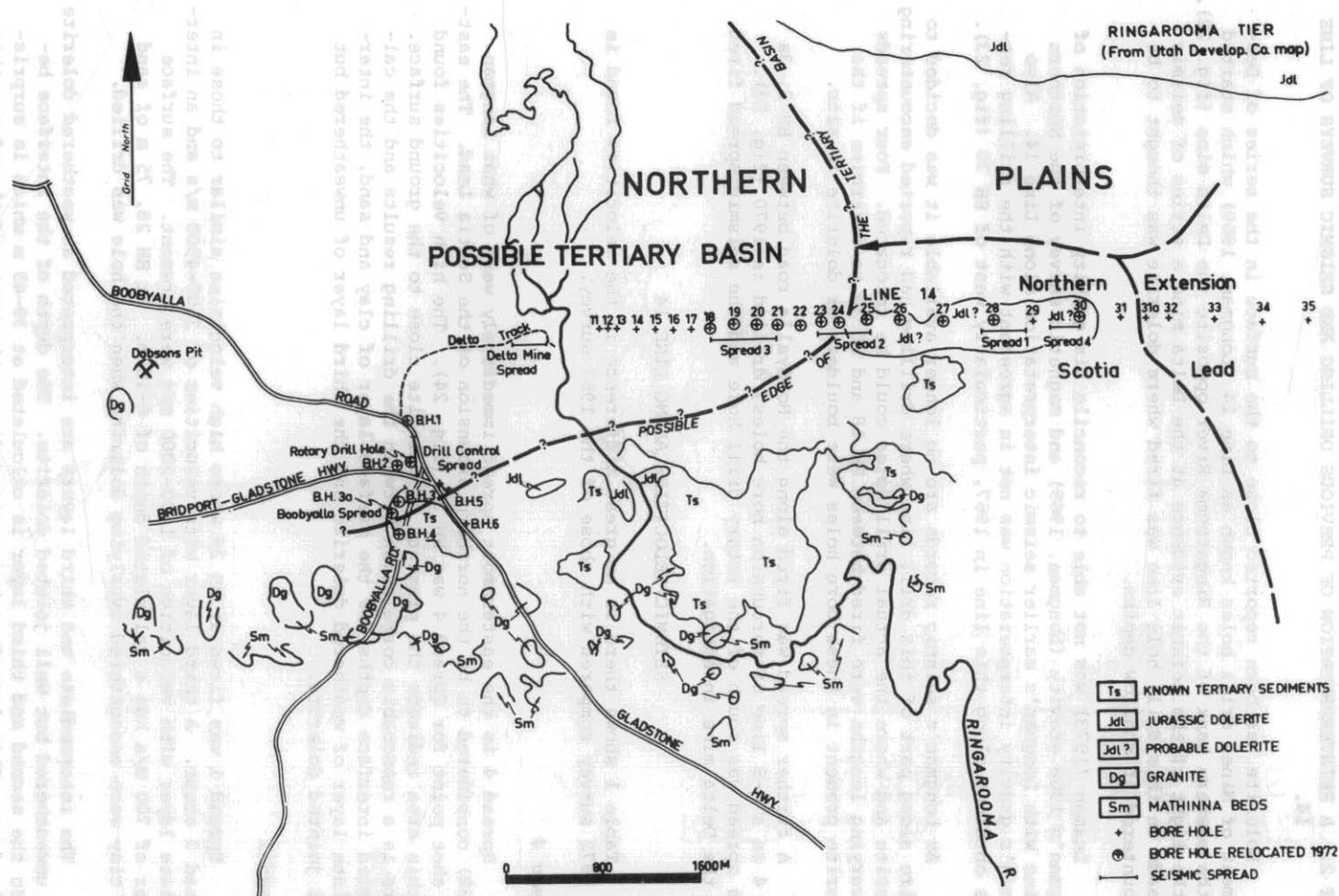


Figure 23. Outcrop map, seismic spreads and drilling, Line 14 and the Boobyalla road area.

5 cm

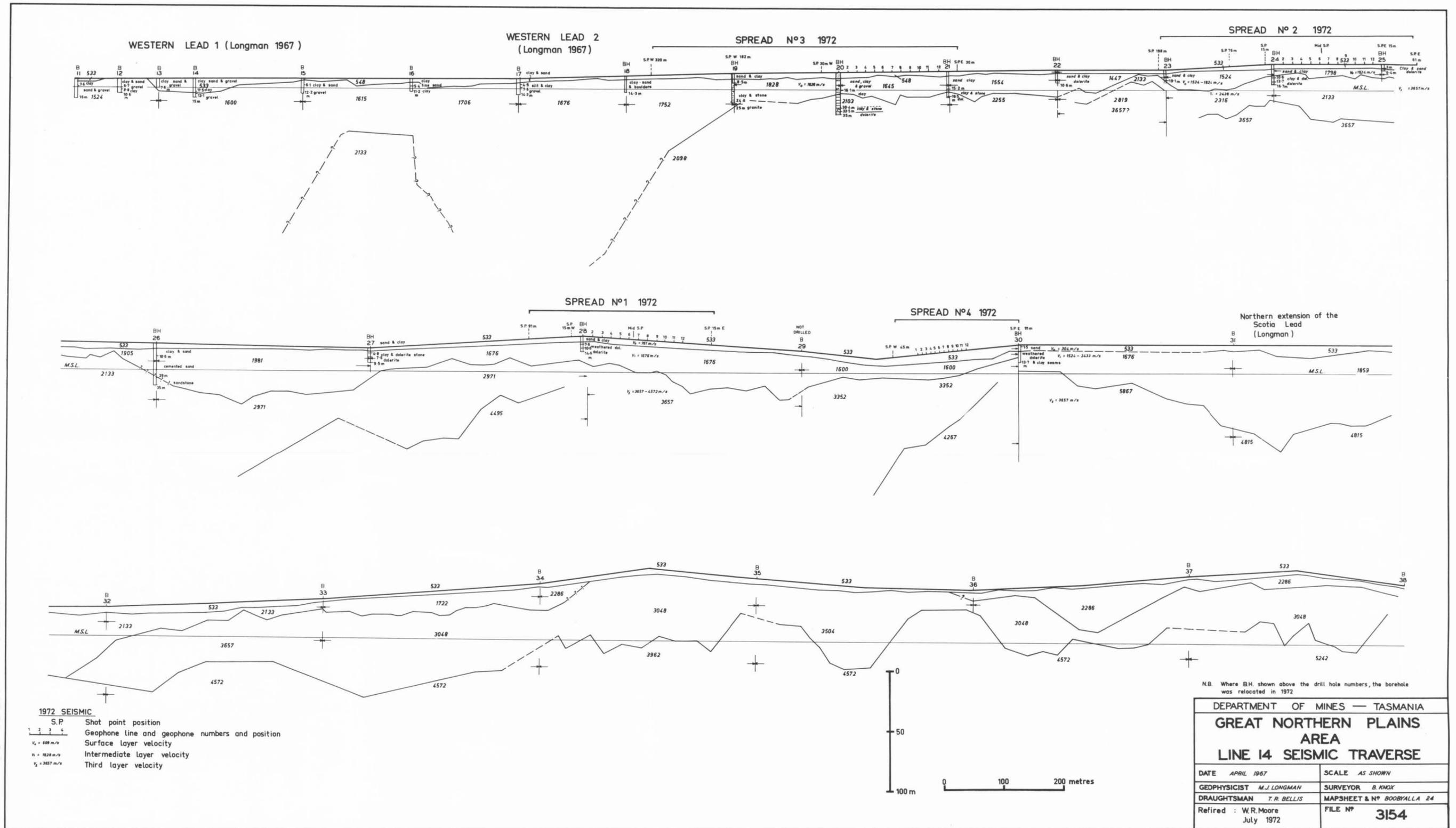


Figure 24.

5 cm

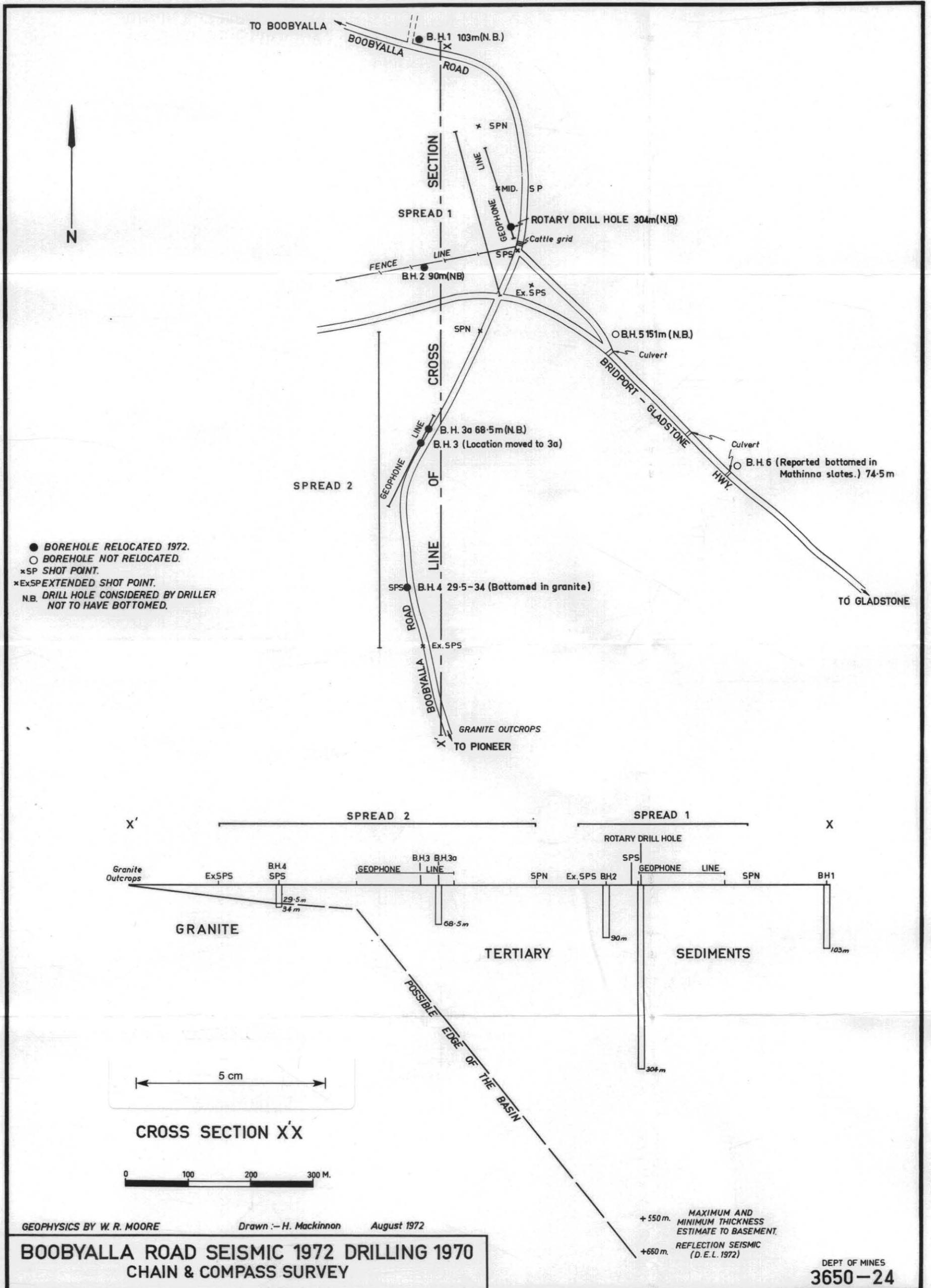


Figure 25.

FIG 92 2611 88-98

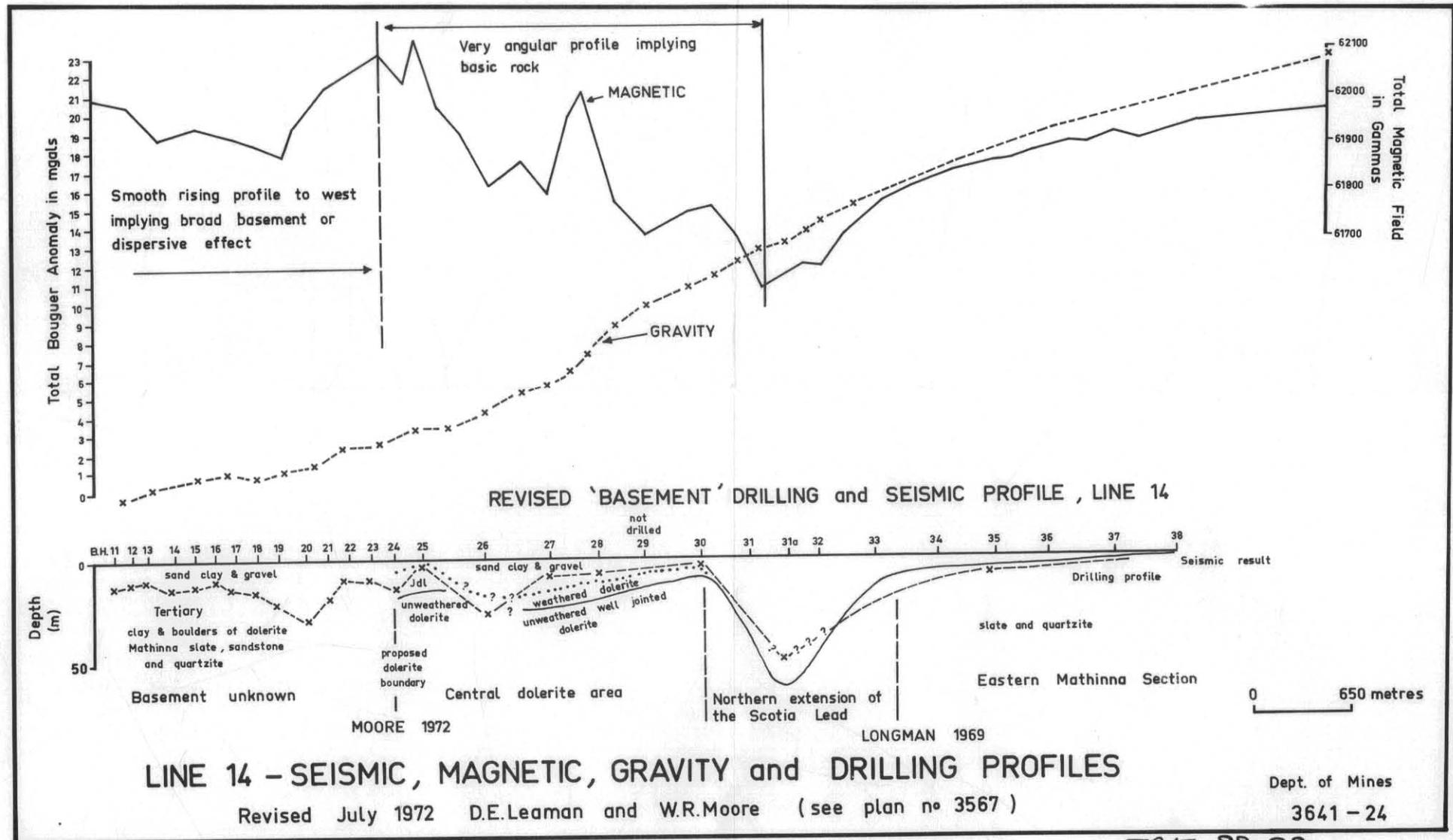
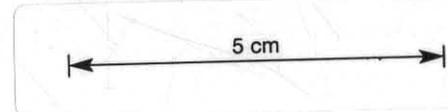


Figure 26.

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## PART 2. A REINTERPRETATION OF PREVIOUS DRILLING AND SEISMIC SURVEYS OF LINE 14.

Dolerite has been reported close to the surface in the series of Department of Mines drill holes known as Line 14 (Longman, 1969) which started on the eastern bank of the Ringarooma River opposite the Delta mine (fig. 22). In the light of the seismic evidence at the Delta mine a series of seismic spreads on this drill hole line was fired where dolerite was thought to be encountered at shallow depths.

Leaman (1973) was not able to reconcile his gravity interpretation of Longman's 1968 gravity (Longman, 1969) and magnetic survey of the Northern Plains with Longman's earlier seismic interpretation along Line 14. Also Leaman's gravity interpretation was not in agreement with the drilling results obtained along this line in 1967, particularly west of BH 30 (fig. 23).

As Longman's seismic records are no longer available it was decided to refire along part of this drill line where drilling had reported encountering dolerite and where the actual drill holes could be relocated. Four spreads of varying lengths were fired between BH 18 and BH 30 to determine if the dolerite present in these bore holes were boulders or dolerite *in situ*.

A further spread was fired along the Boobyalla road between BH 2, 3a and 4 on a N-S line of percussion bore holes, drilled in 1970 (fig. 23). This spread was south of the rotary drill hole and the seismic spread fired for the Delta mine investigation.

### SEISMIC VELOCITIES ALONG LINE 14

Table 1 shows there is no great difference in the velocities found in the 1972 survey compared with those of the 1967 survey.

#### *Spread 4*

Spread 4 is the easternmost spread immediately west of what Longman (1968) considered to be the northern extension of the Scotia Lead. The eastern shot point for Spread 4 was BH 30 (fig. 24). The high velocities found in this area indicate the presence of dolerite close to the ground surface. There is a reasonable correlation between the drilling 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 BH 28 where high velocities similar to those in Spread 3 occur. A third layer with velocities of 3600-4500 m/s and an intermediate layer with velocities of 1600-2000 m/s were present. The surface layer of 700 m/s has a calculated depth of 6-10 m. At BH 28, 75 m of sand and clay were encountered overlying dolerite 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 39-45 m which is surprisingly deep. This interface has a steep dip to the west and therefore, this depth figure is not considered reliable.

Table 1. THE RESULTS AND INTERPRETATION OF THE SEISMIC SURVEY AND DRILLING, LINE 14

Spread	Location	Length of spread and geophone interval (m)	Longman's (1967) velocity layers (m/s)	This report (1972) velocity layers (m/s)	Calculated depth to interface (m)	Geological interpretation of velocity layers	Drilling control (from K. Harper's drilling records, Department of Mines, 1967) (depths in metres)
1	BH 28	290 15	V <sub>0</sub> 500	V <sub>0</sub> 700	6-10  39-45 Slope to the west	V <sub>0</sub> Sand and clay	BH 28 0-7.5 Sand and clay 7.5-10.5 Weathered dolerite 10.5-14.5 Dolerite and dolerite boulders
			V <sub>1</sub> 1600	V <sub>1</sub> 1600-2000		V <sub>1</sub> Weathered dolerite	
			V <sub>2</sub> 3000-3600	V <sub>2</sub> 3600-4500		V <sub>2</sub> Unweathered dolerite	
			V <sub>3</sub> 4400				
2	BH 23-25	425 15	V <sub>0</sub> 500	V <sub>0</sub> 700	3-4.5  West end 25  East end 17	V <sub>0</sub> Surface sand and clay	BH 23 0-9.0 Sand and clay BH 24 0-10.5 Sand and clay 10.5-13.5 Clay and dolerite 13.5-16.5 Dolerite BH 25 1.0-3.5 Dolerite
			V <sub>1</sub> 1500-1800	V <sub>1</sub> 1500-1800		West end	
			V <sub>2</sub> 2000-2200	V <sub>2</sub> 2400 west end of spread		V <sub>1</sub> Tertiary clay and sand	
			V <sub>3</sub> 3600	V <sub>1</sub> 3700 east end of spread		V <sub>2</sub> Tertiary boulders	
						East end	
3	BH 19-21	502	V <sub>0</sub> 500	V <sub>0</sub> 1800-2000	No interface to basement reached	V <sub>0</sub> Tertiary sand, clays and boulder beds	BH 19 0-8.5 Sand clay and gravel 8.5-24.0 Clay and decomposed stone BH 20 0-16.0 Sand clay and gravel 16.0-30.5 Clay 30.5-33.5 Clay and stone 33.5-35.0 Dolerite BH 21 0-15.0 Sand clay and gravel 15.0-19.0 Clay and stone 19.0-19.5 Dolerite
			V <sub>1</sub> 1600-1800				
			V <sub>2</sub> 2000				
4	BH 30	210 7.5	V <sub>0</sub> 200	V <sub>0</sub> 300	3-3.5  15-16	V <sub>0</sub> Sand and clay	BH 30 0-1.0 Sand and clay 1.0-7.5 Weathered dolerite 7.5-13.5 Dolerite with clay seams
			V <sub>1</sub> 1500-1600	V <sub>1</sub> 1500-2000		V <sub>1</sub> Weathered dolerite	
			V <sub>2</sub> 4200-5800	V <sub>2</sub> 3600		V <sub>2</sub> Jointed dolerite	

### Spread 2

Spread 2 was located 900 m to the east of Spread 1, between BH 23 and BH 25. This spread produced different velocity combinations to Spreads 1 and 4.

Firing in the middle of the spread revealed a surface layer with a velocity of 700 m/s and a calculated thickness of 3-4.5 m. At the western end of the spread an intermediate layer with a velocity of 1500-1800 m/s overlies a third layer with a 2400 m/s velocity. In contrast, at the eastern end of this spread an intermediate layer with a velocity of 1500-1800 m/s overlies a third layer with a much faster velocity of 3700 m/s. Even when the shot point was extended 198 m in a westerly direction from the geophone line only a velocity layer of 2400 m/s persisted with no indication of a 3700 m/s velocity layer. If the velocity layer of 3700 m/s is present at the western end of Spread 2, it must be at depth with a steep slope from the eastern end. Alternatively, the faster layer may have lensed out between the two ends of the spread.

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

It should be noted that Longman (1969) has terminated the 3700 m/s velocity layer in the region of Spread 2 between BH 23 and BH 24 and has shown no higher velocities than 2000 m/s west of this point (fig. 24). There is a difference of geological interpretation in the area west of BH 24 between Longman (1969) and the writer.

### Spread 3

Spread 3, the longest spread fired, was located between BH 18 and BH 21. All the shots fired in the spread gave constant velocities of 1800-2000 m/s. Even though the shot point was extended out 320 m in a westerly direction no fast layer was reached.

#### LONGMAN'S INTERPRETATION OF TWO DEEP LEADS FOR THE WESTERN HALF OF LINE 14

Longman (1969) explained the absence of any high velocities west of BH 24 as the result of a deep weathering in the dolerite basement. After completing this seismic traverse across the Northern Plains, Longman fired two very long spreads between BH 13 and 18, to obtain further information about the 'dolerite basement'.

Each of the spreads covered a distance of 700 m and the highest velocity recorded was 2000 m/s. This second velocity layer only appeared between BH 15 and BH 16 at a calculated depth of 45 m. If this 2000 m/s velocity layer is weathered dolerite then its depth of weathering must be considerable between BH 15 and BH 16 as well as between BH 18 and BH 24.

Longman explained the absence of the 2000 m/s velocity layer between BH 13-15 and BH 16-18 by the presence of two deep leads separated by a dolerite basement high between BH 15 and BH 16. These two western leads were separated from the Scotia lead by the existence of another more extensive dolerite basement high between BH 19 and BH 30 (fig. 24). This explanation was forced upon Longman by the drilling reports of dolerite being encountered in nearly all the drill holes between BH 19 to BH 30.

## BOOBYALLA ROAD SEISMIC AND DRILLING RESULTS

At the junction of the Boobyalla Road and the Gladstone-Bridport highway the Department of Mines rotary drill has penetrated into 304 m of what appears to be Tertiary sediments without bottoming. The reflection shots fired in this drill hole indicated that there is a minimum thickness of 550-610 m and possible maximum of 1100 m 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 along the Boobyalla road (Table 2). These sediments appear to be clay with a high percentage of dolerite boulders, Mathinna slate, greywacke sandstone quartzite, 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 a surface layer velocity of 1800-2400 m/s for these sediments. Similar velocities were recorded at the Delta mine, 1.6 km to the north-east (Table 2).

The seismic spread fired between BH 3 and BH 4 on the Boobyalla Road gave different velocity layers for each end of the spread. At the southern end a surface layer with a velocity of 1800 m/s overlies a second layer with a velocity of 3600 m/s. The calculated depth of this interface is 26-27 m; a depth which approximates closely to the Tertiary granite contact in BH 4 which bottomed in granite from 29-34 m (fig. 25).

At the northern end of the spread only a surface layer with a velocity of 1800 m/s was recorded even though the shot point was extended north to 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 the Tertiary basin along the 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 has a very steep dip at this locality. The simplest 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 being continuously filled with coarse boulder material as the trough deepened intermittently over an unknown period of Tertiary time. This theory offers no explanation for the apparent absence of granite boulders in the Tertiary sediments unless the granite was not then exposed to erosion. This explanation appears difficult to reconcile in view of 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 of the Boobyalla Road area with velocities extending from 1500-2400 m/s may extend to line 14, then all the 2000 m/s velocity 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 (3600 m/s).

It appears very likely that all of line 14 west of BH 24 is part of

Table 2. RESULTS AND INTERPRETATION OF THE SEISMIC SURVEY AND DRILLING, BOOBYALLA ROAD, DELTA MINE AREA.

Spread name and number	Location	Length of spread and geophone interval (m)	Velocity layers (m/s)	Calculated depth to interface (m)	Geological interpretation of velocity layers	Drilling control (from K. Harper's drilling records, Department of Mines, 1970) (depths in metres)
Delta mine	Delta mine	E-W 358 7.5	V <sub>0</sub> 1500-1800 V <sub>1</sub> 2400 V <sub>2</sub> 4800	26.0-31.0  42-49	V <sub>0</sub> Tertiary sand, clay and boulders V <sub>1</sub> Tertiary boulder beds V <sub>2</sub> Granite	None.
1. Control spread on the deep drill hole	Boobyalla Rd. BH 2 and rotary drill hole	N-S 320 15	V <sub>0</sub> 300-900 V <sub>1</sub> 1800-2400	2.0-2.5	V <sub>0</sub> Grey sands and soil V <sub>1</sub> Tertiary boulder beds	BH 2 0-1.5 Sand 1.5-15.0 Clay and broken stone 15.0-21.0 Dolerite and clay 21.0-36.5 Stone slate and clay bands 36.5-59.5 Dolerite and clay bands 59.5-67.0 Gravels, clay and stone 67.0-87.0 Mainly slate 87.0-90.0 Quartzite Rotary drill hole 0-304.0 Boulders of dolerite, slate, sandstone and vein quartz and possible aplite
2.	BH 3a and BH 4. Boobyalla Rd. series	N-S 532 15	South end V <sub>0</sub> 1800 V <sub>1</sub> 3000-3600 North end V <sub>0</sub> 2000	South end 27-27 Calculated on critical distance formula Interface not reached	V <sub>1</sub> Sand, clays and gravels V <sub>1</sub> Granite south end North end V <sub>0</sub> Tertiary boulder bed	BH 3a 0-1.0 Sand 1.0-6.0 Clay and stone 6.0-13.5 Clay and quartzite 13.5-41.0 Gravel bed and quartzite 41.0-55.0 Mainly quartzite 55.0-68.5 Mainly clay and quartzite BH 4 0-3.0 Clay, quartzite and gravel 3.0-20.0 Clay seams and quartzite 20.0-23.5 Clay 23.5-29.5 Quartzite 29.5-34.0 Granite

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 (1969). Also the 1967 drilling in BH 20, 21 and 22 does not appear to have bottomed in dolerite but in dolerite boulders.

*In situ* dolerite occurs only between BH 24 to BH 30 and is indicated by the presence of the faster 3600 m/s velocity layer. This dolerite is possibly only a thin sheet with an irregular outline as evidenced in Spread 1 at BH 28, where this fast layer has a significant slope to the west. Longman's high velocity layer also cuts out at BH 26 which was reported to have bottomed in sandstone at 29-35 m.

The interpretation given above allows for a closer correlation of the seismic, gravity and magnetic profiles than is given in Longman's interpretation (fig. 26, see also appendix).

#### THE SCOTIA LEAD

The dolerite between BH 24 and BH 30 appears to separate the Tertiary basin in the western section of line 14 from the Scotia lead found between BH 30 and BH 33 (fig. 23). If this dolerite is an isolated mass and not connected to the extensive area of dolerite known to crop out to the north, then the Scotia lead may swing to an E-W direction between the 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 E-W lead would account for the E-W indent of the Bouguer anomaly contours in this area (Leaman, 1973). Another lead may join this E-W extension of the Scotia lead from the north-east.

Such a lead pattern appears to explain the gravity and magnetic low pattern of Leaman (1973). It also offers an explanation for the presence of Tertiary sediments with high tin values found by drilling north and north-west of the northern extension of the Scotia lead at line 14.

#### FURTHER RECOMMENDATIONS FOR EXPLORATION

An attempt must be made to obtain core of the high velocity Tertiary sediments existing at the Boobyalla Road area before any further exploration is undertaken. Rotary drill chips are a most unsatisfactory method of logging drill holes with jagged and unstable sides. The contamination from higher levels in the hole drilled was considered to be very high and almost continuous.

Coring with the rotary plant was not attempted because of 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 these 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 BH 24 on line 14.

Three or four N-S magnetometer traverses with stations at 3 m intervals should be undertaken from the Dorset Dredge road across the dolerite between BH 24 and BH 30 to the dolerite ridge to the north.

A N-S seismic traverse should be run along one of these magnetometer traverses and finally the area should be geologically mapped.

## REFERENCES

- LONGMAN, M.S. 1969. Seismic traverse line 14. Great Northern Plains. *Tech. Rep. Dep. Mines Tasm.* 13:23-26.
- LEAMAN, D.E. 1973. Summary of geophysical work, Gladstone area. *Tech. Rep. Dep. Mines Tasm.* 16:89-96.

## APPENDIX

As outlined earlier in this report further seismic refraction work in the region of line 14 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 border-filled fault block and the slightly higher velocity quoted in the earlier report on the supposed interfluvium is within the velocity range for the Tertiary materials. In view of the revised seismic results it appears certain that only boulders were encountered in the drilling of BH 15-24.

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 24 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 clays and consequently the magnetic profile was anomalous west of BH 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 earlier, revealed between BH 24 and 31. The original gravity interpretation used a density contrast of  $-0.60 \text{ g/cm}^3$  for the Tertiary materials which presumed clays. The boulder bed present would have a contrast of not more than  $-0.45 \text{ g/cm}^3$  and the basin could therefore be some 200 m deeper than estimated.

Thus, re-evaluation of the seismic profile and the further work has explained two of the three enigmas noted by Leaman (1973).