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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/119

SPENCERS CREEK SEISMIC REFRACTION SURVEY, NEW SOUTH WALES 1950-51

by

O. KEUNECKE

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NEW SOUTH WALES

1950 - 51

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ILLUSTRATIONS

SUMMARY

A seismic refraction survey was made for the Snowy Mountains Hydro-Electric Authority in 1950-51 to aid in selecting a suitable site for a dam on Spencers Creek, NSW. The survey was designed to give information on the nature of the bedrock (granite) and overburden (moraine) and on the bedrock topography.

The seismic results indicate that the overburden thickness varies considerably and is generally greater in the southern part of the surveyed area than in the northern part. A maximum thickness of about 300 feet is indicated.

In parts of the area there appear to be two strata in the moraine.

The depths to bedrock calculated from the seismic results are compared with the drilling results at two dam sites within the surveyed area.

1. INTRODUCTION

The geophysical survey described in this Record was undertaken at the request of the Snowy Mountains Hydro-Electric Authority (SMHEA) for the purpose of investigating possible sites for the proposed Spencers Creek dam. The area surveyed is about two miles above the junction of Spencers Creek with the Snowy River, about six miles east of the summit of Mount Kosciusko, and at an average elevation of about 5700 ft above sea level. The road from Jindabyne to Mount Kosciusko crosses the area about one mile from the Kosciusko Chalet.

Some years before the survey described here, six boreholes were put down on a line across the creek (this line of holes coincides with geophysical Traverse A) to obtain information on the depth and nature of the bedrock and the characteristics of the overburden at a site referred to as site No.1 (see Plates 1 and 2). However, selection of the most suitable position for the dam required more-extensive investigations and it was for this purpose that a geophysical survey was requested. The specific information sought by the survey comprised the following:

(a) Depth and nature of the bedrock,

(b) Contours of the bedrock surface,

(c) Nature of the overburden and, in particular, any variations in physical properties occurring either horizontally or vertically.

The seismic refraction method was used in the survey. The field work was done between November 1950 and April 1951, with an interval of about five weeks in December and January. The field party consisted at first of D.F. Urquhart and O. Keunecke (geophysicists) and later of S. Gunson and I. Mumme (geophysicists). P.B. Tenni (cadet geophysicist) and B.J. Reid (student) assisted for several weeks.

The pegging and levelling of the traverse lines, except for the eastern part of Traverse E, were undertaken by officers of the SMHEA, which also provided the necessary field assistants. Thanks are due to the SMHEA, in particular to D.G. Moye, Head of the Engineering Geology Branch, for the co-operation and assistance extended to the field party.

2. GEOLOGY

The basement rock in the Spencers Creek area is granite. It is covered with a mantle of morainal material, granitic soil, or peaty swamp. Numerous large granite boulders occur on the surface. Granite boulders, probably of fluvio-glacial origin, occupy the valley floor of Spencers Creek, particularly downstream from the dam site. The right abutment is generally thought to be granite weathered in situ and the left abutment a moraine, known as the David Moraine.

The six boreholes that were previously put down along a line across the creek all reached granite bedrock as shown in the cross-section along Traverse A (Plate 3). The bores showed the bedrock to be overlain by soil and decomposed granite ranging from 8 to 100 ft in thickness. An examination of the material struck in the bores may have been useful in connexion with the geophysical survey, but this was not possible as the cores were no longer available.

3. SEISMIC REFRACTION METHOD

Outline of the method

The seismic method of exploration depends on variations in the elastic properties of the subsurface materials, which govern the velocities of propagation of seismic energy. The method consists essentially of generation of seismic waves by means of an explosion and measurement of the time taken by the seismic waves to travel from the shot-point to each of a series of detectors (geophones).

In the seismic refraction method, which is used for shallow exploration work, the time interval between the shot instant and arrival of the first impulse at each geophone is measured. A photographic recorder gives an accurate record of these events and enables the travel times of the seismic disturbance to be measured in milliseconds.

A necessary condition for the application of the refraction method is that the seismic velocities should increase with depth. When the recorded travel times are plotted against the distances of the geophones from the shot-point, a time/distance graph is obtained, from which it is possible, in general, to determine the seismic velocities in the different subsurface strata and the depths to the interfaces. To increase the depth of the investigation it is necessary to increase the distance between the shot-point and the geophone spread so as to ensure that seismic waves refracted at the deeper interfaces will be recorded as first-arrivals.

Seismic measurements can be expected to give reliable depth determinations if the geological strata are horizontal and the boundaries sharply defined. On the other hand, if the strata are inclined or undulating, or the boundaries are not well defined (e.g. in the zone of weathering of bedrock), the interpretation of the results is more difficult and the accuracy of the depth determinations is reduced.

In the survey of the Spencers Creek area the refraction method employed was the 'method of differences' which is particularly suitable for the determination of depths to an irregular bedrock surface, the arrangement of the survey being such that the depth is determined below each geophone position (Edge and Laby, 1931).

Field operations

The first tests were made along Traverse A (Plate 3) where the information from the existing boreholes provided a guide as to the most-suitable layout of geophone spreads and shot-points. The bore data also provided a useful check on the seismic results and particularly on the seismic velocities in the layers overlying the bedrock. The accurate determination of these velocities is essential for the calculation of depths to bedrock. The results obtained along Traverse A are discussed in Section 4.

The complete survey comprised ten traverses viz. A, A-B, A-C, B, C, D, E, F, G, and H (see Plate 2). The geophones were usually spaced at intervals of 50 ft, but in a few places where exceptionally long-distance shots were necessary to obtain sufficient depth penetration, the intervals were increased to 100 ft. In general, satisfactory refractions were recorded from the bedrock and, with a few exceptions, the data were adequate for the calculation of the depth to bedrock at each geophone position.

4. RESULTS AND INTERPRETATION

Cross-sections showing the results along the 10 seismic traverses are given in Plates 3 to 12. Each cross-section shows the bedrock profile and is accompanied by a table of the depths to bedrock for all points where these depths were calculated.

Traverse A (Plate 3)

The survey was started on Traverse A, which was sited so as to cross the creek along the line of existing boreholes. Comparison of the seismic results with the bore data showed that the method was capable of giving the required information regarding the bedrock.

The following geological strata were identified from the observed seismic velocities :

(a) Earth and granitic sand. The velocity ranges from 1500 to 3000 ft/sec and depends largely on the moisture content.

(b) Decomposed granite, in which the velocity is between 5500 and 6000 ft/sec.

(c) Granite bedrock, in which the velocity is about 13,000 to 13,500 ft/sec. Experience in other areas suggests that granite with this velocity may be slightly weathered.

These velocities have been used in the calculation of the depths to bedrock shown in Plate 3.

The geophysical results are in close agreement with the bore results except at bore No.5, where the seismic depth of 64 ft to bedrock is 43 ft less than the depth apparently found in the bore hole. However, some doubt is felt with regard to the bore data, which were recorded as follows :

0-69 ft, earth.

69-107 ft, decomposed granite.

107-152 ft, granite.

This is the only one of the six bore logs which refers to three different strata. The others refer to two strata only, the first consisting of 'earth and decomposed granite' and the second of 'granite', while for bore No.5 the first stratum has been subdivided to show earth with the extraordinarily-large thickness of 69 ft and then decomposed granite. It seems possible that the 'decomposed granite' recorded in the log at 69 ft is the same material as that which, in the other boreholes and in the interpretation of the seismic results, is considered to be granite bedrock.

No results were obtained in Spencers Creek itself, as the deep water did not allow measurements to be made. The cross-section suggests that the deepest part of the bedrock lies not under the creek, but to the east between bores No. 2 and 3.

Traverse A-B (Plate 4)

The seismic observations indicate that the bedrock is at shallow depth along this traverse. This result could be expected, as the traverse is situated on the slope of the hill where granite crops out.

Traverses B, E, F, and G (Plates 5, 6, 7, and 8)

These are parallel traverses, 200 ft apart, which cross Spencers Creek at dam site No. 2. The bedrock is at shallow depth along the north-eastern parts of these traverses and continues at shallow depth under the creek. South-west of the creek, however, there is an increase in the thickness of overburden and the undulations of the bedrock surface are more pronounced. The greatest thickness of overburden, about 300 ft, was observed at the intersection of Traverses B and C on the David Moraine.

South-west of the creek, along Traverse B, the survey not only indicated the depths to the granite bedrock, but also indicated that the overburden probably consists of two different strata, as two different velocities were obtained in the material overlying the bedrock. The velocity in the upper of these two strata is between 5000 and 6000 ft/sec, and intermediate between this velocity and the velocity of 13,000 ft/sec characteristic of granite, a velocity of 7000 to 8000 ft/sec was observed. This could be interpreted as a second morainal stratum. The higher velocity in the lower part of the moraine may be due to the presence of a greater number of granite boulders or to a higher degree of consolidation.

In the cross-section along Traverse E (Plate 6), some depth values are marked as doubtful, as the records were not clear enough to permit reliable interpretation.

Traverse C (Plate 9)

This traverse crosses the David Moraine. In the central part of the traverse, the depths shown are mainly those to the second morainal stratum. The great thickness of overburden in this area was not expected at first, and in the earlier work the distances between shot-point and geophone spreads were not large enough to allow bedrock refractions to be recorded between 100N and 700N. However, it is certain that the depths to bedrock are not less than about 240 ft, otherwise the high velocity in granite would have been detected. Later work gave the depths to bedrock at the intersection of Traverse C with Traverse E and G, and it seems very likely that between 100N and 700N on Traverse C the depth to bedrock is between 240 ft and 270 ft.

Traverse A-C (Plate 10)

This traverse is situated on the hillside west of Spencers Creek. Near the intersection of Traverse A-C and Traverse A, the bedrock is very shallow; elsewhere along Traverse A-C the depth to bedrock does not appear to exceed 100 ft.

Traverse D (Plate 11)

Traverse D runs from east to west across the surveyed area, but only the part west of Spencers Creek was surveyed. The results show that the bedrock approaches the surface at the creek and also towards the western end of the traverse near the intersection with Traverse C.

The two values given for the depth to bedrock at 800W, viz. 142 ft and 210 ft, were derived independently from two different but overlapping geophone spreads. The discrepancy is probably due to a steep escarpment which must exist in the bedrock near this point. It is considered that the actual depth is between the two values given. If any further drilling is done in this part of the area, this discrepancy could be cleared up by means of a test hole at this point.

Traverse H (Plate 12)

This traverse crosses the creek at Site No.3 in the northern part of the area. The cross-section is similar to that along Traverse A, the greatest depth to bedrock occurring on the eastern side of the creek.

The cross-sections shown in Plates 3 and 12 give in detail the results of the seismic depth determinations along the 10 traverses. By using these results and interpolating between traverses, the contours of the bedrock surface have been drawn as shown in Plate 13. The contour plan represents the general picture of the topography of the granite basement as indicated by the seismic survey. Plate 2 shows the surface contours for the same area.

The most important information obtained from the survey is probably the configuration of the bedrock beneath the hill of the David Moraine. There the bedrock does not approach the surface as it does farther north on both sides of the creek, but dips towards the south-west. The overburden of morainal material reaches the maximum thickness of 300 ft.

Furthermore, in the southern part of the area and south-west of Spencers Creek, where the overburden is very thick, two different velocities were observed in the overburden, indicating the existence of two strata with different physical properties. Hence it is concluded that there are two different morainal strata, the velocity being greater in the deeper layer which may be due to that layer having a greater content of granite boulders or a higher degree of consolidation or both. However, it was not always possible to distinguish between the two strata with certainty.

The bedrock contour plan shows that there is a trough or channel which, in the southern part of the area, is south-west of the creek and roughly parallel to it. North of Traverse D the trough strikes north and crosses the creek and, although it then broadens out, probably continues as far as Traverse A and H, along both of which the deepest part of the bedrock is east of the creek.

5. TESTING

Site No. 1

Reference has already been made to the earlier boreholes situated on Traverse A at dam site No.1. The available data from these holes are indicated on the cross-section shown in Plate 3; in Table 1 below, the depths to bedrock from borehole data are compared with the corresponding depths determined by the seismic survey.

Table 1. Drilling and seismic results, dam site No.1.

Bore No.	Depth to bedrock (ft)	
	Bore data	Seismic results
1	72	67*
2	81	80
3	102	102*
5	107	64
6	8	9

* Interpolated

The geophysical results show good agreement with the bore data except for the large discrepancy at bore No. 5. However, as explained earlier, there is some reason to doubt the bore-log data for this hole. Additional testing would be required on this part of Traverse A to decide whether the discrepancy is due to an error in the seismic interpretation or to inaccuracy of the borehole data.

Site No. 2.

Test drilling in the Spencers Creek area was commenced by the SMHEA in December 1950. The drilling results which were available by mid-August 1951, viz. for bores No. 1-9 on site No.2, are discussed below in relation to the results of the seismic survey.

The positions of the test bores are shown in Plate 1; in Table 2 the depths to bedrock as shown by drilling are compared with those calculated from the seismic survey. The table shows the location of each borehole referred to the SMHEA co-ordinate system and also to the seismic layout, the depth to bedrock from seismic results at points closest to the borehole, and under the heading of drilling results, the depth to bedrock (where obtained) and total depth of the bore.

Three of the bores, No. 1, 2, and 3, did not reach solid bedrock and bottomed in weathered granitic material; bores No. 6 and 7 give only a check on depths obtained by interpolation from the seismic results. However, it may be said that the drilling for the most part confirms the seismic results. However, boreholes No. 4 and 7 are exceptional in that they apparently show large errors in the seismic depths.

Bore No. 4 revealed mainly weathered granitic material down to 145 ft, then 10 ft of slightly weathered to fresh granite, followed by more weathered granitic material but with two more occurrences of fresh to slightly weathered granite (6 ft and 5 ft thick), before the true bedrock was reached at 183 ft. If, as seems very likely, the seismic method has detected the first occurrence of slightly weathered granite intersected in the bore at 145 ft, then the depth calculated from the seismic survey, viz. 150 ft, agrees fairly well with the borehole data.

In bore No. 7, bedrock was encountered at a depth about 50 ft less than would be expected by interpolating between the seismic depths at 50 ft on either side of the hole. There is no obvious explanation for this discrepancy. However, the hole confirms that the overburden tends to increase in thickness towards the south-west, as would be expected from the calculated profile.

Applicability of the seismic

In general, the depths to bedrock from the seismic survey agree reasonably well with the test data, and the comparison supports the view that the seismic survey has given a reliable general picture of the bedrock configuration.

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Table 2. Drilling and seismic results, dam site No. 2.

Bore No.	Position referred to:		Seismic results		Drilling results		Remarks
	SMHEA co-ord.	Seismic grid	Depth(ft) to bedrock	Grid position	Depth to bedrock (ft)	Total depth of hole (ft)	
1	A 1001.5 B 1494.1	B 1106	207 212	B 1100 B 1200	-	114	Drilling stopped before reaching bedrock
2	A 1002.5 B 1677	B 923	88 100	B 900 B 1000	-	76	" " " "
3	A 1006.2 B 1542.3	B 1058	100 207	B 1000 B 1100	-	93	" " " "
4	A 2096 B 998	C 1096	152 150	C 1050 C 1100	183	186	Slightly weathered to unweathered granite at 145 ft may explain shallower depth from seismic results
5	A 1003 B 1952	B 648	20 62	B 600 B 650	55	100	Seismic depth agrees with bore data
6	A 2165 B 887	113 ft SW of C 1167	118 70	C 1150 C 1200	92	125	Seismic depth consistent with bore data
7	A 1002 B 1442	B 1158	207 212	B 1100 B 1200	162	213	Bore data confirms increase in overburden thickness to south-west, but actual depth less than predicted by seismic survey.
8	A 1000 B 1000	B 1600	305	B 1600	291	330	Seismic depth in fairly good agreement with bore data.
9	A 1000 B 2157	B 443	27 29	B 400 B 450	29	48	Seismic depth agrees with bore data

The bedrock surface has been shown to be undulating with fairly high relief, and it should be pointed out that the seismic depths are probably more accurate where the bedrock level changes gradually than in places where there are sudden changes in bedrock level and consequently in the overburden thickness. The accuracy of the seismic depths is also likely to be impaired by any irregular variations in the composition of the overburden.

6. CONCLUSIONS

The thickness of the overburden varies considerably and, generally speaking, is greater in the southern part of the surveyed area than in the northern part. The bedrock rises towards both ends of Traverses A and H, which cross Spencers Creek in the northern half of the area. Farther south, e.g. along Traverses B, E, F, and G, the bedrock rises north-east from the creek but falls towards the south-west, and there the overburden formed by the David Moraine reaches a thickness of about 300 ft.

Over parts of the moraine, two different velocities were observed in the overburden and it is concluded that the moraine is not uniform in composition but varies vertically and contains two different morainal strata.

7. REFERENCE

EDGE, A.B. and LABY, T.H.	1931	THE PRINCIPLES AND PRACTICE OF GEOPHYSICAL PROSPECTING. Cambridge, University Press.

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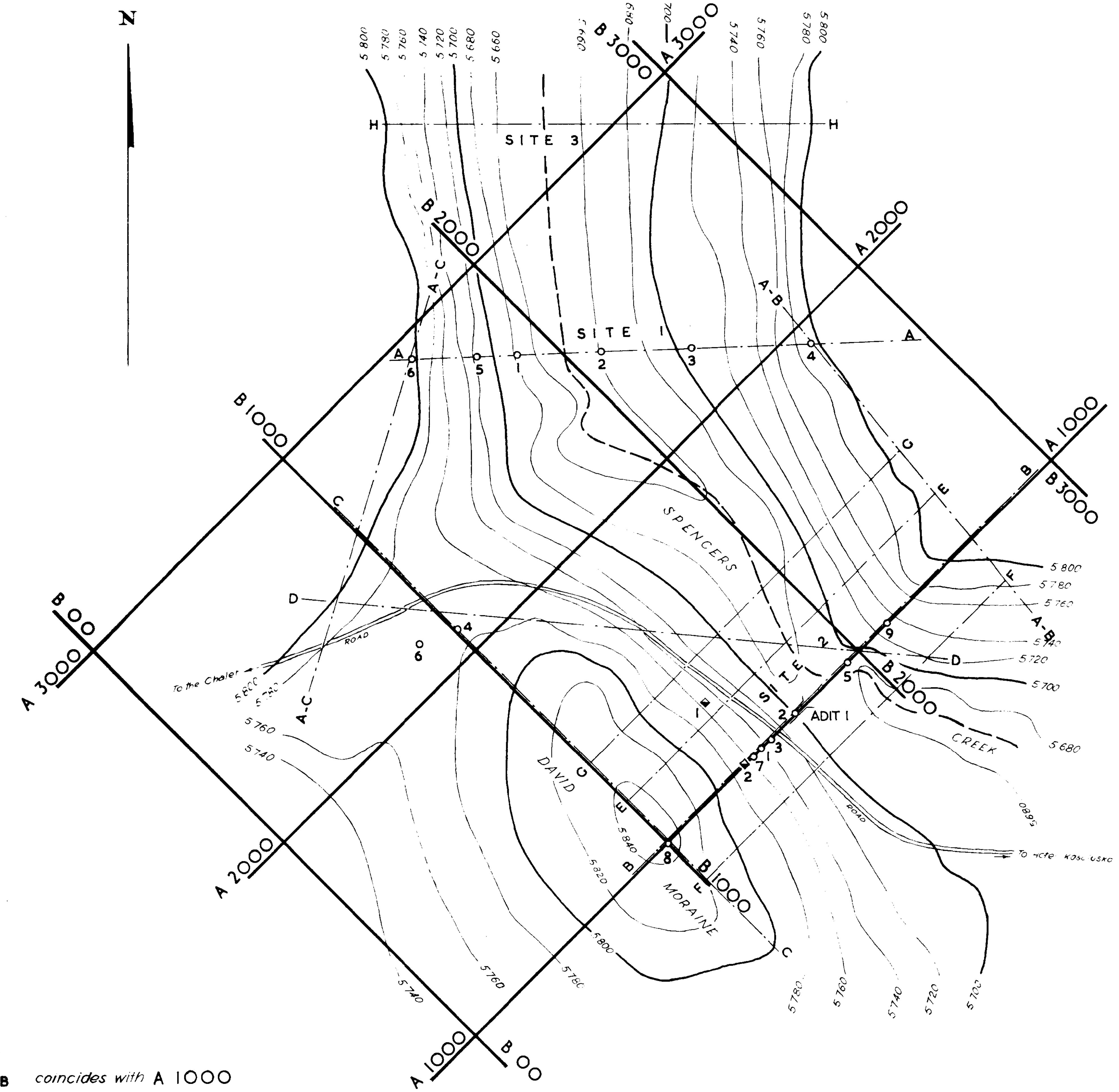
PLATE 1



NOTE

B – B coincides with A 1000

C – C coincides with B 1000

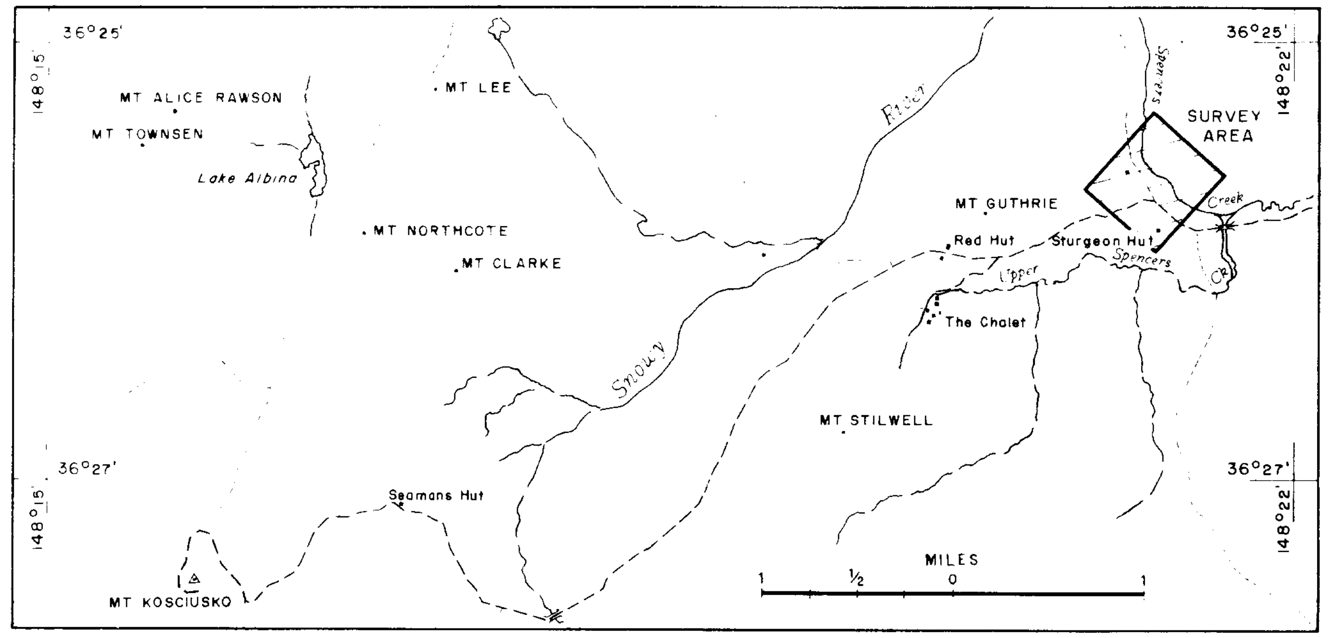
DAM SITE 1 BOREHOLES				
No.	DISTANCE IN FEET FROM No.6	RL IN FEET	DEPTH TO BEDROCK	
			RL	IN FEET
1	368	5680	5608	72^{x}
2	700	5661	5580	81^{x}
3	1030	5703	5601	102^{x}
4	1484	5796	5787	9^{x}
5	254	5709	5601 5640	108^{xx} 69^{o}
6	0	5808	5800	8^{x}

x Earth and decomposed rock

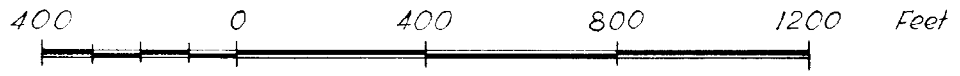
xx Decomposed rock

o Earth

DAM SITE 2 BOREHOLES				
No.	POSITION	RL IN FEET	DEPTH	
			RL	FEET
1	A 1001 B 1494	5742	5628	114
2	A 1002 B 1677	5696	5620	76
3	A 1006 B 1542	5728	5635	93
4	A 2096 B 998	5773	5587	186
5	A 1003 B 1952	5693	5593	100
6	A 2167 B 887	5770	5645	125
7	A 1002 B 1442	5753	5540	213
8	A 1000 B 1000	5844	5514	330
9	A 1000 B 2157	5729	5681	48
SHAFT 1	A 1253 B 1458	5757	5720	37
SHAFT 2	A 1001 B 1399	5765	5749	16
ADIT 1	A 975 B 1710	5681		Dist 10



SCALE



REFERENCE

Seismic traverses shown thus —·—·—

SMHEA coordinate system shown thus ———

REFRACTION SEISMIC SURVEY
SPENCERS CREEK, N S W

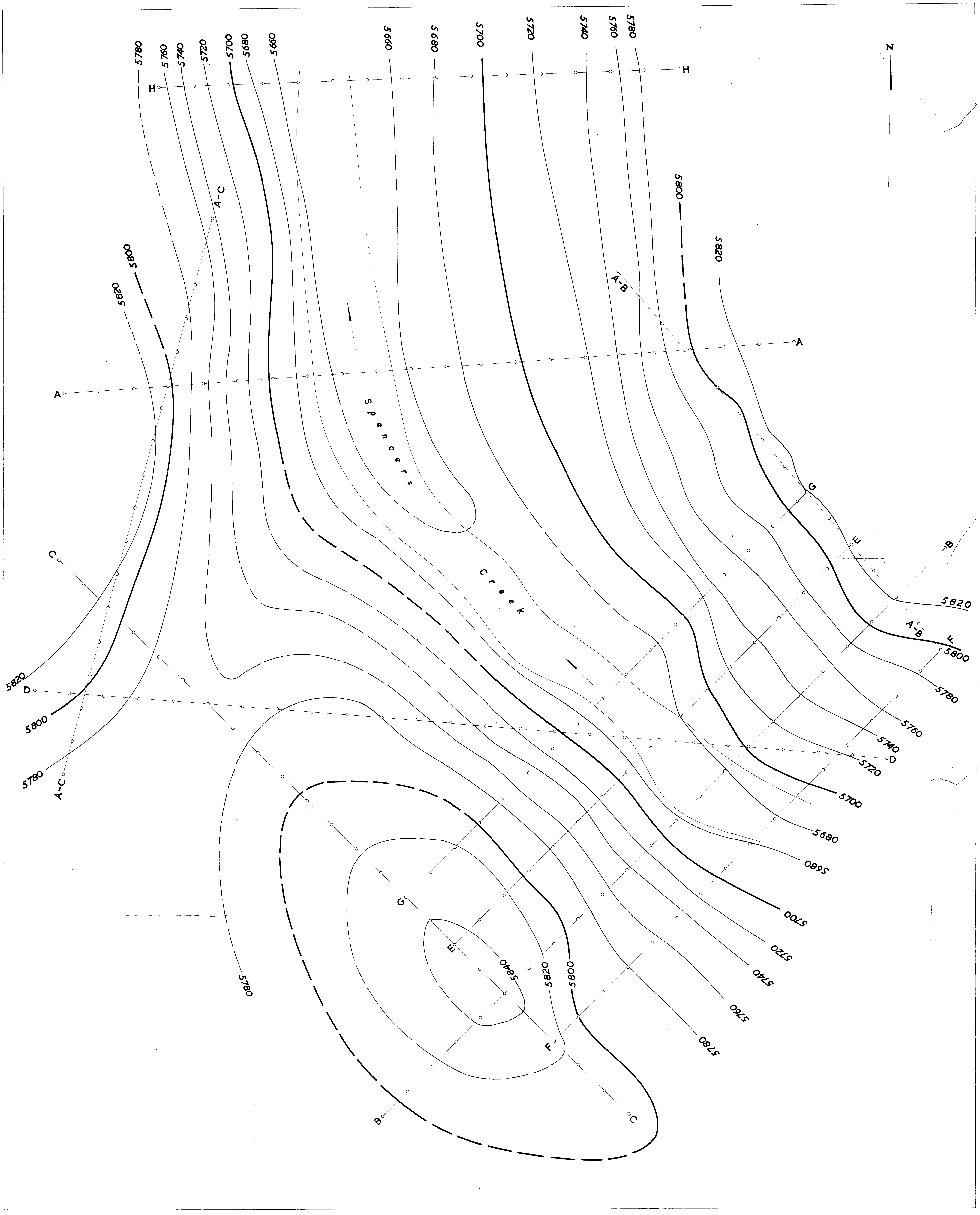
LOCALITY AND TRAVERSE PLANS

Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics J55/B5-3

TO ACCOMPANY RECORD No 1964/119

SPENCERS CRK, NSW, 1951

PLATE 2



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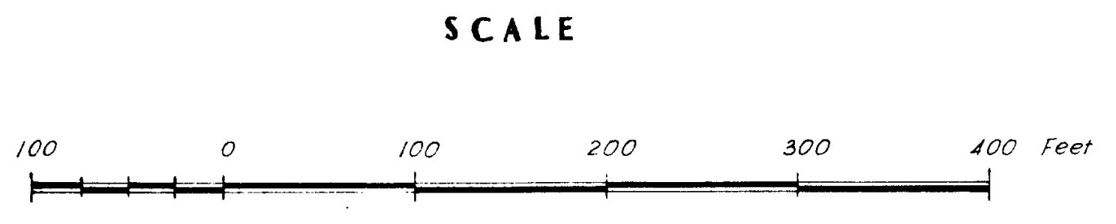

PLAN SHOWING

POSITION OF SEISMIC TRAVERSES AND SURFACE CONTOURS

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J55/B5-4

TO ACCOMPANY RECORD No. 1964/119

PLATE 3

BEDROCK (GRANITE)	From Bore Data.	Depth (fr. Surf.)	8'					107?		72'		81'							102'							9'
		R.L. (feet)	5,800					5,604?		5,608		5,580							5,601							5,787
	From Seismic Results	Depth (from surface)	9'	45'	53'	75'	60'	64'	65'	63'	76'	80'	80'	79'	97'	125'	125'	103'	101'	95'	27'	18'	16'	4'	25'	
		R.L. (feet)	5,799	5,741	5,710	5,668	5,667	5,647	5,633	5,623	5,598	5,581	5,588	5,595	5,583	5,562	5,568	5,595	5,604	5,615	5,688	5,701	5,710	5,737	5,732	

SCALE

HORIZONTAL 0 50 100 150 200 250 FEET

VERTICAL 0 50 100 150 200 250 FEET

CROSS-SECTION ALONG TRAVERSE A
SHOWING
SEISMIC RESULTS & BORE DATA

J55/B5-5

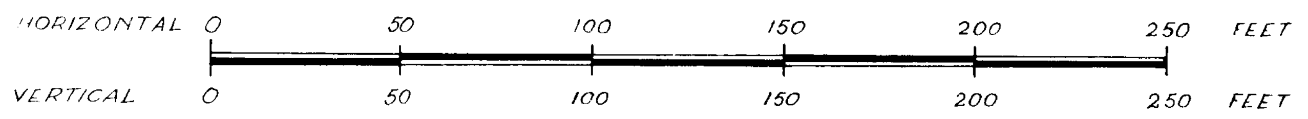
Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics.

TO ACCOMPANY RECORD No 1964/119

PLATE 4

BEDROCK (GRANITE)	from bore data	depth from surface	9															
		RL (feet)	5,787															
	from seismic results	depth from surface	13'	16'	14'	24'	1'	13'	13'	25'	18'	34'	33'	56'	56'	13'	22'	39'
		RL (feet)	5,783	5,783	5,785	5,776	5,798	5,787	5,790	5,780	5,789	5,779	5,787	5,767	5,766	5,809	5,798	5,782

SCALE



CROSS-SECTION ALONG TRAVERSE A-B
SHOWING
SEISMIC RESULTS & BORE DATA

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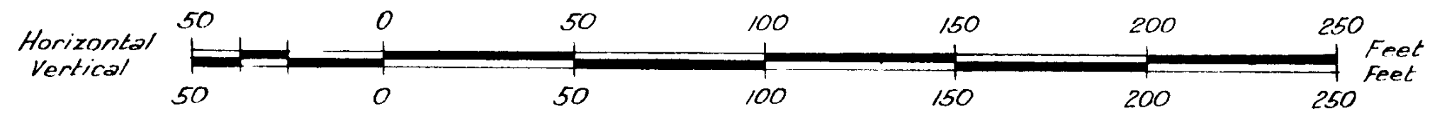
TO ACCOMPANY RECORD No.1964/119

PLATE 5

SECOND MORAINE	From Seismic Results	Depth From Surface																			
		R.L in Feet																			
BEDROCK (GRANITE)		Depth From Surface	39'	38'	8'	27'	70'	66'	56'	31'	27'	29	20'	22'	20'	62'					88'
		R.L (in Feet)	5,782	5,775	5,797	5,765	5,709	5,697	5,697	5,714	5,710	5,700	5,700	5,689	5,683	5,629					5,602

SECOND MORAINE	From Seismic Results	Depth From Surface	48'	54'	90'	99'	126'	169'	140'	117'	75	93'		98'	115'	135'	110'	111'		86'	83'	80'	78'	83'
		R.L in Feet	5,655	5,662	5,639	5,643	5,628	5,598	5,640	5,676	5,728	5,719		5,735	5,724	5,709	5,733	5,731		5,746	5,742	5,739	5,736	5,723
BEDROCK (GRANITE)		Depth From Surface		46' + 54'		108' + 99'		43' + 169'		110' + 117'		118' + 93'		125' + 98'		170' + 135'		145' + 111'		147' + 86'				
		R.L (in Feet)		5,616		5,535		5,555		5,566		5,601		5,609		5,539		5,586		5,599				



CROSS-SECTION ALONG TRAVERSE B
SHOWING
SEISMIC RESULTS

J55/B5-7

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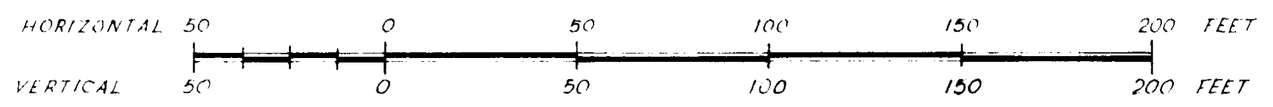
BEDROCK (GRANITE) from seismic results depth from surface	56	40'	25'	3'	3'	10'	17'	17'	37'	32'	45'	8'	18'	53'	25'	5'	10'	30'	45'	45'	90'	? 170'	? 230'	? 233'	170'	190'	129'	165'	190'	220'	207'	246'	268'
BEDROCK (GRANITE) from seismic results RL (feet)	5,767	5,770	5,773	5,782	5,774	5,760	5,737	5,729	5,702	5,700	5,676	5,709	5,680	5,637	5,656	5,667	5,660	5,638	5,648	5,660	5,628	? 5,570	? 5,520	? 5,530	5,608	5,598	5,665	5,642	5,632	5,611	5,629	5,594	5,574

SCALES



CROSS-SECTION ALONG TRAVERSE E
SHOWING
SEISMIC RESULTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

J55/B5-8

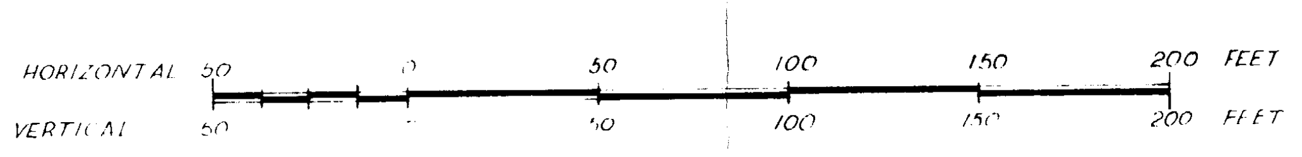
TO ACCOMPANY RECORD No 1964/119

PLATE 7

BEDROCK (GRANITE) from seismic results	depth from surface	20	31'	49'	42'	45'	57	30'	66'	71'	88'	53'	42'	29'
	RL (feet)	5,774	5,753	5,732	5,732	5,725	5,704	5,716	5.672	5,660	5,634	5,659	5,659	5,657

BEDROCK (GRANITE) from seismic results	depth from surface	38'	58'	54'	64'	90'	97'	130'	177'	169'	177'	223'	238'	240'	215'	188'	224'	210'	199'	240'
	RL (feet)	5,640	5,621	5,631	5,626	5,604	5,605	5,587	5,551	5,578	5,573	5,546	5,536	5,543	5,574	5,605	5,573	5,590	5,608	5,585

SCALES



CROSS-SECTION ALONG TRAVERSE F
SHOWING
SEISMIC RESULTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

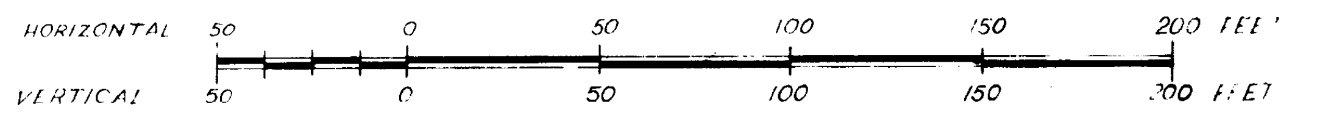
J55/B5-9

TO ACCOMPANY RECORD No 1964/119

		0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	746
BEDROCK (GRANITE) from seismic results	depth from surface	11'	20	6'	11	2	43'	[illegible]	81'	78'	45'	18'	42	35'	39'	37'	42'
	RL (feet)	5,796	5,776	5,780	5,761	5,76[illegible]	5,71[illegible]	5,70[illegible]	5,653	5,640	5,657	5,644	5,639	5,638	5,631	5,632	5,618

		810	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600
BEDROCK (GRANITE) from seismic results	depth from surface	47	48'	66'	60'	87'	151'	232'	237'	176	168'	144	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	RL (feet)	?	5,629	5,624	5,641	5,628	5,578	5,514	5,522	5,599	5,617	5,656	5,651	5,653	[illegible]	[illegible]	[illegible]	[illegible]

SCALES



CROSS-SECTION ALONG TRAVERSE G
SHOWING
SEISMIC RESULTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

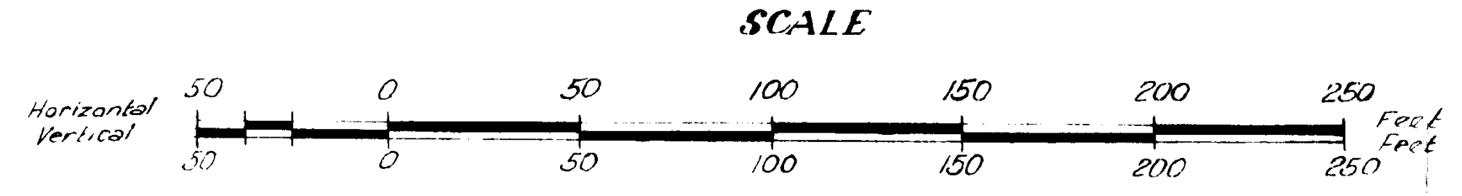
J55/B5-10

TO ACCOMPANY RECORD No. 1964/119

TRAVERSE C

SECOND MORAINE	From Seismic Results	Depth From Surface	69'	66'	69'	66'	66'	92'	105'	129'	128'	135'	117'	123'	111'	96'	87'	90'	98'	111'	96'	105'	108'	106'	121'	101	79'	71'	60'?	50'?	45'?	40'?	30'?	30'?	30'?	30'?	30'?	
		R.L (in Feet)	5,737	5,742	5,741	5,749	5,750	5,733	5,726	5,709	5,713	5,709	5,730	5722	5,732	5,745	5,753	5,745	5,734	5,716	5,737	5,714	5,702	5,700	5,681	5,696	5,713	5,712	5,718	5,724	5,725	5,727	5,741	5,745	5,749	5,755	5,761	
BEDROCK (GRANITE)		Depth From Surface					133'+66'	140'+92' 240'		149'+129'		175'+135'	181'+117'		(268')			(245')					113'+108'		71'+121'		103'+79'	109'+71'	92'+60'	100'+50'	73'+45'	30'+40'	67'+30'	71'+30'	57'+30'	33'+30'	28'+30'	70'
		R.L.(in Feet)					5,617	5,593 5,585		5,560		5,534	5,549		(5,574)			(5,590)					5,589		5,610		5,610	5,603	5,626	5,624	5,652	5,697	5,674	5,674	5,692	5,722	5,733	5,747

SCALE



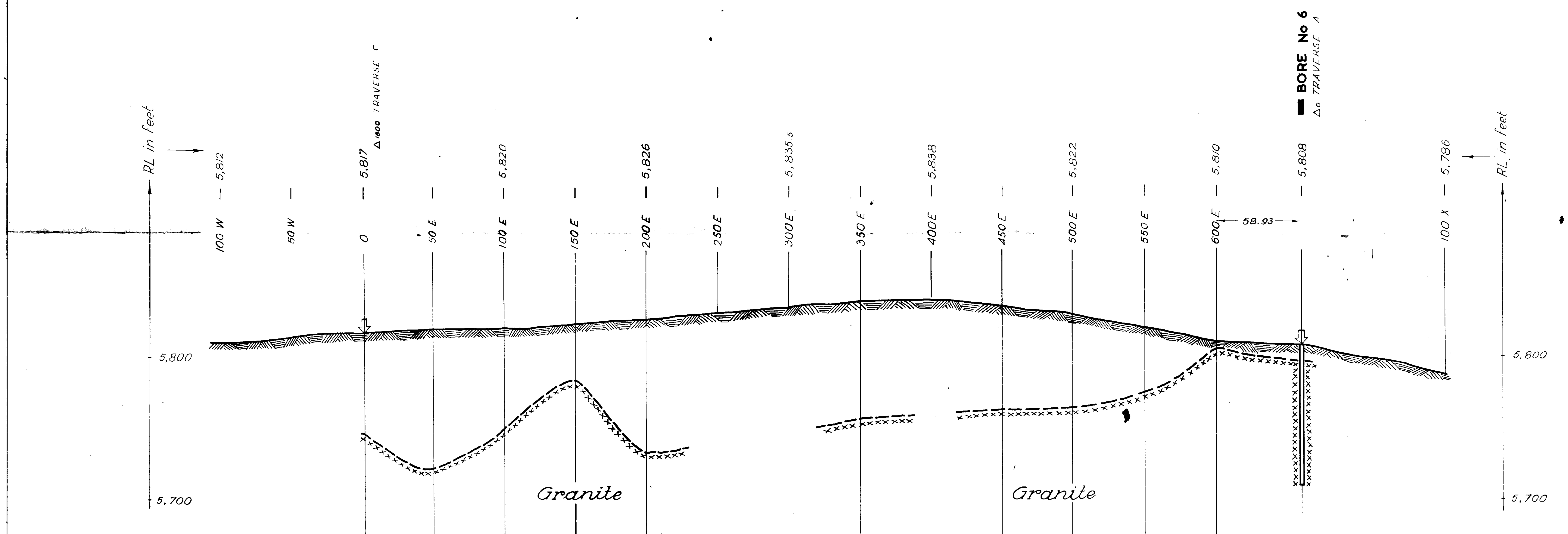
CROSS-SECTION ALONG TRAVERSE C
SHOWING
SEISMIC RESULTS

Geophysical Branch, Bureau of Mineral Resources Geology & Geophysics J55/B5-11

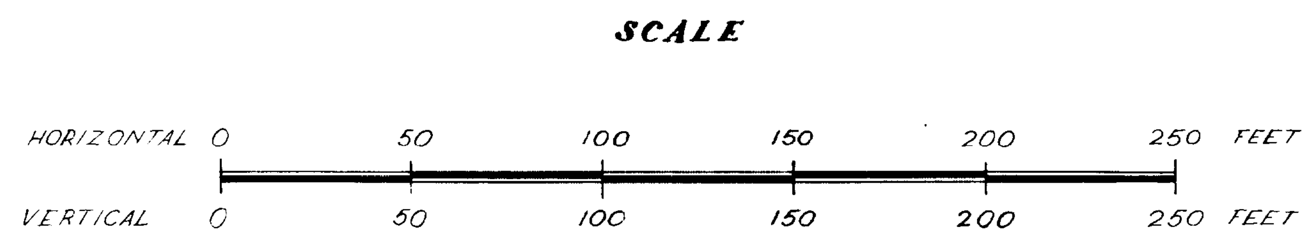
TO ACCOMPANY RECORD No 1964/ 9

PLATE 10

TRAVERSE A-C



BEDROCK (GRANITE)	from bore data	depth from surface											8'
		RL (feet)											5,800
	from seismic results	depth from surface	70'	96'	70'	40'	95'	80'	66'	57'	40'	4'	9'
		RL (feet)	5,747	5,722	5,750	5,783	5,731	5,757	5,763	5,765	5,776	5,806	5,799



CROSS-SECTION ALONG TRAVERSE A-C
SHOWING
SEISMIC RESULTS & BORE DATA

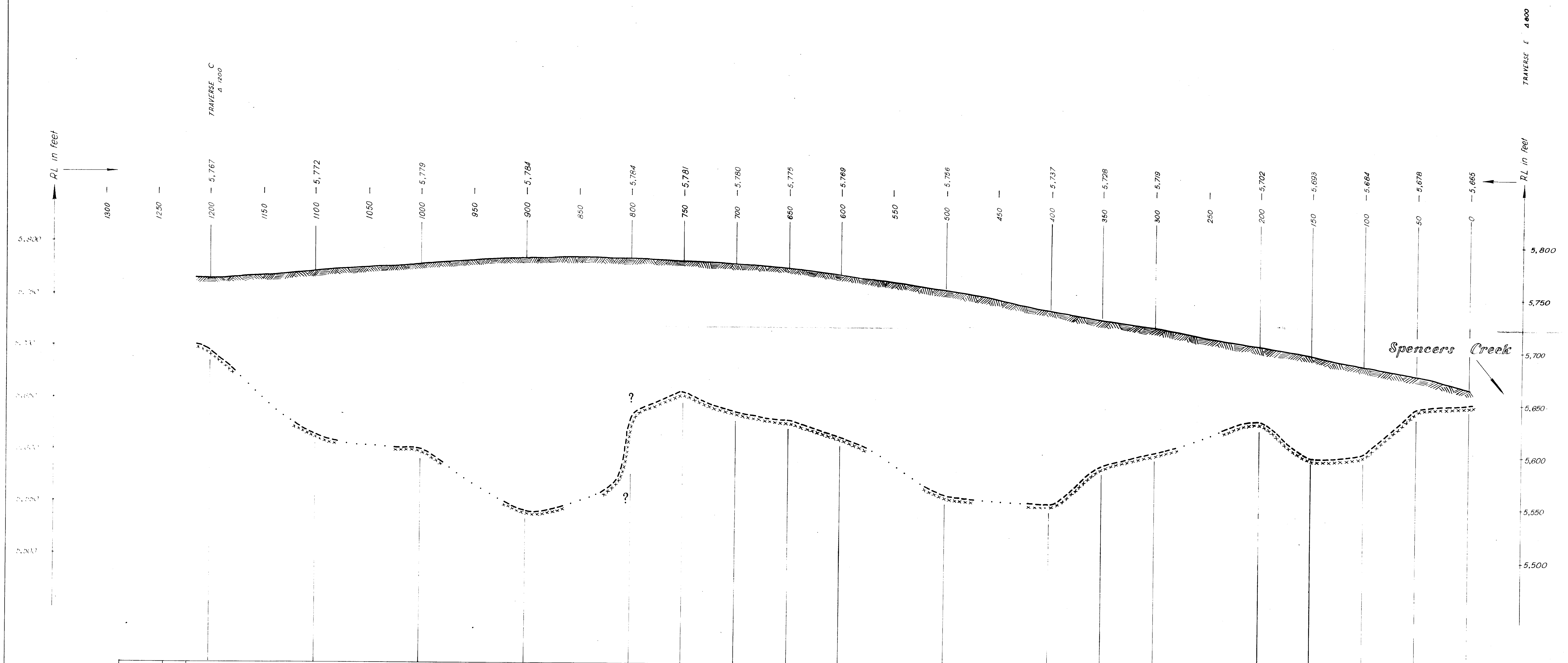
Geophysical Branch, Bureau of Mineral Resources Geology & Geophysics

J55/B5-12

TO ACCOMPANY RECORD No. 1964/119

PLATE 11

WEST **TRAVERSE D** **EAST**



BEDROCK (GRANITE) from seismic results	depth from surface	70'	156'	175'	239	210' 142'	122'	140'	143'	153'	195'	182'	138'	114'	69'	95'	82'	32'	15'
	RL (feet)	5,697	5,616	5,604	5,545	5,574 5,642	5,659	5,640	5,632	5,616	5,561	5,555	5,590	5,605	5,633	5,598	5,602	5,646	5,650

SCALES

HORIZONTAL 50 0 50 100 150 200 FEET
VERTICAL 50 0 50 100 150 200 FEET

CROSS-SECTION ALONG TRAVERSE D
SHOWING
SEISMIC RESULTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

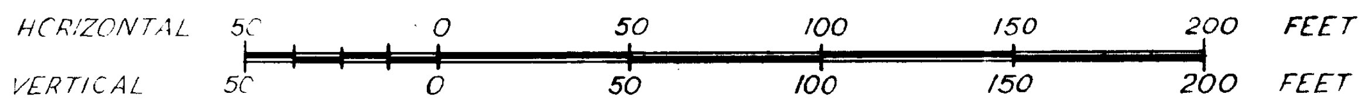
J55/B5-13

TO ACCOMPANY RECORD No.1964/119

PLATE 12

BEDROCK (GRANITE) from seismic results	depth from surface	15'	19'	44'	78'	75'	57'	78'	18'	37'	61'	67'	130'	89'	100'	101'	116'	149'	144'	131'	137'	118'	136'	105'	86'	86'	74'	54'	54'	71'
	RL (feet)	5,755	5,732	5,689	5,640	5,627	5,631	5,596	5,642	5,608	5,582	5,575	5,517	5,564	5,558	5,562	5,556	5,532	5,545	5,566	5,566	5,591	5,579	5,619	5,644	5,651	5,673	5,704	5,716	5,711

SCALES



CROSS-SECTION ALONG TRAVERSE H
SHOWING
SEISMIC RESULTS

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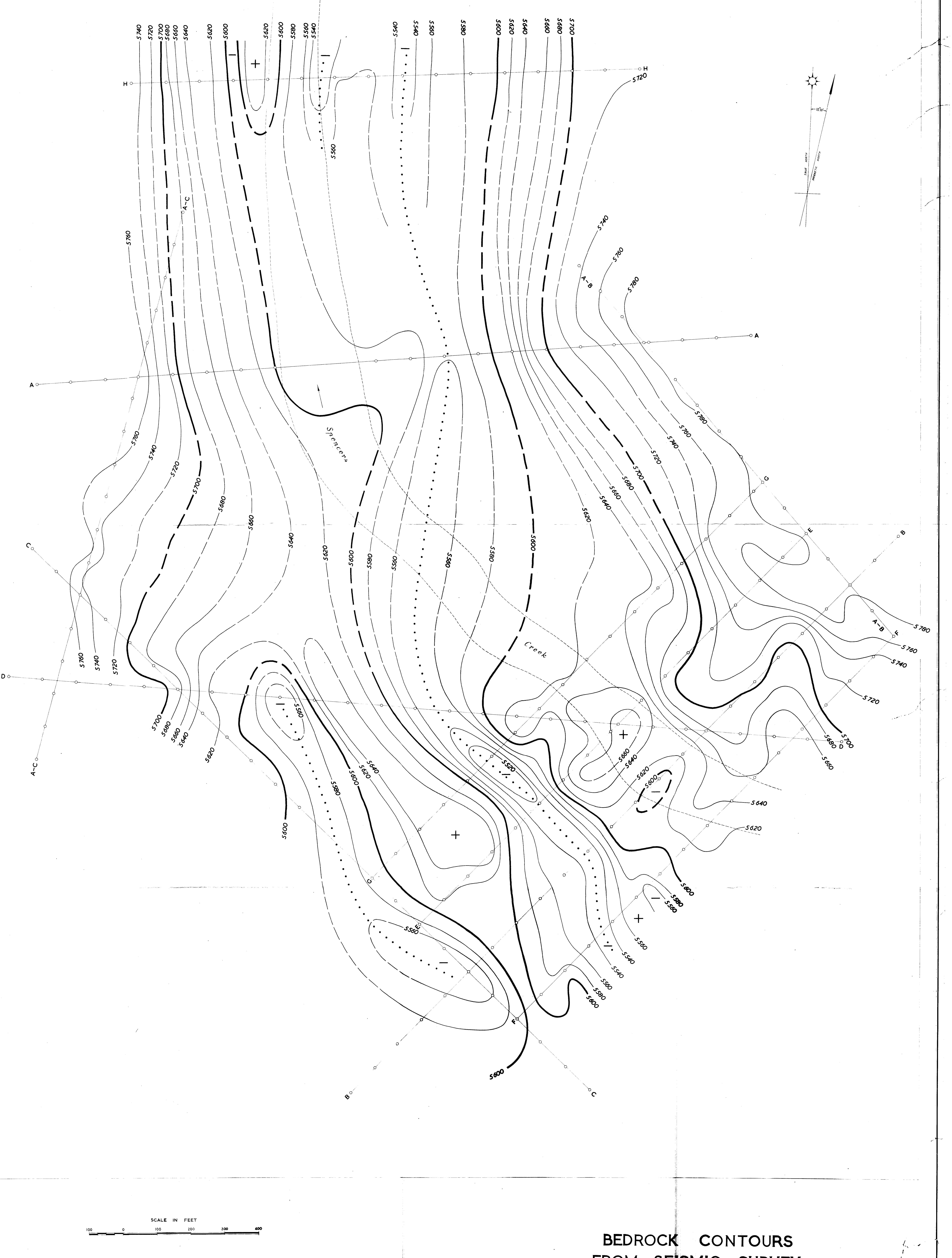
TO ACCOMPANY RECORD No. 1964/119



BEDROCK CONTOURS FROM SEISMIC SURVEY

Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics,

J55/B5-15

TO ACCOMPANY RECORD No. 1964/119