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TOPPER MOUNTAIN DEEP LEAD, GEOPHYSICAL SURVEYS, NEAR TINGHA, NSW, 1960-61

by

M.J. O'Connor

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SUMMARY

The Bureau of Mineral Resources made geophysical surveys over three alluvial tin prospects in the Tingha District, NSW during 1960-61. This Record describes the surveys over the Topper Mountain deep lead. The methods used in the surveys were seismic refraction, magnetic, and resistivity.

The results of the surveys showed that the seismic refraction and resistivity methods were able to detect the bedrock depressions with which the deep lead is associated. The seismic method allowed the computing of a bedrock contour plan on which could be recognised the most probable course of the deep lead. The resistivity method gave the locations of the bedrock depressions but did not measure the depths to bedrock.

The magnetic method was not successful in locating the deep lead but it delineated the boundaries of the basalt flows which cover the leads.

Three shaft or borehole sites are recommended to test the results of the geophysical survey.

1. INTRODUCTION

The township of Tingha is about 400 miles by road north from Sydney and 16 miles south-east of Inverell. The Topper Mountain deep lead extends from its origin, which is five miles north-east of Tingha, for about three miles to the Brickwood Extended lead, which is three miles north of Tingha. The geophysical survey described in this Record was made over the central and north-eastern portions of the Topper Mountain lead and a portion of Schumann's lead, which is a tributary of the Topper Mountain lead.

Tin was first discovered in the Tingha district in 1871. Between 1875 and 1955, over 67,000 tons of tin concentrate were produced from the Tingha district (Ivanac, Pearson, and Kalix, 1957). Although some lode tin has been mined in the area, most of the tin concentrate has been produced from alluvial deposits. The principal alluvial tin deposits were in stream gravels along Copes Creek (see Plate 1) which flows through the township of Tingha. These deposits have been worked by dredging and small-scale sluicing. Several deep leads have also been worked for tin by shaft-sinking and driving along, and across, the leads.

Geophysical surveys over deep leads in the Tingha area had previously been made by Rayner (1932). Rayner carried out a magnetic prospecting campaign chiefly (a) between the Topper Mountain and Brickwood leads and (b) immediately south and west of Gilgai. The ground magnetic method was used to trace the courses of the basalt-covered deep leads. In 1958 the Bureau of Mineral Resources made an airborne magnetic and radiometric survey over about 400 square miles in the Inverell 1-mile map area (Forsyth, 1960). This survey covered the area shown on Plate 1.

The geophysical survey described in this Record was made by the Bureau of Mineral Resources, at the request of the Department of Mines, NSW. The area was selected after a joint inspection of the Tingha tin district by E.O. Rayner and J.C. Lloyd, geologists of the NSW Department of Mines, and Dr J. Horvath, geophysicist of the Bureau, in June 1960. The objects of the survey were :

(a) to find out which geophysical methods were best suited to locating bedrock depressions, which could contain alluvial tin deposits, and

(b) to use these methods to delineate the extent of any such depressions.

Similar surveys were made in the Tingha area in 1960 and 1961 by the Bureau of Mineral Resources at Symes area (O'Connor, 1963a) and the Jealousy lead (O'Connor, 1963b). The geophysical field work at Topper Mountain was done in two periods, viz. in December 1960 and in June-July 1961. The 1960 geophysical party consisted of M.J. O'Connor (party leader), J.J. Hussin and E.N. Eadie (geophysicists), and four field assistants. In 1961, party leader O'Connor was assisted by geophysicists R.J. Smith and F. Maranzana and five field assistants. The topographical survey of the geophysical grid was made by Surveyor K. Watson of the Department of the Interior, Sydney, assisted by two chainmen.

2. GEOLOGY

The geology of the Tingha district, as described by Carne (1911) is shown on Plate 1. Tin released during erosion in Mesozoic and early Tertiary times became concentrated in the then-existing river channels. Oligocene basalts, which spread out over much of the New England plateau, filled in the old valleys, but subsequent erosion removed some of the basalt cover (Voisey, 1953). The concealed stanniferous leads derived their metal content from favourable parts of the bedrock, mainly from granite. Primary tin deposits of cassiterite occur in the acid granite and the basic 'Tingha' granite, but production has been considerably less than from the alluvial deposits (Ivanac et al., 1957).

At the Topper Mountain lead, the bedrock is acid granite. Several shafts have been sunk to bedrock along the lead. The depths to the granite bedrock are generally about 130 ft. A typical geological cross-section is the one encountered in Whites shaft near the southern boundary of ML 207 (see Plate 2).

Depth (ft)	Geological formation
0 - 40	concretionary or pisolitic ironstone
40 - 130	bouldery basalt
130 - 130½	fine white drift sand
130½ - 133	coarse water-worn wash with coarse water-worn black tin
133 -	soft granite bedrock dipping north-west

The basalt is very weathered, particularly in the top part of the flow.

The direction of the Topper Mountain lead is slightly south of west. Most of the buried channels in the Tingha area have this south-westerly trend which is also the trend of the present drainage system.

The Victorian shaft also falls within the area covered by the geophysical survey (see Plate 2). Other important shafts that were sunk to the Topper Mountain lead were Woods (west of area surveyed) and Sydney and Brisbane (both east of area surveyed).

3. METHODS AND EQUIPMENT

The applicability of geophysical methods to the problem of locating alluvial deposits has been discussed by O'Connor (in prearation). The methods used for the Tingha surveys were seismic refraction ('method of differences'), magnetic, and resistivity (Wenner electrode configuration, constant separation).

The seismic survey at Topper Mountain in December 1960 was done with an SIE refraction seismograph and TIC geophones of natural frequency 20 c/s. In 1961 a Midwestern 12-channel reflection/refraction seismograph and Electro-Tech geophones of natural frequency 20 c/s were used. The magnetic readings were made with an ABEM torsion magnetometer, model 4, which measured changes in the vertical magnetic field. An Evershed and Vignoles Geophysical Megger (0-30 ohm) was used for the resistivity measurements.

4. FIELD WORK AND RESULTS

The geophysical work done at Topper Mountain deep lead in 1960 was in the nature of a test survey. Six parallel traverses were pegged and surveyed between 9000E and 11,500E. The traverses ran in a north-westerly direction and were spaced 500 ft apart. In 1961, an intermediate traverse (Traverse 9750E) was pegged and surveyed, as well as nine traverses between 12,000E and 16,000E; these traverses were parallel to the traverses of the 1960 survey and similarly spaced 500 ft apart. In the eastern part of the area, Traverses 250N, A, and B were put across Schumann's lead.

Pegs were placed every 50 ft along the traverses and the level was taken at the base of each peg. Plate 2 shows the traverse layout and the surface contours.

Seismic

Fifteen traverses were surveyed by the seismic method. Traverses 9500E, 10,000E, and 11,500E were done in 1960 and Traverses 9750E, 12,000E to 13,500E, 14,500E to 16,000E, 250N, A, and B were done in 1961. The total length of seismic traverses was almost 30,000 ft. There were 75 normal spreads and 18 weathering spreads. In the normal spreads the geophones were placed at 50-ft intervals and the shot-points were generally from 400 to 500 ft beyond both ends of the spreads. In some cases, mostly near the deep lead, shot-points were also placed at both ends, and at the centres of the spreads. In the weathering spreads, geophone intervals were 10 ft and shots were fired at 5 ft and 100 ft beyond both ends of the spreads.

From the results obtained from normal spreads, the vertical travel times (VTT) to the bedrock were computed using the 'method of differences'. These VTT were converted to depths to bedrock by using conversion factors (Dyson and Wiebenga, 1957) that were computed from the information obtained from normal and weathering spreads. The seismic cross-sections are shown on Plate 3 and a bedrock contour plan on Plate 4. Although there were several deep shafts in the area covered by the survey, they were not open at the surface and therefore could not be used for velocity logging.

Magnetic

All the traverses at Topper Mountain except Traverse 9750E were surveyed by the magnetic method. Traverses 9000E to 11,500E were surveyed in 1960 and the remainder were done in 1961. Readings were made at 50-ft intervals along the traverses over a total length of 40,500 ft. The magnetic profiles are shown on Plate 5.

Resistivity

Resistivity profiles were made along Traverses 10,000E and 11,500E in 1960 and along Traverses 9000E, 9750E, and 12,000E to 13,500E in 1961. The Wenner configuration of electrodes was used with a constant spacing of 150 ft. The resistivity profiles are shown on Plate 7. The apparent resistivities have been plotted on a logarithmic scale and the distances along the traverses on a linear scale. The resistivity work in 1960 was done within a few days after very heavy rain. The results were easily obtained and the profiles were smooth. In 1961, resistivity measurements were commenced on 15th June after heavy rains on 10th June, and Traverses 9750E, 12,000E and 12,500E were measured. On the 16th June Traverses 13,000 and 13,500 were measured and Traverse 9000E was measured on the 17th June. It can be seen from the profiles that the resistivity results became less reliable with each successive day. The resistivity survey was abandoned on the 17th June when it was found that readings could not be repeated.

5. INTERPRETATION OF RESULTS

Seismic

The results on Plates 3 and 4 show that the seismic method can be used to trace the course of the Topper Mountain deep lead beneath the basalt cover. The profiles of the granite bedrock have been drawn after analysis of the seismic results along each traverse. It was assumed that the deep leads would be located in the depressions in the bedrock. These indicated depressions in the bedrock can be seen in the profiles on Plate 3. The profiles show that the bedrock topography is more pronounced in the eastern part; the valleys are narrow there but they widen out towards the west.

The probable course of the main deep lead has been traced on the bedrock contour plan (Plate 4) from 16,000E to 9500E. The course of the lead, as indicated by the seismic work, is quite straight between 16,000/1700N and 13,500E/1950N and the seismic work suggests that there is no appreciable drop in the level of the lead over that portion but that the lead drops about 30 ft in level between 13,500E and 13,000E and that it rises about 10 ft between 13,000E and 12,500E. It is doubtful whether the actual lead would in fact have such a rise and fall. Owing to lack of information relating to the vertical velocity in the overburden, the conversion factors were computed by using the velocities obtained from the time/distance curves. This could have caused errors in the depth calculations. Although the seismic method is able to indicate the positions of the bedrock depressions with which the deep leads are associated, the depth calculations to these depressions may be sufficiently in error to indicate local apparent anomalies. The bedrock level determined by the seismic method is that of the unweathered bedrock and will generally be somewhat deeper than the bedrock level recorded in the drill holes; the difference in depth depends upon the strength of the weathering process. The differences in extent of weathering could also account for some anomalies found along the course of the lead, e.g. reversal of the fall or basin-like contours. This must be remembered when studying the bedrock contour plan computed from seismic work. The bedrock contour plan on Plate 4 shows the lead as being flat between Traverses 12,500E and 12,000E and a sharp fall then to Traverse 11,500E. There is a gap of 1500 ft on the next traverse and it appears as if there could be a splitting of the lead over this portion, ie between Traverses 11,500E and 10,000E. The seismic work suggests that there are two bedrock depressions beneath Traverses 10,000E and 9750E but only one broad depression along Traverse 9500E.

The seismic work also indicates some bedrock depressions that could have tributary leads associated with them. One such depression was detected near 12,500E/2400N and it is possible that there is a tributary lead coming from the north-east associated with it. Traverse 15,500E was extended to 1300S and it appears as if two tributary leads could cross this traverse, one near 300N and the other near 550S, and then join together before crossing Traverse 16,000E near 700N.

The seismic records obtained from shooting along the traverses over Schumann's lead were difficult to read because here the higher-frequency seismic waves were not recorded. The first-breaks of the lower-frequency waves were not easily recognisable; for Traverse A (parallel to Traverse B and 500 ft north-east of it), these times could not be estimated with sufficient accuracy to allow reliable vertical calculations of the depths to bedrock to be made, For this reason the seismic cross-section along Traverse A has not been included in Plate 3.

The seismic velocities measured in the granite bedrock (see Plate 3) range between 10,000 and 20,000 ft/sec. Along most of the traverses, the velocity is lower in the bedrock 'valleys' than in the bedrock 'hills'. This is probably due to the old streams having followed zones of weakness in the granite. In the zones of weakness the seismic velocity is less than in unaltered granite.

Magnetic

The magnetic results from the Topper Mountain lead area show some interesting features. The airborne survey (Forsyth, 1960) by the Bureau of Mineral Resources in 1958 covered an area on the Inverell one-mile series that included the boundaries of the geological sketch plan on Plate 1. Briefly summarising the main results of that survey, the most intense magnetic anomalies are associated with the occurrence of basalt flows; appreciably less-intense anomalies occur over areas describes by Carne (1911) as 'acid' granite, and the magnetic field over the 'Tingha' granite is almost free of anomaly, apart from the regional gradient.

The main features of the ground magnetic survey are:

(a) the more intense magnetic anomalies are connected with the basalt deposits, the lateral limits of which can be determined from the magnetic profiles,

(b) it appears as if there have been at least two basalt flows covering the deep lead. The original flow is characterised by the weak magnetic anomalies that occur between Traverses 13,000E and 15,000E, and the later basalt flow is associated with the stronger anomalies,

(c) the very strong magnetic anomalies that were measured at the southern ends of Traverses 14,500E to 15,500E could be associated with a basalt flow covering a tributary deep lead,

(d) the magnetic profiles along Traverses 250N, A, and B which cross Schumann's Lead. The magnetic anomalies along Traverse 250N would suggest that there is basalt underlying the soil between about 16,100E and 17,000E and also near 17,400E. Along Traverse A, the magnetic readings were extraordinarily disturbed over the whole length covered by the magnetometer. It seems probable that Traverse A runs near the edge of a basalt flow. The magnetic profile along Traverse B shows some small anomalies that could be caused by underlying basalt but may be due to the 'acid' granite.

The later basalt flow need not have any close relation with the position of the main deep lead at Topper Mountain and therefore the magnetic results are not helpful in tracing the course of the lead except where the anomaly due to the previous basalt flow can be recognised. This occurs between Traverses 13,000E and 15,000E, where the magnetic maxima were recorded at 75 to 200 ft north of the corresponding seismic indication of a bedrock depression (see Table 1).

Resistivity

With the Wenner electrode configuration, the depth of penetration is roughly equal to the electrode separation of the potential electrodes which in this case was 150 ft. Where the resistivity of the bedrock is higher than that of the overburden, it can be expected that the apparent resistivity is a minimum where there is the greatest thickness of lower-resistivity material (overburden) above the bedrock. It is interesting to compare the results of the seismic survey with the resistivity results (see Table 1)

TABLE 1

Comparison of geophysical results at Topper Mountain lead

Traverse	Seismic indication of bedrock depression	Resistivity minimum	Magnetic maximum
13,500E	1950N	1950N	2050N
13,000E	2050N	2150N	2200N
12,500E	1950N	1825N to 1975N	Large fluctuations
12,000E	2050N	2175N to 2025N	" "
11,500E	2250N	2250N to 1975N	" "
10,000E	3050N	3075N	" "
	2300N	2275N to 2425N	" "
	1775N		" "
9750E	2300N	2325N	
	2100N	2175N	

It will be noticed that in most cases there is good agreement between the seismic locations of bedrock depressions and the resistivity minima. After the promising resistivity results obtained along Traverses 10,000E and 11,500E in 1960, it was decided that for the 1961 survey, the resistivity results should be used as a guide to the location of deep leads so that the length of traverse to be surveyed by the seismic method could be reduced. However, this plan had to be abandoned as it was impossible to persist with the resistivity method owing to the effects of the dry soil cover. As the soil dried out after the rain had fallen, it became increasingly difficult to obtain reliable measurements.

6. CONCLUSIONS AND RECOMMENDATIONS

The geophysical survey at the Topper Mountain lead has shown that the seismic refraction and resistivity methods were applicable to tracing the course of the basalt-covered lead.

The seismic refraction method indicated the depressions in the bedrock with which the deep lead would be associated. As well as indicating the location of these depressions, the seismic method also gave estimates of their depths. Unfortunately there were no suitable shafts or drill holes in the area that could be used for vertical velocity determinations. The depth calculations were made by using the horizontal velocity information measured from surface spreads, and the accuracy of the results was naturally less than the accuracy that could have been obtained if vertical velocity determinations had been practicable.

The resistivity results were qualitative rather than quantitative. They indicated the location where the overburden was thickest, but did not give a measure of the thickness. However, by using an 'expanding electrode' method, it may be possible to obtain a measure of the overburden thickness, but it would be most unlikely that such resistivity work could give quantative results with the same degree of accuracy as the seismic refraction method.

The magnetic method was useful in delineating the areas over which basalt had flowed. There were no basalt outcrops in the area; the basalt was hidden under a covering of detrital and alluvial material. Magnetic anomalies with a wide range of intensities were recorded over the basalt deposits. The more intense anomalies were probably due to a later basalt flow, and over most of the main deep lead these anomalies have obscured the smaller anomalies caused by the earlier basalt flow which covered the stanniferous wash in the old streams.

The most likely place for an accumulation of tin along the lead would be where there are bends in the lead and at the bottom of a sudden drop in the lead. Guided by the seismic contour plan (see Plate 4) the best place in the area covered by the geophysical survey would be near 11,500E/2250N. It is recommended that a drill hole or shaft be sunk to bedrock at this point. The depth of bedrock at this point was estimated by the seismic work to be about 160 ft.

Another place where tin could be expected is near 12,000E/2050N, if the tributary lead assumed because of the bedrock depression indicated at 12,500E/2450N is tin-bearing and joins the main lead as drawn on Plate 4.

Farther upstream, a drill hole or shaft site is recommended at 16,000E/675N.

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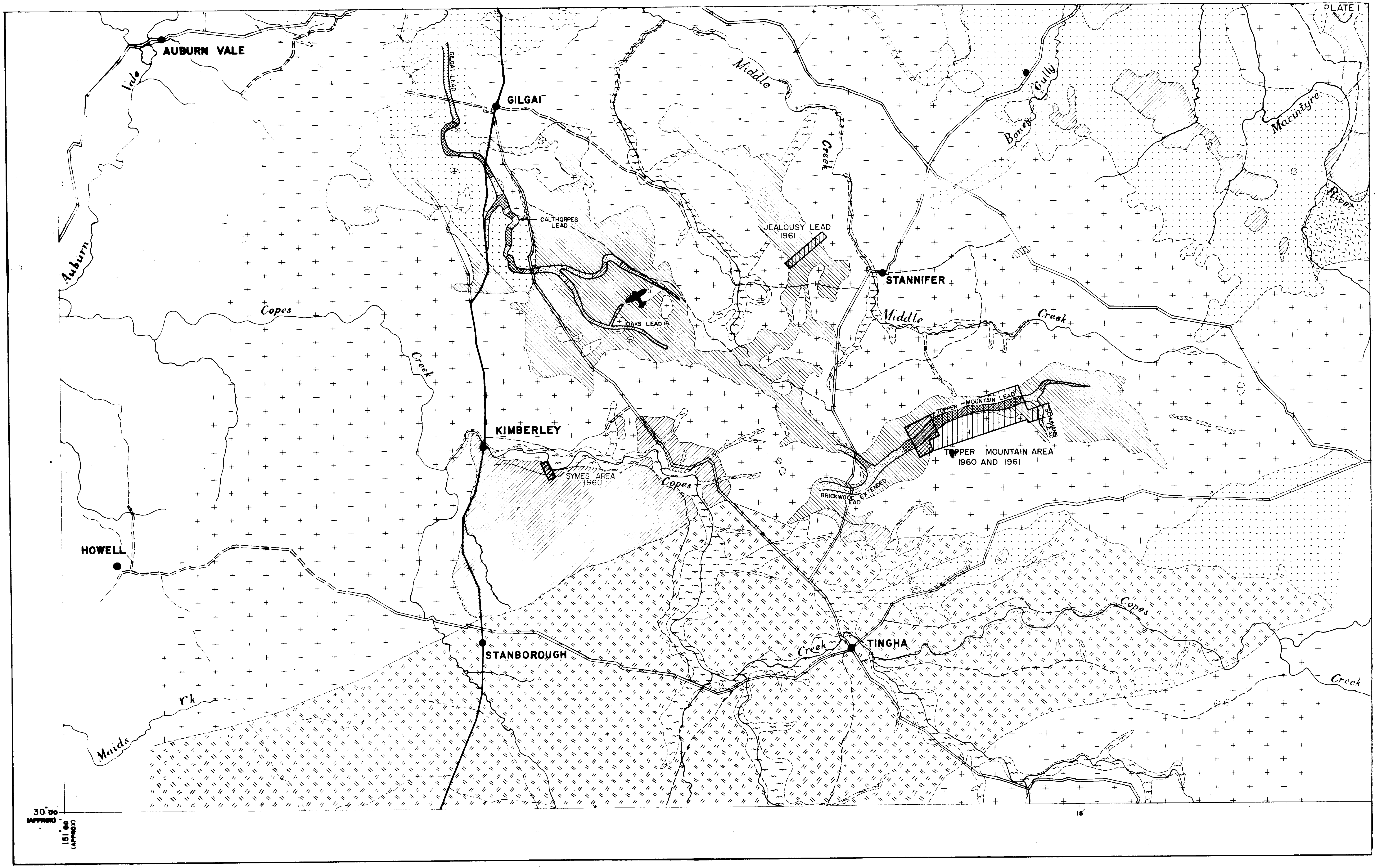


GEOLOGY

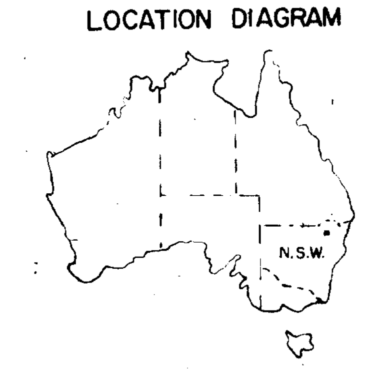
Recent and Pleistocene		Alluviums and drifts along stream channels (worked)
Tertiary		Red soil, concretionary iron oxide (bauxitic) in places overlying basalt and covering early drainage channels ("leads") Frequently cloaked with granite soil, obscuring boundaries
		Basalt overlying in many parts ancient tin-bearing stream channels ("leads")
Upper Paleozoic Permo-Carboniferous		Sandstones, quartzite, jointed slates and cherts much altered by granitic and porphyritic intrusions
		"Tingha" granite (basic)
		Acid granite probably intrusive in "Tingha" granite
		Quartz porphyry, intrusive in Upper Palaeozoic, "Tingha" and acid granite

The basalt boundaries are generally only approximate

Well tested or worked leads
Unworked leads
Unworked leads (probable course only)
(Rayner, 1932)

M.N. T.N. 10½°

(BASED ON G345-2)



1-MILE MAP REFERENCE

WARIALDA	BYRON	GLEN INNES
BINGARA	INVERELL	GLENCOE
COBBADAH	TINGHA	LLAN GOTHIM

LEGEND

TOPOGRAPHICAL DATA

RIVER OR CREEK — MAIN ROAD
ROAD — TRACK
TOWNSHIP — AERODROME
GEOPHYSICAL SURVEY 1960
" " 1961

GEOPHYSICAL SURVEY FOR ALLUVIAL TIN DEPOSITS, IN THE TINGHA AREA, NEW ENGLAND DISTRICT, NSW, 1960-61

GEOLOGICAL SKETCH MAP

(AFTER CARNE, 1911)

SCALE

MILES 1 0 1 2 3 4 5 MILES

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS. H 56/ B7-5-2
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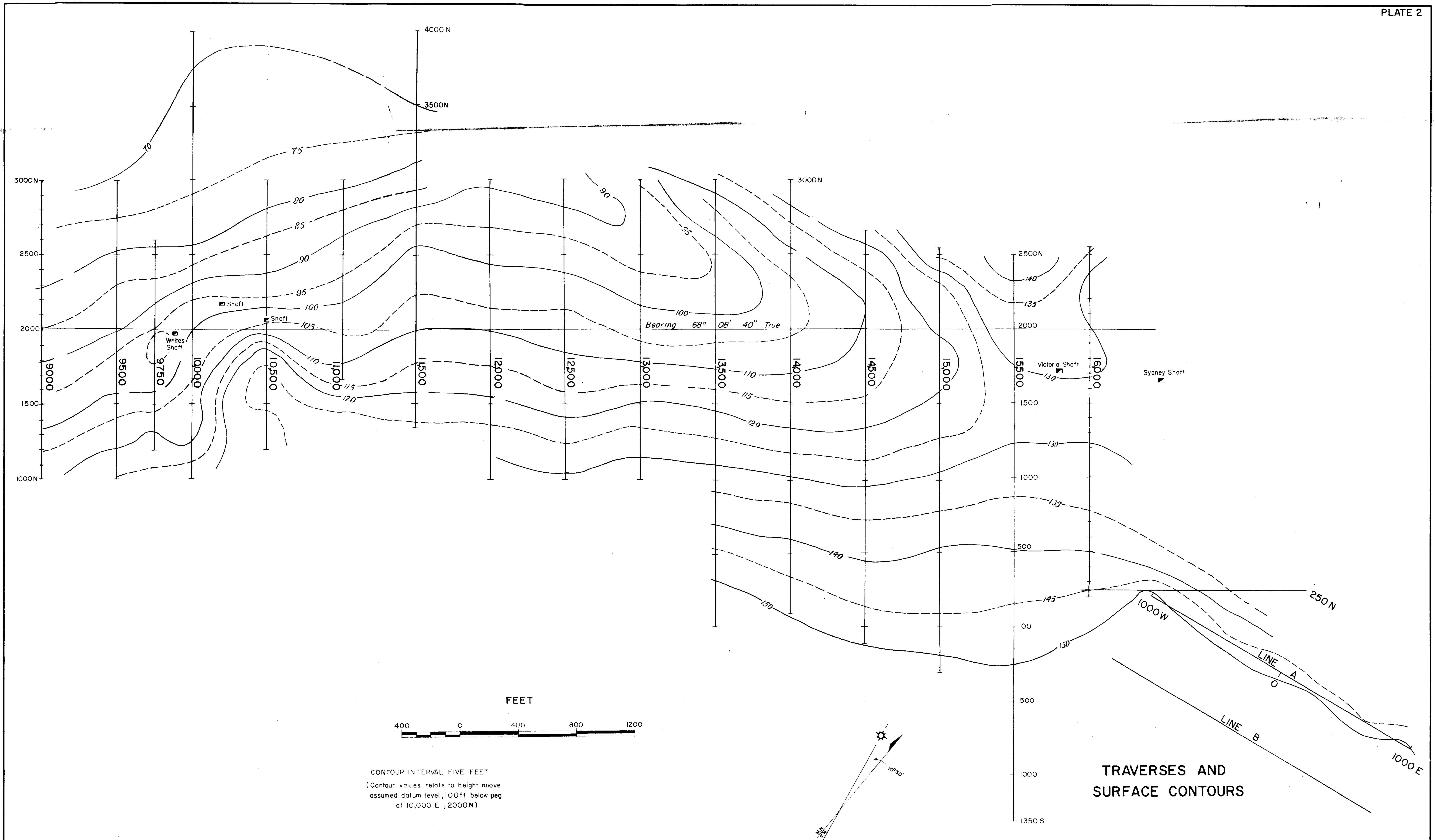
TINGA TOPPER MNTN.



(Based on Dept of the Interior negative no's 11913 and 2015 NSW)

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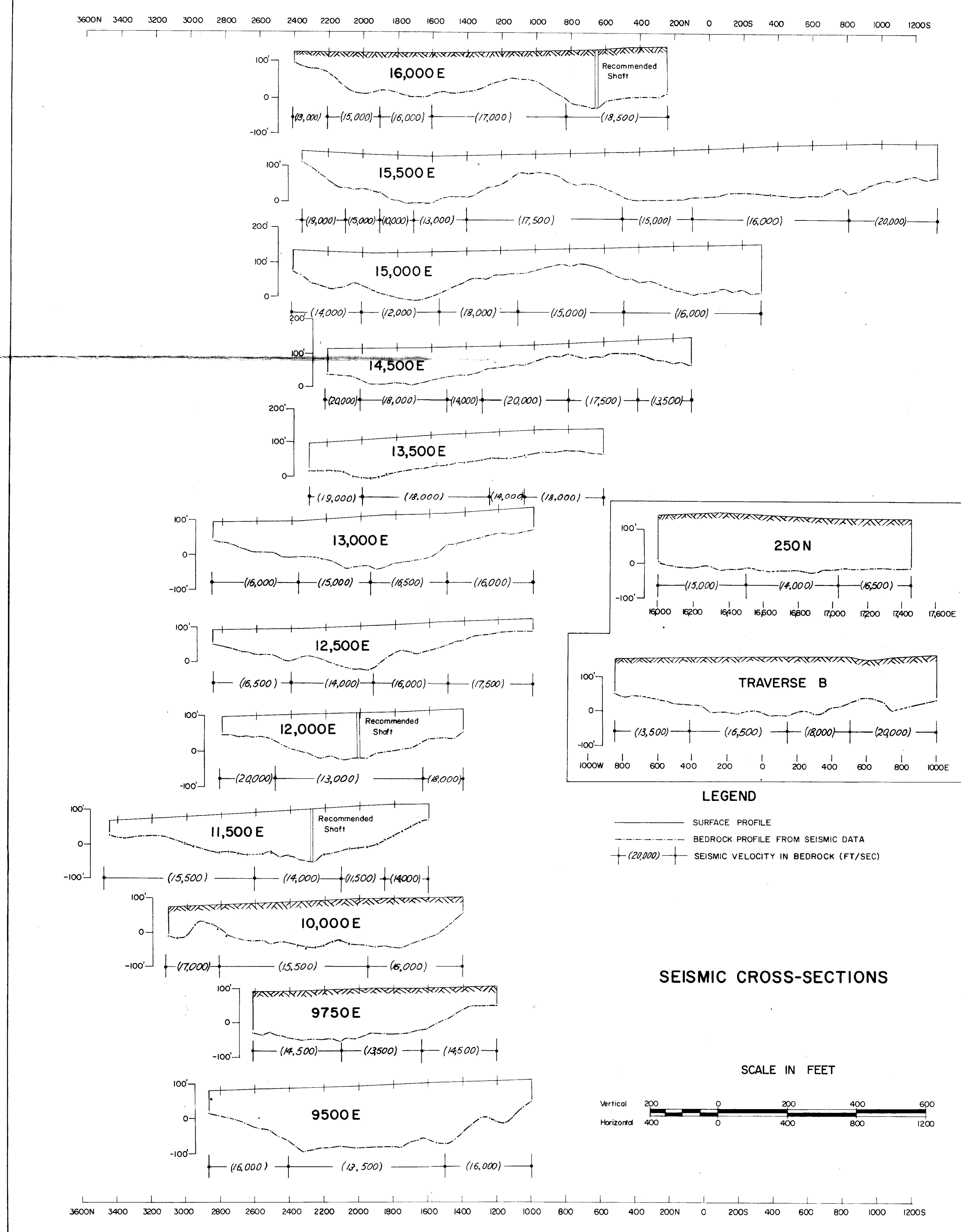
PLATE 3



SEISMIC CROSS-SECTIONS

TOPPER MOUNTAIN NEAR TINGHA N.S.W. 1960-61

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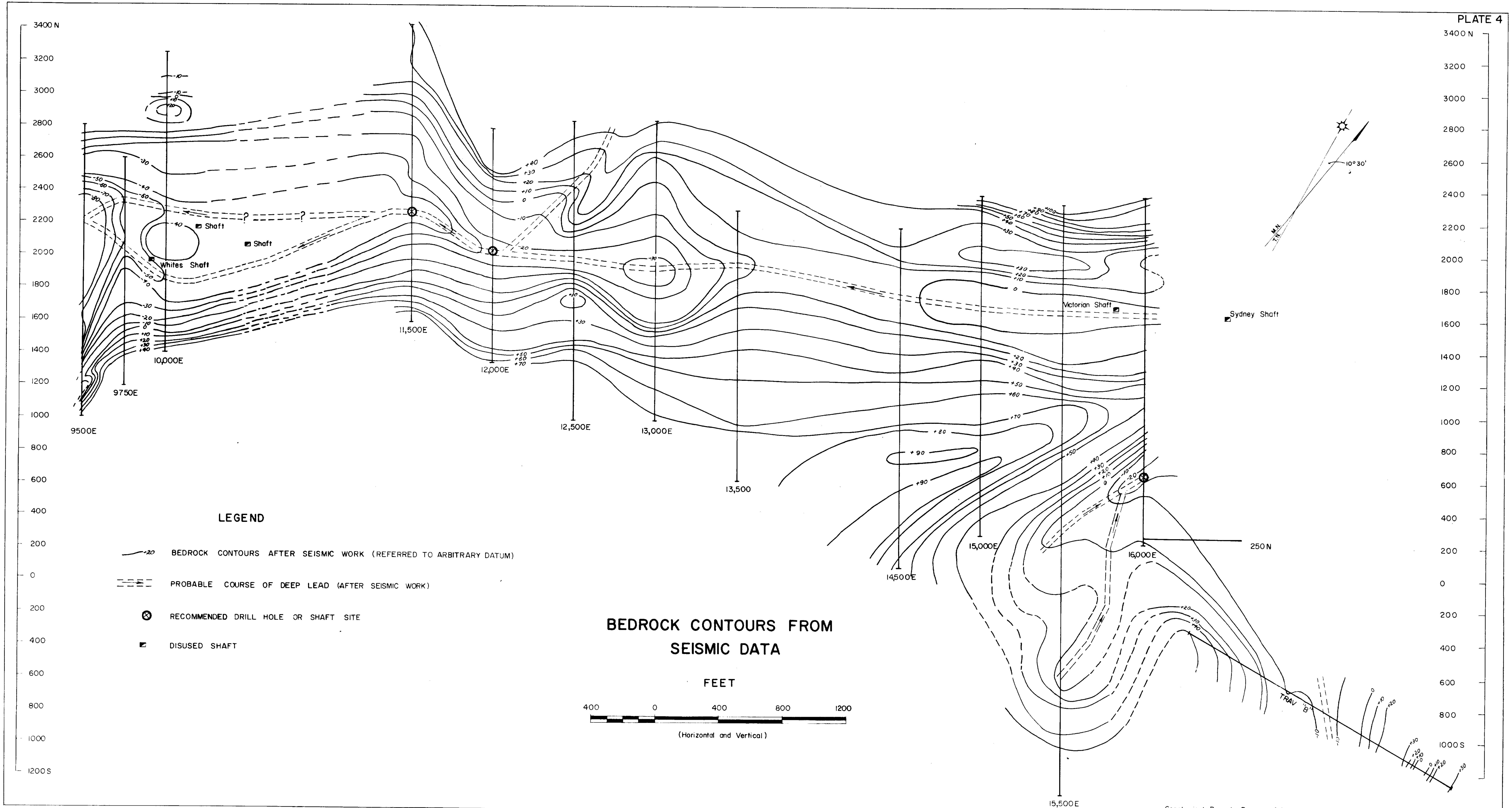
PLATE 4



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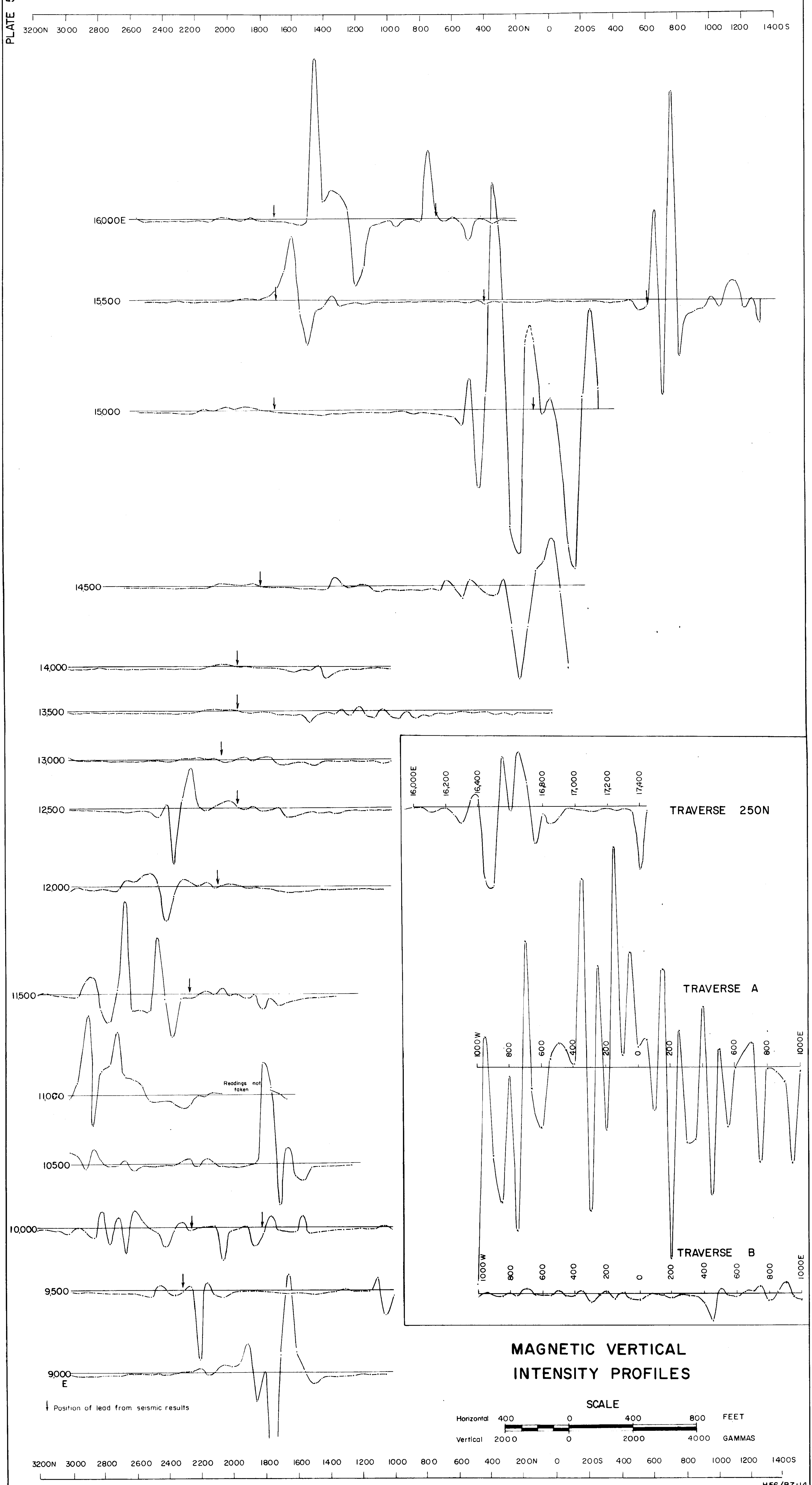
Copper Mountain Near Tingha N.S.W. 1960-61

PLATE 5



MAGNETIC VERTICAL INTENSITY PROFILES

H56/B7-14

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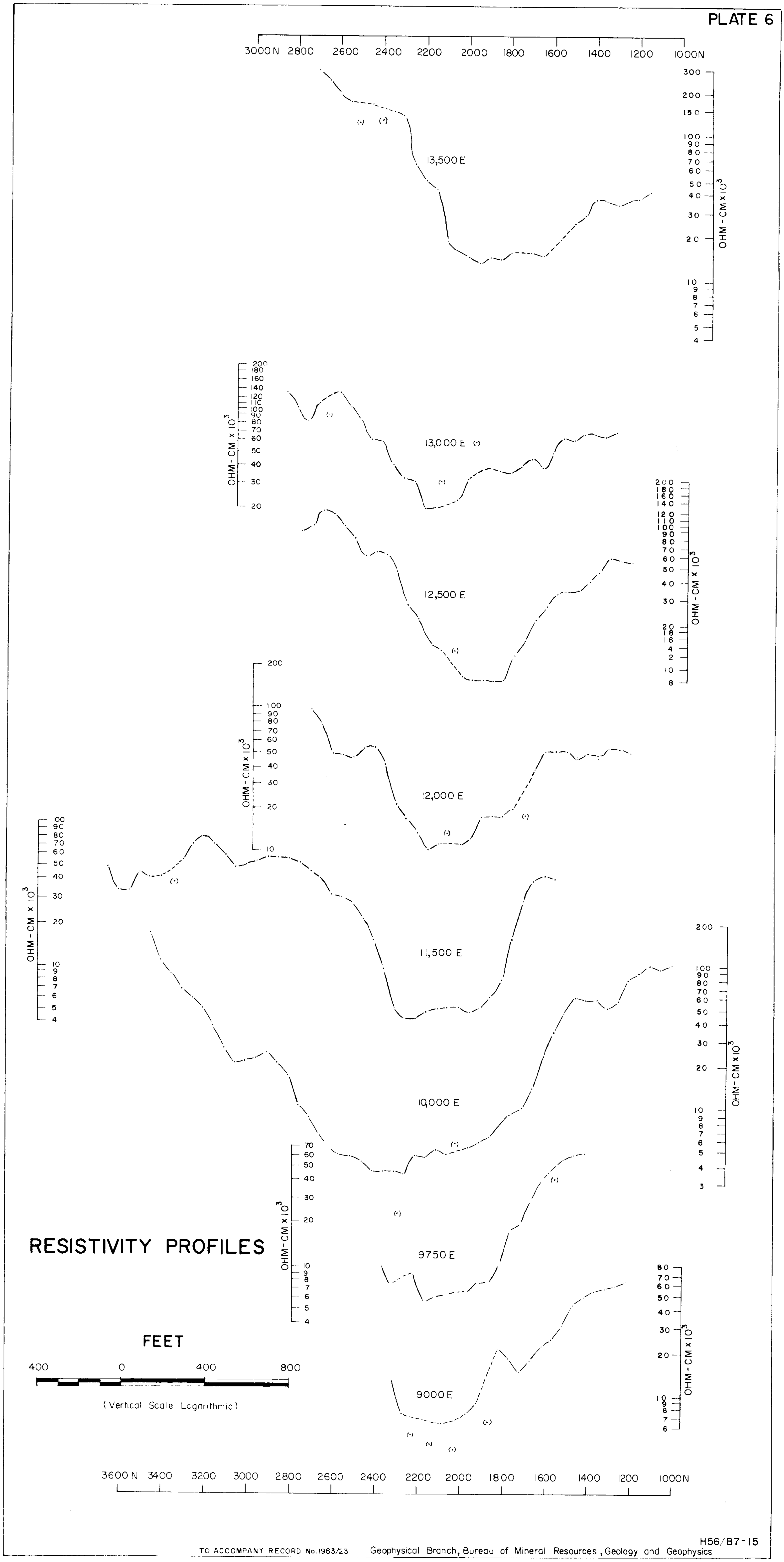

Copper Mountain near Tingha N.S.W. 1960-61