COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORDS 1958, No. 71

GEOPHYSICAL SURVEY AT THE
YITHAN ALLUVIAL TIN MINE,
ARDLETHAN, N.S.W.

by
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ABSTRACT

A seismic refraction survey was made in the area around the Yithan Alluvial Tin Mine, N.S.W., which is operated by Prospectors Pty.Ltd. Fifteen traverses were surveyed, thirteen of these being in an area to the north of the main shaft. Depths to unweathered bedrock were computed at fifty-foot intervals along the traverse and profiles and a contour plan of the unweathered bedrock were drawn.

The survey indicated that the main lead to the north of No.3 shaft does not continue in the same direction as the known lead between the main shaft and No.3 shaft, but swings to the north-west. Further upstream, a junction of two leads was indicated near traverse Q, one from the north and one from the north-west.

Results also indicated a tributary lead joining the main lead near No.3 shaft. In the northern part of the area, a large depression in the bedrock was indicated; this could have an important influence on the tin distribution in the lead, Several lines of drill-holes have been recommended to test the geophysical indications of the position of the lead.

1. INTRODUCTION

The Yithan Alluvial Tin Mine is situated near the old village of Yithan, about 3 miles north-west of the township of Ardlethan, New South Wales, which is 343 miles west of Sydney.

Tin was discovered in the area in 1912 at the White Crystal Mine near Yithan. The White Crystal and Carpathia Mines proved to be very rich and a wild boom followed in which hundreds of leases were taken up, many of them of no economic value (Godfrey, 1915). Tin was mined from a shallow lead on a false-bottom between the Carpathia and Southern Cross hillsides. Mt.Isa Mines Pty.Ltd., which exercised an option over the White Crystal leases at Yithan, began a drilling programme in March 1951 to the north, south and east of the White Crystal leases in search of alluvial tin. The drilling revealed a tin-bearing lead at a depth of about 160 feet, approximately ¾-mile to the south-east of the White Crystal leases. Because of the large thickness of overburden, it was decided to mine the tin rather than adopt the normal procedure of hydraulic sluicing. In 1952, No.1 shaft was sunk to the deep lead. Two more shafts were sunk later, but No.2 shaft was abandoned due to the collapse of the underground workings. In 1953, Mt.Isa Mines Pty.Ltd., abandoned the option over the White Crystal leases and it was taken up by Prospectors Pty.Ltd., who began working the deep-lead tin in the same year.

A seismic refraction survey was carried out by the Bureau of Mineral Resources in 1949 to locate possible deep leads in the alluvial area immediately to the east of the Bygoo Mines (Urquhart, 1956), which are 4 to 5 miles north of Yithan (see Plate 1).

The present report describes the geophysical survey made by the Bureau over the alluvial ground around the Yithan Tin Mine. The survey was requested by Prospectors Pty.Ltd. and the request was supported by the Department of Mines, New South Wales. The object of the survey was to detect and follow the course of the tin-bearing deep lead worked in two shafts of the Yithan Tin Mine.

J.Horvath, a senior geophysicist of the Bureau, inspected the area with A.A.C.Mason, of Prospectors Pty.Ltd., in May, 1956. Six traverse lines A to F, were later surveyed and pegged by Surveyor L.Daws of Prospectors Pty.Ltd. Nine additional traverse lines were subsequently surveyed and pegged by the geophysical party. The geophysical party consisted of M.J. O'Connor (party leader) and L.V. Skattebol, geophysicists of the Bureau of Mineral Resources. The survey was made between September and November, 1956. Two field assistants were supplied by Prospectors Pty.Ltd. for the duration of the survey, mainly to drill shot holes.

2. GEOLOGY

The geology and mineralisation of the Ardlethan area have been described by Godfrey (1915), Harper (1919), and Garretty (1953).

The Ardlethan Tin Field lies on the eastern edge of a line of low hills west of the township of Ardlethan. Tin deposits occur along the eastern margin of a north-trending belt of granite, approximately 12 miles long by 5 miles wide, which has intruded Silurian sediments. The sediments, which consist of quartzites, micaceous sandstones, slates and breccias, have a westerly dip and have been altered to mica schists close to the granite contact. In places, the granite has been extensively altered to quartz-tourmaline rock and greisen. Tin lodes are associated with this altered rock.

The lode tin occurs as cassiterite in places accompanied by small amounts of wolfram and various sulphides. The primary tin occurs in pipes, as at the Carpathia Tin Mine, and in veins, as at the Wild Cherry Mine. In general, the primary ore shoots are small.

The alluvial tin is found in leads or stream channels. The tin values are found mainly in the wash consisting of fragments of decomposed granite and sedimentary rocks embedded in a red clay. In places, large tin nodules are found but most of the tin is much finer, ranging in size from that of granular sugar to walnuts. The alluvium consists mainly of red lateritic and sandy clay which rests on the weathered bedrock of granite or Palaeozoic sediments (mainly slates). The depth to weathered bedrock in the surveyed area is about 150 feet and the width of the tin-bearing wash is roughly 100 feet. The tin values are found mainly in the deep lead on the uneven floor of the bedrock. Although in the Yithan Mine the tin is produced exclusively from the deep lead, tin values are also found in horizons nearer to the surface. In particular, a lead about 30 feet deep resting on a harder layer in the clay - a false-bottom - was mined in earlier days. Production from this lead was never as great as that from the deep lead.

3. APPLICABILITY AND DESCRIPTION OF METHOD.

The seismic refraction method was used in this survey because of the nature of the problem. Although there is no known geophysical method of detecting the tin in a deep lead directly, the seismic refraction method may be used to determine the position of the deep lead. By using this method the depth from the surface to the unweathered bedrock along each seismic traverse is determined and from this information the profiles of the unweathered bedrock beneath the traverses can be drawn; if the traverses are closely spaced, a contour map of the top of the unweathered bedrock can be compiled.

The upper surface of bedrock on which the tin bearing wash rests is weathered. If the thickness of this weathered bedrock is uniform, the profile of unweathered bedrock will parallel that of the weathered bedrock at a lower elevation and the contours of unweathered bedrock will indicate accurately the positions of the leads. However tests over known sections of the lead indicate that the depth of weathering is variable, ranging from 50 to 80 feet and this complicates the interpretation of the unweathered bedrock profiles.

The magnetic method of survey has also been used for detecting buried leads where there is a concentration of magnetite associated with the lead.

In the seismic refraction method, elastic waves are set up in the earth by detonating an explosive charge at, or near, the surface. The velocity of propagation of these waves is governed by the elastic constants of the ground through which they travel.

Consider a two-layer case (Fig. 1), in which the velocities of the elastic wave in the upper and lower layers are V_1 and V_2 respectively. Then, applying Snell's Law of Refraction:-

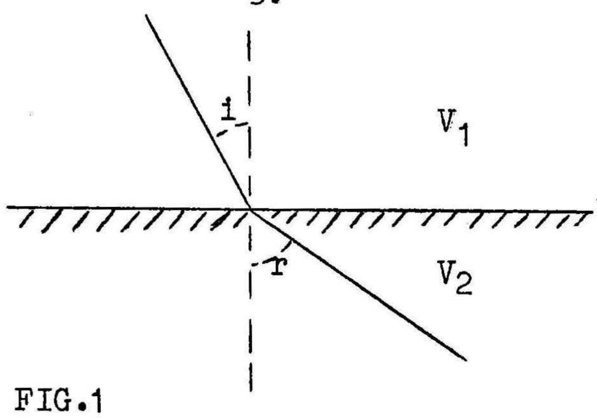

FIG.1

$$\frac{\sin i}{\sin r} = \frac{V_1}{V_2}$$ where i = angle of incident wave, r = angle of refracted wave

If V_2 is greater than V_1, then for a certain critical angle of incidence, i_c, the angle of refraction is 90^o, and the wave travels along the interface of the two layers with velocity V_2. The above equation becomes:-

$$\text{Sin } i_c = \frac{V_1}{V_2}$$

In the "Method of Differences" (Broughton Edge and Laby, 1931) used in this survey, eleven detectors (geophones) were placed at equal intervals (usually 50 feet) along a traverse and shots were fired at sufficient distances from either end of the spread of geophones for the geophones to record refraction times from the bedrock over the entire spread. In Fig.2, C represents one geophone of the spread, and A and B are reciproval shot points. The times for the refracted waves from shot points A and B are given by:-

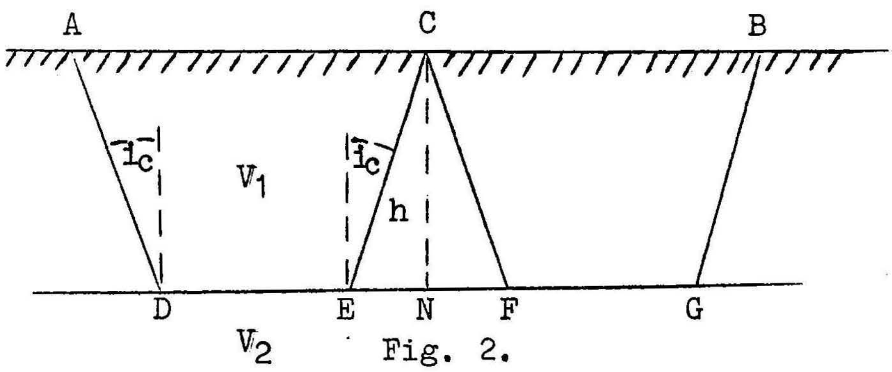

Fig. 2.

$$T_{ADEC} = t_1 = \frac{AD}{V_1} + \frac{DE}{V_2} + \frac{EC}{V_1}$$

$$T_{BGFC} = t_2 = \frac{BG}{V_1} + \frac{GF}{V_2} + \frac{FC}{V_1}$$

$$T_{ADGB} = t_3 = \frac{AD}{V_1} + \frac{DG}{V_2} + \frac{GB}{V_1}$$

$$t_1 + t_2 - t_3 = \frac{EC + FC}{V_1} - \frac{EF}{V_2}$$

$$= \frac{2h}{V_1 \cos i_c} - \frac{2h \tan i_c}{V_2}$$

$$= \frac{2h}{\cos i_c} \left\{ \frac{1}{V_1} - \frac{V_1}{V_2^2} \right\} \quad \text{since } \sin i_c = \frac{V_1}{V_2}$$

$$= \frac{2hV_2}{\sqrt{V_2^2 - V_1^2}} \left\{ \frac{V_2^2 - V_1^2}{V_1 V_2^2} \right\} \quad " \quad \cos i_c = \sqrt{1 - \left(\frac{V_1}{V_2}\right)^2}$$

$$= \frac{2h}{V_1} \times \frac{\sqrt{V_2^2 - V_1^2}}{V_2}$$

For values of $V_2 \gg V_1$ this reduces to $\frac{2h}{V_1}$. The times t_1, t_2, and t_3, can be measured from the seismic records. V_1 was measured by firing small charges at the bottoms of No.1 and No.3 shafts and recording the times for the elastic wave to reach geophones at the surface.

The depth h was calculated from the formula:-

$$h = \frac{t_1 + t_2 - t_3}{2} \times V_1$$

The mean value obtained for V_1 was 3,100 feet/second, which is the average velocity from the surface to the bottom of the wash (about 160 feet). V_2 velocities ranged from 9,000 feet/second to 20,000 feet/second.

Weathering spreads, using smaller geophone spacings, were also shot in order to measure V_1, but these did not prove successful due to the presence in the clay of a cemented layer with a velocity of about 4,500 feet/sec. This higher velocity layer prevented measurement by seismic refraction methods of the velocity in that part of the over-burden beneath it. The cemented layer was also found by Urquhart (1956) in the seismic survey in the Bygoo area.

4. FIELD WORK AND RESULTS.

Forty-four normal spreads, with geophone spacings of 50 feet, and three weathering spreads, with geophone spacings of 10 feet, were shot. The total length of traverse surveyed was about 19,500 feet.

The equipment used was a Heiland 12-channel seismograph mounted in a Land Rover. The shot-holes were bored by means of a post-hole digger driven from a Land Rover power take-off. For normal spreads, the depth of the shot-holes ranged from 3 feet to 20 feet, the average being 7 feet. The explosive charges ranged from 1 lb. to 4 lb. of 60 per cent gelignite, the average being 2½ lb.

The depths to unweathered bedrock were computed by the "Method of Differences" (see section 3). Plates 2A, 2B and 2C shows the surface profiles and the profiles of the unweathered bedrock as computed from the seismic results. Plate 3 is a contour map of the surface of the unweathered bedrock, drawn from the profiles of Plates 2A and 2B.

Readings with a vertical force magnetometer were taken along traverses F and G. As the magnetic profiles did not show any significant anomalies the method was not persevered with. Because the magnetic results are not significant, they are not included in this report.

5. DISCUSSION OF RESULTS

The seismic profiles along traverses C and D (Plate 2A) indicate a depression in the unweathered bedrock which is both wider and deeper than the depressions indicated along any of the other traverses. Traverses C and D are the only ones which cross the worked portion of the deep lead. On traverse C, the centre of the depression was found by the seismic survey to be about 50 feet east of the centre of the wash, and 55 feet below it. On traverse D, the centre of the seismic depression was found to be about 50 feet east of the centre of the wash and 80 feet below it. This suggests that the depth of weathering of the granite is not uniform and that the position of the deep lead may be slightly displaced laterally from the centre of the depression in the unweathered bedrock as indicated by the seismic results. The seismic profiles along traverses P, E, Q and J each indicate two separate depressions in the unweathered bedrock, e.g. along traverse P, one depression is centred below P550 and the other below P1050. The profiles of traverses north of traverse J do not indicate two separate depressions.

The profiles along traverse G, H and N are shown on Plate 2B. Traverses H and N are parallel to one another in a northerly direction. The profiles along these traverses indicate depressions centred below H350 and N400. The profile along traverse G, which runs diagonally across traverse P, shows two depressions, one centred below G500, the other below G1050.

Plate 2C shows the profiles along traverses A and B, which are about 4800 and 1800 feet respectively south of No.1 shaft. East of B900 the unweathered bedrock profile shows a gentle slope towards the east; it is fairly flat between B1600 and B1800 but it is not known whether the deepest part has already been reached or not. This traverse could not be extended east of B1800 as the proximity of a house prevented the suitable location of a shot-hole in that direction. Traverse A is along the Kamarah Road, and is approximately 3,000 feet south of traverse B. The profile along traverse A shows two depressions in the unweathered bedrock, one centred below A2500E and the other below A100E.

A contour map of the unweathered bedrock for the area north of traverse C, i.e. north of No.1 shaft, is shown on Plate 3. The contours, which are drawn from the profiles shown on Plates 2A and 2B, represent the most likely configuration of the surface of the unweathered bedrock. It must be understood that the possible inaccuracies in the contours are greatest in places where the traverses are furthest apart.

The position of the deep lead is inferred from the contour lines and can therefore be regarded as approximate only. The width of the wash cannot be predicted. The area south of traverse C has not been included in the contour plan because the traverses in that area are too far apart. Interpolation of contour lines between traverses so far apart (3,000 ft) could not be expected to show the configuration of the unweathered bedrock with any reasonable degree of accuracy.

The main features of the contour map are:-

(1) A channel in the contours between traverses C and D. This channel is slightly to the east of the known lead.

(2) To the north of traverse D there are two channels in the unweathered bedrock contours, one from the north and the other from the north-west. The channel from the north-west must be the main lead because the depression is much more pronounced. That from the north is most likely a tributary lead. It crosses traverse Q near Q1150, but to the north of traverse Q it is not well-defined. The north-west channel passes through No.3 shaft and shows near Q400 another junction of channels, one coming from the west through N400 and H350, the other coming from the north through J450.

(3) The closed contours (380 ft. and 390 ft.) in the northern part of the area, which suggest a basin-like structure in the unweathered bedrock. Alternatively, this could be an area with a lower seismic velocity in the overburden.

(4) The closed seismic contours (250 ft., 260 ft. and 270 ft.) crossing traverse D, which may represent an actual depression in the unweathered bedrock or may be due to a lower average seismic velocity in the overburden caused by subsidence of the ground over the stoped-out workings near Traverse D, between No.2 and No.3 shafts.

The velocities in the V_1 layer and in the V_2 layer (unweathered bedrock) are shown in the sections. The V_2 velocity covers a wide range from 9,000 feet/second (Traverse D, 0 to 500) to 19,000 feet/second (Traverse P, 600 to 950). It is considered that the higher velocities, 16,000 to 19,000 feet/second, correspond mainly to granite, while the lower velocities, 9,000 to 13,000 feet/second, indicate the presence of sedimentary rocks. It is possible that velocities between 13,000 and 16,000 feet/second correspond to the contact zone of silicified sediments or hornfels near the granite contact. An approximate boundary between the areas of low and high velocities in the bedrock is drawn on Plate 1. This line is considered to represent the approximate boundary between the granite situated mainly to the east and the sediments found mainly in the western part of the surveyed area. The lead over the greater part of its length appears to follow approximately this boundary.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the seismic refraction survey, as shown on Plates 2 and 3, indicate that the main course of the lead to the north of No.3 shaft does not continue along the more or less straight course of the lead between No.1 and No.3 shafts. Near No.3 shaft the main lead swings to the north-west, between traverses D and G. There is also an indication of a tributary lead from the north joining the main lead near No.3 shaft. It is possible that this is an older course of the lead between traverses D and K, and that the lead later changed its course to the one passing through J450. Probably of importance as regards the distribution of tin values is the junction of the two leads near Q400, one coming from the west through N400 and the other from the north through J450.

Also important economically is the investigation of the true nature of the depression indicated mainly on traverses L and F. If this depression corresponds to a basin-like structure (perhaps a lake), high tin values might be expected near traverse K, but little tin can be expected between traverses L and Q.

It is also possible that the lead originally passed through F800, J1150 and Q1150, and for some reason changed its course to a more westerly position, joining the other lead at Q400. Alternately it is possible that the seismic depression is caused by deeper weathering of the bedrock near traverses L and F. Early investigation of this problem by drilling is advisable.

The V_2 velocities on traverses A and B are mainly below 16,000 feet/second, while granite usually has a velocity higher than that. It is therefore probable that the lead leaves the granitic bedrock not far south of No.1 shaft. As the tin values decrease more rapidly over sediments than over granite, the prospects south of the main shaft may not be very good.

Several lines of boreholes are suggested for drilling, and are shown on Plate 3. It is not expected that the course of the leads has been determined so precisely that the first hole will strike the lead. Some small displacements of the leads should be anticipated. The seismic results do not give any indications of the tin content in the lead.

The following borehole lines are suggested:-

P500 to P600

P1000 to P1100

Q350 to Q450

Q1100 to Q1175

H300 to B400

J400 to J500

K500 to K700.

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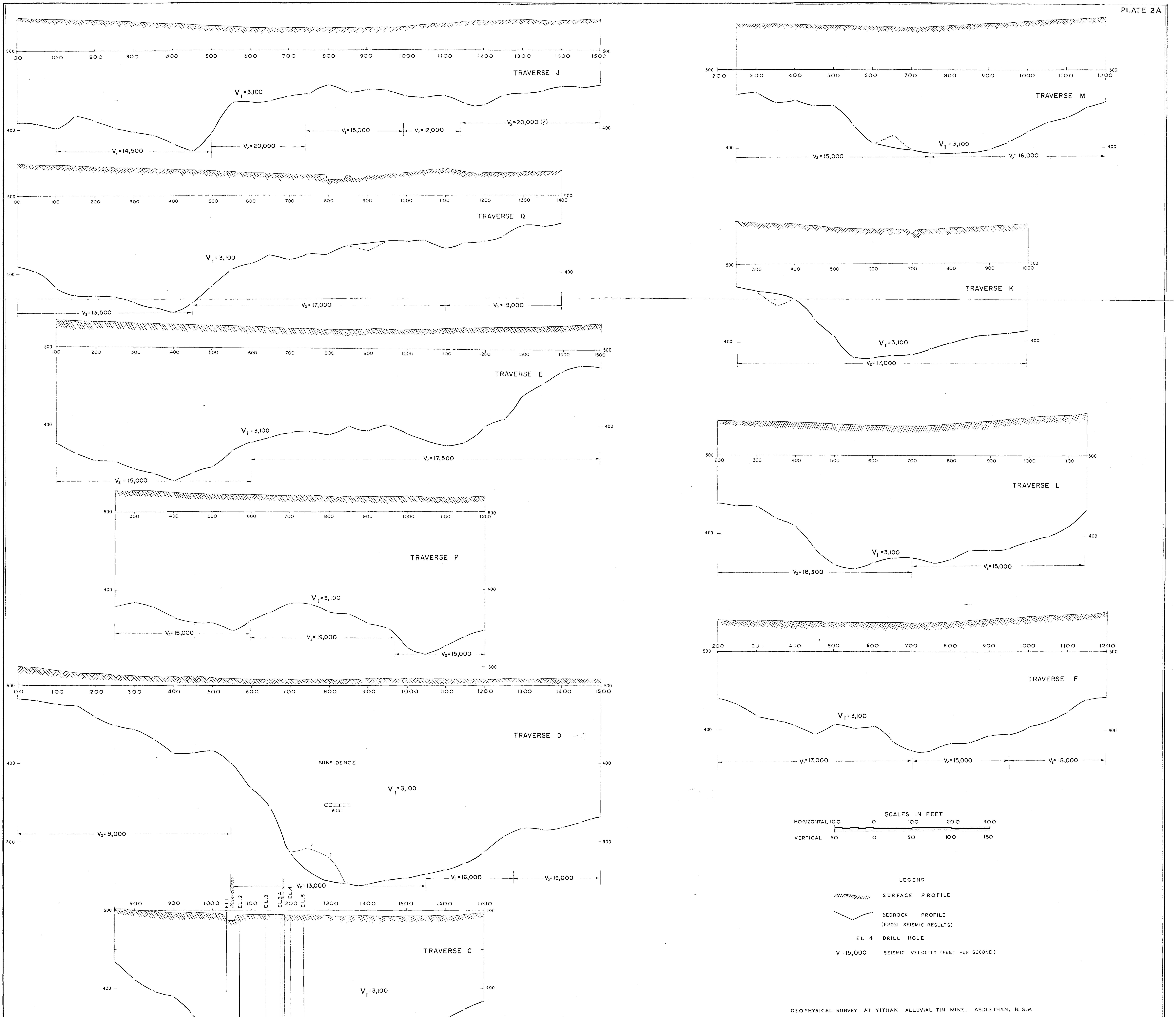
GEOPHYSICAL SURVEY AT YITHAN ALLUVIAL TIN MINE,
ARDLETHAN, NEW SOUTH WALES

PLAN SHOWING GEOPHYSICAL TRAVERSES,
SURFACE CONTOURS AND OTHER SURFACE FEATURES

PLATE 2A



GEOPHYSICAL SURVEY AT YITHAN ALLUVIAL TIN MINE, ARDLETHAN, N.S.W.

PROFILES OF SURFACE AND UNWEATHERED BEDROCK

(FROM SEISMIC RESULTS)

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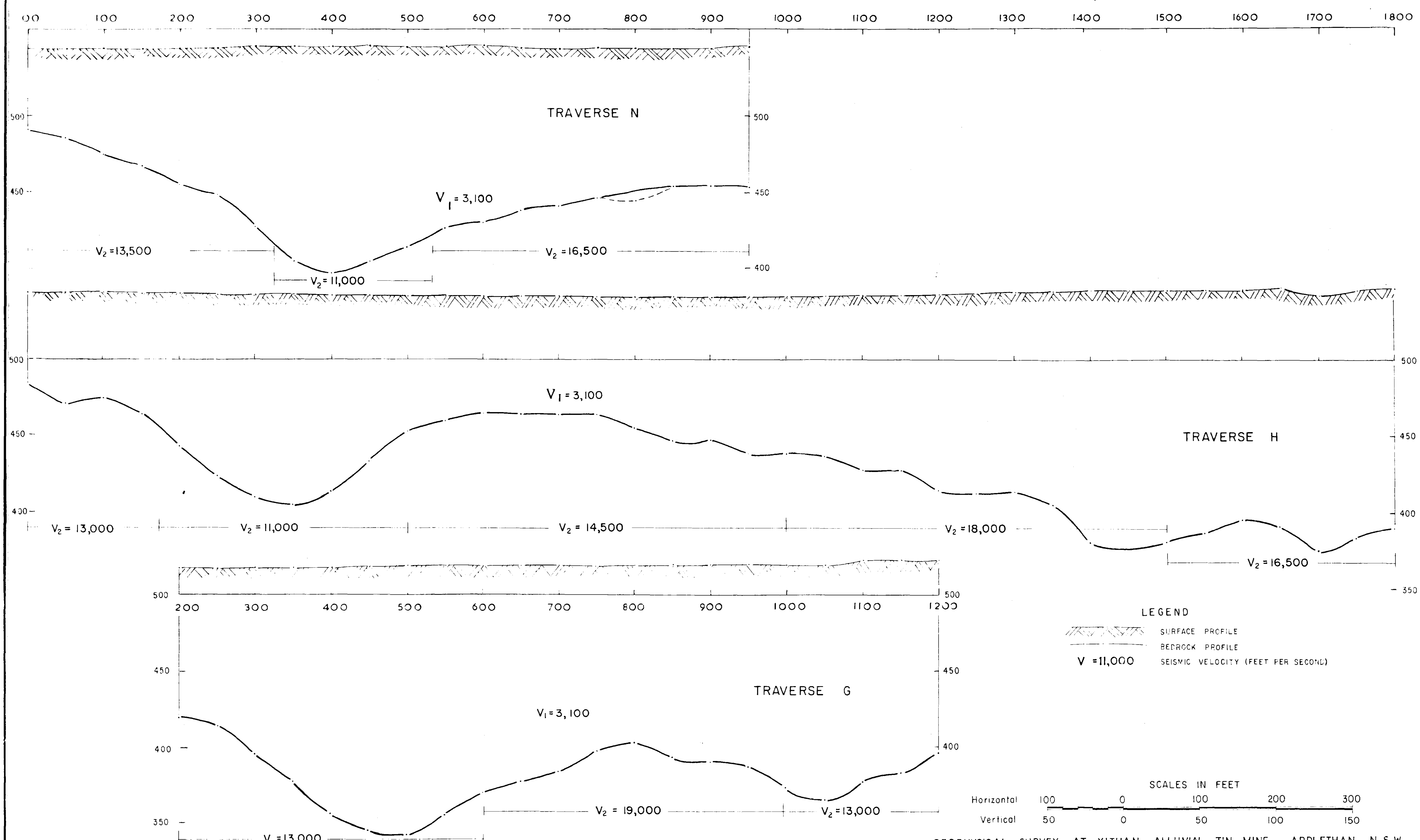
PLATE 2B



GEOPHYSICIST

M. J. O'Connor

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Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

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PLATE 2C

GEOPHYSICAL SURVEY AT YITHAN ALLUVIAL TIN MINE, ARDLETHAN, N.S.W.

PROFILES OF SURFACE AND UNWEATHERED BEDROCK

(FROM SEISMIC RESULTS)

PLATE 3

GEOPHYSICAL SURVEY AT YITHAN ALLUVIAL TIN MINES
ARDLETHAN, NEW SOUTH WALES

CONTOUR PLAN OF UNWEATHERED BEDROCK

(FROM SEISMIC RESULTS)

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