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

RECORDS 1957, No. 5

GEOPHYSICAL SURVEY AT THE ENDURANCE TIN MINE, SOUTH MOUNT CAMERON, TASMANIA

by
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ABSTRACT

In response to an application by the Endurance Tin Mining Company, N.L., and the Department of Mines, Hobart, a geophysical survey was made by the Bureau of Mineral Resources over the western extension of the Company's workings near the township of South Mount Cameron. The object of the survey was to trace the western extension of the lead now being worked by the Company, as a guide to further drilling and prospecting.

Thirteen traverses, totalling about 15,000 feet, were surveyed by the seismic refraction method, and tests were also carried out using the resistivity and magnetic methods of survey. As the results of the resistivity tests were inconclusive and no anomalies were revealed by the magnetic work, use of both of these methods was discontinued.

Results of the seismic survey revealed a trough in the bedrock which is considered to be related to the continuation of the deep lead. The probably general course of the lead is indicated, and estimates are made of the thickness of the overburden along the course. Recommendations are made regarding the most suitable locations for test boring.

1. INTRODUCTION

The Endurance Tin Mining Company, N.L. is working alluvial tin deposits in an area about one mile north-east of the township of South Mount Cameron, in north-eastern Tasmania. South Mount Cameron is about 77 miles by road from Launceston on the Herrick-Gladstone road (Plate 1). This road branches off the main Tasman Highway (Launceston-St. Helens) at Herrick.

Tin deposits were discovered in the area, which is drained by the Ringarooma River and its tributaries, in 1874 and since then have been worked by companies, syndicates and individuals with varying success.

The deep lead tin deposits were formed along the courses of an ancient river system (the Ringarooma River), and have been covered by sand and gravel and in places by Tertiary basalt. There is no basalt cover at the Endurance lead. To the west of the present workings the sand and gravel above the tin-bearing lead are more than 100 feet thick and the course of the lead cannot be traced on the surface. At the request of the Endurance Tin Mining Company, N.L. and the Department of Mines, Hobart, a geophysical survey was made by the Commonwealth Bureau of Mineral Resources over the western extension of the company's workings. The object of the survey was to trace the western extension of the lead now being worked by the company, as a guide to further drilling and prospecting.

Thirteen traverses, totalling about 15,000 feet in length, were surveyed in an area measuring 8,000 by 2,000 feet. The area surveyed is on the lower southern slopes of Mt. Cameron. The survey was made between December 1955 and March 1956, the first two or three weeks being spent in testing different geophysical methods to determine the most suitable for the problem. The field party consisted of O. Keunecke (party leader) and E. Sedmik, geophysicists, and two company employees as field assistants. The company carried out the pegging and levelling of the traverses, which were laid out at right angles to the supposed direction of the lead. Near the mine workings, swampy button grass plains predominate, while farther to the west the surface is undulating and tree-covered and gravels cover most of the area.

2. GEOLOGY

The geology of the tin deposits in the Ringarooma Valley has been thoroughly studied and described by Nye (1925). A more recent paper by Alexander (1947) deals more specifically with the operations of the Endurance Tin Mining Co. N.L. and the geology of the area near the company's workings.

The oldest sedimentary rocks in the district are slates and sandstones of Cambro-Ordovician age. These rocks were intruded during the Devonian age by large masses of granite. Mt. Cameron and other hills in the district are of granite and were formed during that period. Nye considers that the present Ringarooma drainage system was already established at the beginning of the Tertiary period. The river beds were already filled with tin-bearing sands and gravels, when large areas, including the upper part of the Ringarooma valley, were covered with basaltic flows during this period. The basalt forced the river to change its course from west of Mount Cameron to east of it, as it is to-day.

The secondary (alluvial) tin deposits in the district derive mainly from tin lodes in the granitic mountains south of the river system and were formed mainly during pre-Tertiary times. Eroded granitic and sedimentary material such as sands, grits etc., which are called "Drift", cover the tin-bearing lead.

At South Mount Cameron and other workings in the district the deposits were partly retransported and re-deposited in narrow leads and terraces in recent geological times. This second type of deposit is fairly shallow and usually has only a low and irregularly distributed tin content.

The Endurance Tin Mining Company N.L. is at present working a lead which was probably formed by a tributary flowing into the ancient Ringarooma river near the Boobyalla road.

The western extension of the deep lead has an overburden about 100 feet thick, consisting of gravel, sand and clay, and containing a fair amount of carbonaceous material such as logs and tree roots which are partly changed to lignite and in many places replaced by marcasite. In some places the sands and grits are cemented by oxides of iron.

The cassiterite is black in colour and fine-grained. Other minerals found in the lead are marcasite and pyrite and to a lesser extent tourmaline, monazite, pleonaste, topaz, corundum, zircon and wolframite.

A series of bores west of the workings (see Plate 1) indicated an overburden up to 100 feet thick and values of tin from zero to 1.7 lbs. per cubic yard; over a width of about 250 feet the values are greater than 0.5 lbs. per cubic yard (see Plate 3).

The general trend of the lead is about west-south-west, but sharp bends occur within short distances (Alexander, 1947). These changes in direction greatly increase the difficulties in tracing and working the lead.

3. SELECTION AND APPLICABILITY OF GEOPHYSICAL METHODS.

A. General.

As cassiterite cannot be detected directly by any known geophysical method, the only alternative is to locate the deep lead indirectly either by its mineral content or by its geological structure. The lead at South Mount Cameron is formed by an old river valley, and is therefore situated in the deepest part of the granitic bedrock. By determining the configuration of the bedrock the lead may be traced.

If sufficient magnetic material such as magnetite or ilmenite is concentrated in a lead, it might be possible to trace it directly with a magnetometer. At the Endurance lead no appreciable quantities of magnetite are present and tests with the magnetic method did not reveal any anomalies. Also, sulphides of high electrical conductivity do not exist in sufficient quantity to be able to trace the lead by electrical methods and the survey was therefore carried out using mainly the seismic refraction method; electrical resistivity methods were tried along two traverses.

B. Seismic Method.

The seismic method depends on the contrast in velocities of seismic wave propagation through different kinds of rocks. In the application of the method, only the fastest waves, namely the longitudinal waves, are taken into account. The velocities of the longitudinal waves range from 12,000 to 20,000 feet per second (f.p.s.) in crystalline rocks, 6,000 to 12,000 f.p.s. in consolidated sedimentary rocks, 1,500 to 6,000 f.p.s. in unconsolidated sedimentary rocks and 300 to 2,000 f.p.s. in loose surface soils.

Seismic waves are reflected and refracted at interfaces between layers of different velocity in a manner similar to the reflection and refraction of light. Depths to the interfaces can be determined by the refraction method where each successively deeper layer has a velocity higher than the one above it - a condition necessary for the return of the refracted wave to the surface. The refraction method may be used for shallow depth determinations and is best suited to investigation of horizontal or near-horizontal layers.

The field procedure in carrying out a refraction survey is to detonate an explosive charge at a depth of a few feet below the surface. The resulting seismic waves are detected by a spread of geophones set out on the ground at measured distances from, and in a straight line through, the shot point. The geophones are connected through amplifiers to galvanometers recording on a fast-moving strip of photographic paper. Provision is made for recording the shot instant on the same strip, together with time marks at intervals of 10 milliseconds. The travel times of the seismic waves between shot point and geophones are read from the photographic record and comprise the basic data for calculation of layer velocities and interface depths.

In the refraction method, only the first arrivals of the seismic disturbance at the geophones are used. For geophones near the shot point the first arrivals are direct waves through the surface layer. As the shot point-geophone distance is progressively increased, the first arrivals will be waves reflected from successively deeper layers. When the travel times are plotted against shot point-geophone distances, a time-distance curve is obtained from which the velocities of the layers and the depths to their interfaces can be derived.

In the present survey, a variation of the refraction technique known as the "reciprocal method" or "method of differences" was used. Shot points are located in turn beyond each end of the geophone spread and travel times are recorded for waves travelling in both directions. The method is designed to give depths to refracting surfaces below each geophone position. By moving the spread along a traverse, a profile of the refracting surface is obtained.

The methods described above are referred to as "in-line" shooting, as the geophones and shot point are placed in one straight line. In-line shooting was mainly used in the present survey, but to obtain additional information a method known as "fan" shooting was also used. In fan shooting the geophones are placed along the arc of a circle whose centre is the shot point. The recorded travel times are proportional to the depths to the refracting layer and although actual depths cannot be determined, the travel time profile will indicate relative depths to the refractor along the geophone spread. The deeper parts of the refractor will correspond to greater travel times.

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C. Geoelectrical Methods.

These methods of survey are based on the different electrical conductivities of rocks and minerals. Several electrical methods are known and the one most suitable for the problem encountered in the present survey is known as the "resistivity method."

High resistivities are usually associated with dry loose surface soils, sands and gravel, and crystalline rocks; much lower resistivities are encountered in clays, silts and rocks containing sulphide minerals. In non-metallic rocks the solution contained in the rock pores acts as the electrical conductor. The conductivity is therefore dependent on the porosity, the degree of saturation of the rock and the conductivity of the solution itself.

In the resistivity method, an electric current is applied to the ground at two outer electrodes and the potential difference between two additional electrodes (usually located between the outer ones) is measured. Two different procedures were used in the present survey, namely the "expanding electrode" and "constant separation" techniques. The expanding electrode method operates with increasing electrode spacing, so that the prospect is probed to greater depth. The method is generally applied to determine the depths of more or less horizontal layers characterised by different electrical resistivities. In the constant electrode separation method the electrode arrangement as a whole is moved along a traverse maintaining the geometry of the electrode system constant. The method is designed to show lateral variations in resistivity of the rocks between the surface and a more or less constant depth.

Tests were made with both these resistivity techniques in the present survey. However, the resistivity work was discontinued when it became apparent that the results were inconclusive.

D. Magnetic Method.

The magnetic method of exploration makes use of the earth's magnetic field. The local magnetic field is influenced by the presence of rock formations of different magnetic susceptibilities. Igneous rocks usually have a higher magnetic susceptibility than sedimentary rocks, as they contain a greater amount of magnetic minerals such as magnetite, pyrrhotite, ilmenite and hematite. It is sometimes possible therefore to obtain information on the configuration of an igneous bedrock by means of magnetic measurements. A deep lead might also be traced directly if magnetic material is concentrated in it in larger quantities. Tests with the magnetic method did not reveal any anomalous trends and the method was discontinued.

4. SEISMIC SURVEY

A. Equipment and Field Procedure.

A set of Swedish ABEM 6-channel portable seismic equipment was used in the survey.

The lay-out of seismic traverses used for the in-line shooting is shown in Plate 1. The traverses were placed at right-angles to a baseline which was on a bearing of 244° magnetic. The geophones were spaced 50 feet apart and the shot point was at distances of up to 1900 feet from the most distant geophone.

The lay-out of traverses and shot points used in the fan shooting is indicated in Plate 5. East of traverse 25W, the geophones were placed at 50 feet intervals along arcs of radius up to 500 feet. West of traverse 25W, the radius was increased to 1000 feet because of the greater thickness of overburden there. The shot points were placed at points where the in-line shooting indicated maximum thickness of overburden. Several narrow-angle fans also were shot, with the geophones placed along a straight line instead of along an arc. This arrangement reduced the time required for laying out the geophone spread, but introduced the need for correction to the observed travel times to allow for variation in the shot point-geophone distance.

B. Results of In-line Shooting.

Sections showing the results of the in-line shooting are shown on Plate 2.

On traverses 00 to 20W, the seismic results indicated two layers. The seismic velocity in the upper layer (V_1 layer) was about 5,200 f.p.s., and in the lower layer (V_2 layer) between 16,000 and 17,000 f.p.s. On traverses west of 20W, a surface layer (V_o layer) with velocity ranging from 2,100 to 3,300 f.p.s. was indicated.

On Plate 3 the seismic section along traverse 00 is shown in comparison with the bore data projected on to the traverse line.

Contours of the surface of the lowest or V_2 layer are shown on Plate 4.

C. Results of Fan Shooting.

The travel times recorded in the fan shooting are shown on Plate 5. The distance between shot point and geophone spread was made large enough to ensure recording of refracted waves from the V_2 layer. The travel times recorded are proportional to the depths to this layer along the geophone spread and maximum depths are indicated by the greatest travel times. The fan shooting provides an independent check on the results of the in-line shooting. A trough in the V2 layer is indicated and its position in general agrees with that shown by the in-line shooting.

5. INTERPRETATION OF RESULTS.

The lowest or V_2 layer shown in the sections on Plate 2 is characterised by velocities between 16,000 and 17,000 f.p.s. which indicate that this layer must be interpreted as unweathered granite. The 5,200 f.p.s. layer represents the unconsolidated overburden consisting of sand, gravel and clay and must be considered also to include highly weathered granite, as it is not possible from the seismic results to differentiate between highly weathered granite and overlying unconsolidated material. The V_o layer with velocities between 2,100 and 3,300 f.p.s., recorded on traverses west of 20W, consists of dry sands and gravels above the water table.

A comparison between the seismic section along

Traverse 00 and the drilling data is shown on Plate 3. The line of bores does not coincide exactly with the seismic traverse and the drilling data is projected onto the seismic section. The bore holes reached only the weathered granite and do not provide an accurate check on the seismic depth determinations to the solid granite. The depression in the granite surface is more pronounced in the seismic section than the depression in the level of weathered granite shown by the drilling results. The lead carries pyrite and marcasite, the oxidation of which results in acid conditions which would probably tend to produce deeper weathering in the granite under the lead.

The sections on Plate 2 and the contours of the surface of the granite (Plate 4) indicate a fairly broad trough which probably marks the continuation of the tin lead. As it has not been possible to differentiate between the weathered granite and the overburden, the seismic results would not be expected to give the precise location of the lead or an accurate determination of its depth below the surface.

The deep lead has been struck between bores R8 and R11. A south-western continuation of the general direction of the lead from the present mine workings over the bores R8 to R11 would cross traverse 00 between 400N and 600N. If this is regarded as the position of the lead at traverse 00, it will correspond to the deepest part of the trough in the granite as shown by the seismic results. The probable course of the deep lead as indicated on Plate 4 is drawn to follow the depressions in the granite, but west of Traverse 40W where the trough in the granite is broader, the most probable course of the lead is considered to be at the foot of the buried granite slope. The course of the lead may be more irregular than shown on Plate 4 and bends not detected by the seismic survey might occur between traverses.

Several of the seismic sections show small irregularities in the granite profile. These may be due to irregularities in the depth of weathering or may indicate the existence of tributary leads.

The contours on Plate 4 indicate a fairly deep depression between Traverses 20W and 40W. This may be due to local deep weathering of the granite and could be the result of local tectonics such as a fracture zone, shear or the intersection of two fault systems. If the depression is due only to deeper local weathering, the tin content of the lead might continue downstream. If, however, it is an actual depression in the old surface, which was perhaps filled by a lake, then a concentration of tin values might be found near Traverse 30W, but little tin would be expected further to the west and there would be some doubt as to whether the fall of the lead would continue to the west. It must be regarded as a possibility that the lead runs from west to east between Traverses 70W and 30W. In this case, an outlet to the south would probably be found near Traverses 25W to 20W or perhaps at 35W. Further seismic work would be necessary to determine whether or not there exists an outlet to the south.

6. CONCLUSIONS AND RECOMMENDATIONS.

From the results of the seismic survey it was possible to trace a trough in the granite bedrock, which is considered to be related to the continuation of the South Mount Cameron deep lead. The probable general course of the lead has been inferred from the seismic results, but there may be irregularities in the course of the lead not indicated by the seismic survey.

Depths have been determined to the unweathered granite but not to the lead itself. The fall of the lead can be estimated if it is assumed that there is a fairly uniform depth of weathering in the granite. On this basis, the average fall over the distance of 4,500 feet between Traverses 00 and 45W is about 70 feet, i.e. about 1.5 feet in 100 feet. Over the same distance, the surface rises by about 54 feet and the effective increase in the thickness of overburden is probably about 2.7 feet in 100 feet.

In considering the selection of drilling sites to test the seismic results, it is convenient to divide the surveyed area into three parts:-

(i) Traverses 00 to 20W. The course and fall of the lead appear to be about the same as in the known part of the lead. A few bores on Traverses 5W, 10W and 20W near the indicated probable position of the lead should verify the course of the lead and provide information on the tin content.

(ii) Traverses 20W to 40W. If the depression indicated by the seismic survey represents an actual depression in the old surface, this part of the area could be the most promising for further exploration. The steep drop and then the levelling off of the lead, as well as the change in direction, should be favourable for the concentration of cassiterite. Several bore holes will be needed near Traverses 25W and 30W to determine the nature of the depression and to investigate the behaviour of the lead in this part of the area.

(iii) Traverses 40W to 70W. If the fall of the lead is the same as that of the granite as indicated by the seismic survey, the economic prospects between 40W and 70W are not favourable, as little tin could be carried beyond the deepest section near 30W. If the lead runs from west to east between 70W and 40W, the tin content would depend on the amount of tin shed from the western part of Mt. Cameron. Recommendations for test boring would depend largely on the results of testing referred to in (ii) above.

Small tributary leads can be expected on the slope beyween the deep lead and the granite outcrop. It is not expected that these would reach economic importance, but if it is desired to investigate them, drilling sites could be selected from a study of the seismic sections.

7. REFERENCES.

Alexander, F.M. 1947 — Sluicing at ENDURANCE TIN MINE. Chemical Eng. and Min. Rev., Vol.39.

Carey, S.W., 1947 — Geological Report on the Launceston Quadrangle S.E. Quarter. (unpublished report for the H.E.C.).

Nye, P.B. 1925 The Sub-Basaltic Tin Deposits of the Ringarooma Valley. Geological Survey Bulletin No. 35. Department of Mines, Tasmania.


PLATE I
Reference to Australian 4 mile Military Map Series
SMITHTON
DEVONPORT
LAUNCESTON
QUEENSTOWN
HOBART
PORT DAVEY
HUON
LOCALITY MAP
SCALE IN MILES
RINGAROOMA BAY
TOMAHAWK RIVER
BOOBYALLA RIVER
RINGAROOMA RIVER
Gladstone
Mt Cameron
AREA SURVEYED
South Mount Cameron
DAM
Bradshows Creek
Herrick
Moorina
Derby
Branxholm
M.N.
T.N.
12°
21°
ENDURANCE WORKINGS
42 M 51
43 M 51
ENDURANCE TIN MINING CO. N.L.
BORE LINE
BASE LINE MAGNETIC BEARING 244°
TO SOUTH MT CAMERON
• R 10 BORE HOLE
DATUM FOR LEVELS B.M. "A" (RL=306·25 FT.)
GEOPHYSICAL SURVEY AT ENDURANCE TIN MINE,
SOUTH MOUNT CAMERON, TASMANIA
SURFACE CONTOURS
AND LAYOUT OF SEISMIC TRAVERSES
SCALE IN FEET
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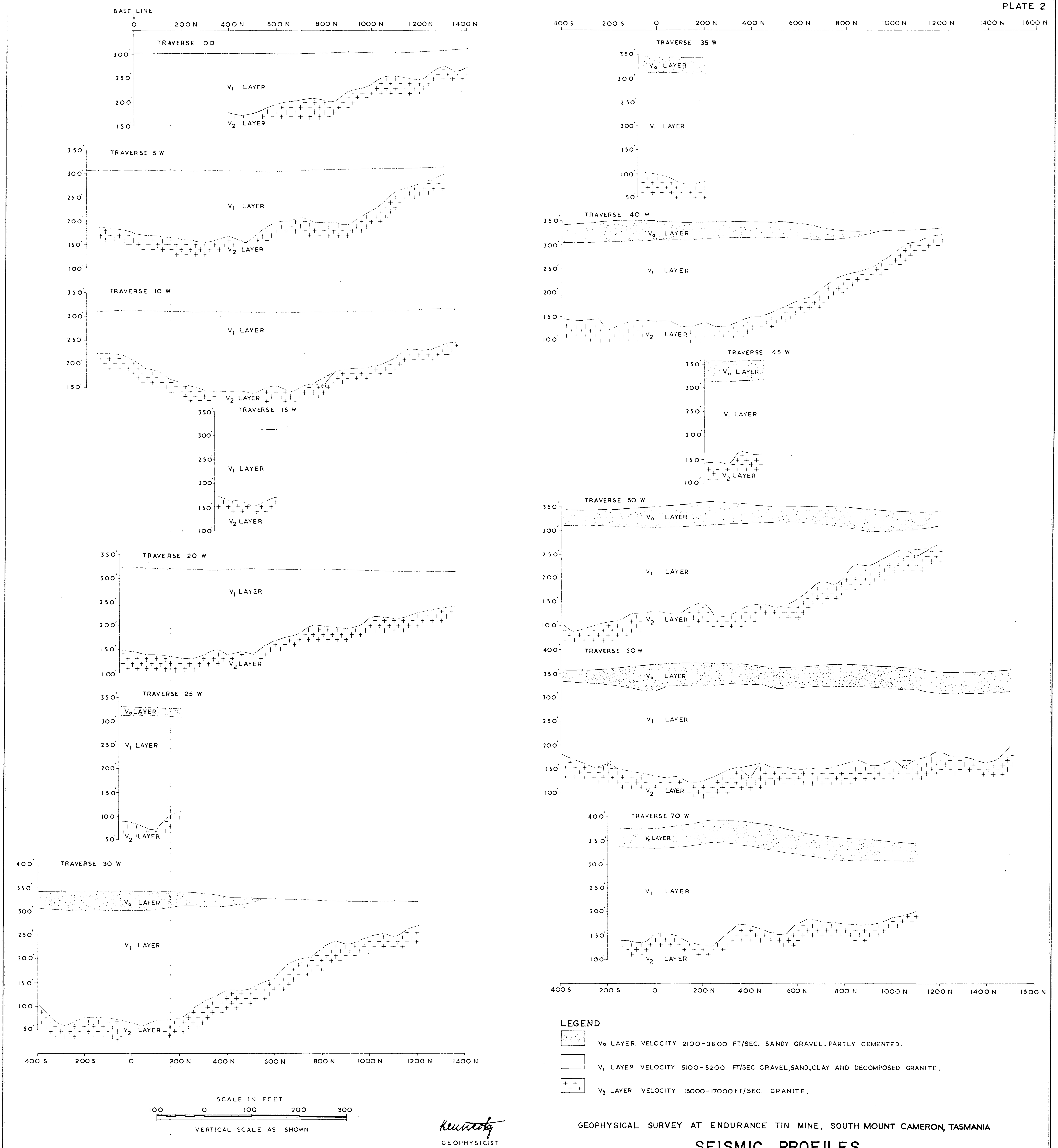
G 262 – 4

PLATE 2



LEGEND

- V0 LAYER. VELOCITY 2100–3800 FT/SEC. SANDY GRAVEL. PARTLY CEMENTED.
- V1 LAYER VELOCITY 5100–5200 FT/SEC. GRAVEL, SAND, CLAY AND DECOMPOSED GRANITE.
- V2 LAYER VELOCITY 16000–17000 FT/SEC. GRANITE.

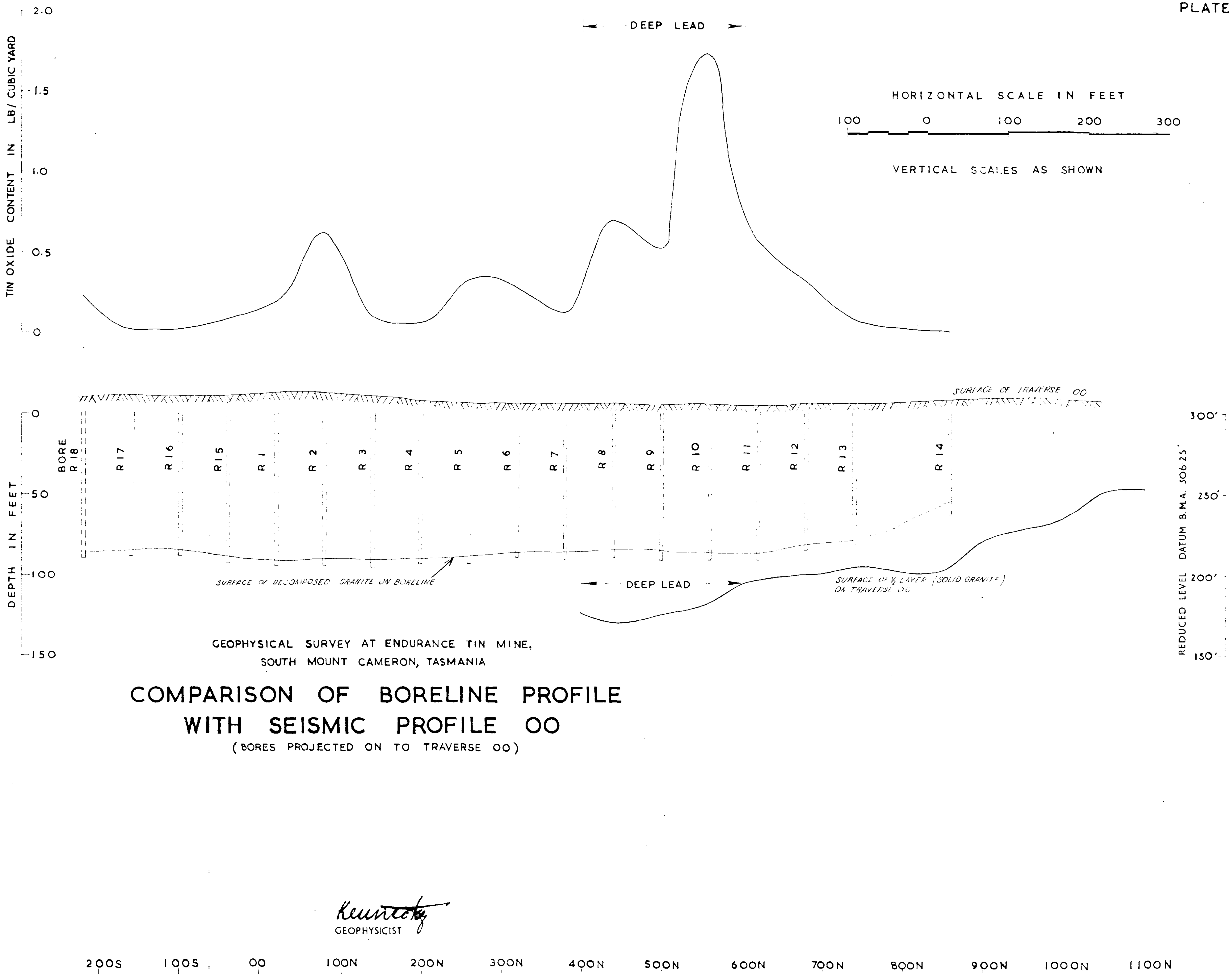
Kennedy
GEOPHYSICIST

GEOPHYSICAL SURVEY AT ENDURANCE TIN MINE, SOUTH MOUNT CAMERON, TASMANIA

SEISMIC PROFILES

G 262-3

PLATE 3



GEOPHYSICAL SURVEY AT ENDURANCE TIN MINE,
SOUTH MOUNT CAMERON, TASMANIA

COMPARISON OF BORELINE PROFILE WITH SEISMIC PROFILE OO

(BORES PROJECTED ON TO TRAVERSE OO)

Keunecke

GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 262-2


PLATE 4
APPROXIMATE TOE OF MT. CAMERON (GRANITE)
PROBABLE COURSE OF DEEP LEAD
ENDURANCE WORKINGS
ENDURANCE TIN MINING CO. N.L.
42 M
51
43 M
BORE LINE
BASE LINE MAGNETIC BEARING 244
TO SOUTH MT CAMERON
R 14
R 10
R 5
R 15
12°
21°
M.N.
T.N.
GEOPHYSICAL SURVEY AT ENDURANCE TIN MINE,
SOUTH MOUNT CAMERON, TASMANIA
RESULTS OF SEISMIC SURVEY
SCALE IN FEET
400 0 400 800 1200 1600 2000
LEGEND
R 10 BORE HOLE
PROBABLE COURSE OF DEEP LEAD
100 50 CONTOURS ON SURFACE OF V2 REFRACTOR (GRANITE)
DATUM FOR LEVELS B.M. "A" (RL=306·25 FT.)
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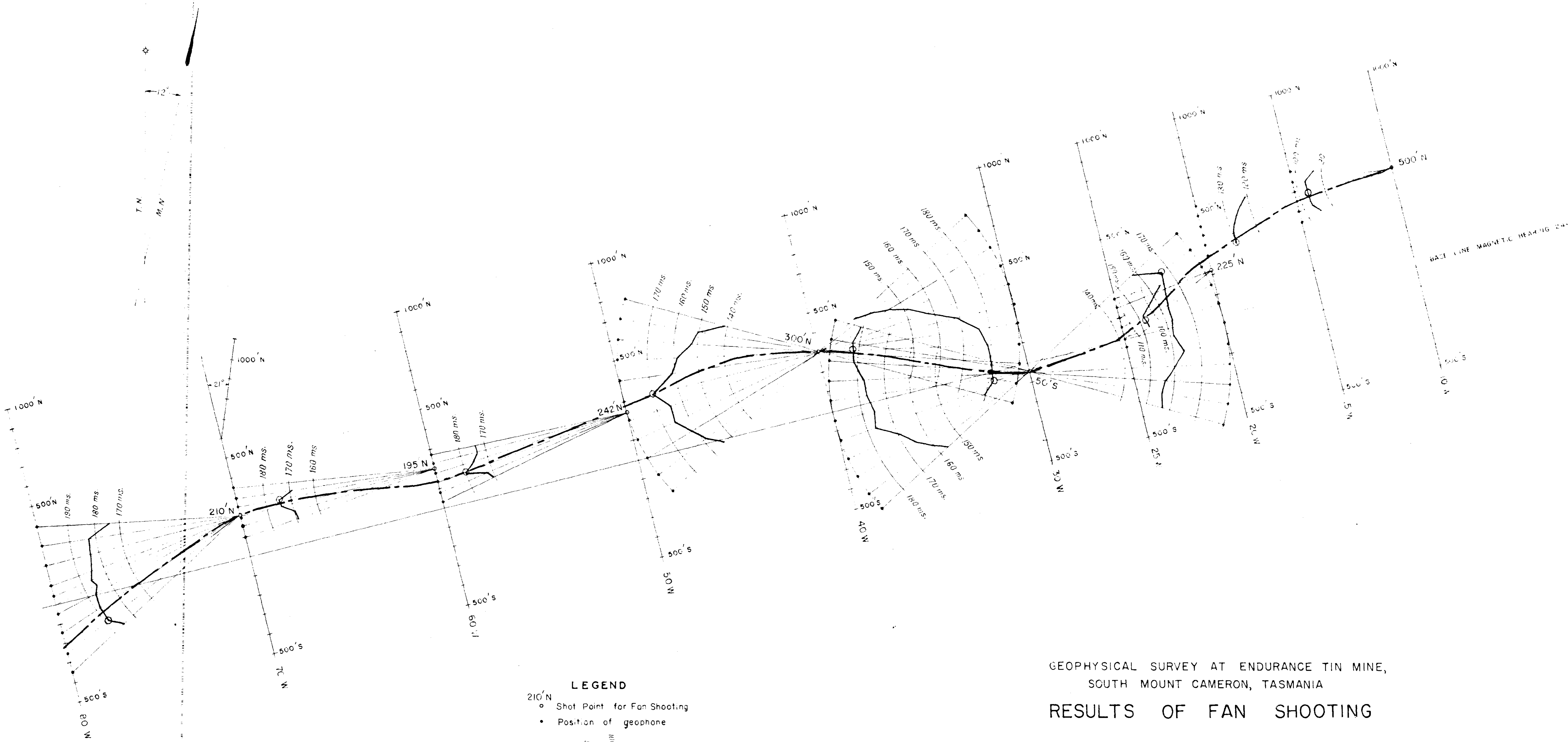

LEGEND

210'N
∘ Shot Point for Fan Shooting
• Position of geophone

90 ms
110 ms
Longest Travel Time
Traveltime Between Shotpoint and Resp. Geophone in Millisec

Approx. Position of Deep Lead from Traveltimes

NOTE The traveltimes shown for straight line geophone spreads are corrected for variation in shot point-geophone distance.

GEOPHYSICAL SURVEY AT ENDURANCE TIN MINE,
SOUTH MOUNT CAMERON, TASMANIA

RESULTS OF FAN SHOOTING

SCALE IN FEET

400 0 400 800 1200

Kuntzky

GEOPHYSICIST