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MOUNT GARNET SEISMIC REFRACTION SURVEYS FOR ALLUVIAL TIN.

QUEENSLAND 1962

by

E.C.E. SEDMIK and J.P. WILLIAMS

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CONTENTS

ILLUSTRATIONS

SUMMARY

Geological investigations by the Bureau of Mineral Resources in the Mount Garnet area had suggested that several alluvial tin prospects may be related to pre-Cainozoic westerly drainage systems. The Geophysical Branch was requested to investigate and clarify the position in the ATR and Wurruma prospects and in the extension of the dredge course at Smiths Creek. Gravity and seismic surveys were made to delineate the buried river channels.

The seismic refraction surveys consisted of normal seismic spreads and borehole velocity logging. This work indicated certain traceable layers identified by the velocity of the refracted longitudinal seismic waves. Correlation with known geological beds from borehole information proved difficult mainly owing to the complex weathering of the different rock types present, and to the variations in alluvial deposits.

However, certain trends that may be related to an earlier drainage system are recognisable, but tend to follow the present north-south drainage pattern. Drill sites have been recommended to test the hypotheses put forward.

1. INTRODUCTION

In 1962, the Bureau of Mineral Resources (BMR) conducted geological and geophysical investigations of alluvial tin prospects in the Mount Garnet district of North Queensland. At that time the alluvial deposits near Mount Garnet township yielded nearly half of Australia's tin production. Two bucket dredges were in operation, one at Smiths Creek, the other at Battle Creek. Both creeks are south-flowing tributaries of the Herbert River (Plate 1).

Interpretation of regional geological mapping in North Queensland, carried out jointly by the BMR and the Geological Survey of Queensland from 1956 to 1961, revealed the possibility of alluvial tin deposits occurring outside the drainage system of the present streams. It was thought possible that, prior to the Cainozoic Period, most of the streams in the Mount Garnet area had a westerly course and that epeirogenic movement during the middle Tertiary caused many streams in the area to be beheaded and captured by east flowing streams (Best, 1962).

Preliminary geomorphological study of the area near Mount Garnet indicated several new alluvial tin prospects in the heavily alluviated flats south of Mount Garnet township. The Ancestral Tate River (ATR) prospect between Smiths Creek and Lower Return Creek was thought to be part of an ancient west-flowing system. The Wurruma prospect situated in the area of the present Wurruma Swamp was thought to be an ancient channel of Return Creek. The Smiths Creek prospect was presumed to be the continuation of the buried stream channel which Tableland Tin Dredging N.L. were dredging for alluvial tin deposits. The dredge was working north of the Northern Inland Highway and the prospect continued to the south in the approximate position of the present Smiths Creek.

A refraction seismic survey was undertaken to investigate these three prospects. The work was done by two separate geophysical parties. A party consisting of E.J. Polak (party leader), J.E. Gardener and T. Andrews (geophysicists), J. Piggot (geophysical assistant), and five field assistants worked in the area from 19th May until 13th July 1962. A second party consisting of E.C. Sedmik (party leader), R.J. Smith, J. Williams (geophysicists), and six field assistants worked between 25th September and 23rd November 1962 to complete the seismic programme.

The topographic survey of traverse lines was made by surveyors of the private firm of Fuller, Little, and Brown of Sydney, operating under contract to the Department of the Interior.

The geophysical programme in the Mount Garnet area also included a gravity survey, the results of which are described by Horvath and Hussin (1966). In addition, a geological party from the BMR conducted a programme of geological mapping and percussion drilling (Zimmerman, Yates, & Amos, 1963).

Acknowledgement is made to Tableland Tin Dredging N.L. for assistance in making drilling information available and to Mineral Deposits Pty Ltd for releasing information on their work in adjacent areas.

2. GEOLOGY

The geology of the Mount Garnet area has been described by Best (1962) and Zimmerman et al (1963). A geomorphological investigation of the alluvial tin deposits in the area was made in 1962 by Dr M. Bik of the Division of Land Research and Regional Survey, CSIRO (Bik, 1963).

The oldest rocks in the area are metamorphics of Precambrian age. Greywacke, siltstone, limestone, and sandstone of Silurian-Devonian age, known under the term of Mount Garnet Formation, crop out in many places (Plate 2).

Stanniferous granite intruded these older formations during the Upper Carboniferous period. The granite is of two distinct types. The older granite, referred to as Mareeba or Herbert River type is grey, massive, medium-grained and contains ferromagnesian minerals in abundance. The younger granite, referred to as Elizabeth Creek Granite, ranges from coarse-grained and porphyritic to medium-grained massive type, is dominantly pink, and is almost devoid of ferromagnesian minerals.

The tin ore occurring in the Herbert River Granite appears to be mainly in tourmalinised and greisenised zones around the margin of the granite. Very little cassiterite is found in the country rock bounding this type of granite. The Elizabeth Creek Granite appears to have introduced much cassiterite into the country rock in lodes and veins.

Most of the primary deposits in the Mount Garnet area were exposed and in places deeply eroded during Mesozoic and early Tertiary times. The cassiterite freed by weathering was transported into stream channels, where it was sorted and concentrated.

Until the middle of the Tertiary, most of the streams in the North Queensland area are believed to have flowed westward, the divide then being much closer to the present coastline. Epeirogenic movement during the middle Tertiary resulted in stream capture by the eastern draining system, the divide migrating westward - in places up to fifty miles - and leaving, in places, several miles of abandoned river channels. A strip about fifty to sixty miles wide, adjacent to the present coast line, was the area most affected by this movement.

It was suggested (Best, 1962) that alluvial tin deposits might occur in the Mount Garnet area in abandoned river channels which have no connection with the present drainage system. The Ancestral Tate River prospect was thought to be part of the ancient Tate River system and the Wurruma prospect an ancient channel of Return Creek.

Basic extrusions accompanied the Tertiary earth movements, and large areas were covered by basaltic flows. Stringers from the main flows continued down the valleys diverting and damming streams and covering areas of alluvium. Remnants of the basaltic flows help in tracing the old drainage pattern in the extreme southern portion of the area.

In the northern part of the Smiths Creek area, the basement rock is the Elizabeth Creek Granite covered by alluvial and colluvial deposits (Bik, 1963). However, in the south of the area (near traverses F, G, and H) the basement may comprise Precambrian meta-sediments. This is suggested by the gravity survey (Horvath & Hussin, 1966) and the geomorphological survey (Bik, 1963).

The Cainozoic sediments range from nearly pure quartz sands to clays and lateritic type semi-consolidated sediments. In the northern area the near-surface deposits are quartz sands. Clays and outcrops of laterite are predominant in the south. No laterite has been logged as such in the boreholes but may have been recorded as red or brown clays. There is no geological evidence of basalt flows in the Smiths Creek area.

Many boreholes were put down by Tableland Tin Dredging N.L. to explore the future course of the dredge. They were drilled by percussion rigs, and tin values were assessed. However, it was not possible to construct geological sections from these logs in the area surveyed.

3. METHODS AND EQUIPMENT

In a tin-bearing country, alluvial tin deposits can be expected to occur within, or more often at the bottom of, the over-burden layer which covers the weathered bedrock surface.

Most of the rich alluvial tin deposits successfully mined in the past were formed by stream action in ancient rivers which carved their beds deep into the weathered bedrock forming well defined channels which were later filled with detrital or volcanic material.

There is no known geophysical method that could be used to detect directly the small amounts of tin ore in alluvial tin deposits. However, there are several methods that can give an indication of the general shape of the bedrock underlying the alluvial overburden.

The main geophysical methods used in the Mount Garnet survey were the seismic refraction and gravity methods.

The seismic method of exploration depends on the contrast in velocity of elastic waves travelling through different rock formations. The method can be used to determine depressions in the bedrock if appreciable velocity contrast between bedrock and overlying sediments exists.

Two sets of seismic equipment were used for the survey from May to July. The survey commenced with 12-channel Mid-western equipment but was later supplemented with 24-channel T.I.C. equipment. The seismic equipment used from September to November was an S.I.E. 12-channel portable refraction seismograph type PRO-11-6" and T.I.C. geophones of natural frequency of 20 cycles per second.

In the seismic refraction method an explosive charge is fired in a shallow hole, and the time of arrival of different seismic waves to a series of detectors (geophones) placed on the ground is measured. Generally, the charge and geophones are set up in a straight line with geophones equally spaced, but this arrangement may be varied to suit a particular survey. From data obtained by timing the first arrival of seismic waves, a time-distance curve is obtained. This indicates the apparent velocity of propagation of the seismic waves through different media encountered.

The field arrangement and the corresponding method of calculation known as the 'method of differences' was used (Heiland, 1946, p. 548) to determine vertical travel times at each geophone station. These were later converted into actual depths by using the intercept method and conversion factor technique as described by Hawkins (1961). The applicability of the seismic refraction method to the location of deep leads is described by Urquhart (1956).

4. FIELD WORK AND RESULTS

ATR and Wurruma areas

The seismic work was commenced in the ATR and Wurruma Swamp areas. Traverses ATR 2 (between 55W and 18E), ATR 3 (between 50N and 20S), and ATR 1 (between pegs 68 and 174) were surveyed as a first reconnaissance. The location of the traverses is shown in Plate 2.

The preliminary interpretation of the seismic results in these two areas suggested that the prevailing geological conditions were much more complicated than was originally anticipated. There was no indication of any channel with a general course different from that of the present drainage system and the depths calculated for the unweathered bedrock surface were very large. Consequently, it was decided to have a much larger area surveyed by the cheaper and quicker gravity method before continuing with any further seismic work. On the basis of the gravity results (Horvath & Hussin, 1966) additional seismic work was planned to obtain more detailed information on the probable bedrock channels.

Traverses AA, AB, AC, and the Lower Return Creek traverse were added later at the request of the geological party.

The total length of traverses surveyed with the seismic refraction method in the ATR and Wurruma areas was approximately 21 miles.

The seismic work consisted of :

1. Weathering spreads. Geophones were spaced at 5 and 10-ft intervals and shots were fired from 5 ft, 50 ft, 100 ft, and sometimes 200 ft from each end of the spreads. These spreads were used to obtain the thickness and seismic velocity of soil and near-surface layers. They were selected at locations where the time-distance curves indicated changes in velocity in the near-surface layers. Absence of irregular variations in the time-distance curves of the highest velocity refractor suggested that there were no marked lateral variations in soil velocities.

2. Normal spreads. These were used to measure the velocities in the formations beneath the soil and in the bedrock and also to calculate the vertical travel times to these formations. Geophones were spaced at 50-ft intervals. Seven shots were fired - one in the middle of the spread, one 25 ft from each end, one 225 or 275 ft from each end, and one 525 ft from each end. The intermediate shots were designed to coincide with the central shots on the adjacent spreads. This allowed for continuous velocity profiles. When the highest velocity refractor was very deep, an additional shot was fired 1025 ft from each end of the spread in order to locate it more accurately.

3. Bore hole velocity logging. This was used to measure directly the average seismic velocity between the surface and different points in the bore hole.
Shots were fired at the bottom of and at regular 10-ft intervals up each bore hole and the times of arrival of the energy to geophones set on the surface near the collar of the hole were measured. These times gave a direct measurement of the average seismic velocity (in the vertical direction) of that section of the sediments between the shot and the surface.
Four geophones were laid as close to the collar of the hole as practical and the remaining eight were laid in pairs at intervals of 25 and 50 ft from opposite sides of the hole in a straight line. The holes were tamped

with water to a level of a few feet above the point of detonation as this appeared to give more consistent and repeatable results. In some cases, marsh-type geophones were lowered down the holes at 10-ft intervals and a shot was exploded on the bottom of the hole. The records thus obtained did not prove reliable or repeatable, probably because it was not possible to ensure that the marsh geophones made good contact with the sides of the hole.

Vertical travel times (V.T.T.) were computed at each geophone station for normal spreads by using the method of differences. Depths to the unweathered bedrock surface were computed by multiplying the V.T.T. with the average seismic velocity of the overburden calculated using the standard intercept method of computing depths to various refractors (Hawkins, 1961).

In the ATR and Wurruma areas, the depths calculated to the unweathered bedrock surface were very much in excess of the depths at which test drilling for alluvial tin was being carried out by Tableland Tin Dredging N.L. Some of the holes bottomed in definite weathered bedrock, but a great number ended in hard silty or sandy clay (see Table 1) and it is very doubtful whether they reached the actual weathered bedrock. However, the seismic cross-sections obtained over those portions of traverses AA and ATR 1 where drilling results were available indicate that the layer drilled follows approximately the refractor with a longitudinal wave velocity of 6000 to 7500 ft/s (i.e. between stations 212 and 174 on traverse ATR 1 and stations 3 and 59 on traverse AA). Consequently, wherever possible, the method of differences was applied also to the 6000 to 7500 ft/s refractor.

The seismic results are presented as sections in Plates 3 and 4, unweathered bedrock contours in Plate 8, and contours of the 6000 to 7500 ft/s refractor in Plate 9.

Velocity logging was carried out in boreholes MRW 8, MRW 17, MRW 18, MRW 19, and MRW 20 to obtain detailed information about the velocity distribution within the overburden and to find out how these velocities compared with the geological logs known from actual drilling. The results of this work are presented in Plate 7. Only the accessible part of these holes could be logged and the velocities obtained appear in reasonable agreement with those observed in the ordinary time-distance curves. No detailed correlation between changes in velocity and changes in the geological logs could be observed for most of these holes. The V.T.T. recorded when shooting from the bottom of drillholes were found to be much smaller than those calculated for the unweathered bedrock. If the top of the weathered bedrock has been correctly identified in the drillholes, a considerable weathering zone must exist.

The velocity log of MRW 19 shows a definite change in velocity from 5000 ft/s to 6500 ft/s at a depth of 73 ft, just below where the last layer of wash was found. This is 18 ft shallower than the boundary calculated using the intercept method in the routine survey. The velocity of 6500 ft/s is well established in the portion between 73 and 115 ft depth. Assuming that the 6500 ft/s velocity continues beyond 115 ft, the depth to unweathered bedrock may be obtained graphically using the time-distance curve shown in Plate 7. For the V.T.T. of 49.5 milliseconds obtained using the method of differences in the routine survey, the graphically calculated depth to the unweathered bedrock is 268 ft as against 276 ft obtained by the conversion factor method.

Similar agreement between depths calculated graphically and with the conversion factor apply to the other drillholes if velocities corresponding to those found in the velocity log time-distance curves are assumed for the refractor immediately above the unweathered bedrock.

Smiths Creek area

The seismic work at Smiths Creek was mainly carried out from May to July 1962 with some additional work in October. Both the T.I.C. and Mid-western seismic equipments were used, having spreads of twenty-four channels and twelve channels respectively. The geophone interval was 50 ft, allowing spreads of 1000 ft and 500 ft, respectively. Some extra work was carried out in October 1962 by the second seismic party. This consisted of an eastern extension to traverse E and long spreads with shot-points 1000 ft from the ends of the spreads to locate deep refractors, on traverses F and G.

The alphabetical naming of the traverses indicates the chronological order in which they were surveyed. The preliminary interpretation of the progress results was used as a guide in selecting traverse positions. In this way each location of a possible buried channel was investigated as fully as possible. This fact and the complexity of the contour maps (Plates 8 and 9) explain the non-uniform nature of the traverse layout.

As at the Wurruma and ATR prospects, normal and weathering spreads and borehole velocity logging were carried out. The length of the normal spreads depended on the instrument used. The survey was commenced with the Mid-western equipment. Traverses B, T, U, V, W, and H1-60 were surveyed with the T.I.C. equipment. The shot pattern selected was similar in both cases, viz., one shot in the middle of the spread, one at each end, and one 500 ft from each end. This means that when the Mid-western equipment was used, shot-points were 250 ft apart, but with the T.I.C. equipment they were usually 500 ft apart.

Originally the survey had been designed primarily to locate the high-velocity refractor which was used for interpretation in the Ardlethan area (O'Connor, 1959). However, it became evident that this layer was too deep to be of economic importance. The work was then directed to locating the refractor immediately above, which, it has been suggested, represented the weathered bedrock surface.

The seismic reductions at Smiths Creek were carried out in a similar manner to those of the Wurruma and ATR areas, using the intercept and conversion factor method (Hawkins, 1961).

Weathering spreads were used to obtain information on the layer immediately below the surface of the topography as described. Certain variations in this velocity were expected at Smiths Creek owing to the variations in the near-surface geology. Generally a value of 1000 ft/s was accepted, except in the southern area where a velocity of 1500 ft/s was used when the normal time-distance curves suggested that this velocity was applicable over a reasonably large area.

As in the Wurruma and ATR areas, velocity logging of boreholes was also carried out at Smiths Creek. Most of the holes had been drilled some years previously and in places had fallen in, with the result that few were accessible to a depth greater than 100 ft and the amount of information that could be obtained in the lower strata was very limited. The drilling logs available were those recorded by the drilling teams and did not provide detailed geological data. In no case was there conclusive evidence of the hole bottoming in hard or fresh bedrock.

The boreholes logged were TTW Nos. 594, 595, 596, 597, 598, 577, 578, 579, 580, 589, 585, 692, 693, 696, 702, 745, and 746. Most of these were in the northern part of the area, in the proximity of the dredge. As they were not well distributed over the survey area and the measurements were subject to the limitations already mentioned, the average vertical velocity determined from the borehole velocity logging was not used in the reduction of the seismic results, although the logging results were useful in some places for comparison with the velocities deduced from those obtained by the intercept and conversion factor method.

The profiles of the Smiths Creek area, presented in Plates 5 and 6 have been constructed by use of the intercept method. The most prominent and continuous refractor recorded was the 14,000 to 20,000 ft/s layer. This was the deepest refractor recorded and was located at depths to 300 ft below the surface. It can be considered to continue in depth. A contour map of this refractor is shown in Plate 8.

In general, the next refractor is characterised by velocities in the range 6000 to 8000 ft/s. Above this, a layer with velocities in the range 4000 to 6000 ft/s is present on some traverses, e.g. traverse T. On others, it is not recognisable probably because of a more gradual increase of velocity with depth, resulting in an averaging process to give one refractor instead of two. This may be the case for traverse D and may also explain the apparent bar on traverse G near station 40 W.

Excluding the surface layer, which has already been discussed, the remaining refractor is the 2500 to 4000 ft/s one. This layer is particularly prominent in the south, e.g. traverse F. It may disappear for the same reason as the 4000 to 6000 ft/s layer, and in some cases an apparent average does exist, e.g. traverse G.

This division should not be regarded as a tightly defined range in that the velocity in any refractor may increase or decrease by 1000 ft/s or more.

5. INTERPRETATION OF RESULTS

ATR and Wurruma areas

Velocities measured with the seismic refraction method are characteristic of the physical properties of the rock types penetrated. Hence these velocities may be used to identify different geological formations provided that the physical properties of these formations show sufficient contrast.

The seismic velocities obtained from time-distance curves are generally grouped as follows :

Group	Longitudinal velocity (ft/s)	Rock type
1	1000-2000	Top soil
2	2000-4500	Unconsolidated overburden, dry
3	5000-8000	Unconsolidated overburden, wet
4	6000-12,000	Weathered bedrock
5	13,000-20,000	Unweathered bedrock

From this table it can be seen that there is no clear differentiation in seismic velocities between overburden and weathered bedrock, whereas there is a distinct velocity difference between weathered and unweathered bedrock. Layers showing seismic velocities of 6000 to 8000 ft/s can be interpreted either as weathered bedrock, as unconsolidated bedrock, or as a combination of both, while layers showing seismic velocities in excess of 13,000 ft/s are always considered to represent unweathered bedrock.

The fact that in the Mount Garnet area the seismic refraction method does not seem able to determine without ambiguity the boundary between overburden and weathered bedrock seriously limits the usefulness of this method in the search for alluvial tin deposits. Because of this ambiguity, the interpretation of seismic results is usually based on the boundary between the weathered and unweathered bedrock, which is well defined and which can be determined more readily. In such an interpretation, the results of the seismic survey are of practical value only if there is reason to expect that depressions in the unweathered bedrock surface coincide in position with corresponding depressions in the weathered bedrock. This is generally the case when the channel in the unweathered bedrock is well defined and the weathered zone is not too thick. If the channel in the unweathered bedrock is wide and a thick weathering zone exists, then it is quite possible for alluvial tin deposits to occur in relatively narrow channels on the weathered bedrock surface. This appears to be the case in the ATR and Wurruma areas where the depths calculated to the unweathered bedrock surface are exceedingly large and no direct correlation between depressions in the unweathered bedrock surface and occurrence of alluvial channels can be made.

A careful study of the distribution of tin values in the alluvial overburden was made taking into account all the available drilling results in the ATR and Wurruma areas. This showed that most of the alluvial tin is irregularly distributed in lenses located at different levels within the overburden layer and only seldom concentrated in depressions of the weathered bedrock surface, where alluvial tin deposits are generally found. Identification of the boundary between overburden and soft weathered bedrock in drill holes proved rather difficult and the possibility of drill holes being stopped in alluvium or drill holes continued in soft weathered bedrock should not be disregarded.

There seems to be no correlation between unweathered bedrock profiles and tin values, but the 6000 to 7500 ft/s refractor appears roughly to delimit the tin-bearing zone. Consequently, the interpretation of seismic results was based mainly on the 6000 to 7500 ft/s refractor, which in many cases appears to indicate the weathered bedrock surface.

The seismic results presented in the form of a contour map for the 6000 to 7500 ft/s velocity refractor (Plate 9) show several interesting features :

1. There appear to be two distinct channel systems in the ATR and Wurruma areas separated by a ridge which extends from known outcrops of Herbert River type granite near peg 20E on traverse ATR2 to the outcrops known as Luceys Knob.

2. The channel system north-east of this ridge is ill-defined with branches splitting and joining again apparently at random which indicate a nearly flat relief for the 6000 to 7500 ft/s refractor. The relief of this refractor changes between traverses AB and AC, becoming quite pronounced on traverse AC, which shows a distinct depression between AC 30 and AC 40. The general course of the channel system is in a south-easterly direction. This system has been explored extensively by Tableland Tin Dredging N.L. and alluvial tin was found in most of the holes, but values were poor and erratic. Holes MRW 17 to 27 and MRW 30 were drilled for the BMR by a contractor in the southern part of the area. Of these only MRW 18 showed tin values of economic grade.

3. The channel system west of the ridge is well defined, with the main branch crossing traverse ATR 3, once at peg 80 N and again at 5S. Only a limited amount of relatively shallow drilling was carried out over this system by Tableland Tin Dredging N.L. and the tin values obtained were very poor. This channel system appears to be indicated also in the unweathered bedrock surface (Plate 8) and in the Bouguer anomaly map (Horvath & Hussin, 1966).

4. There is a possibility that a third depression may exist. This could be in the Wurruma Swamp area, but not enough seismic work was done to prove it.

Smiths Creek area

As already stated there are certain recognisable refractors at Smiths Creek, and they may or may not represent geological boundaries of interest in the search for alluvial tin. Each of these refractors will be discussed in turn :

The 14,000 to 20,000 ft/s layer. This is generally considered to represent the unweathered bedrock. A contour map of this refractor has been constructed (Plate 8). It shows a major north-south depression which deepens to the south and meets, south of traverse F, an easterly-trending depression deepening to the east.

There is also a suggestion of another north-south channel which follows approximately the course of Smiths Creek. The further course of the channels is uncertain. The depths of these depressions range from 200 to 300 ft over the area, giving a fall of over 100 ft. Except on traverses A and B, the boreholes provide no confirmation of these depths. One reason may be the reluctance of the mining company to drill to such depths when the maximum economical depth for tin dredging here is about 100 ft.

Working on the assumption that this refractor was to be unweathered bedrock surface, two of the holes on traverse A (TTW595 and 596) were deepened to their present depth and appeared to bottom in the predicted range. No such extentions were attempted on the other traverse, where only the original drilling information exists. In no case has a borehole conclusively bottomed on hard bedrock.

The 6000 to 8000 ft/s layer. This may represent weathered bedrock, a lithological change in alluvium, or the watertable. If it is the weathered bedrock, it implies a very deep zone of weathering. What information there is on the geological environment in relation to the weathering process does not discount this idea entirely (Bik, 1963). The contour map of this refractor (Plate 8) shows two north-south channels, which are in a similar position to those in the lower refractor, but there is no evidence of a similar east-west channel.

This refractor could also represent the surface of the watertable, which may increase the velocity of the sediments below it enough to cause a recognisable velocity difference. Borehole information is of no use in this connection because of marked seasonal changes. However, whereas a rise in the table approaching Smiths Creek would be expected, the opposite is true for the refractor.

The 4000 to 6000 ft/s layer. This layer should represent alluvium and would merely be a lithological change if the material below is also alluvium. Because of its irregularity in appearance the surface of this layer could not be contoured.

The 2000 to 4000 ft/s layer. Again, this layer would have to be layer of sediments with different properties. There is a possibility that it is representative of the lateritic deposits observed but not mapped in detail by the geologists.

The 1000 to 1500 ft/s layer. This is considered to be due to the immediate effects of surface weathering as is recognised in most seismic surveys.

Nowhere in Smiths Creek has the seismic work indicated evidence of basalt flows, and their existence is not expected. On some traverses a regular lateral change in velocity has been observed (e.g. on traverse D there is a gradation from 4000 to 5000 ft/s in the east to 8000 ft/s in the west). If the refractor represents alluvium this may be due to a facies change. If the refractor is weathered or unweathered bedrock, it can only be explained by a local difference in weathering processes or composition of the bedrock.

Thus there are certain features which are unexplained. Both the 14,000 to 20,000 ft/s and the 6000 to 8000 ft/s layers have a prominent north-south valley bounded by a 'high' on the west and a high ridge in the centre of the area. On the eastern side of this ridge, there appears to be another south-trending valley approximately along the present position of Smiths Creek. The central north-south ridge coincides with the position of an outcrop that was prospected for wolfram early in the history of the area. South of this ridge the depressions appear to meet in the vicinity of traverse F and may or may not continue south.

6. CONCLUSIONS AND RECOMMENDATIONS

In the ATR and Warruma areas the seismic refraction survey did not reveal any east-west channels in the unweathered or weathered bedrock to support the theory of ancient rivers having had a westerly course prior to the Cainozoic Period. The seismic results indicate that the old drainage system was approximately in the same direction as the present system, that is, to the south-south-west.

Deep bedrock weathering was indicated in these areas. Depressions in unweathered bedrock surface were found at depths which, in many places, exceeded 300 ft. No correlation was possible between these depressions and the tested tin-bearing zone, which was found to be fairly shallow and to follow roughly the 6000 to 7500 ft/s refractor.

The interpretation of the seismic results is based on the assumption that the 6000 to 7500 ft/s refractor represents the top of the weathered bedrock, on or above which the alluvial tin was concentrated. During 1962 and 1963, nineteen holes were drilled on traverses ATR1, AB, AC, and AA. The drilling results are summarised in Table 1 and the seismic data shown for comparison. The results from about half of the drill holes seem to verify the assumption that the 6000 to 7500 ft/s layer is the top of the weathered bedrock, but the remainder show considerable discrepancies between the seismic and drilling results. Possible explanations are the presence of weathered bedrock with unusually low seismic velocities and the uncertainty in identification of weathered bedrock in the drill holes.

Drill holes MRW 26 and 27 on the Lower Return Creek traverse have identified as basalt the refractor with a velocity of about 11,000 ft/s shown in the seismic section (Plate 4).

The seismic results in the ATR and Wurruma areas indicate that the most probable areas for accumulation of alluvial tin would be:

(1) Around AC 30, where the 6000 to 7500 ft/s refractor indicates a definite channel in the weathered bedrock surface.

(2) Along the channel indicated west of the ridge that connects Luceys Knob with the granite outcrops near peg 20E on traverse ATR 2. This channel is indicated

in both the unweathered and weathered bedrock surfaces and would appear to be deeper and better defined than the channel system located east of the ridge. Very little drilling was done in this area in the past and this was rather shallow and did not actually reach definite weathered bedrock. Should alluvial tin deposits be found along this channel they would constitute new finds, whereas any alluvial tin discovered east of the ridge would be a continuation of the known Return Creek deposits.

The first area was tested by drill holes MRW 18, MRW 21, and MRW 22, which intersected tin-bearing wash. Good tin values were obtained in MRW 18 and MRW 21 but only fine traces of tin in MRW 22 (see Table 1). Further north the same channel in weathered bedrock was tested by MRW 19 on traverse AB and showed good tin values over two short intervals. Holes MRW 24 and MRW 23 on either side of MRW 19 on traverse AB showed only fine traces of tin, but MRW 17 near the second channel to the east intersected good tin values in a one-foot interval. Apart from MRW 18, the overall grade in these holes was very low and does not indicate payable dredging ground.

In the second area, MRW 25 drilled near the western end of traverse AA, intersected only fine traces of tin, but was not in a favourable location to test the channel indicated by the seismic survey. It would be advisable to drill one complete bore line across the channel, preferably along traverse ATR 4 between pegs 7 and 25. Drilling should start at peg 10 with further holes perhaps at 8.5, 11.5, 7, 13, etc., depending on the progress results of the drilling.

In the Smiths Creek area, the agreement between the two refractors contoured (Plates 8 and 9) regarding the existence of two north-south channels suggests that any channel system present would follow a southerly trend, which is in accordance with the present day drainage. In the southern part of the area, more detailed information might help to resolve the apparent divergence in the two refractors.

It is not possible to define accurately a refractor that indicates the weathered bedrock surface. If this could be determined it would set a limit to the depth of possible exploration. Whether the top of the 6000 to 8000 ft/s layer represents weathered bedrock or a sedimentary change is not important, as in either case it may show the existence of channels and guide the selections of drilling sites. The refractors overlying the 6000 to 8000 ft/s layer do not show sufficient continuity for the identification of stream patterns. Hence any recommendations for further exploration could be based on the top of the 6000 to 8000 ft/s layer.

Although drilling has been done on and near traverse F, a hole at F35 would be of interest, as three refractors, the 6000 to 8000, 4000 to 6000, and 2000 to 4000 ft/s refractors, show a depression at that point. A line of holes on traverse H, between H50 and H70, is also recommended, as the junction of the two separate channels suggested in this locality may be favourable for tin concentration.

The western channel in the 6000 to 8000 ft/s layer is well defined at F75 and a drill hole is suggested here. All the drill holes should go deep enough to positively identify the bedrock.

7. REFERENCES

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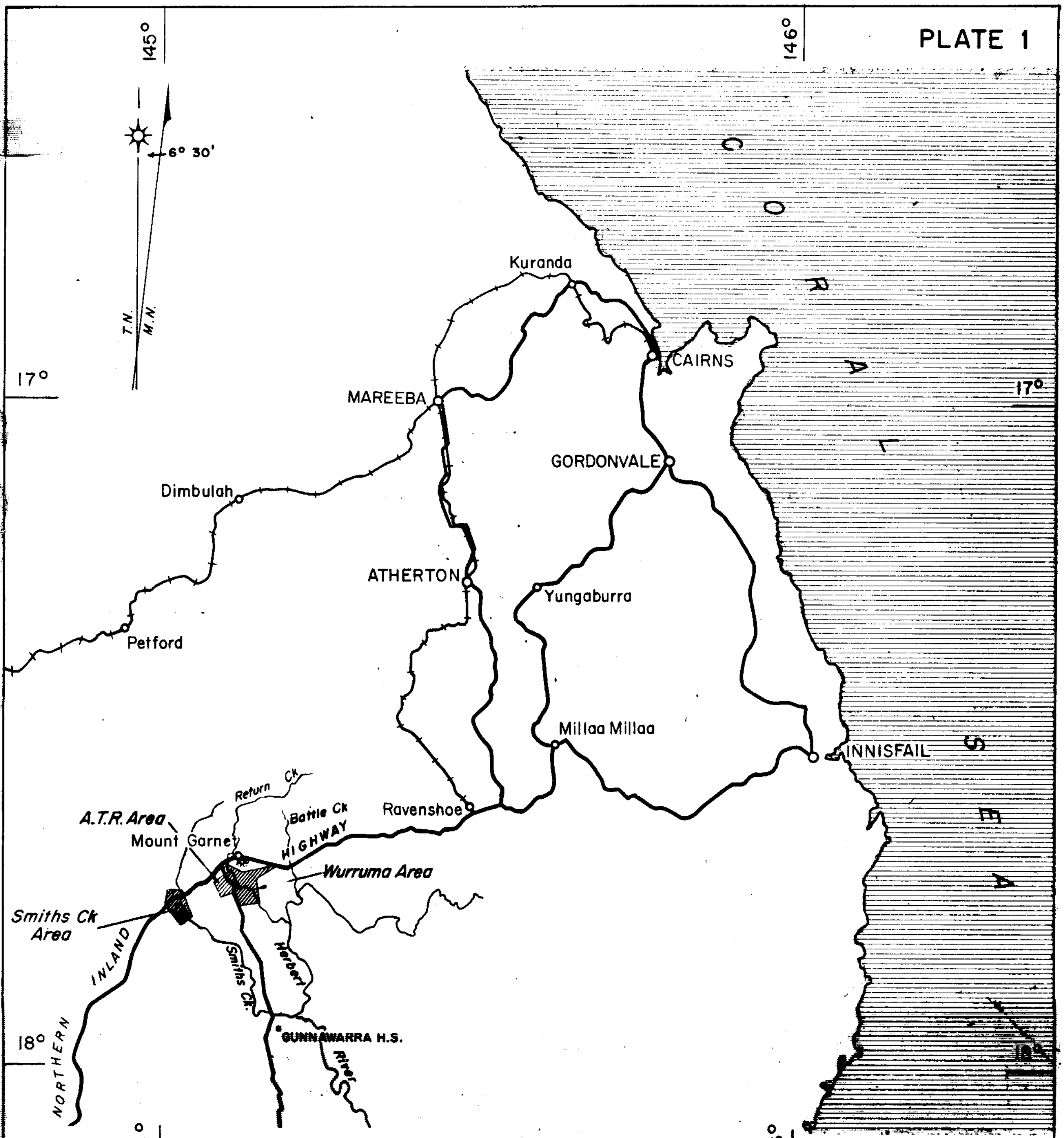
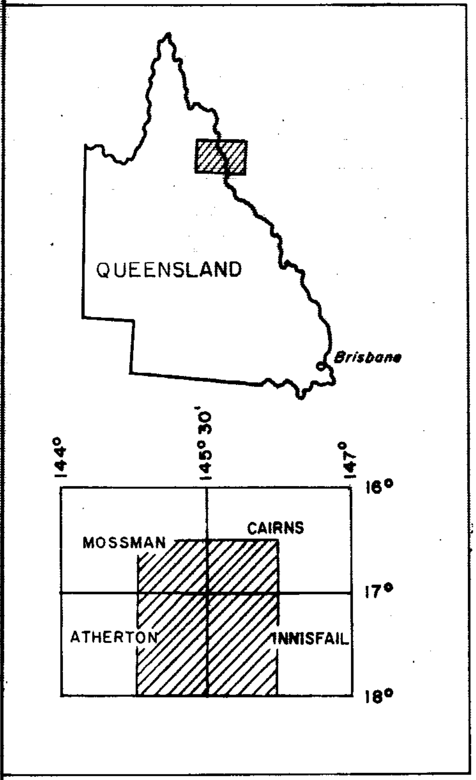
TABLE 1

Summary of drilling and seismic results

Drill hole	Location Trav/Peg	Calculated depth to unweathered bedrock (ft)	Calculated depth to 6000-7500 ft/sec refractor (ft)	Total depth of drill hole / Depth to weathered bedrock	Tin values	Observations
MRW 1	ATR1/107	287	53	102/56	Nil -	Definite weathered bedrock
MRW 2	ATR1/128	412	125	166/138	4'-5' traces 30'-36' traces 117'-121' traces (negligible) 122'-127' very fine traces	Some small water-worn stones at 122'. One fairly large water-worn stone at 138'. No definite weathered bedrock.
MRW 3	ATR1/117	285	165	119/	1'-6' traces	No definite weathered bedrock. Last wash layer at 87'.
MRW 4	ATR1/137	343	143	159/149	15'-16' traces 41'-42' traces	No definite weathered bedrock. Hard fine silty clay (reddish brown) bottom 149'. (possible bedrock).
MRW 5	ATR1/157	193	78	50/40	0'-10' traces 33'-38' traces	Definite weathered granite bedrock
MRW 6	ATR1/162	195	105	91/90	0'-2' traces 24'-28' traces	Definite weathered granite bedrock
MRW 7	ATR1/166	167	63	53/49	0'-5' traces	Definite weathered bedrock
MRW 8	ATR1/172	200	35	167/162	0'-2' traces 20'-26' good traces 35'-37' fine traces 79'-83' very fine traces	Definite decomposed schist at 162'. Depth of 35' refers to layer showing velocity of 5900 ft/s. Large piece of rounded quartz at 153'.
MRW 9	ATR1/97	211	45	44/40	Nil	Definite decomposed schist at 40'
MRW 17	AB/30	260	97	52/42	16'-17' 2.78 oz/yd^3	Definite decomposed granite
MRW 18	AC/30	292	117	106/89	82'-89' 3.11 oz/yd^3	Soft decomposed granite at 89'. Hard decomposed granite at 106'
MRW 19	AB/50	276	91	174/84	37'-41' 8.62 oz/yd^3 65'-68' 8.02 oz/yd^3	Probably decomposed igneous rock at 84' (J. Best, pers. comm.). Definite decomposed granite at 174'.
MRW 20	AC/66	290	40	63/60	51'-60' big traces	No definite weathered bedrock. Hard tough pinky clay at 60'.
MRW 21	AC/28	287	107	85/76	2'-8' traces 8'-14' 5.46 oz/yd^3 70'-72' traces	Definite decomposed granite at 85'
MRW 22	AC/32	272	114	85/82	0'-2' very fine traces 8'-11' very fine traces	Definite decomposed granite at 85'
MRW 23	AB/53	307	69	150/96	26'-32' very fine traces 55'-57' } very fine 7[illegible]'-88' } traces 105'-110' very fine traces	Few wash stones at 89' Little sand at 95' Hard decomposed rock at 150'
MRW 24	AB/42	265	67	85/68	0'-5' fine traces 11'-13' very fine traces 15'-40' very fine traces	Silty clay with water-worn stone at 30'. Hard silty clay with odd stone at 40'. Hard silty clay with angular quartz indicating decomposed rock at 68'. Hard decomposed rock at 85'.
MRW 25	AA/85	360	36	280/	0'-2' very fine traces 7'-15' very fine traces 226'-235' very fine traces 245'-255' very fine traces	Sandy clay wash at 9' and 15' Kaolin at 201' Hard silty clay with rounded quartz sand below 207'. Drilling stopped at 280' in silty clay carrying fine sand.
MRW 26	Lower Return Creek/15	--	120	149/	0'-2' trace 12'-15' trace 71'-74' 13.89 oz/yd^3	Hard claybound wash 71'-74'. Hard decomposed basalt 110'-128'. Hard decomposed red yellow rock bottom.
MRW 27	Lower Return Creek/70	--	100	274/	0'-2' trace 25'-27' fine trace 41'-44' very fine traces	Very hard claybound wash [illegible]'-41'. Hard decomposed basalt [illegible]1'-149'. Hard tough clay 152'-181'. Hard medium-coarse very sandy clay with gravel at 273'. Very hard pegmatite bottom at 274'.
MRW 30	AC/8	221	92	80/70	Nil	Silty clay with few stones to 68'. Decomposed granite at 70'. Definite granite at 80'.

PLATE 1





REFERENCE TO AUSTRALIA STANDARD MAP SERIES

MOUNT GARNET SEISMIC SURVEY, 1962

LOCALITY MAP

TO ACCOMPANY RECORD No. 1967/30

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

E55/B7-12-1

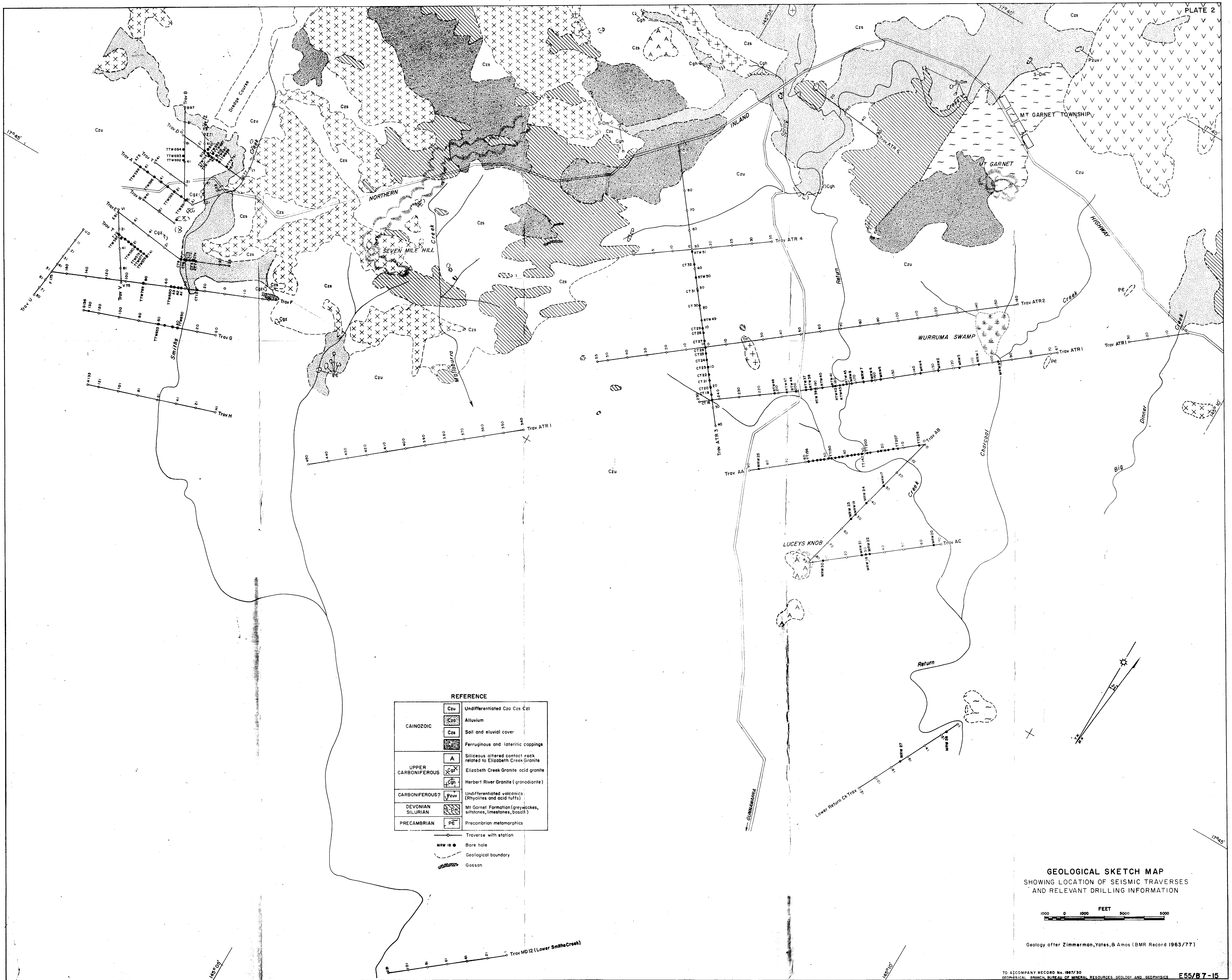


PLATE 2
GEOLOGICAL SKETCH MAP
SHOWING LOCATION OF SEISMIC TRAVERSES
AND RELEVANT DRILLING INFORMATION
FEET
1000 0 1000 3000 5000
Geology after Zimmerman, Yates, & Amos (BMR Record 1963/77)
TO ACCOMPANY RECORD No. 1967/30
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS
E55/B7-15
REFERENCE
CAINOZOIC
Czu Undifferentiated Cza Czs Czl
Cza Alluvium
Czs Soil and eluvial cover
Czl Ferruginous and lateritic cappings
UPPER CARBONIFEROUS
A Siliceous altered contact rock related to Elizabeth Creek Granite
Cgz Elizabeth Creek Granite acid granite
Cgh Herbert River Granite (granodiorite)
CARBONIFEROUS? Pzuv Undifferentiated volcanics (Rhyolites and acid tuffs)
DEVONIAN SILURIAN S-Dm Mt Garnet Formation (greywackes, siltstones, limestones, basalt)
PRECAMBRIAN P€ Precambrian metamorphics
Traverse with station
MRW 18 Bore hole
Geological boundary
Gossan
MT GARNET TOWNSHIP
MT GARNET
SEVEN MILE HILL
WURRUMA SWAMP
LUCEYS KNOB
NORTHERN
INLAND
HIGHWAY
Smiths
Creek
Return
Charcoal
Big
Dinner
Gunnawarra
Dredge Course
Trav ATR 1
Trav ATR 2
Trav ATR 3
Trav ATR 4
Trav ATR 6
Trav AA
Trav AB
Trav AC
Trav F
Trav G
Trav H
Trav U
Trav V
Trav B
Trav D
Trav MD12 (Lower Smiths Creek)
Lower Return Ck Trav
17°45'
17°40'
145°05'
145°10'

PLATE 3


A.T.R. 4
A.T.R. 6
A.T.R. 2
A.T.R. 1
A.T.R. 1
A.T.R. 1
LEGEND
(17,000) Formation with seismic velocity of 17,000 ft/s
32' Depth to formation with different seismic velocity
Boundary between seismic velocities (inferred)
" " " " (calulated for each geophone)
Unweathered Bedrock Boundary
MRW8 Drillhole
ATR AND WURRUMA AREA
SEISMIC CROSS-SECTIONS
TRAVERSES ATR1, ATR2, ATR4, ATR6
FEET
HORIZONTAL 500 0 500 1000 1500 2000
VERTICAL 250 0 500 1000
TO ACCOMPANY RECORD No. 1967/30
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
E55/B7-24

PLATE 4

ATR AND WURRUMA AREA

SEISMIC CROSS-SECTIONS

TRAVERSES ATR3, AA, AD, AC, AND LOWER RETURN CREEK

TO ACCOMPANY RECORD No. 1967/30

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

E55/B7-21

PLATE 5

LEGEND

(17,000) Formation with seismic velocity of 17,000 ft/s

-32′ Depth to formation with different seismic velocity

------ Boundary between seismic velocities (inferred)

- - - - " " " " (calculated for each geophone)

Unweathered Bedrock Boundary

MRW8 Drillhole

SMITHS CREEK AREA

SEISMIC CROSS-SECTIONS

TRAVERSES D, Z, B, Y, A, C, W, T, AND E

FEET

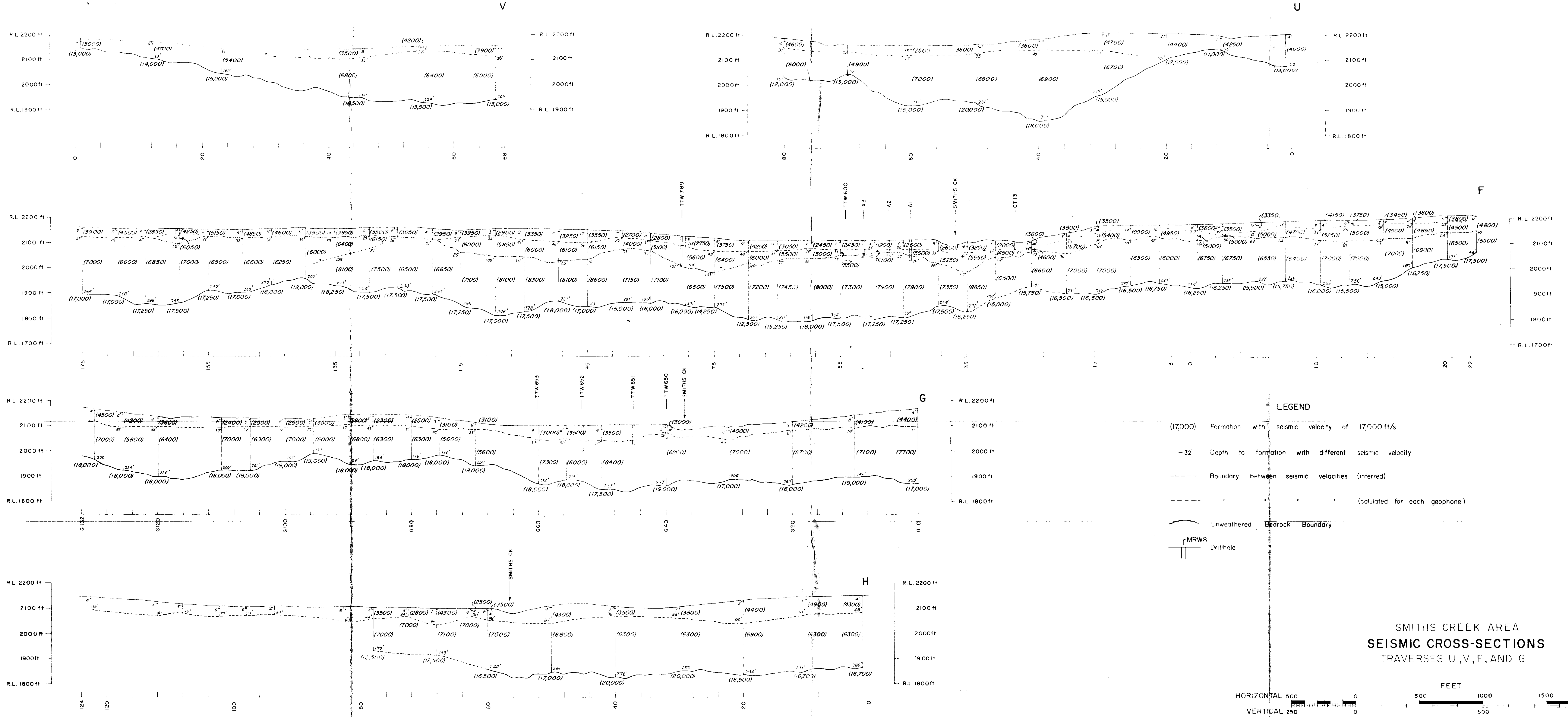
HORIZONTAL 500 0 500 1000 1500 2000

VERTICAL 250 0 500 1000

TO ACCOMPANY RECORD No. 1967/30

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

E55/B7-22



LEGEND

(17,000) Formation with seismic velocity of 17,000 ft/s

– 32' Depth to formation with different seismic velocity

- - - - Boundary between seismic velocities (inferred)

- - - - " " " (caluiated for each geophone)

⌒ Unweathered Bedrock Boundary

MRW8 Drillhole

SMITHS CREEK AREA

SEISMIC CROSS-SECTIONS

TRAVERSES U, V, F, AND G

FEET

HORIZONTAL 500 0 500 1000 1500 2000

VERTICAL 250 0 500 1000

TO ACCOMPANY RECORD No. 1967/30

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

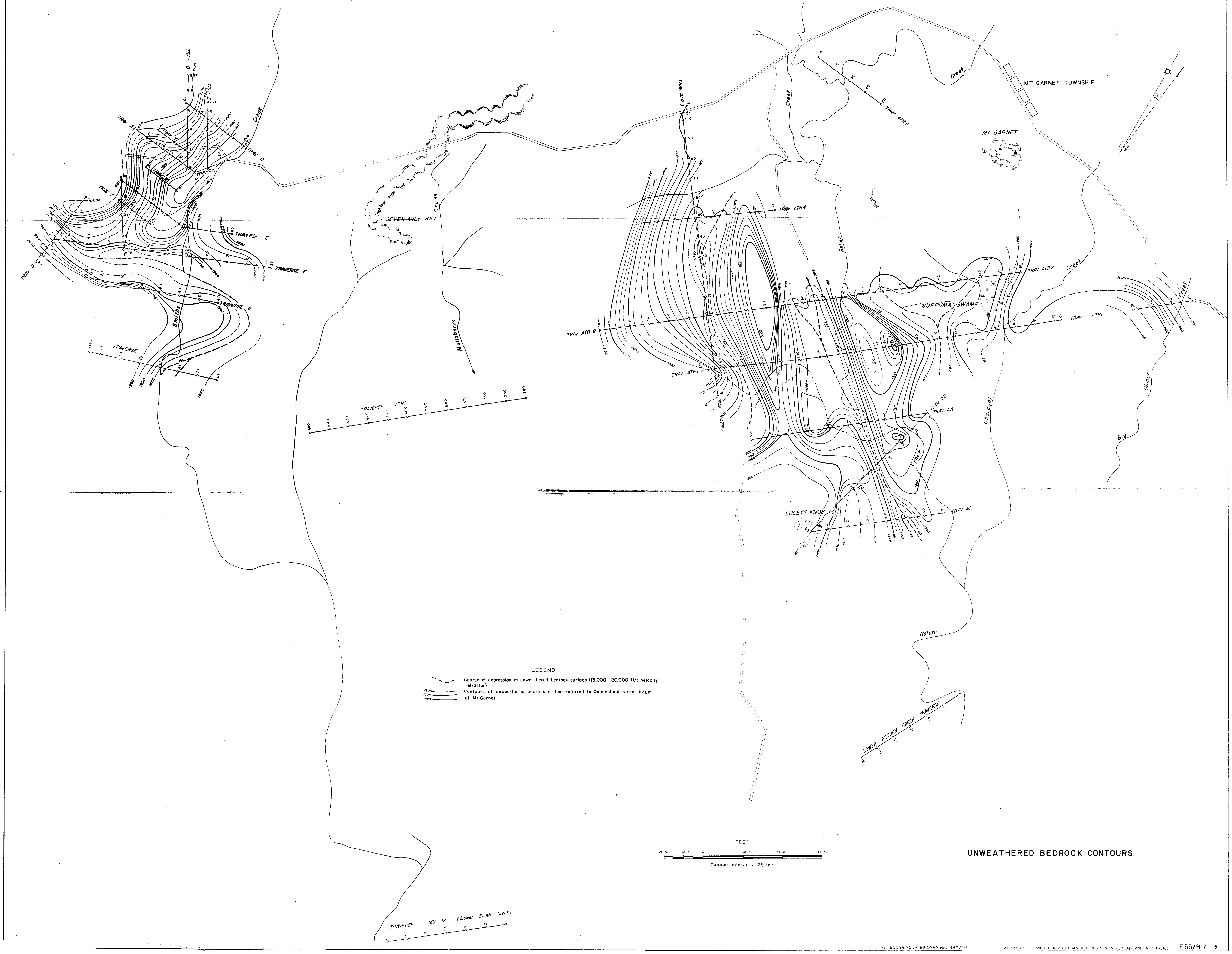
E55/B7-23

PLATE 7

VELOCITY LOGS IN DRILL HOLES

TO ACCOMPANY RECORD No 1967/30 Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics E55/B7-20

MT GARNET SEISMIC SURVEY NQA QLD 1962



LEGEND

Course of depression in unweathered bedrock surface (13,000 - 20,000 ft/s velocity refractor)

1875, 1900, 1925 — Contours of unweathered bedrock in feet referred to Queensland state datum at Mt Garnet

FEET

2000 1000 0 2000 4000 6000

Contour interval = 25 feet

UNWEATHERED BEDROCK CONTOURS

MT GARNET SEISMIC SURVEY 1962

6000 – 7000 FT/S REFRACTOR CONTOURS

MT GARNET SEISMIC SURVEY 1962

TO ACCOMPANY RECORD No. 1967/30

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

E55/B7-17