COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1963/81

GREAT FRASER RIVER, GREAT MUSSEL ROE RIVER, AND ST HELENS GEOPHYSICAL SURVEYS, GLADSTONE TIN DISTRICT,

TASMANIA 1962

by

E.C.E. SEDMIK

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SUMMARY

Reconnaissance gravity and seismic refraction surveys were made by the Bureau of Mineral Resources in areas chosen by the Tasmanian Department of Mines to test for depressions in bedrock, which could contain alluvial tin deposits of economic importance.

Eight traverses totalling about 10 miles in length were surveyed in three different areas. The results obtained from gravity surveys were in agreement with those obtained from seismic surveys.

In the Great Fraser River area enough geophysical work was done to conclude that a definite channel in the bedrock existed. In the other two areas, depressions in the bedrock were indicated but insufficient traverses were surveyed to prove that channels existed.

Recommendations are made regarding the most suitable locations for test drilling in the Great Fraser River area and in the Great Mussel Roe River area.

1. INTRODUCTION

The Tasmanian Department of Mines is concerned about the future of the alluvial tin mining industry in north-eastern Tasmania. The present rate of production will decline unless new deposits are found to replace those sources of supply which will be worked out in the near future. Since 1953, several potential tin-bearing areas have been investigated and the more promising prospects were drilled but no relevant discoveries were made.

In 1960 the Department of Mines asked the Bureau of Mineral Resources to conduct geophysical surveys to assist in the investigation of several areas in the Gladstone district of north-eastern Tasmania. The object of the surveys was to locate depressions in the bedrock which might contain deposits of alluvial tin and to indicate the most favourable sites for test drilling.

Plate 1 shows the general location of the areas selected. This Record describes the geophysical surveys in the Great Fraser River area, Great Mussel Roe River area, and St Helens area. The fourth area surveyed, situated north of Winnaleah, is the subject of a separate Record (Sedmik, in preparation).

The Great Fraser River area is located on the eastern bank of the Great Fraser River, about half a mile from the headwaters. It is traversed by the old bullock track that once connected Gladstone with St Helens. Approach to this area is from the Gladstone-Ansons Bay road (see Plate 2).

The Great Mussel Roe area is situated on the eastern side of the river, south of the Gladstone-Ansons Bay road (see Plate 3).

The St Helens area lies west of the township of St Helens, extending over the old alluvial workings known as Tureaus deep lead (see Plate 4).

The geophysical field work was done in February and March 1962 and comprised three weeks of gravity work and four weeks of seismic work. The geophysical party consisted of party leader E.C.E. Sedmik, geophysicists J.J. Hussin, F. Maranzana, and R.J. Smith (for part of the survey), assistant geophysicist I. Ripper, and seven field assistants. The topographical survey of traverses was done by T. Howard of the Department of the Interior, Canberra, assisted by two chainmen.

2. GEOLOGY

The general geology of the areas investigated is discussed by Jack (1960).

The oldest rocks in the district are quartzite, slate, and sandstone, probably of Silurian age into which Devonian granite has been intruded over large areas. The alluvial tin is believed to be shed from the large granitic mass of the Blue Tier. The Silurian sediments are devoid of tin mineralization.

During the lower Tertiary, the north-eastern part of Tasmania subsided and sedimentation gradually filled up the old river valleys. With further subsidence, the lower reaches of the rivers at first formed broad lakes and estuaries. Then the sea gradually encroached upon large areas, and marine sediments, coarse conglomerate, grit, and fine sand were deposited. Towards the end of this subsidence, during the upper Tertiary, basalt extruded and spread along the valleys covering the sediments.

With the land rising again, a new erosion cycle started and much of the surface was stripped off, in some places revealing the old Tertiary tin-bearing gravels.

The Great Fraser River area was selected for geophysical investigation because it was considered that the low ridges, which cross the area in a north-westerly direction, could represent a partially dissected valley or flood plain. Most of the area is covered with fine quartz gravel but some large pebbles were also noticed in the northern part. Tertiary wash has been observed along the middle portion of the southern-most traverse, Traverse Z.

The Great Mussel Roe River area was selected because it was an untested area covered by sedimentary rocks close to other similar areas situated west and north of the Great Fraser River, which were thoroughly tested by Keid (1954) and proved to contain concentrations of alluvial tin.

Traverse A in the St Helens area was selected along the proposed bore line No. 1 which was one of several lines of bores chosen by the Mines Department to test Thureaus deep lead. This lead was worked successfully in the past.

3. METHODS AND EQUIPMENT

Gravity method

The gravity method depends on the detection of variations of the Earth's gravitational field due to distribution of rocks of different densities in the subsurface.

Before being useful as a possible indication of subsurface conditions, the observed gravity values must be corrected for instrumental drift, altitude, free-air, elevation (Bouguer), and sometimes for terrain.

The gravity method can be used to estimate the thickness of overburden over deep valleys if certain favourable conditions exist such as flat topography, homogeneous bedrock, and marked density contrast between bedrock and overburden. Under these conditions gravity profiles over a deep valley show a negative anomaly, the general shape of which is very similar to the bedrock profile.

Gravity observations were made with the World Wide gravity meter No. 35, which is a quartz-type meter capable of measuring differences of gravity of about 0.01 mgal. The dial constant of the meter was 0.11504 mgal/dial division.

Seismic refraction method

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

The seismic equipment used during this survey consisted of a SIE 12-channel refraction seismograph and Electro-Tech geophones having a natural frequency of 20 c/s.

The field arrangement and calculation method known as the 'Method of Differences' was used (Heiland, 1946 p. 548; Hawkins, 1961). The application of the seismic refraction method to the location of deep leads is described in detail by Urquhart (1956).

4. FIELD WORK AND RESULTS

Gravity work preceded the seismic work in each area. In order to save time and explosives, parts of the traverses where the gravity work indicated shallow ground were not surveyed with the seismic method.

Great Fraser River area

Initially three traverses, viz. R, S, and T, were laid out in this area(see Plate 2). They started from the eastern bank of the Great Fraser River, extending in an easterly direction for about 1½ miles and finishing on, or close to, granite outcrops. Later, Traverse Z was surveyed in the south-eastern part of the area. All traverses were accurately levelled at 50-ft intervals. Surface elevations were referred to an arbitrary datum. The locations of traverses are shown on Plate 2. Total length of surveyed traverses was about 5½ miles.

Gravity

All gravity observations were referred to a base station, S3200, the elevation of which has been taken as reference level for elevation corrections. The elevation corrections (combined free-air and Bouguer corrections) were calculated twice, assuming constant densities of 2.0 and 2.5 g/cm^3 for the rocks above the reference level. Consequently, two Bouguer gravity profiles were produced although it is realised that a Bouguer correction using varying surface densities would have been more appropriate if the density distribution above the reference level was known.

Bouguer corrections made using the assumed density of 2.5 g/cm^3 throughout would be correct only for the areas where the basement rock, presumably granite, crops out; the Bouguer corrections would be in error wherever soil cover or overburden exists. Bouguer corrections made using an assumed density of 2.0 g/cm^3 throughout would be correct over areas where the basement rock is below the reference level but would be incorrect wherever the basement rock rises above the reference level.

A latitude correction of 1.296 mgal/mile was applied to compensate for the change of gravity with latitude.

The Bouguer gravity profiles showed a strong regional effect with the gravity values decreasing sharply from east to west. This regional effect, caused by deep-seated changes in the subsurface conditions, tended to obscure the much smaller effect caused by changes of overburden thickness. Lines corresponding to the regional effect were drawn on the assumption that the gradient determined by the gravity values obtained at points where the bedrock cropped out applied for the whole profile and was linear.

Residual gravity profiles were obtained by subtracting the regional gravity values from the corresponding Bouguer gravity values. The residual gravity results are shown as profiles on Plate 5 and as contours on Plate 6.

All residual profiles show negative anomalies of about one milligal, suggesting a considerable thickness of overburden. The profiles along Traverses R and S in the northern part of the area indicate a very broad basin with no definite channels; the profiles along Traverses T and Z indicate narrower depressions.

Seismic

The total length of traverses covered by the seismic method was about 4 miles.

The seismic work consisted of :

(a) weathering spreads to obtain the thickness of, and seismic velocity in, the soil and near-surface layers. Geophones were spaced 5 and 10 ft apart and shots were fired at 5, 10, and 100 ft beyond each end of the spread and in line with it,

(b) normal spreads to measure the velocities in the formations beneath the soil and in the bedrock and also to calculate the vertical travel times. Geophones were spaced at 50-ft intervals and the shot-points were from 25 ft to 525 ft beyond each end of the spread and in line with it.

Vertical travel times to unweathered bedrock were computed at each geophone station from normal spreads by using the method of differences. Average velocities and depth to layers of different velocities within the overburden were calculated using the time/distance curves and the intercept method.

The seismic results are shown as cross-sections on Plate 7 and as unweathered bedrock contours on Plate 8.

Great Mussel Roe River area

Three traverses were surveyed in this area. The first two, viz. P and Q, were laid out in a south-easterly direction, starting from the right bank of Great Mussel Roe river, opposite the old Elizabeth Workings, and finishing close to granite outcrops in the southern part of the area. Traverse U was laid out in continuation of a known line of bores which was drilled by the Tasmanian Department of Mines during 1953. Traverse U extended about 1000 ft over this line of bores thus allowing a comparison between gravity, seismic, and drilling results to be made.

Total length of traverses exceeded three miles.

The gravity observations were referred to a base station, P3000, the elevation of which was taken as reference level for elevation corrections. Corrections for instrumental drift, elevation, and latitude were made as in the Great Fraser River area but no residual gravity values were calculated as there was not enough information about the regional effect.

The results of the gravity survey are shown as Bouguer gravity profiles on Plate 9.

The seismic work was done in the same manner as at the Great Fraser River area. The results of the survey are presented as seismic cross-sections on Plate 10.

St Helens area

One short test traverse was surveyed in this area along the Mines Department's proposed bore line No. 1. This traverse started from a point on Hogans Track, about one mile west of the St Helens golf course, extending in a southerly direction for 2500 ft and in a northerly direction for 800 ft. The most northerly observation point was in the Golden Fleece Rivulet.

Only the gravity method was used and the gravity observations were referred to a base station at 500S. Reference level for elevation correction was taken as 1.2 ft below the elevation of the base. Latitude corrections were applied. Bouguer gravity profiles were calculated using densities of 2.0 and 2.5 g/cm^3 for elevation correction. The gravity profiles are shown on Plate 11.

5. INTERPRETATION AND CONCLUSIONS

The seismic velocities calculated from time/distance curves are characteristic for the rock types penetrated. These may be grouped as follows :

Group	Longitudinal velocity (ft/sec)	Rock type
1	800 - 2000	soil
2	2000 - 5000	unconsolidated overburden dry
3	5000 - 8000	unconsolidated overburden wet
4	6000 - 14,000	weathered bedrock
5	14,000 - 20,000	unweathered bedrock

In tin-bearing country, alluvial tin deposits are expected to be found within, or more often at the bottom of, the overburden layer that 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 surface forming well-defined channels before being filled with detrital or volcanic material, thus forming the deep leads.

Determination of channels in the interface between overburden and unweathered bedrock is highly desirable when searching for deep leads. However, this boundary is difficult to obtain with the seismic refraction method if there is no clear differentiation between wave velocities in the overburden and those in the weathered bedrock.

Layers showing seismic velocities of 8000-14,000 ft/sec can be interpreted with some certainty as representing weathered bedrock. Seismic velocities of 6000-8000 ft/sec could correspond to weathered bedrock as well as to unconsolidated overburden.

Because of this uncertainty, the interpretation of seismic results is usually based on the boundary of the unweathered bedrock, which is well defined and therefore can be determined more readily. In such an interpretation, the results of the seismic survey are likely to be of practical value only if the depressions in the unweathered bedrock coincide in position with depressions in the weathered bedrock. This is generally the case when the depression in the unweathered bedrock is narrow and well defined and the weathered zone is not too thick. If the depression in the unweathered bedrock is wide and a thick weathering zone exists, then it is quite possible for relatively narrow channels to be present on the weathered bedrock surface without any corresponding features on the unweathered bedrock surface. In such a case the interpretation of seismic results based on determination of the unweathered bedrock surface is not reliable.

The seismic cross-sections presented on Plates 7 and 10 show the calculated depths to the unweathered bedrock. Intermediate layers and their respective velocities, which could only be calculated at the ends of each spread, are also shown.

The accuracy of the depth determinations depends on how accurately the average velocity in the layers above the unweathered bedrock can be determined. In calculating the average velocity from the time/distance curves, errors may arise due to the presence of layers that are not indicated by the time/distance curves, either because the layers are too thin or the velocities in them are lower than in the layers above them. Errors may also arise if no allowances are made for the effects of dips of the different layers. The average velocity in the layers above the unweathered bedrock can be more accurately obtained by direct measurement where there is a sufficient number of accessible shafts or drill holes down to the unweathered bedrock. This was not the case during the present survey.

Great Fraser River area

The weathered bedrock profiles appear to follow the general shape of the unweathered bedrock profiles (Plate 7) and depressions in the unweathered bedrock (Plate 8) probably correspond approximately with the position of channels in the weathered bedrock.

The thickness of the weathered zone above the unweathered bedrock seems to be larger on the northern traverses, viz. R and S, and gradually decreases towards the southern traverses, viz. T and Z. The velocity in the weathered zone increases from 6000 ft/sec on Traverse R to 8000 ft/sec on Traverse Z. This increase in velocity could mean that the degree of weathering of the bedrock decreases towards the southern part of the area.

The residual gravity contour map (Plate 6) and the unweathered bedrock contour map obtained from the seismic survey (Plate 8) both indicate a channel in the unweathered bedrock in the Great Fraser River area. The position of the channel obtained from the gravity survey is in general agreement with the one obtained from the seismic survey. Where differences exist, the latter is considered to be more accurate. The channel is well defined on Traverses Z and T, gradually becoming broad and ill-defined towards Traverses S and R.

From the examination of the geophysical results in the Great Fraser River area it can be concluded that alluvial tin is most likely to occur in the area above the channel indicated in the unweathered bedrock contours. It is recommended that this area should be drilled and the recovery from the holes tested for tin content.

Drilling should commence in the southern part of the area on Traverses T and Z, where the channel in the bedrock appears to be better defined. It would be advisable to drill several holes on each traverse as experience has shown that the best tin values are not always in the deepest part of the depression and also because the 'low' indicated in the unweathered bedrock might not coincide closely with the position of the deep lead. Holes could be put down from Z 1300 to Z 2500 and from T 7000 to T 7800 at 200-ft intervals at first and, if the results warrant further testing, additional holes should be drilled at closer intervals.

Great Mussel Roe area

A comparison between seismic results and actual drilling results can be made on the westernmost portion of Traverse U, where 12 holes were drilled by the Department of Mines during 1953 (Plate 10). The weathered granite layer in which these drill holes bottomed corresponds fairly well with the refractor in which the velocity is 7000 ft/sec. However, the 7000-ft/sec refractor could not be followed over the whole length of the traverse. No velocity logging of these holes could be made because they were inaccessible.

The thickness of the weathered zone above the unweathered bedrock profile appears to vary considerably along the traverses and therefore the unweathered bedrock profile might not be reliable as a guide for drilling recommendations.

Only a very limited amount of drilling is recommended. This should be confined to those regions where the cross-sections show depressions in the unweathered bedrock surface. The most favourable regions for test drilling would be from P 500 to P 1700 and Q 900 to Q 1500. It is recommended that drilling should start at Q 1250. Although gravity and seismic results on the western part of Traverses P and Q do not agree very well, it might be worthwhile to probe a possible depression at P 4000.

St Helens area

The gravity results along Traverse A (Plate 11) show a gentle decrease of the gravity values starting from 800N towards a minimum at 1700S, followed by a slow increase towards the southern end of the traverse at 2500S. The Bouguer gravity profiles calculated using the density of 2.5 g/cm^3 for elevation correction appears to mirror the surface topography, thus indicating that the density chosen for elevation correction is too high. The Bouguer profile obtained by using the density of 2.0 g/cm^3 for elevation correction seems to be more suited for this area as it gives a smoother gravity profile which neither mirrors nor follows the surface topography.

The general shape of the gravity profiles indicates a steady increase of the depth to bedrock from both ends of the traverse towards 1700S.

Since the completion of the gravity work, the Department of Mines drilled five holes along this traverse to test for economic concentration of alluvial tin. The positions and depths of these holes are shown on Plate 11 to facilitate a comparison between gravity and drilling results. Drilling generally confirms the increase in depth indicated by the gravity results. However, drilling has been discontinued along this traverse because the tin values were poor and the depth of holes rather large. Lines of bores closer to the source of tin are being drilled west of Traverse A.

6. REFERENCES

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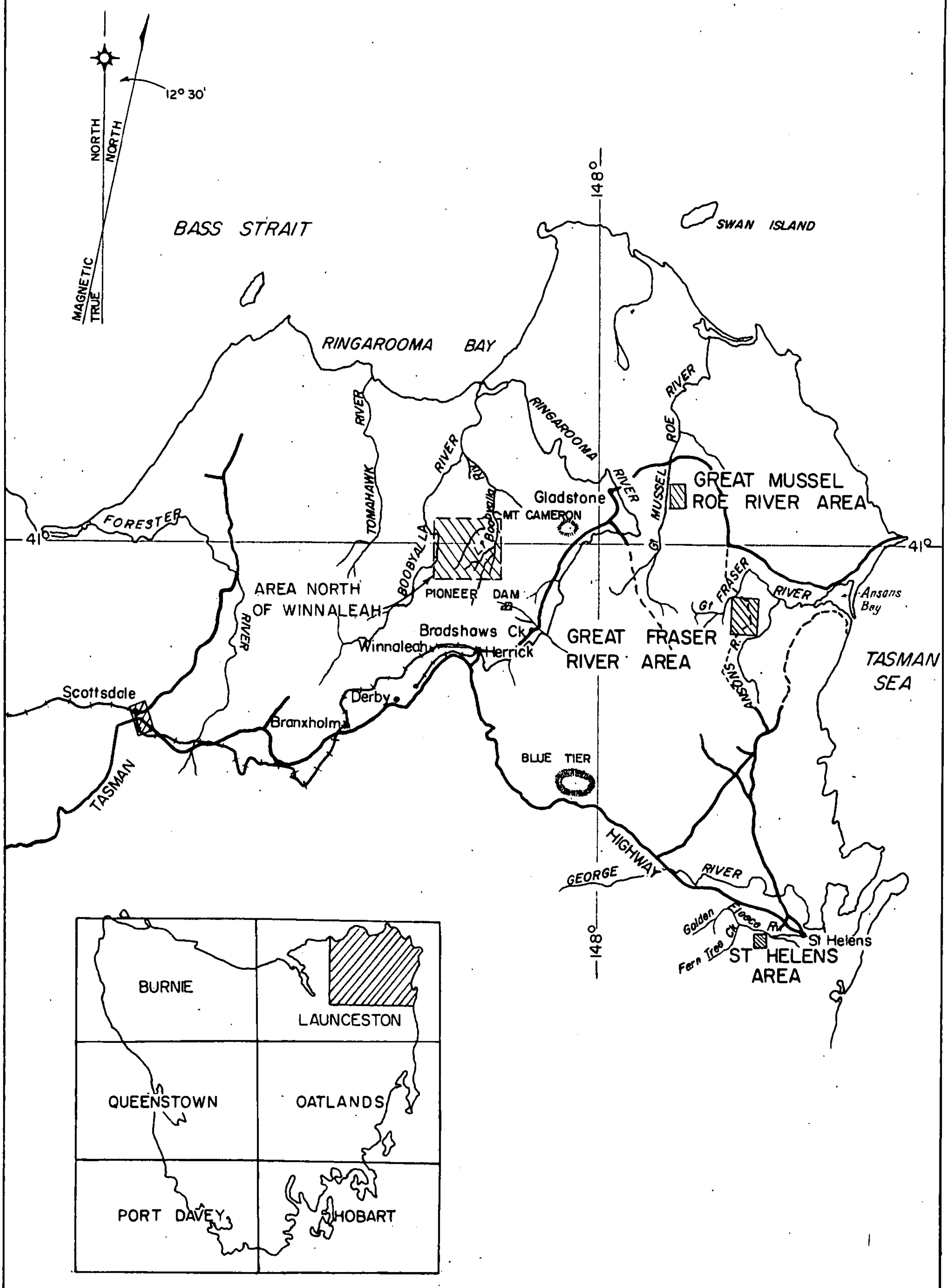
PLATE I



REFERENCE TO AUSTRALIAN
4-MILE MAP SERIES

SCALE IN MILES

8 0 8 16

GEOPHYSICAL SURVEYS
FOR
ALLUVIAL TIN
GLADSTONE TIN DISTRICT
N E TASMANIA 1962

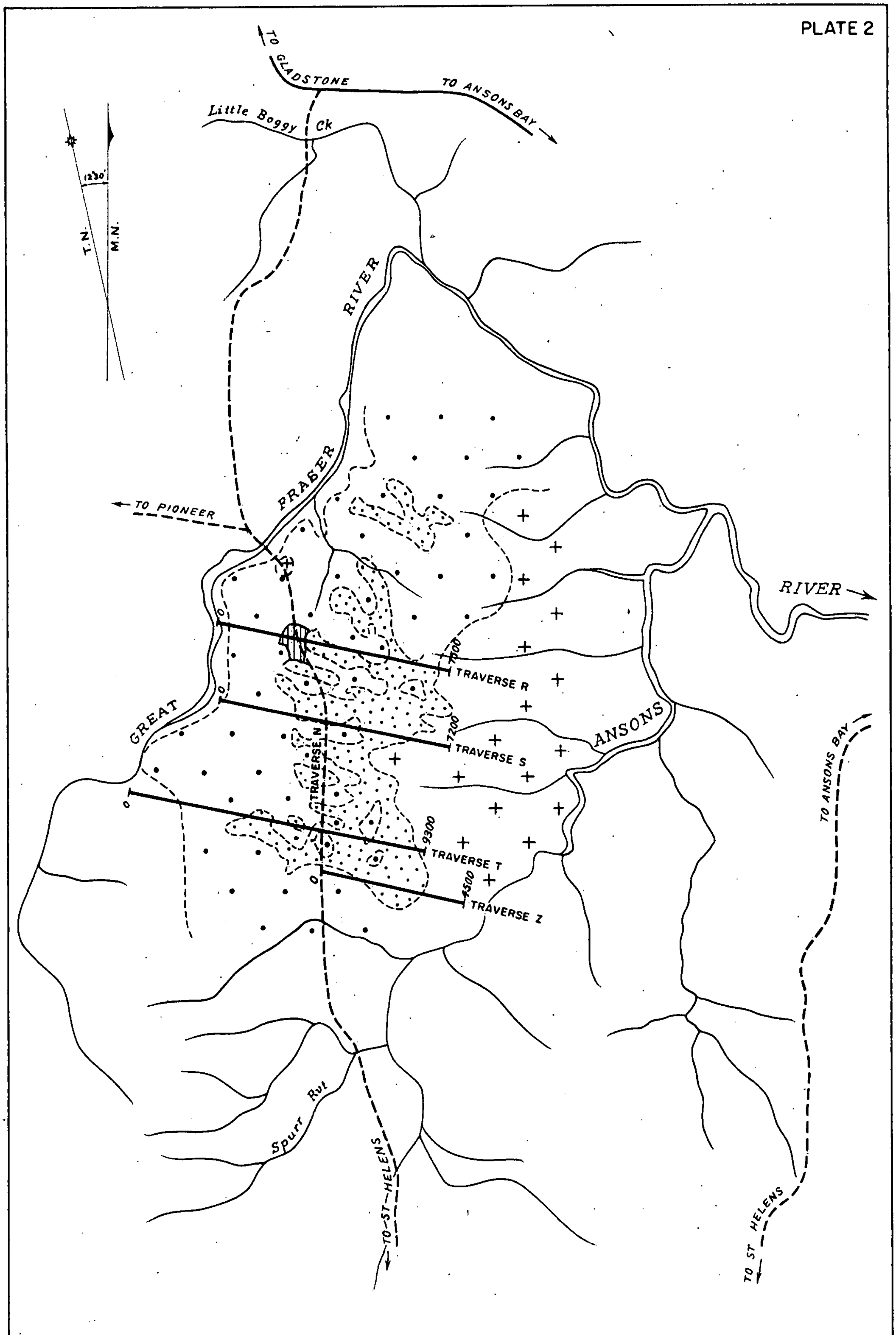
LOCALITY MAP

K55/B7-25

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

TO ACCOMPANY RECORD No 1963/81

PLATE 2



LEGEND

QUATERNARY

Sandy soil. (from Tertiary drifts)

Swamp soil

TERTIARY

Pebble beds, gravel, sand etc.

DEVONIAN

Granite

GEOLOGY AFTER R. JACK GEOLOGIST
TASMANIAN MINES DEPT OCT 1960

TO ACCOMPANY RECORD No 1963/81

GREAT FRASER RIVER AREA

LAYOUT OF TRAVERSES AND GEOLOGY

FEET

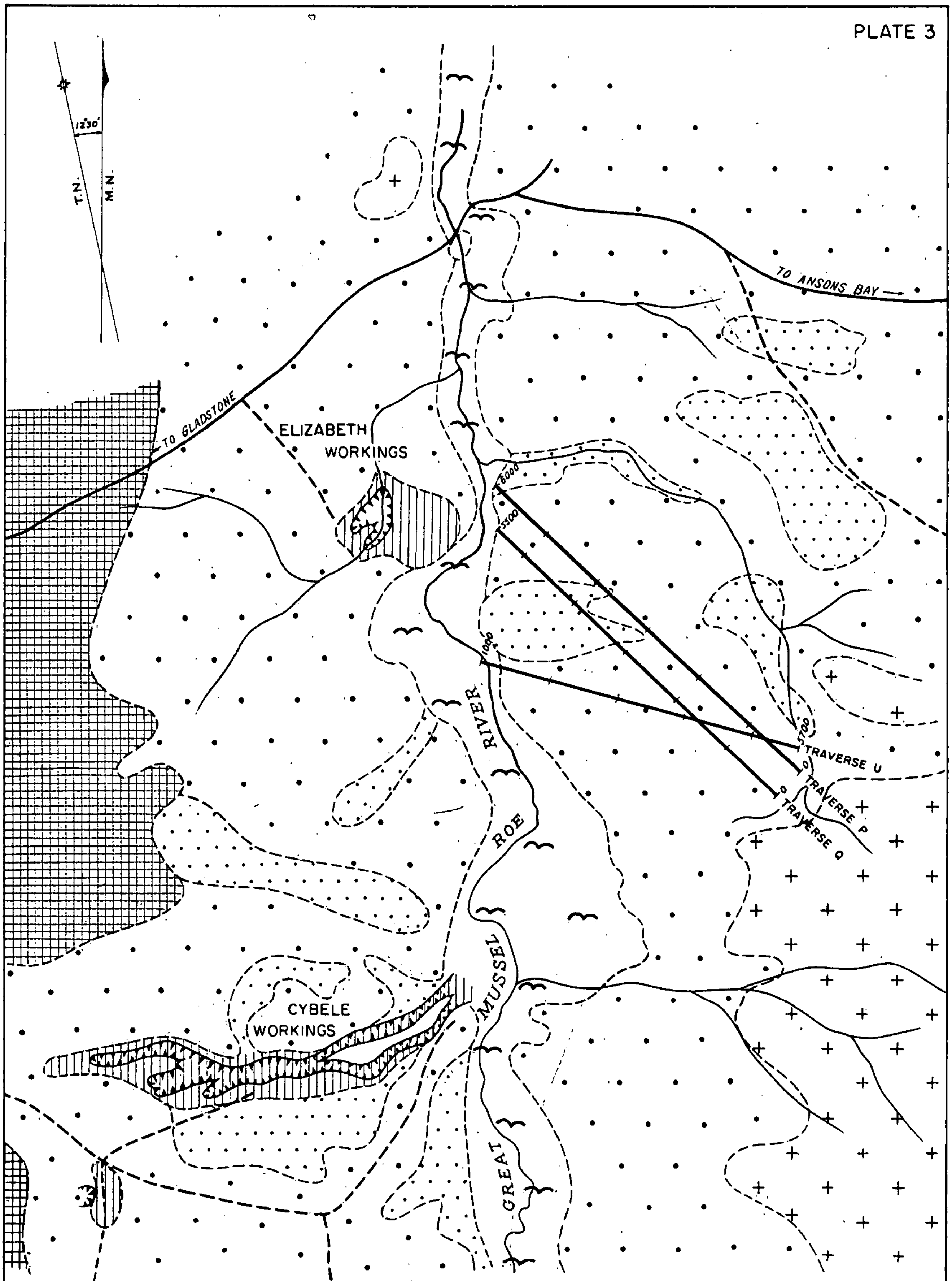
4000 2000 0 4000

K55/B7-26

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

GLADSTONE TIN DISTRICT, NE TAS. 1962

PLATE 3



LEGEND

QUATERNARY

Alluvial deposits, sand etc.

Sandy soil (from Tertiary drifts)

Swamp soil

TERTIARY

Pebble beds, gravel, sand etc.

SILURIAN

Mathinna group

DEVONIAN

Granite

GEOLOGY AFTER R. JACK GEOLOGIST
TASMANIAN MINES DEPT OCT 1960

GREAT MUSSEL ROE AREA

LAYOUT OF TRAVERSES AND GEOLOGY

FEET

2000 1000 0 2000

K55/B7-27

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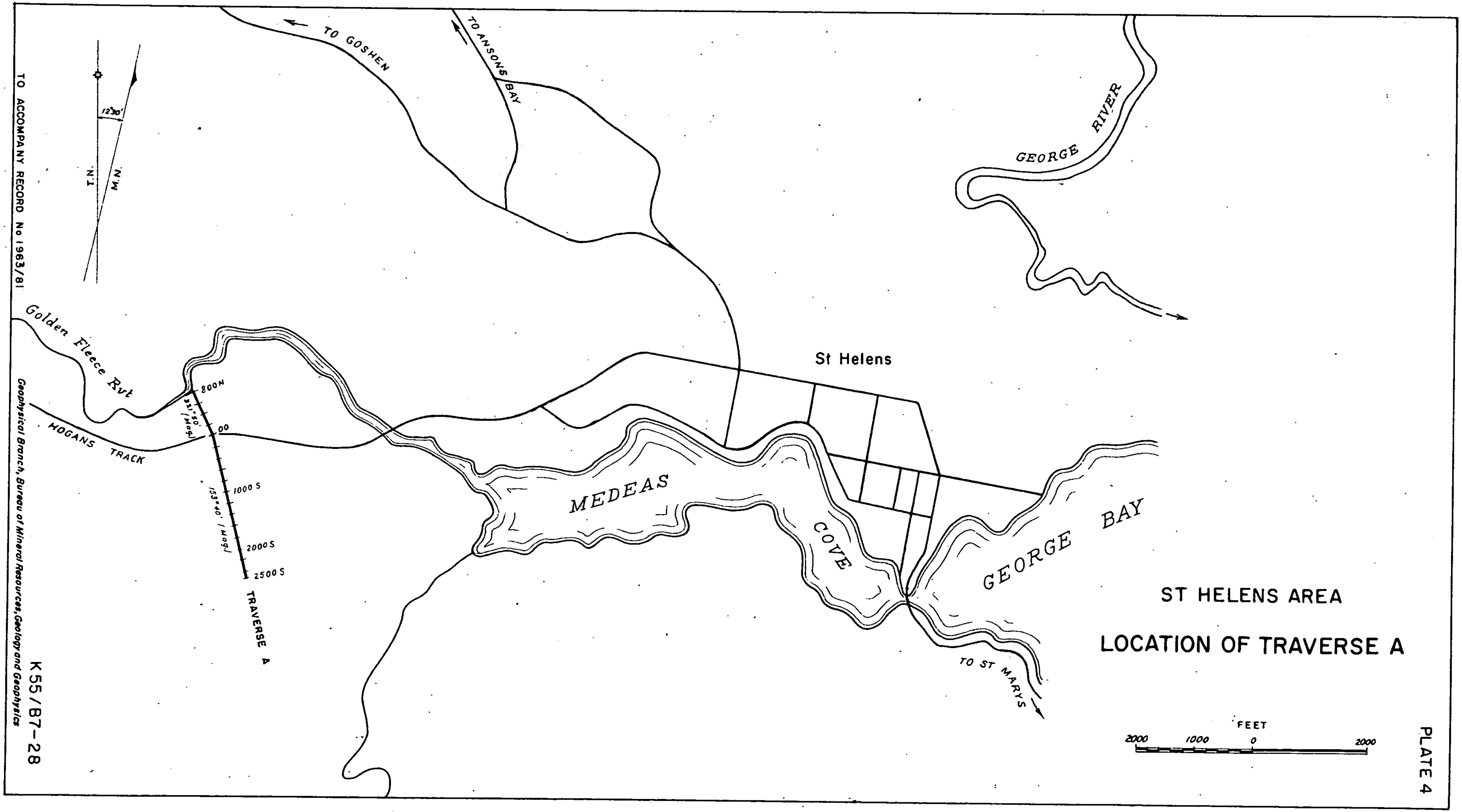
GLADSTONE TIN DISTRICT, NE TAS. 1962



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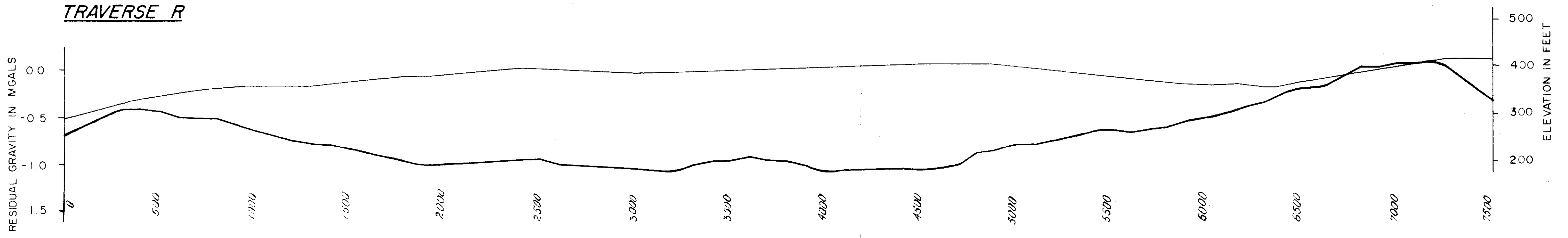
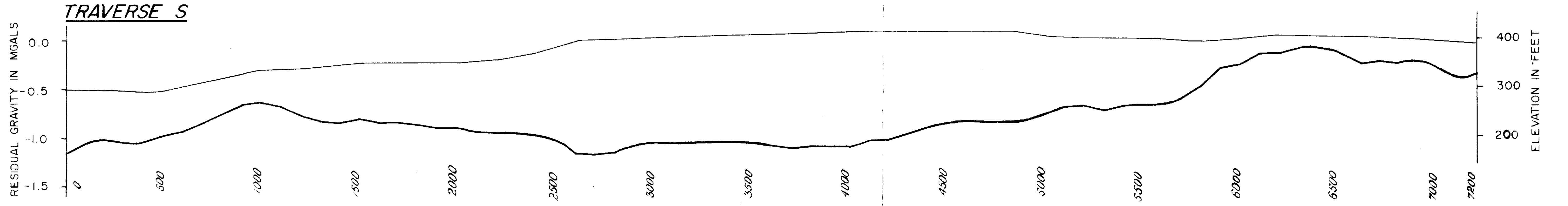
K55/B7-28

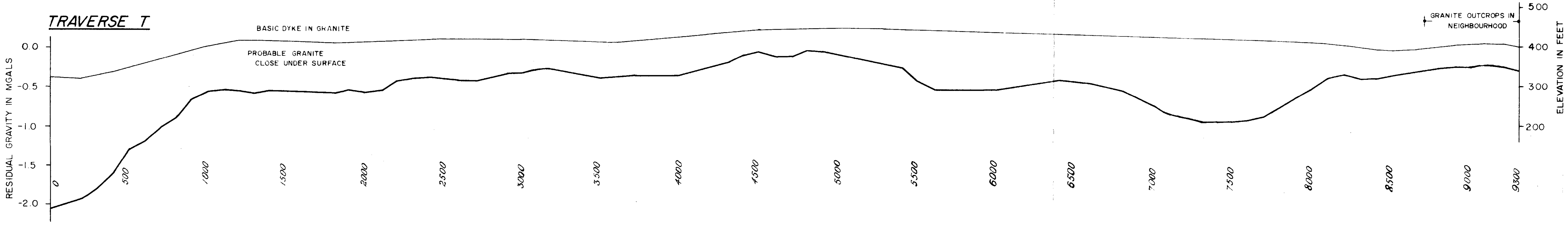
ST HELENS AREA
LOCATION OF TRAVERSE A

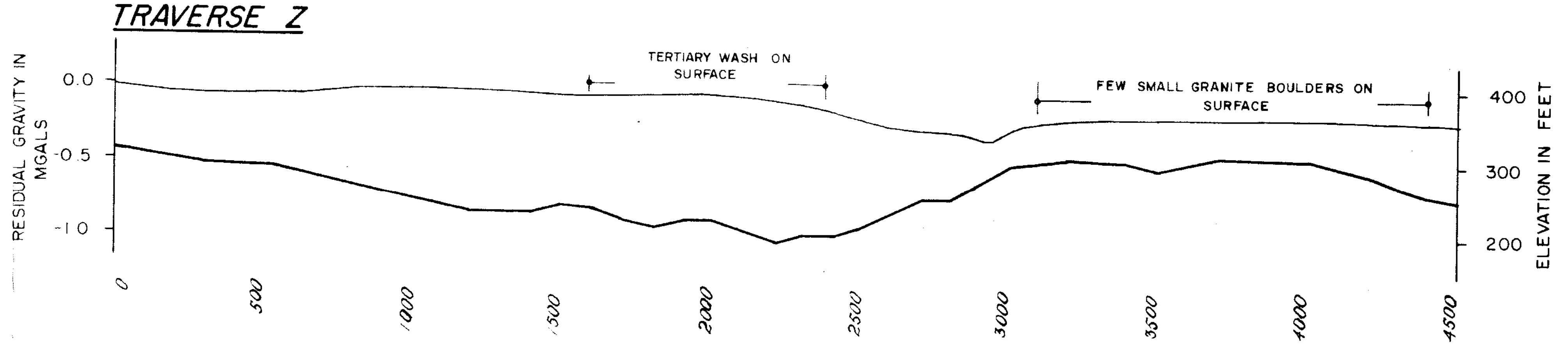
PLATE 4

PLATE 5









GREAT FRASER RIVER AREA
TRAVERSES R, S, T, and Z
GRAVITY PROFILES

LEGEND

Gravity profile (RESIDUAL) calculated using density 2.0 g/cm³

FEET

500 0 500 1000 1500 HORIZONTAL
200 0 200 400 600 VERTICAL

MILLIGALS

1.0 0.5 0 1.0 2.0 3.0
VERTICAL

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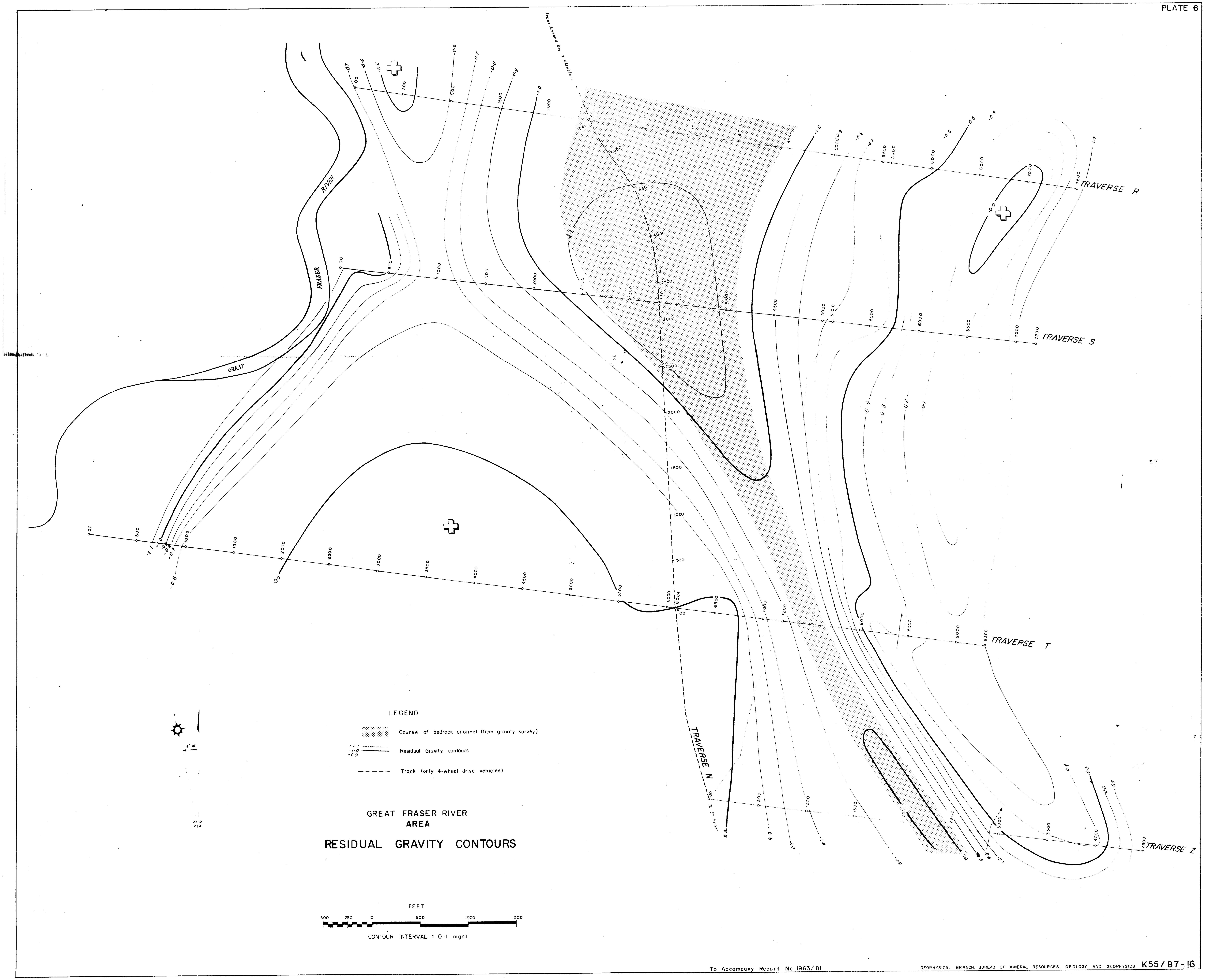
GREAT FRASER RIVER AREA



GREAT FRASER RIVER
AREA

RESIDUAL GRAVITY CONTOURS

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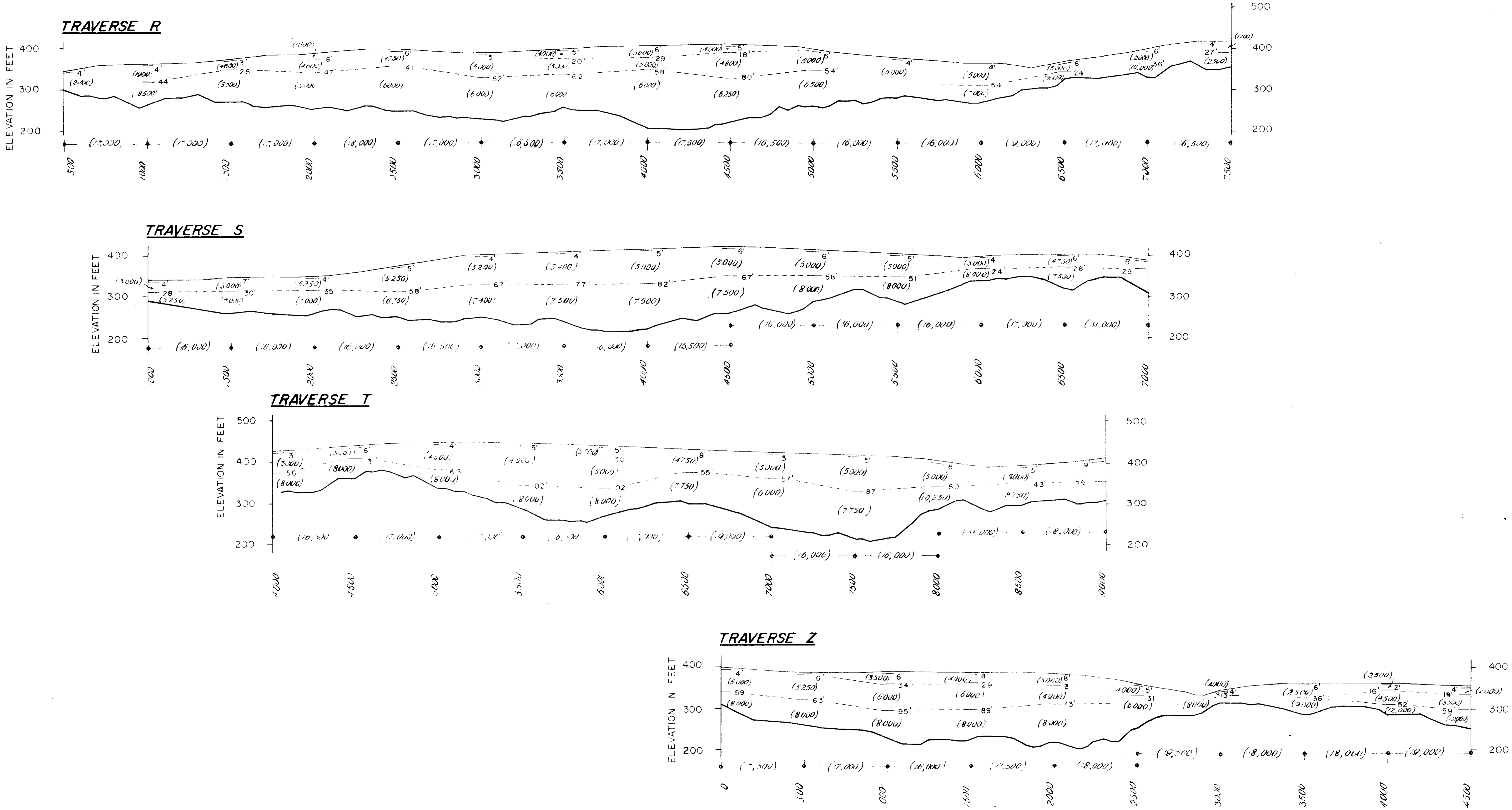
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS K55/B7-16



GREAT FRASER RIVER AREA
TRAVERSES R, S, T, and Z

SEISMIC CROSS-SECTIONS

LEGEND

(17,000) Formation in which seismic velocity is 17,000 ft/sec

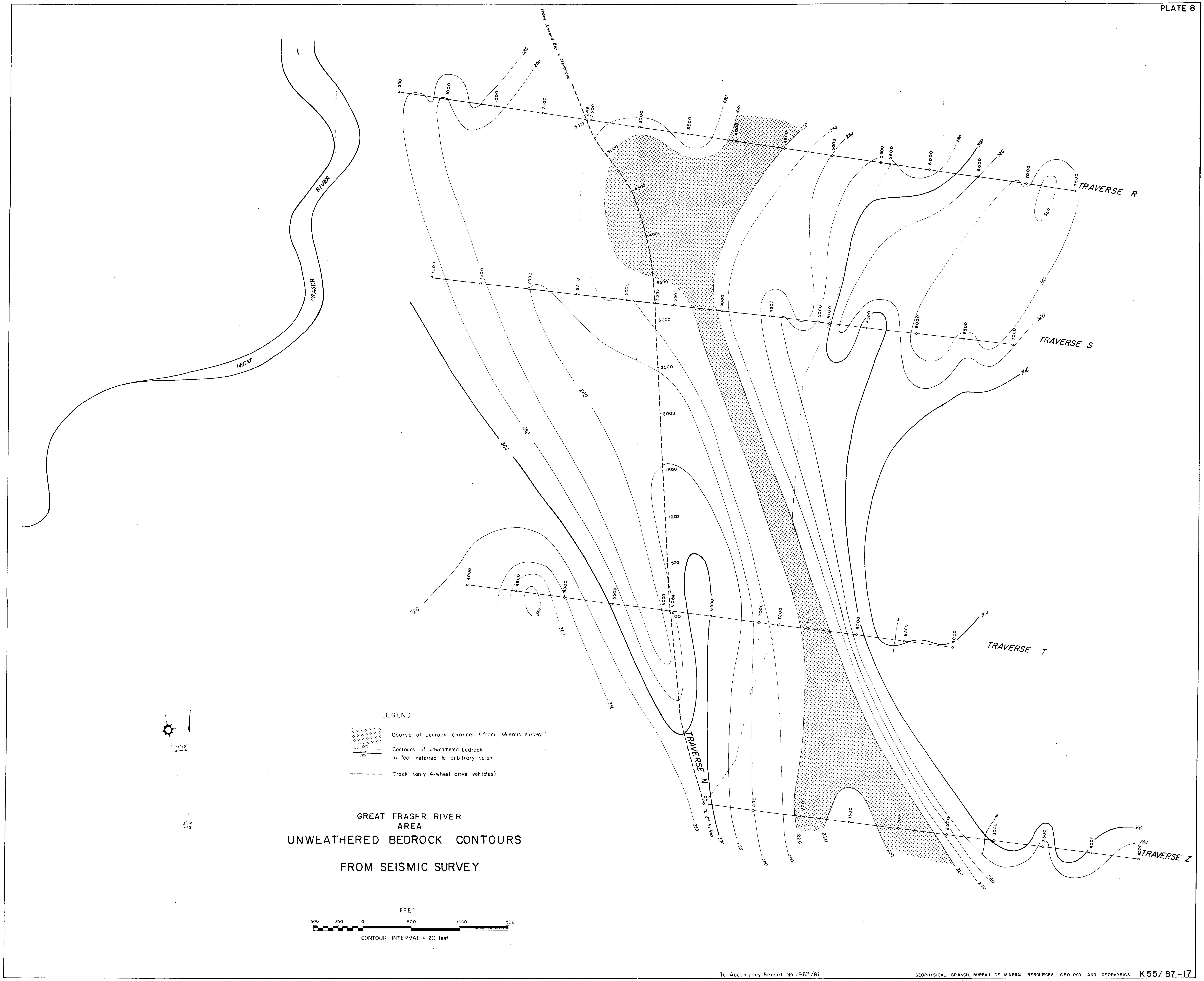
— 31' Depth to formation boundary

Unweathered bedrock boundary

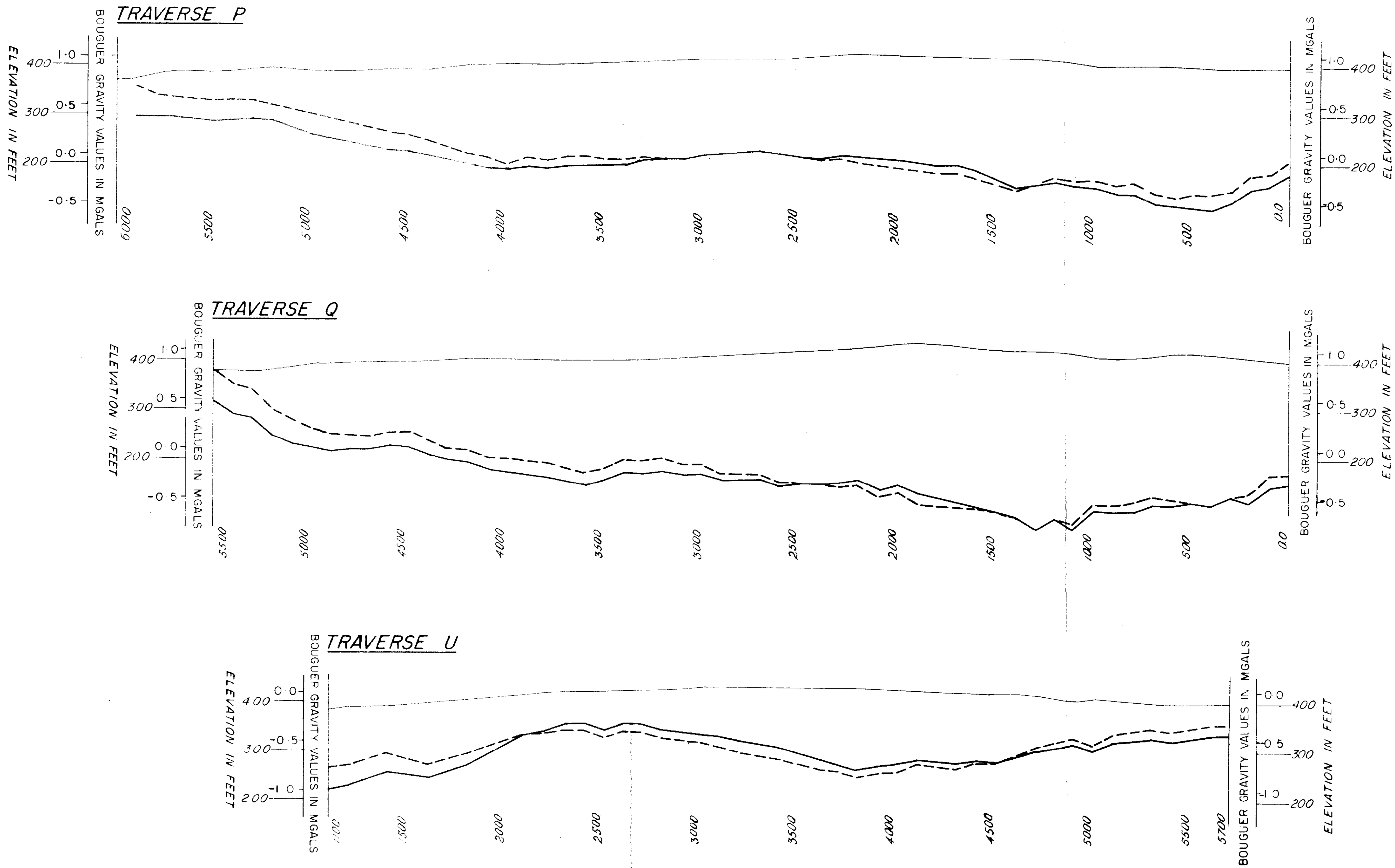
FEET

HORIZONTAL 500 0 500 1000 1500

VERTICAL 200 0 200 400 600



GREAT FRASER RIVER
AREA
UNWEATHERED BEDROCK CONTOURS
FROM SEISMIC SURVEY

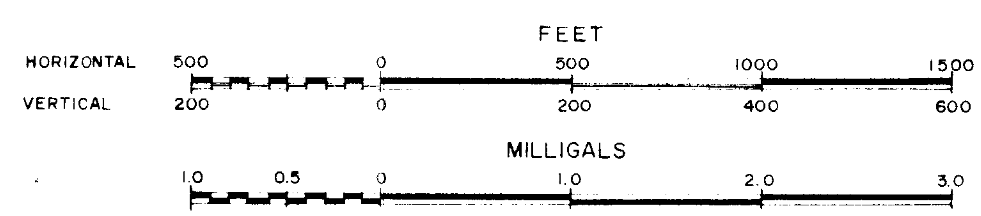


GREAT MUSSEL ROE RIVER AREA
TRAVERSES P, Q, and U
GRAVITY PROFILES

LEGEND

——— Gravity profile (BOUGUER) calculated using density 2·0 g/cm³

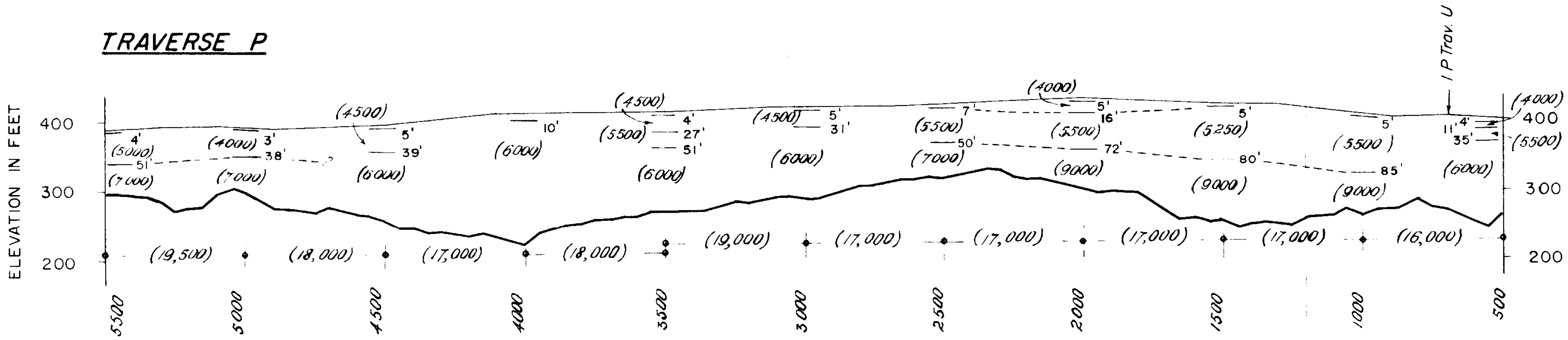
– – – Gravity profile (BOUGUER) calculated using density 2·5 g/cm³



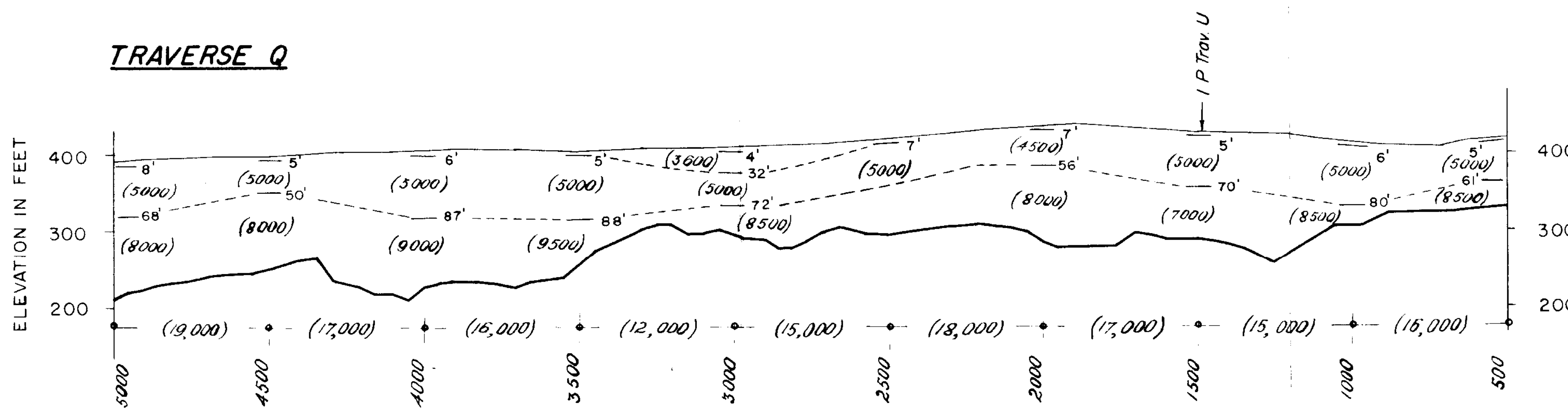
GREAT MUSSEL ROE RIVER AREA

PLATE 10

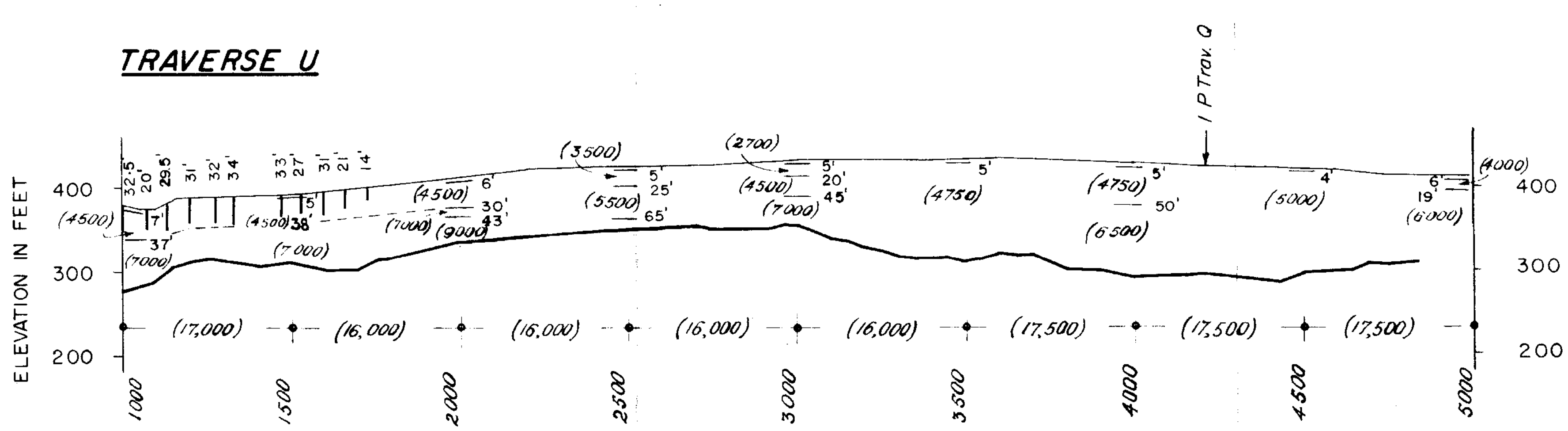
TRAVERSE P



TRAVERSE Q



TRAVERSE U



LEGEND

(17,000) Formation in which seismic velocity is 17,000 ft/sec

— 32' Depth to formation with different seismic velocity

I P Intersection point

Unweathered bedrock boundary

27' Drillholes (by Dept of Mines, 1953)

GREAT MUSSEL ROE RIVER AREA
TRAVERSES P, Q, and U

SEISMIC CROSS-SECTIONS

FEET

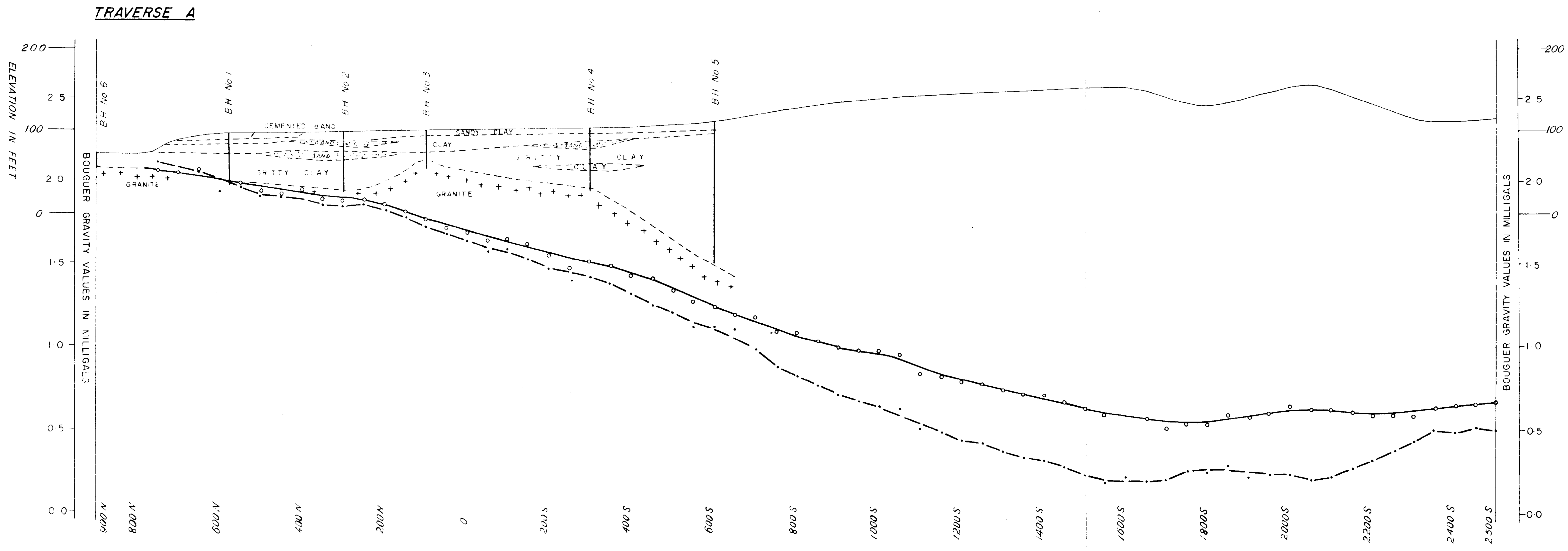
HORIZONTAL	500	0	500	1000	1500
VERTICAL	200	0	200	400	600

GREAT MUSSEL ROE RIVER AREA, TASMANIA, 1962

To Accompany Record No 1963/81

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

K 55/B7-20

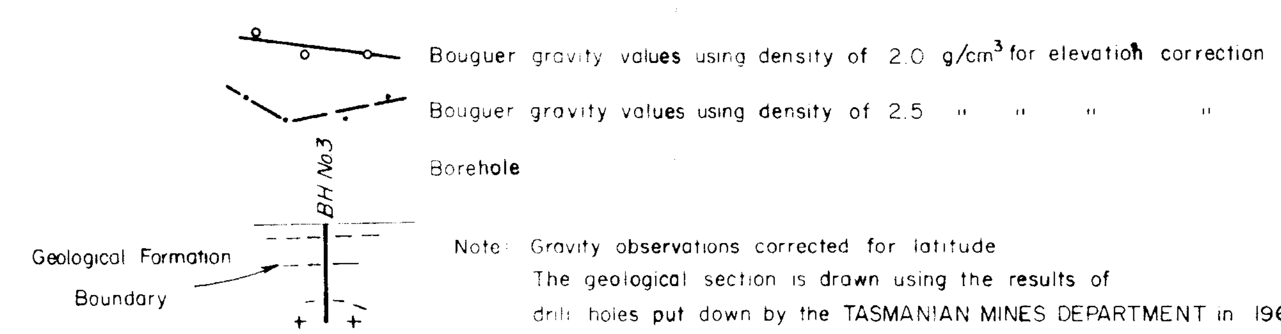


ST HELENS AREA

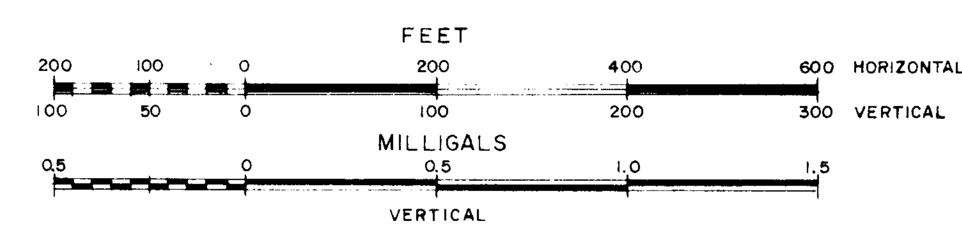
TRAVERSE A

BOUGUER GRAVITY PROFILES
AND GEOLOGICAL CROSS-SECTION FROM DRILLING RESULTS

LEGEND



Note: Gravity observations corrected for latitude
The geological section is drawn using the results of drill holes put down by the TASMANIAN MINES DEPARTMENT in 1961-62



ST HELENS AREA.