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

RECORDS 1958, No. 85

GEOPHYSICAL SURVEY AT
NO. 2 TUNNEL LINE
AND
NO. 2 PENSTOCK LINE,
KIEWA, VICTORIA

by

W. A. WIEBENGA, D. F. DYSON and M. J. O'CONNOR

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ABSTRACT

In response to an application from the State Electricity Commission of Victoria, a geophysical survey over the proposed No.2 tunnel and penstock lines, Kiewa, was conducted by the Bureau in order to detect shear zones, fault zones and dykes and to estimate the degree of weathering and fracturing in them. These data are important in planning the design and construction of the tunnel and penstock anchors.

Electrical resistivity, magnetic, seismic refraction and radiometric methods were used and the results of the various methods are discussed and illustrated in the form of profiles along the traverses. The geophysical results are also compared with available drilling data.

The results indicate that over about one-third of its total length of 3 miles, the tunnel will intersect relatively pronounced shear zones. Along the penstock line, the depth to unweathered rock is probably greater than 100 feet.

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1. INTRODUCTION

In response to an application from the State Electricity Commission of Victoria, a geophysical survey was made by the Bureau of Mineral Resources along the proposed Kiewa No.2 Head Race Tunnel line and Penstock line.

The Kiewa No.2 Development Scheme (Plate 1) consists of:-

(i) No.2 Dam, which will divert water through

(ii) No.2 Head Race Tunnel, about 3 miles long, and

(iii) No.2 Penstock lines, which lead to

(iv) No.2 Power Station to be situated near the junction of the Pretty Valley and Rocky Valley Branches of the East Kiewa River.

Geophysical investigations of the dam site (Wiebenga, Dyson and O'Connor, 1956) and the power station site (Dyson and O'Connor, 1957) were conducted simultaneously with the investigations of the Head Race Tunnel line and the Penstock line with which this report is concerned.

The tunnel line consists essentially of three sections, namely:-

(i) from the dam site (inlet portal) to Turnback Creek,

(ii) from Turnback Creek to Sassafras Creek, and

(iii) from Sassafras Creek along Junction Spur to the outlet portal at approximately R.L.3400 (Beavis,1956).

The penstock line is down Junction Spur to the power station at approximately R.L.2300.

The purpose of the survey was to detect any shear zones, fault zones and dykes which may exist along the tunnel and penstock lines and, if possible, to confirm the geological findings. It was also hoped to determine more accurately, the positions of the shear zones indicated by the earlier geological investigation. It is assumed that the shear zones, fault zones and dykes continue to tunnel level.

The results will:-

(i) enable an estimate to be made of the amount and degree of shearing which may be expected,

(ii) indicate possible improvements which can be made in the layout of the tunnel line, and

(iii) enable a more systematic investigation to be made of suitable anchor points for the penstock line.

The party consisted of D.F. Dyson (party leader) and M.J. O'Connor, geophysicists, J.P. Pigott, field assistant, and up to six field hands provided by the Commission. The survey, together with those of the dam site and power station site, was carried out between October, 1955 and May, 1956.

The topographical survey of the traverse lines was carried out by the Kiewa Survey Section of the State Electricity Commission.

2. GEOLOGY

The geology of the area is fully described by Beavis (1956), and is here only briefly outlined.

The proposed tunnel line is located in granodiorite which crops out in places. The granodiorite is deeply weathered. According to Beavis, the maximum thickness of the weathered zone is 200 feet. Deeply weathered layers generally occur beneath the crests of spurs and near shear zones.

The area contains several fault and shear zones of different ages. At the intersection of fault and shear zones (referred to by Beavis as "fault nodes") the rock is very broken and contains numerous joints, slip planes and minor faults. Geological mapping also disclosed that many of the shear and fault zones are associated with dykes. The major geological features shown on Plate 1 are described by Beavis (1956) and are summarised below.

Pretty Valley Fault:

The width of the shear zone is 450 feet to 600 feet. The strike is north-easterly and the dip 45° to the north-west. Weathering to depths in excess of 200 feet is not unusual.

Frying Pan Fault:

The width of the shear zone is 220 feet to 250 feet. The strike is north-easterly and the dip 65° to the south-east. Basic dykes occur on the walls of the shear zone.

Turnback Creek Fault:

The width of the shear zone is 60 feet. The strike is easterly and the dip vertical. Drilling data indicate that this fault is not deeply weathered (80 feet). A system of subsidiary faults, associated with the Turnback Creek Fault, intersects the Frying Pan Fault, and forms what Beavis refers to as a "fault node".

Sassafras Fault:

This fault has the character of a high-angle thrust fault; it strikes easterly and dips at 65° to the south. Rock within the shear zone is strongly brecciated. Basic dykes appear to be restricted mainly to the walls of the shear zone.

Shear Zone "A".

This is a complex structure crossed by another shear zone close to traverse A. Basic dykes occur on the walls and within shear zone "A".

Shear Zone "B".

Appears to contain belts of relatively unsheared rock.

Shear Zones "C" and "D".

These are narrow belts of fractured granodiorite. A basic dyke is present along the southern wall of shear zone "C".

Shear Zone "E".

This zone consists of a complex of narrow shears and basic dykes. The width of the zone is about 900 feet. A broad basic dyke is present on the southern wall of the shear zone.

In addition to the abovementioned shear zones, a volcanic plug at least 200 feet in diameter and consisting of basalt, tuffs and agglomerate, was discovered about 700 feet south of shear zone "A".

The positions of many of the geological features mentioned above are not accurately known and, as shown on Plate 1, may be in error by a few hundred feet.

3. METHODS

Table 1 indicates the geophysical methods used along particular traverses.

Table 1.

Method	Where Used
Resistivity	All traverses
Magnetic	All traverses
Seismic Refraction	Sections of traverses A and C and total length of traverse B.
Radiometric	Traverses A, B and C.

Although the seismic refraction method yields the most precise information it is the most expensive and tedious, particularly where unweathered rock is overlain by a considerable depth of low velocity material as is the case along the majority of the No.2 Headrace Tunnel Line. These sections along traverses A and C which were surveyed by the seismic refraction method were used as a control for the interpretation of the profiles obtained from the resistivity traversing.

(a) Resistivity

The resistivity of a rock depends mainly on its porosity, the degree of saturation of the pores and the conductivity of the solutions within the pores. Loose dry gravel and soil and fresh crystalline rocks have a high resistivity, whereas moist weathered rocks have a low resistivity.

The Wenner configuration of electrodes was used; this employs four electrodes inserted into the ground in line, at equal intervals. The outer electrodes supply current and the potential is measured at the inner electrodes.

In a homogeneous medium, the ratio of the potential to the current, multiplied by a spacing factor, gives the resistivity of the medium, i.e.

$$\rho = 2\pi a \frac{V}{I}$$

where ρ = resistivity in ohm-centimetres

V = measured potential in volts

I = current in amperes

a = electrode spacing in centimetres.

If horizontal discontinuities in the sub-surface are present, the same expression is used, but the normal resistivity is replaced by the apparent resistivity (ρa), i.e. $\rho a = 2\pi a \frac{V}{I}$.

The effective depth penetration of the current is of the same order as the electrode spacing. It is also dependent upon the relative resistance values of the various sub-surface layers through which the current passes to close the electrical circuit between the outer electrodes.

If the spacing, and therefore the depth penetration, is kept constant and the electrode arrangement is moved as a whole, horizontal variations in rock character may be determined. This technique is known as "resistivity traversing". By using several electrode spacings, a series of profiles is obtained representing the apparent resistivity to different depths.

Weathered rock has a lower resistivity than unweathered rock because the porosity and the salt content of the pore solutions are higher. It is therefore possible, by means of the resistivity method, to locate zones of weathered rock and possibly indicate shear zones, rock contacts and dykes, with which weathered zones are often associated.

A disadvantage of this method is that the observed apparent resistivity values are strongly affected by surface conditions. Large variations in the depth of, and the resistivity of the surface soil, tend to mask the effects of changes in resistivity at depth, and precise interpretation of shear zones and their boundaries is difficult because of this fact.

In the present investigation it was found that the resistivity of the surface layer varied considerably and in many places was very high. Such high resistivity appeared to be caused by leaching and drainage and lack of salt in the ground water. It was difficult to establish satisfactory ground contacts with the electrodes over most of the area and instrument readings were not always exactly reproducible on successive days. Salt was used to improve the ground contacts of the electrodes.

The geophysical Megger (maximum range 30 ohms) was used on traverses with 200 and 300-foot electrode spacing. As the influence of the high-resistivity surface layer is relatively large in measurements made with 100-foot (or less) electrode spacing, a Megger Earth Tester with a maximum range of 3000 ohms was used on traverses with 100-foot electrode spacing.

(b) Magnetic.

The magnetic method depends for its success upon the susceptibility contrast between formations and involves measurement of changes in the vertical component of the earth's magnetic field from point to point.

Variations in magnetic intensity are due mainly to:-

(i) Variations in the content of magnetic minerals in the unweathered rocks.

(ii) Weathering: Magnetite and most other magnetic minerals partially lose their magnetic properties when weathered, and variations in the thickness of weathering over a magnetic body produce changes in the magnetic intensity. Other factors remaining constant, the thickness of the weathered layer controls the sharpness of the magnetic features.

(iii) Concentration of magnetic minerals, as in some ore bodies and mineralized shears.

(c) Seismic refraction.

The seismic technique used in this survey was that of the "method of differences" (Dyson and O'Connor, 1956).

The seismic refraction method enables a quantitative estimate to be made of the depth to a high velocity layer which corresponds to unweathered rock. The velocity of the seismic wave through the refracting rock is also obtained, thereby enabling an estimate to be made of the rock type or an indication to be obtained of the degree of weathering. For example, the seismic velocity over broad shear zones within unweathered granodiorite is lower than that normally observed in the unweathered granodiorite.

Two types of geophone spread were used:-

(i) Normal spreads, in which the geophones were placed at 50-foot intervals, and an explosive charge detonated near each end of the spread and at a distance of about 500 feet from each end.

(ii) Weathering spreads, in which the geophone spacing was 10 feet and charges were detonated at 10 feet, 50 feet and any distance considered necessary from each end of the spread. Weathering spreads provide more detailed information on near-surface velocities than do normal spreads. A Century 12-channel portable refraction unit, Model 506, was used.

(d) Radiometric.

Under certain conditions, faults and shear zones are characterized by a greater concentration of radioactive minerals or emanations. Provided there is little or no soil cover or the soil is derived from the underlying rocks, a suitable scintillation detector may detect such radioactive zones.

4. INTERPRETATION PRINCIPLES

As shear and fault zones in granodiorite are the main subject of this investigation, their relation to the measured geophysical quantities is discussed below in detail.

Shear zones are usually characterized by zones of brecciated rocks and faults. In such zones, surface water finds easy access to the rock body as a whole, rock minerals are chemically changed, and part of the base metals and silicates go into solution and may be carried away. But whatever the process of weathering is in detail, the result is that rocks within shear zones have a higher porosity than similar rocks outside the shear zone, and the pores are saturated with more or less saline solutions. Furthermore, as surface solutions can penetrate to much greater depth within shear zones than in unsheared rock, shear zones are characterized by thick weathered layers, funnel-shaped in section. If surface water carried off the weathered material as soon as it is formed, as on hill slopes or in steep valleys, the weathered layer may be thin or even completely absent. Seismically, the presence of a shear zone is indicated by:-

(a) Sub-normal seismic velocities in the unweathered rock.

(b) Sub-normal seismic velocities in the weathered zones.

(c) And sometimes by a great thickness of the weathered layer.

Table 2 shows the correlation between seismic velocity and rock type identified by surface observations and drilling data.

Table 2.

Velocity of longitudinal waves (ft/sec).	Rock Type
1100 ± 200	Soil (surface observations)
2100 ± 200	Hillslip material or unconsolidated completely weathered granodiorite (surface observation)
3700 ± 800	Completely weathered granodiorite (no core recovery)
6500 ± 1000	Weathered and fractured granodiorite, as indicated by drilling data at No.1 Power Station site
11000 ± 1000	Sheared or fractured granodiorite, probably slightly weathered along fractures
15000 ± 2000	Unweathered granodiorite, but sheared, jointed or fractured
19000 ± 1000	Unweathered, unbroken granodiorite

Resistivity profiles measured with electrode spacings of 100 feet or less usually indicate variations in thickness and water content of the near-surface weathered layers. Shear zones are more clearly indicated by resistivity profiles measured with electrode spacings of 200 feet or more. In the detection of shear zones, the absolute resistivity values are not as important as the contrast between zones of low resistivity and neighbouring zones of high resistivity.

It has already been stated that poor electrode contacts and irregularities near the surface caused irregular resistivity profiles. As a result, the interpretation of the resistivity profiles is not always unambiguous.

Because granodiorite contains a percentage of magnetite and ilmenite, the magnetic susceptibility of granodiorite is relatively high (about 0.004 e.m.c.g.s. units). If the magnetic minerals are evenly distributed within the granodiorite, the induced magnetization vector along a profile varies very little.

Weathering changes magnetite and ilmenite partly or completely into hematite or limonite, and/or iron may go into solution and be carried off. The chemical change of magnetite and ilmenite by weathering is accompanied by a substantial reduction in susceptibility. Hence, magnetic profiles over weathered zones in rocks containing magnetic minerals show negative anomalies over a shear zone, as a result of this reduction in susceptibility of the rock within the shear zone.

Intrusions or dykes containing more magnetic minerals than the intruded rock show large positive anomalies; conversely, intrusions or dykes containing less magnetic minerals than the intruded rock show negative anomalies.

The magnetic profiles in the area surveyed contain many small magnetic anomalies which makes the interpretation of the magnetic profiles difficult.

These small anomalies may be assigned to one or more of several causes, such as:-

(a) Uneven distribution of magnetic minerals within the granodiorite. Such uneven distribution may be associated with mineralised veins or dykes, or may have been originally caused by xenoliths or by magmatic differentiation within the granodiorite.

(b) Rocks may exhibit "remanent" (permanent) magnetization. The "remanent" magnetization vector may vary from point to point, both in quantity and direction, and may even be opposite in direction to the earth's present magnetic field vector.

In the Kiewa area, the delineation of shear zones was based on resistivity and magnetic profiles, in places combined with seismic refraction profiles, according to the principles outlined in this chapter.

Some radiometric surveying was done, but this yielded no significant results because over most parts of the traverses the weathered layer was too thick.

5. RESULTS

The results are shown on Plates 1 to 8, and are discussed below, commencing with the tunnel entrance section in the "Pretty Valley" fault (near Mackay Creek) and finishing with the penstock line section of No.2 Power Station Site (near the junction of Pretty Valley and Rocky Valley (branches of E.Kiewa River).

Traverse C(Plate 2).

The seismic velocities in the weathered zone along traverse C have not been accurately determined. It is estimated that the depth of the unweathered rock may be up to 20 per cent in error, but the shape of the unweathered rock profile is considered to be fairly accurate.

The Pretty Valley Fault zone is clearly indicated by the resistivity profiles and by the low seismic velocity in the unweathered rock. The zone crosses traverse C at the surface between stations 401 and 386. Within the Pretty Valley fault zone the vertical magnetic intensity profile shows several small magnetic anomalies, possibly associated with mineralization. Two weak radiometric anomalies indicate that some of the shears or faults are permeable.

If the Pretty Valley fault zone dips at 45° to the north-west, as suggested by Beavis, its position at tunnel level will be displaced from that indicated at the surface.

A small shear or dyke containing less magnetic material than granodiorite contains is indicated between stations 374 and 376.

A wide shear zone is indicated by the resistivity and seismic profiles between stations 367 and 349. The portion between stations 359 and 349 is marked by low seismic velocities in the unweathered rock. The negative magnetic anomaly at station 364 may indicate a dyke (e.g. porphyry or pegmatite) containing no magnetic minerals. The shear zone referred to in this paragraph was not disclosed by geological mapping.

A shear zone with a pegmatite or porphyry dyke is indicated between stations 343 and 338.

Another shear, possibly with a pegmatite or porphyry dyke is indicated between stations 332 and 329.

Traverse B (Plate 3).

On this traverse, the indications of shear zones obtained by the seismic method are considered to be more reliable than those obtained by the resistivity and magnetic methods, mainly because minor irregularities on the resistivity and magnetic profiles are numerous and make their interpretation ambiguous.

Shear zones are indicated between stations 301 and 298, 295 and 284, 279 and 260, 249 and 215, and 205 and 202.

Within the general shear zones, the rocks appear to be more sheared and faulted in some places, for example between stations 287 and 285, 262 and 260, 249 and 244, 227 and 219, and 205 and 202.

The presence of weak radioactive anomalies may indicate that some of the shears are permeable.

The extent of the shear zones, as indicated by the geophysical investigation, is much greater than that suggested by geological mapping. About one third of the rock along the tunnel line is badly sheared, and it appears that, except for about 700 feet, the tunnel will be sited in more or less sheared and faulted rock along this traverse.

Traverse D (Plate 4).

This traverse is parallel to, and about 1000 feet east of, traverse B. The geophysical methods were limited to magnetic and resistivity.

The resistivity profile indicates a shear zone between stations 513 and 508, two relatively small shear zones between 492 and 490, and between 465 and 463, and a very wide shear zone between 454 and 424. The very wide shear zone is identified as the junction or intersection of the "Frying Pan" and "Sassafras" faults.

The magnetic profile shows numerous small anomalies especially in the wide shear zone between stations 454 and 424. These anomalies may be attributed to dykes or veins carrying either more or less magnetic minerals than the neighbouring rock, or to small leached-out zones.

Traverse E (Plate 5).

Investigations along this traverse which is at right angles to traverse B and D were limited to resistivity and magnetic traversing. The information given by the respective profiles is not very clear. However, several possible small shear zones are indicated.

No shear zone was indicated by the geophysical results where the "Frying Pan" fault is shown on the geological plan. Possibly the shear zones east of station 813 form part of the "Frying Pan" fault zone.

Traverse A (Plate 6).

Constant spacing resistivity traversing with spacings of 100, 200 and 300 foot intervals, magnetic and radioactive methods were used continuously along the traverse and seismic investigations were made between stations 118 and 99 and between stations 49 and 31.

The resistivity profiles indicate the "Sassafras Fault" but the northern boundary is not precisely indicated because of the deep soil cover present. The lower surface levels in this area are swampy and consequently have low surface resistivity. The combination of this and the relatively low resistivity of the deep soil cover cause the general downward gradient of the profiles south from approximately Station 148. A pronounced negative magnetic anomaly between stations 179 and 174 probably indicates a dyke (porphyry or pegmatite) containing less magnetic minerals than the neighbouring rock. This could also be explained by a "demagnetised" zone caused by deep weathering.

A narrow, but probably deep, shear zone is indicated between stations 156 and 153, and a weaker shear zone between stations 148 and 140.

The part of the traverse between stations 124 and 4 is marked by an almost continuous series of major and minor shear zones, with possible wide zones of fractured rock, possibly with dykes.

The sharp negative magnetic anomaly between stations 125 and 122 may be caused by a reversely magnetized dyke or mineralized zone, but is more probably due to a dyke (porphyry or pegmatite) devoid of magnetic minerals.

The volcanic plug near station 110 is marked by two narrow but intense positive magnetic anomalies, and slightly wider negative resistivity anomalies. The feature may be interpreted as basalt pipes within a brecciated volcanic zone, or as mineralized bodies within a volcanic zone.

Weak radioactive anomalies were recorded over some of the shear zones. A reading of twice background count was recorded over Shear Zone "C" - this is probably due to sheared rock exposed at the surface.

Traverse P (Plate 7).

This traverse is along the upper-most part of the penstock line, and, with traverse Q, roughly follows a spur down to the power station site. Resistivity traversing using 100 and 200 ft. electrode spacing and magnetic traversing was done along the traverse. No seismic surveying was done because an explosives magazine belonging to the Commission was located near the traverse.

The resistivity profiles indicate several shear zones.

The magnetic profile is remarkably smooth between stations 600 and 645, except for the anomaly near station 633. This smoothness can be adequately explained by a thick overburden; the positive anomaly near station 633 is probably associated with a thin vein containing magnetic minerals.

Traverse Q (Plate 8).

This traverse is along the lower part of the penstock line and the methods used were the same as for Traverse P.

The resistivity profile indicates a shear zone between stations 688 and 692, and the magnetic profile a zone of dykes or veins, containing magnetic minerals, between stations 694 and 699.

As on traverse P, the smoothness of the magnetic profile between stations 677 and 693 indicates a thick overburden.

Drilling Data.

The drilling yielded few significant results and only a limited amount of data is available. The data available are shown on Table 3. The Commission usually assumed that a low core recovery indicates weathered rock. On this assumption, unweathered rock in drill holes 160, 162, 90 and 75 is at depths greater than 150, 150, 200 and 250 feet respectively.

TABLE 3.

Drill Hole No.	Location	Drill Hole Data	Geophysical Results
150	75' down hill from trav. C, near stn. 350	Unweathered rock at 85'	Unweathered but sheared rock at depth of 70', within shear zone.
942	Trav. B, near stn. 287	Unweathered rock at 80'	Unweathered but jointed or fractured rock at depth of about 70' near station 290, within weak shear zone
943 and 75	Trav. A, near stn. 177 Trav. B, near stn. 221	Unweathered rock at 240' (943). No data to 250'.	Sheared rock, weathered along fractures or joints at depth of 115'
90	Trav. A, near stn. 90	No data to 200'	Within weak shear zone; depth of unweathered rock probably exceeds 150'
162	Trav.A, near stn. 50	No data to 150'	Unweathered, but fractured or jointed rock at depth of 176', within weak shear zone

TABLE 3 (Contd.)

Drill Hole No.	Location	Drill Hole Data	Geophysical Results
160	Trav.A, stn. 39	No data to 150'	Unweathered, but sheared rock at depth of 135', within shear zone.
944	Trav.A, Stn. 1	No recovery to 71' unweathered rock at 184'. According to the geologist, alternating zones of sheared and unsheared rock	Shear zone 150' south of drill hole, near Stn.4.

6. CONCLUSIONS

Along the tunnel line (traverses C,B and A) the geophysical survey has indicated with reasonable certainty, several shear zones, dykes and a volcanic plug. The positions of these features so indicated is probably more accurate than where indicated by previous geological mapping.

A distinction is made on the profiles between weak shear or fracture zones and zones in which the shearing of the rock is more intense.

The length of the proposed tunnel is about 3 miles. It is estimated that of this length about one-third will be through relatively pronounced shear zones. The most pronounced of these shear zones may be expected at the following positions:-

(a) Traverse C, between stations 401 and 386, within the "Pretty Valley Fault" zone, not far from the proposed tunnel portal.

(b) Traverse C, between stations 359 and 349.

(c) Traverse B, near station 286.

(d) Traverse B, between stations 227 and 219 within the intensely sheared "Sassafras Fault" zone.

(e) Traverse A, between stations 45 and 33.

(f) Traverse A, between stations 6 and 4, this is within the geologically identified shear zone E.

In the penstock line area (along traverse P and Q) the resistivity data indicate a depth to unweathered rock probably greater than 100 feet. This estimate is based on comparison of the resistivity results with data from drill hole 944 (traverse A, station 1), in which the depth to unweathered rock is 184 feet.

The geophysical results should be checked by diamond drilling. Cores of the unweathered rock could verify whether the rock is sheared or not.

7. REFERENCES

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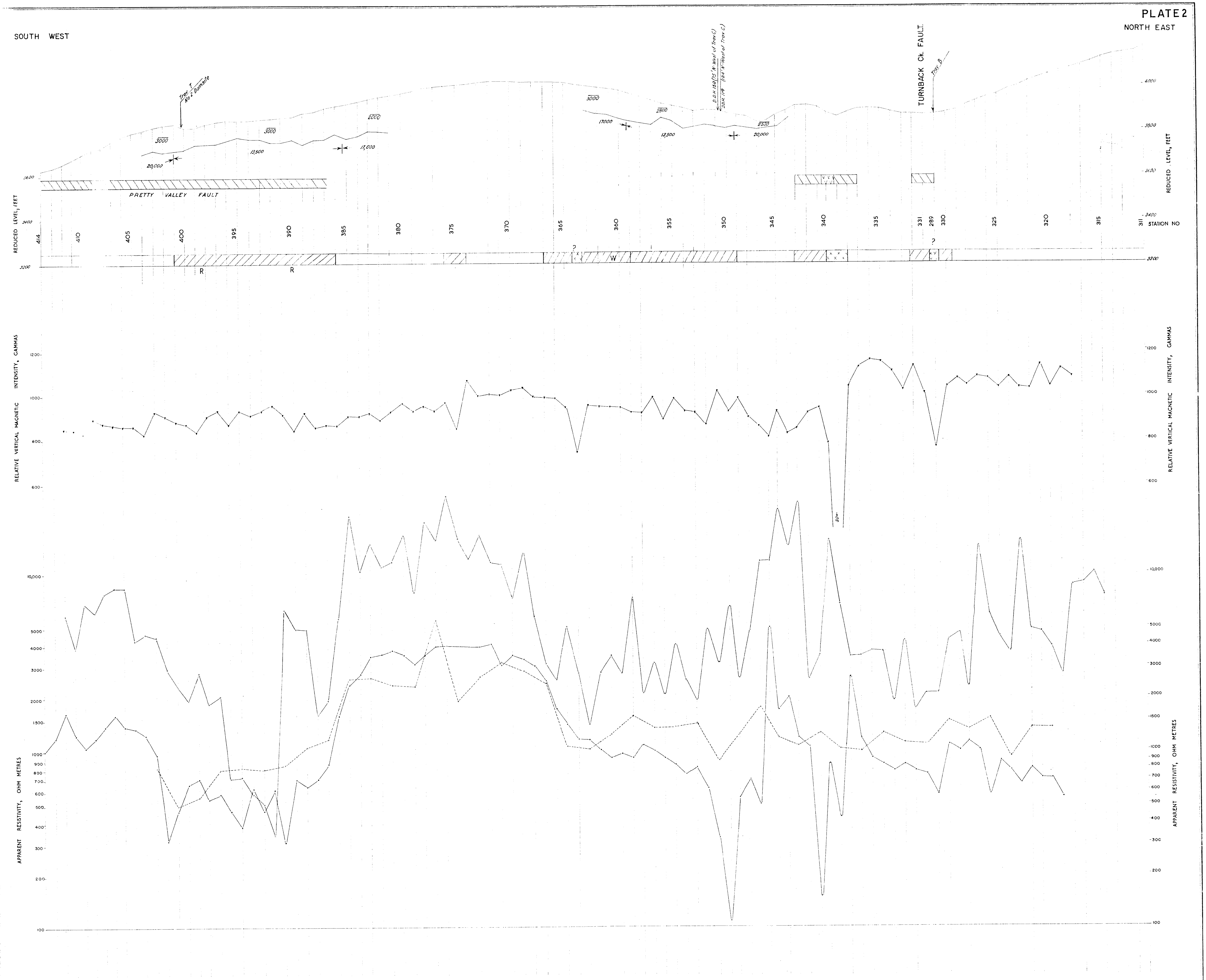
PLATE I

1,560,000 E
1,561,000 E
1,562,000 E
1,563,000 E
1,564,000 E
1,375,000 N
1,374,000 N
1,373,000 N
1,372,000 N
1,371,000 N
1,370,000 N
1,369,000 N
1,368,000 N
1,367,000 N
1,366,000 N
1,365,000 N
1,364,000 N
1,363,000 N
1,362,000 N
1,361,000 N
1,360,000 N
1,359,000 N
1,358,000 N
1,357,000 N
PRETTY VALLEY BRANCH
EAST KIEWA RIVER
POWER STATION SITE
TRAVERSE O
TRAVERSE P
EAST KIEWA RIVER ROCKY VALLEY BRANCH
SHEAR ZONE E
D.D.H. 944
SHEAR ZONE D
SHEAR ZONE C
D.D.H. 160
SHEAR ZONE B
D.D.H. 162
FAULT
TRAVERSE A
D.D.H. 90
SHEAR ZONE A
VOLCANIC PLUG
FAULT
SASSAFRAS CREEK
SASSAFRASS FAULT
D.D.H. 75
D.D.H. 943
TRAVERSE B
FRYING PAN FAULT
TRAVERSE E
TRAVERSE D
TURIBACK CREEK
TURIBACK CREEK FAULT
D.D.H. 942
D.D.H. 110
TRAVERSE C
LINE T DAMSITE SURVEY
MACKAY CREEK
PRETTY VALLEY FAULT
LOCALITY MAP
SCALE IN FEET
LEGEND
No 2 PENSTOCK LINE
GEOPHYSICAL SURVEY
OF No 2 POWER DEVELOPMENT SCHEME,
KIEWA, VICTORIA
HEADRACE TUNNEL LINE AND PENSTOCK LINE
TRAVERSE PLAN, LOCALITY MAP
AND GRAPHIC INTERPRETATION
LEGEND
350 STATION No
D.D.H.119 DIAMOND DRILL HOLE
SHEAR ZONE
DYKE OR VEIN
AFTER BEAVIS (1956)
SHEAR ZONE
WEAK SHEAR ZONE
DYKE OR VEIN
RADIOACTIVE ANOMALY
VOLCANIC PLUG
INDICATED BY GEOPHYSICAL RESULTS
SCALE IN FEET
400 0 400 800 1200
GEOPHYSICIST
G 232-14

PLATE 2



LEGEND

- 300' ELECTRODE SPACING } APPARENT RESISTIVITY PROFILES
- 200' ELECTRODE SPACING
- 100' ELECTRODE SPACING
- VERTICAL MAGNETIC INTENSITY PROFILE
- 17,000 SEISMIC VELOCITY (FT/SEC)
- 3,000 AVERAGE SEISMIC VELOCITY (FT/SEC)

SHEAR ZONE	INDICATED BY GEOPHYSICAL RESULTS	SHEAR ZONE	AFTER BEAVIS (1956)
W WEAK SHEAR ZONE OR FRACTURE ZONE		DYKE OR VEIN	
DYKE OR VEIN			
R RADIOACTIVE ANOMALY			

HORIZONTAL SCALE IN FEET

200 0 200 400 600

VERTICAL SCALES AS SHOWN

D. F. Dyson
GEOPHYSICIST

GEOPHYSICAL SURVEY OF No 2 HEADRACE TUNNEL LINE, KIEWA VICTORIA

TRAVERSE C

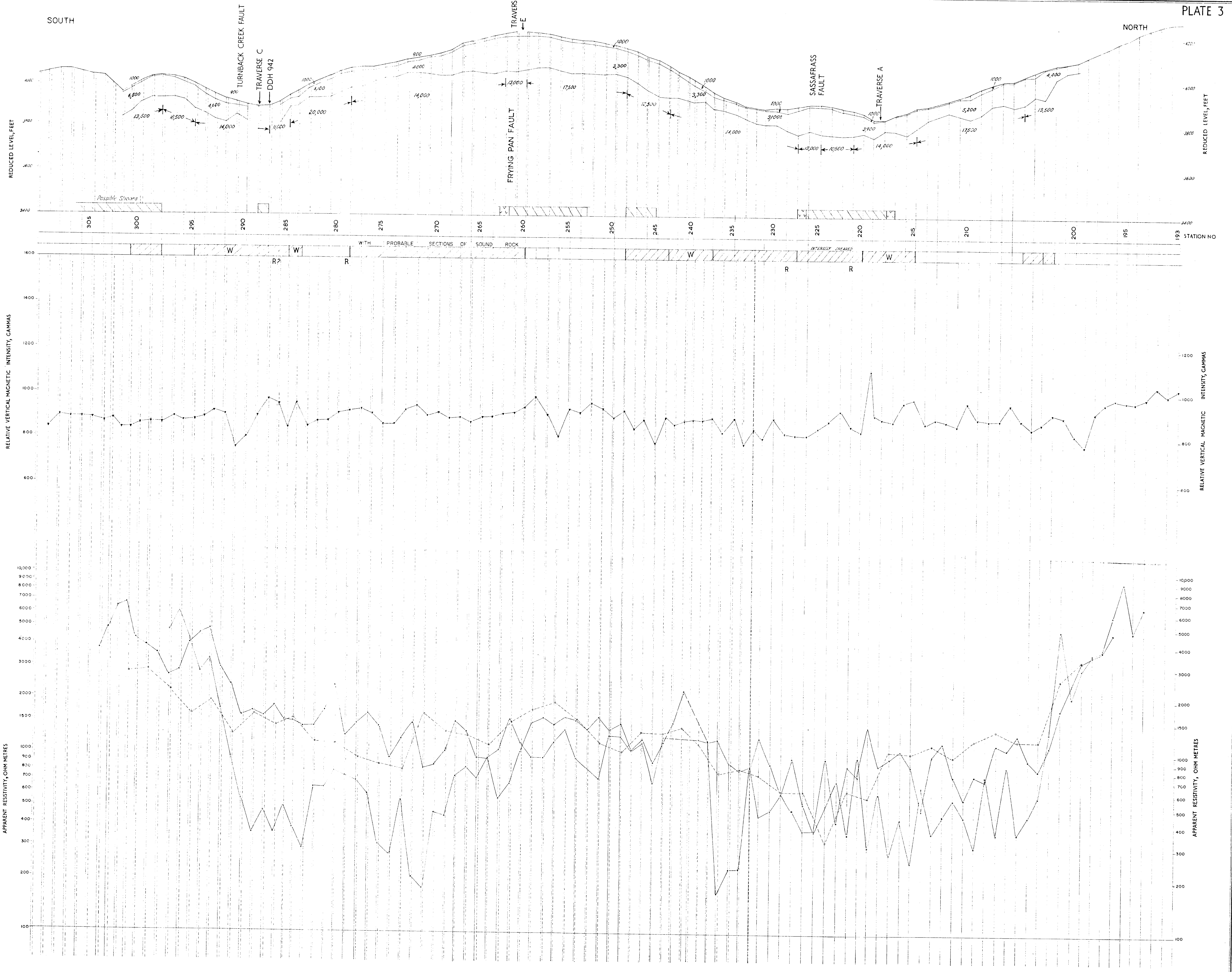
TOPOGRAPHICAL, APPARENT RESISTIVITY, MAGNETIC AND SEISMIC PROFILES AND GRAPHIC INTERPRETATION

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 232-17

To accompany Records 1958, No 65

PLATE 3



LEGEND

- 300' ELECTRODE SPACING, 200' ELECTRODE SPACING, 100' ELECTRODE SPACING — APPARENT RESISTIVITY PROFILES
- VERTICAL MAGNETIC INTENSITY PROFILE
- 17,000 — SEISMIC VELOCITY (FT/SEC)
- SHEAR ZONE; W — WEAK SHEAR ZONE OR FRACTURE ZONE; R — RADIOACTIVE ANOMALY — INDICATED BY GEOPHYSICAL RESULTS
- SHEAR ZONE; DYKE OR VEIN — AFTER BEAVIS (1956)

HORIZONTAL SCALE IN FEET

200 0 200 400 600

VERTICAL SCALES AS SHOWN

GEOPHYSICIST

GEOPHYSICAL SURVEY OF No 2 HEADRACE TUNNEL LINE, KIEWA, VICTORIA

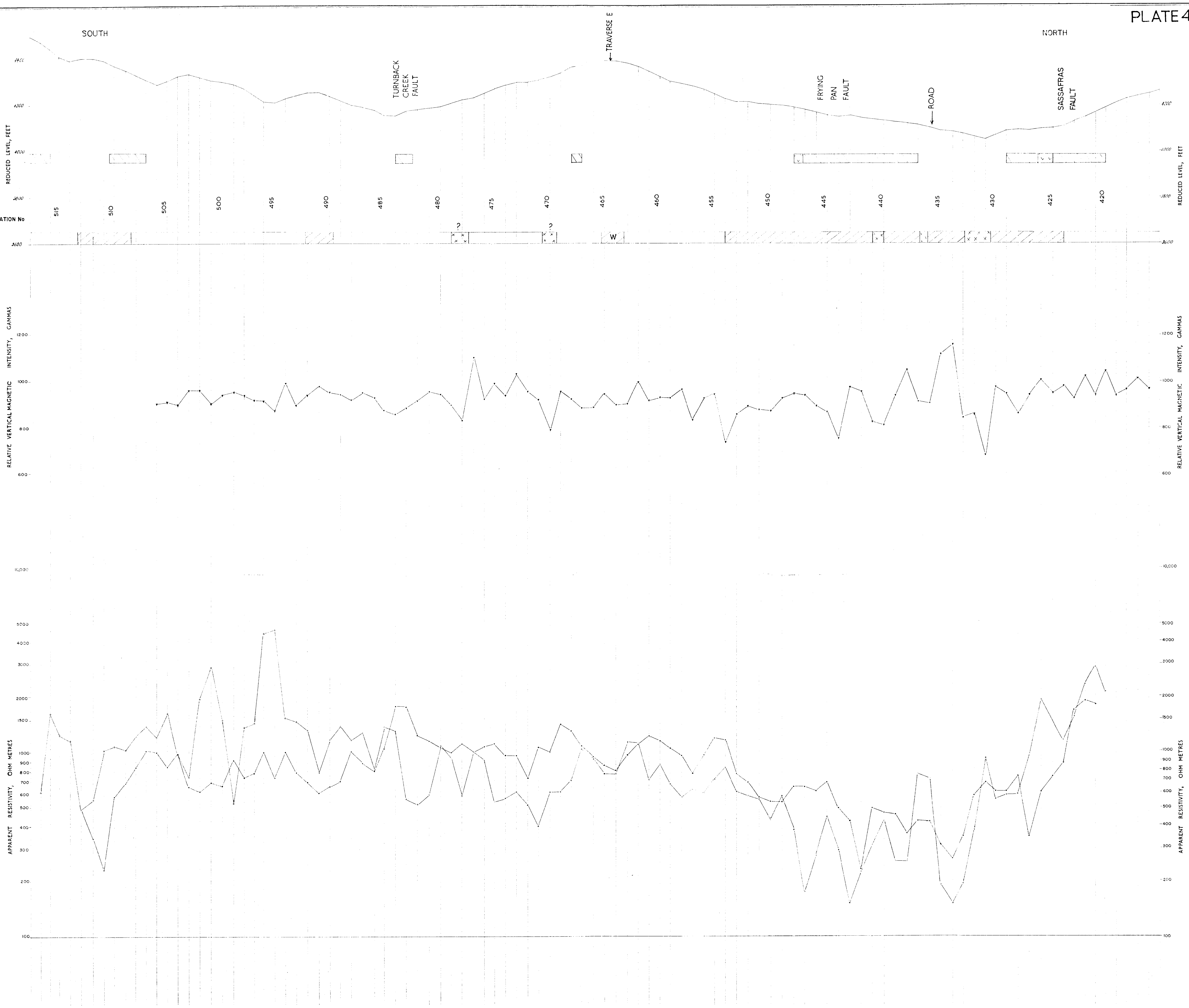
TRAVERSE B

TOPOGRAPHICAL, APPARENT RESISTIVITY, MAGNETIC AND SEISMIC PROFILES AND GRAPHIC INTERPRETATION

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 232-16

PLATE 4



LEGEND

200' ELECTRODE SPACING
100' ELECTRODE SPACING } APPARENT RESISTIVITY PROFILES
VERTICAL MAGNETIC INTENSITY PROFILE

SHEAR ZONE
WEAK SHEAR ZONE OR FRACTURE ZONE } INDICATED BY GEOPHYSICAL RESULTS
DYKE OR VEIN

SHEAR ZONE
DYKE OR VEIN } AFTER BEAVIS (1956)

HORIZONTAL SCALE IN FEET

200 0 200 400 600

VERTICAL SCALES AS SHOWN

D. F. Dyson
GEOPHYSICIST

GEOPHYSICAL SURVEY OF No 2 HEADRACE TUNNEL LINE, KIEWA, VICTORIA

TRAVERSE D

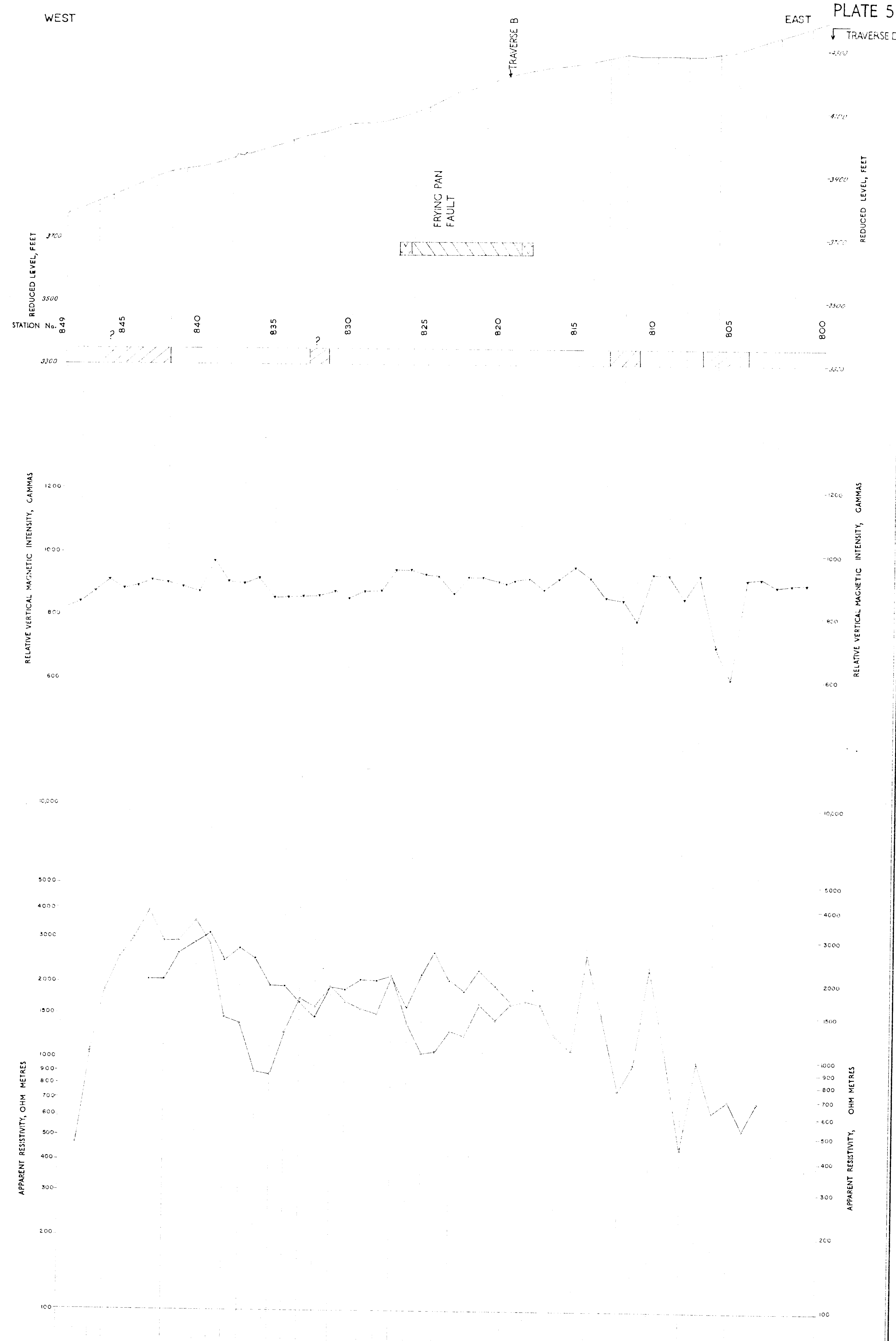
TOPOGRAPHICAL, APPARENT RESISTIVITY AND MAGNETIC PROFILES AND GRAPHIC INTERPRETATION

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics.

G 232-18

To accompany Record 1958, No 85

PLATE 5



LEGEND

200' ELECTRODE SPACING } APPARENT RESISTIVITY PROFILES
100' ELECTRODE SPACING
VERTICAL MAGNETIC INTENSITY PROFILE
SHEAR ZONE - INDICATED BY GEOPHYSICAL RESULTS
SHEAR ZONE } AFTER BEAVIS (1956)
DYKE OR VEIN

HORIZONTAL SCALE IN FEET

200 0 200 400 600

VERTICAL SCALES AS SHOWN

GEOPHYSICAL SURVEY OF No 2 HEADRACE TUNNEL LINE, KIEWA, VICTORIA

TRAVERSE E

TOPOGRAPHICAL, APPARENT RESISTIVITY AND MAGNETIC PROFILES AND GRAPHIC INTERPRETATION

GEOPHYSICIST

G 232-19

To accompany Records 1958, No.55

PLATE 6

GEOPHYSICAL SURVEY OF No 2 HEADRACE TUNNEL LINE, KIEWA, VICTORIA

TRAVERSE A

TOPOGRAPHICAL, APPARENT RESISTIVITY, MAGNETIC AND SEISMIC PROFILES AND GRAPHIC INTERPRETATION

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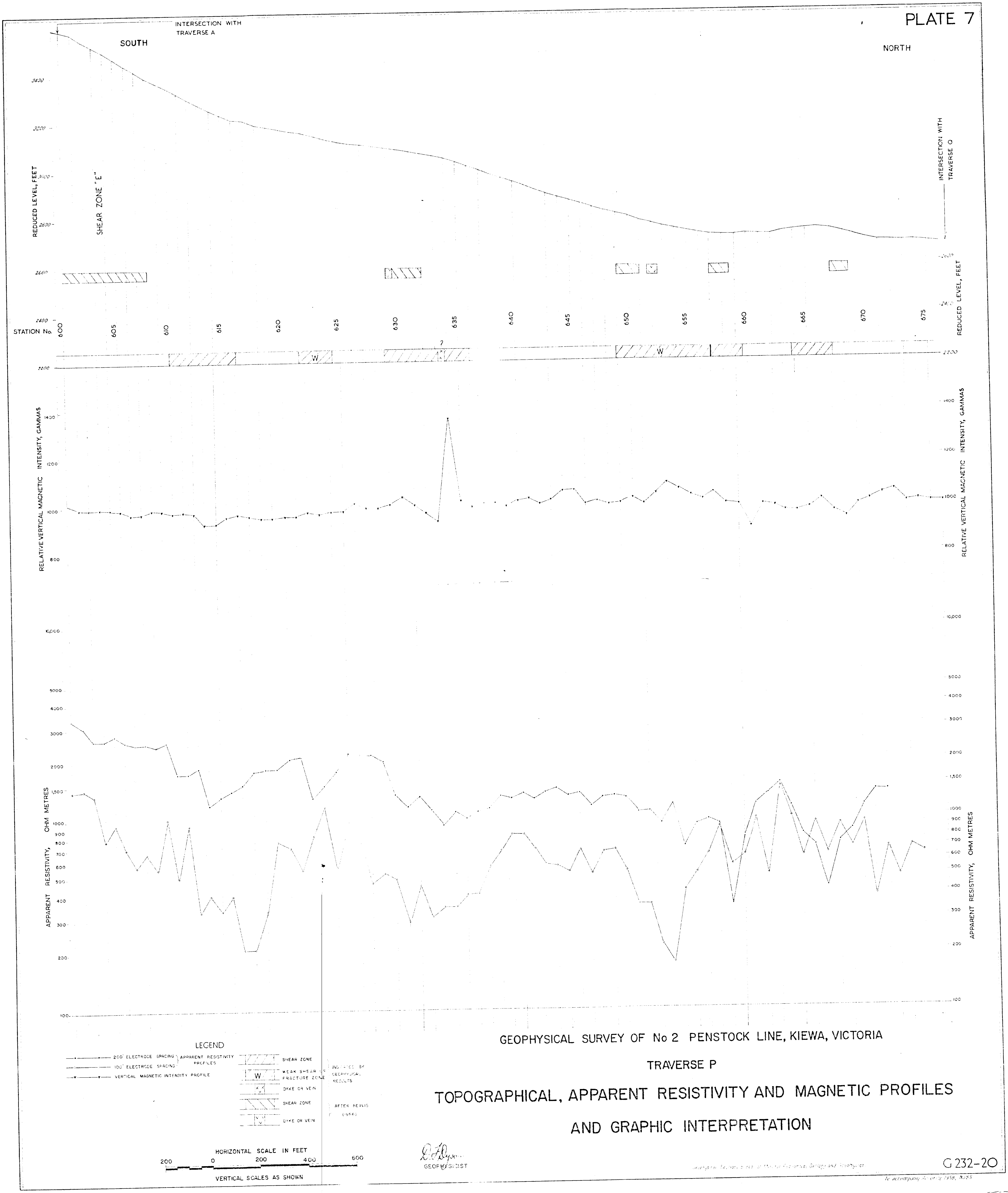


GEOPHYSICAL SURVEY OF No 2 PENSTOCK LINE, KIEWA, VICTORIA

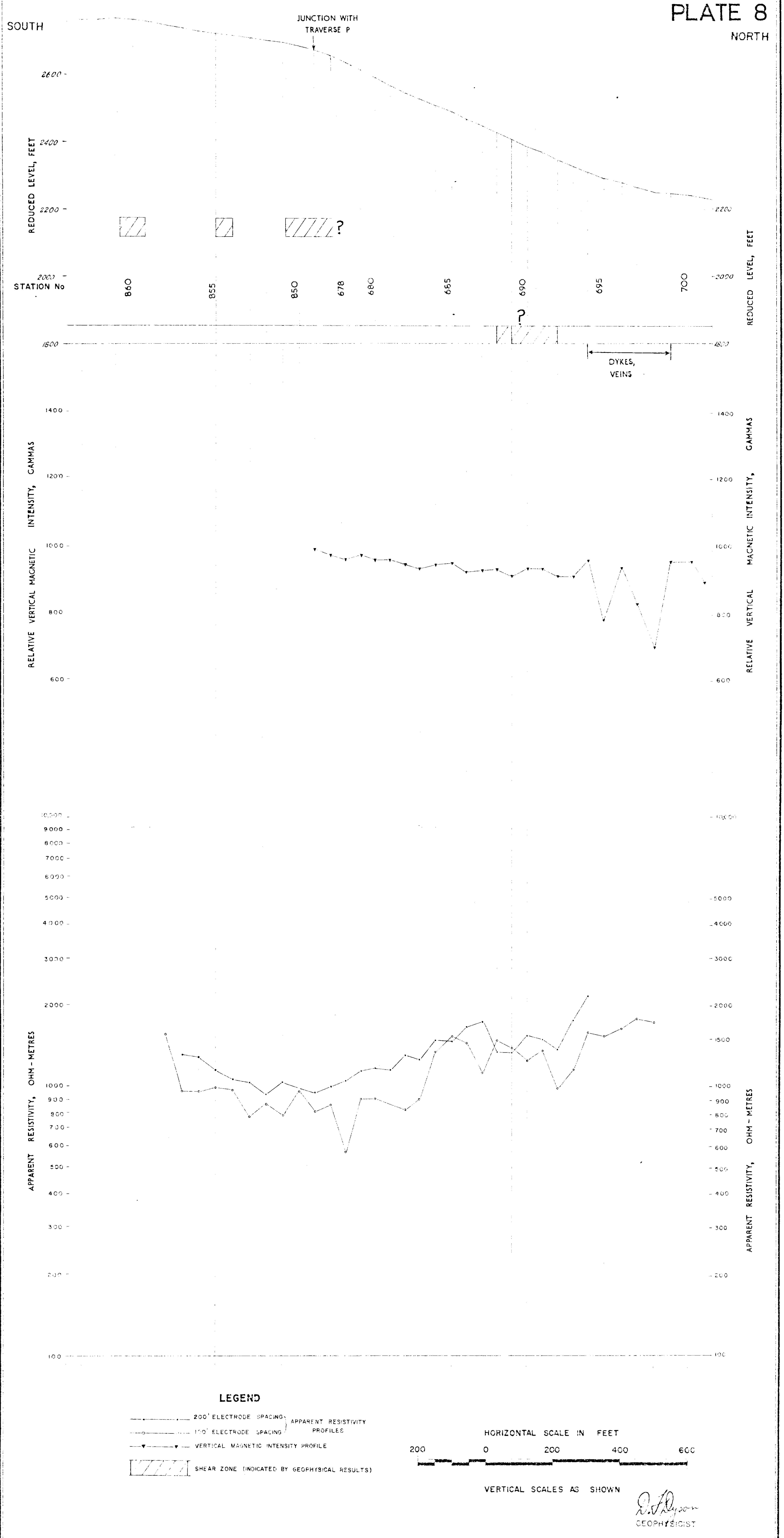
TRAVERSE P

TOPOGRAPHICAL, APPARENT RESISTIVITY AND MAGNETIC PROFILES AND GRAPHIC INTERPRETATION

GEOPHYSICIST

G 232-20

PLATE 8



GEOPHYSICAL SURVEY OF No 2 PENSTOCK LINE, KIEWA, VICTORIA

TRAVERSE Q

TOPOGRAPHICAL, APPARENT RESISTIVITY AND MAGNETIC PROFILES AND GRAPHIC INTERPRETATION

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