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LABORATORY TESTS ON CORES FROM THE RUM JUNGLE AREA, NORTHERN TERRITORY, 1968

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SUMMARY

The electrical properties of core samples from drill holes in four areas in the Rum Jungle area were studied to assist the interpretation of geophysical exploration results. The four areas were the Batchelor Laterites Area Extended, the Rum Jungle Creek South to Castlemaine Hill area, the Mount Burton to Mount Fitch area, and the Mount Fitch Prospect.

In several cases conductive black carbonaceous slate was found to be the cause of electromagnetic and induced polarization anomalies; near-surface effects are considered to be the source of other anomalies. In no case could the surface electromagnetic anomalies be attributed solely to sulphide mineralization. It is concluded that the Turam electromagnetic method is more effective than the Slingram method in detecting resistivity discontinuities below the depth of weathering in the Rum Jungle area; the Slingram results frequently reflect near-surface inhomogeneities.

1. INTRODUCTION

Langron (1969) made a preliminary compilation and assessment of the results of geophysical surveys conducted by the Bureau of Mineral Resources (BMR) in the Rum Jungle area, Northern Territory. In his report Langron recommended follow-up work to clarify problems arising in certain areas. Gardener (1971) describes the results of this fo low-up work. In conjunction with this work, a program of laboratory core studies was conducted to investigate the sources of many of the geophysical anomalies obtained in the Rum Jungle area. The aim was to measure physical properties of diamond-drill cores and relate them to the geophysical survey results. Anomalies were examined in the following four areas:

Batchelor Laterites Area Extended:

Rum Jungle Creek South to Castlemaine Hill;

Mount Burton to Mount Fitch; and

the Mount Fitch Prospect.

The geophysical methods which yielded anomalies in these areas were the Slingram and Turam electromagnetic (EM) methods and the resistivity, induced po arization (IP), and magnetic methods.

The laboratory procedures involved measurement of the resistivity and polarizability of core specimens; frequency domain IP apparatus was used.

The main criterion in selecting rock samples for testing was to sample representative rock types rather than unique specimens, unless the unusual cores could be considered to significantly affect the distribution of electric current in the ground. The core from the drill holes selected was examined superficially along its length, and a typical sample was selected from ten to twenty feet of core. In addition, specimens of particular interest were taken: for example, from shear zones, carbonaceous beds, or unusually sulphide-rich bands.

2. APPARATUS AND PROCEDURE

The frequency domain IP apparatus used was a modification of the four-electrode, electrolyte-buffered, horizontal-cell system described by Emerson (1969, p. 54). The method of measuring core impedance invo ved passing a sine wave current through both the core sample and a precision resistor of 10 000 ohms and comparing the voltage drop across each. The current was supplied from a Hewlett Packard 202A function generator. Voltage drops were measured with a Tektronix Type 321 cathode-ray oscilloscope.

Copper/copper sulphate electrodes were used. The sample to be tested was set between two perspex baths each containing a current electrode and a potential electrode of perforated copper sheet; the bath electrolyte was saturated copper sulphate. Since it was desired to use tap water to saturate the samples, a plaster-faced bath was developed to separate the copper sulphate bath electrolyte and core saturant. One face of the baths was made of plaster of paris saturated with NaCl and gelatine to comprise an impervious ionic conductor. The plaster face of each electrolyte bath abbutted the ends of the core sample. Electrical contact with the sample face was attained using water-soaked chamois pads. Applied current was forced through the entire core sample; the voltage drop across it was measured at each frequency, and from this the resistivity was calculated.

The impedance contribution of the system without the sample in position was first measured at each frequency. This yielded a reliable correction to the measured impedance to give the sample impedance only, as well as comprising a test for polarization within the apparatus.

The ends of the drill core samples to be tested were cut off squarely using a diamond saw, and the dimensions of the cylinders were measured with vernier callipers. The average core sample length was about 6 cm, but thin discs had to be cut from resistive cores so that the sample impedance would not exceed 1% of the CRO input impedance; this was to avoid loading errors in the voltages measured.

The core samples were placed in a large glass desiccator sealed with grade M Apiezon high-viscosity grease. The chamber was evacuated with a Speedivac two-stage model 2S-20 high-vacuum pump for half an hour. Tap water was then forced into the desiccator by atmospheric pressure and the core samples were left for several hours to become saturated. The pore saturant was not de-aerated by boiling but it was estimated that 90% saturation was attained. The pore electrolyte resistivity and temperature were measured using a Fann resistivity meter and thermometer. For the first samples tested, determinations of the porosity were made by weighing the core samples before and after saturation.

Resistivity measurements were made at 1, 10, 100, and 1000 Hertz. A current of one milliamp was applied across most of the core samples; a current of 0.1 milliamp was used for resistive samples. Current density ranged from about one amp per square metre to about 0.1 amp per square metre. The minimum voltage range of 0.01 volts per division on the oscilloscope necessitated this high current density. No consideration was given to temporal current variations.

Temperature was constant for any core test, but varied during the day and from day to day. Resistivities were not normalized to any specific temperature.

All measurements were conducted at atmospheric pressure. Ambient variations were considered unlikely to have affected the data.

The use of vernier callipers, a 1% precision standard resistance and a 3% accuracy of CRO voltages enabled resistivities to be measured to an accuracy of 10%. Very low resistivities and resistivities at very low frequencies are 24% accurate.

3. RESULTS

Batchelor Laterites Area Extended

In 1960 a Turam survey (Daly & Rowston, 1962) outlined a conducting zone close to and apparently related to the Rum Jungle Creek South uranium orebody. In 1961, 1962, and 1963 Slingram and Turam surveys were made to map this conducting zone to the north and south of Rum Jungle Creek South and around Castlemaine Hill. Part of these surveys were Slingram and Turam surveys made in the Batchelor Laterites Area Extended (Douglas, 1964), where numerous imaginary-component Slingram anomalies were found. These were attributed to a complicated distribution of subsurface conductors. One linear imaginary-component anomaly with a weak corresponding real-component anomaly (denoted anomaly B) was attributed to an unmineralized shear. The Turam survey yielded a strong phase anomaly over anomaly B; the ratio contours (Plate 2) show a weak anomaly over B plus a strong anomaly west of B and designated anomaly A. This anomaly has a weak phase anomaly but no corresponding Slingram anomaly. Anomaly A was considered a potential prospect for mineralization because of its similarity in intensity and width to the Rum Jungle Creek South Turam anomaly (Douglas, 1964, p. 5).

An induced polarization survey was made over anomaly A in 1963 using 200-foot dipoles (Eadie, 1964). This traverse was repeated in 1963 using 100-foot dipoles. Both results show a weak resistivity anomaly and a moderate near-surface metal-factor anomaly slightly east of the Turam anomaly. The 1968 results are shown in Plate 3. A self-potential survey in 1968 yielded no significant anomaly. Eadie (1964, p. 10) attributed anomaly A to pyritic black slate.

In January 1963, drilling of the conducting horizon commenced in the Batchelor Laterites Area Extended. The holes intersected black, partly calcareous slate and amphibolite whose position in the stratigraphic sequence is unknown. They do not appear to correspond to the ore-bearing host rocks at Rum Jungle Creek South (Spratt, 1963). D.A. Berkman (pers. comm.) suggested that the rocks represent a stratigraphic transition zone between the Golden Dyke Formation and the Coomalie Dolomite. There is no conclusive evidence for the continuation of the syncline at Rum Jungle Creek South into the Batchelor Laterites Area Extended. The location of drill holes is shown on the surface geology map in Plate 2.

To determine what rock types caused anomaly A, resistivity and IP measurements were made on core from eight diamond-drill holes.

The core testing results are presented as vertical sections by plotting the calculated parameter at the depth of sampling. The profiles on traverse 4N are shown in Plate 3 together with geological logs and surface geophysical data. No structure is inferred in the geological section; DDH 705 has been projected onto the section to represent the western amphibolite. The amphibolites in DDH 685 and DDH 691 are probably the same rock unit; however, there is insufficient evidence for a syncline to relate them to the amphibolite in DDH 705. With the exception of the clay and weathered rock horizons, the lithological units are therefore shown as blocks.

The resistivity section shows the amphibolite to be very resistive and the calcitic, sericitic, or chloritic slates to be moderately resistive. The material bounded by the 10 ohm-metre contour is highly conductive black carbonaceous slate and must be regarded as the source of the Turam anomaly. The near-surface weathered rock is moderately conductive, and its possible screening effect is discussed later.

The induced polarization parameter used is percent IP for the frequencies one Hertz and 1000 Hz. This parameter is discussed by Fraser, Keevil & Ward (1964); it is similar to the frequency-effect parameter used in prospecting and is defined in Plate 3. A fairly broad zone of polarizable rock is contained by the 20-percent contour, but it is the conductive polarizable material that has given rise to the metal factor anomaly found in the field results. The field resistivity results contain fairly small variations (6 ohm-metres to 49 ohm-metres). This suggests poor current penetration so that only the polarizable material near the surface is likely to have affected the field measurements. The IP metal factor anomaly is between 152.5E and 154.5E.

The Turam anomaly axis is at 153.5E and this suggests that the zone bounded by the 10 ohm-metre contour, and containing bands with resistivity less than one ohm-metre, is the source.

The Slingram profile (Plate 3) shows no anomaly coinciding with the Turam anomaly (anomaly A) but outlines a broad, intense imaginary-component anomaly between 155E and 159E. It would appear that the relatively high conductivity of the weathered zone together with the low resolution with 200-foot coil spacing and poor penetration for the 1760-Hz signal used has effectively screened the conductive black slate. East of 154E the depth of weathering increases; the imaginary component anomaly is probably due to conducting clay below the water-table in an area of relatively deeper weathering. Part of the anomaly corresponds to anomaly B, which probably overlies a shear (Douglas, 1964) characterized by deeper and more saturated weathering.

The Turam profiles (Plate 3) show a weak phase anomaly corresponding to anomaly B. The source of the electromagnetic anomalies is complex and made up of a westerly dipping conductor overlain by a surface layer of varying thickness and conductivity.

Cores from drill holes 700, 704, and 667 were tested to find the reason for the short strike length of anomaly A. The geological and resistivity sections are shown in Plate 4. Generally the slate above 150 feet is moderately conductive, but the 10 ohm-metre resistivity contour defines a zone of the highly conductive rock.

In conclusion, a block of conductive rock with resistivity less than 10 ohm-metres and containing bands with resistivity less than one ohm-metre is considered to be the source of the Turam anomaly (anomaly A). The block is lens-shaped and dips approximately west at about 25 degrees. Sufficient polarizable material occurs within the geological sequence to explain the IP field results. The IP response is not due to sulphides (pyrite). Microscopic examination of seven thin sections of core from the anomaly source revealed negligible sulphide content (less than 3%) and a significant content of carbonaceous material.

Rum Jungle Creek South to Castlemaine Hill

Slingram and Turam surveys from Rum Jungle Creek South to Castlemaine Hill located many anomalies lying in a distinct conducting zone (Rowston, 1962). This zone, is best defined by the Slingram imaginary-component contours and is about 400 feet wide.

An induced polarization survey on one traverse found no well-defined resistivity and metal-factor anomalies corresponding to the Turam and Slingram anomalies; some low resistivity and high metal-factor readings were observed, but similar local anomalies were found distributed over much of the resistivity and metal-factor sections (Eadie, 1964, p. 9).

The electromagnetic anomalies were attributed to pyritic slates by Eadie and to either sulphide or graphite concentrations or to shears by Rowston. Laboratory measurements were made on core from 15 drill holes to determine what rock types could give rise to the Turam and Slingram anomalies, as well as the anomalous resistivity readings.

The locations of the drill holes are shown on the traverse plan in Plate 5, together with surface geology compiled by Miezitis (1967).

Only two significant real-component Slingram anomalies were delineated in the Rum Jungle Creek South to Castlemaine Hill survey. These are bounded by the 95-percent contour as shown in Plate 6 as C1 and C2; a small real-component anomaly C3 is also shown. C1 and C2 are narrow and of low intensity (for example, compare the anomalies E, F, and H on the Mount Fitch grids in Plate 15, where significant anomalies may be defined by the 85-percent contour). There is no apparent relation between the anomalies C1, C2, and C3.

Two zones of broad elongate imaginary-component Slingram anomalies, C1 and C3, are shown in Plate 7. The imaginary-component anomaly C1 has a similar shape but greater intensity than the real-component anomaly. The anomalous zone extends from C1 to a group of broad imaginary-component anomalies designated C4.

There is no imaginary-component anomaly corresponding to C2. The small real-component anomaly C3 coincides with the centre of a broad elongate imaginary-component anomaly of quite high intensity.

Summarizing, C1, C2, C3, and C4 denote four different types of Slingram anomaly.

Anomaly	Real component	Imaginary component
C1	Narrow, elongate and of low intensity	Narrow, elongate and of fairly high intensity
C2	Narrow, elongate and of low intensity	No anomaly
C3	Very small and of low intensity	Broad, elongate and of high intensity
C4	No anomaly	Broad elongate and moderately intense.

The four anomalies probably arise from four sources of different composition, location, or orientation. Rowston (1962, p. 3) points out that the imaginary-component anomaly at 80E/250S (C4) occurs 200 feet from the C2 real-component anomaly, suggesting a displacement similar to that observed in the Turam results at Rum Jungle Creek South. It seems unlikely, both here and at Rum Jungle Creek South, that the anomalies arise from one source, but rather that there are separate adjacent sources which give rise to displacement of real and imaginary-component Slingram anomalies and to displacement of ratio and phase Turam anomalies.

Most of the traverses from Rum Jungle Creek South to Castlemaine Hill were resurveyed with Turam. Small, low-intensity ratio anomalies coincide with Slingram anomalies Cl and C3 (Plate 8). The Turam survey did not extend as far south as C2 or as far east as C4. Plate 9 shows a narrow elongate Turam phase anomaly of moderate intensity coinciding with C1, and a weaker phase anomaly coinciding with C3.

The Results of the laboratory measurements from each line of drill holes are now considered in turn.

<u>Traverse 50E</u> (Plate 10). The real-component anomaly C3 is located over the same chloritic schist that contains the Rum Jungle Creek South orebody (the 'orebody chloritic schist' shown in Plate 10, 11, and 12). It coincides with a broad imaginary-component anomaly. Samples of this chloritic schist from drill hole D639 and a sample of the calcareous sericitic slate and of the grey limestone from D642A were tested. The resistivity values indicate the chloritic slate to be moderately resistive and the sericitic slate and limestone to be very resistive. No evidence of a conductive rock capable of giving rise to the Slingram anomaly was found, and the source may be a weathering effect, a saturation effect, or a central synclinal rock not intersected by the drill holes.

<u>Traverse 58E</u> (Plate 11). Representative samples of all consolidated material from the five drill holes on traverse 58E were tested. A 1000 ohm-metre contour corresponds to the limestone contact to the east. The chloritic schist which contains the Rum Jungle Creek South orebody farther north also shows resistivities greater than 1000 ohm-metres. The only specimen of black slate showing a resistivity below ten ohm-metres is part of the generally resistive slate penetrated in D627. The soft porous carbonaceous slate in D641 shows moderately low resistivities typical of weathered rock.

Half-width depth estimates from the Turam profile on anomaly C1 suggest that the source of the anomaly occurs about 100 feet below the surface. Though there is electrical contrast between the black slate and adjacent rocks, variations in the fresh rock are evidently too deep to affect the electromagnetic data. Resistivity measurements indicate little electrical contrast within the weathered zone. When fully saturated the weathered material from the three drill holes D634, D641, and D646 proved very conductive. The centre of anomaly C1 occurs only about 30 feet west of D646. The in.mediate conclusion is that either conductive weathered black slate occurs within 100 feet of the surface between D641 and D646, or that the anomaly is due to variations in weathering depth, weathering product, or degree of saturation rather than to the presence of a conductive stratigraphic unit.

<u>Traverse 66E</u> (Plate 12). The broad Slingram imaginary component anomaly C3 and narrow anomaly C1 are the major features of the electromagnetic profiles. Anomaly C3 occurs over the relatively resistive 'orebody chloritic schist'. The resistivity of the grey or calcareous slate in drill holes D629 and D637 is high except where shears are present. Anomaly C1 is over the fault zone shown in drill hole D637. If this zone corresponds to the lower fault zone in D648 as shown, then the fault probably strikes roughly parallel to the traverse, because it is most likely to be steeply dipping. Thus the fault zone is unlikely to be the cause of anomaly C1, which strikes roughly at right angles to the traverse. The fault zone crossing drill holes D648 and D624 is not related to any electromagnetic anomaly. No highly conductive rocks were located by the resistivity measurements, and the broad imaginary-component anomaly C3 is apparently due to weathering or saturation effects.

<u>Traverse 74E</u> (Plate 13). A relatively narrow imaginary-component Slingram anomaly with a weak real-component anomaly is situated on the apparent surface trace of a fault inferred from the cavity, overlain by clay, at a depth of 110 feet in drill hole D623. Any conductive rocks that might

have affected the Slingram measurements must be in D623 and D635. The fresh chloritic schist in D635 showed moderately low resistivity, increasing with depth; the calcareous mica slate in D623 was highly resistive. It seems unlikely that either rock type could have caused the Slingram anomaly, especially as the depth of weathering exceeds 100 feet. The Slingram anomaly would appear to be due to weathering or saturation effects associated with a steep fault zone.

Traverse 82E (Plate 14). The real-component Slingram anomaly C2 is well defined at 500S; a very broad imaginary-component anomaly (C4) occurs from 350S to 150N over the 'orebody chloritic schist'. Like the other imaginary-component anomalies over this unit, C4 is probably due to weathering or saturation effects.

Anomaly C2, however, is evidently due to the near-surface (45 to 65 feet) occurrence of black carbonaceous slate, whose resistivity ranges from two to ten ohm-metres.

Summarizing, anomalies C1, C3, and C4 are probably due to weathering or to saturation effects, though C3 may possibly be due to a rock type not intersected and C1 may possibly be due to weathered black slate. Anomaly C2 is due to conductive black carbonaceous slate. The anomaly on traverse 74E is due to weathering or saturation effects probably associated with a fault.

No relation between electrical resistivity and sulphide content was observed during the testing of core from the fifteen Castlemaine drill holes. Consequently no electromagnetic anomaly is considered to be due to sulphides.

The following results are presented showing the high resistivity of some of the more pyritic cores, and the very low resistivities of some carbonaceous slate core from DDH 631 and 636 with pyrite content ranging from zero to 3%.

Traverse	DDH	Depth (feet)	Core Description	Resistivity (ohm-metres)
58E	634	218	Hard, dark chloritic slate, 5% disseminated pyrite	92
58E	634	251	do, 4% disseminated pyrite	2060
66E	637	223	Grey biotite slate, 6% disseminated pyrite	760

Traverse	DDH	Depth (feet)	Core description	Resistivity (ohm-metres)
66E	637	298	do, 8% disseminated pyrite	422
82E	631	100	Porous black carbonaceous slate, 2% pyrite	98
82E	631	145	Black carbonaceous mica slate, 1% pyrite	2.5
82E	631	192	do, nil pyrite	2.4
82E	636	96	Black carbonaceous slate, 3% pyrite	1.8
82E	636	154	do, 3% pyrite	2.5
82E	636	165	do, about 2% pyrite	1.6

Mount Burton to Mount Fitch area

Geophysical surveying in 1963 delineated a zone of electromagnetic anomalies extending from Dolerite Ridge to the Mount Fitch Prospect (Ashley, 1965). The zone is over the Golden Dyke Formation adjacent to the Coomalie Dolomite Formation. The Slingram real-component contours shown in Plate 15 define narrow elongate anomalies which are generally associated with broad imaginary-component anomalies. BMR diamond drilling of some of these anomalies in 1964 found amphibolite, dolerite, and carbonaceous sediments all containing pyrite and pyrrhotite but no economic mineralization (Prichard, 1964).

Three traverses surveyed with a magnetometer in 1963 (Ashley, 1965) showed anomalies due to near-surface sources superimposed on broad anomalies due to deep-seated sources. The separation of the effects of the near-surface and deep-seated sources on traverses near the diamond-drill holes is shown in Plate 16. Induced polarization surveys in 1968 yielded resistivity and IP anomalies corresponding to the Slingram anomalies (Gardener, 1971).

To determine the cause of the geophysical anomalies, core from four diamond-drill holes (64/1, 64/2, 64/3 and 64/4) was examined and the resistivity measured.

DDH 64/1 (Plate 17). Diamond-drill hole 64/1 was planned to test a strong real and imaginary-component Slingram anomaly. It was also considered to be within the limits of the magnetic anomaly on traverse 37875N. The hole entered amphibolite immediately below alluvium and continued in this rock for the full depth of 300 feet. The Slingram anomaly is shown as being over amphibolite near a contact between amphibolite and black slate. To determine whether the amphibolite was conductive enough to cause the Slingram anomaly, 30 samples of core from 64/1 were tested. The results are presented in Plate 17.

The fresh amphibolite is generally resistive; the samples tested ranged from 11 to 6 300 ohm-metres and their average was 1 720 ohm-metres. The seven samples of weathered core showed an average resistivity of 46 ohm-metres. The most pyritic rocks usually showed fairly low resistivity, but most of these were weathered as well. Only two samples containing more than three percent sulphides were unweathered, and one of these had a resistivity of 2 700 ohm-metres. The most conductive fresh sample contained only about two percent sulphides.

The sulphides content does not appear to control the resistivity; its effect is probably governed by mode of occurrence and degree of weathering. It is unlikely that the Slingram anomaly is due to the sulphide content of the impermeable amphibolite.

A resistivity anomaly coincides with the Slingram anomaly, but though frequency effects are generally high, no frequency-effect anomaly coincides with the resistivity anomaly. The low resistivities yield corresponding high metal factors. The resistivity anomaly shows increasing conductivity with depth and increasing water saturation. The resistivity high at 132E is due to quartzite of the Acacia Gap Tongue.

A 1 200-g amma magnetic anomaly coincides with the amphibolite (Plates 15, 16, and 17). Thin sections of core from 64/1 show the presence of pyrrhotite but no magnetite. The magnetic and Slingram anomalies do not coincide and are probably not related.

DDH 64/2 (Plate 18). Diamond-drill hole 64/2 was sited on the axis of a strong real and imaginary component Slingram anomaly. No magnetic anomaly due to a near-surface source occurs at 64/2, and it is unlikely that the hole tested the deeper source (Plate 16). 64/2 is on the edge of a low resistivity and high frequency-effect anomaly.

The geological log shows the hole to penetrate 26 feet of soil, then black slate to 81 feet and amphibolite to 210 feet. Re-examination of the core showed the amphibolite to be a metasediment: a chloritic slate or chloritic metagreywacke with a sulphide content less than five percent. The balck slate was partly graphitic and very shattered and difficult to sample.

Twenty-five samples from 64/2 were tested in the laboratory. The resulting data are shown in Plate 18. It is notable that no extremely high resistivities were measured like those of the amphibolite in 64/1. No very low resistivities were observed, though the two lowest values (four ohm-metres at 73 feet and five ohm-metres at 86 feet) may represent part of the material which gave rise to the Slingram anomaly. Sulphide content again is not the major factor controlling resistivity, for though the sample from 86 feet is richly pyritic the sample from 73 feet contains negligible sulphides.

DDH 64/3 (Plate 19). This hole was sited to test a narrow elongate Slingram real-component anomaly west of and roughly parallel to that tested by 64/2. It is located on a broad imaginary-component anomaly. Low resistivity and high frequency-effect anomalies coincide with the Slingram anomaly. No near-surface magnetic anomaly occurs close to the hole.

Carbonaceous and chloritic beds were penetrated to 273 feet and then calcareous beds to the total depth of 290½ feet. The material above 75 feet was deeply weathered and mostly uncohesive. Pyrite occurs throughout, usually with pyrrhotite.

Thirty samples from the core of 64/3 were tested in the laboratory. Observed resistivities ranged from less than one ohm-metre to 19 200 ohm-metres. The samples with resistivities below ten ohm-metres are described in the following table.

Depth (feet)	Core description	Resistivity (ohm-metres)	Sulphide (percent)
266	Dark green amphibolite	0.66	15
255	Black slate	0.82	10
262	Black slate	1.52	3
181	Black carbonaceous slate	3.1	½
160	Quartz (50%)-pyrite vein (20%); porous	5.5	20

Depth (feet)	Core description	Resistivity (ohm-metres)	Sulphide (percent)
177	Black carbonaceous slate	6.0	negligible
205	Black carbonaceous slate	7.6	5
131	Soft, porous weathered slate	9.8	negligible

The most conductive rocks are black slates (regardless of sulphide content) and material with a sulphide content of ten percent or more. Either of these might give rise to an electromagnetic anomaly if in sufficient quantity and close enough to the surface.

Black carbonaceous slates with negligible sulphide showed high conductivity, but these were mostly at depth. The shale above 100 feet was broken, weathered, and difficult to sample. The material tested has a resistivity of around 20 ohm-metres.

DDH 64/4 (Plate 20). This hole was sited on the axis of a weak real-component Slingram anomaly associated with a broad, strong imaginary-component anomaly. This is the same electromagnetic axis tested by 64/1 but displaced by a southwest-striking fault. The Slingram anomaly is in an area of low resistivity and within a broad steep-sided magnetic anomaly of 3 000 gammas.

Hard, coarse-grained non-porous pyrrhotitic amphibolite was penetrated from under the soil and weathered amphibolite to the full depth of 324 3/4 feet.

Pyrrhotite veins varying in width from 3 mm to 8 cm occur within the amphibolite. Five samples selected to represent the veined rock yielded the lowest resistivities observed for core from 64/4, and these resistivities are the first five in the following table of low-resistivity core from 64/4.

Depth (feet)	Resistivity (ohm-metres)	Sulphides (percent)	Graphite (percent)	Cause of conductivity
81	0.4	50	10	Pyrrhotite vein and graphite
150	0.7	6	?	Continuous pyrrhotite vein, plus pyrite
249	1.0	10	10	Continuous pyrrhotite vein, plus graphite

Depth (feet)	Resistivity (ohm-metres)	Sulphides (percent)	Graphite (percent)	Cause of conductivity
180	1.9	10	?	Continuous pyrrhotite vein
85	3.1	8	?	Continuous pyrrhotite vein
235	7.4	1	5	Graphite
260	17	8	?	Pyrrhotite and pyrite
103	26	7	?	" " "
114	52	5	?	" " "

Veining in four of the five veined core samples (from 150, 249, 180, and 85 ft) was axially continuous; the fifth (from 81 ft) consisted half of amphibolite and half of massive pyrrhotite. Significantly, the most conductive rock was amphibolite with no continuous sulphide path.

The most conductive non-veined core (from 235 ft) contained only one percent sulphides. In general the amphibolite showed high resistivity. The average resistivity of all the samples tested from 64/4 was 3 200 ohm-metres. Close examination of the conductive non-veined core listed above from 235 feet revealed fine-grained graphite dispersed between amphibole crystals and forming a continuous path for electrical conductivity; the five percent graphite content is the reason for the high conductivity. Study of the conductive core with discontinuous veining (from 81 ft) showed the amphibolite to be impregnated with fine graphite also.

The samples taken at depths of 103, 114, and 260 feet contained no visible graphite, and their conductivity is due to their sulphide content. However, many of the more sulphide-rich rocks are highly resistive, as shown in the fol owing table.

Depth (feet)	Rock type	Resistivity (ohm-metres)	Sulphides (percent)
226	Calcite-veined amphibolite	3200	8
76	Hard foliated amphibolite	306	8
241	Coarse calcareous amphibolite	348	7
132	Foliated coarse amphibolite	221	5
266	Calcitic amphibolite	750	5

Depth (feet)	Rock type	Resistivity (ohm-metres)	Sulphides (percent)
220	Dark green amphibolite	4300	4
280	Hard dark green amphibolite	4200	4
146	" " " "	620	4

Apparently the mode of occurrence of the sulphides is an important control on resistivity. The samples tested from shallow depth show high resistivities because only unweathered material was tested.

The influence of the pyrrhotite veins on the Slingram results depends on their length and continuity. If they are isolated within the resistive amphibolite they will have no effect. More probably they would be fairly continuous, and interstitial graphite would considerably improve continuity. The Slingram anomaly is therefore attributed to a conductive band of pyritic, pyrrhotitic, and graphitic amphibolite about 30 feet wide and within 80 feet of the surface. The magnetic anomaly is broader than the Slingram anomaly and is attributed to the pyrrhotite.

Summing up, the Slingram anomalies tested by 64/2 and 64/3 appear to be due to carbonaceous shale or slate, the anomaly tested by 64/4 is due to conducting amphibolite, and the anomaly tested by 64/1 is due to a conducting zone in the weathered amphibolite. The magnetic anomalies are due to pyrrhotite.

Mount Fitch Prospect

Slingram and Turam surveys in the vicinity of the Mount Fitch Prospect delineated anomalies along the boundary of the Coomalie Dolomite and the underlying Crater Formation. The anomaly source was considered to be copper mineralization (Ashley, 1965).

The surface geology (Plate 21) is based on compilation by Miezitis (1967) with the exception that his Beestons Formation is shown as Crater Formation; this alteration is based on more recent mapping (Miezitis, pers. comm.).

Slingram anomaly A follows the eastern edge of the Coomalie Dolomite from Mount Burton to Mount Fitch North (Ashley, 1965). Near and to the south of the Mount Fitch Prospect the anomaly represents a weak conductor; to the north it represents a moderately strong conductor.

The area of interest extends from 426N to 454N and was covered by both Turam and Slingram surveys (Plate 21). A weak Turam ratio anomaly of up to 1.1 and a Turam phase anomaly of from -5° to -20° coincides with Slingram anomaly A. A weak near-surface conductor is indicated.

An IP survey on traverse 432N yielded a weak resistivity anomaly at about 119E with no corresponding frequency effect anomaly (Eadie, 1964).

A number of copper geochemical anomalies at the Mount Fitch Prospect were drilled in 1963. This drilling indicated that primary copper mineralization probably occurs as shallow pitching lenses, and that 100 000 tons of two percent supergene copper mineralization may be present in the weathered Coomalie Dolomite in the Tamblyn's Shaft area (Pritchard & French, 1965).

In order to determine whether any of the copper-bearing rocks were conductive enough to cause an electromagnetic anomaly, cores from diamond-drill holes DG 24, DG27, DG28, DG30, and DG31 (Plate 21) were studied. Throughout these holes, the main rock types were hard fresh crystalline limestone, and extremely weathered rock (clay). The latter was soft, uncohesive, and very difficult to sample.

DG27. This hole is the nearest to anomaly A. It was an inclined hole and was completed in schist and sheared arkose of the Crater Formation at 163½ feet. The geological log (Prichard & French, 1965, Appendix 1) shows sandstone and clay to 80 feet, weathered limestone to 86 feet, a hard siliceous siltstone (with fine blebs of chalcocite) to 93 feet, and sheared schist to 139 feet. The hole penetrated cupriferous hematite siltstone between 123 and 127 feet, the copper occurring mainly as malachite; soft clay and mud were penetrated to 161 feet, followed by Crater Formation schist and arkose. From 93 to 161 feet almost all the material was broken, unconsolidated, and clay-like. From resistivity measurements on clays in the area from Rum Jungle Creek South to Castlemaine Hill, a range of one to ten ohm-metres could be expected for the resistivity of this material. Slickensides on the more solid siltstone around 140 and 150 feet provide evidence of shearing.

Resistivity measurements showed the solid rock deeper than 100 feet to be resistive.

Depth	Rock type	Resistivity
110 ft	Fine hard sericitic slate	91 ohm-metres
163 ft	Sheared arkose	255 " "

The amount of clay and the small amount of copper, mainly malachite, together with the high country rock resistivity and the evidence of slickensides suggest that saturated clays associated with a shear gave rise to the electromagnetic anomalies.

DG24. This hole was drilled parallel to DG27, also to intersect the Coomalie Domomite/Crater Formation boundary (Plate 21). Of the total footage of 430 feet, 117 feet consisted of cavities. Most of the material recovered was fine unconsolidated silt with no visible copper mineralization. Spectrographic analysis however showed up to 5000 ppm copper.

The only solid rock was a hard brown siliceous rock. Two samples were tested and high resistivities were recorded: 3800 ohm-metres at 243 feet and 3200 ohm-metres at 330 feet. The clays would be expected to show low resistivities.

DG28. This was a vertical hole collared at the same location as DG24 (Plate 21). It intersected clay to 87 feet, limestone to 522 feet, then weathered limestone and a 3-foot cavity to 537 feet, and then weathered, strongly sheared green talc (virtually clay) with numerous slickensides.

The only copper mineralization observed was minor chalcocite at 127 feet. A deep and a shallow sample of the limestone showed the following high resistivities:

108 ft	4500 ohm-metres
533 ft	1000 ohm-metres

DG30. Copper-bearing rocks from this hole were tested for conductivity, with the following results:

Depth (feet)	Description	Resistivity (ohm-metres)
616	Yellow limonitic leached and porous limestone with less than 1% finely disseminated copper.	4500

Depth (feet)	Description	Resistivity (ohm-metres)
619	Coarse crystalline calcite and fine cupriferous limestone with about 8% chalcocite.	195
622	Coarse white limestone with one large bleb of chalcocite among finer chalcocite; total sulphide about 3%.	730

The high chalcocite content of the sample from 619 feet failed to yield a significant resistivity anomaly.

DG31. This was a vertical hole drilled to intersect the Coomalie Dolomite/Golden Dyke Formation boundary. However, at 733½ feet, still in limestone, the rods sheared off and the hole was abandoned. The hole is 100 feet west of the Slingram and Turam anomalies centred at about 113E (Plate 21).

Above 115 feet almost all the material was soft, broken, and sheared. Any conductive material in this zone would probably be in weathered material.

Nine samples were tested, with the following results:

Depth (feet)	Rock type	Resistivity (ohm-metres)
62	Unweathered grey chloritic and sericitic slate	226
90	Weathered greenish black slate	25
94	Hard vuggy cherty dolomite	1320
590	Mottled limonitic limestone, 1% chalcocite	285
591	" " " , 1% native copper	380
641	Greyish limestone, 2% native copper	4600
644	Chloritic schist; 5% disseminated chalcocite	10
693	Yellow-white limestone; no copper	3000
725	" " " ; less than 1% native copper	520

Fresh cupriferous limestone tested was not conductive. The chloritic schist with 5% chalcocite and resistivity of 10 ohm-metres was partly weathered and is electrically comparable to clays.

The solid material above 100 feet is quite resistive. It is unlikely to be representative of the more weathered material.

The upper parts of DG30 and DG31 are in the Golden Dyke Formation. The electromagnetic anomaly at about 113E/432N is probably due to a carbonaceous bed within the Golden Dyke Formation.

DG30 and DG31 were originally drilled to test an IP anomaly found in 1963 (Eadie, 1964). This IP anomaly appeared to indicate a western extension of the copper anomaly tested by DG24, DG27, and DG28 (Prichard & French, 1965). The IP anomaly is probably due to carbonaceous slate of the Golden Dyke Formation.

4. CONCLUSIONS

Geophysical data from the Rum Jungle area have been reinterpreted in the light of studies of diamond-drill core described in this report.

In the Batchelor Laterites Area Extended, a Turam and IP anomaly was previously attributed to pyritic black slate. The drill core measurements showed that the Turam anomaly is attributable to a lens-shaped block of carbonaceous graphitic black slate. This slate showed high polarizability and is regarded as the source of the IP anomaly.

In the Rum Jungle Creek South to Castlemaine Hill area, electromagnetic surveys located anomalies of various types lying within a conducting zone defined mainly by Slingram imaginary-component anomalies with weak or no real-component anomalies. Laboratory measurements indicated that the Slingram imaginary-component anomalies are due to weathering or saturation effects in the near-surface material. No conductive rock was found to explain a well-defined narrow elongate Slingram and Turam anomaly (anomaly C1). The anomaly may be due to an increase in the degree of weathering or saturation, or to weathered near-surface black slate. Conductive black carbonaceous slate was penetrated at a depth of 65 feet below a well-defined Slingram real-component anomaly (anomaly C2). The nearest imaginary component anomaly is 200 feet away and is probably due to a weathering or saturation effect. The cause of anomaly C2 was established by the laboratory measurements to be carbonaceous black slate with negligible pyrite.

Strong and continuous Slingram anomalies were outlined in 1963 between Mount Burton and Mount Fitch. The zone in which the anomalies occurs was considered by Ashley (1965) to outline a likely uranium environment. Four holes were diamond-drilled to investigate the anomalies. Diamond-drill hole 64/1 penetrated mainly resistive rock. However, the near-surface weathered rock showed resistivities as low as four ohm-metres, and this material may have caused the Slingram anomaly.

Diamond-drill hole 64/2 intersected broken and partly graphitic black slate from 26 to 80 feet. The conductivity of the deeper rocks proved to be independent of sulphide content; the carbonaceous black slate appears to be the source of the Slingram anomaly.

In diamond-drill hole 64/3, soft weathered grey slate between 75 and 145 feet is moderately conductive and may have produced the Slingram anomaly.

The Slingram anomaly tested by diamond-drill hole 64/4 is attributed to a band of pyritic, pyrrhotitic, and graphitic amphibolite about 30 feet wide and occurring within 80 feet of the surface.

At the Mount Fitch Prospect, testing of core showed that almost all copper sulphides occur in a non-porous, insulating matrix. Reinterpretation of the drilling results indicates the source of electromagnetic anomalies along the Coomalie Dolomite/Crater Formation boundary to be saturated clays of a major shear zone.

The studies described in this report illustrate: (1) the usefulness of laboratory measurements to establish the cause of electromagnetic anomalies; (2) the limitations in penetration and resolution of the Slingram method; (3) the difficulty in recognizing in hand specimens carbonaceous rocks of high conductivity; and (4) the uncertainty in estimating electrical conductivity from sulphide content.

Though a project such as described in this report would not normally be included in an exploration program, a detailed re-examination of previous interpretation and subsequent drilling information should form part of any long-term evaluation of a mining area.

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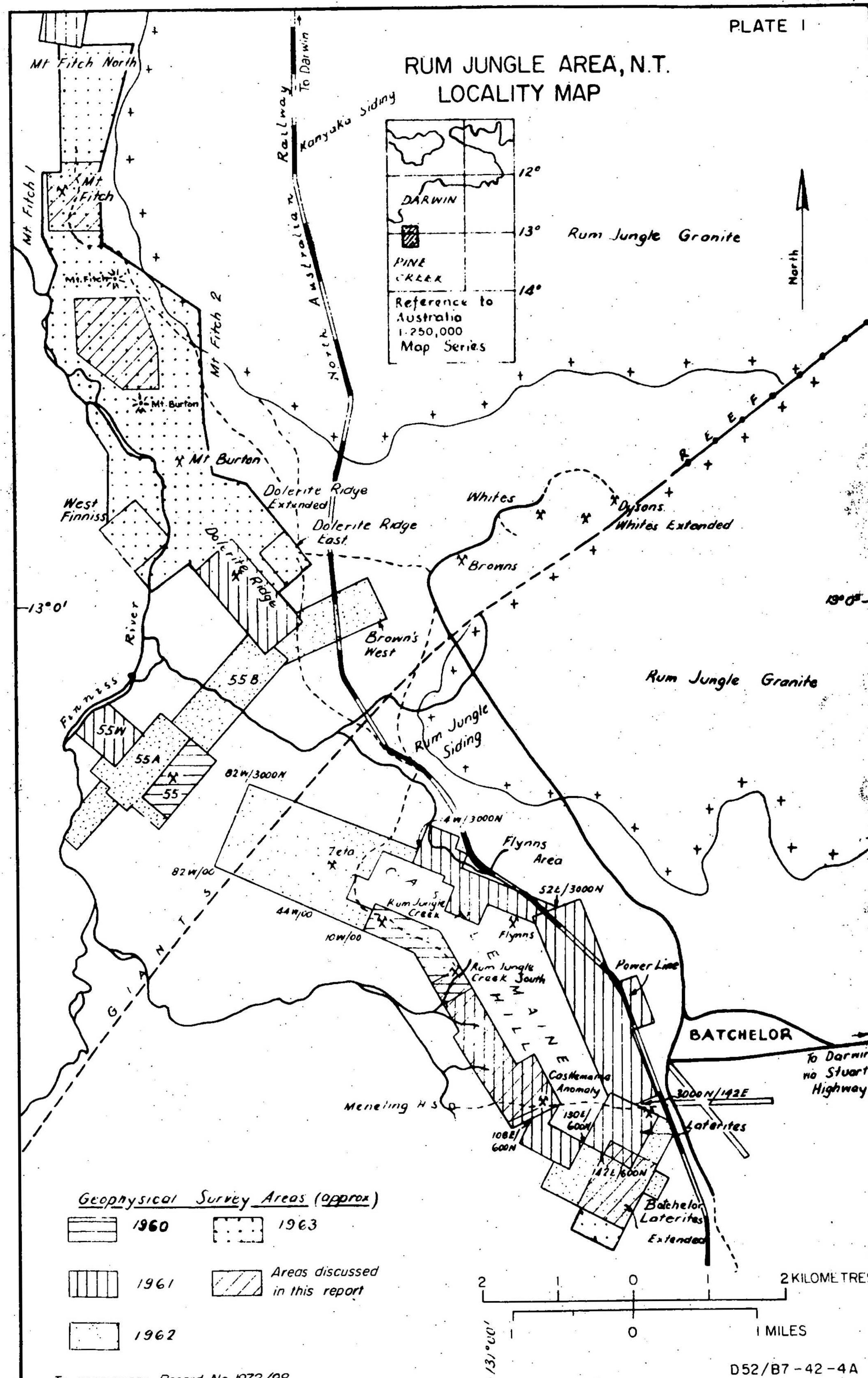
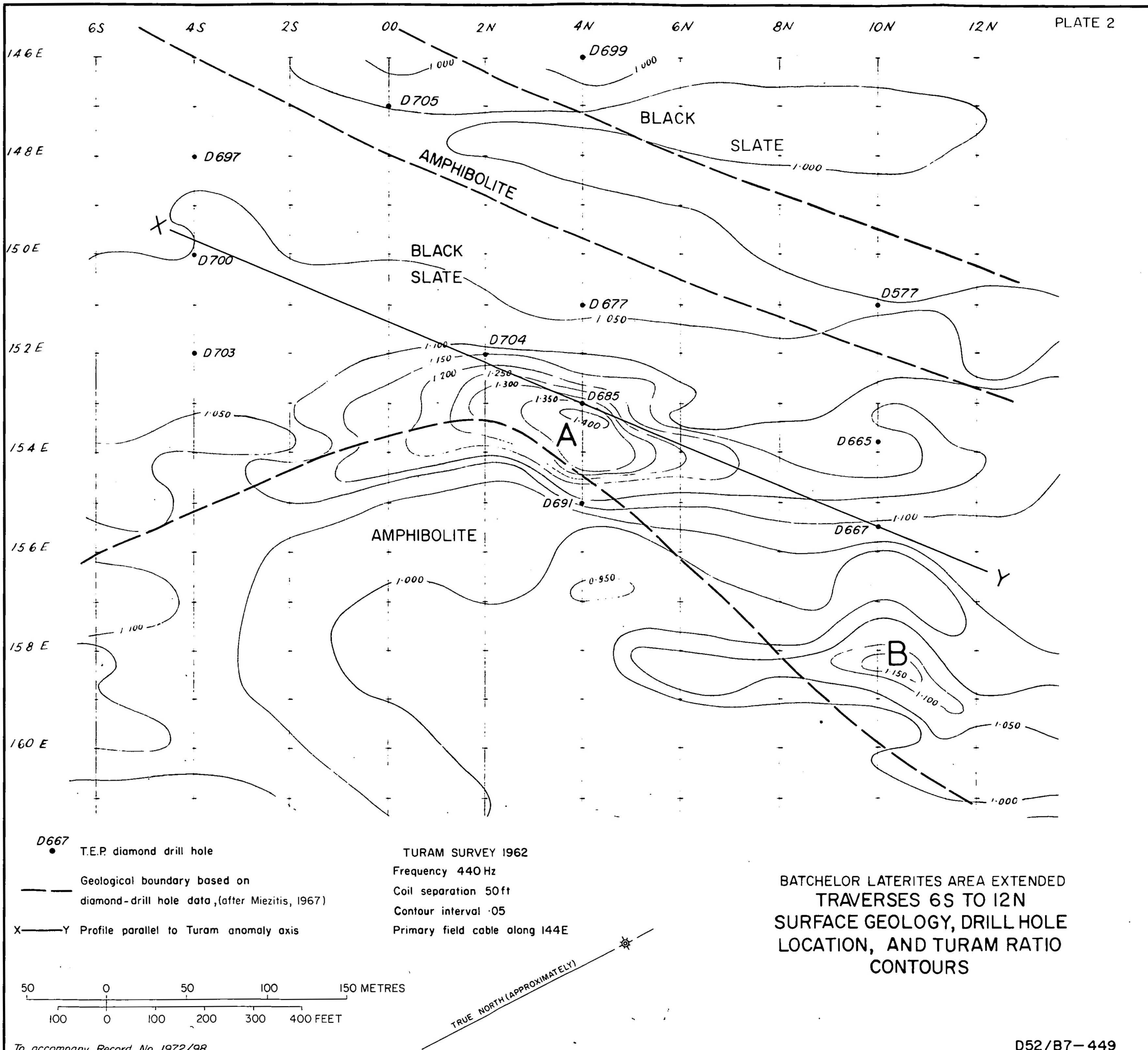
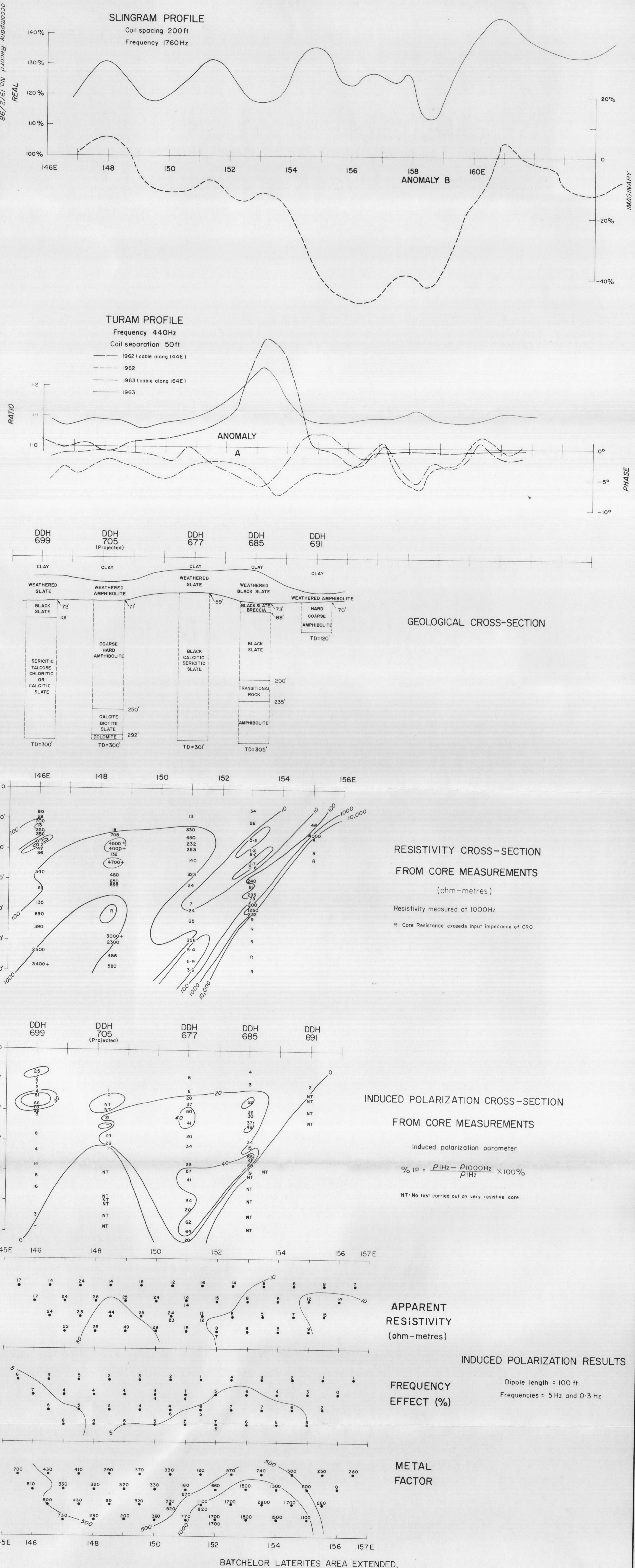


To accompany Record No 1972/98



(Based on D52/B7—71)

To accompany Record No 1972/98



BATCHELOR LATERITES AREA EXTENDED,

TRAVERSE 4N

COMPARISON OF GEOPHYSICAL RESULTS,
DRILL HOLE INFORMATION AND LABORATORY MEASUREMENTS.

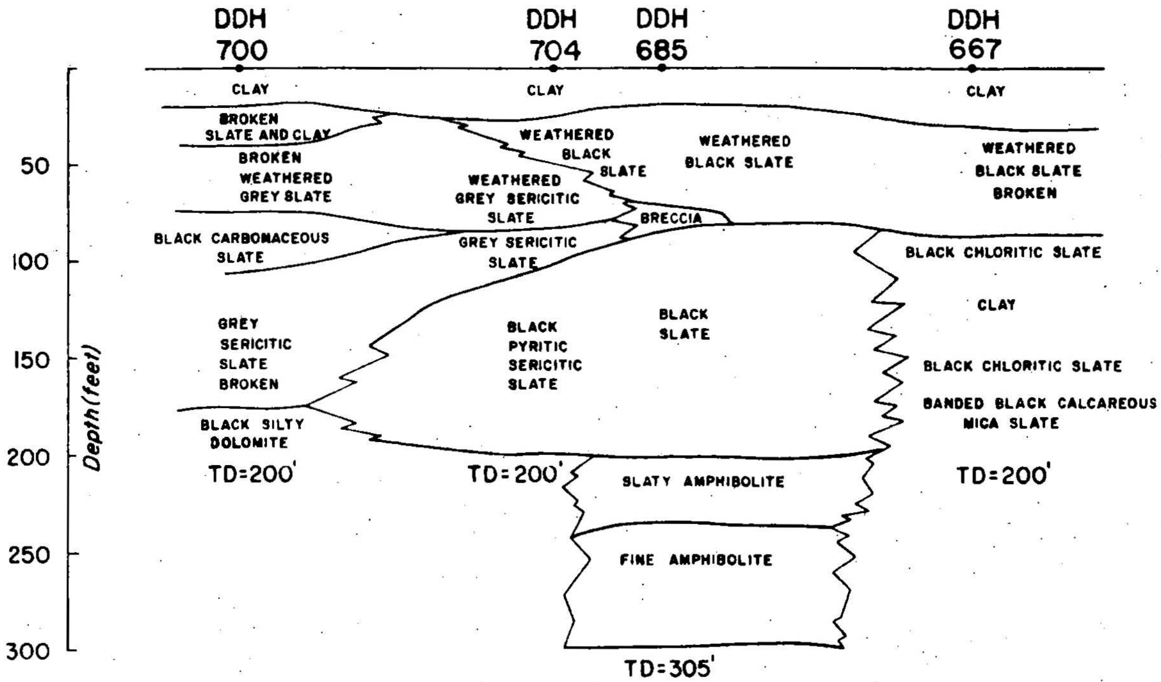
50 0 50 100 150 METRES
100 0 100 200 300 400 FEET

D52/B7-471

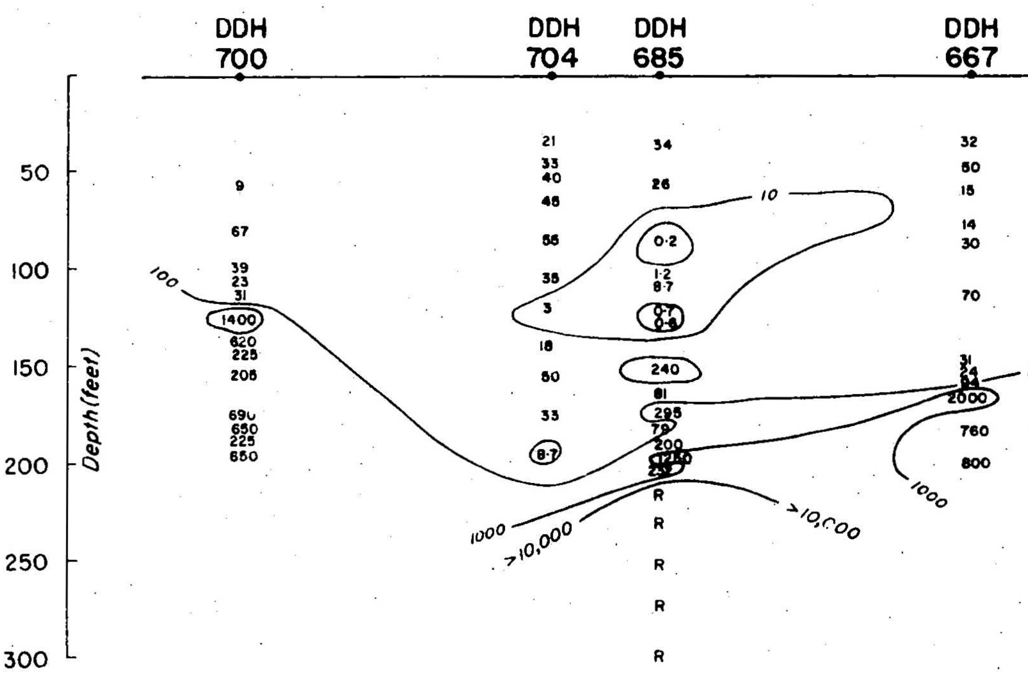
PLATE 3

PLATE 4

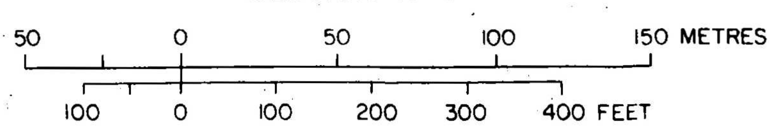
GEOLOGICAL CROSS-SECTION



RESISTIVITY CROSS-SECTION FROM CORE MEASUREMENTS
(ohms-metres)

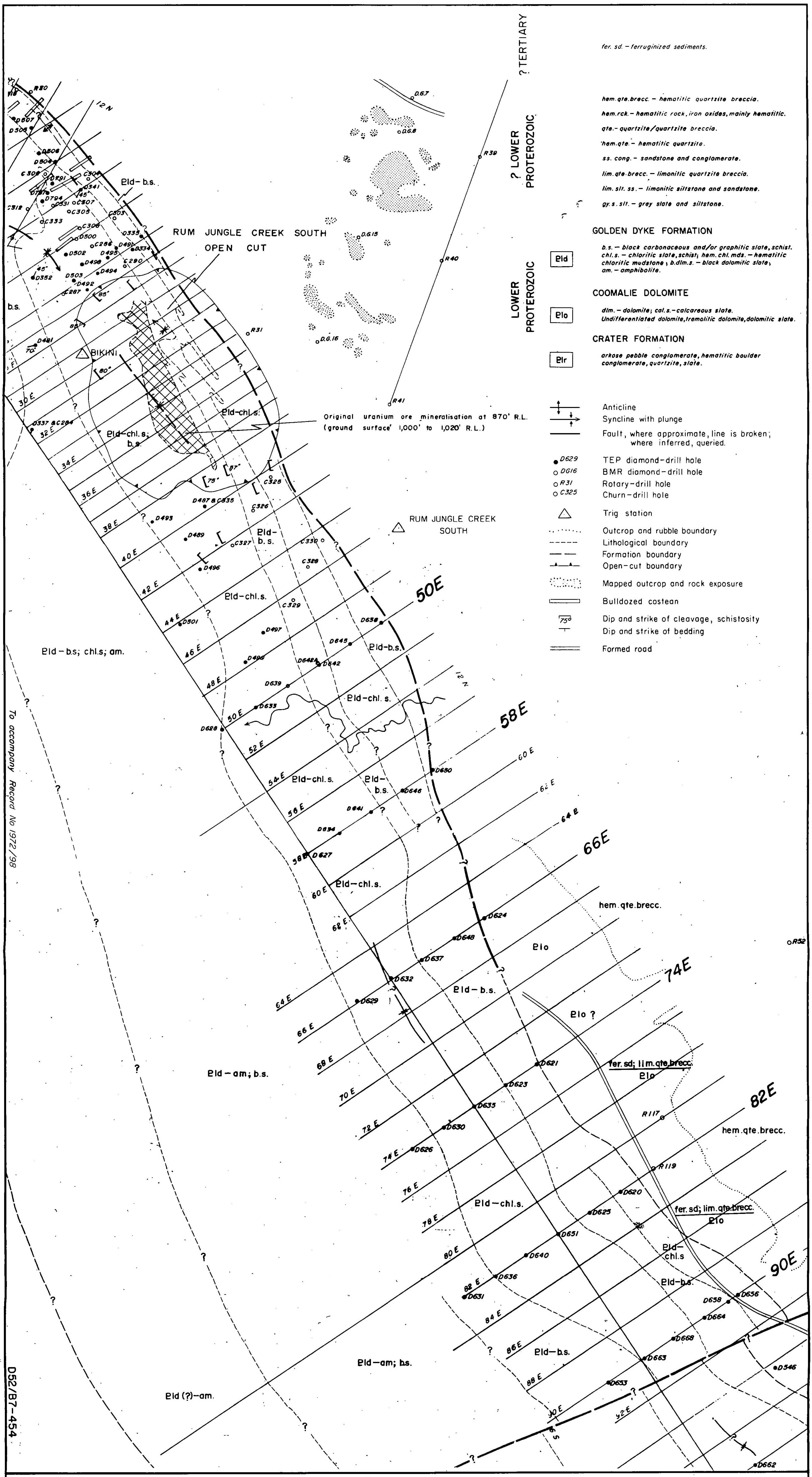


BATCHELOR LATERITES AREA EXTENDED SECTION X–Y



To accompany Record No. 1972/98

D52/B7-468A



RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL

SURFACE GEOLOGY, DRILL HOLE AND TRAVERSE LOCATIONS

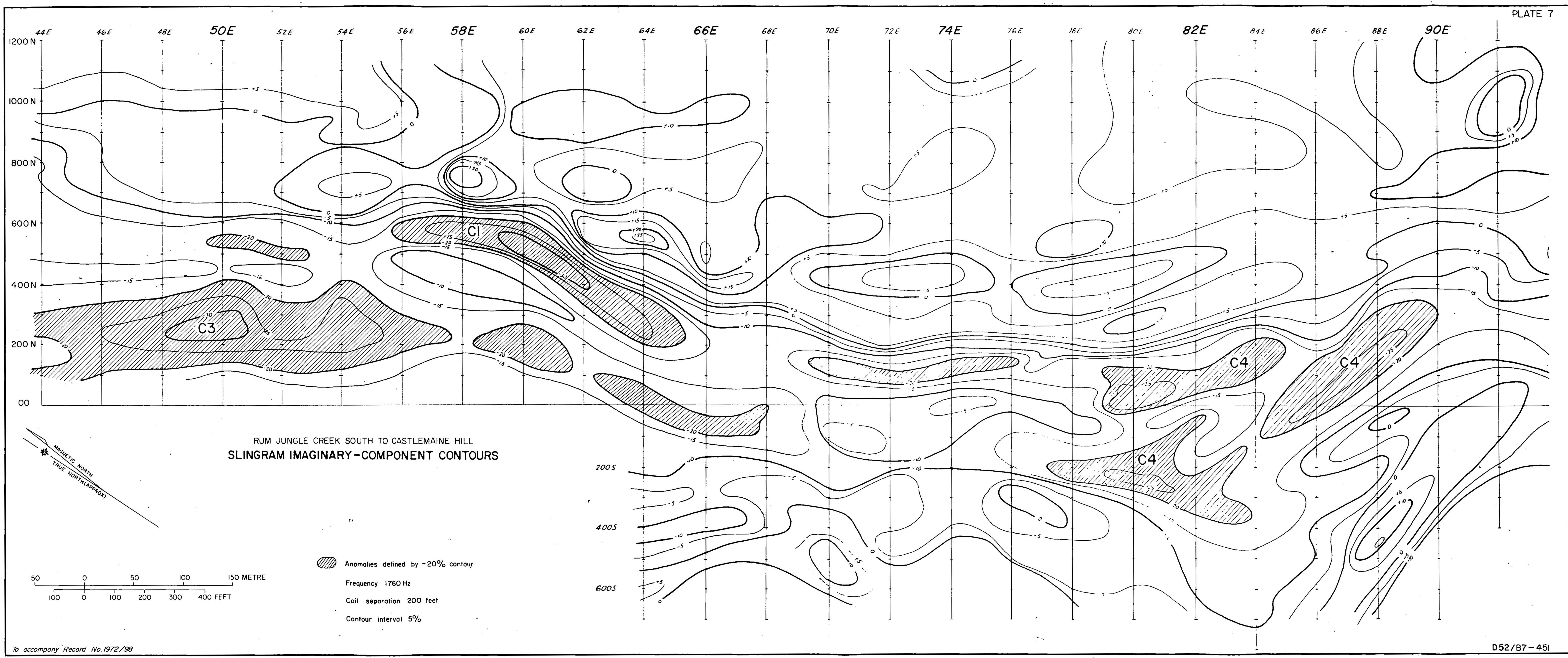
Geology after Miezitis (1967)

100 0 100 200 300 METRES

200 0 200 400 600 800 FEET

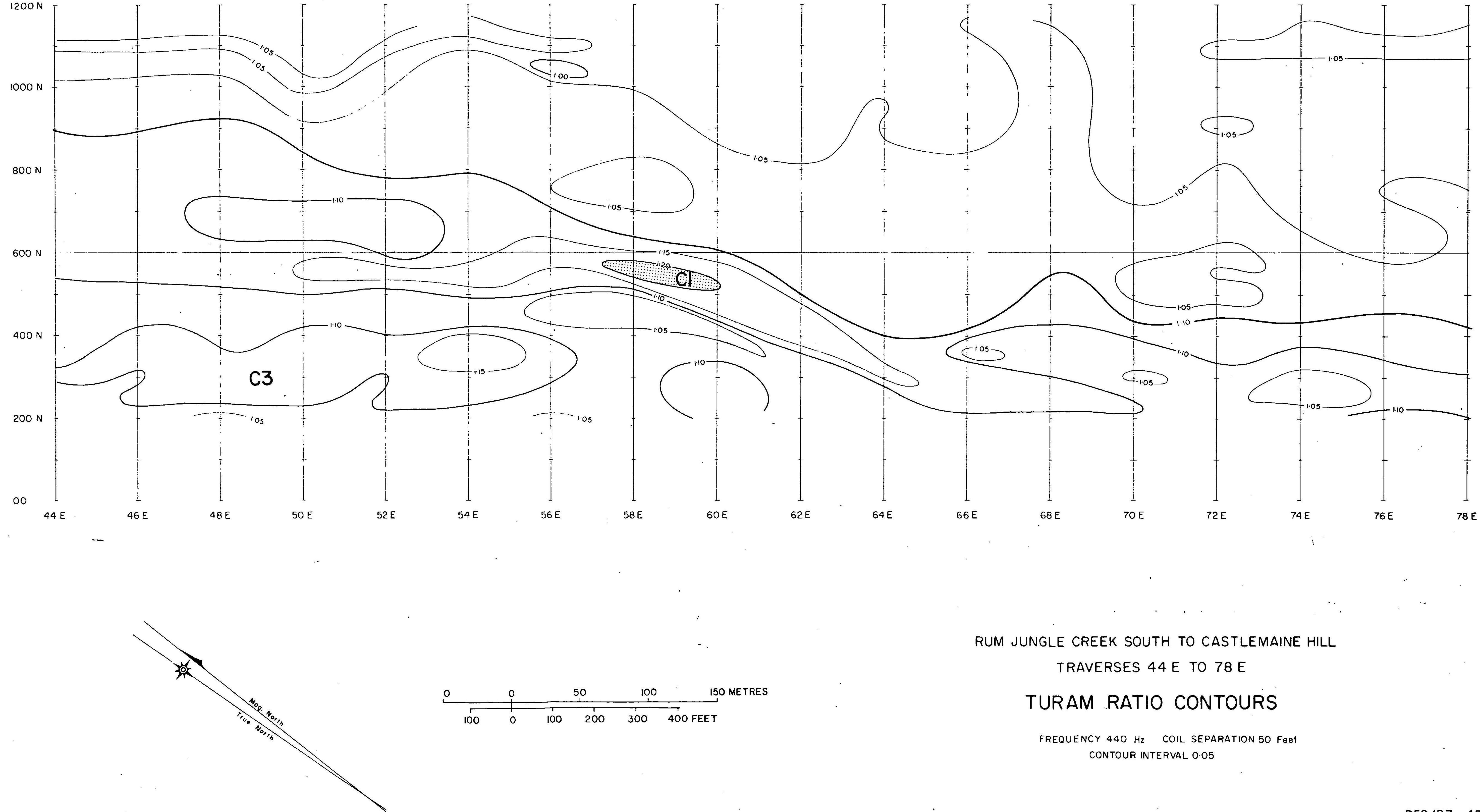
PLATE 5

(Based on G71-241)



(Based on G 71-242)

PLATE 8



RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL

TRAVERSES 44 E TO 78 E

TURAM RATIO CONTOURS

FREQUENCY 440 Hz COIL SEPARATION 50 Feet

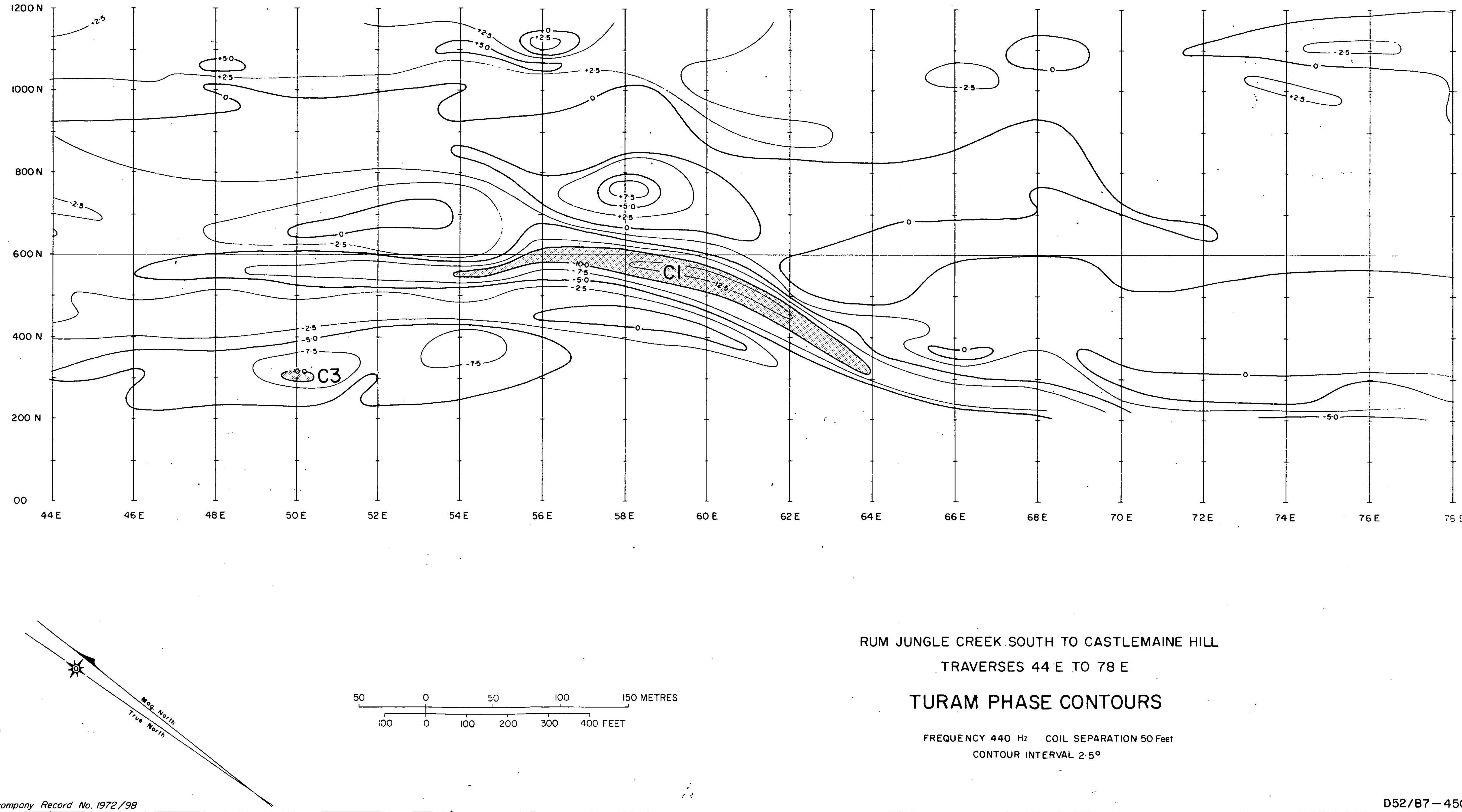
CONTOUR INTERVAL 0·05

To accompany Record No. 1972/98

(Based on G71-243)

D52/B7-452

PLATE 9



RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL

TRAVERSES 44 E TO 78 E

TURAM PHASE CONTOURS

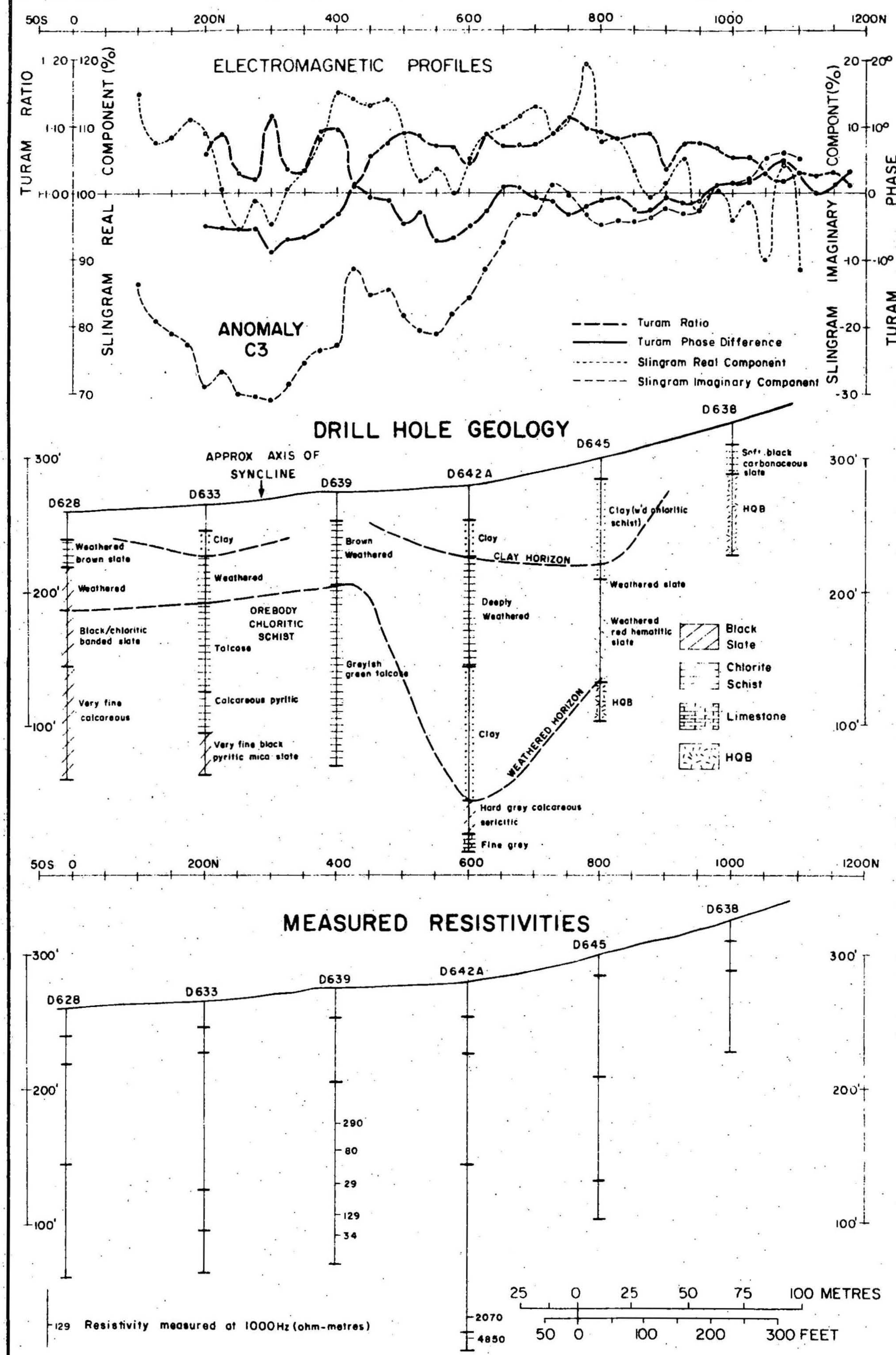
FREQUENCY 440 Hz COIL SEPARATION 50 Feet

CONTOUR INTERVAL 2·5°

To accompany Record No. 1972/98

D52/B7—450

(Based on G71-244)

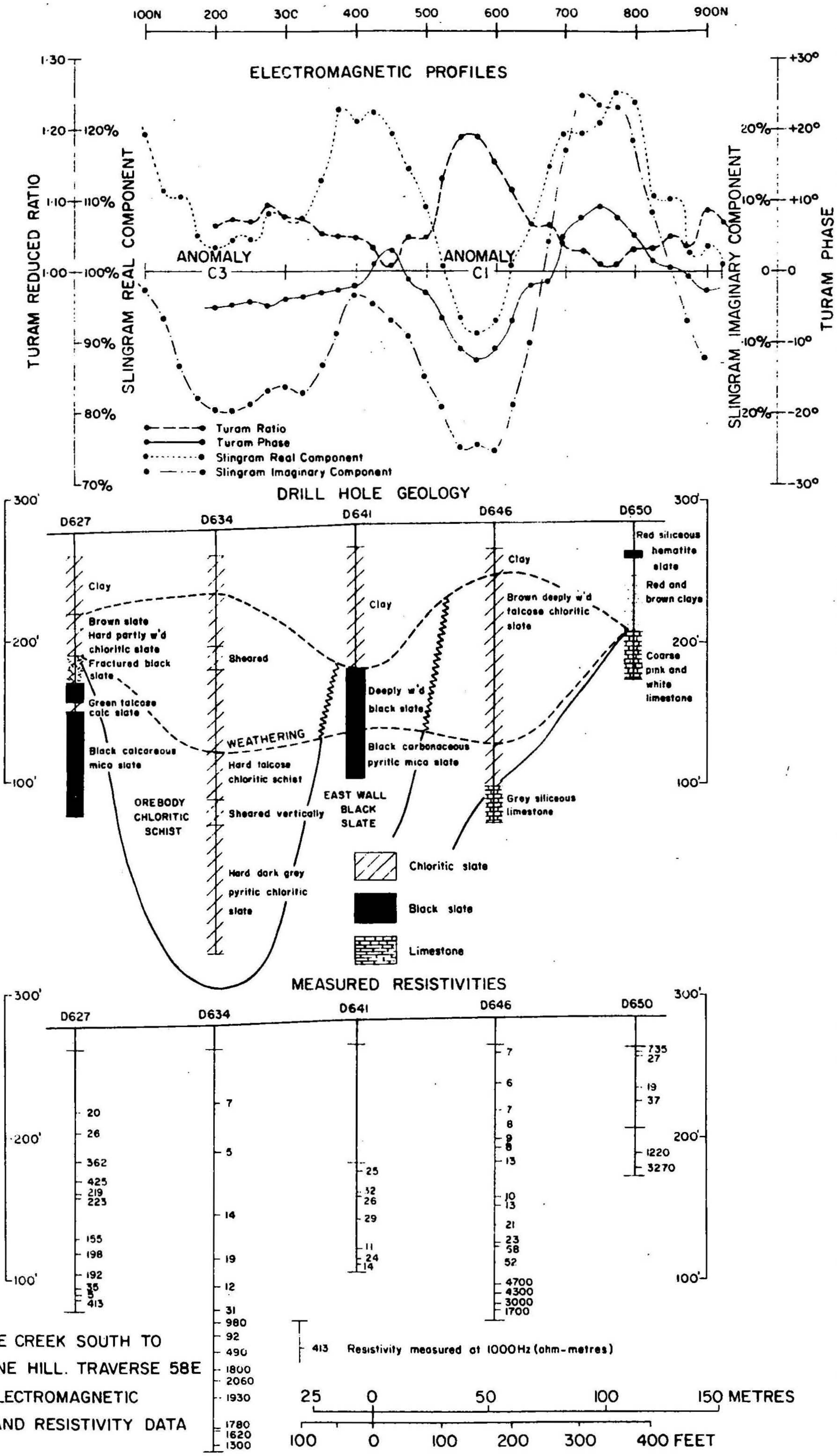


RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL

TRAVERSE 50E GEOLOGY, ELECTROMAGNETIC PROFILES, AND CORE RESISTIVITY DATA

To accompany Record No 1972/98

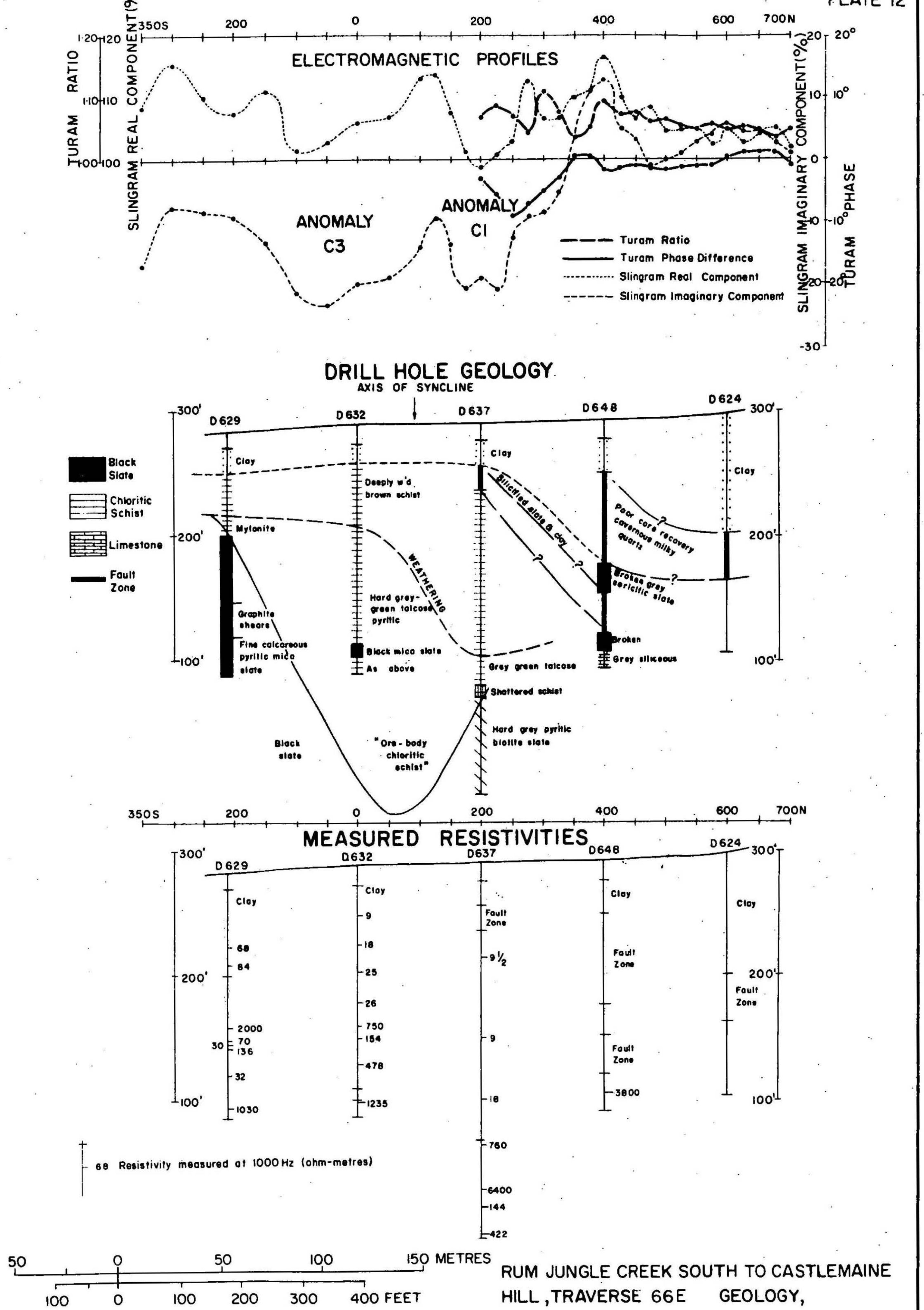
D52/B7-469 A



RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL. TRAVERSE 58E GEOLOGY, ELECTROMAGNETIC PROFILES, AND RESISTIVITY DATA

To accompany Record No. 1972/98

D52/B7-472 A

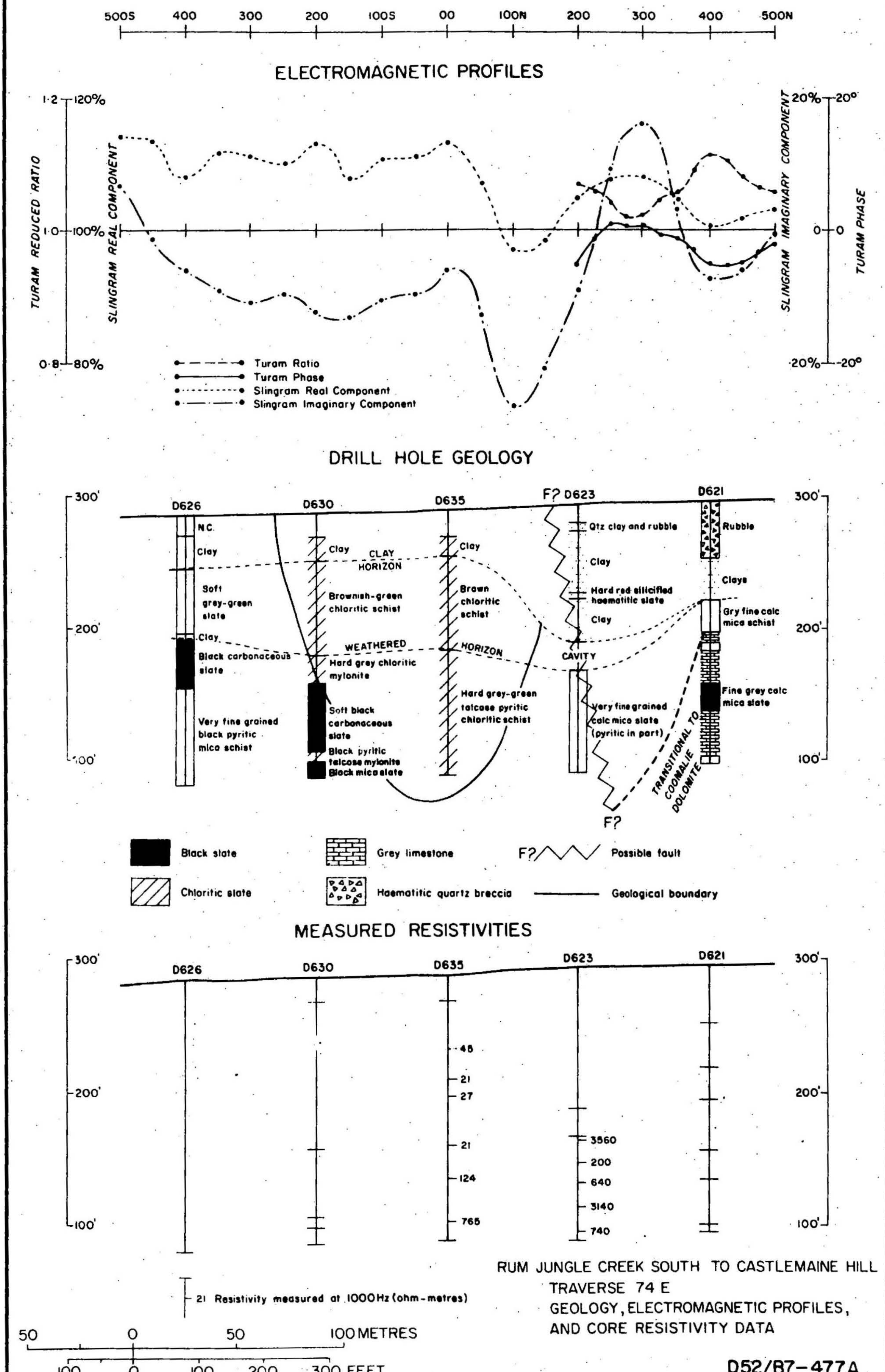


RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL, TRAVERSE 66E GEOLOGY, ELECTROMAGNETIC PROFILES, AND CORE RESISTIVITY DATA

To accompany Record No. 1972/98

D52/B7-470A

PLATE 13

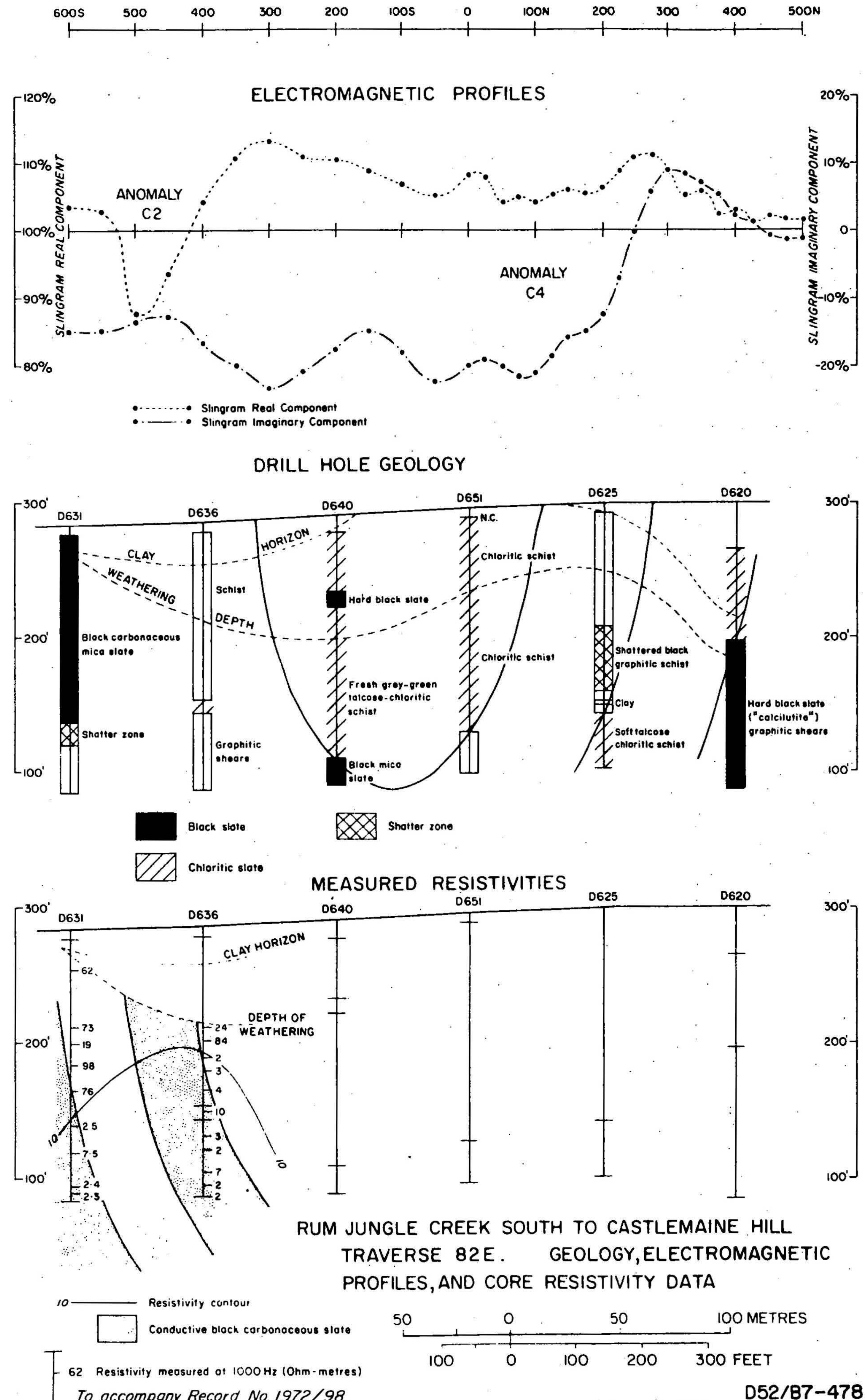


RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL
TRAVERSE 74 E
GEOLOGY, ELECTROMAGNETIC PROFILES,
AND CORE RESISTIVITY DATA

D52/B7-477A

To accompany Record No. 1972/98

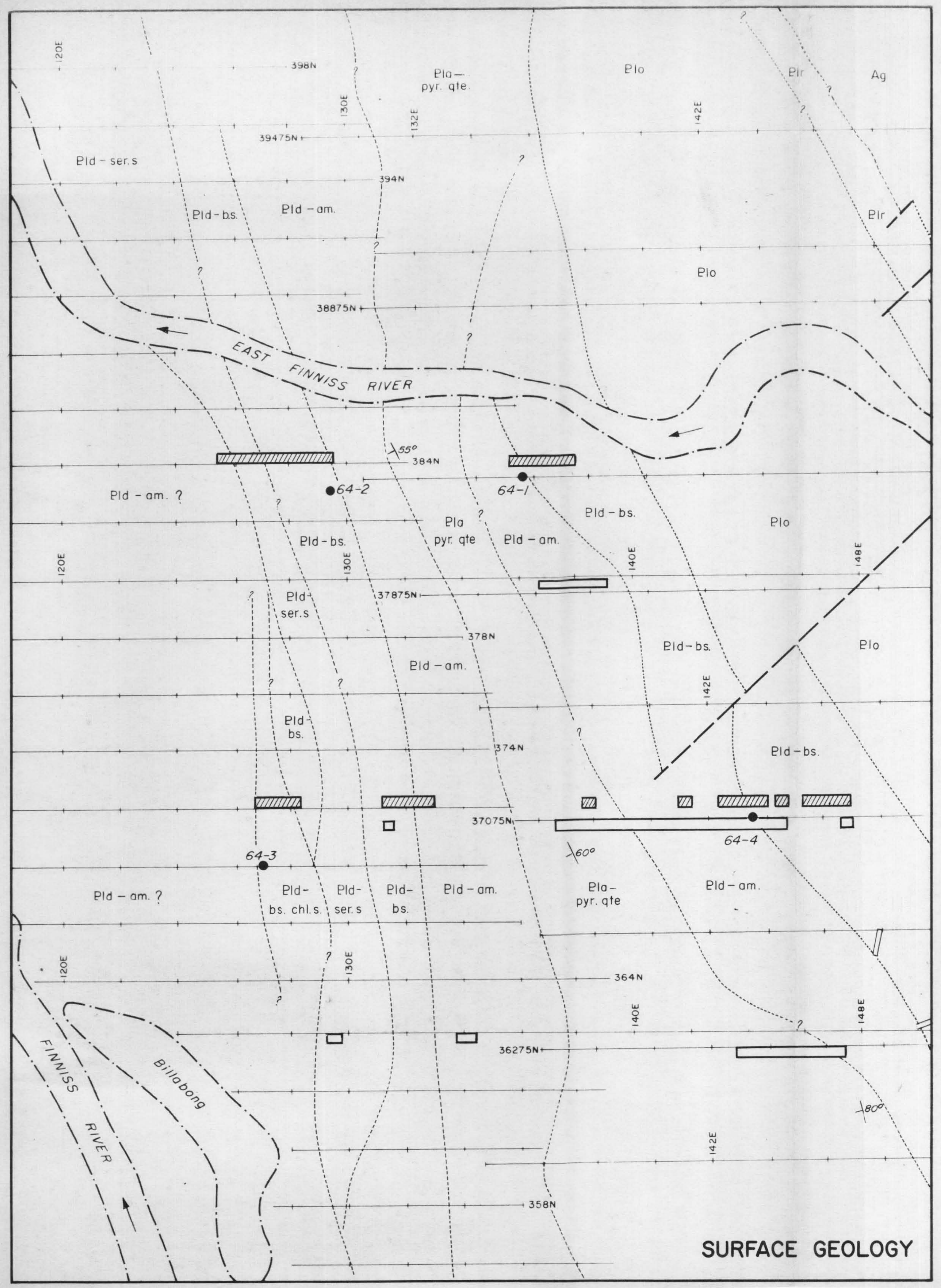
PLATE 14

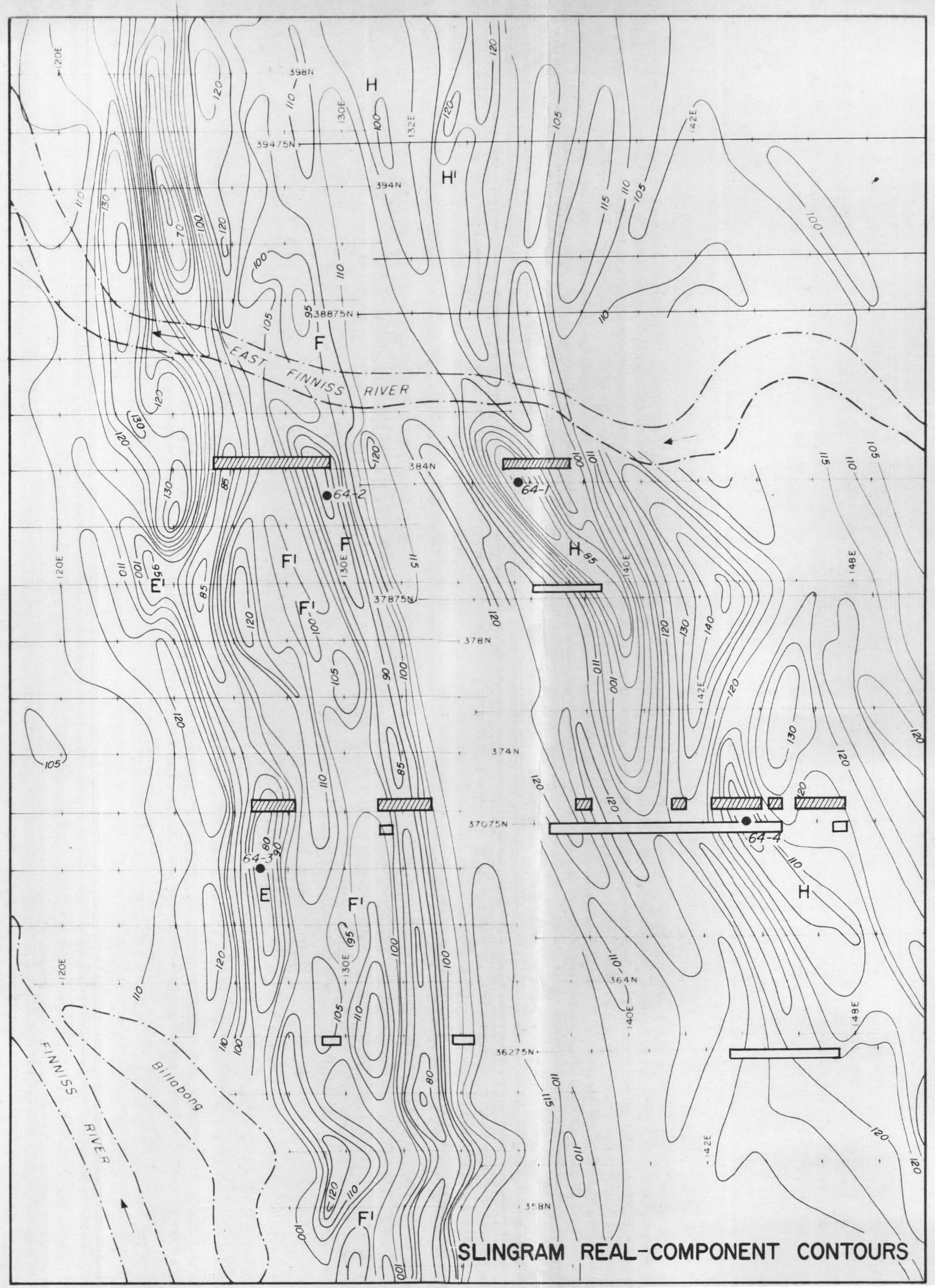


RUM JUNGLE CREEK SOUTH TO CASTLEMAINE HILL
TRAVERSE 82E. GEOLOGY, ELECTROMAGNETIC PROFILES, AND CORE RESISTIVITY DATA

To accompany Record No. 1972/98

D52/B7-478A





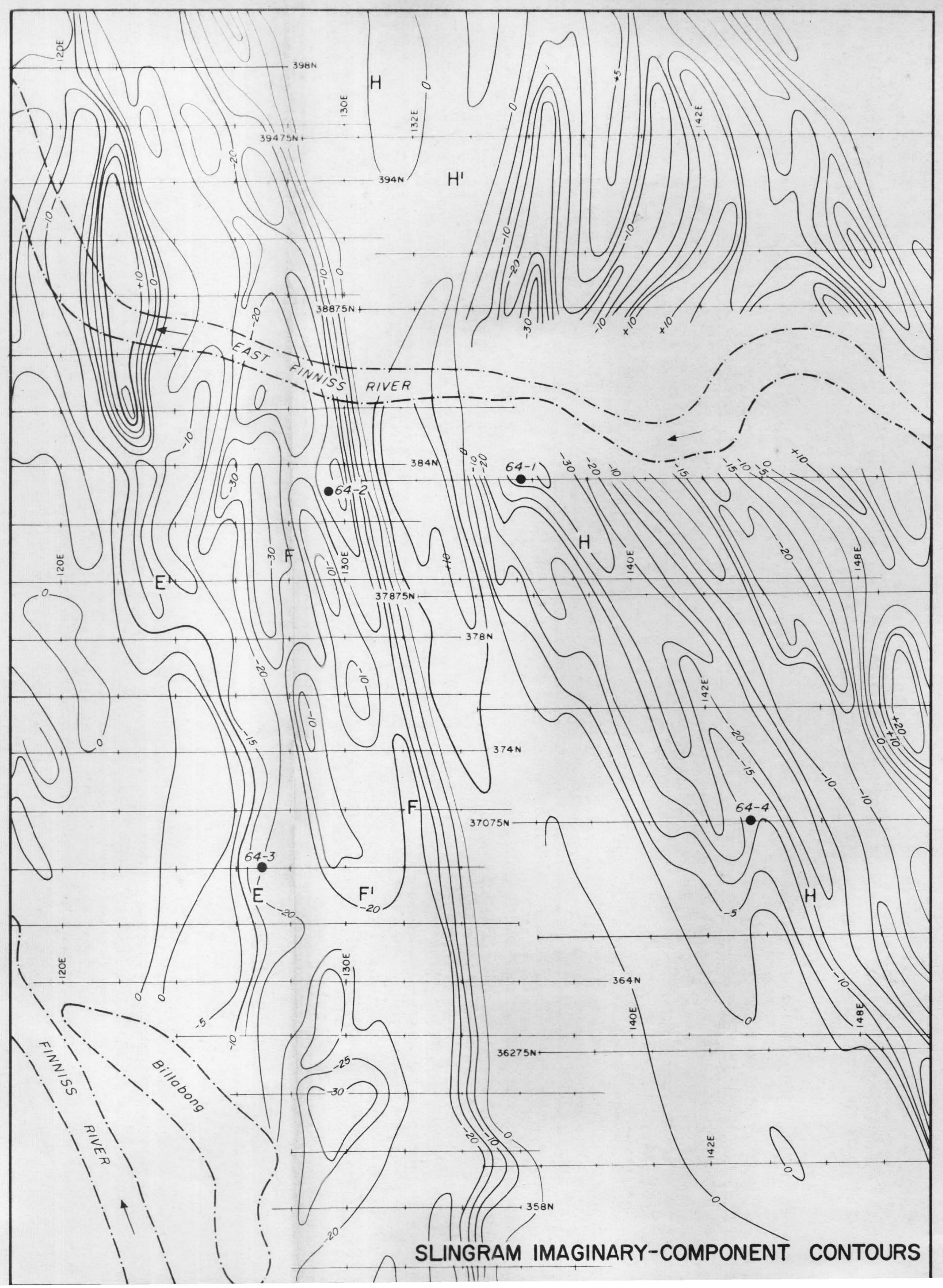


PLATE 15

LEGEND

	Stream boundary (approximate)
	Traverse line
	Slingram contour
	Resistivity and IP anomaly
	Near – surface magnetic anomaly
●	BMR diamond – drill hole
H	Slingram anomaly notation

GEOLOGY

Pld	GOLDEN DYKE FORMATION b.s. – black carbonaceous and /or graphitic shale, slate, schist: chls – chloritic schist, slate: ser.s – sericitic schist, slate: am – amphibolite
Pla	MASSON FORMATION Acacia Gap Tongue pyr.qte – pyritic quartzite
Plo	COOMALIE DOLOMITE dolomite, tremolitic schist, chloritic dolomite, kaolinitic schist, sandstone
Plr	CRATER FORMATION arkose, hematitic boulder conglomerate, quartz tourmaline rocks
Ag	RUM JUNGLE COMPLEX undifferentiated granite, gneiss
	Fault
	Formation boundary; lithological boundary
60°	Dip and strike of bedding

Geology from E52 compilation sheet (Miezitis, 1967) and based on TEP auger drilling and BMR surface mapping

SLINGRAM RESULTS:

Frequency	1760 Hz
Coil separation	200 ft
Contour interval	5%

100 0 100 200 300 METRES
200 0 200 400 600 800 FEET

RUM JUNGLE, NT 1968

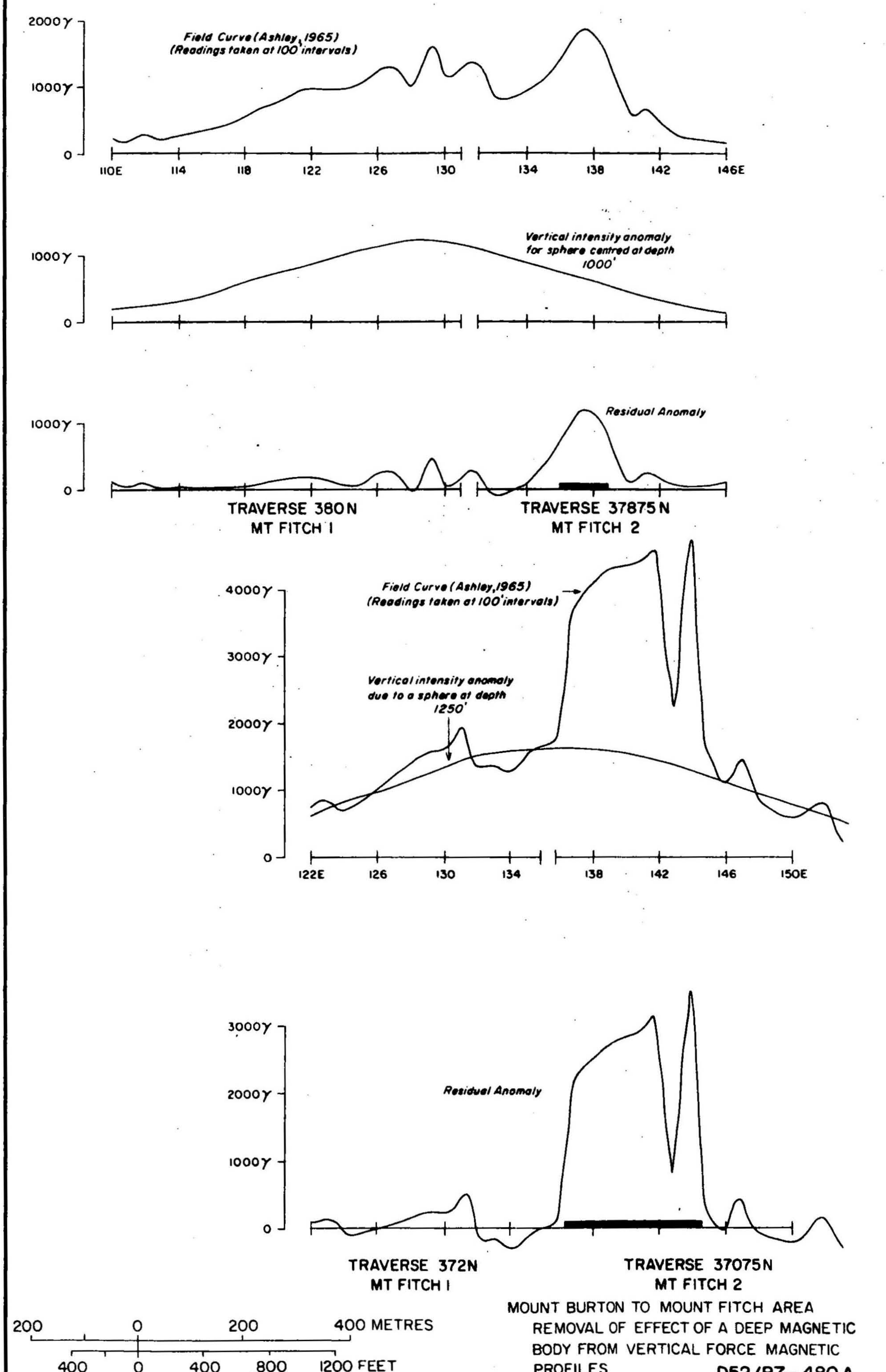
MOUNT BURTON TO MOUNT FITCH AREA

TRAVERSES 358N TO 398N

SURFACE GEOLOGY, DRILL HOLE LOCATIONS, AND SLINGRAM CONTOUR MAPS

To accompany Record 1972/98 D52/B7–479

PLATE 16



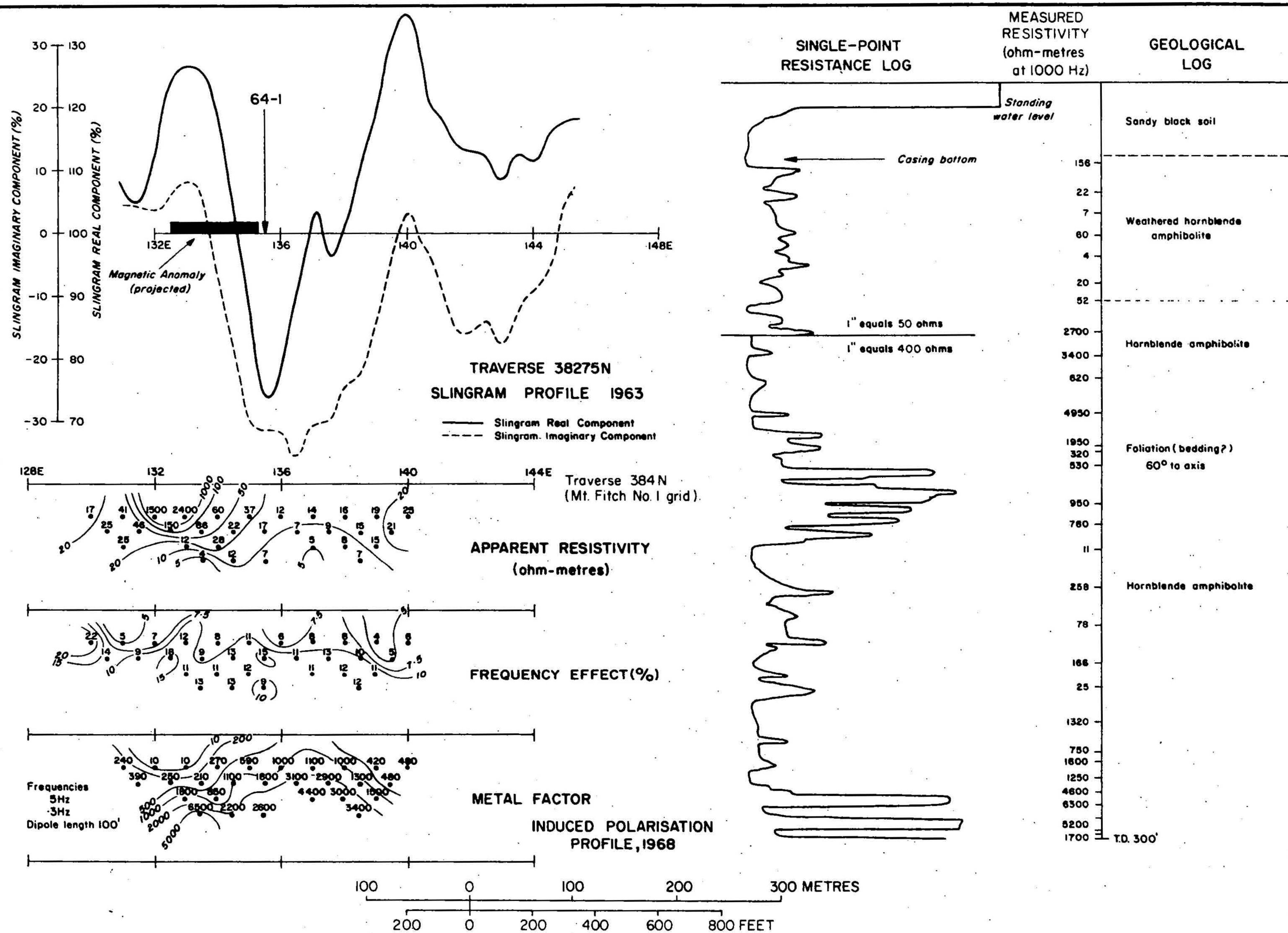
MOUNT BURTON TO MOUNT FITCH AREA
REMOVAL OF EFFECT OF A DEEP MAGNETIC
BODY FROM VERTICAL FORCE MAGNETIC
PROFILES

D52/B7-480A

To accompany Record No. 1972/98

To accompany Record No. 1972/98

MOUNT BURTON TO MOUNT FITCH AREA, GEOLOGICAL AND GEOPHYSICAL DATA. BMR DDH 64-1



D52/B7-481A

PLATE 17

To accompany Record No. 1972/98

MOUNT BURTON TO MOUNT FITCH AREA, GEOLOGICAL AND GEOPHYSICAL DATA. BMR DDH 64-2

D52/B7-482A

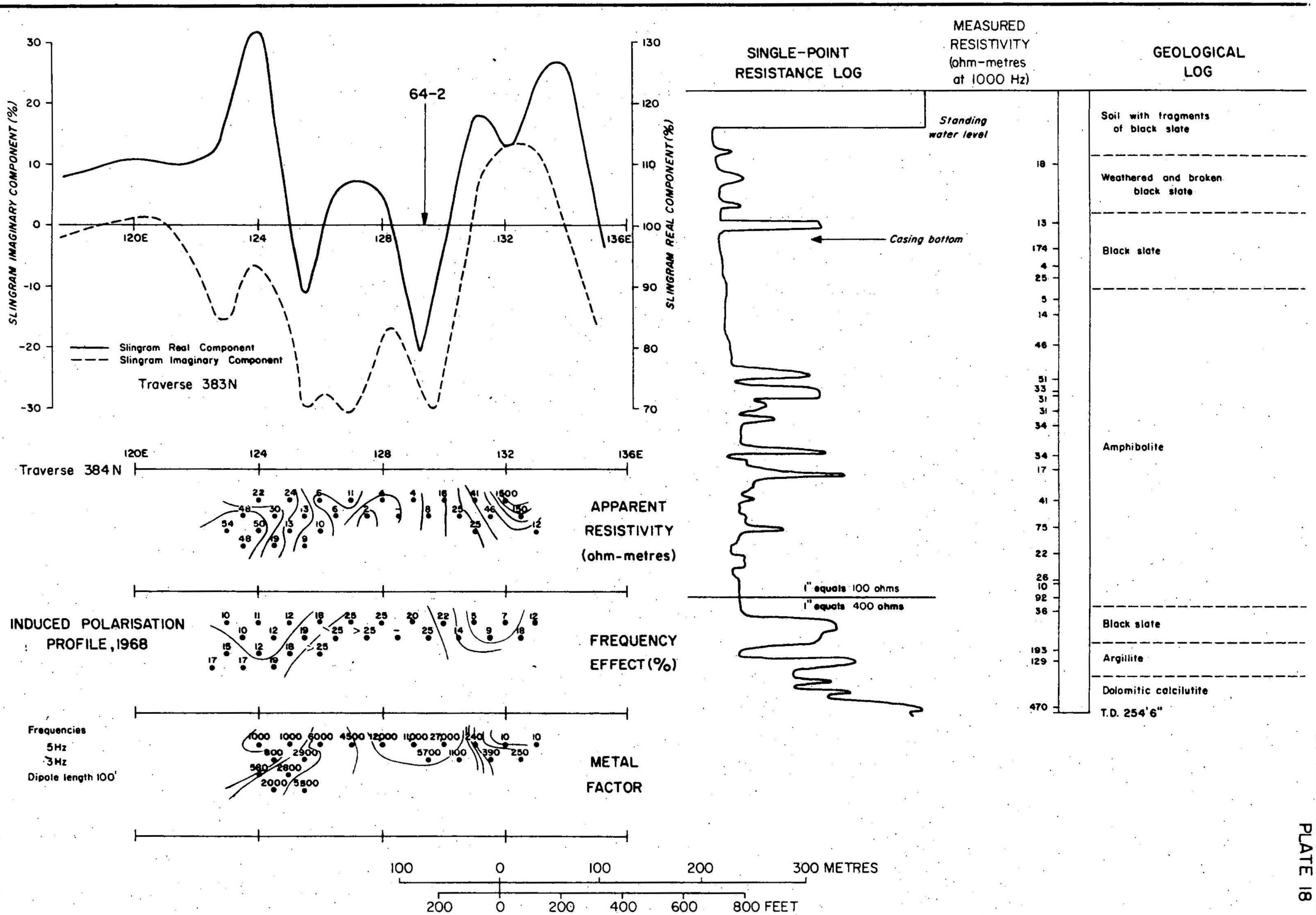


PLATE 18

To accompany Record No. 1972/98

MOUNT BURTON TO MOUNT FITCH AREA, GEOLOGICAL AND GEOPHYSICAL DATA. BMR DDH 64-3

D52/B7-483A

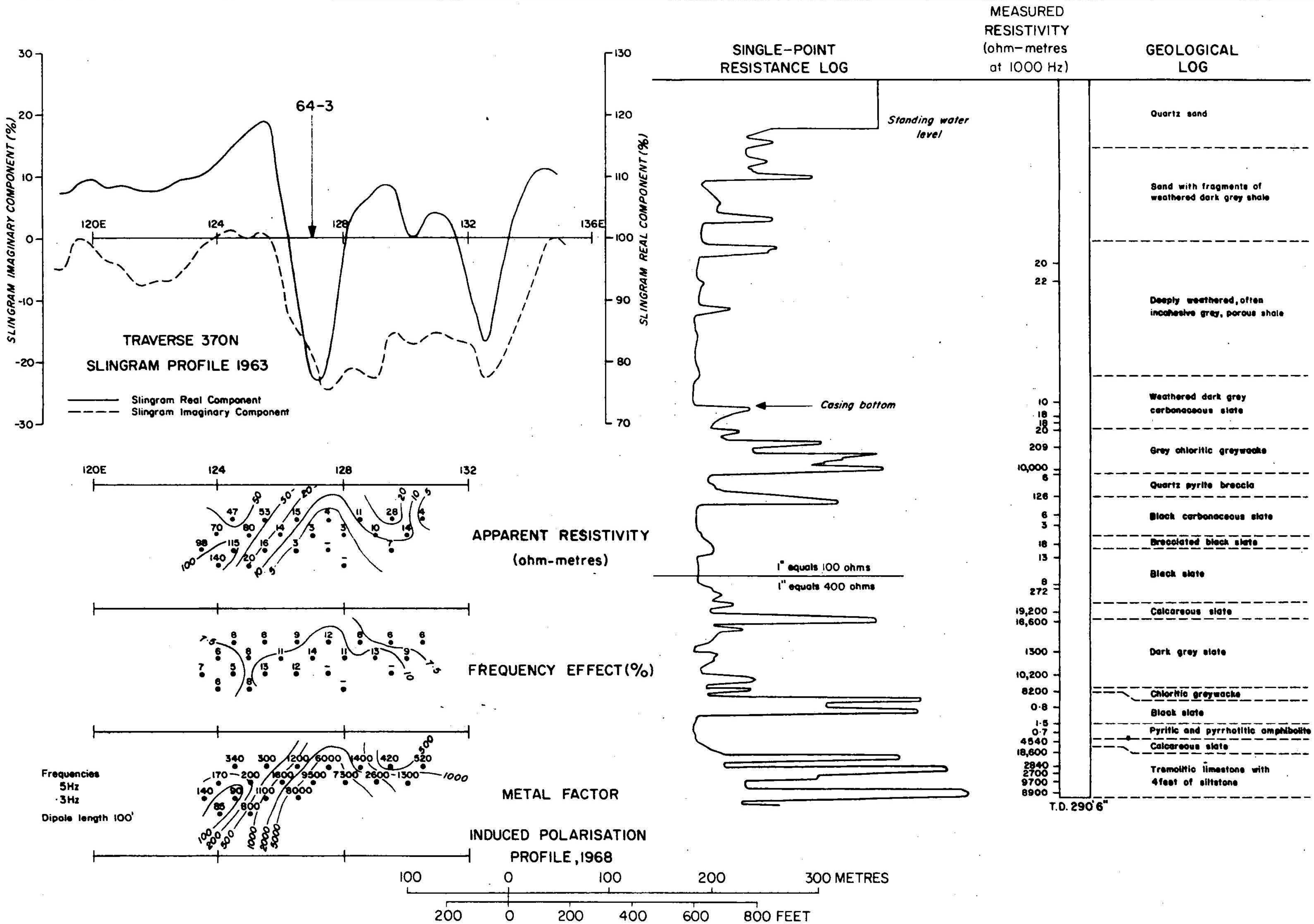
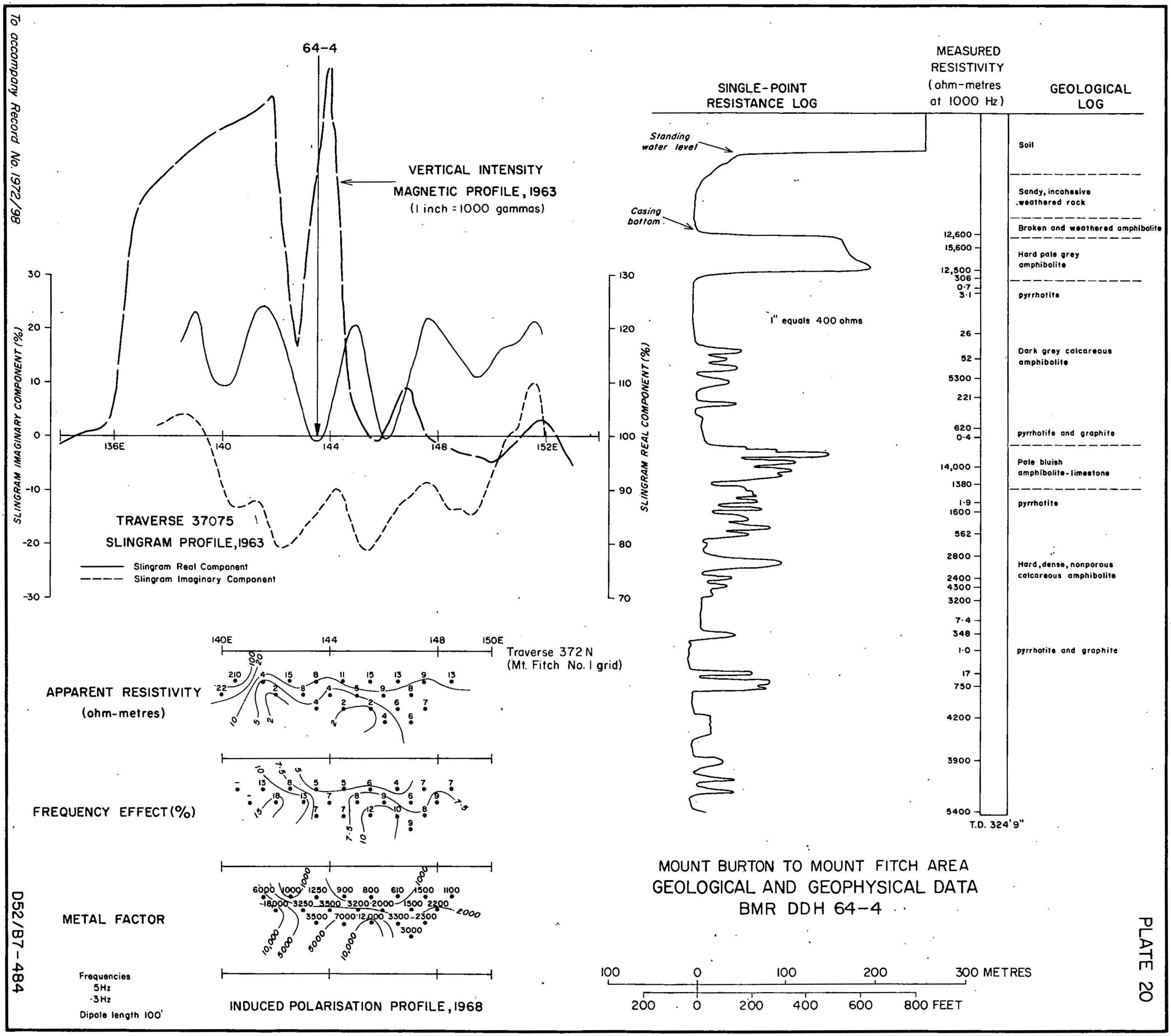
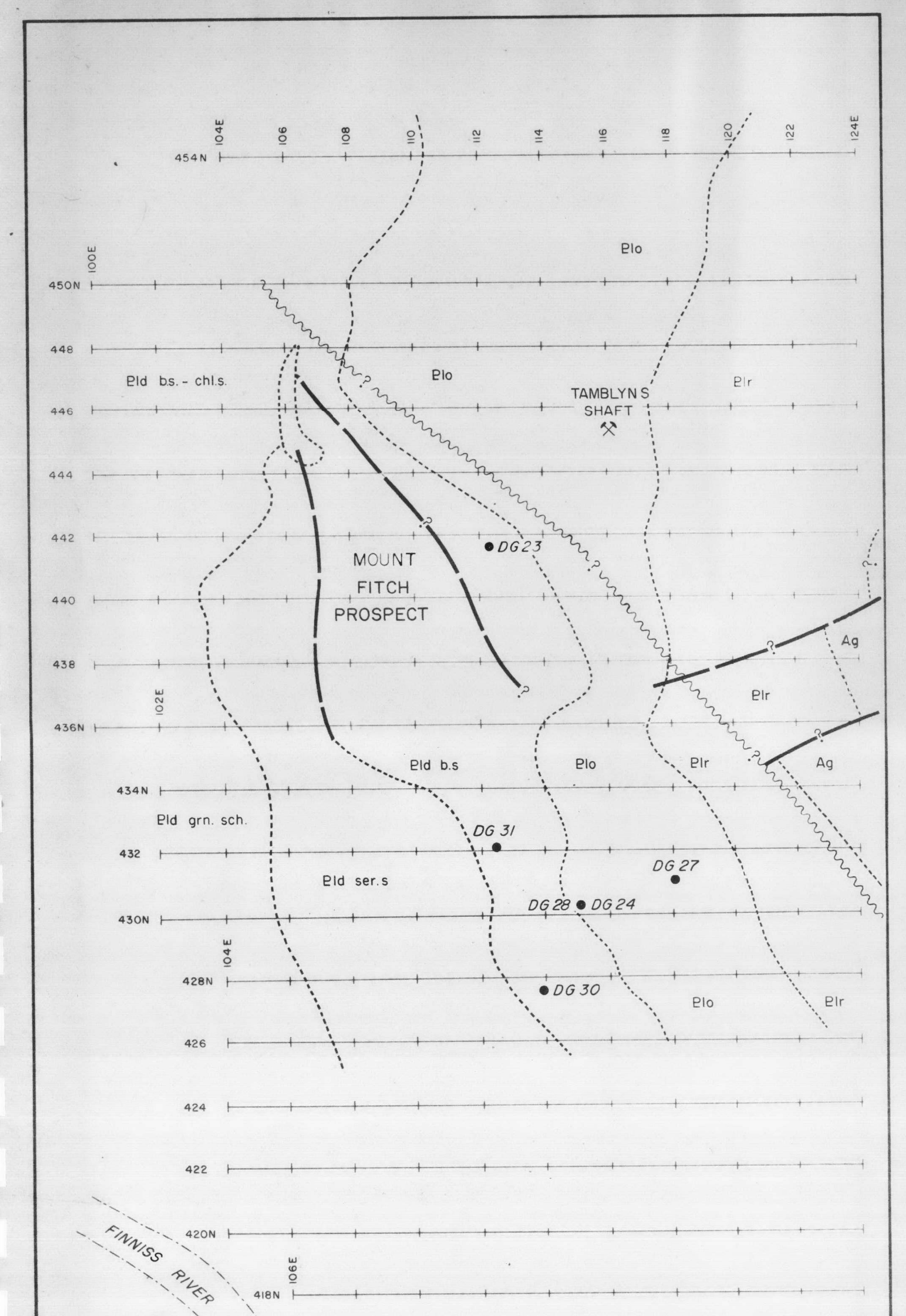


PLATE 19

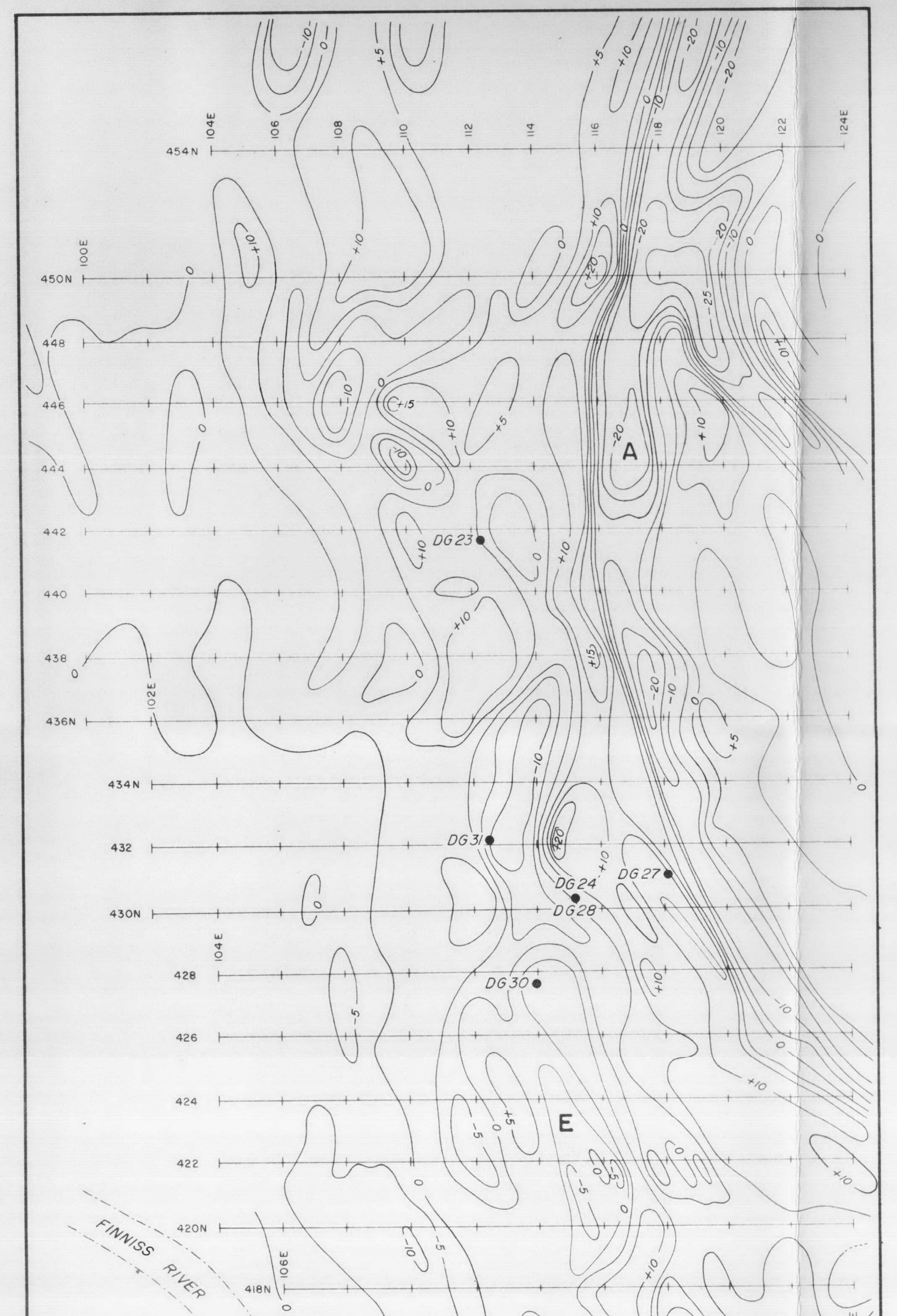


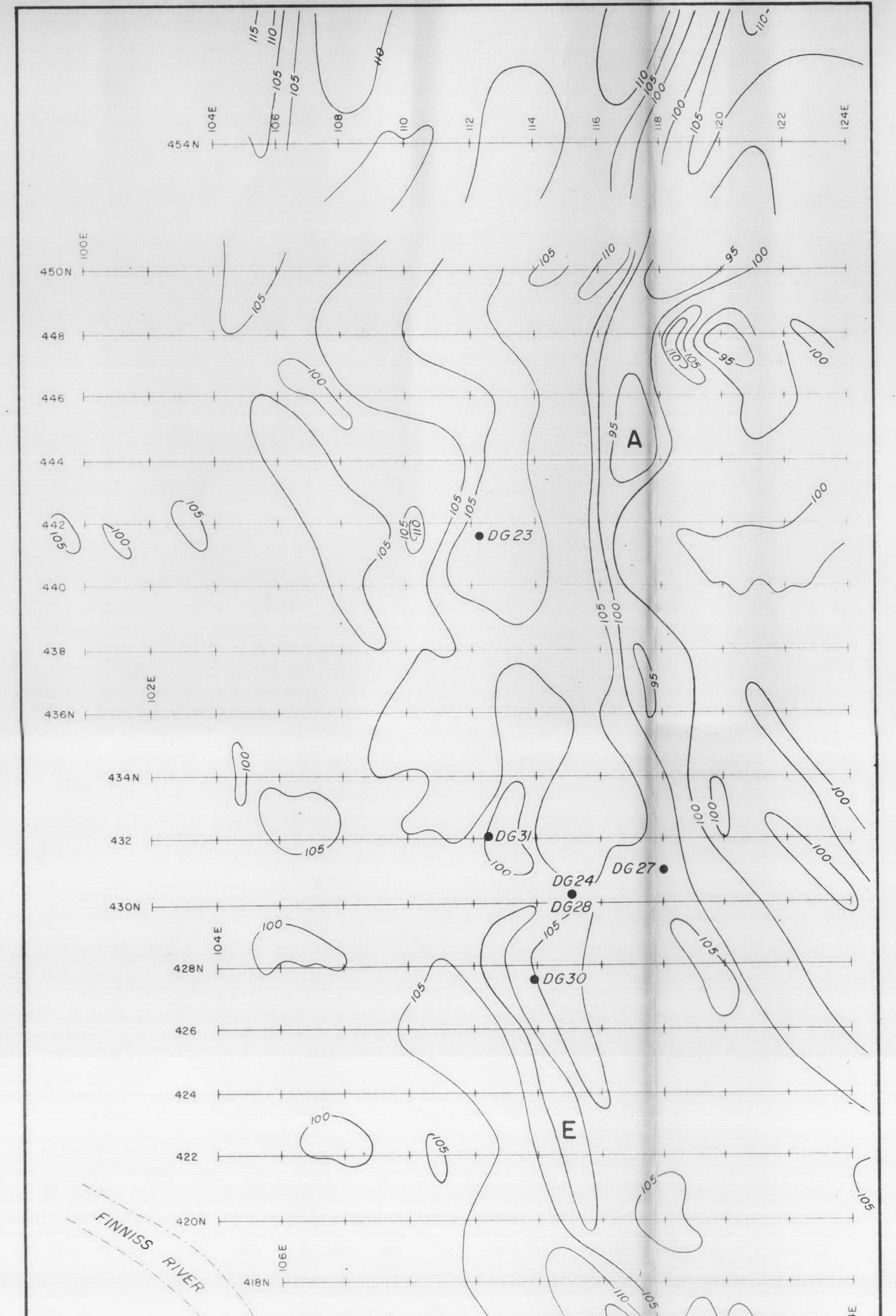
MOUNT BURTON TO MOUNT FITCH AREA
GEOLOGICAL AND GEOPHYSICAL DATA
BMR DDH 64-4

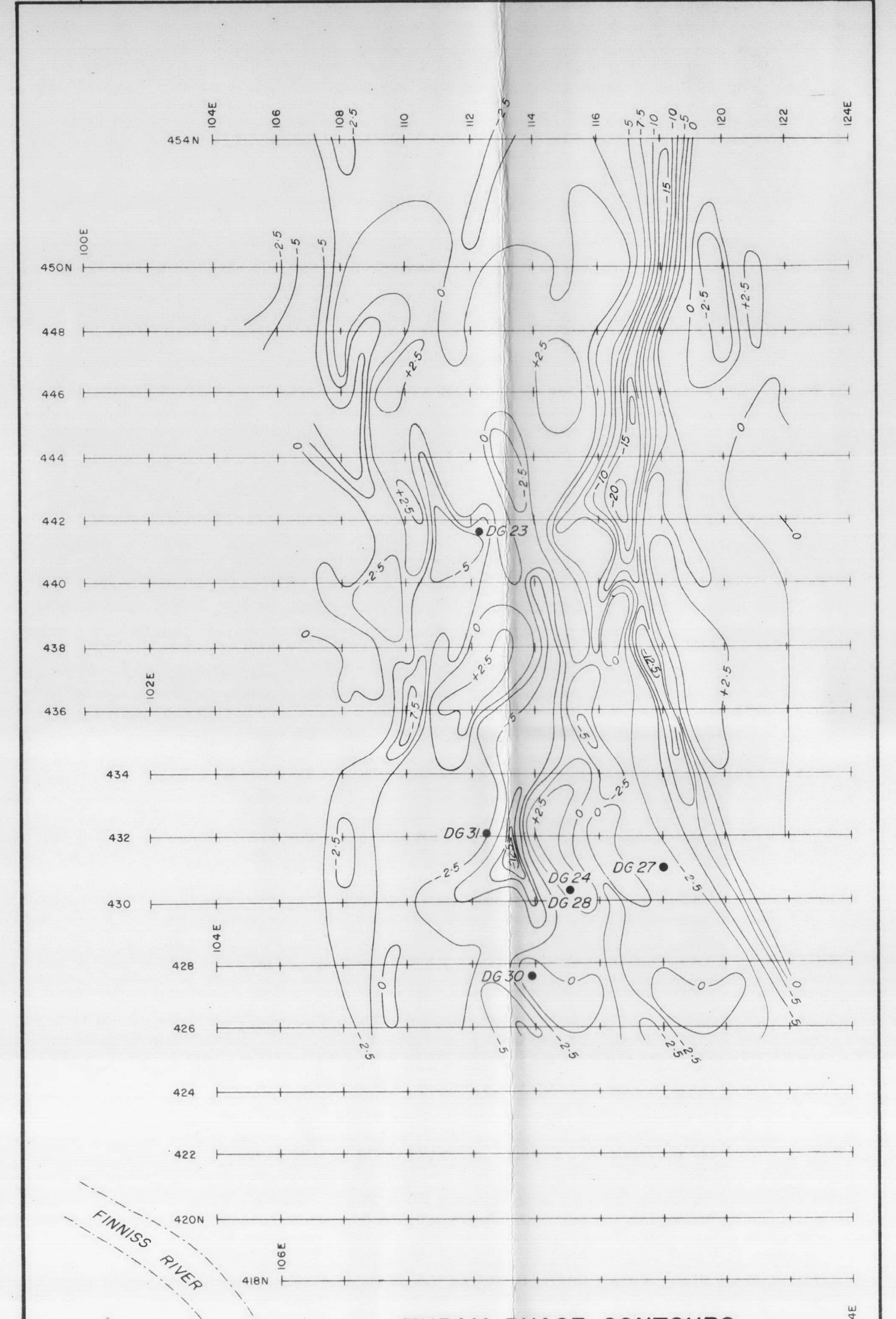
PLATE 20

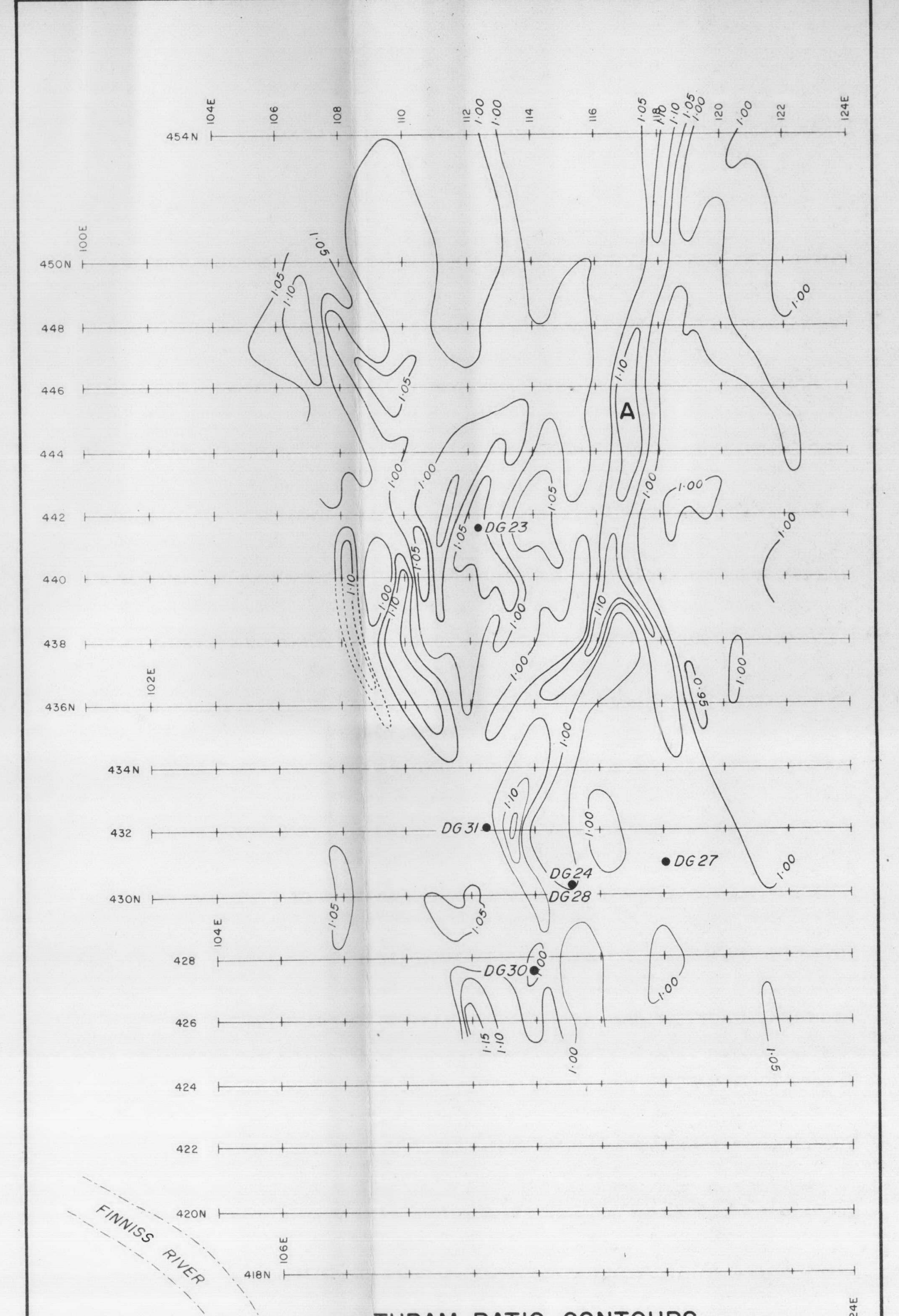


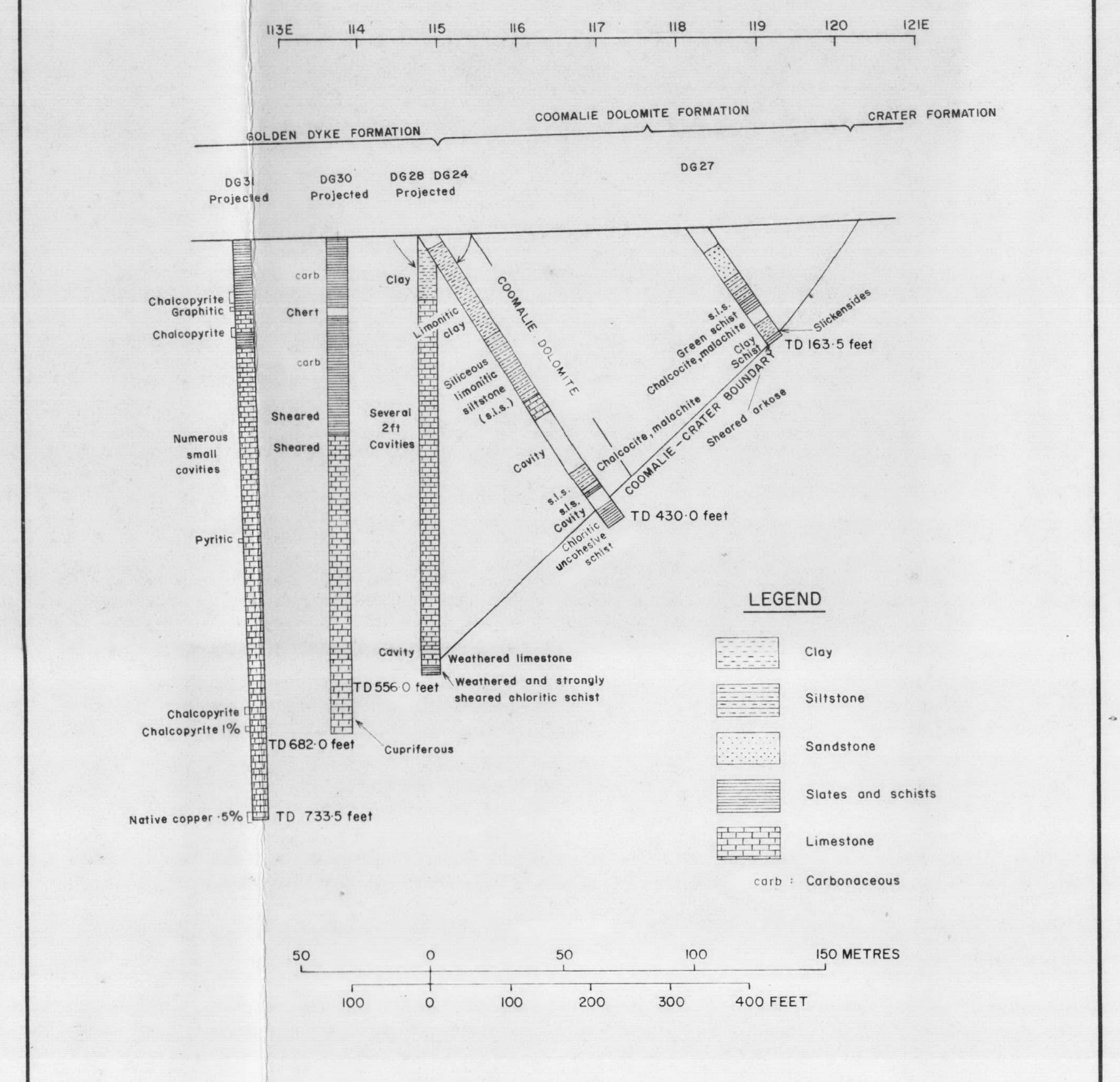
GEOLOGY


SLINGRAM IMAGINARY-COMPONENT CONTOURS


SLINGRAM REAL-COMPONENT CONTOURS


TURAM PHASE CONTOURS


TURAM RATIO CONTOURS



GEOLOGICAL CROSS-SECTION FOR TRAVERSE 431N
CONSTRUCTED FROM PROJECTED DRILLING INFORMATION

PLATE 21

LEGEND

—·—·—·	Stream boundary (approximately)
├──┤	Traverse line
DG30 ●	BMR diamond–drill hole

GEOLOGY

Pld	GOLDEN DYKE FORMATION b.s. – black carbonaceous and/or graphitic shale, slate, schist: chls – choritic schist, slate: ser.s – sericitic schist, slate: am – amphibolite grn.sch – green schist
Plo	COOMALIE DOLOMITE dolomite, tremolitic schist, chloritic dolomite, kaolinitic schist, sandstone
Plr	CRATER FORMATION arkose hematitic boulder conglomerate, quartz tourmaline rocks
Ag	RUM JUNGLE COMPLEX undifferentiated granite, gneiss
▬ ▬	Fault
-----------	Geological boundary
∿∿∿∿	Shear zone

Geology from E41 and E42 compilation sheers (Miezitis, 1967) and based on TEP auger drilling and BMR surface mapping

SLINGRAM SURVEY RUM JUNGLE, 1963

Frequency	1760 Hz
Coil separation	200 ft
Contour interval	5%

TURAM SURVEY RUM JUNGLE, 1963

Frequency	44 Hz
Coil separation	50 ft
Contour interval	0.05 (ratio), 5° (phase)

100 0 100 200 300 METRES

200 0 200 400 600 800 FEET

RUM JUNGLE, NT 1968

MOUNT FITCH PROSPECT

SURFACE GEOLOGY, ELECTROMAGNETIC CONTOUR MAPS, AND GEOLOGICAL SECTION

To accompany Record 1972/98

D52/B7–485