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TESTS OF THE RONKA EM16 VLF PROSPECTING EQUIPMENT, WESTERN AUSTRALIA 1969

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ILLUSTRATIONS

SUMMARY

Tests to evaluate suitability of the Ronka EM16 prospecting equipment were conducted in several areas of Western Australia using the signals transmitted from the VLF radio station on North West Cape.

A major aim of the tests was to obtain a measure of depth penetration of the method, but in the Wiluna area the aim was to test the applicability of the method for tracing freshwater aquifers.

The depth penetration of the Ronka EM16 method under geological conditions prevailing in Western Australia was found to be about 15 metres.

The tests at Wiluna were inconclusive.

1. INTRODUCTION

Preliminary tests on the Ronka EM16 prospecting equipment were carried out in New South Wales and Tasmania during 1968 and 1969 (Haigh, 1970a, b).

A further series of tests in Western Australia were planned; these were commenced in the Geraldton/Mount Magnet area in June 1969 but were interrupted owing to a maintenance shutdown of the transmitting station and were resumed in the Kalgoorlie area in September. A major aim of the tests was to obtain a measure of the depth penetration of the method, but in the Wiluna area the aim was to test the applicability for tracing freshwater aquifers.

Field strength measurements as proposed in a previous report (Haigh, 1970b) were attempted using two field strength meters (FSM). However, instrumental problems were encountered and the FSM tests had to be abandoned. The readings obtained were confined to those with one meter in Area D (Plate 8).

The VLF tests carried out in the Kalgoorlie area were over leases held by private companies. In order to guarantee the security of the confidential information supplied by the companies, the exact location of traverses has not been shown on the locality plan. Sincere thanks are offered to all companies and individuals who gave willing co-operation both in the field and in supplying detailed information on traverses where readings were taken. In particular, the help offered by the following companies and individuals is acknowledged: Anaconda (Aust.) Inc., Central Pacific Minerals N.L., Mr G. Compton, Geotechnics Consultants, The Homestake Iron Company of Aust. Ltd., Hussin Geophysics, McPhar Geophysics Inc., Metals Exploration N.L., Mid East Minerals N.L., Seigel and Associates, Western Mining Corporation.

2. DISCUSSION OF RESULTS

Kalgoorlie area

For reasons already given the exact location of the areas discussed here cannot be shown and they will be referred to only in broad terms as areas A-G. The regional strike of the rocks in the areas is generally about 330°.

Considering the results from the Kalgoorlie area generally, it is noted that there is a great variation in response throughout the area; e.g. anomalies in Area D (Plates 8 and 9) have amplitudes several times greater than those in Area B (Plates 3 and 4). Another observation is that well defined in-phase anomalies may be associated with quadrature gradients of either strong positive or negative slope (both cases are illustrated on Traverse 2, Plate 9). Field examples quoted by Paterson & Ronka (1971) suggest that a reversed (positive) slope of the quadrature component profile probably indicates the presence of a good conductor below a weakly conductive overburden. A similar slope of in-phase and quadrature profiles is commonly associated with a moderate conductor of large dimensions, such as a disseminated sulphide body, below non-conductive overburden.

Results from a selection of individual areas will be discussed in relation to the information supplied by the companies. The companies' geophysical data have been presented in the same form as supplied. It will be noted that different conventions have been adopted in plotting induced polarization (IP) results, and in particular that the apparent resistivity pseudo-sections appear inverted in Plates 4, 5, 6, and 7.

Area A. The VLF profiles together with IP and magnetic results and geological section are shown in Plate 2.

A feature of the profiles is their irregularity, but some anomalies of small amplitude are present. One such poorly expressed anomaly occurs at about 5560E. It is doubtful whether this anomaly could be related to the known nickel mineralization as the ground is highly weathered to a depth of almost 60 metres. The IP results show an anomaly extending from 5250E to 5550E, which is probably caused by disseminated mineralization rather than by the massive nickel sulphide body shown in the geological section.

A clearer VLF anomaly is located at 7530E but no geological or other geophysical information is available for comparison. The form of the anomaly suggests a narrow conductor at shallow depth. Another anomaly at about 5080E appears to originate from a deeper conductor. It coincides with a weak IP anomaly evidenced by slightly higher field effect (F.E.) values which may be associated with the same source. The sharp magnetic feature at 5200E is probably due to the surface laterite.

In this area, the irregularities in the VLF profiles are probably largely a reflection of the distribution of highly weathered rock and saline water. No definite VLF anomaly can be correlated with the known mineralization.

Area B. The VLF profiles along two traverses together with other geophysical and some drilling results are shown in Plates 3 and 4.

The VLF profiles show considerable 'noise' but there are a few features that warrant some discussion. In Plate 4 the only clear VLF anomaly, at 6250E, does not agree with the IP (F.E. and chargeability) anomaly but a smaller VLF anomaly about 5950E appears to coincide with this IP anomaly.

In Plate 3 there are several small anomalies but only the one at about 5880E agrees in position with an IP chargeability anomaly. The resistivity profile shows a zone of low resistivity values between 7000E and 7600E and then high resistivity values at the eastern end of the traverse. VLF readings here suggest there could be an anomaly beyond the eastern end of the traverse near the resistivity minimum but readings were not extended far enough to confirm this.

Area C. The VLF profiles along three traverses together with other geophysical results are shown in Plates 5-7. Only some rather sparse surface geological mapping (and no geological sections) were available on this area.

There is no clear VLF anomaly on Traverse 1 (Plate 5). The IP results indicate a zone of low resistivity at depth near the western extremity of the traverse, coinciding with the magnetic anomaly.

On Traverse 2 (Plate 6) the only well defined VLF anomaly occurs at about 100870E and coincides closely with a magnetic anomaly. There are no IP results over this portion of the traverse. The remainder of the VLF profile shows only minor irregularities that are probably due to variation in near-surface resistivity.

The profiles on Traverse 3 (Plate 7) are in a zone of generally low resistivity with significant departures from the noise envelope at the western end and at about 100100e. The anomalies at the western end correspond to an IP (resistivity and M.F.) anomaly although there is little F.E. anomaly, and could, for example, represent shear zones. The feature at 100100E has no support in IP or magnetic results. There is no obvious correlation between the VLF results and either the magnetic results or the IP (M.F.) anomaly about 99400E.

Area D. The VLF profiles together with drilling results and other geophysical information are shown in Plates 8 and 9.

On traverse 1 (Plate 8) there is a VLF anomaly at about 1969.5E corresponding to the IP anomaly and the sulphide intersection shown. The slope of the quadrature component is consistent with the effect normally attributed to a disseminated sulphide body. No information is available on the attitude of the mineralized zone but apparently it was not intersected in the hole collared at 1969.8E. The VLF anomaly is considered to be due to the sulphide body although no estimate can be obtained of the depth of detectability. The smaller anomaly at 1962.2E indicates a conductor beneath a moderately conductive overburden on this portion of the traverse.

On traverse 2 (Plate 9), VLF anomalies occur at about 1935E and 1939.6E, but no geological or drilling information is available for comparison.

The strong VLF anomaly shown in both the in-phase and quadrature components at about 1908.5E on traverse 3 (Plate 9) is apparently due to the known mineralization. The magnetic anomaly suggests a basic dyke adjacent to the mineralized zone, but no geological information on this feature is available. Of the other VLF anomalies present on this traverse, those at about 1886E and 1900E appear to originate from broad conductors, and that at 1892E suggests a narrow conductor.

On Traverse 4 (Plate 8) there is a clear VLF anomaly associated with the IP anomaly and the known mineralization. The profiles suggest the presence of two conductors, possibly due to the mineralization forming into two separate zones above the intersection shown.

Field strength measurements were conducted on traverses 1 and 4 and the results are shown by the FSM profiles in Plate 8. In general the FSM profiles exhibit well defined peaks coinciding with the cross-over points obtained from the VLF readings.

Area E. The VLF profiles together with the IP results and some surface geological mapping are shown in Plates 10 and 11.

On traverse 1 (Plate 10), VLF readings show an anomaly at 3980SW which agrees with a resistivity and metal factor anomaly. The smaller VLF anomaly at 3670SW corresponds to a minor surface resistivity low but is otherwise not reflected in the IP results.

On traverse 2 (Plate 11) there is no clear correlation between the VLF and IP results. However, the disturbed VLF readings in the zone 3700-4300SW coincide with a strong IP anomaly and in part with gossan capping and a sedimentary unit containing abundant sulphides (See geological map). On the profile of the northeastern portion of this traverse, a VLF anomaly at 3760NE agrees in position with an IP anomaly which exhibits near-surface low resistivity.

The VLF profile on traverse 3 (Plate 10) is much smoother but shows one clear anomaly at 3400SW, which coincides with an IP (F.E.) anomaly.

The wire fence, whose position is shown on the plan and each profile, apparently had little, if any, effect on the VLF readings.

Area F. The VLF profiles (Plate 12) are disturbed and show no clear correlation with the geological section except perhaps if one were to take the whole of the profile as consisting of one anomaly (shown as a dotted line).

Area G. The VLF results together with the geological cross-section are shown in Plate 12. The VLF anomaly at 330W coincides very closely with the top of the sulphide body although no great depth of penetration is indicated.

Geraldton/Mount Magnet area

In the area east of Geraldton, two major faults have been delineated by geological and gravity surveys (Thyer & Everingham, 1956). In the area near Eradu siding a traverse five kilometres long was read with the EM16 at 100-foot (33-m) intervals in the area of the fault postulated by Thyer & Everingham. The purpose of this traverse was two-fold: firstly to determine whether the VLF method could be used for regional mapping of the type encountered in this area, and secondly to determine whether a large station interval can be used for covering areas on a regional basis. The results are not presented here but they indicate that the answer to both these questions is negative. It must be realized that the fault zone postulated from the gravity data could be quite broad and the traverse read may not in fact have covered the zone. However, it would be expected that if a regional trend existed it would be apparent over the 5-km length of the traverse.

The local variations exhibited in the profile read at 100-foot intervals clearly indicate that readings taken at large station spacings will be of doubtful value even in a regional reconnaissance, as there is no means of distinguishing local and regional effects from a single reading.

An attempt to take readings over the Darling Fault near Mullewa was thwarted by the extreme level of radio noise in the district. Some of this emanated from numerous telephone lines and fences in the area but other intense sources seemed to be present. A lot of farming machinery was operating in the area at that time. In many cases the noise was so intense that there was no variation in signal strength in any azimuth.

In the area near Yalgoo two aeromagnetic anomalies delineated by Waller & Beattie (1971) were investigated and the results are shown in Plate 13. Traverse 1 is in an area consisting almost entirely of schist, quartzite, and amphibolite which crop out or occur under thin scree cover. The profile is extremely irregular, a feature which has been found in other areas of outcrop.

Traverse 2 is in an area of flat alluvial cover and the southwestern ends of the VLF profiles are quite smooth. From 2100SW to 00 the alluvium contains small rounded pebbles of ironstone, and it seems apparent that the VLF anomalies over this zone are due to the same source as the aeromagnetic anomaly. From the limited distrubition of the ironstone float it seems likely that the overburden in this area is very thin.

Wiluna area

In the Wiluna area, agricultural development is based on the supplies of fresh water available from calcrete deposits. These calcrete deposits overlie a granitic basement and vary widely in thickness and porosity. Resistivity methods have been used in the area and have been partially successful in delineating the boundaries of the calcrete deposits (D.L. Rowston, pers. comm.). Delineation of the aquifers within the calcrete by resistivity methods is made difficult by the variability of the salinity and hence the resistivity of the water.

The tests in the area were designed to determine any correlation between the VLF results and the known aquifers and calcrete boundaries. The locations of the traverses that were read are shown in Plate 14. The VLF results along these traverses are shown in Plates 14 and 15.

Traverse B across a known aquifer (the Town Wells aquifer) produced no significant VLF anomaly. A long traverse, A, across a granite-calcrete section contains three distinct zones of response. Between 00 and about 9600 and between about 18000 and 22000 there is almost no vertical component of the field. The zone between 9600 and 18000 is disturbed and contains several distinct anomalies of rather small amplitude; these may be due to variations in the depth of calcrete, the salinity of the water, or the composition of calcrete, but without detailed drilling no precise correlation is possible. Only sparse geological information is available for the area; but it is certain that this zone contains a change of geology. Profiles along traverse C also contain similarly disturbed features, and it is possible that if the area could be gridded at close spacing the trends of contour lines could be associated with variations in the depth or composition of the calcrete deposits.

3. CONCLUSIONS

The Ronka EM16 VLF prospecting equipment is simple to operate and is an extremely rapid exploration tool. However, it suffers from a number of disadvantages for use in routine geophysical surveying.* In Australia there is only one station available for reliable routine use, and many areas suffer from an unfavourable orientation with respect to the energizing field.

In common with all other electromagnetic methods the depth of penetration depends on the resistivity of the country rock; in Western Australia, where the resistivity of the surface weathering layer is very low, the depth of penetration may be as little as 50 feet (15 m). Subsequent to this work, Langron & Gillespie (1970) carried out further tests in Tasmania and concluded that the depth penetration of the method there is about 100 feet (30 m).

The large area covered by the uniform primary field may perhaps give good coupling with large features such as faults and geological contacts, and thus improve the depth of detection of such bodies, but this theory has not been tested sufficiently by the current work. The EM16 may prove useful as a geological mapping tool for tracing known contacts and faults below areas of overburden or weathering cover, but in some cases at least it will be less efficient than the magnetic method.

In areas of outcrop or thin overburden the EM16 profiles are generally found to be very irregular indicating variations in conductivity due probably to differential weathering, and this may cause difficulty in tracing anomalous zones.

The mapping of large areas using the EM16, although very rapid, is probably of little value unless some specific target is sought. However, if an airborne version of the equipment could be operated as a routine secondary system during aeromagnetic surveying, the results used in conjunction with aeromagnetic maps may be of assistance in tracing lineaments etc., particularly in areas of little or no magnetic relief.

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* Since this survey, a second station, NDT in Japan, transmitting on 17.4 kHz, has become available for VLF measurements in Australia.

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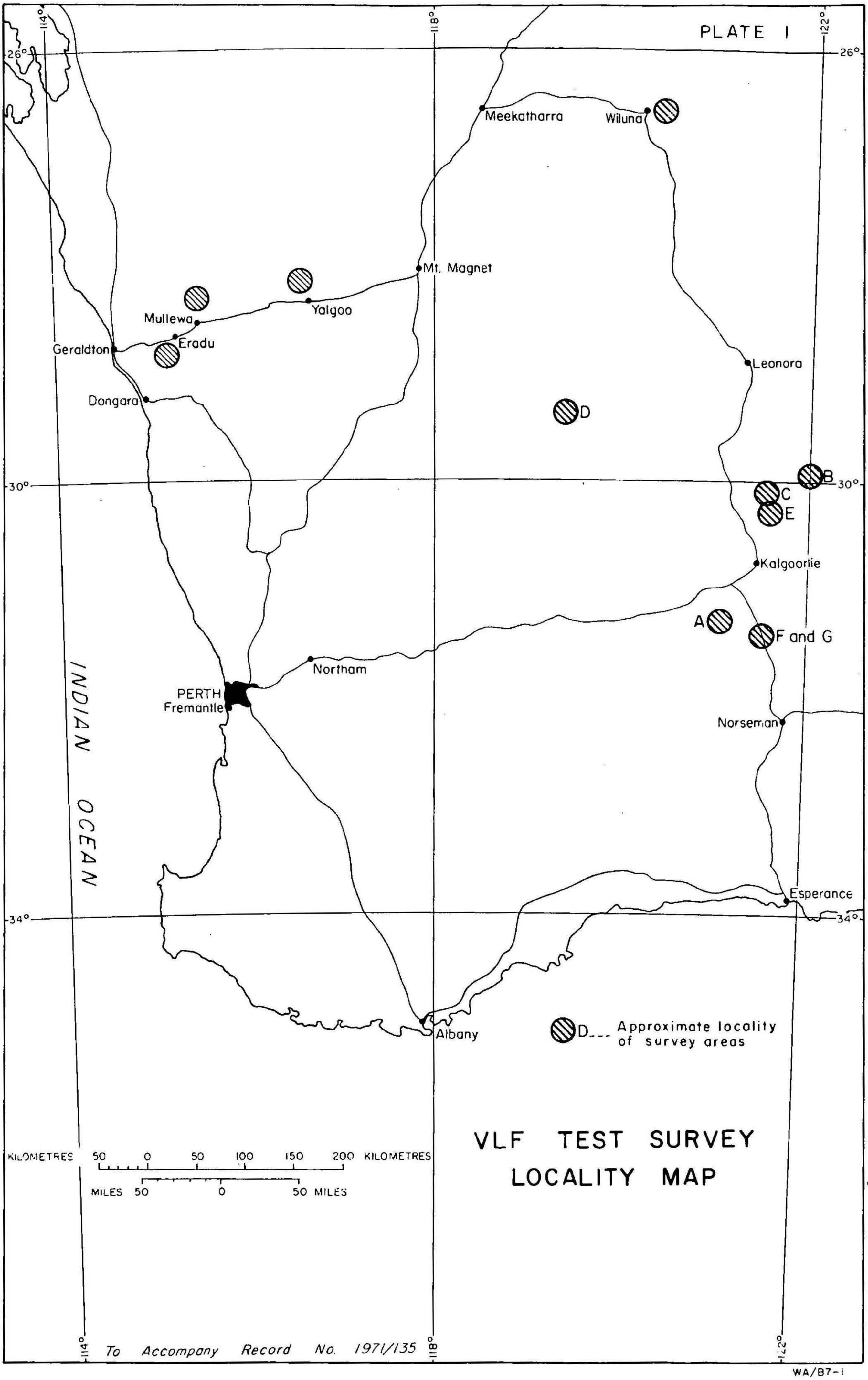
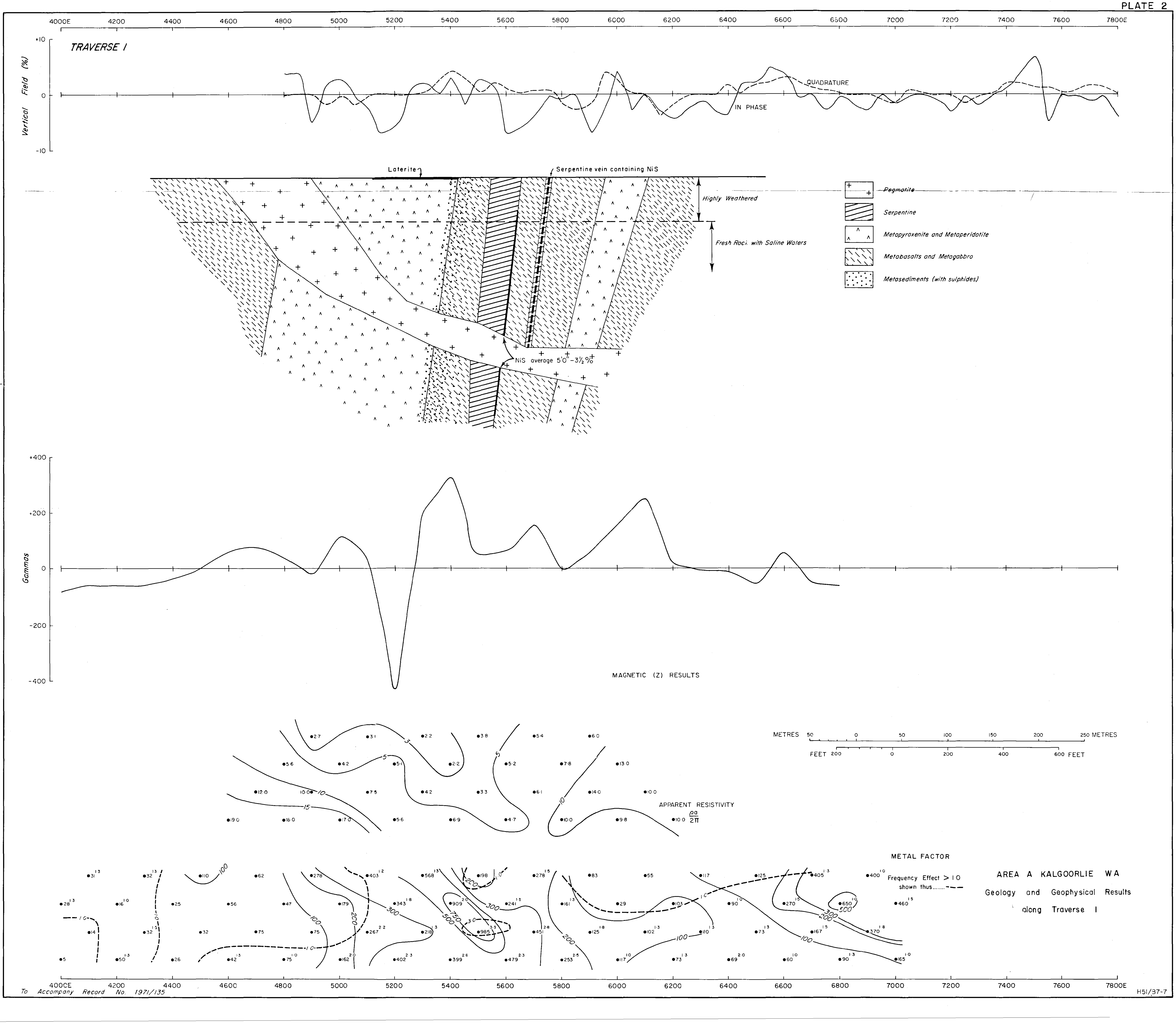
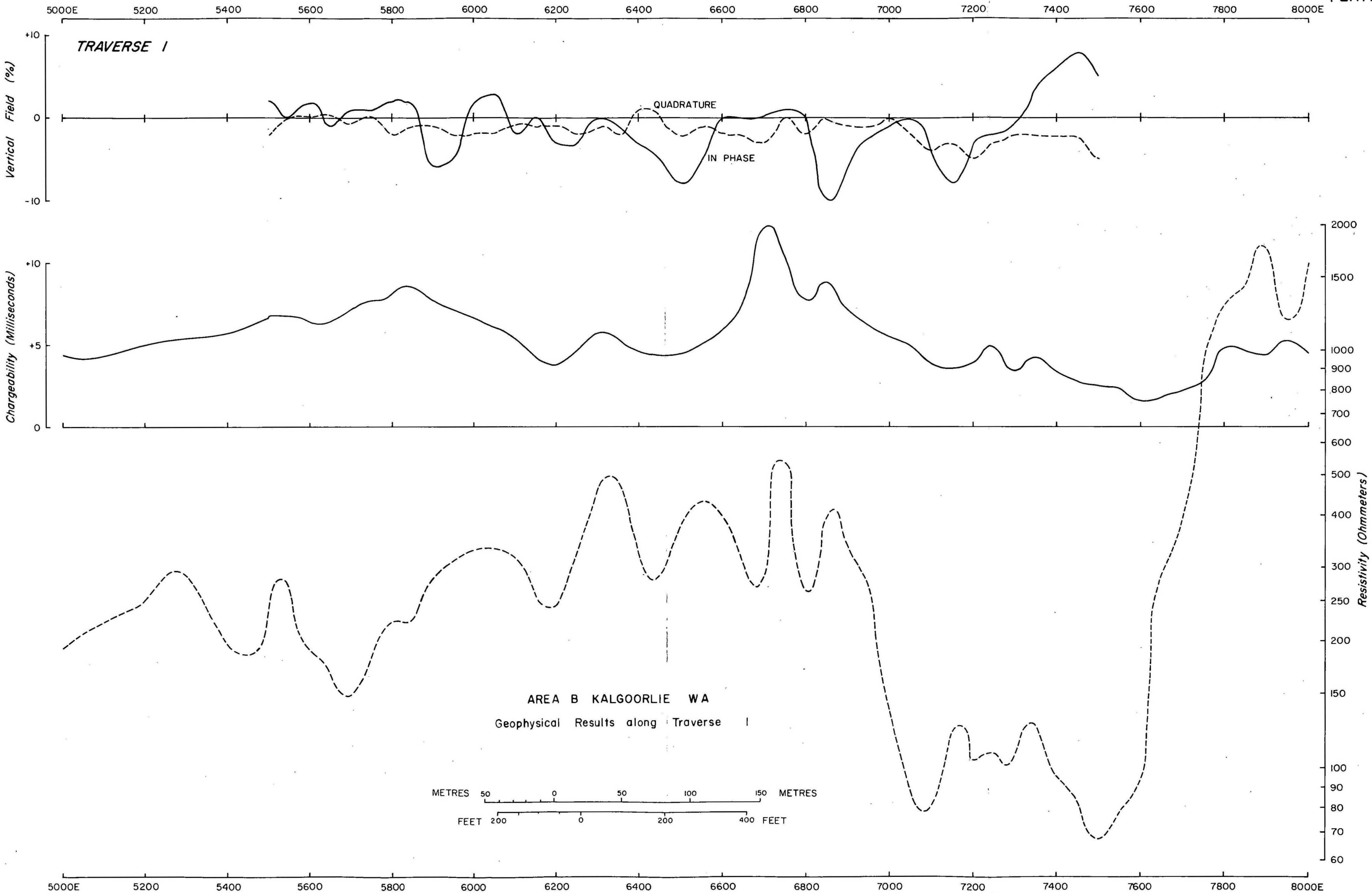


PLATE I
114°
118°
122°
26°
30°
34°
Meekatharra
Wiluna
Mt. Magnet
Yalgoo
Mullewa
Eradu
Geraldton
Dongara
Leonora
D
B
C
E
Kalgoorlie
A
F and G
Northam
PERTH
Fremantle
Norseman
INDIAN OCEAN
Esperance
Albany
D--- Approximate locality of survey areas
KILOMETRES 50 0 50 100 150 200 KILOMETRES
MILES 50 0 50 MILES
VLF TEST SURVEY
LOCALITY MAP
To Accompany Record No. 1971/135
WA/B7-1

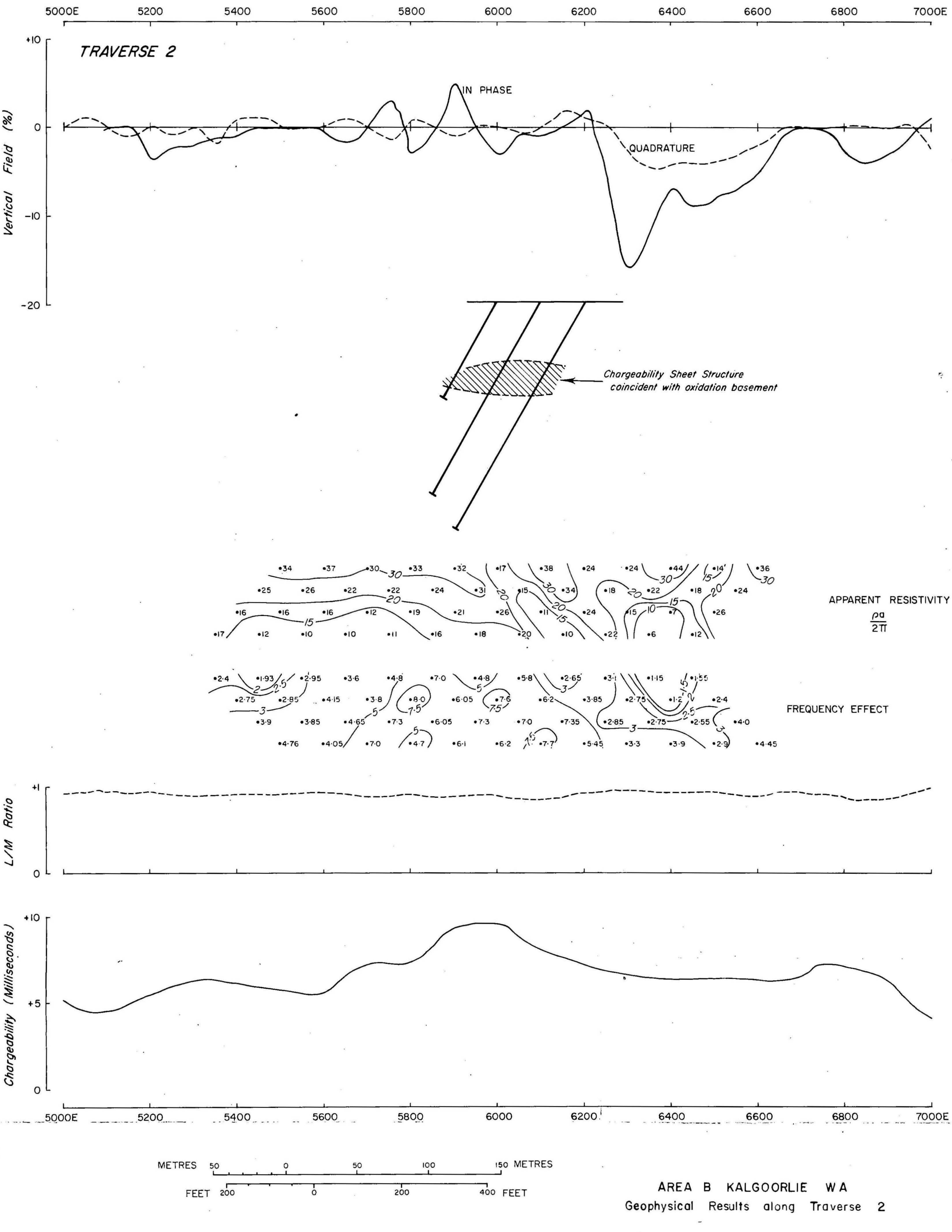
PLATE 2


TRAVERSE I
Vertical Field (%)
QUADRATURE
IN PHASE
Laterite
Serpentine vein containing NiS
Highly Weathered
Fresh Rock with Saline Waters
NiS average 5'0" - 3½ %
Pegmatite
Serpentine
Metapyroxenite and Metaperidotite
Metabasalts and Metagabbro
Metasediments (with sulphides)
Gammas
MAGNETIC (Z) RESULTS
METRES
FEET
APPARENT RESISTIVITY $\frac{\rho a}{2\pi}$
METAL FACTOR
Frequency Effect > 1.0 shown thus
AREA A KALGOORLIE WA
Geology and Geophysical Results along Traverse I
To Accompany Record No. 1971/135
H51/37-7



AREA B KALGOORLIE WA

Geophysical Results along Traverse I

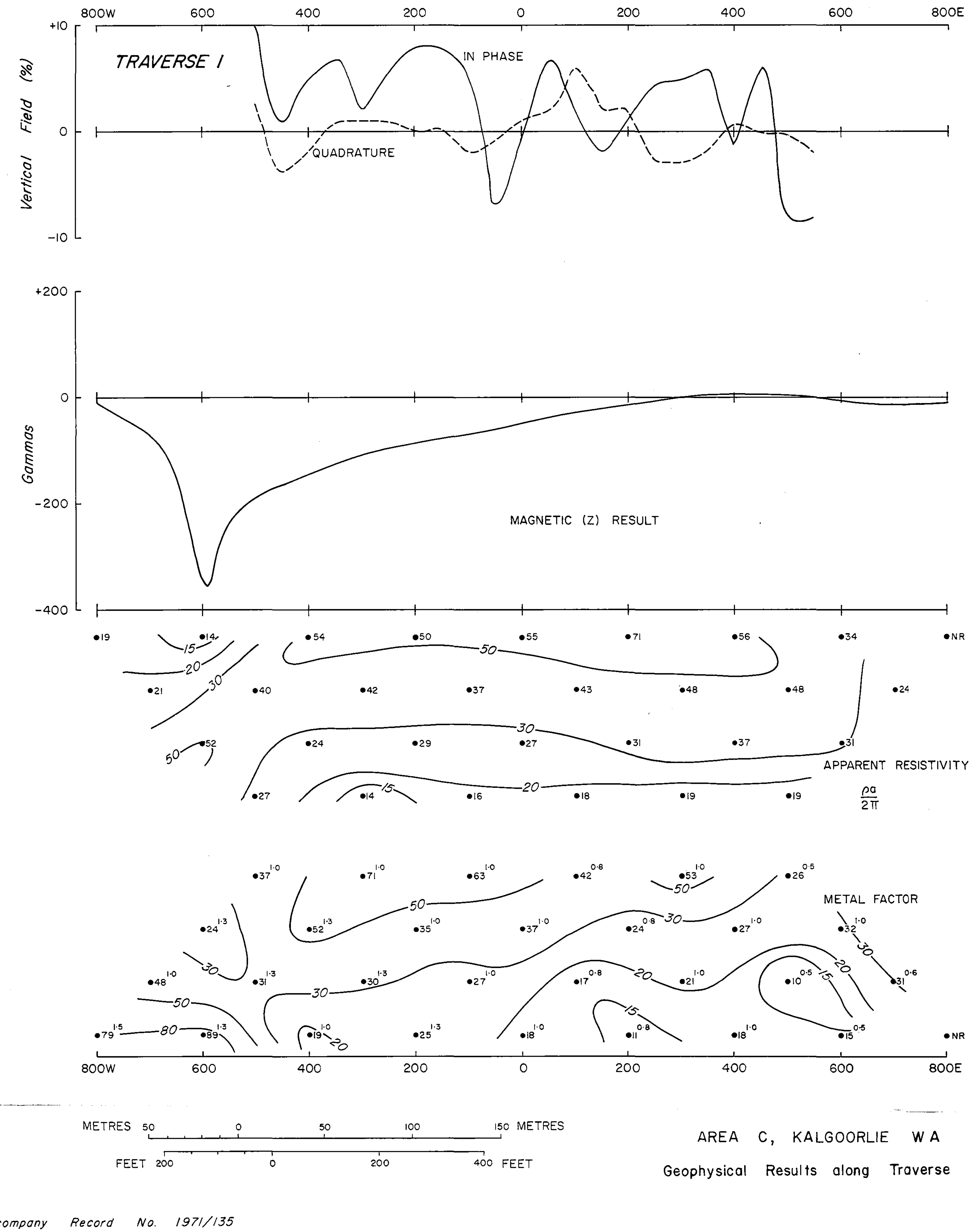


AREA B KALGOORLIE W A

Geophysical Results along Traverse 2

To Accompany Record No. 1971/135

H51/B7-9

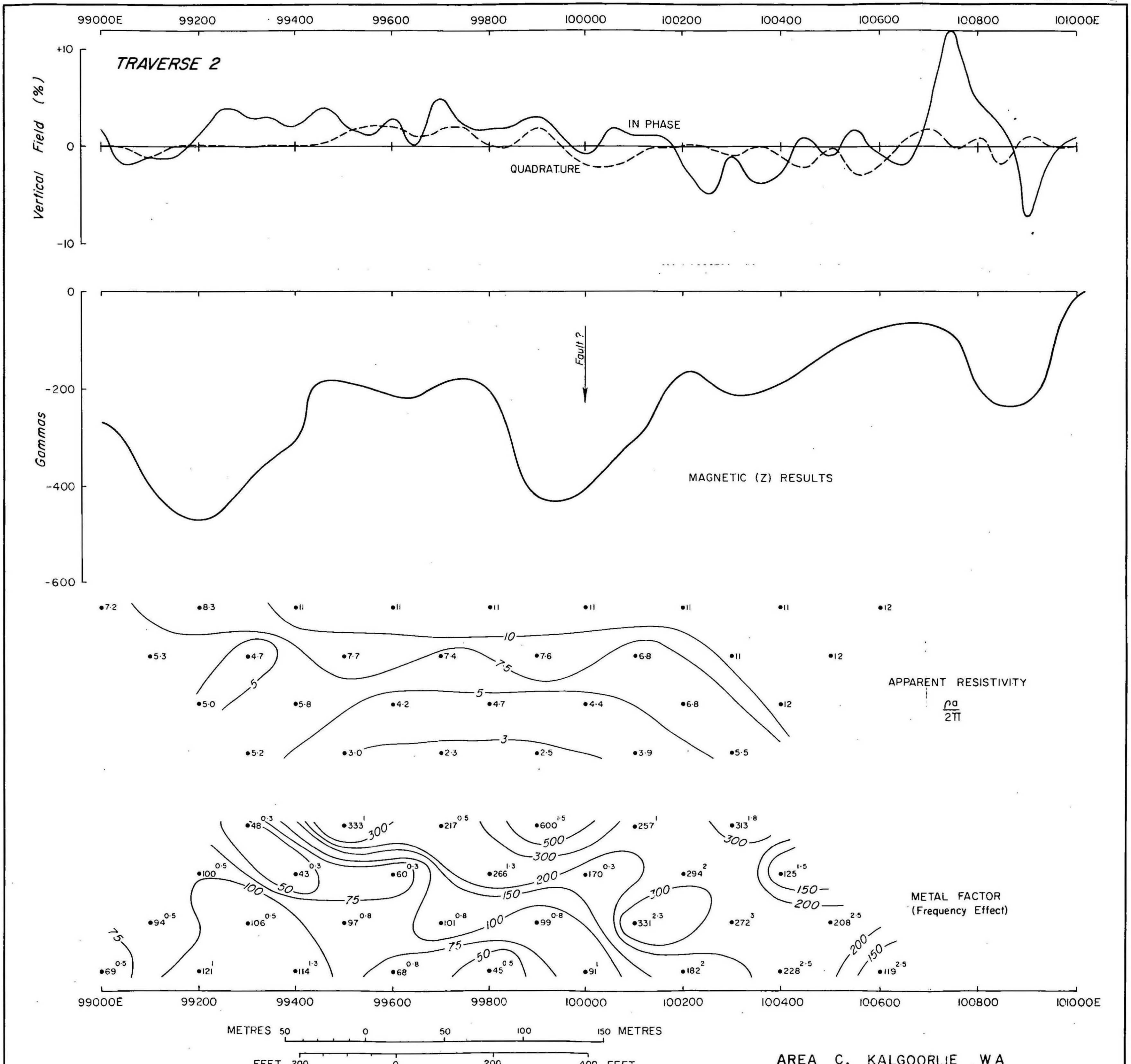


AREA C, KALGOORLIE W A

Geophysical Results along Traverse I

To Accompany Record No. 1971/135

H51/B7-10



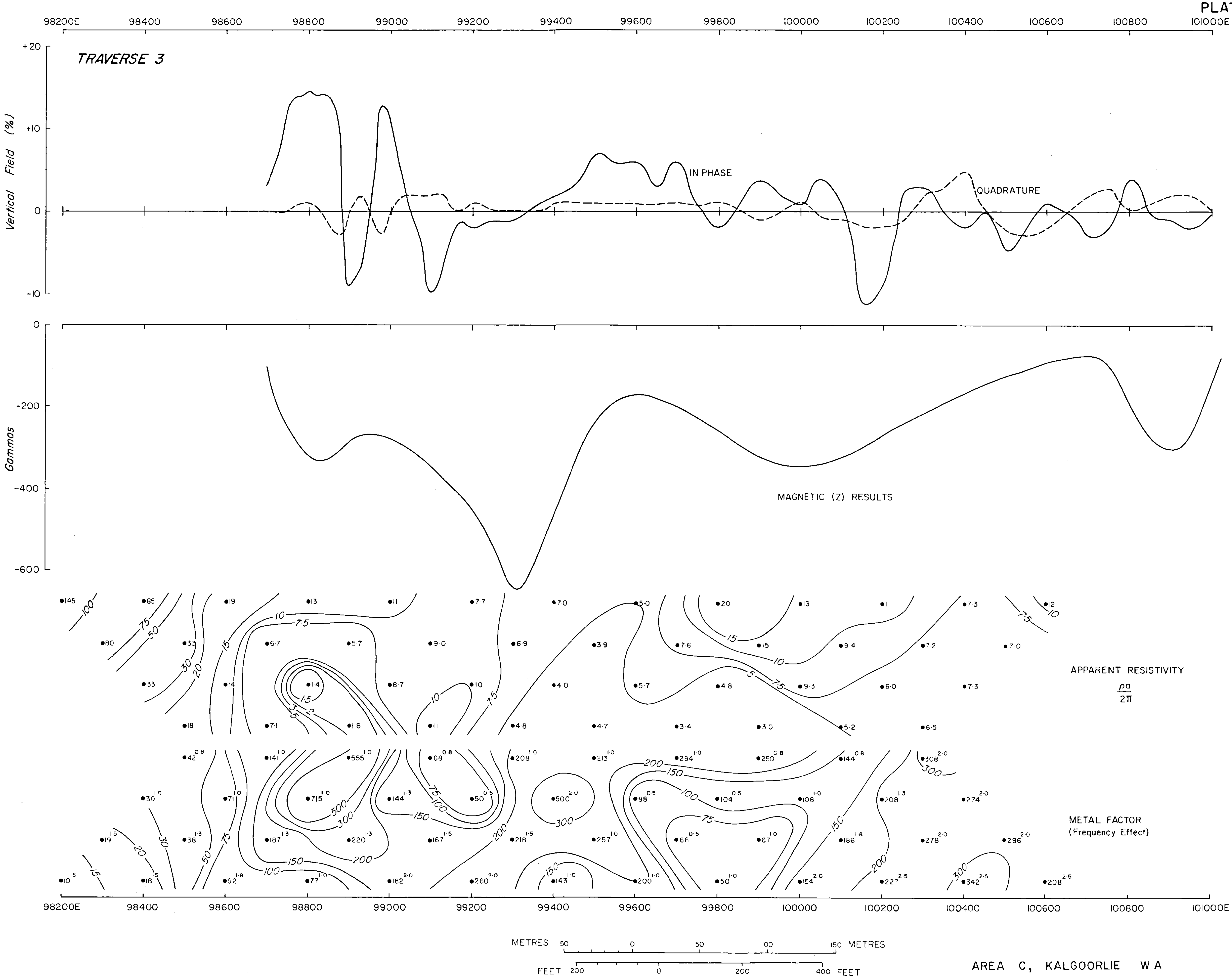
To Accompany Record No. 1971/135

AREA C, KALGOORLIE WA

Geophysical Results along Traverse 2

H51/B7-11

PLATE 7

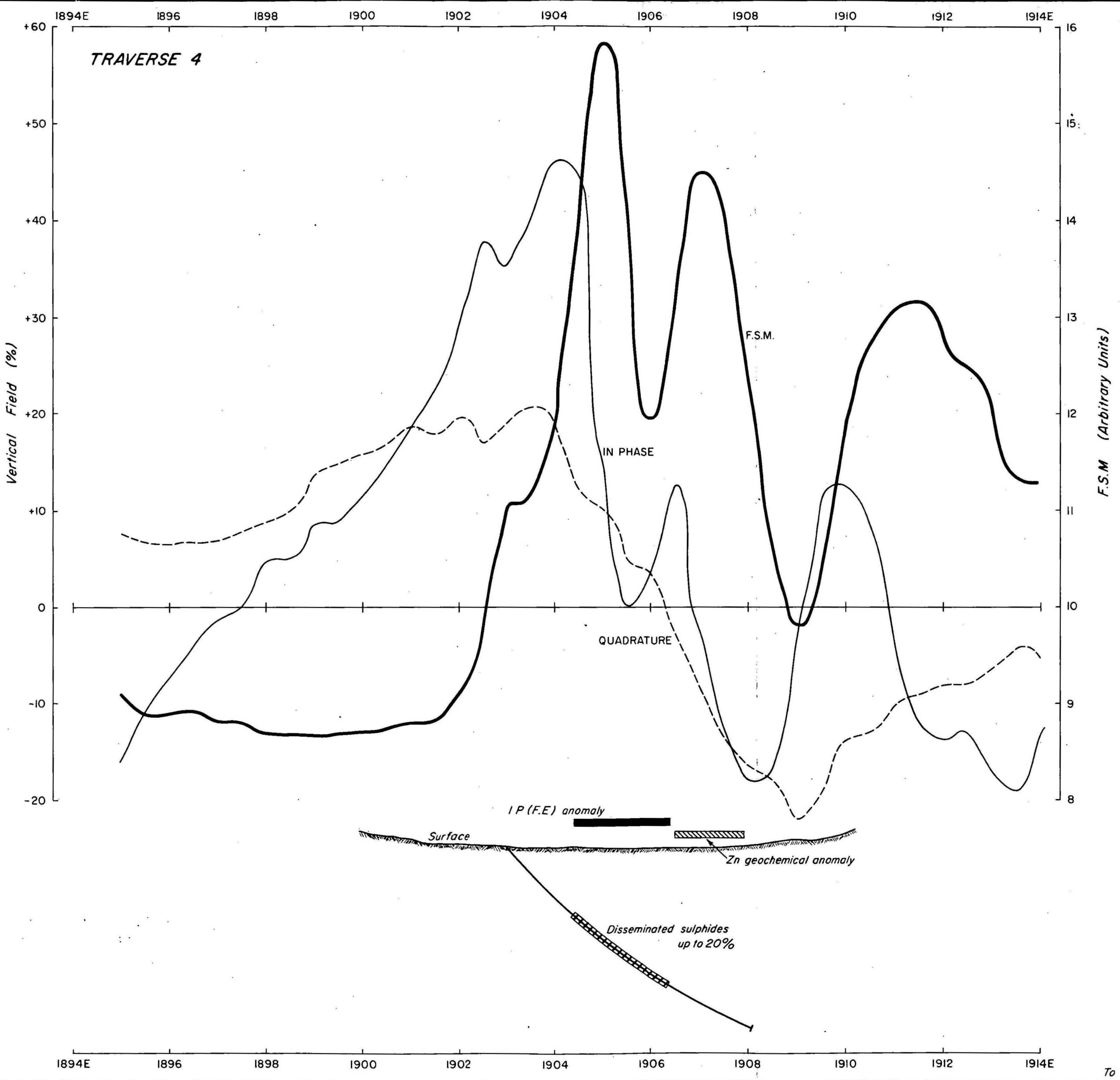


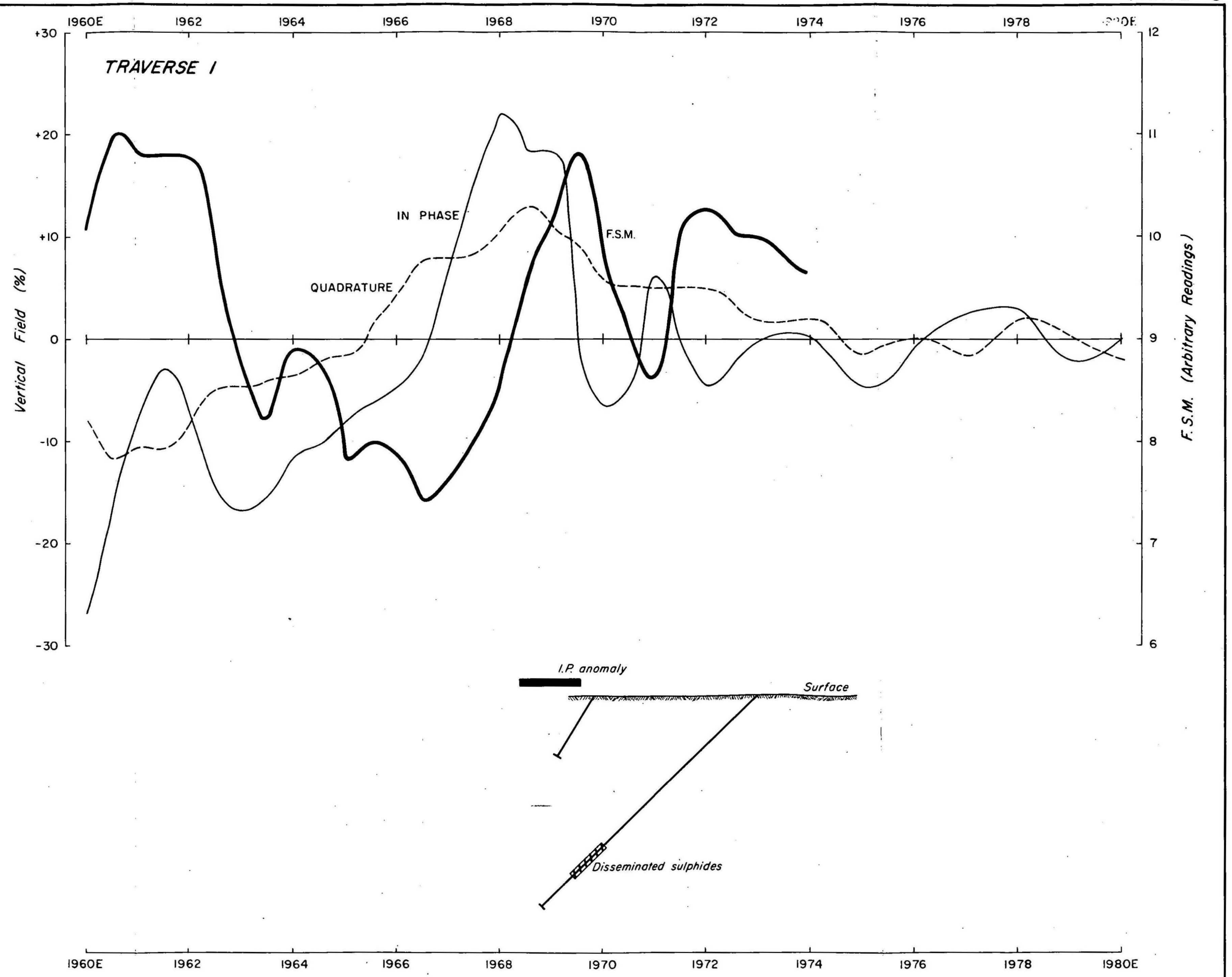
AREA C, KALGOORLIE W A

Geophysical Results along Traverse 3

To Accompany Record No 1971/135

H'll/B7-12





METRES 50 0 50 100 150 METRES

FEET 200 0 200 400 FEET

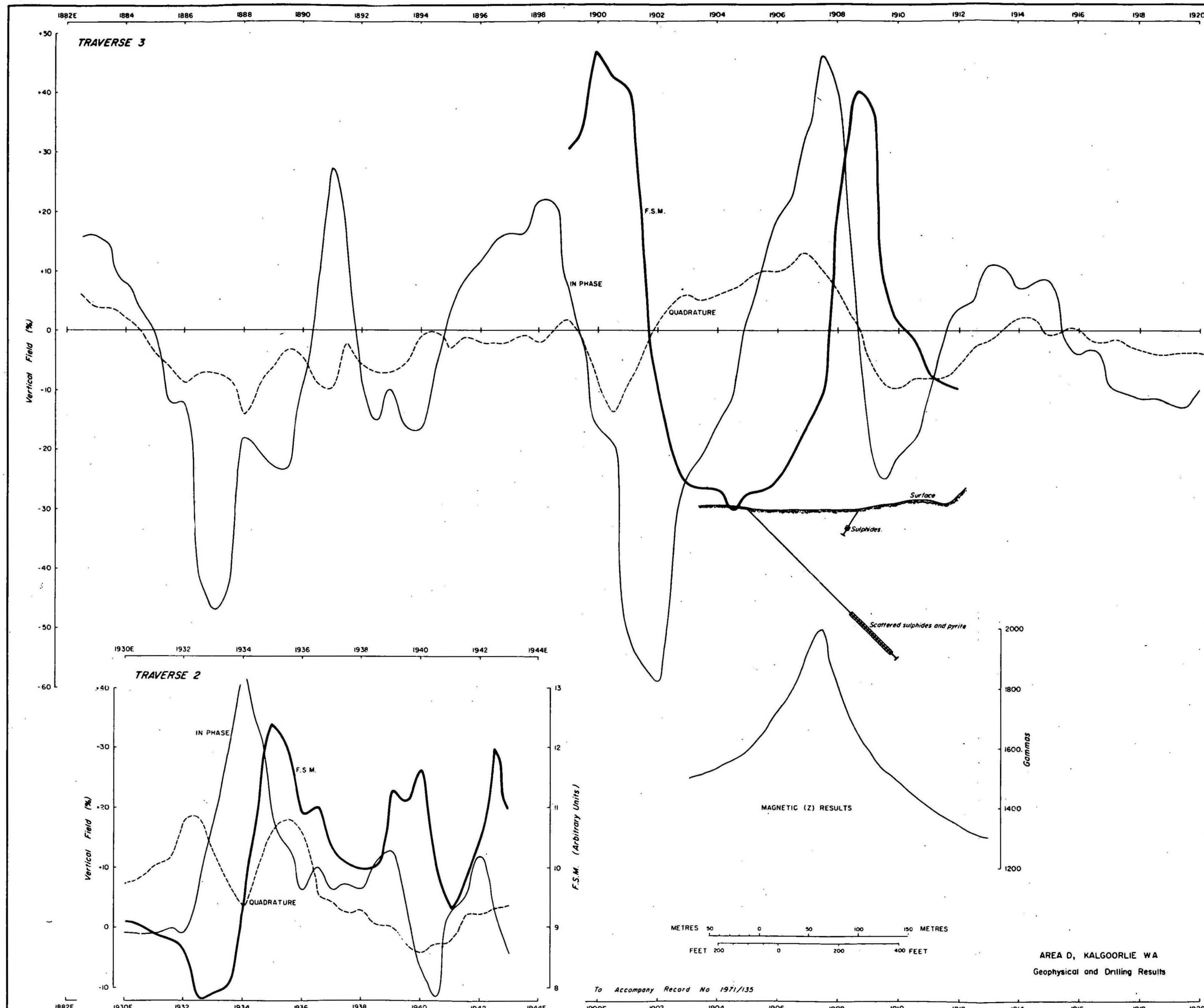
AREA D, KALGOORLIE, W.A.

Geophysical and Drilling Results

To Accompany Record No. 1971/135

H51/B7-4

PLATE 9

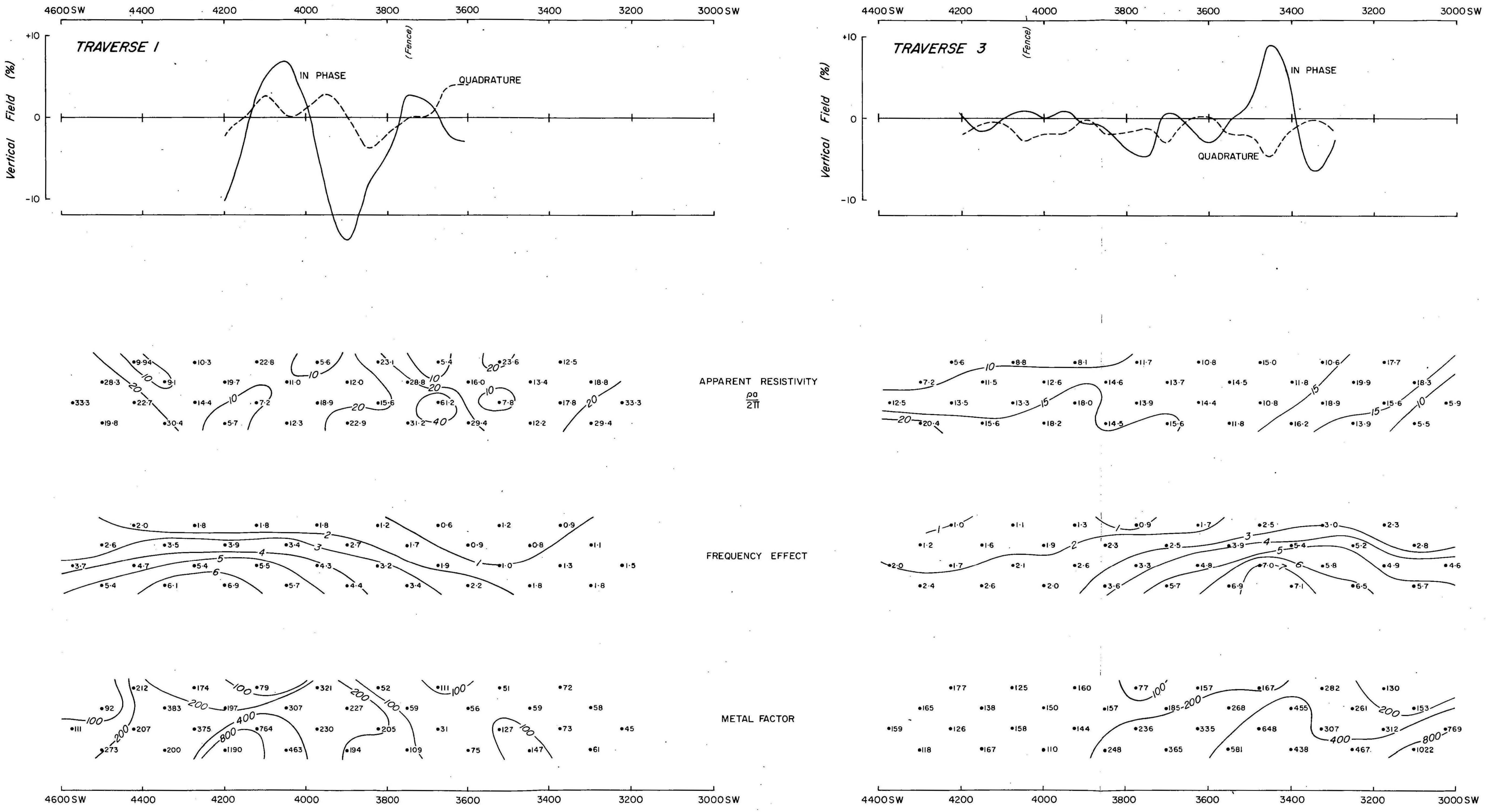


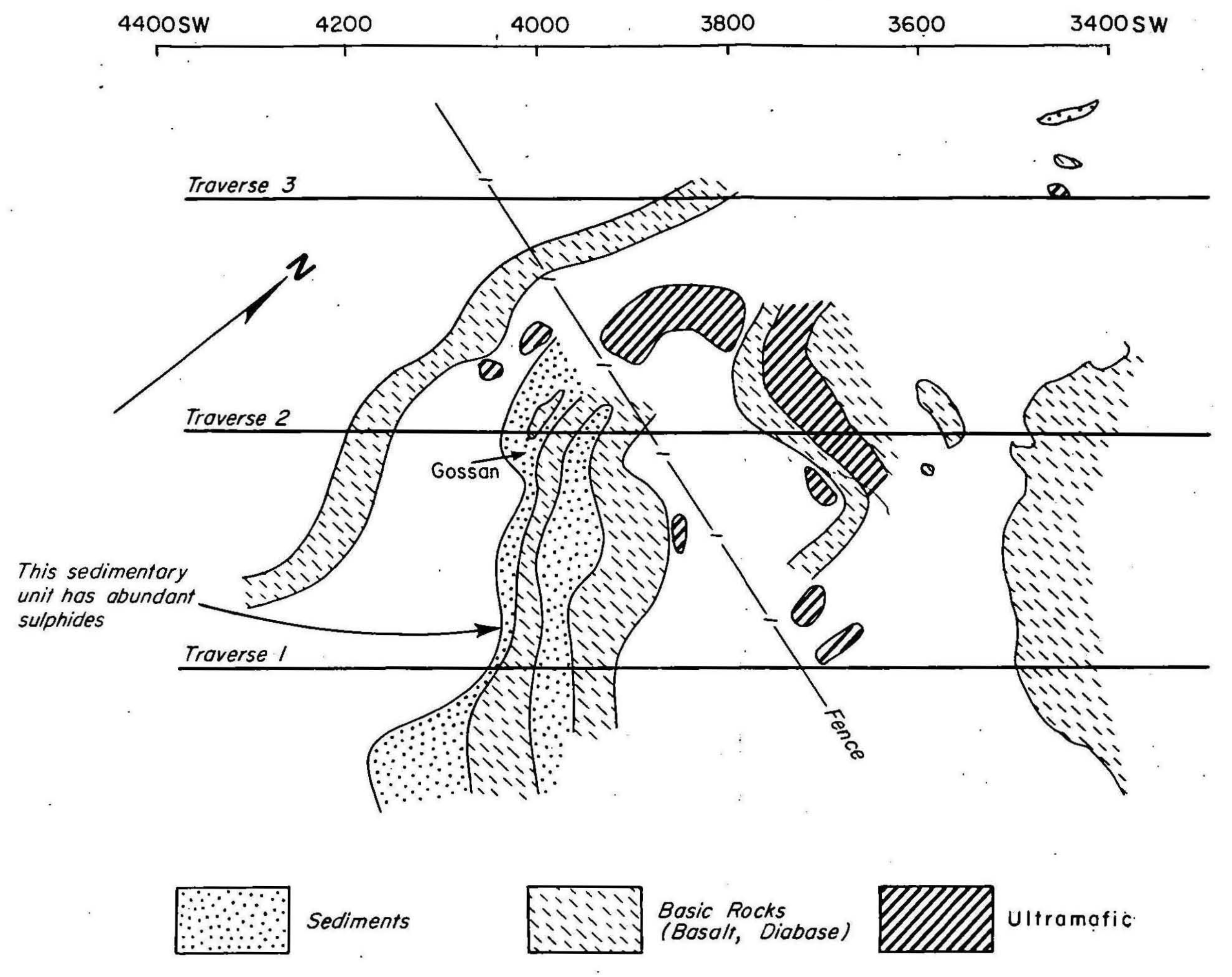
AREA D, KALGOORLIE WA

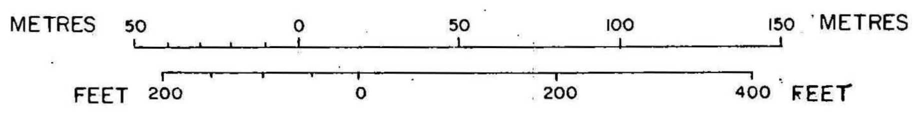
Geophysical and Drilling Results

To Accompany Record No 1971/135

H51/B7-6







AREA E KALGOORLIE W.A.

Locality Map, Geology and Geophysical Results along Traverses 1 and 2

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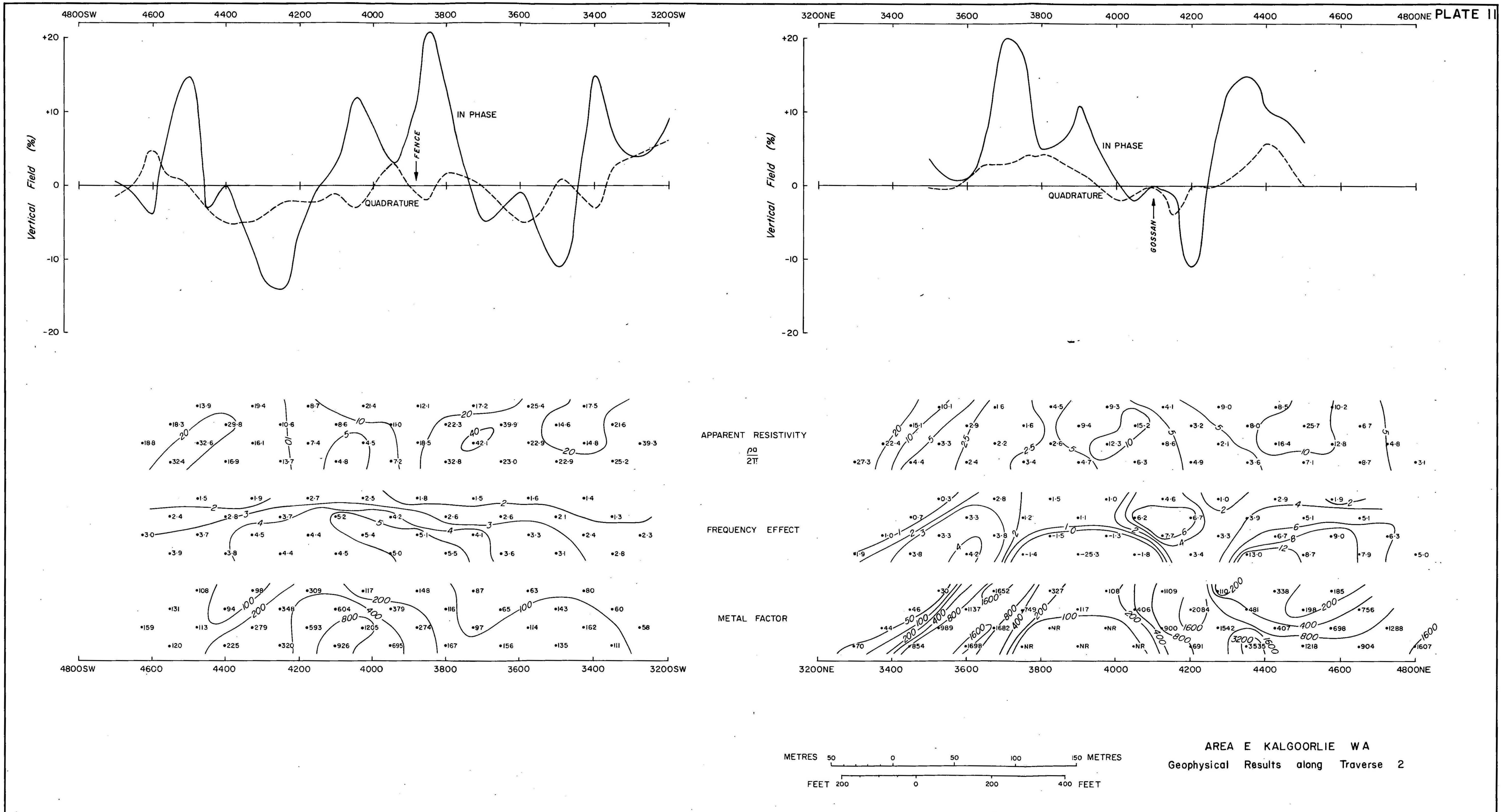
H51/B7-13



To Accompany Record No. 1971/135

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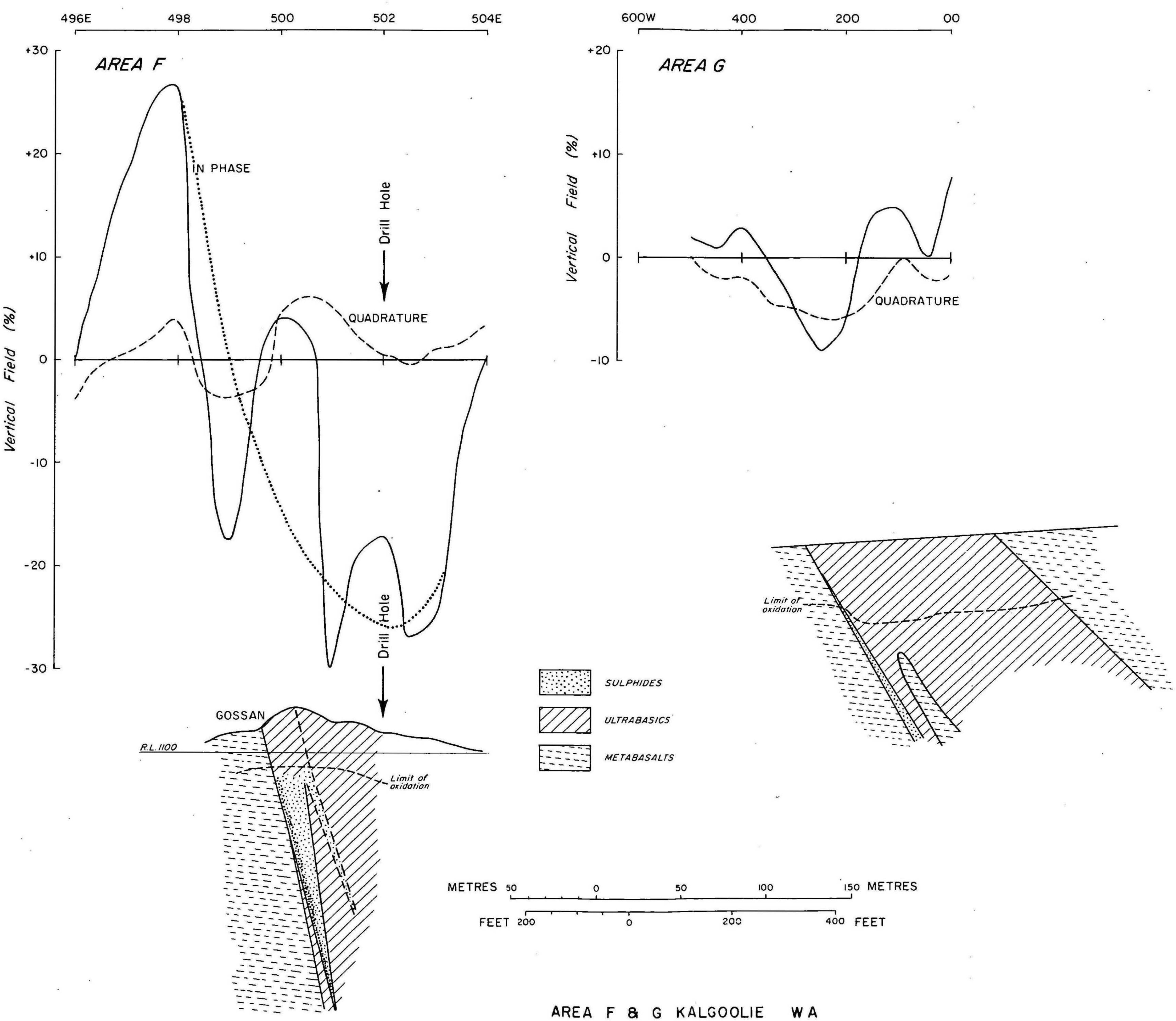
PLATE 12



AREA F & G KALGOOLIE WA

VLF Results and Geological Sections

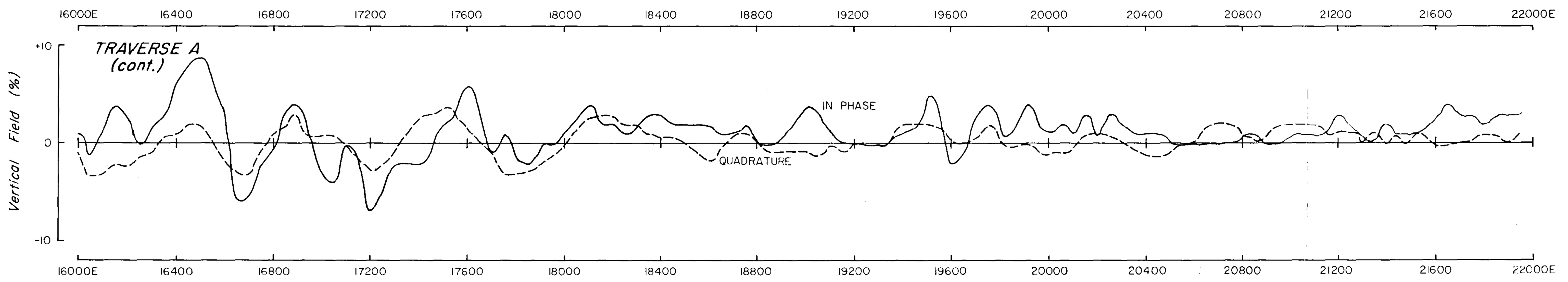
To Accompany Record No. 1971/135

H51/B7-15

GERALDTON MOUNT MAGNET AREA, W.A.

VLF Results and Aeromagnetic Anomalies near Yalgoo

To Accompany Record No. 1971/135



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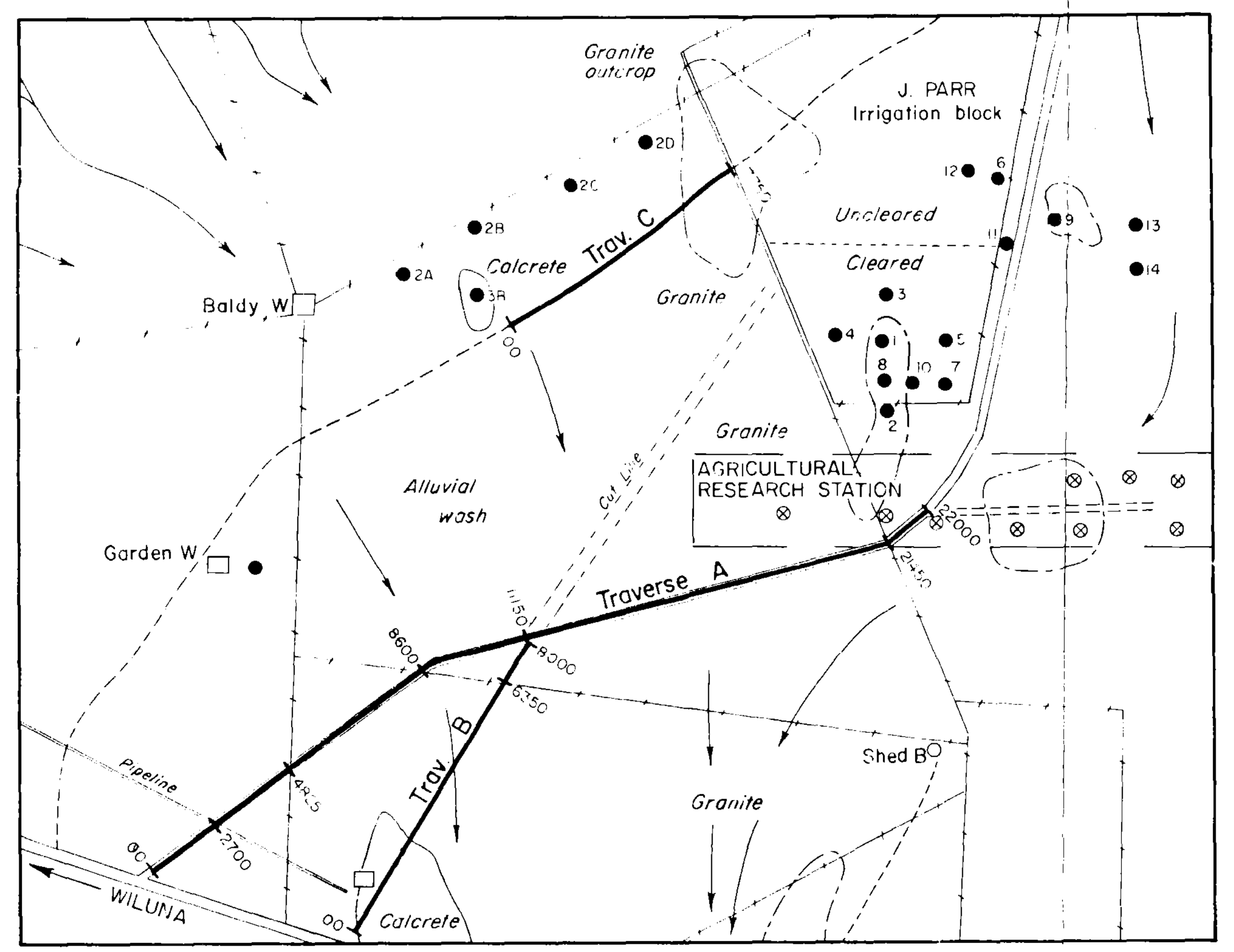


●12 J. Parr bores

⊗ Agricultural Dept. exploratory bores

Drainage trend

Track

Road

Poorly defined surface calcrete

Well defined calcrete

Trav. B VLF Traverse

KILOMETRES 1 0 1 2 3 KILOMETRES

MILES 1 0 1 MILES

METRES 100 0 100 200 300 METRES

FEET 400 0 400 800 FEET

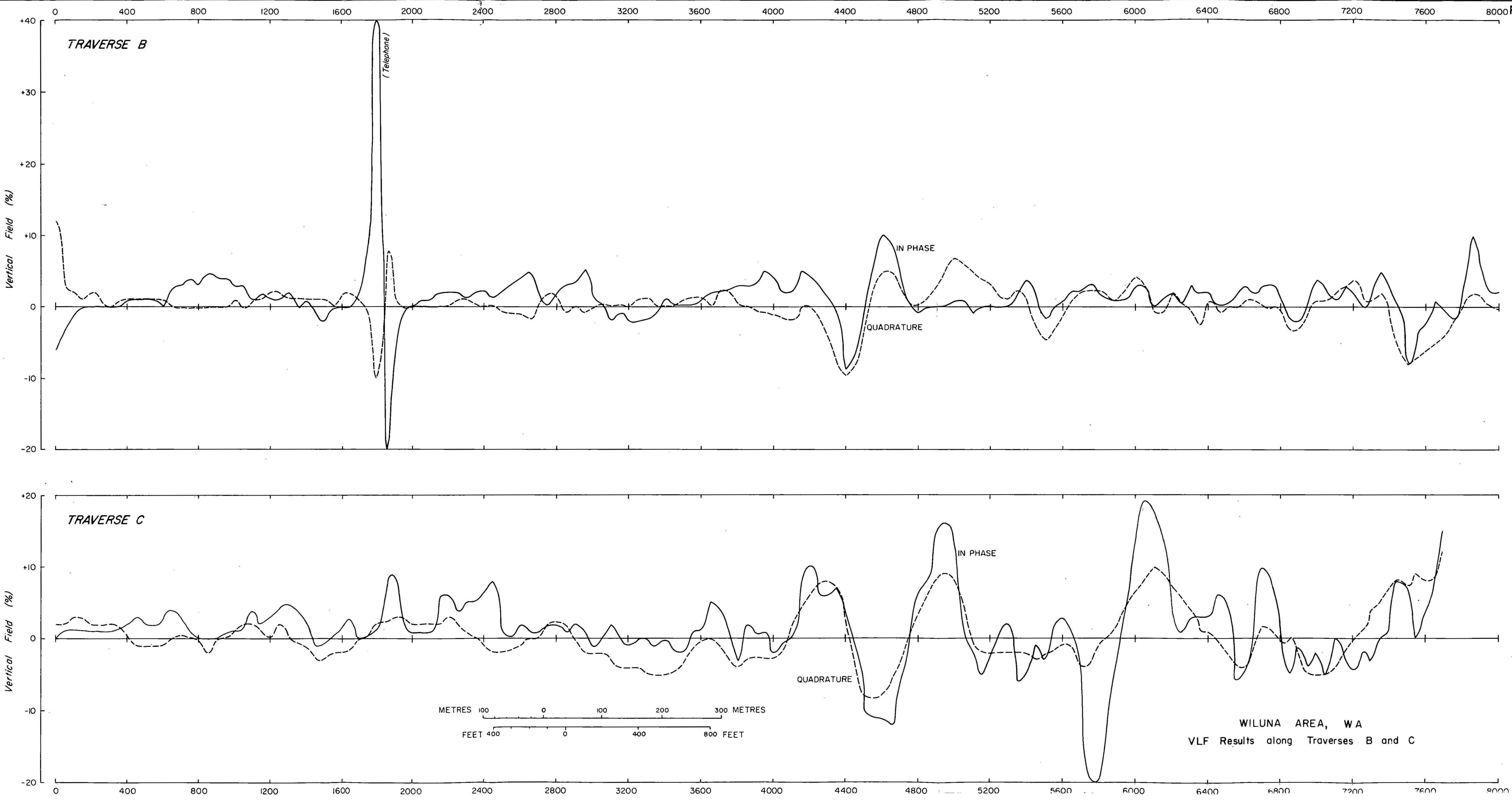
WILUNA AREA, W.A.

Location of Traverses and VLF

Results along Traverse A

G51/B7-1

PLATE 15



WILUNA AREA, W A

VLF Results along Traverses B and C