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Geophysical and Geochemical Case Study of the Que River deposit, Tasmania, Australia.

BY: S.S.WEBSTER AND E.H.SKEY

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ABSTRACT

The Que River deposit, discovered in 1974, comprises several separate massive sulphide lenses located within an area 800 metres by 100 metres. The lenses occur within a sequence of pyritic dacites and andesites approximately 300 metres wide over a strike length of 4 kilometres. The lenses are vertical with average width 9 metres. One lens is predominantly pyrite and chalcopyrite, the others being predominantly pyrite, sphalerite and galena. Outcrop of massive sulphides is non-existent.

The exploration area was selected within a well-mineralised belt of Cambrian calc-alkaline volcanics marking the eastern edge of the Dundas Trough in Tasmania. Initial reconnaissance covered an area of 60 square kilometres, with geological traverses and stream sediment sampling. Several areas of anomalous geochemistry were located in favourable rock types.

Progress of the reconnaissance programme and follow-up investigation was impeded by dense rainforest and rugged terrain. Accordingly an airborne electromagnetic survey was flown. Though this technique had not been an ore-finder in Australia, the geophysical environment in Tasmania was such that application of the method was warranted. A conductor was immediately identified in one area of anomalous stream sediment geochemistry.

The target was subsequently delineated by soil geochemistry and ground electromagnetic techniques. Initial drilling proved the conductor to be a single lens of predominantly copper and iron sulphides. Additional drilling intersected a comparatively major zone of zinc, lead and iron sulphides which was not detected by the electromagnetic surveys, but was expressed by soil geochemistry. An integrated orientation survey showed that the induced polarisation technique, combined with soil geochemistry, optimised drill target definition.

EXPLORATION HISTORY

The Que River deposit is located within the main mining district of North-Western Tasmania. The deposit is sited 2 kilometres east of the Murchison Highway, approximately 25 km north-east of Rosebery, as shown in Figure 1.

The Exploration Licence, which covered the Que River deposit, was acquired by the Aberfoyle group in 1970, and exploration was undertaken by regional mapping and stream sediment geochemical sampling. Upon acquisition of the Aberfoyle group by Cominco Ltd., in 1971, the programme was continued. As progress of this work was impaired by dense rain forest and rugged terrain, an airborne electromagnetic survey was initiated in February,1972.

Eight electromagnetic anomalies were selected for follow-up in the following field season, utilising reconnaissance traversing techniques. Soil geochemical samples were collected along regional electromagnetic traverses. One electromagnetic conductor was selected for particular attention, due to a coincident stream sediment geochemical anomaly.

This anomaly was gridded with traverse lines 50 metres apart for a strike length of 600 metres. The grid was surveyed with the vertical and horizontal loop electromagnetic techniques and soil geochemistry at a station spacing of 50 metres. Several one metre deep pits indicated the presence of sulphide mineralisation.

A seven hole diamond drilling programme was designed to evaluate the prospect. The first hole encountered 11.4 metres of sulphide mineralisation which assayed 2.10% Cu, 5.08% Pb, 7.86% Zn and 105 g/t Ag. The second hole was sited as a deep test of this zone and as an evaluation of a broad soil geochemical anomaly. A second mineralised zone was intersected over 3.81 metres which averaged 0.86% Cu, 13.72% Pb, 22.03% Zn, 371 g/t Ag and 3.8 g/t Au.

As this second zone was not indicated by the ground electromagnetic surveys an Induced Polarisation survey was initiated. This survey defined the width of the mineralised horizon and reflected the second ore lens.

The first phase drilling programme revealed the inadequacy of the survey grid and exploration data. The survey grid was extended to allow more extensive detailed soil geochemistry, on a 10 metre sampling interval, and further IP traversing.

An ore delineation drill programme of 108 drill holes totalling 25,500 metres, based on the results of this exploration, enabled an ore reserve estimate of 6 million tonnes containing 800,000 tonnes of lead and zinc, to be calculated.

REGIONAL GEOLOGY

The Que River deposit occurs within the Mount Read Volcanics, a Cambrian calcalkaline suite which is also host to the Mt.Lyell (Cu) and Rosebery (Zn-Pb) orebodies. The pyroclastics, lavas and intrusives form an arcuate belt 10km wide and 240 km long marginal to the Precambrian Tyennan Nucleus as shown in Figure 1. To the west is the Dundas Trough comprised of late Proterozoic and early Palaeozoic sediments which are partly facies equivalents of the volcanics, (Corbett et al 1974).

LOCAL GEOLOGY

Mapping has resulted in identification of three fundamental stratigraphic units from east to west, as shown in Figure 2.

The Farrell Slates is a west dipping and facing sequence represented by micaceous sandstones, siltstones, grey to black shales and foliated acid tuffs intruded by pyritic and magnetite-bearing dacites. This group is succeeded westwards by a broad exposure of predominantly andesitic agglomerates, lavas and feldspar crystal tuffs. The Que River Beds conformably overly the andesites and dip west at 25 to 60 degrees. They comprise carbonaceous pyritic shales with interbedded acid volcanics. Correlation with a suite of shales and volcanics exposed north east of the Que River prospect is made on the basis of geographic and structural convergence and the similarity of the interbedded and overlying rhyolitic pyroclastics.

The Que River Beds are late Middle Cambrian in age, (Gee et al 1970).

At detailed scale (Figure 3),the paucity of outcrop necessitates that a geological plan be substantially interpreted from drilling results (Figure 4). The sub-vertical sequence from east to west consists of, from the bottom, footwall andesitic pyroclastics, unaltered but with traces of sphalerite and galena; a porphyritic dacitic unit containing "stringer" mineralisation; heavily pyritised lower dacitic pyroclastics with sericite-carbonate-silica alteration and disseminated to massive base metal sulphides; barren dacitic lavas which form a wedge between the lower sequence and the upper sequence and western ore lenses; several repetitions of barren dacites and mineralised pyroclastics containing the major galena-sphalerite ore lenses; hanging-wall andesitic-pyroclastics, unaltered and virtually devoid of sulphide mineralisation.

The eastern (S) ore lens consists of bands and veins of coarsely crystalline pyrite, which is also locally framboidal or coloform. Galena, sphalerite and chalcopyrite occur within the pyrite host and associated silica-carbonate gangue. In part this lens is comprised of massive pyrite with chalcopyrite only.

The western (P) lenses commonly exhibit bands in the range 1 mm to 1 cm of pyrite, sphalerite and galena with minor chalcopyrite. Framboidal and coloform textures are microscopically visible. Gangue minerals include silica, carbonate, sericite and barite.

STREAM SEDIMENT GEOCHEMISTRY

a) Regional Reconnaissance Programme

During 1970-71, 276 stream sediment samples were collected throughout the property with a sample density of approximately 3 to 5 samples per square kilometre. After sieving at minus 20 mesh, the fine-grained gravel and silt was pulverised and digested in hot perchloric acid then analysed by AAS for copper, lead and zinc. Results from the vicinity of the Que River prospect are shown in Figure 5.

Stream sediment values of the order 45 ppm Cu, 300 ppm Pb and 340 ppm Zn occurred in the vicinity of the later identified Que River prospect and were recognisably anomalous in a regional sense. Inspection of the metal values in adjacent samples within the volcanics revealed local background to be of the order 15-20 ppm Cu, 20-80 ppm Pb, 50-100 ppm Zn, thus further enhancing the character of the anomaly.

b) Local Orientation Programme

Three streams draining the prospect were sampled in detail for orientation purposes. This programme was conducted concurrently with the grid geophysics and geochemistry in 1974 and also during 1976.

The geographic disposition of streams A,B and C relative to the prospect are illustrated in Figure 2. All samples were dried and fractionally sieved. Copper, lead and zinc were determined by AAS after digestion in hot perchloric acid. Iron was determined by stannous chloride titration against standard potassium dichromate following potassium bisulphate fusion and hydrochloric acid dissolution.

The range of results achieved for -200, -100 +200, -40 +100 and -40 (100%) mesh size fractions is shown in Figs. 6,7 and 8. In streams A and B in particular there is a marked tendency for metals to be of greater value in the (progressively) finer fractions. The minus 40 mesh results approximate to an average of the individual fraction analysis.

In general lead and iron values peak nearer to the source than copper or zinc, reflecting the greater mobility of the latter, though this pattern is confused by probable additions of metals, particularly zinc, from footwall sources. Sampling was not pursued far enough downstream to encompass the complete geochemical dispersion, however broad spaced sampling was confirmed as an acceptable reconnaissance technique.

A-horizon metal values were substantially lower than equivalent C horizon values.

Distribution patterns are broadly similar to those for C horizon and delineate the south eastern andesites as well as producing anomalies in the general vicinity of the ore lenses. However, linear trends were less evident compared with C horizon data (with the exception of iron over the western lenses). For this reason and because of the greater contrast between anomaly and background, the presumably reduced importance of hydromorphic transporation, and ease in avoiding the collection of depleted clays at the A-C horizon interface, only C-horizon samples were used in follow-up.

During the 50m sampling programme, gossanous fragments and fresh sulphides in some auger samples prompted a pitting programme. Sampling of soils from pit walls, (digestion and analysis of the minus 80 mesh fraction as previously described), demonstrated that an impoverished zone occurs at the base of the A horizon. Metal values then increase progressively with depth. At some locations iron-rich cellular gossans and mineralised bedrock were encountered. Best gossan values were 1100 ppm Cu, 3400 ppm Pb, 800 ppm Zn and 50% Fe and rock values attained 420 ppm Cu, 1025 ppm Pb, 10500 ppm Zn and 15.5% Fe.

Auger samples collected from weathered bedrock had values up to 6000 ppm Cu, >10,000 ppm Pb and 3400 ppm Zn which subsequently were related to the subcrop of the eastern lens as defined by drilling. This work confirmed the attractiveness of C horizon sampling in the attempt to define a linear anomaly associated with the EM conductor and 10m spaced sampling was initiated.

As shown by Figures 11 and 12, several linear geochemical trends were found but only partly coincident with the EM conductor. Zinc, with iron, continued to define the andesites but elsewhere was less than 100 ppm except for extremely localised anomalous values in excess of 1000 ppm, which were later found to correlate with faults.

Comparison of the geochemical trends for copper, lead and iron with the position of EM conductors and subcropping ore (as subsequently determined by drilling) revealed local correlations. Elsewhere the anomalies relate to accumulations of metal after modern hydromorphic transport and to traces of base metal in pyritic zones.

Closer spaced sampling was not considered a practical exploration technique

SOIL GEOCHEMISTRY

During the preliminary programme samples were collected at 50m intervals from A and C horizons using hand screw augers. After drying and sieving to obtain the minus 80 mesh fraction, (for analytical convenience) the samples were digested and analysed in the same way as the stream sediments. Iron was analysed as an indicator of pyrite and as a potential lithological marker.

Over sericitized pyroclastics a superficial A horizon soil of black or dark brown humus, 5 to 45 cms thick, is underlain by grey clays which are patchily ironstained and occasionally overly massive gossan above fresh pyritic rock. This (C) horizon is typically 50cms to 3 metres in thickness and is usually underlain by rotten grey ironstained pyroclastics to a depth of 20 metres or more.

Virtually no C horizon soil occurs above silicified zones. Fresh sulphides may be seen by removal of the thin humus rich surface layer.

On sulphide poor dacites pink to fawn clays or feldspathic sands are present beneath the A horizon.

Orange to brown clays with clasts of thoroughly weathered rock lie above weathered andesites. The C horizon may be 50 cm to 3 metres thick and the andesites beneath, whilst compact, are weathered to approximately 20 metres with kernels of fresher rock.

The C horizon results for lead (immobile) and zinc (mobile) are illustrated by Figures 9 and 10. Contour levels were selected by inspection, with the assistance of cumulative frequency plots. The absence of direct correlation between geochemical responses and EM conductors is apparent, however, the marked geochemical relief suggests that the C horizon data is reflecting sulphide occurrences. The sample spacing of 50m x 50m was considered too broad to consistently identify a narrow source.

Iron values (Figure 12) in excess of 10 per cent broadly correlate with lead-zinc anomalies and an area of high background values for iron and zinc in the south-eastern sector of the grid was identified by mapping as outcropping and subcropping andesitic agglomerates with trace sulphides. The sharp termination of this geochemical zone to the north-west was inferred to be a fault of strike 045^{o} grid, as shown in Figure 3.

compared to geophysical methods, but one metre-spaced samples were collected on line 7400N after drilling, for research purposes. Figure 13 shows stacked geochemical profiles of C horizon soil values for portion of line 7400N in the form of bar charts where each bar represents the arithmetic average of 5 point samples collected at one metre intervals.

Copper, lead and iron data show broadly coincident maxima related to mineralised pyroclastics separated by sulphide poor massive dacites. The greater level of copper values in the eastern zone (5225E to 5270E) is attributed to secondary supply of metal from the relatively copper rich eastern lens. Iron is also greater in this zone due to numerous veins of massive pyrite within the pyroclastics.

The erratic lead response and the displacement of the trough between the major maxima, relative to copper and iron, is due to the relative immobility of this metal. Trace amounts of galena in this environment may cause soil anomalies as strong as those caused by subcropping ore.

Although varying from metal to metal, a narrow anomaly is evident over, or adjacent to, the eastern lens. That this anomaly is not in proportion to the grade of subcropping ore, relative to the dominant anomaly, must be due to secondary dispersive effects. Zinc in particular shows a narrow anomaly succeeded westwards by a depleted zone through which the metal passes before reaching the stagnant swamp environment.

Clearly, detailed soil geochemistry at Que River is not an adequate tool alone for the identification of drill targets. The role of geochemistry in this environment is in the selection of zones for geophysical appraisal.

AIRBORNE GEOPHYSICS

In February 1972, a total area of 400 sq.kms, was flown with a 320 metre line spacing by McPhar Geophysics Pty.Ltd., employing the magnetic and electromagnetic techniques. The total magnetic field was measured by a Barringer proton precession magnetometer with a noise envelope of 5 gammas. The electromagnetic measurements were made using a McPhar H400, two frequency (340 hz and 1070 hz) quadrature system utilising a large transmitter (horizontal dipole) to receiver (vertical dipole) separation of 130 metres (400 feet), mounted in a helicopter (Jet Ranger 206B). This system and its installation is described in more detail by Fountain and Bottos (1970).

The data from the two systems were recorded in analogue form as shown in Figure 14, which illustrates the discovery data from the 1972 survey for traverse line 43A.

Normal qualitative interpretation of H-400 data, as outlined by Fountain and Bottos (1970), is performed by assessing three anomaly characteristics; the amplitude and shape of the anomaly and the ratio of low frequency response to high frequency response. If this ratio is less than 0.5 the conductor is rated as " poor ", between 0.5 and 0.75 the conductor is "fair" and between 0.75 and 1.00 the conductor is considered "good". The shape of the anomaly is rated from A for a steep sided, bell-shaped pattern through to D for a broad, flat-topped curve. The anomaly pattern in Figure 14 over Que River has an amplitude of 4 ppt, is rated as an A shape and exhibits a relative amplitude ratio of 0.5 which indicates the response of a shallow tabular source of "fair" conductivity.

Quantitative interpretation of the data at fiducial 1622 on line 43A, using the charts of Ghosh, (1972), indicates a conductivity - thickness parameter of 2.3 mhos, not allowing for the effects of finite length and depth extent. This estimation is indicative of a "fair" conductor, according to the classification outlined in Table 1.

The line recovery for this survey (Figure 15) shows the poor survey control in the vicinity of the ore lenses resulting in only one line crossing the conductor. Due to this survey deficiency and the acquisition of additional tenure to the west, a second survey was flown by Geoex Pty.Ltd., in 1975 with 160 metre (1/10th mile) line spacing. This detailed survey, utilising an improved version of the H-400 system, obtained a three line anomaly over the Que River orebody. Altitude attenuation tests over the orebody are illustrated in Figure 16 and indicate a recognisable response to 800 feet terrain clearance, confirming the scale model results of Ward (1969), and conclusions of Seiberl (1975).

In 1975, Comstaff Pty.Ltd. conducted an INPUT airborne electromagnetic survey in the district and extended several traverses to cover the Que River orebody. The INPUT response over the deposit, illustrated in Figure 17, comprises a four channel response indicative of a fair conductor. A similar response is observed over the more extensive black shale unit to the west of the deposit.

GRID GEOPHYSICS

To accurately locate and delineate the Que River airborne electromagnetic anomaly a survey grid was established with cross lines, each 400 metres long, cut every 50 metres for a base-line length of 600 metres over the position inferred from the 1973 follow-up. The geophysical survey was conducted with the horizontal-loop electromagnetic method and a proton precession magnetometer. After the anomaly had been positively identified, the grid was surveyed with the vertical loop electromagnetic method, in the broadside-setup procedure, to accurately locate the axis of the anomalous source.

A McPhar VHEM unit was chosen for the grid survey work because of its versatility in either horizontal or vertical loop mode of operation and its dual frequency (600 hz and 2400 hz) capability. A transmitter to receiver separation of 92 metres (300 feet) was used for the horizontal loop e.m. survey to achieve a reasonable depth of penetration. Some short cable (terrain) effects were expected, but these only constituted a minor problem in the area. Total magnetic field measurements were recorded with a McPhar GP 70 proton precession magnetometer, to an accuracy of ± 1 gamma.

The vertical loop electromagnetic data were recorded by Geoex Pty.Ltd., with a McPhar SS15 unit which utilises a 5 metre diameter vertical loop which is positioned over the conductor axis and kept in maximum coupling with the receiver as lines are traversed. The operational frequencies were 1,000 hz and 5,000 hz. The grid was surveyed with the vertical loop e.m. from two transmitter locations 7150N, 5270E (Figure 19) and 7400N, 5275E, thus covering the area of interest within the most effective range of the equipment.

1) Qualitative Analysis

The horizontal loop electromagnetic traverses (Figures 18) showed the presence of a definite conductor from lines 7500N to 7250N with strongest response on lines 7450N and 7400N in the vicinity of 5250E to 5300E. Responses detected along strike on lines 7250N to 7350N are indicative of a poor conductor. These e.m. anomalies are clearly due to the eastern (S.lens) mineralisation.

All traverse lines crossed the western (P lens) mineralisation, but no response is evident. This result is surprising, when consideration is given to coil spacing, source geometry and the resistivities of the flanking rock types.

A weak, but definite magnetic anomaly was detected on lines 7350N, 7550N, with a maximum relief of 200 gammas on line 7500N in the vicinity of 5150E. The magnetic data, however, proved not to be of use in this environment, due to the lack of magnetic minerals in the ore and related rock units, and the results are not included in this paper.

For ease of presentation, the VEM data have been transformed to their first derivatives by the procedure of Fraser (1969) and plotted in contour form in Figure 20. This procedure results in anomaly axes being located along contour highs, instead of at cross-over points. The VEM data show the presence of a conductor between lines 7250N and 7500N in close proximity to the base line, i.e. 5300E. The presence of a weak second conductor is readily observed at 5250E on lines 7350N and 7300N (this response is due to a barren pyrite lens, known as R lens). The main conductor can be classified "strong" from 7350N to 7450N whilst the western flanking conductor can be classified as "poor". The proximity of this second "poor" conductor probably explains the only "fair" overall HEM response on line 7350N. The two conductors are observed to merge on line 7400N. There are again no significant responses over the (P) western mineral lenses.

2) Quantitative Analysis

The horizontal-loop electromagnetic data recorded at Que River have been analysed, according to the charts of Strangway (1967), to determine conductivity-thickness (σt) parameters and source depths for classification purposes. These parameters are only approximate, as readings were taken every 50 metres along traverses, i.e. at approximately half-loop separation.

Table I lists the results of this analysis, and the classification of the conductivity-thickness parameters according to the system outlined in Table I. Each anomaly gave an apparent depth to source value of less than 10 metres, i.e. 0.1 times the coil separation, the limit of resolution for this technique. The interpretation curves used in this analysis were those

computed for a vertically dipping source, which was assumed appropriate from geological consideration and inferred from the near symmetry of e.m. data. Minor asymmetries in the HEM curve shapes are probably due to the multiple sources indicated on several lines by the VEM data. These limitations were not expected to be a source of major error in the results.

TABLE I

SUMMARY OF H.E.M. INTERPRETATION

Line	Anomaly	σt (mhos) High Frequency	Cominco Classification	σt (mhos) Low Frequency	Cominco Classification	Remarks
7500N	5310E	1.2	Poor	-		
7450N	5290E	11.5	Good	11.5	Good	
7400N	5285E	11.5	Good	9.1	Good/Fair	
7350N	5285E 5250E	2.9	Fair	3.9	Fair	Double Conductor
7300N	5285E 5250E	2.9	Fair	-		Double Conductor
7250N	5270E	0.9	Poor	-		
7200N	5240E	N.D.	Probably Poor			

N.B. Cominco Classification

Classification	σ_t mhos
Excellent	>15.0
Good	6.0 -15.0
Fair	1.5 - 6.0
Poor	<1.5

SELF POTENTIAL

A Self-Potential survey conducted over the original grid produced a strong anomaly of the order of -200 to -300 millivolts over the electromagnetic conductor. (Figure 21). This sharp anomaly was superimposed on a broad anomaly of -20 to -30 mv, which appears to delineate the pyritic suite. A weak NE-SW gradient crosses 5300E on line 7200N and marks the fault contact between mineralised pyroclastics and non-mineralised andesite.

MISE-A-LA-MASSE

As intersections of conductive mineralisation were anticipated in the drill programme, provisions were made to survey the prospect with the mise-a-la-masse technique. The aim of this work was an attempt to ascertain the strike length of the eastern mineralisation and its electrical conductivity, by placing a current electrode in drill hole QR 1 adjacent to the mineralisation.

The surface potential mapped when this electrode was energised is shown in Figure 22 and indicates electrical continuity within the eastern mineralisation between 7300N and 7550N, with possible continuity to 7200N, which was confirmed by drill results. The asymmetrical pattern is due to the effects of the far current electrode, at about 4300E on line 7500N, plus asymmetry of the host rock conductivity along strike relative to the conductivity normal to strike. The combination of these effects precludes quantitative estimation of the conductivity of the mineralisation.

At attempt was made to energise the western mineralisation via an electrode in QR 2, however, the resulting surface potential pattern suggested that the host pyroclastic unit was being energised in preference to the mineralisation.

Down-hole electrical logging of the mineralisation and lithologies could not be undertaken due to poor ground conditions which prevented the holes from remaining accessible.

IP SURVEY

Following the discovery of the western (P) ore lens in drill hole QR 2, a short Induced Polarisation survey was designed to ascertain if this technique could detect the apparently non-conductive mineralisation and possibly distinguish between the two ore types. A dipole-dipole, frequency domain survey using Geoscience equipment and frequencies of 0.3 and 3 hertz, was initially undertaken with array spacings of 25 metres and 50 metres on nine lines spaced 50 metres apart.

The resistivity and frequency effect data for line 7350N, with 25 metre spreads, are shown in Figure 23 and clearly show two types of anomalous response. The eastern conductive lens at 5275E is depicted by a strong apparent resistivity low, less than 5 ohms, in the usual "double-pants leg" pattern for a shallow tabular source. The asymmetry of the anomaly pattern is probably due to the location of electrodes relative to the conductor and the resistivity asymmetry of flanking rock-types. A broad diffuse frequency effect anomaly is evident from 5250E to 5325E, due to multiple sources and disseminated sulphides in the host pyroclastics.

The strong frequency effect anomaly deep beneath 5175E is inferred to represent the relatively non-conductive western mineralisation, which produces only a minor inflection in the resistivity gradients in this vicinity. This composite anomaly pattern is evident on lines 7300N to 7600N inclusive, beyond which the eastern anomaly becomes subordinate to the western mineralisation, as is evident in data for line 7250N (Figure 24a) and line 7800N (Figure 24b).

An important feature of the dipole-dipole pseudo-section is the apparent depth control which indicates that the eastern mineralisation outcrops whilst the western zone is "topped off" on nearly all lines. This interpretation is confirmed by the drilling results which show the western lenses only partially coming to surface, and may explain the lack of e.m. response over this lens position.

The geology for section 7350N was computer modelled for IP response, by the procedure of Dodds (1976), to confirm the above interpretation. The model results (Dodds, pers.comm.) shown in Figure 25, are in close agreement with the observed data, considering that the computer model is two dimensional. The cost of the computer modelling, to test 13 models to obtain the best fit, was equivalent to the cost of acquiring the data. The success of the computer modelling exercise, in duplicating a real, complex IP pseudo-section, illustrates the need for readily available, inexpensive programs to facilitate the use of this procedure on a routine basis prior to drilling.

The IP coverage was later extended to the north (8900N) and south (6400E) in an attempt to assist the siting of development drilling plus locate targets for exploratory drilling. This coverage was completed with 25 metres dipole on lines spaced 100 metres apart compared with the discovery grid coverage of lines spaced 50 metres apart. Plan presentation of this data, Figure 26 & 27 was accomplished by averaging the data for the first three dipole separations at each receiver position. Three dipole separations were averaged to remove the noise often evident in n=1 data plus obtaining some response from "topped-off" anomalies.

A qualitative interpretation of these results clearly shows the mineralised "host" dacite over 2500 metres strike length flanked by resistive barren andesite and dacitic units. The barren dacitic unit between the two ore lenses is clearly evident. The structural displacements which bound the ore lenses are also well illustrated, indicating the use of geophysics for post discovery geological purposes. The resistivity low over the eastern lens indicates the short strike length (300m) of the conductor which was detected in the airborne surveys relative to the strike length of the western mineralisation (700m). which was not detected.

CONCLUSIONS

The discovery of the Que River deposit resulted from the implementation of an integrated multi-technique exploration programme. The ability to focus onto a specific target, as defined by an airborne electromagnetic response coincident with a zone of anomalous stream sediment geochemistry, considerably reduced exploration expenditure.

Broad spaced stream sediment geochemistry was shown to be a valid technique in the north-west Tasmania drainage environment, and for the first time in Australia (to the authors knowledge) the airborne electromagnetic method was successful as the prime focusing technique.

Soil geochemistry was found not generally acceptable for sole selection of drilling targets due to secondary dispersion effects and the intermittent subcrop of ore lenses.

The application of several electrical and electromagnetic techniques failed to indicate the presence of the significant western sulphide mineralisation. That these ore lenses did not outcrop may partially explain the lack of responses, but effectively the mineralisation is non-conductive. The same mineralisation was strongly responsive to the induced polarisation technique.

It was therefore found to be a necessary criterion, in this environment, for drill targets to exhibit both a soil geochemical anomaly and an induced polarisation anomaly in near proximity.

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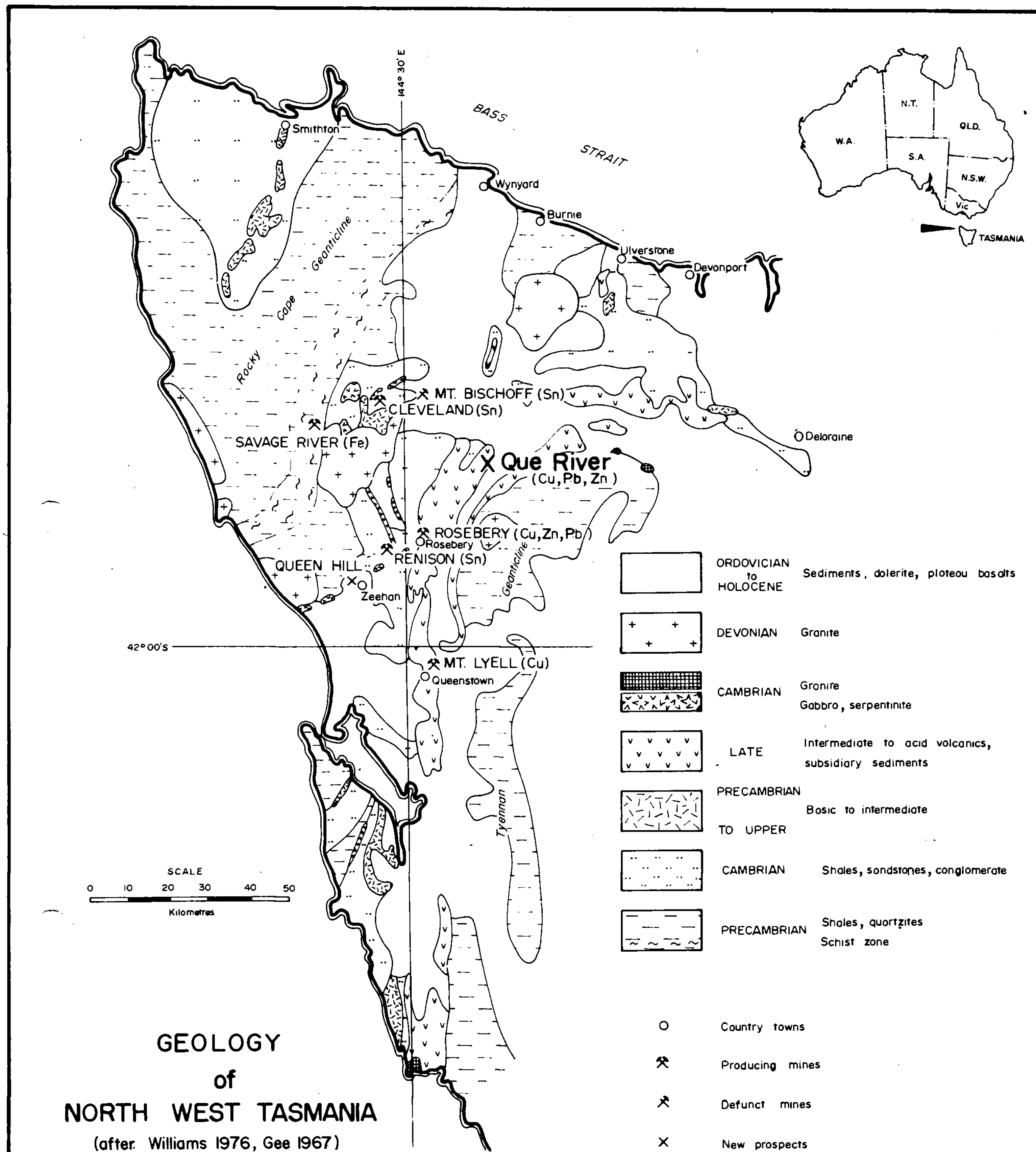


GEOLOGY
of
NORTH WEST TASMANIA
(after Williams 1976, Gee 1967)

Fig. 1

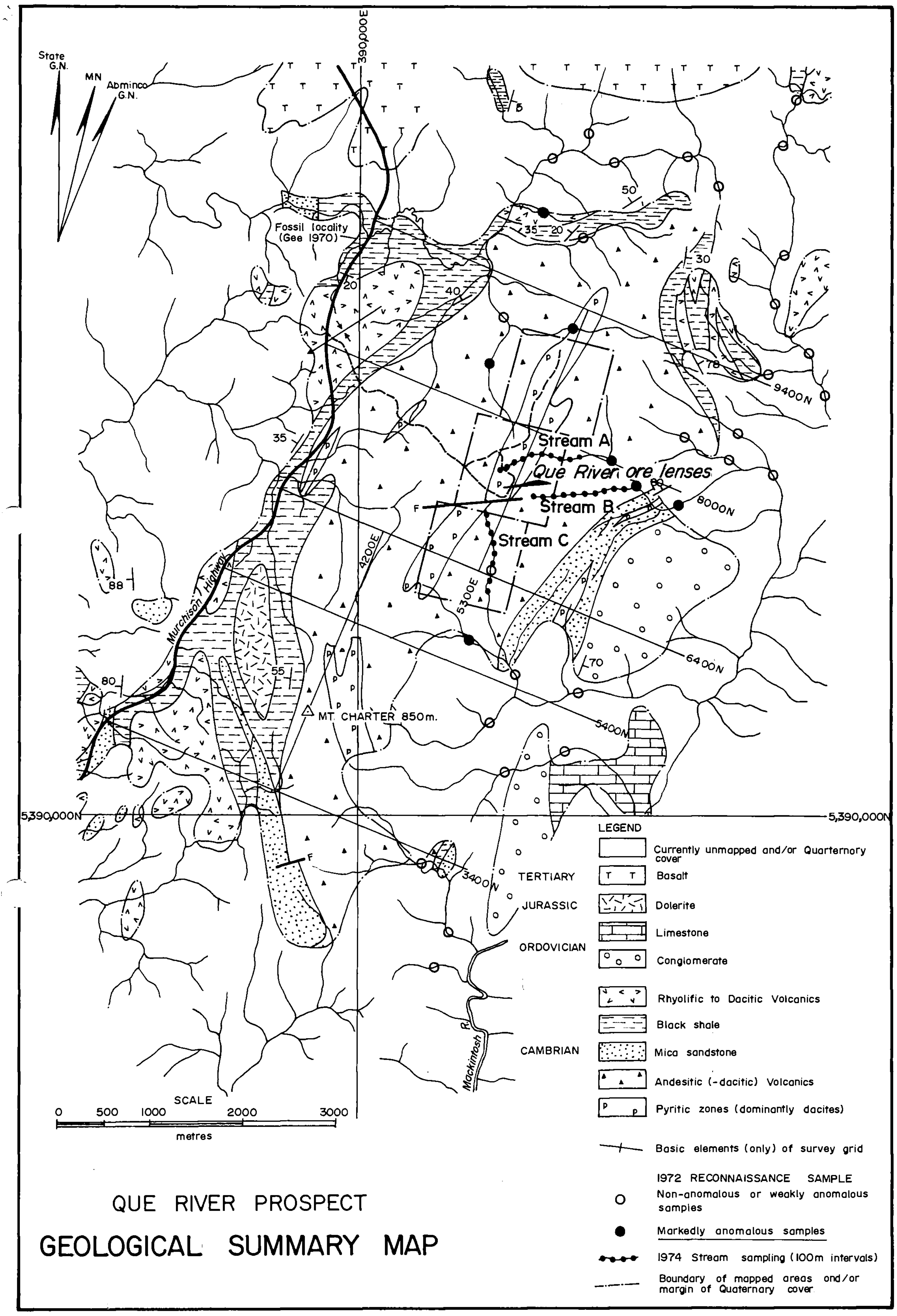
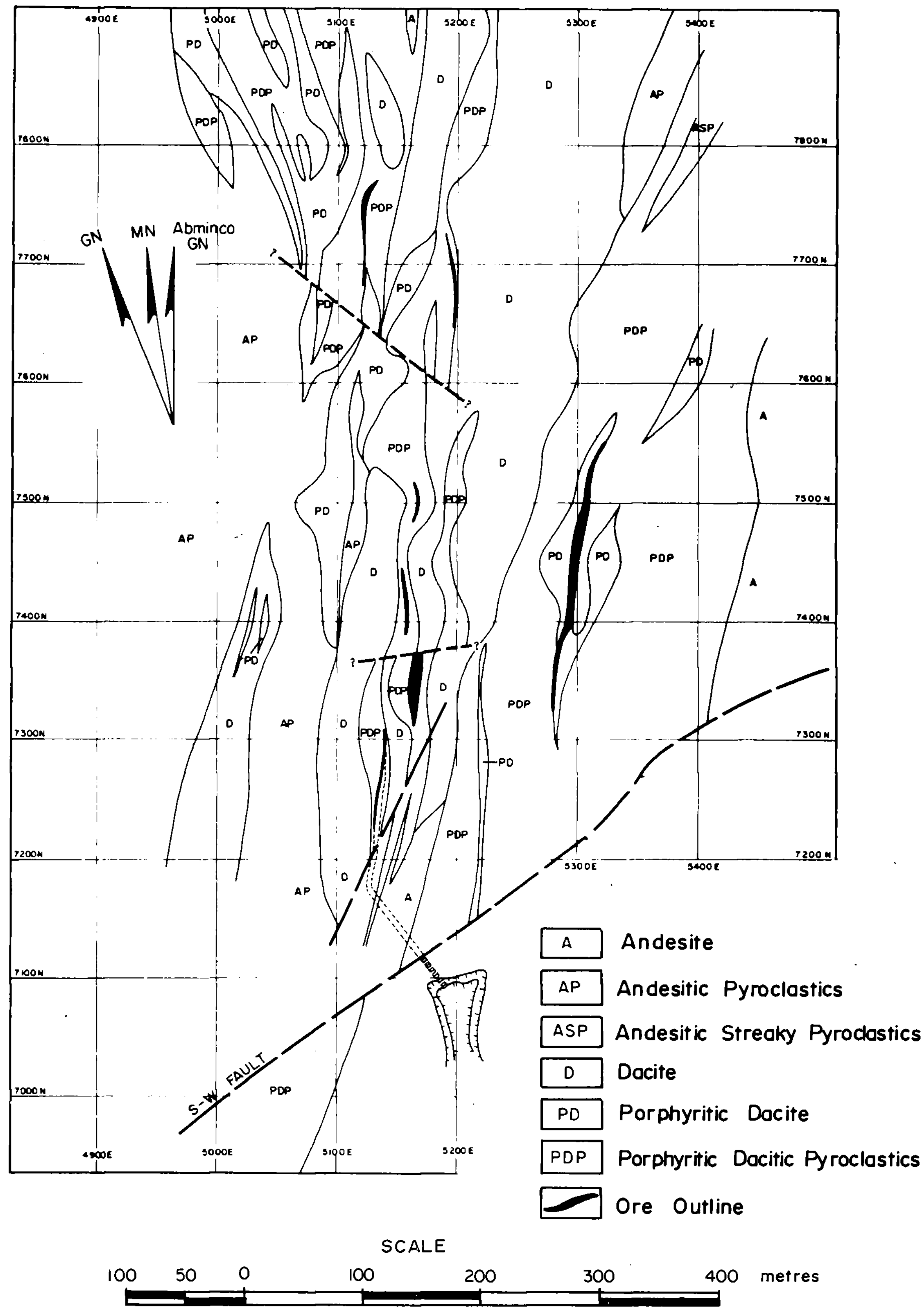

State G.N.
MN
Abminco G.N.
390,000E
Fossil locality (Gee 1970)
Stream A
Que River ore lenses
Stream B
Stream C
MT. CHARTER 850m.
Murchison Highway
4200E
5300E
9400N
8000N
6400N
5400N
3400N
5,390,000N
5,390,000N
Mackintosh R.
LEGEND
Currently unmapped and/or Quarternory cover
TERTIARY
Basalt
JURASSIC
Dolerite
ORDOVICIAN
Limestone
Conglomerate
CAMBRIAN
Rhyolific to Dacitic Volcanics
Black shale
Mica sandstone
Andesitic (-dacitic) Volcanics
Pyritic zones (dominantly dacites)
Basic elements (only) of survey grid
1972 RECONNAISSANCE SAMPLE
Non-anomalous or weakly anomalous samples
Markedly anomalous samples
1974 Stream sampling (100m intervals)
Boundary of mapped areas and/or margin of Quaternary cover
SCALE
0 500 1000 2000 3000
metres
QUE RIVER PROSPECT
GEOLOGICAL SUMMARY MAP

FIG. 2



INTERPRETIVE SURFACE GEOLOGY

Fig. 3

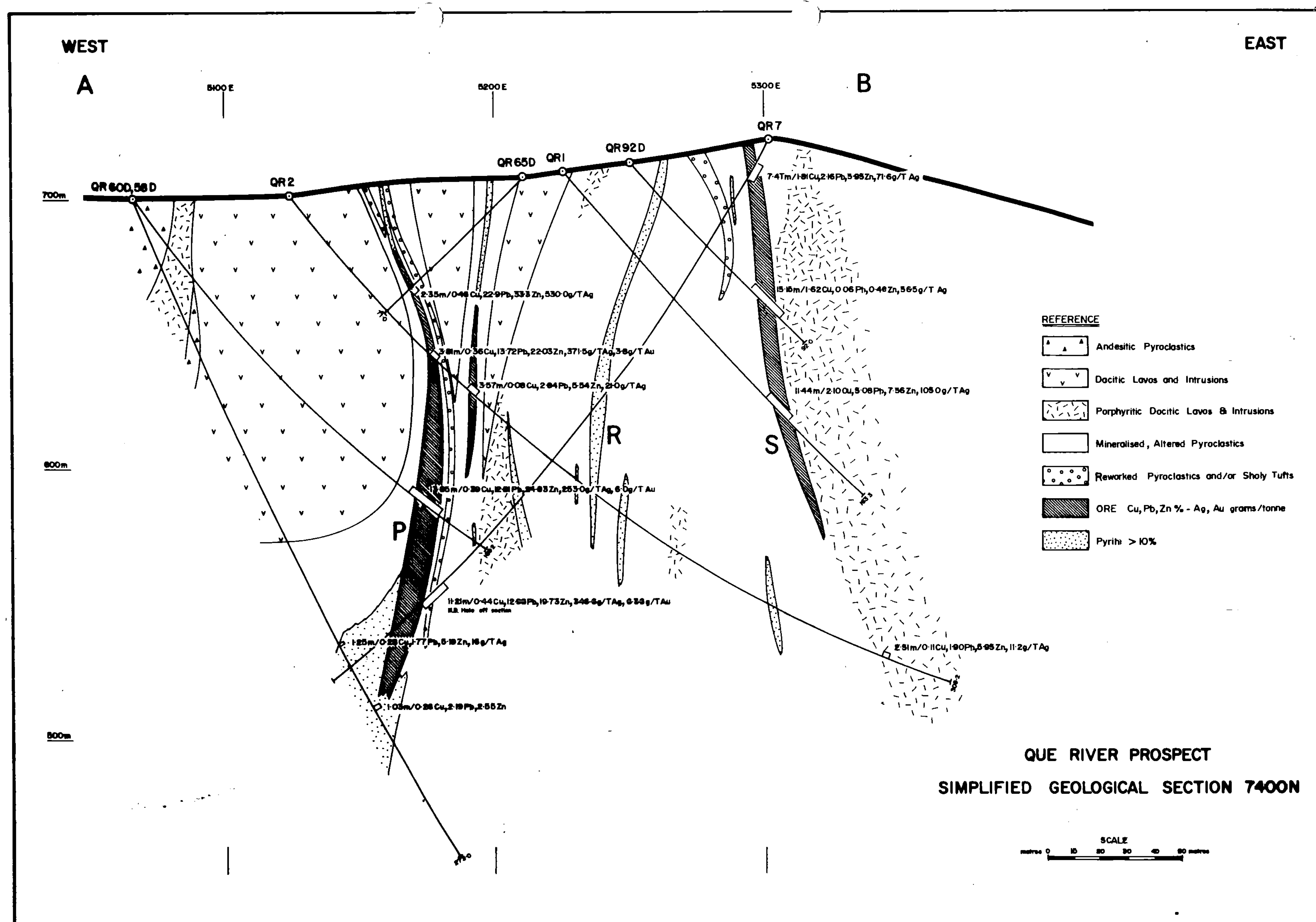
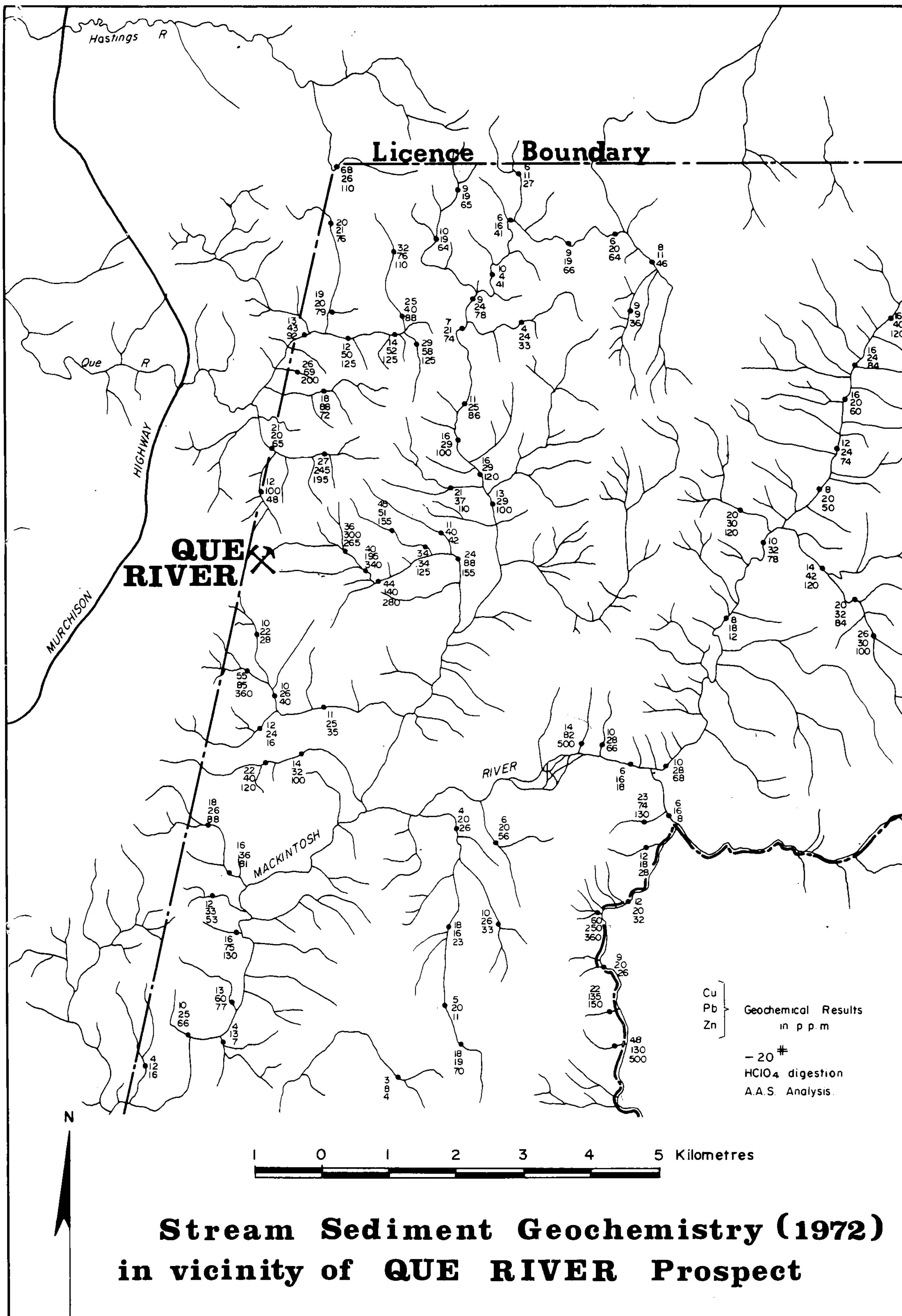
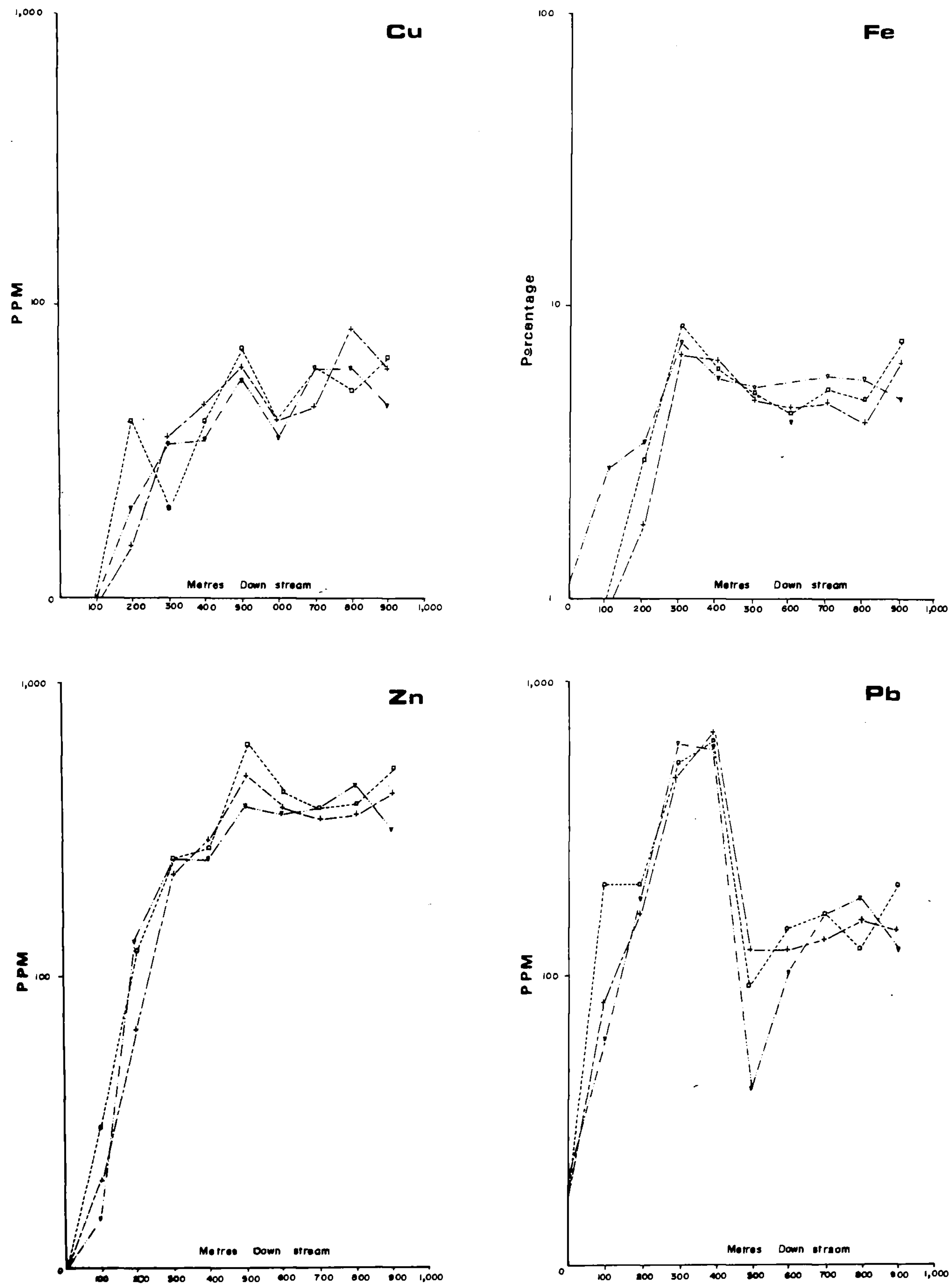

WEST
EAST
A
B
5100 E
5200 E
5300 E
QR 60D,58D
QR 2
QR 65D
QR 1
QR 92D
QR 7
700m
600m
500m
P
R
S
2·35m/0·46Cu,22·9Pb,33·3Zn,530·0g/TAg
3·81m/0·36Cu,13·72Pb,22·03Zn,371·5g/TAg,3·8g/T Au
3·57m/0·08Cu,2·64Pb,5·54Zn,21·0g/TAg
11·21m/0·44Cu,12·63Pb,10·73Zn
N.B. Hole off section
1·03m/0·28Cu,2·19Pb,2·55Zn
7·4Tm/1·81Cu,2·16Pb,5·95Zn,71·6g/T Ag
15·16m/1·62Cu,0·06Pb,0·46Zn,56·5g/T Ag
11·44m/2·10Cu,5·08Pb,7·56Zn,105·0g/TAg
2·51m/0·11Cu,1·90Pb,5·95Zn,11·2g/TAg
REFERENCE
Andesitic Pyroclastics
Dacitic Lavas and Intrusions
Porphyritic Dacitic Lavas & Intrusions
Mineralised, Altered Pyroclastics
Reworked Pyroclastics and/or Shaly Tuffs
ORE Cu, Pb, Zn % - Ag, Au grams/tonne
Pyrite > 10%
QUE RIVER PROSPECT
SIMPLIFIED GEOLOGICAL SECTION 7400N
SCALE
metres 0 10 20 30 40 50 metres

FIG. 4



Stream Sediment Geochemistry (1972) in vicinity of QUE RIVER Prospect

FIG. 5



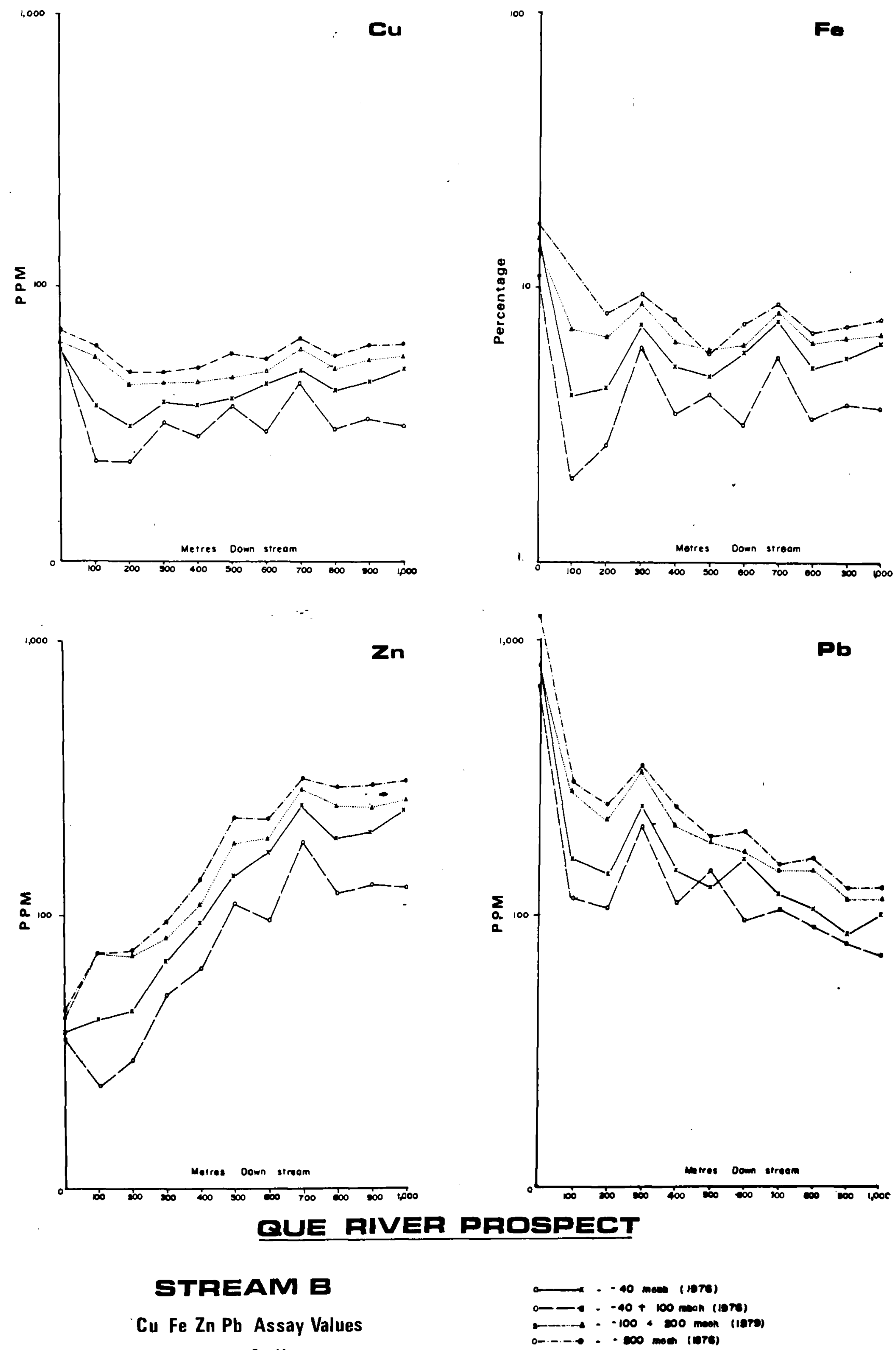
QUE RIVER PROSPECT

STREAM C

Cu, Fe, Zn, Pb Assay Values
in Stream Sediments
Stream Commences 5145E 7050N

- -40 + 120 mesh (1974)
- -120 + 200 mesh (1974)
- -200 mesh (1974)

FIG. 6



QUE RIVER PROSPECT

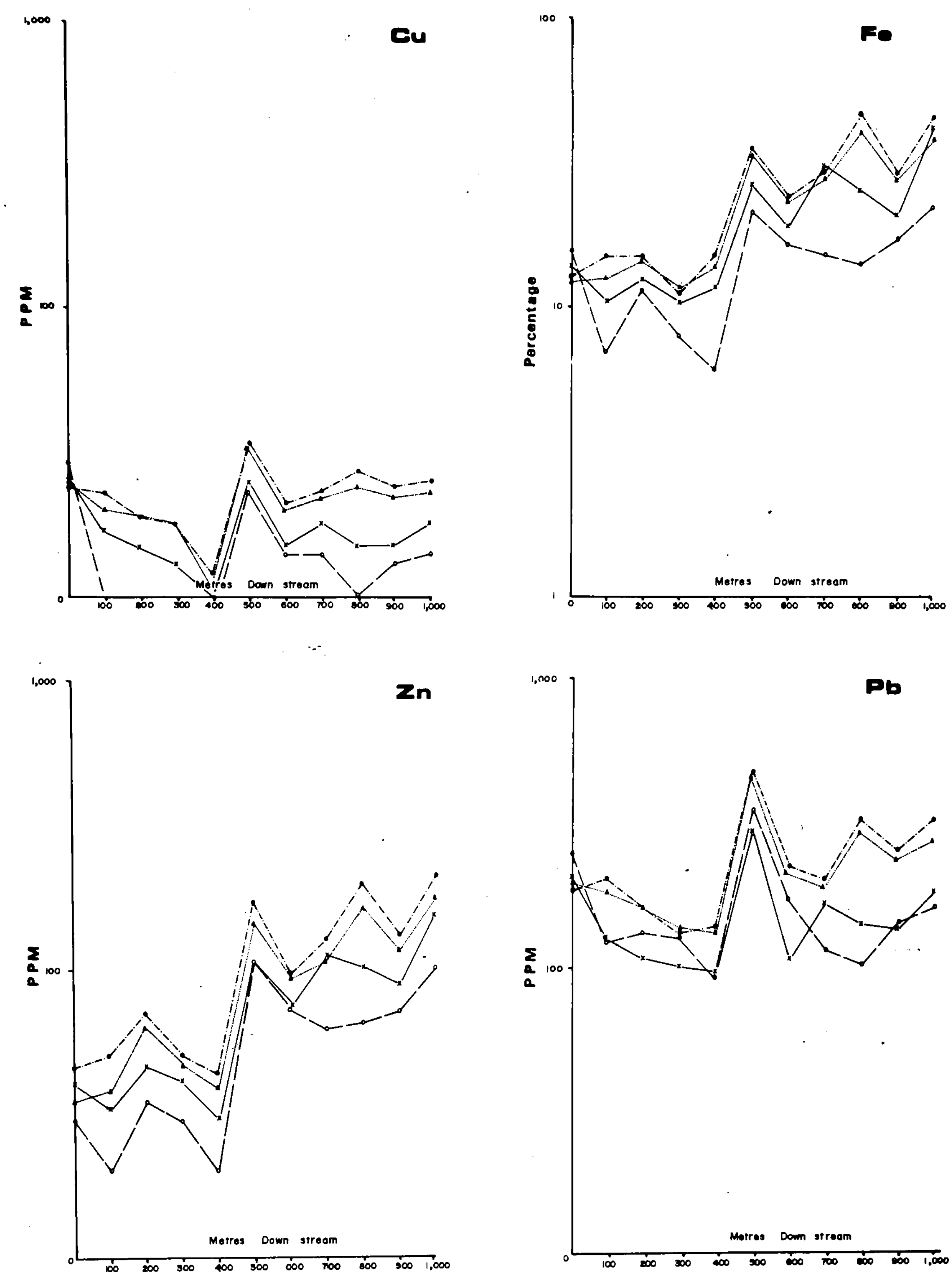
STREAM B

Cu Fe Zn Pb Assay Values

in Stream Sediments

Stream Commences 5400E 7300N

FIG. 7



QUE RIVER PROSPECT

STREAM A

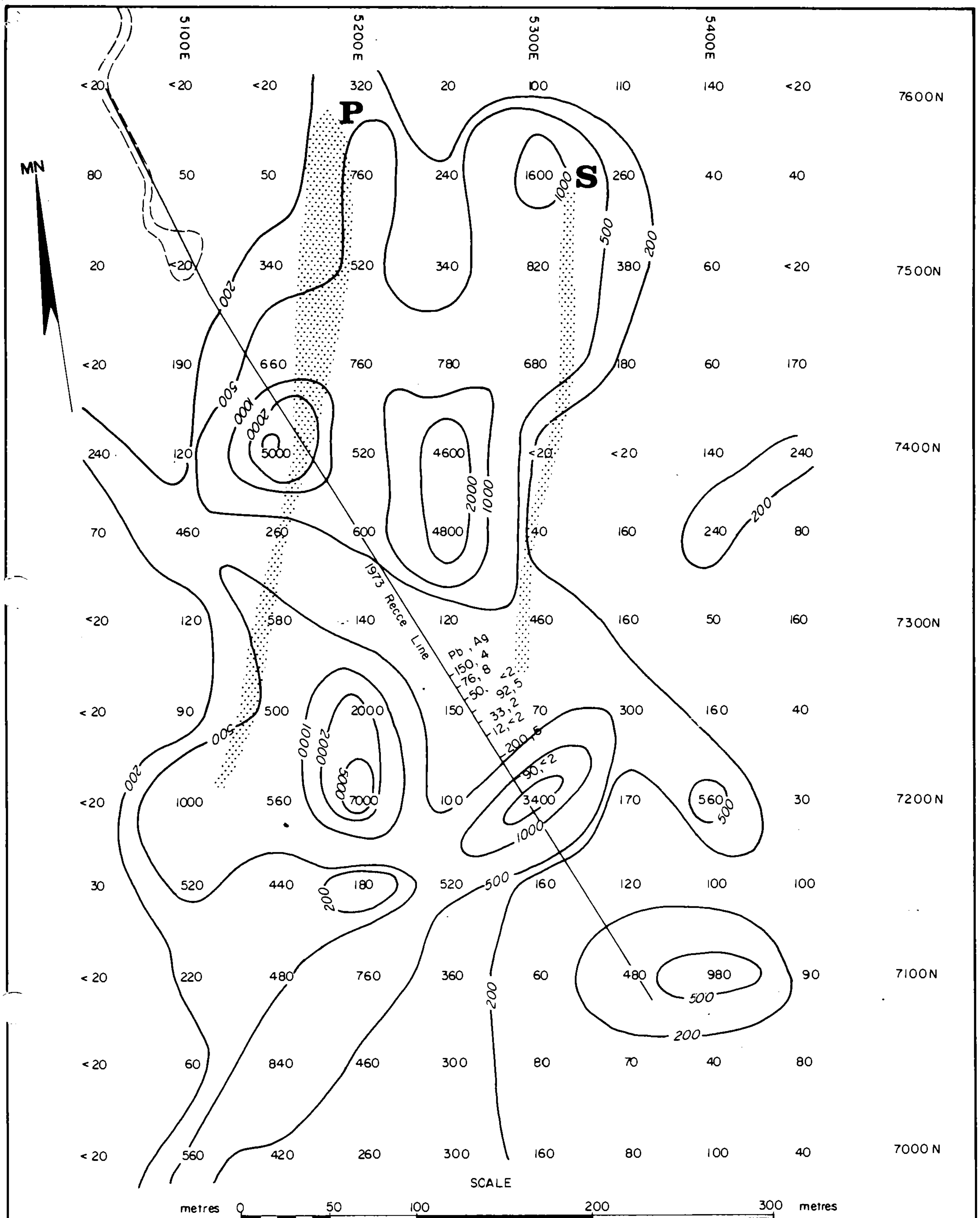
Cu, Fe, Zn, Pb Assay Values

in Stream Sediments

Stream Commences 5100E, 7475N

x——x - -40 mesh (1976)
o— —o - -40 + 100 mesh (1976)
A·······A - -100 + 200 mesh (1976)
o—·—o - -200 mesh (1976)

FIG. 8



All values shown in ppm

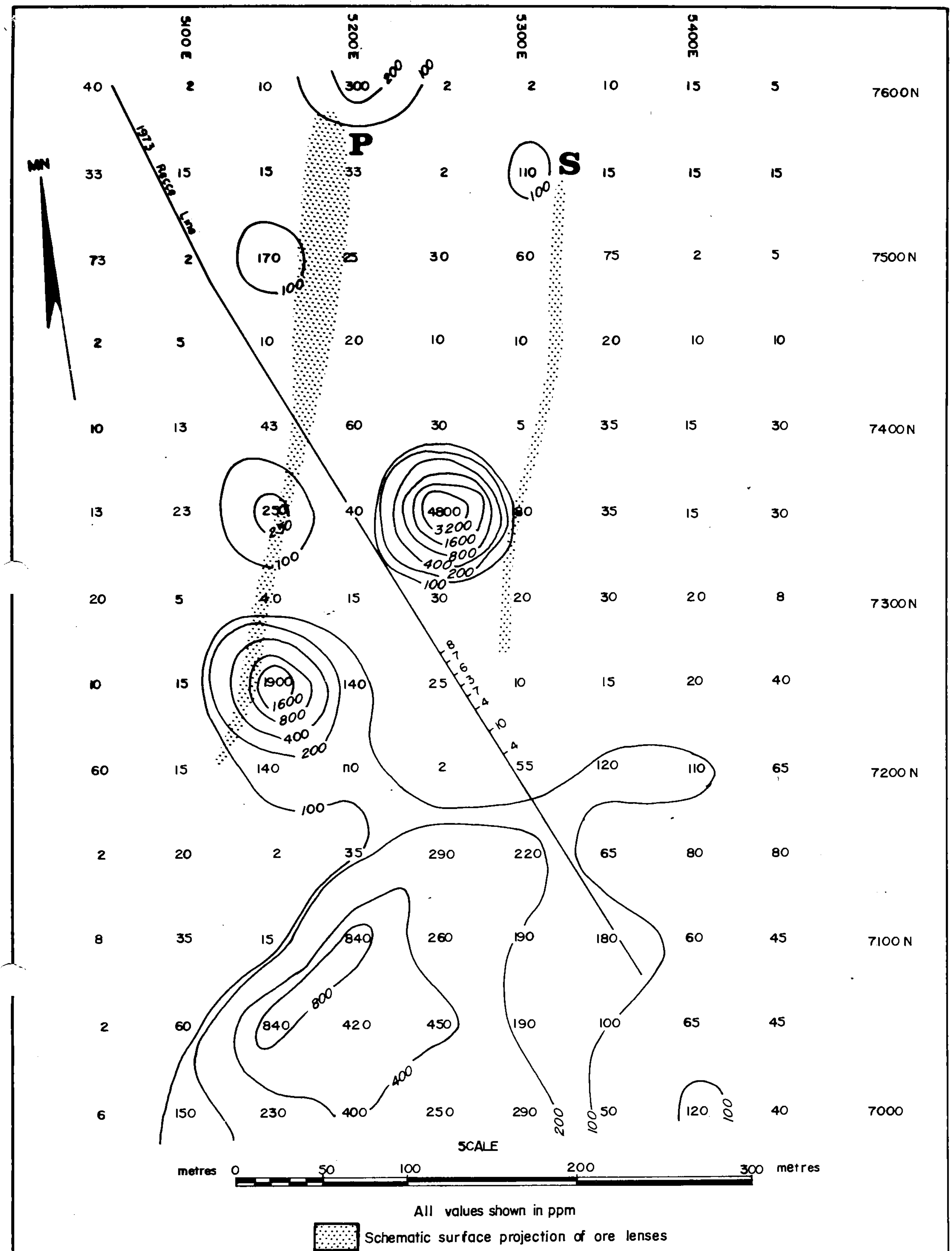
Schematic surface projection of ore lenses

QUE RIVER PROSPECT

Lead Values - 'C' Horizon Soils

50m x 50m Grid

FIG. 9

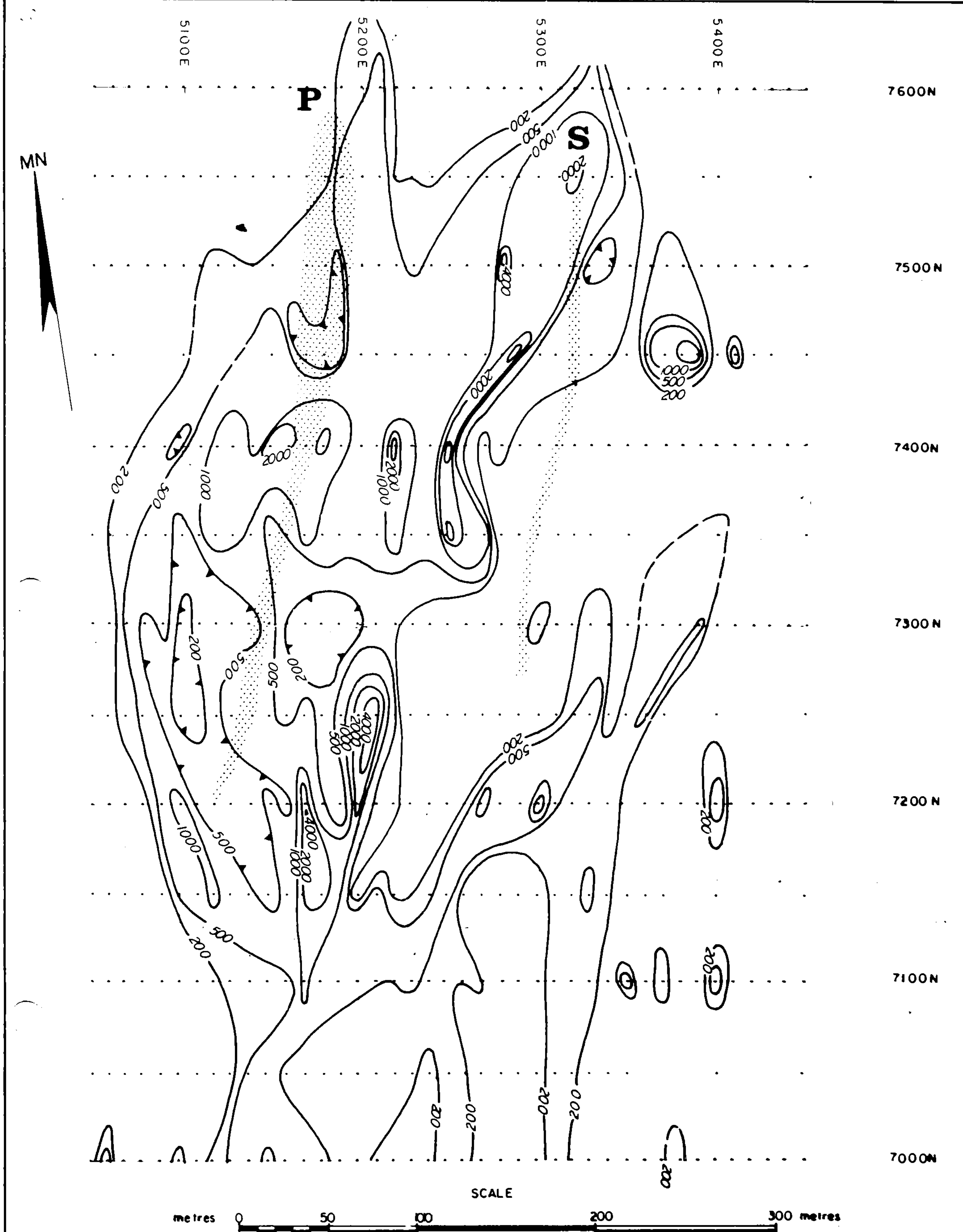


QUE RIVER PROSPECT

Zinc Values 'C' Horizon Soils

50m x 50m Grid

FIG. 10



All values shown in ppm

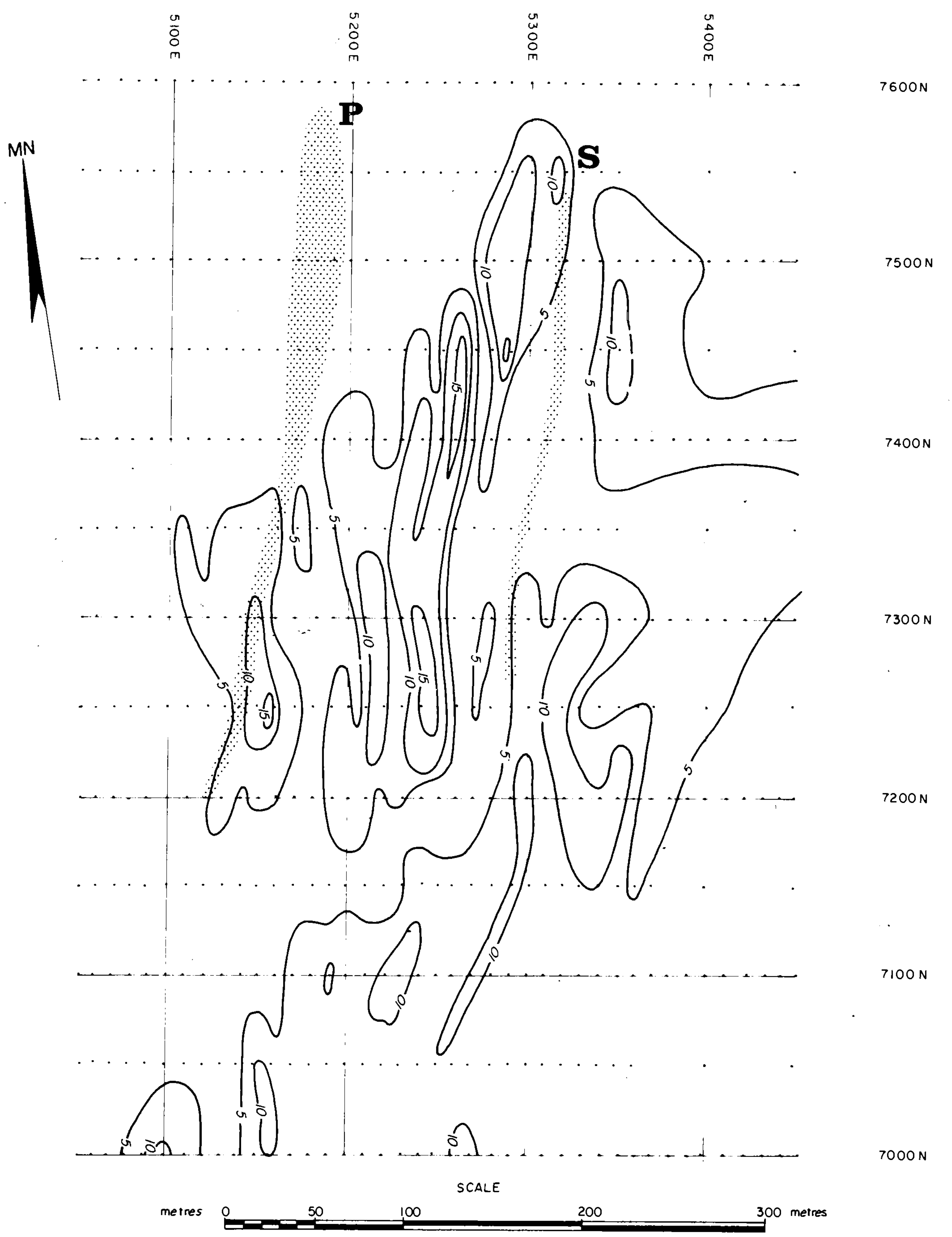
Schematic surface projection of ore lenses

QUE RIVER PROSPECT

Lead in 'C' Horizon Soils

50m x 10m Grid

FIG. 11



All values shown in percentage

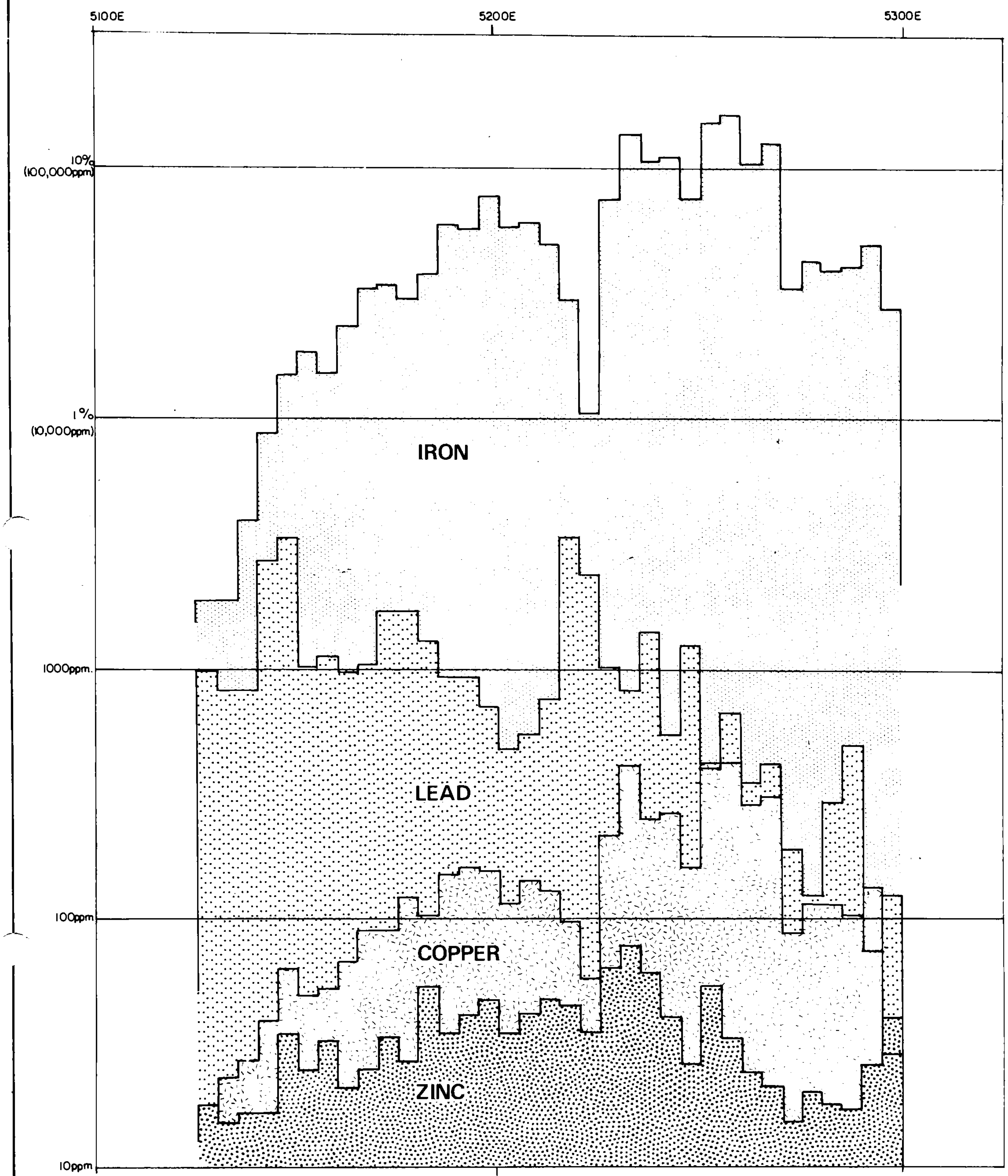
Schematic surface projection of ore lenses

QUE RIVER PROSPECT

Iron in 'C' Horizon Soils

50m x 10m Grid

FIG. 12



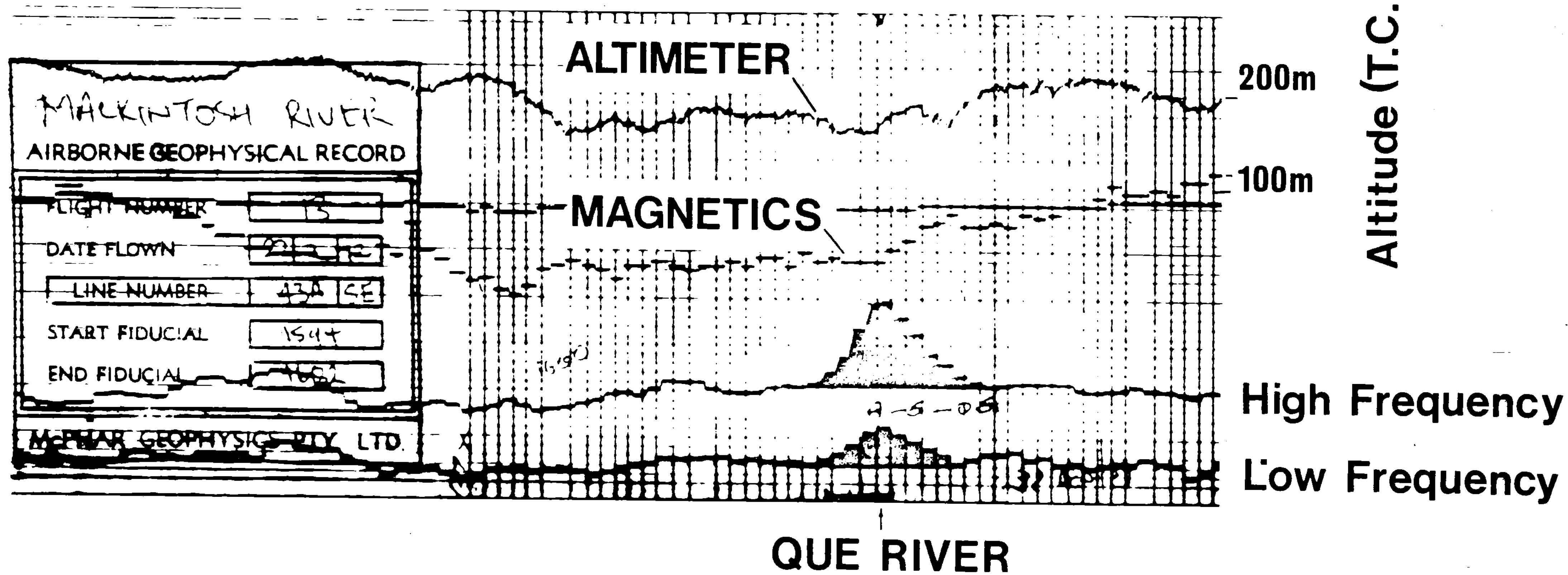
NOTE Each bar is arithmetic mean of 5 samples collected at an 1m spacing

QUE RIVER

'C' HORIZON SOIL SAMPLING

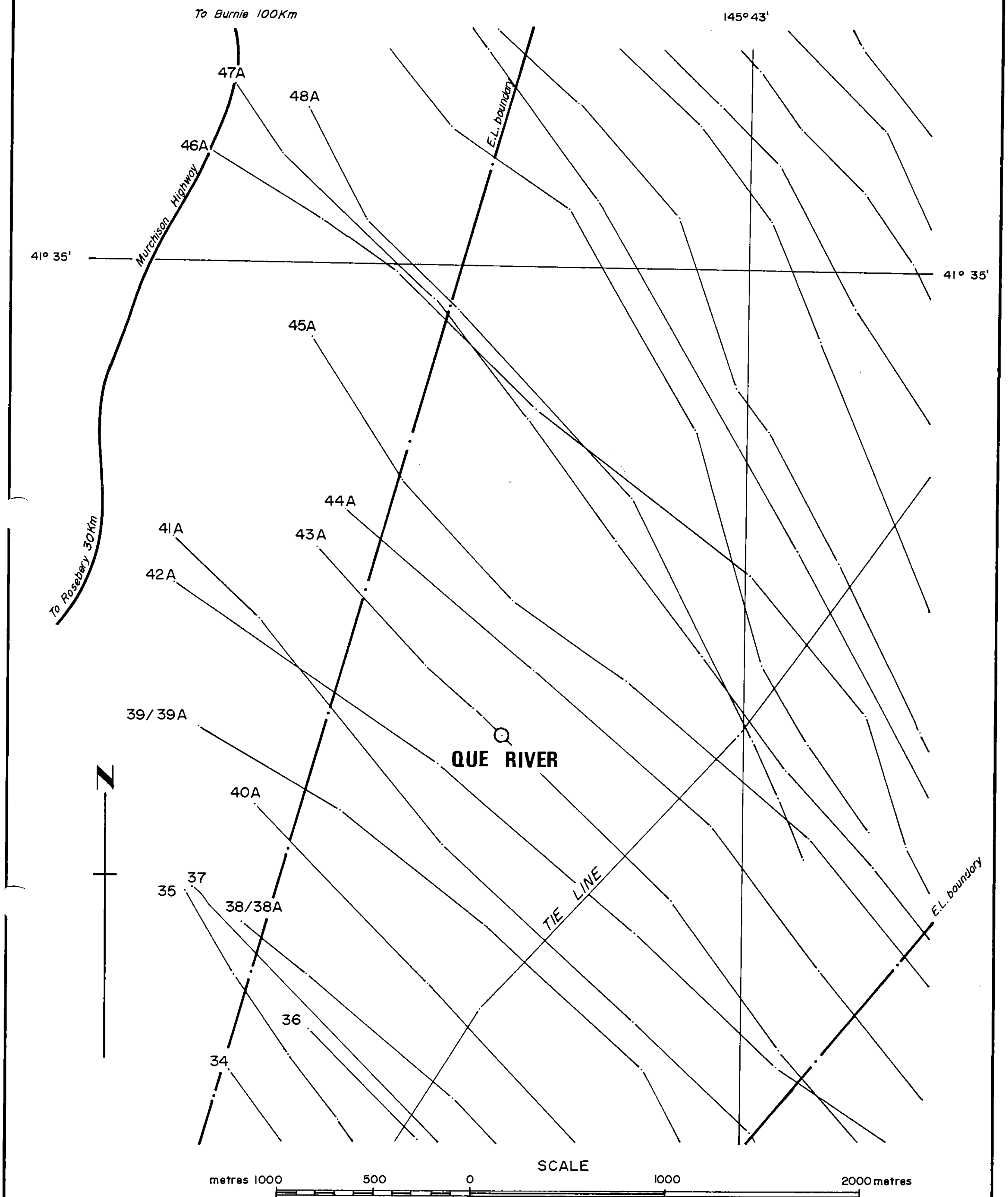
7400N

FIG. 13



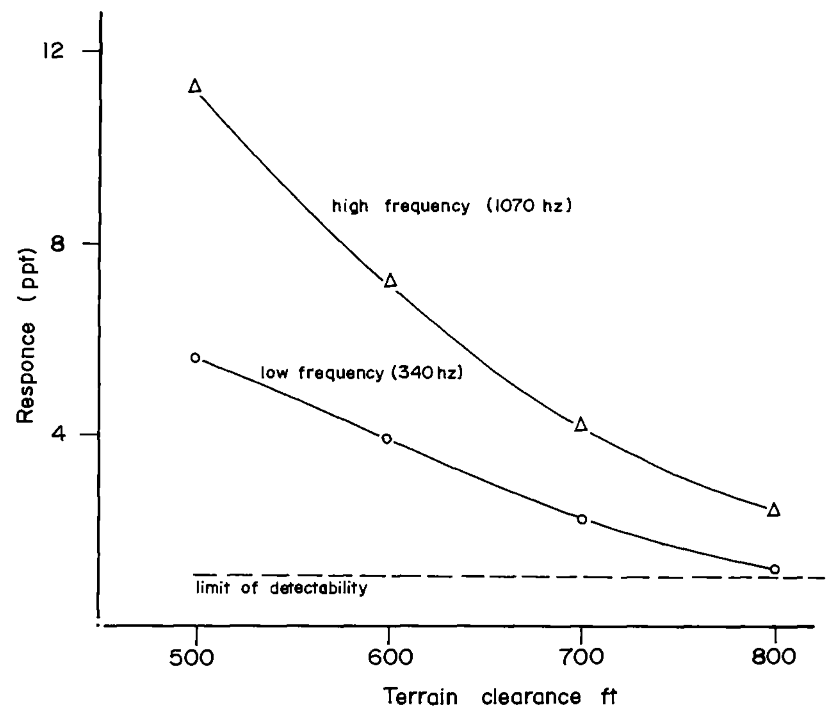
AIRBORNE ELECTRO-MAGNETIC DISCOVERY TRAVERSE McPHAR H400 - 1972

FIG. 14



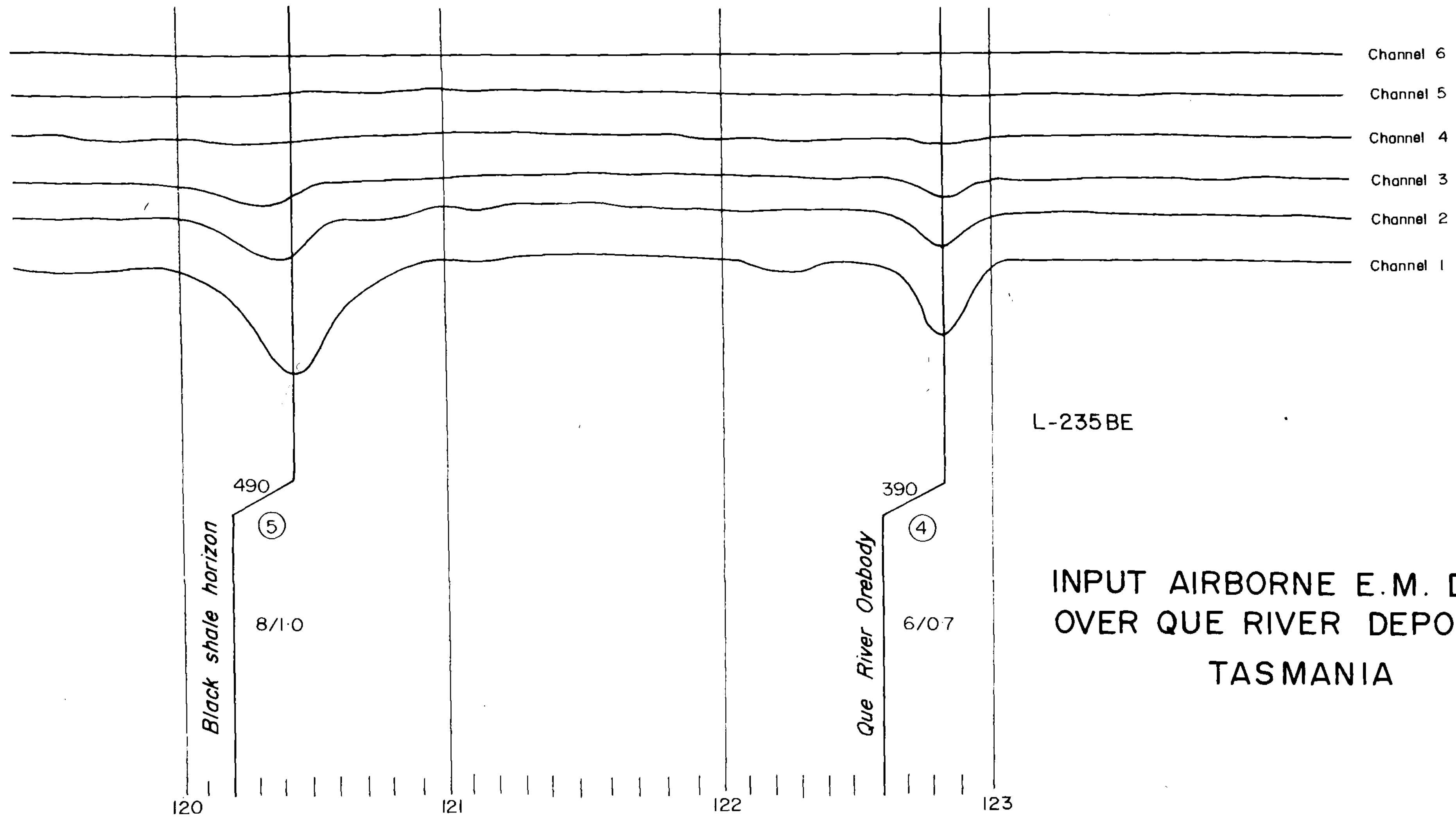
FLIGHT PATH RECOVERY
Airborne E.M. Survey
1972

FIG. 15



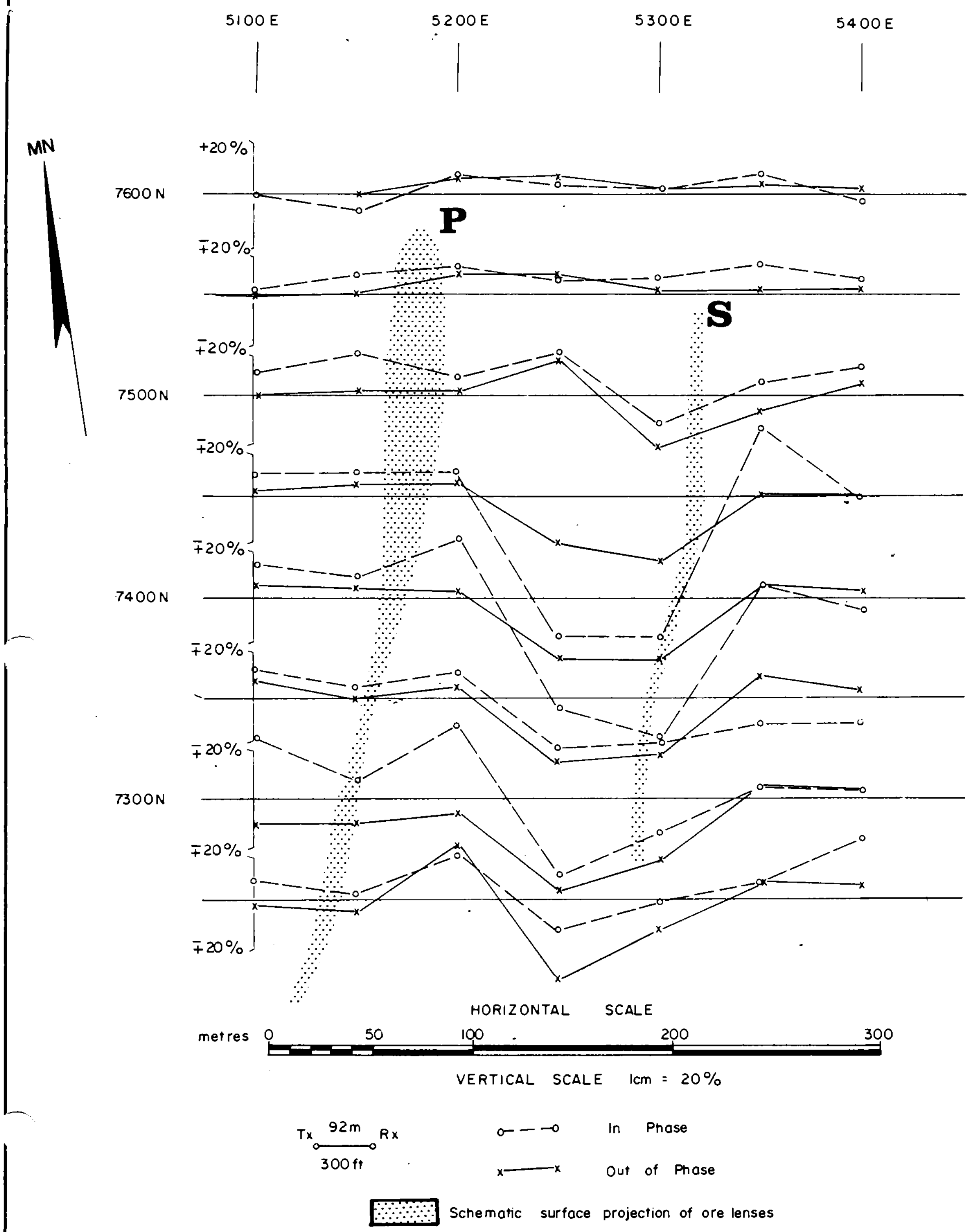
H-400 E.M. System
Attenuation tests over Que River Anomaly

FIG. 16



INPUT AIRBORNE E.M. DATA
OVER QUE RIVER DEPOSIT
TASMANIA

FIG. 17

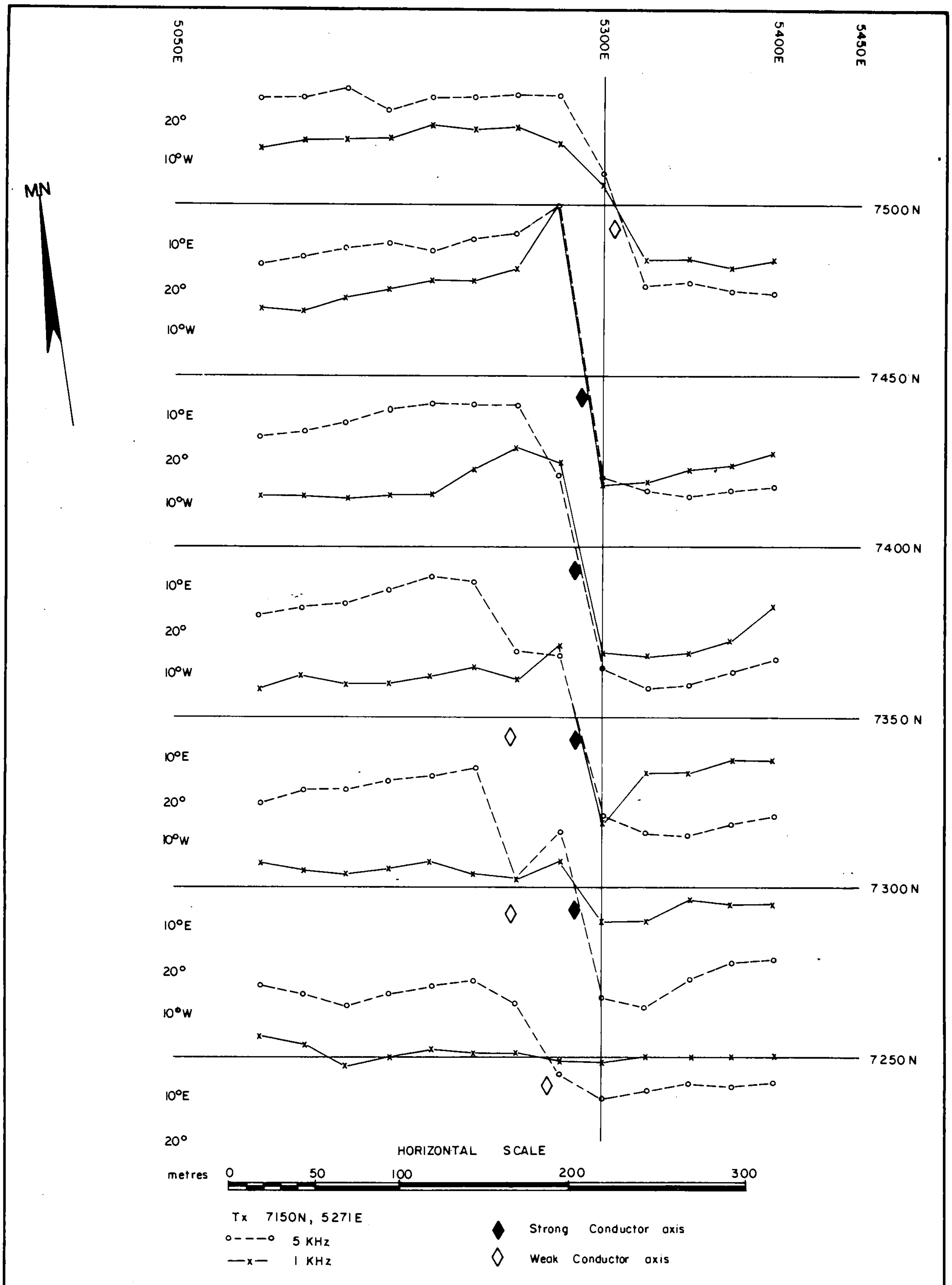


QUE RIVER PROSPECT

Horizontal Loop E.M. Profiles

High Frequency (2400 Hz) data

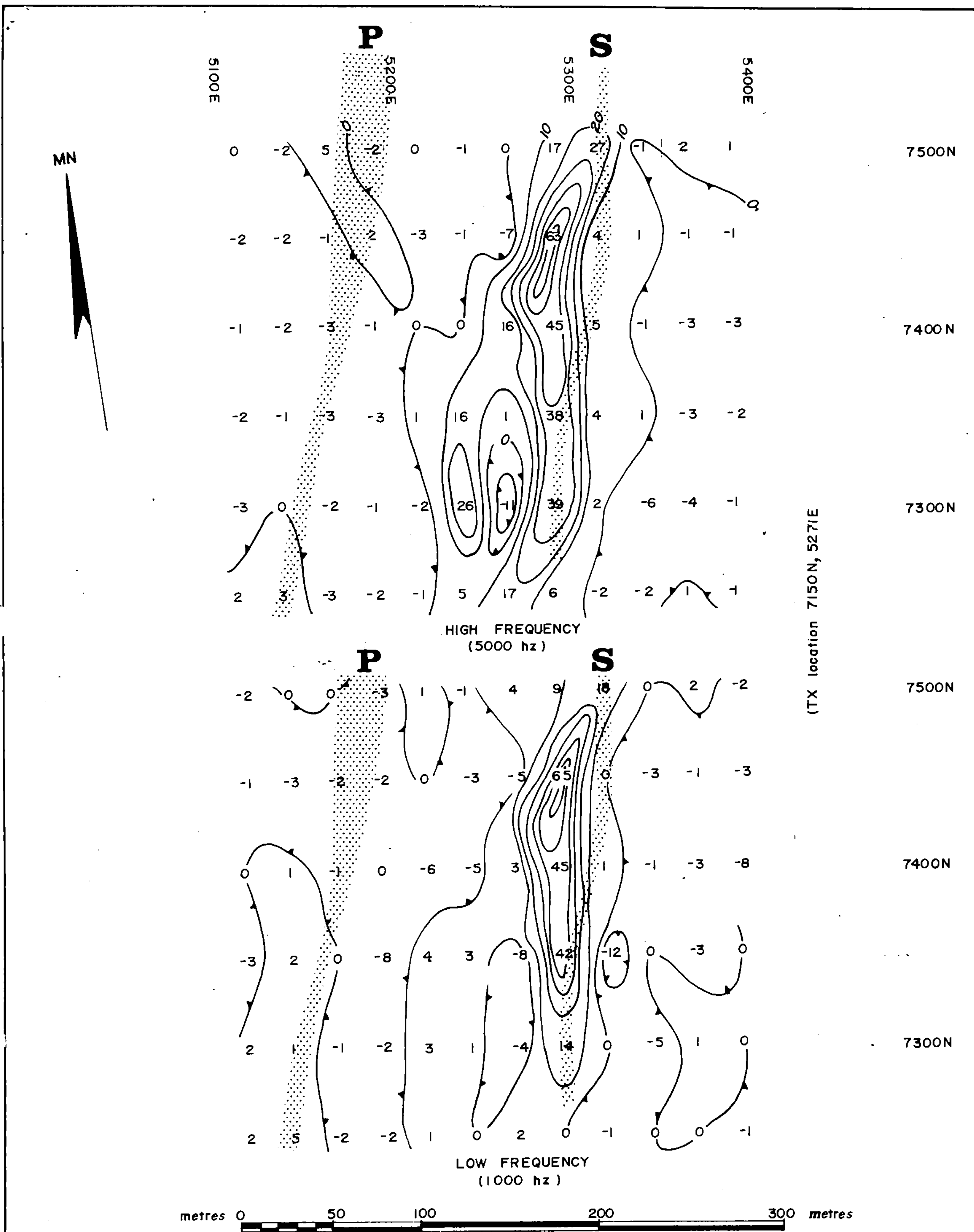
FIG. 18



QUE RIVER PROSPECT

Vertical Loop E.M.

FIG. 19



QUE RIVER PROSPECT

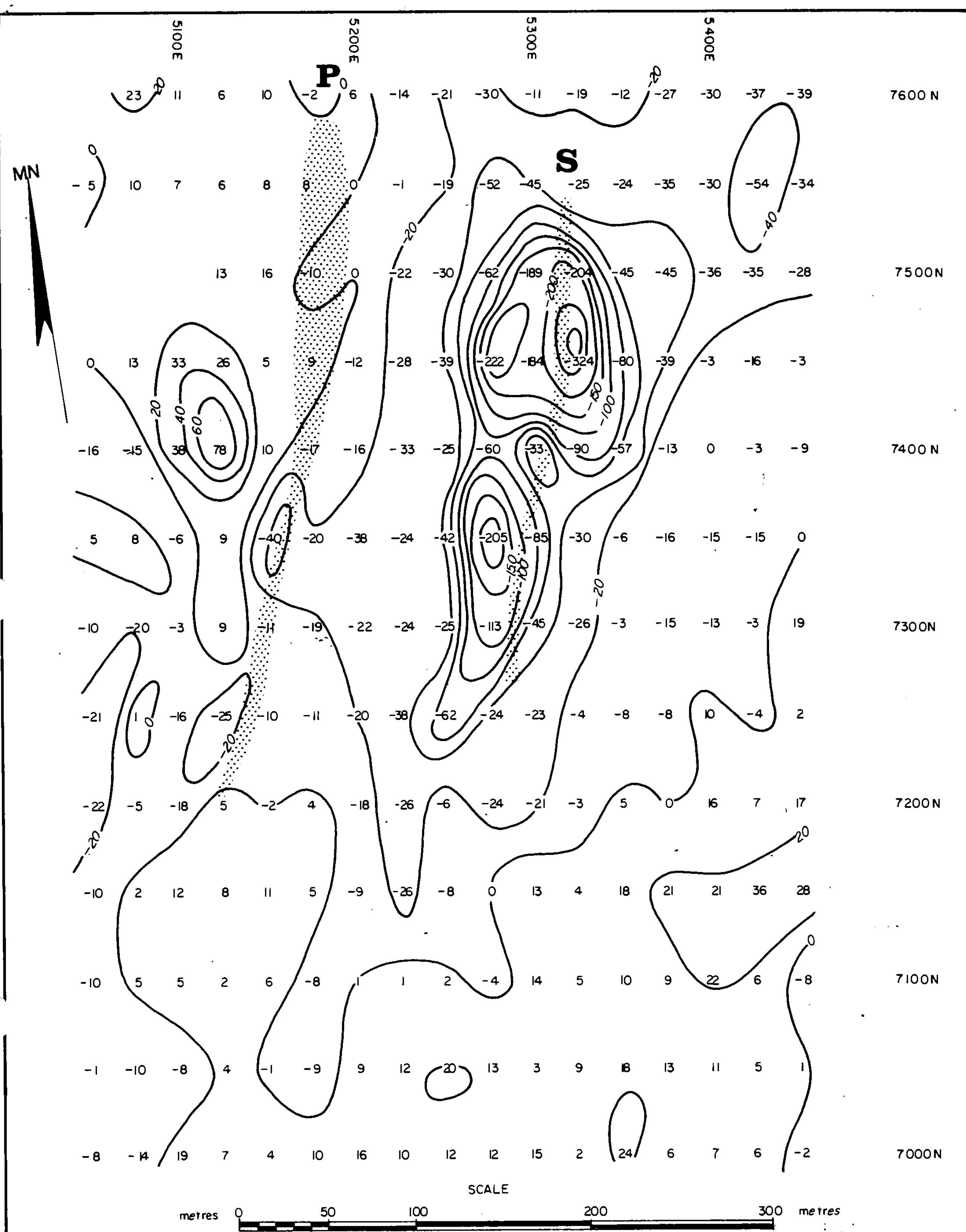
Vertical Loop EM Data

(Transformed and contoured after Fraser)
(1969)

Schematic surface projection of ore lenses

Contour Interval 10%/25m

FIG. 20



Contour Interval ± 20 mv to −100 mv thence 50 mv

QUE RIVER PROSPECT

Self - Potential Contours

Schematic surface projection of ore lenses

FIG. 21

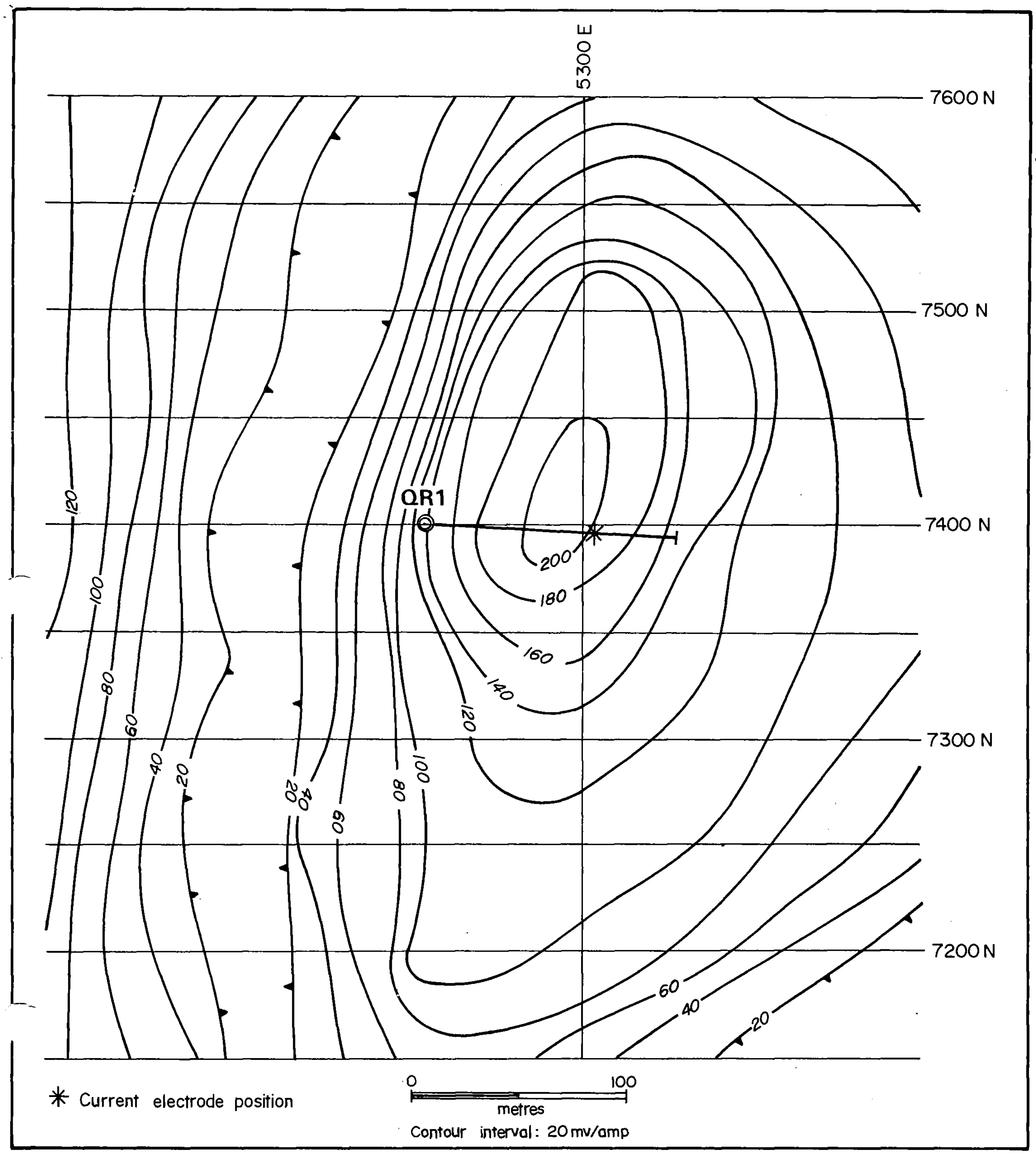
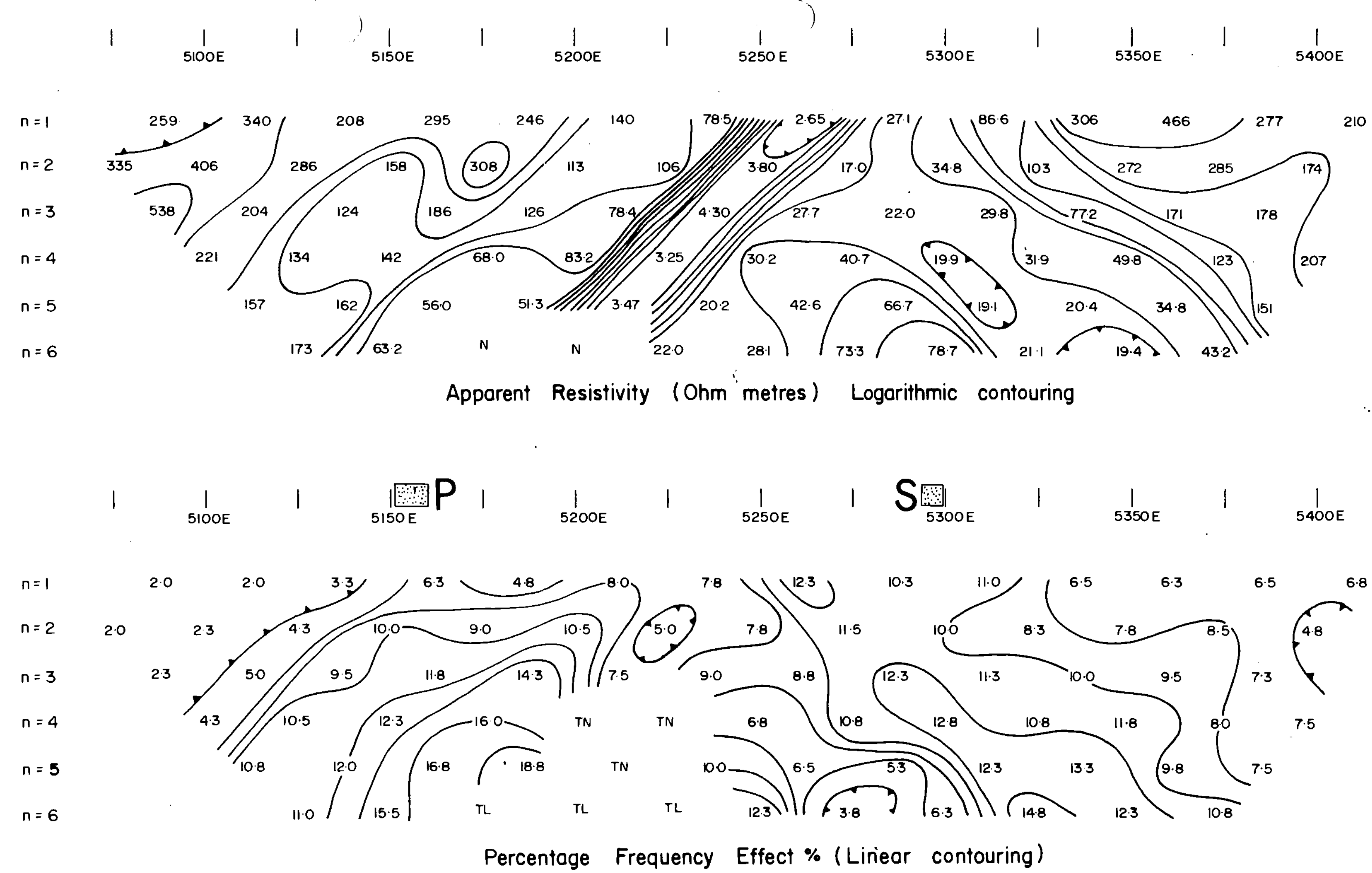


Figure 22. Mise a la masse survey - Que River

Current in eastern mineralisation via drill hole QR I



QUE RIVER PROSPECT

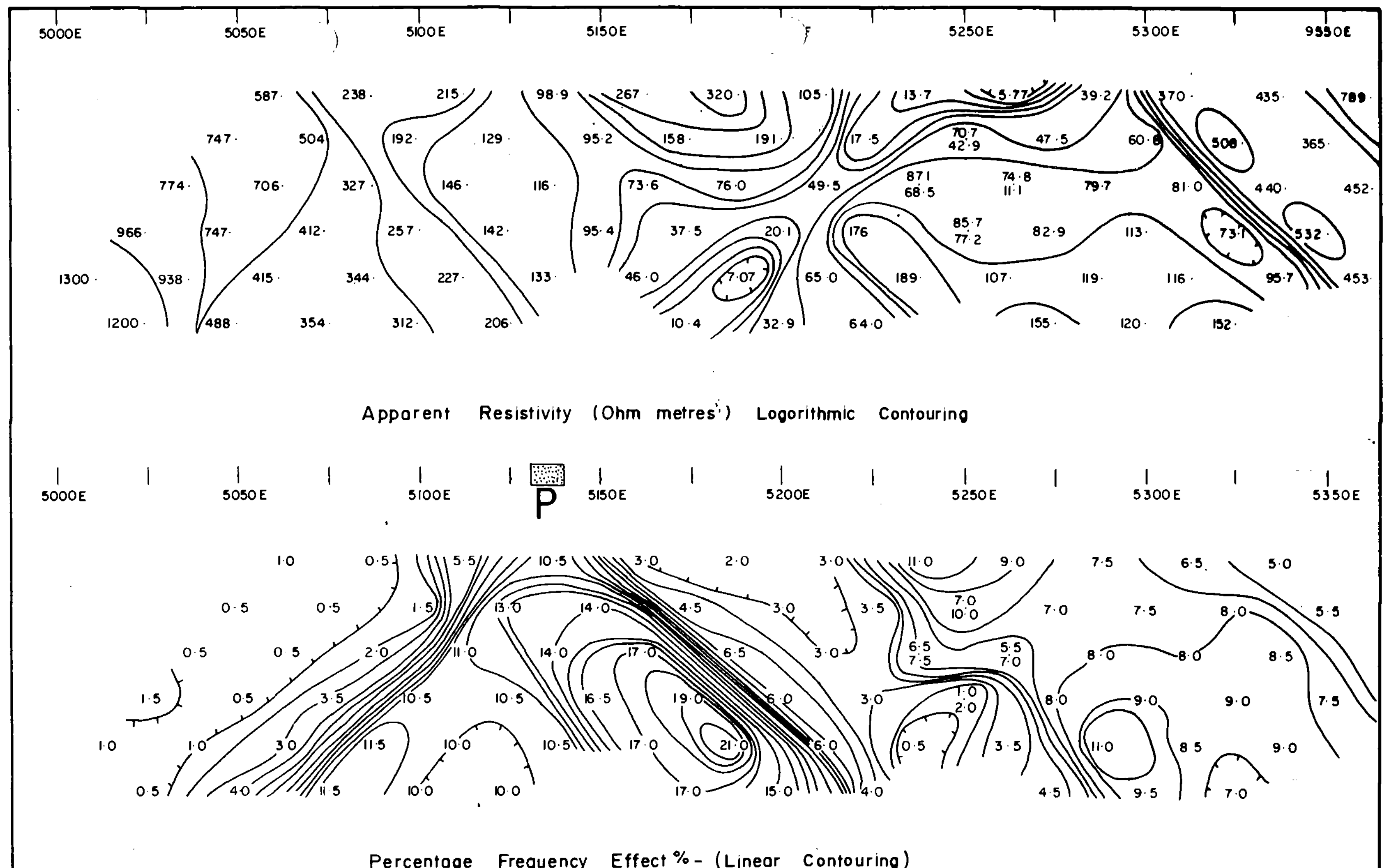
Resistivity and I.P. Survey - Traverse 7380N

Frequencies 2·5-0·3 Hz

0 25 50 100 metres

TN,TL Readings either too noisy or voltage too low for measurement

FIG. 23



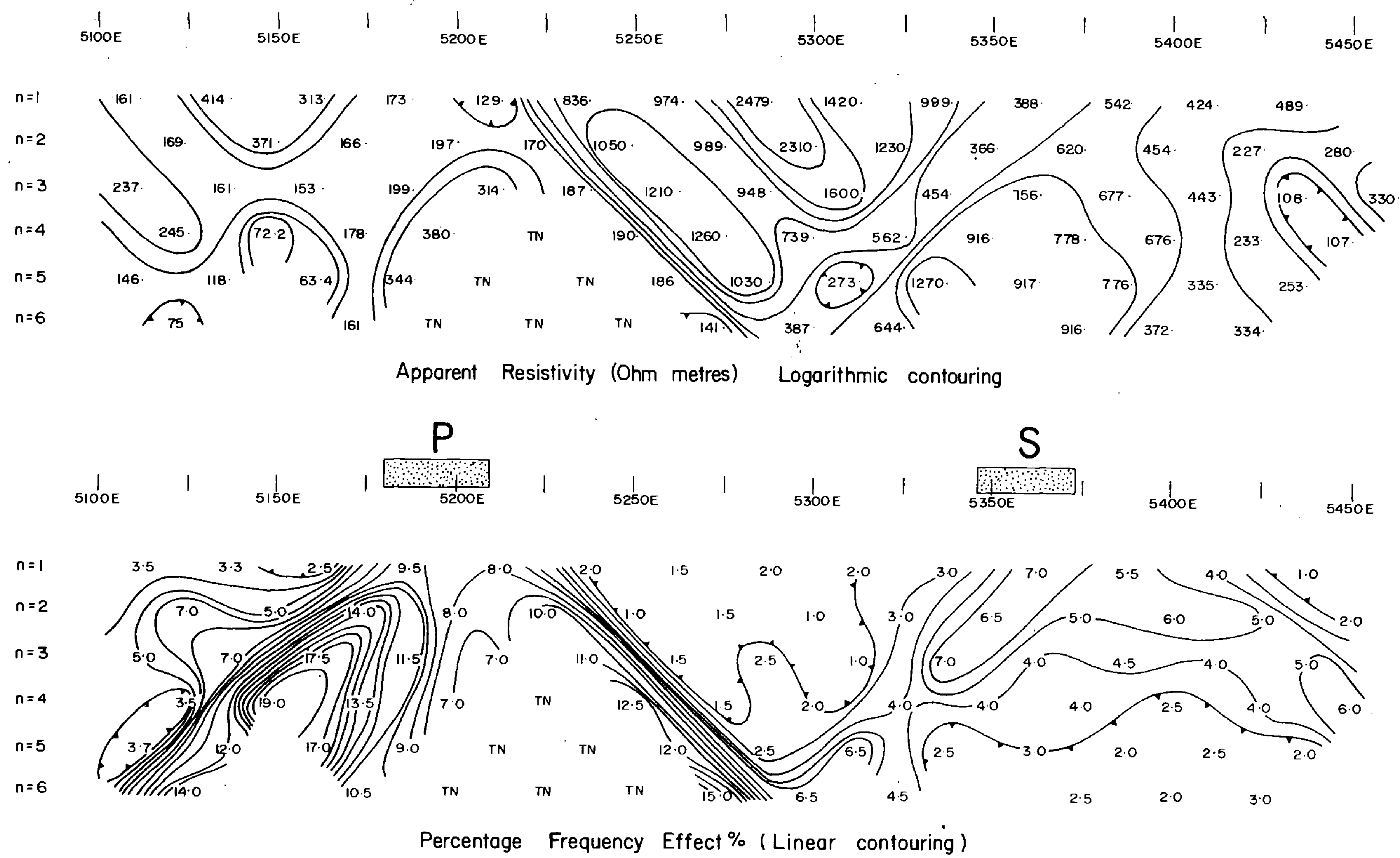
QUE RIVER PROSPECT

Resistivity and I.P. Survey - Traverse 7250N

FREQUENCIES 2·5 – 0·3 Hz

0 25 50 100 metres

FIG. 24a



QUE RIVER PROSPECT

Resistivity and I.P. Survey - Traverse 7800N

Frequencies 2·5-0·3Hz

0 25 50 100 metres

TN Readings not taken

FIG. 24b

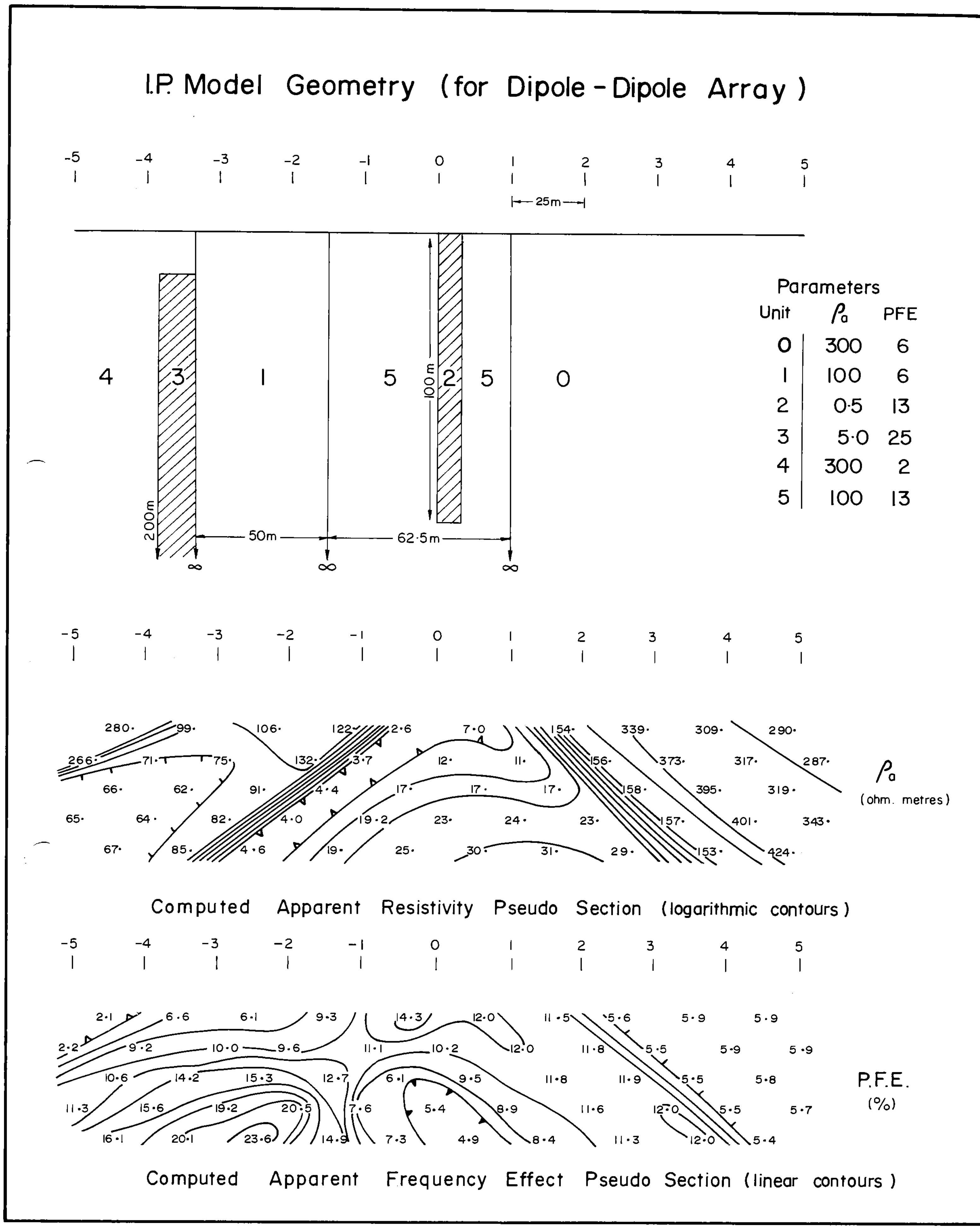

I.P. Model Geometry (for Dipole - Dipole Array)
25m
100m
200m
50m
62·5m
Parameters
Unit ρa PFE
0 300 6
1 100 6
2 0·5 13
3 5·0 25
4 300 2
5 100 13
ρa (ohm. metres)
Computed Apparent Resistivity Pseudo Section (logarithmic contours)
P.F.E. (%)
Computed Apparent Frequency Effect Pseudo Section (linear contours)

FIG. 25

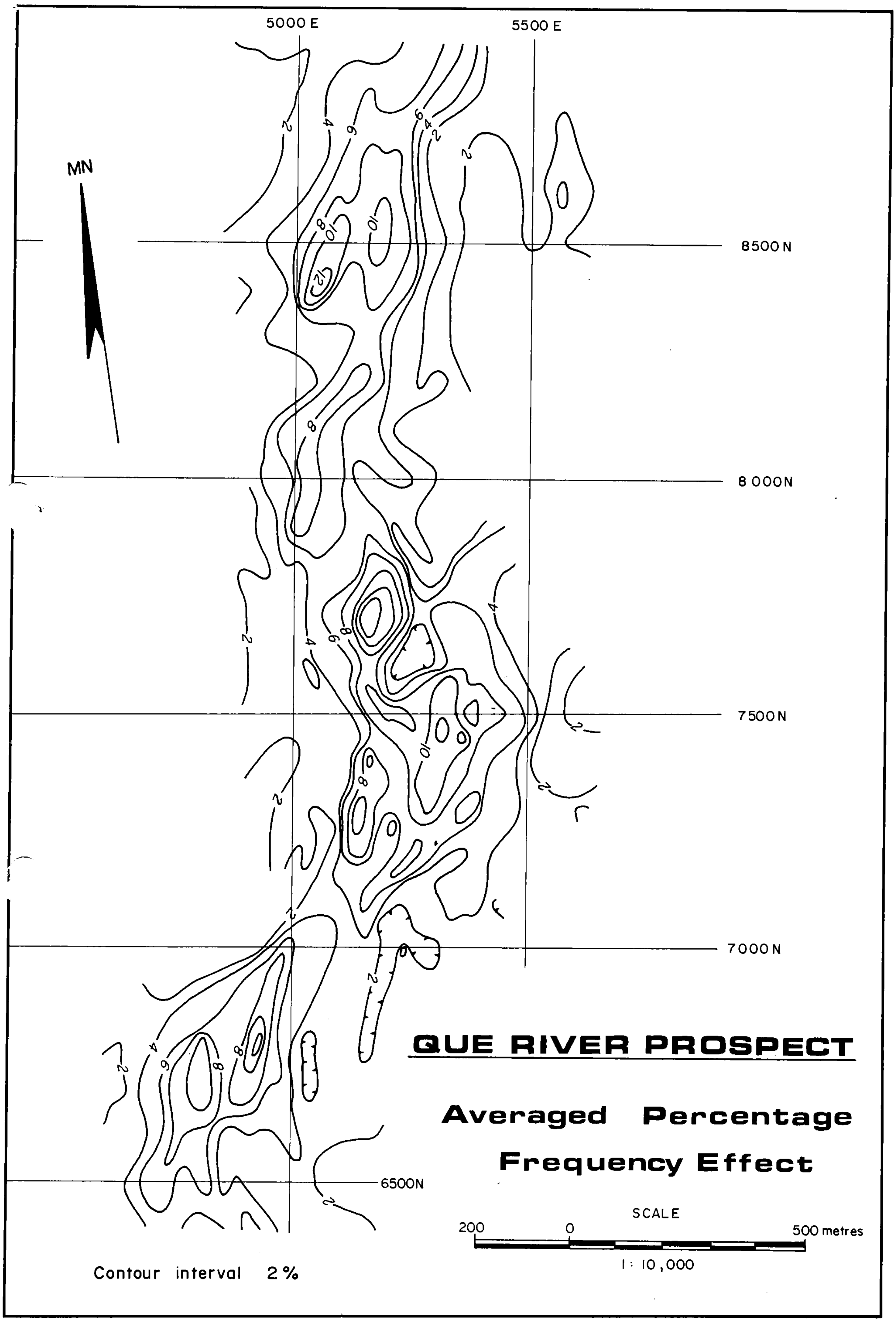
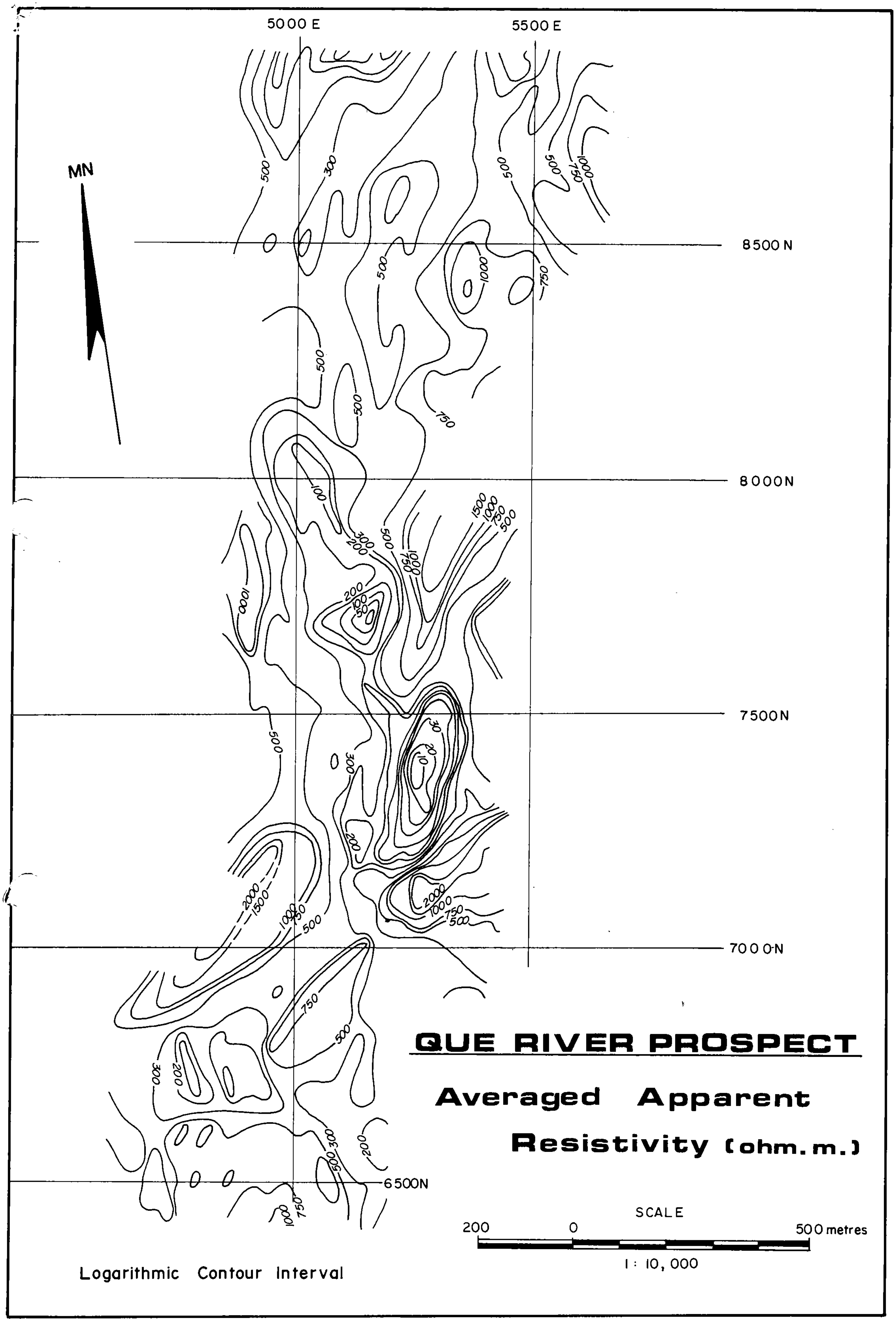

5000 E
5500 E
MN
8500 N
8 000N
7500N
7000N
6500N
QUE RIVER PROSPECT
Averaged Percentage
Frequency Effect
SCALE
200
0
500 metres
1 : 10,000
Contour interval 2 %

FIG. 26

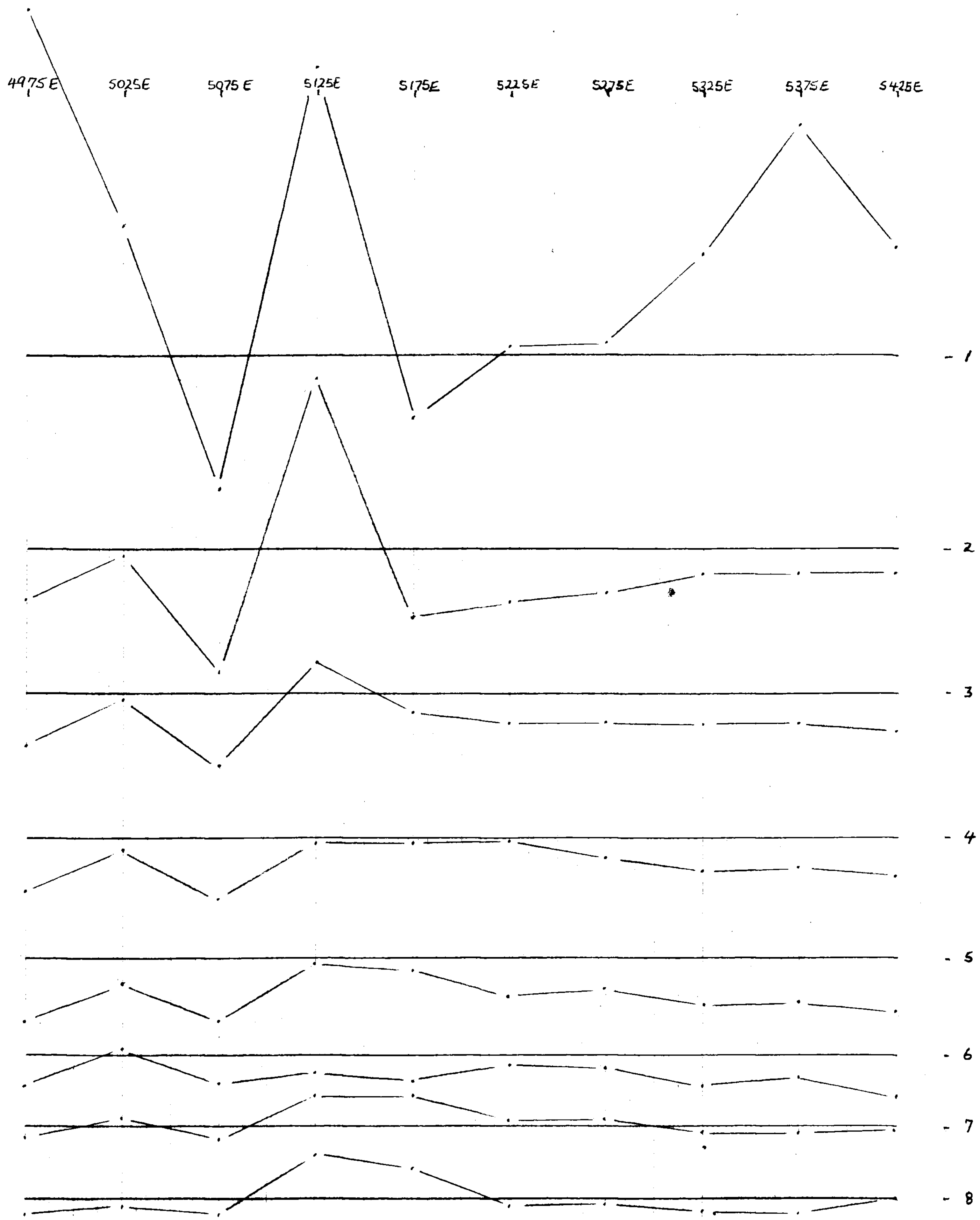


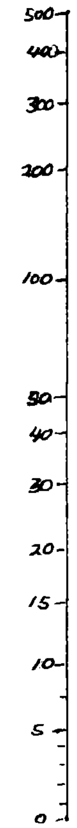
5000 E
5500 E
MN
8500 N
8000N
7500N
7000N
6500N
QUE RIVER PROSPECT
Averaged Apparent Resistivity (ohm. m.)
SCALE
200 0 500 metres
1 : 10, 000
Logarithmic Contour Interval

FIG. 27

27

P.E.M. SURVEY. COMINCO
QUE RIVER PROSPECT TAS
LINE 7500N SCALE 1cm = 25m
FEB77 Job No 85-1033 T→R = 50m



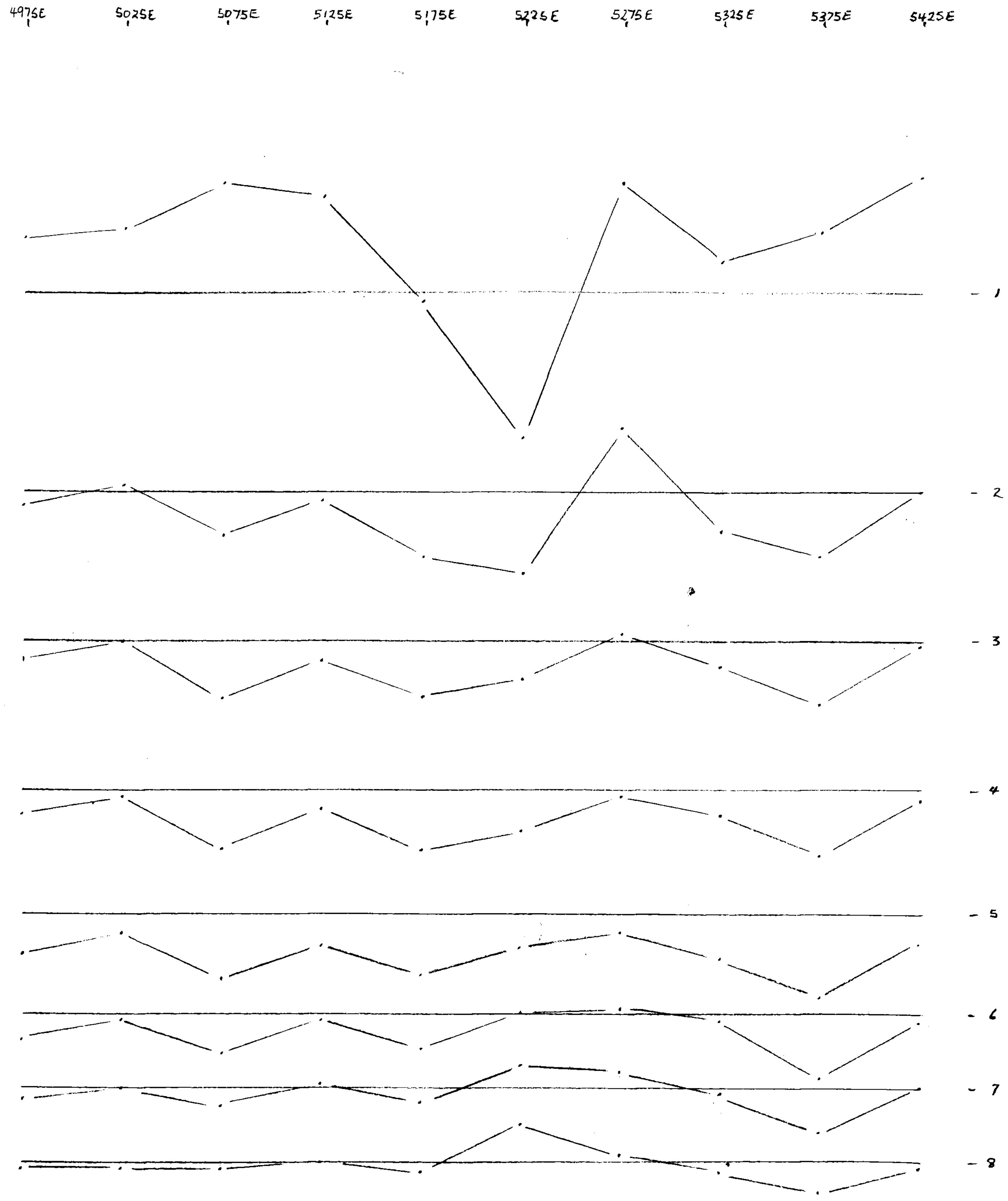


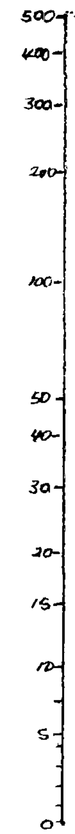
P.E.M. SURVEY COMINCO

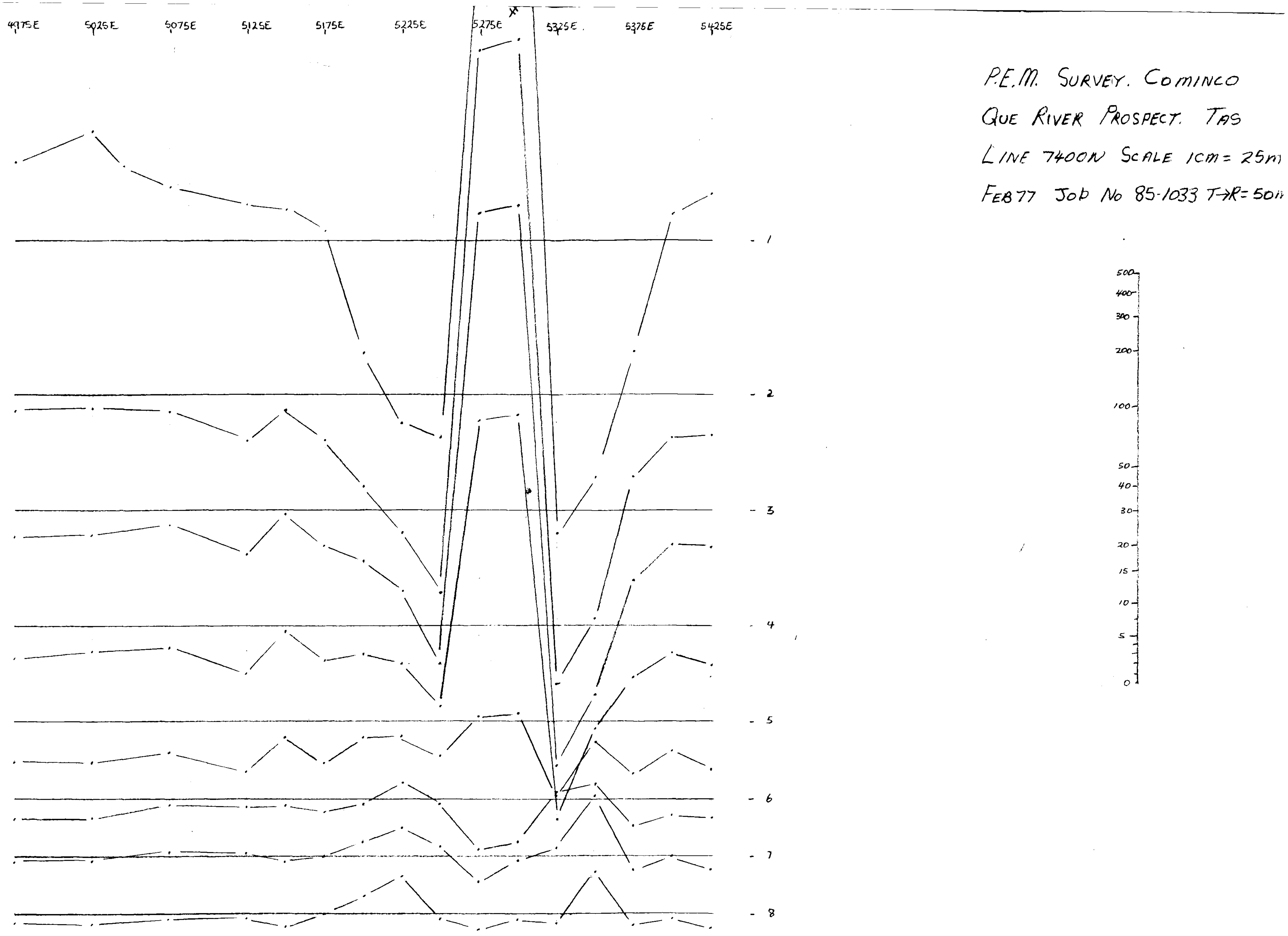
QUE RIVER PROSPECT TAS

LINE 7200N SCALE 1CM = 25m

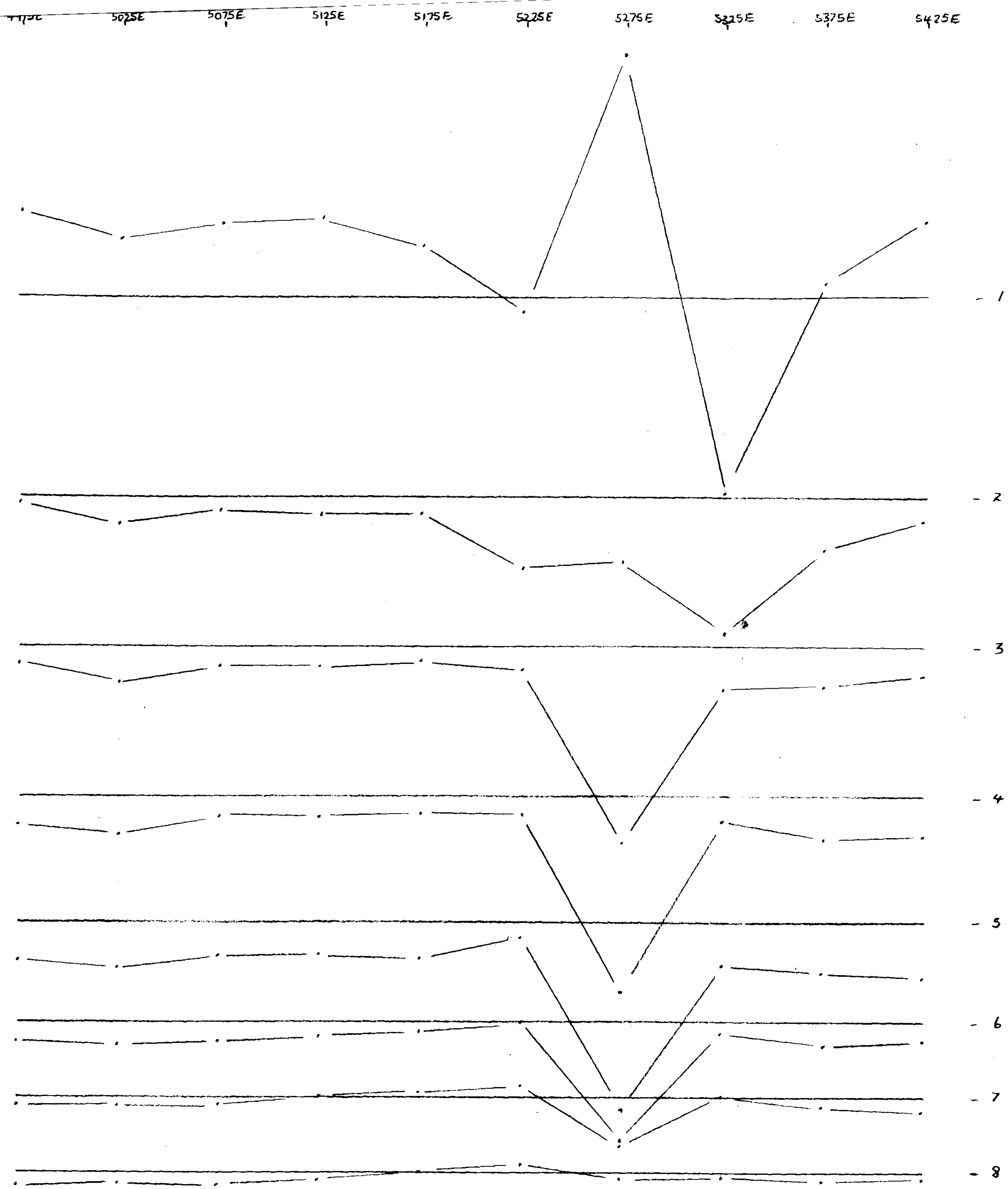
FEB 77 Job No 85-1033 T→R = 50m

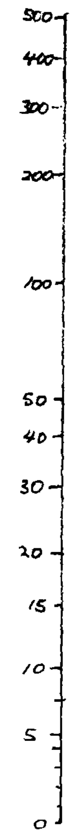


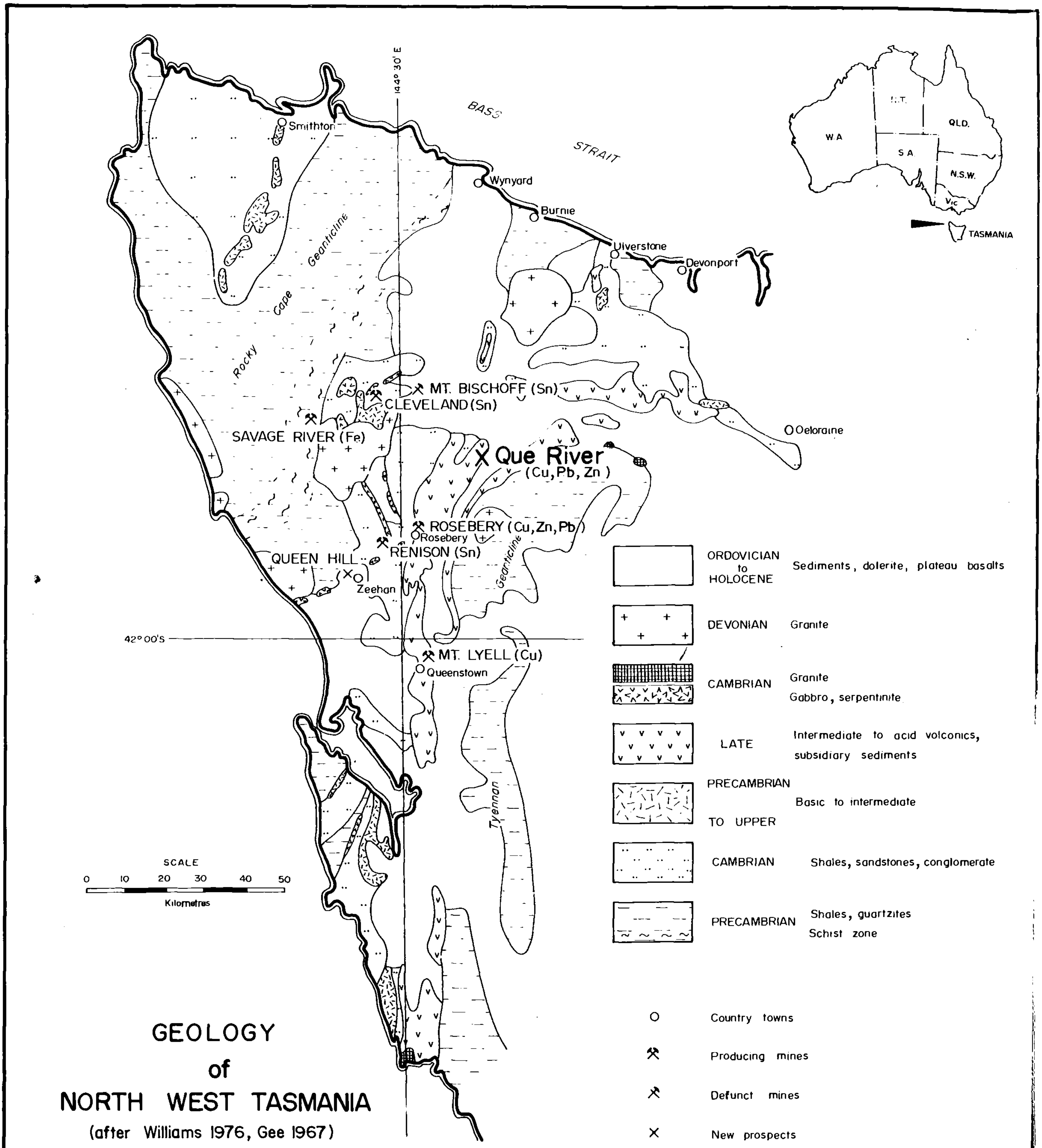



4975E
5025E
5075E
5125E
5175E
5225E
5275E
5325E
5375E
5425E
P.E.M. SURVEY. COMINCO
QUE RIVER PROSPECT. TAS
LINE 7400N SCALE 1cm = 25m
FEB 77 Job No 85-1033 T→R = 50m
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
500
400
300
200
100
50
40
30
20
15
10
5
0

P.E.M. SURVEY COMINCO
QUE RIVER PROSPECT TAS
LINE 7300N SCALE 1cm = 25m
FEB 77 Job No 85-1033 T→R = 50m

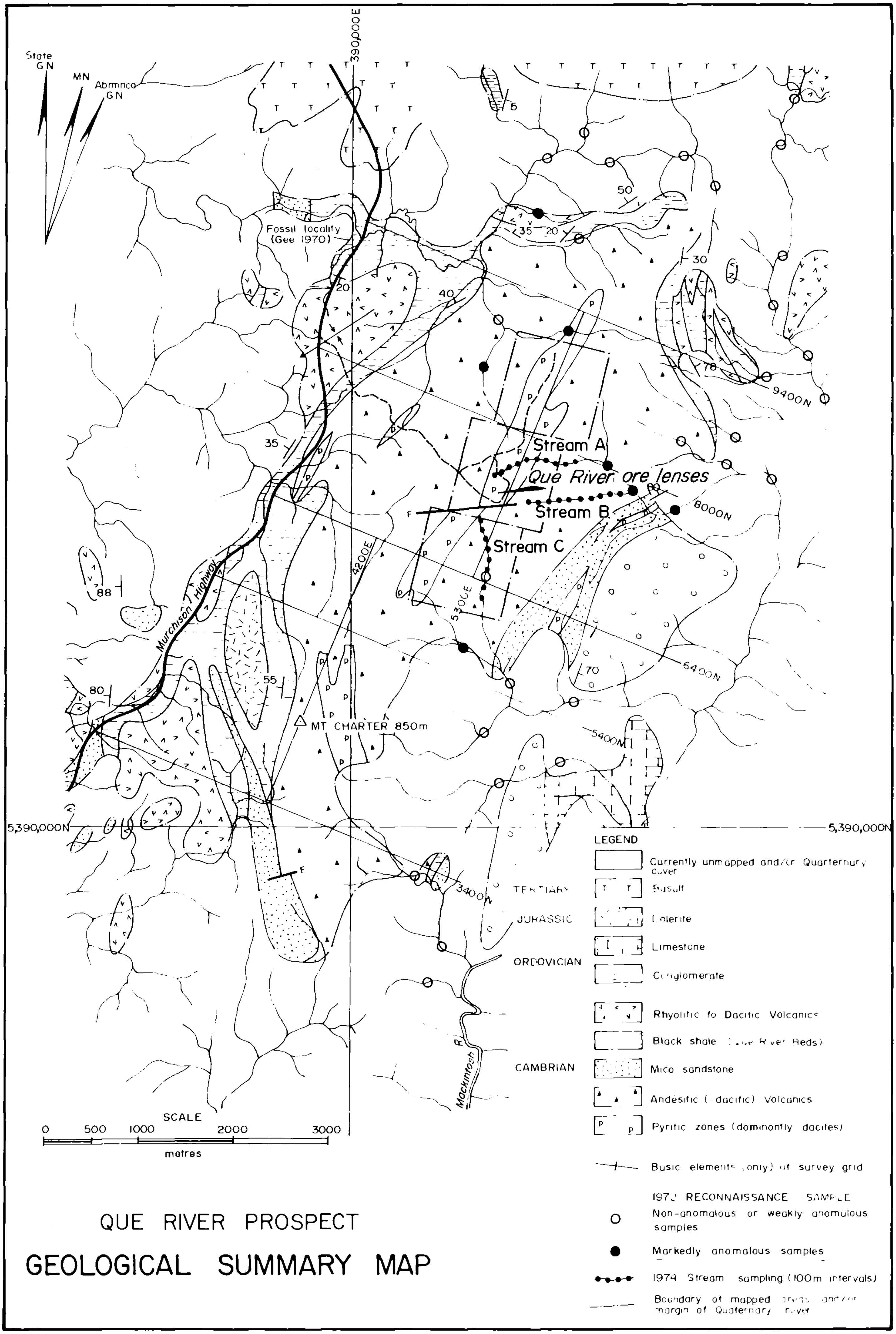






144° 30' E
BASS STRAIT
Smithton
Wynyard
Burnie
Ulverstone
Devonport
Deloraine
Rocky Cape Geanticline
MT. BISCHOFF (Sn)
CLEVELAND (Sn)
SAVAGE RIVER (Fe)
Que River
(Cu, Pb, Zn)
ROSEBERY (Cu, Zn, Pb)
Rosebery
RENISON (Sn)
QUEEN HILL
Zeehan
Geanticline
42° 00'S
MT. LYELL (Cu)
Queenstown
Tyennan
W.A
N.T.
QLD.
S.A
N.S.W.
Vic
TASMANIA
SCALE
0 10 20 30 40 50
Kilometres
ORDOVICIAN to HOLOCENE
Sediments, dolerite, plateau basalts
DEVONIAN
Granite
CAMBRIAN
Granite
Gabbro, serpentinite
LATE PRECAMBRIAN TO UPPER CAMBRIAN
Intermediate to acid volcanics, subsidiary sediments
Basic to intermediate
Shales, sandstones, conglomerate
PRECAMBRIAN
Shales, quartzites
Schist zone
Country towns
Producing mines
Defunct mines
New prospects
GEOLOGY of NORTH WEST TASMANIA
(after Williams 1976, Gee 1967)

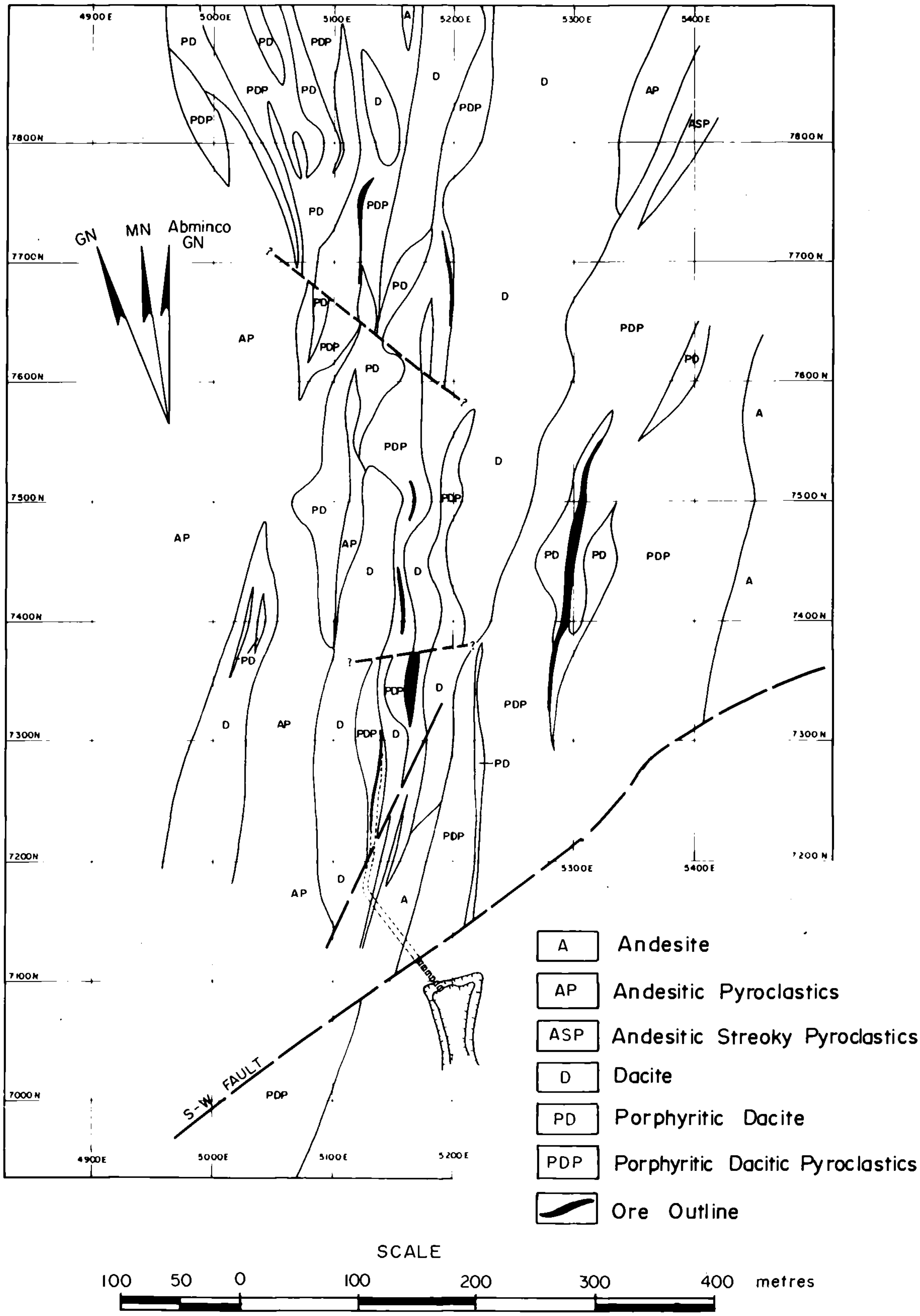
Fig. I



QUE RIVER PROSPECT

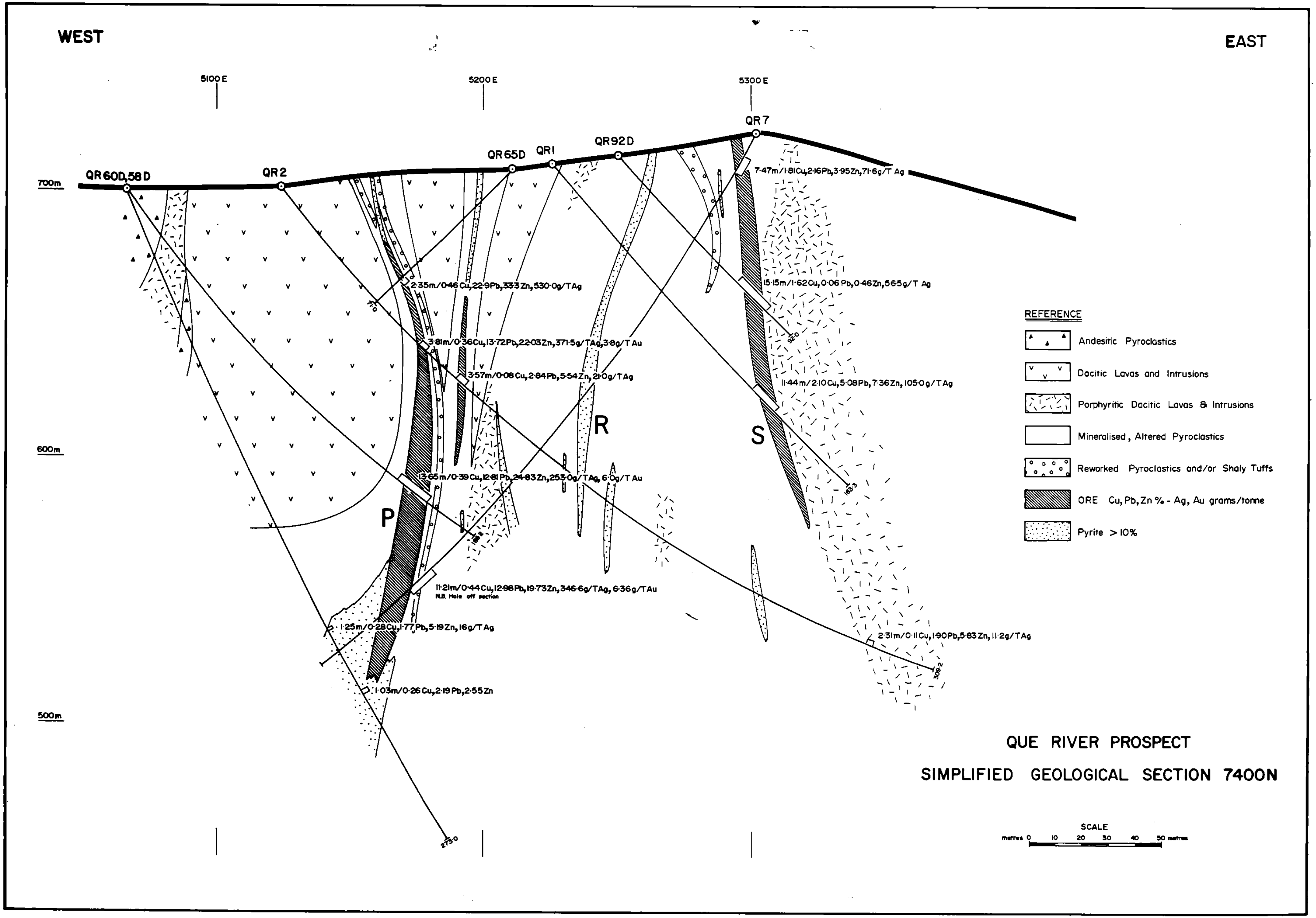
GEOLOGICAL SUMMARY MAP

FIG. 2



INTERPRETIVE SURFACE GEOLOGY

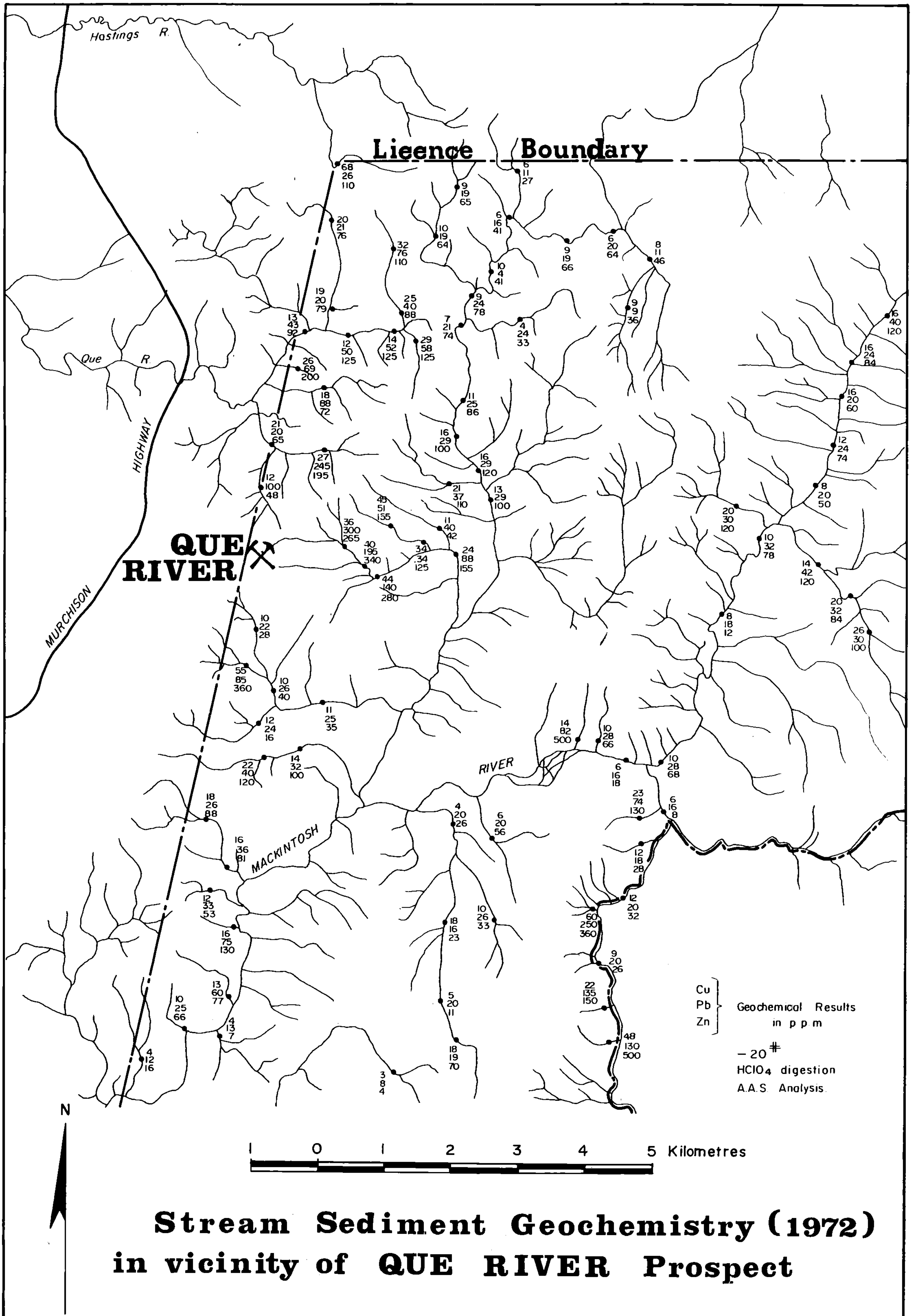
Fig. 3



QUE RIVER PROSPECT

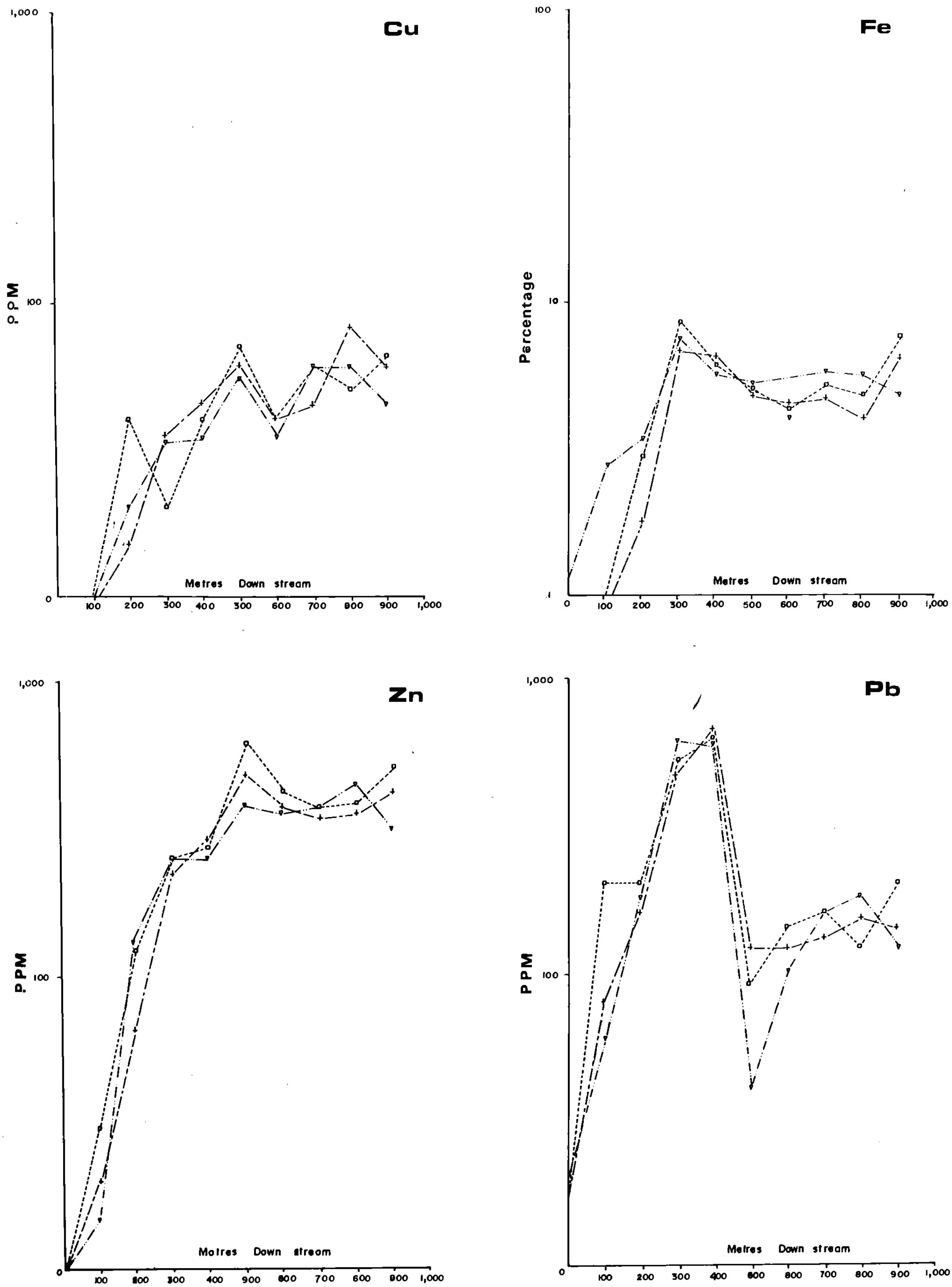
SIMPLIFIED GEOLOGICAL SECTION 7400N

FIG. 4



Stream Sediment Geochemistry (1972) in vicinity of QUE RIVER Prospect

FIG. 5



QUE RIVER PROSPECT

STREAM C

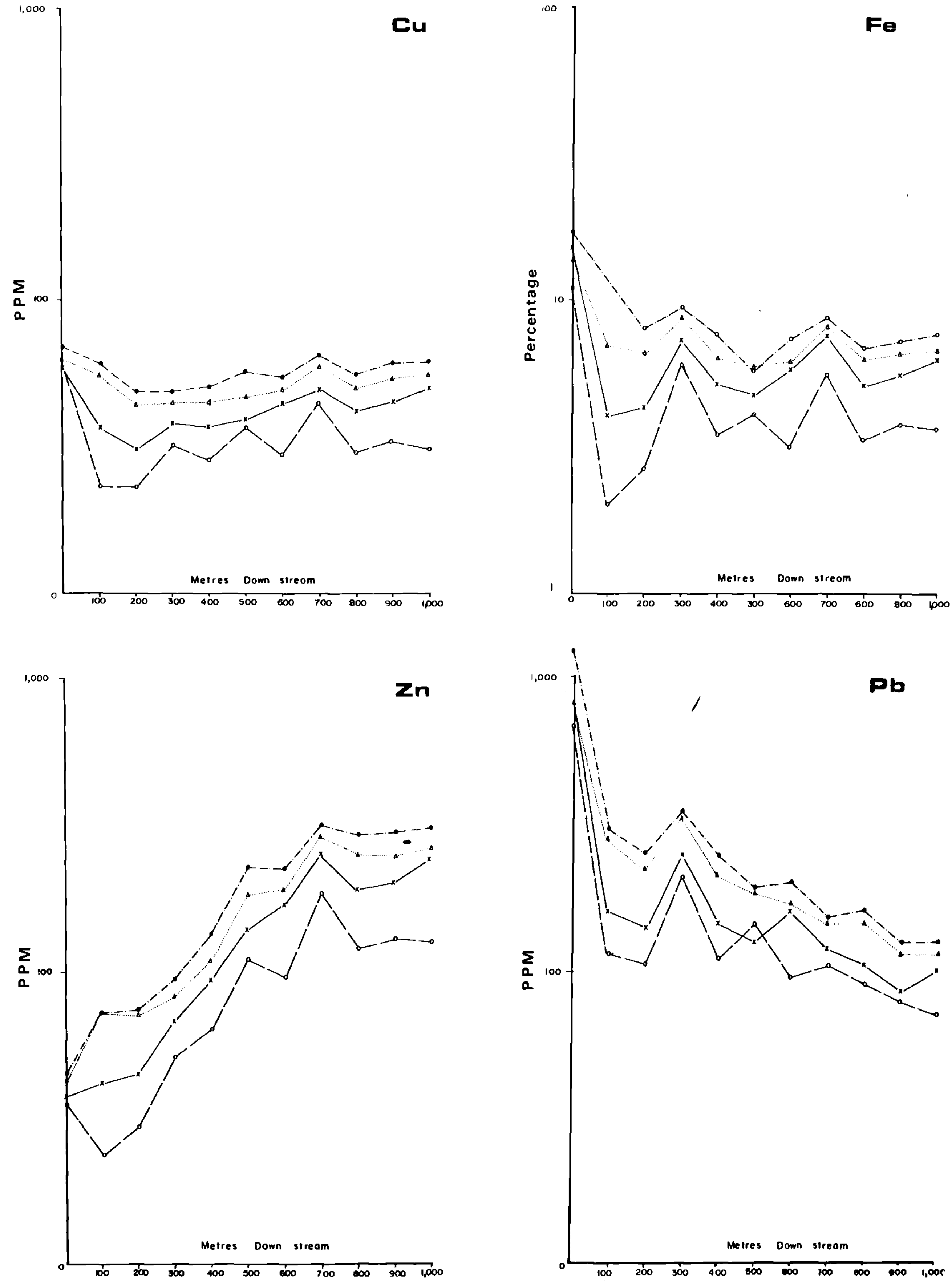
Cu, Fe, Zn, Pb Assay Values

in Stream Sediments

Stream Commences 5145E 7050N

- ▽- - - - ▽ - -40 + 120 mesh (1974)
- +—·—·—+ - -120 + 200 mesh (1974)
- o— — —o - -200 mesh (1974)

FIG. 6



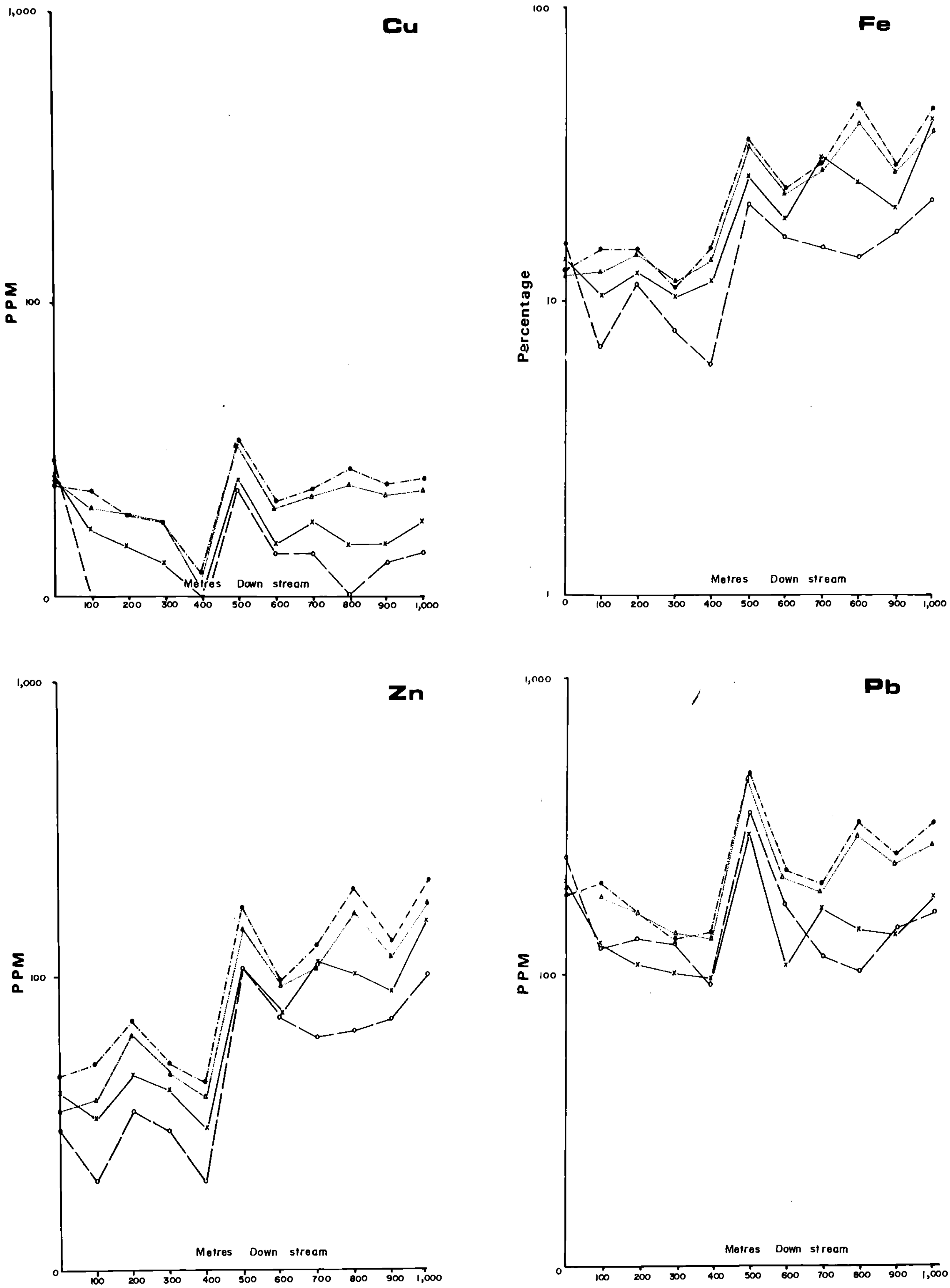
QUE RIVER PROSPECT

STREAM B

Cu Fe Zn Pb Assay Values
in Stream Sediments
Stream Commences 5400E 7300N

x——x - -40 mesh (1976)
o——o - -40 + 100 mesh (1976)
Δ·····Δ - -100 + 200 mesh (1976)
o– – –o - -200 mesh (1976)

FIG. 7



QUE RIVER PROSPECT

STREAM A

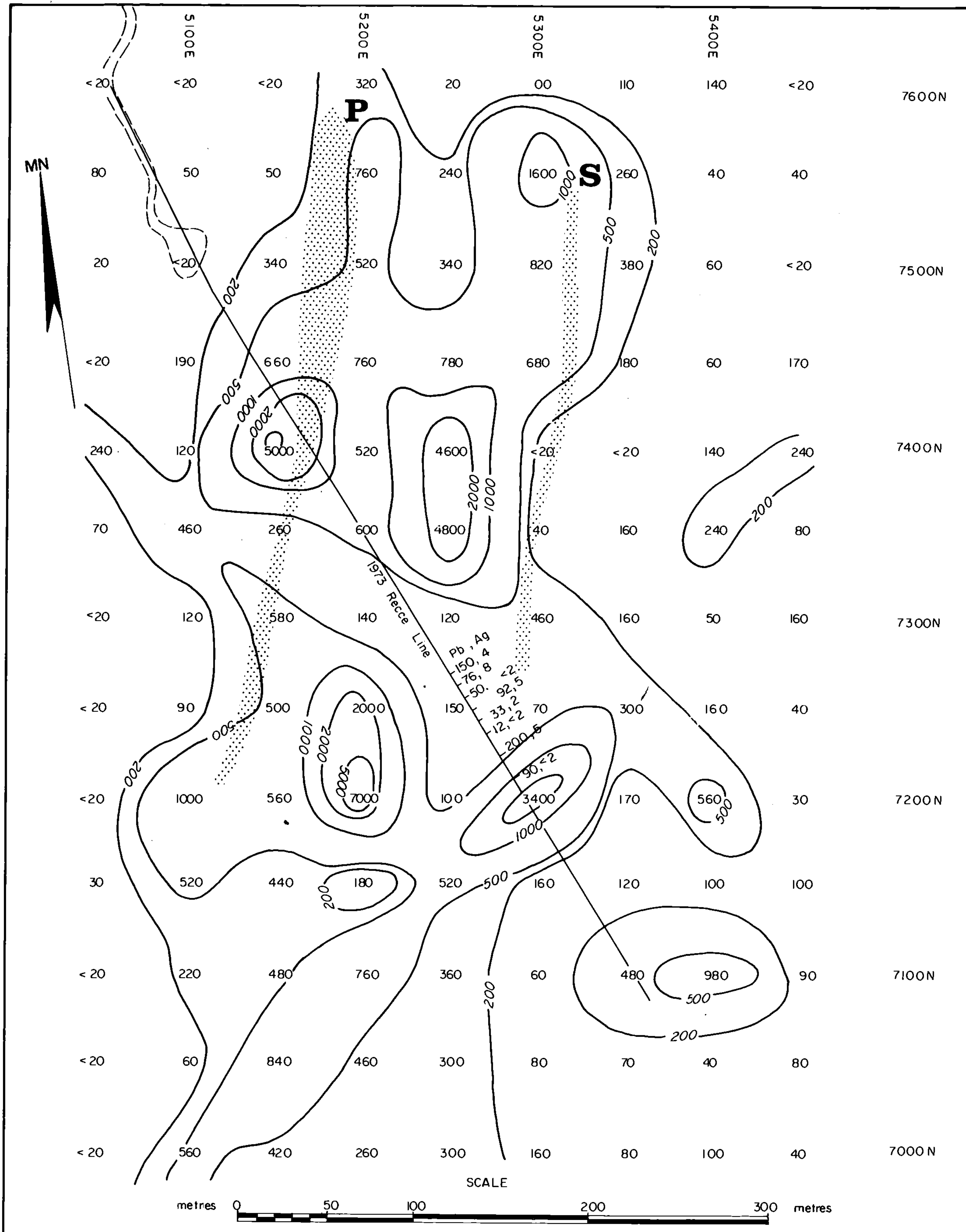
Cu, Fe, Zn, Pb Assay Values

in Stream Sediments

Stream Commences 5100E, 7475N

x——x - -40 mesh (1976)
o— —o - -40 + 100 mesh (1976)
Δ·······Δ - -100 + 200 mesh (1976)
o—·—o - -200 mesh (1976)

FIG. 8



All values shown in p.p.m.

Schematic surface projection of ore lenses

QUE RIVER PROSPECT

Lead Values - 'C' Horizon Soils

50m x 50m Grid

FIG. 9

All values shown in ppm

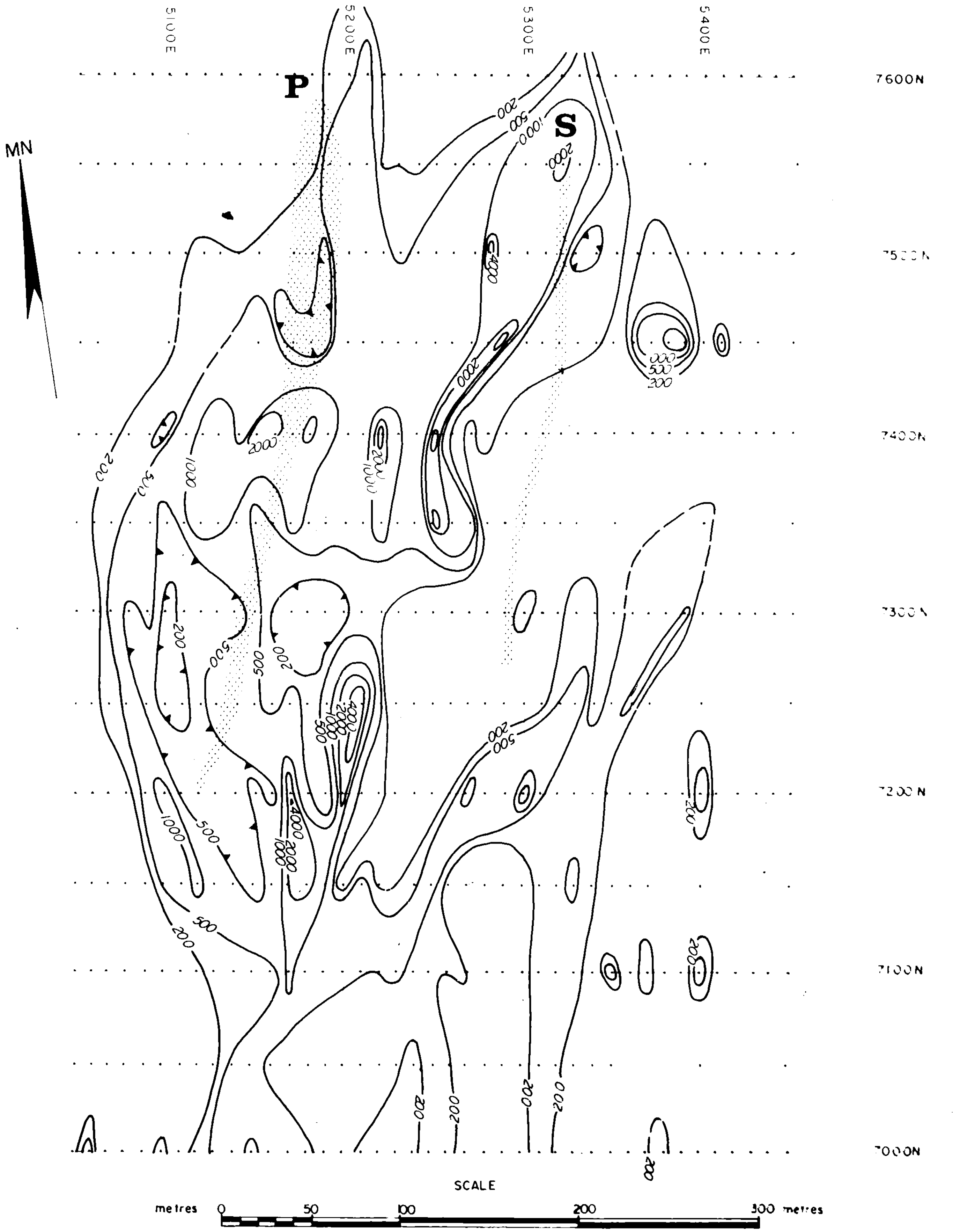
Schematic surface projection of ore lenses

QUE RIVER PROSPECT

Zinc Values 'C' Horizon Soils

50 m x 50 m Grid

FIG. 10



All values shown in ppm

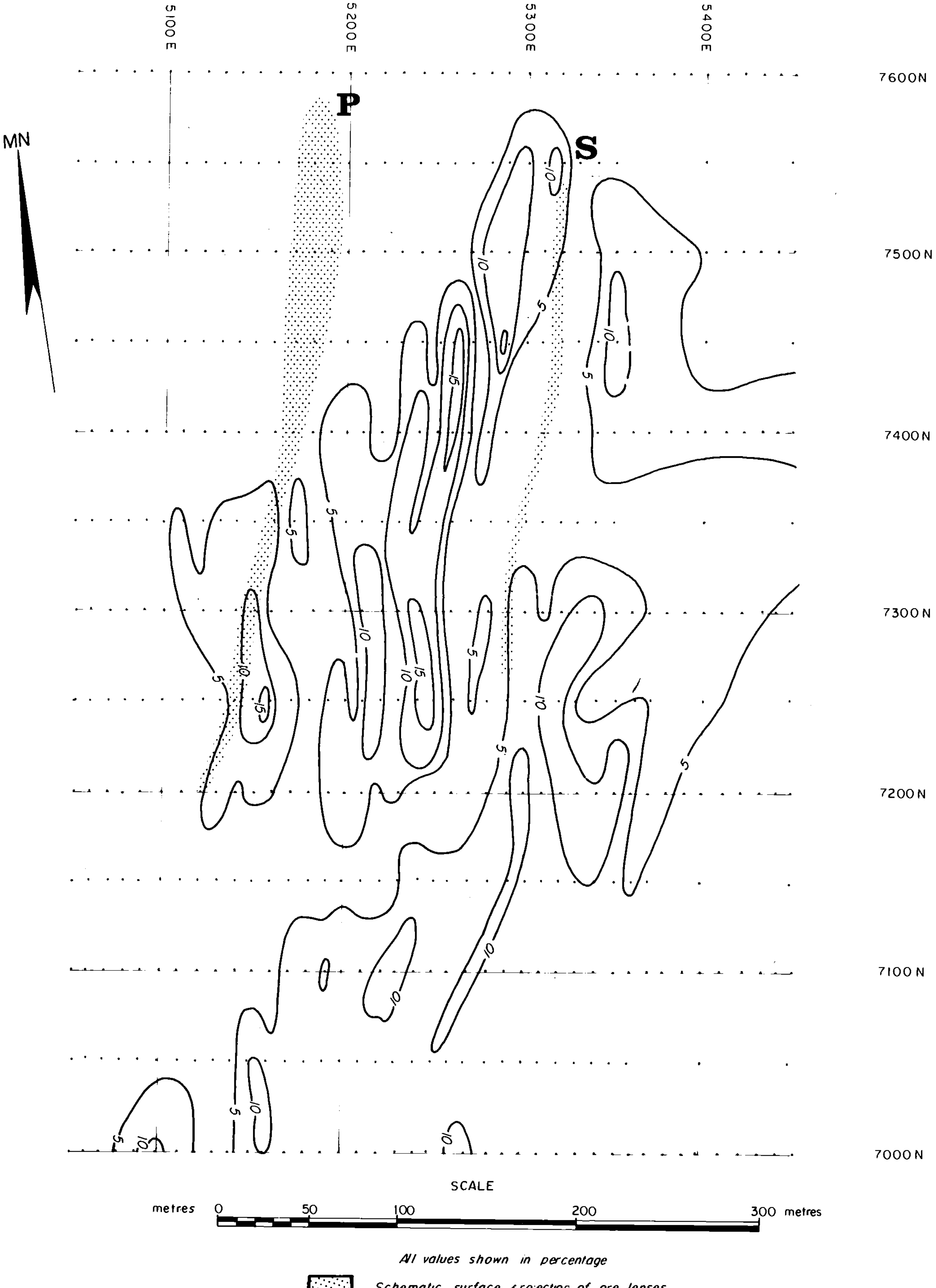
Schematic surface projection of ore lenses

QUE RIVER PROSPECT

Lead in 'C' Horizon Soils

50m x 10m Grid

FIG. II



All values shown in percentage

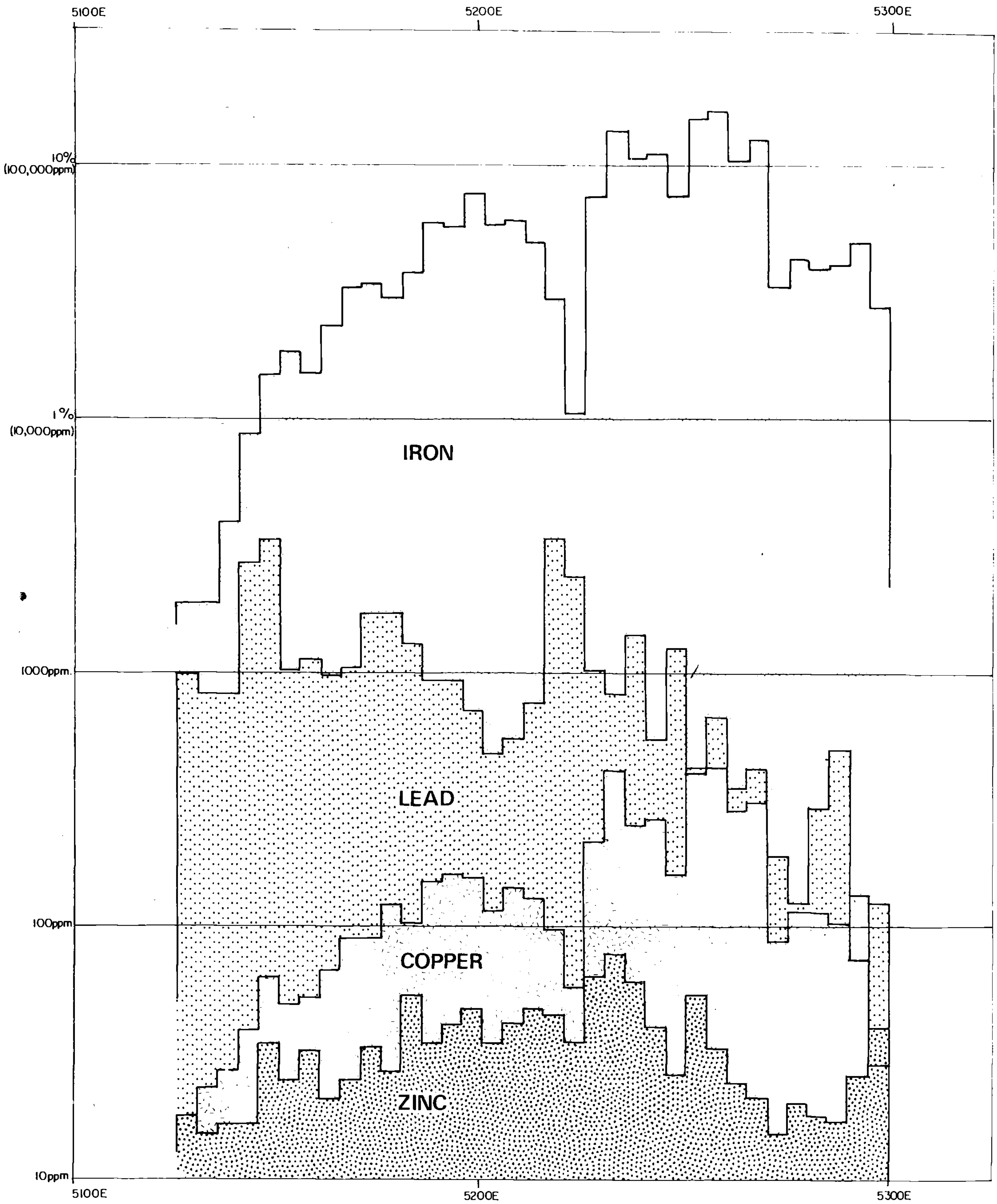
Schematic surface projection of ore lenses

QUE RIVER PROSPECT

Iron in 'C' Horizon Soils

50m x 10m Grid

FIG. 12

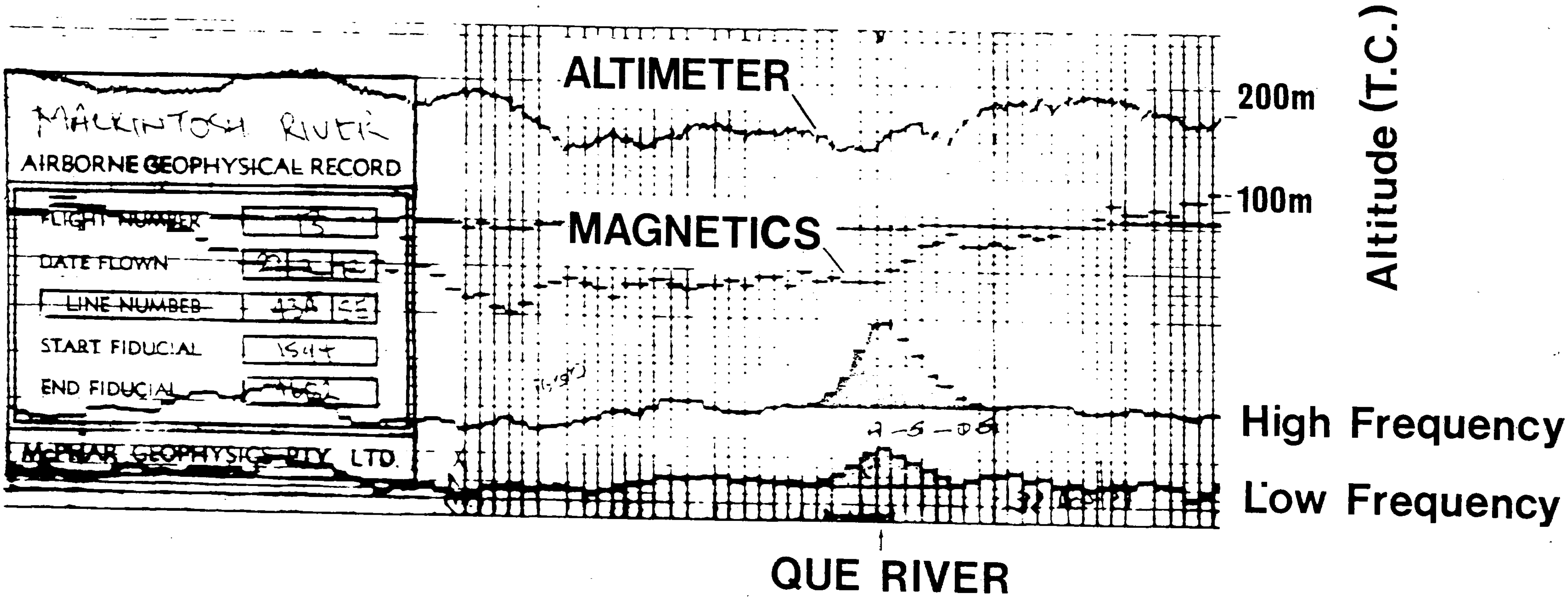


NOTE Each bar is arithmetic mean of 5 samples collected at an Im spacing

QUE RIVER
'C' HORIZON SOIL SAMPLING
7400N

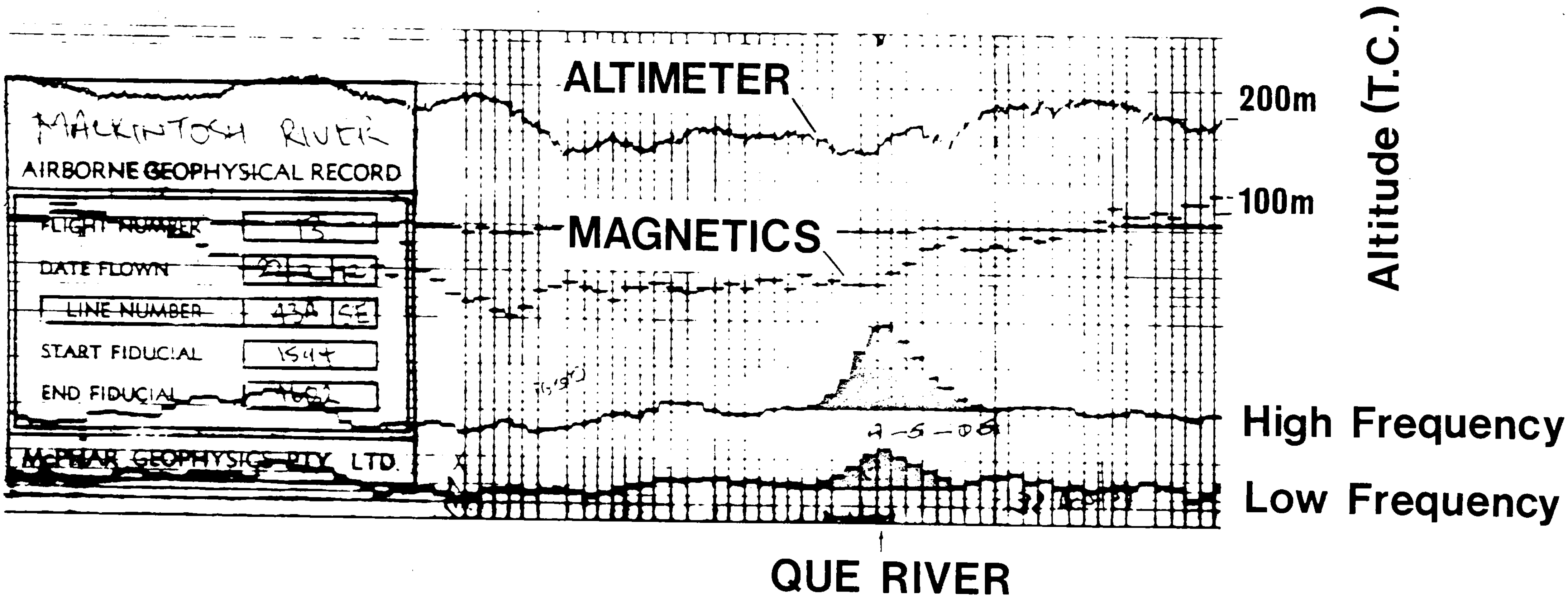
metres 0 10 20 30 40 50 100 metres
SCALE

FIG. 13



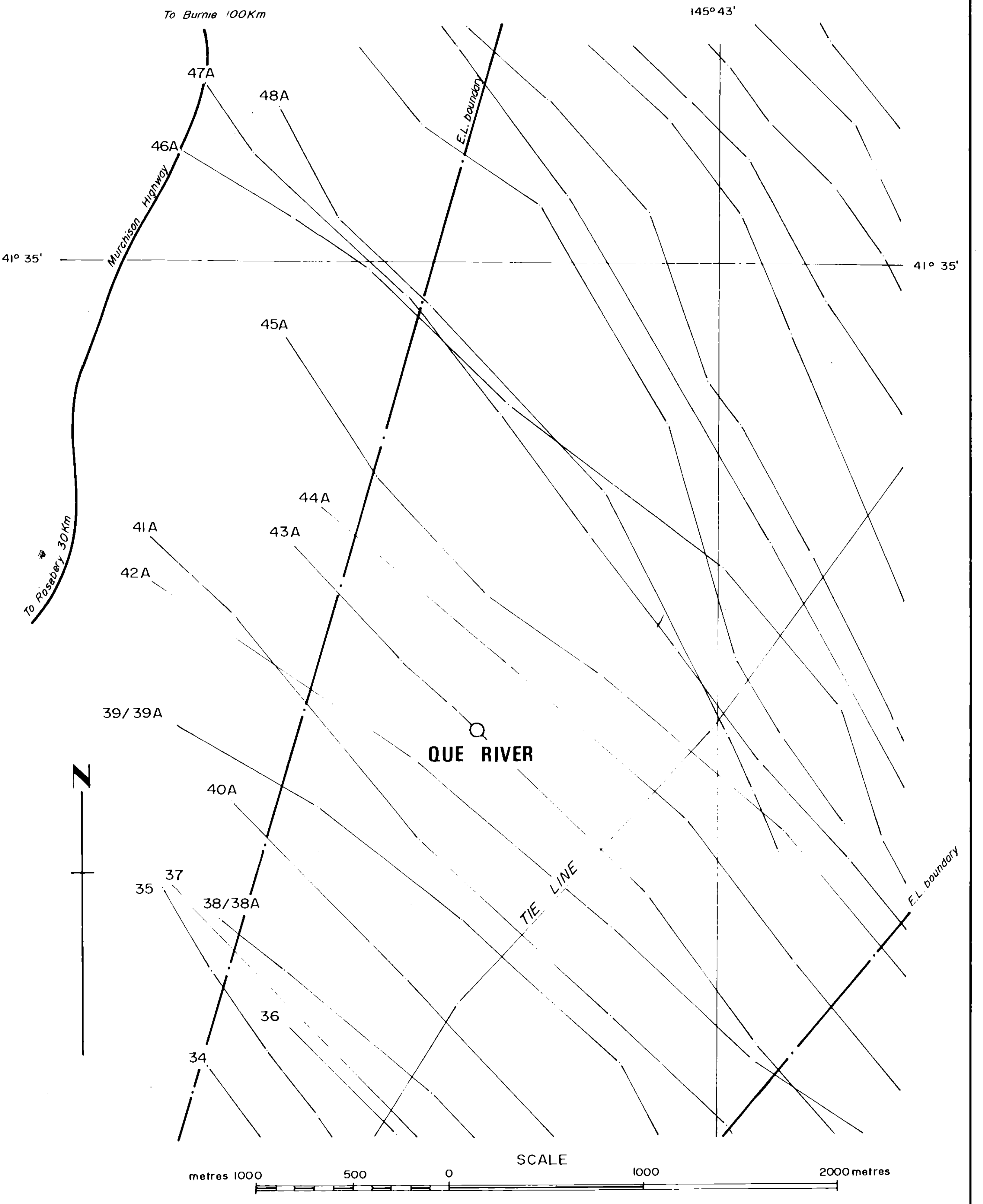
AIRBORNE ELECTROMAGNETIC DISCOVERY TRAVERSE McPHAR H400 - 1972

FIG. 14



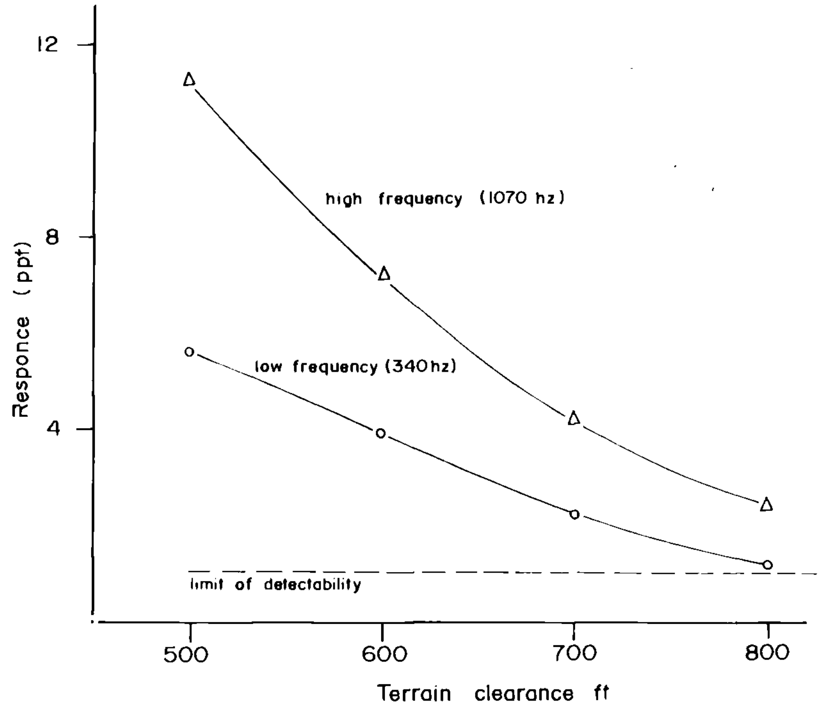
AIRBORNE ELECTROMAGNETIC DISCOVERY TRAVERSE McPHAR H400 - 1972

FIG. 14



FLIGHT PATH RECOVERY
Airborne E.M. Survey
1972

FIG. 15



H-400 E.M. System
Attenuation tests over Que River Anomaly

FIG 16

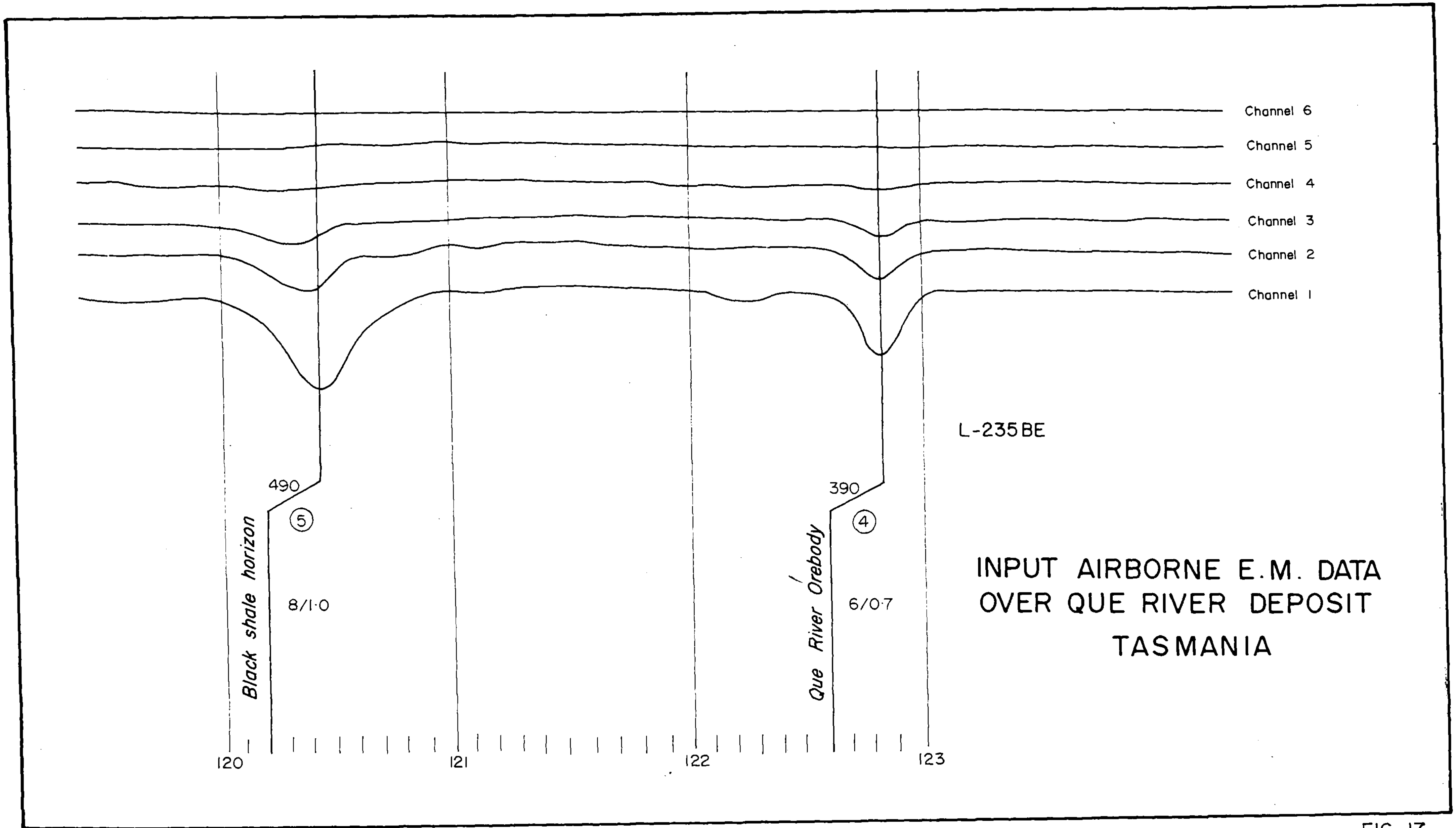
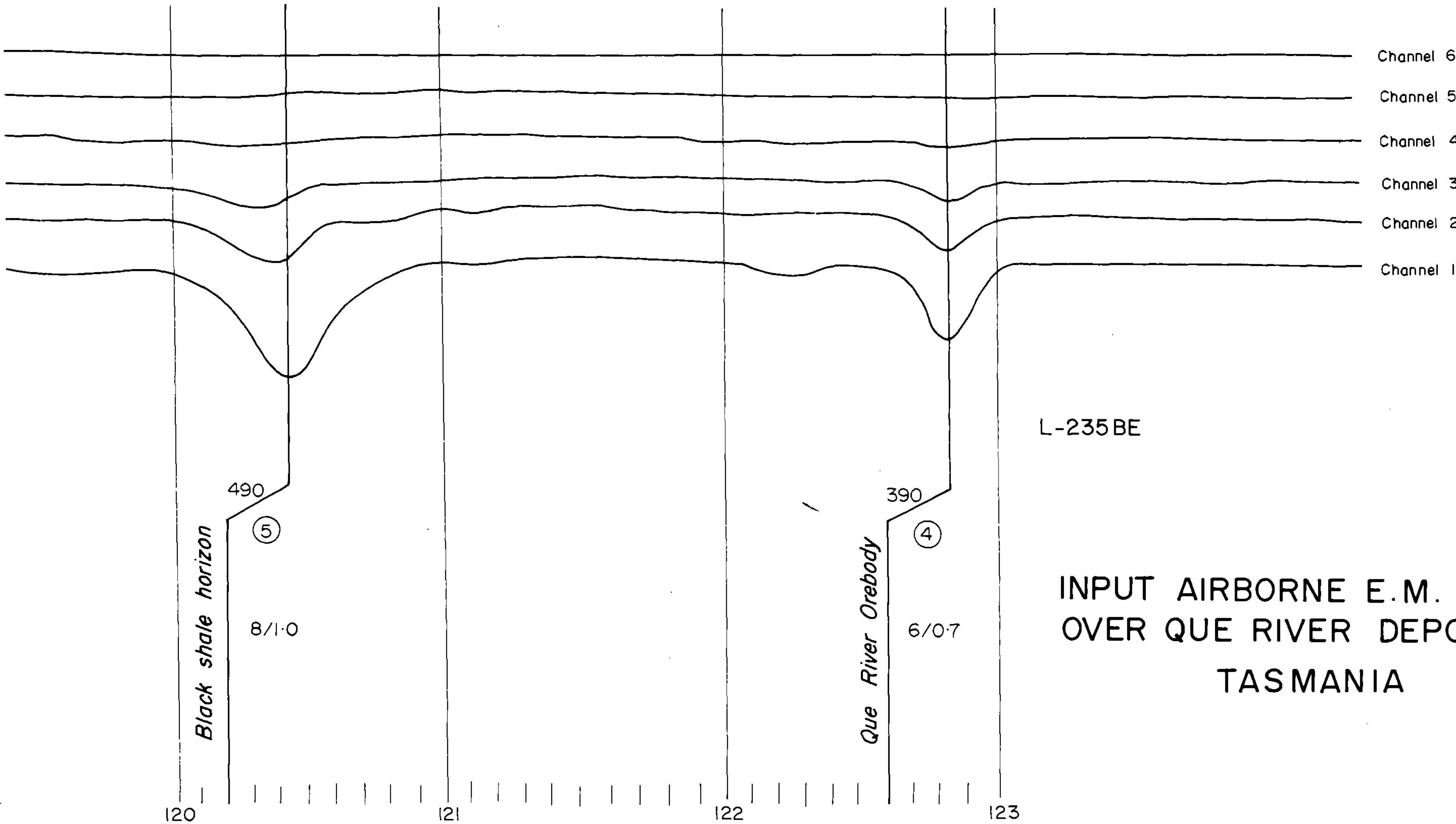
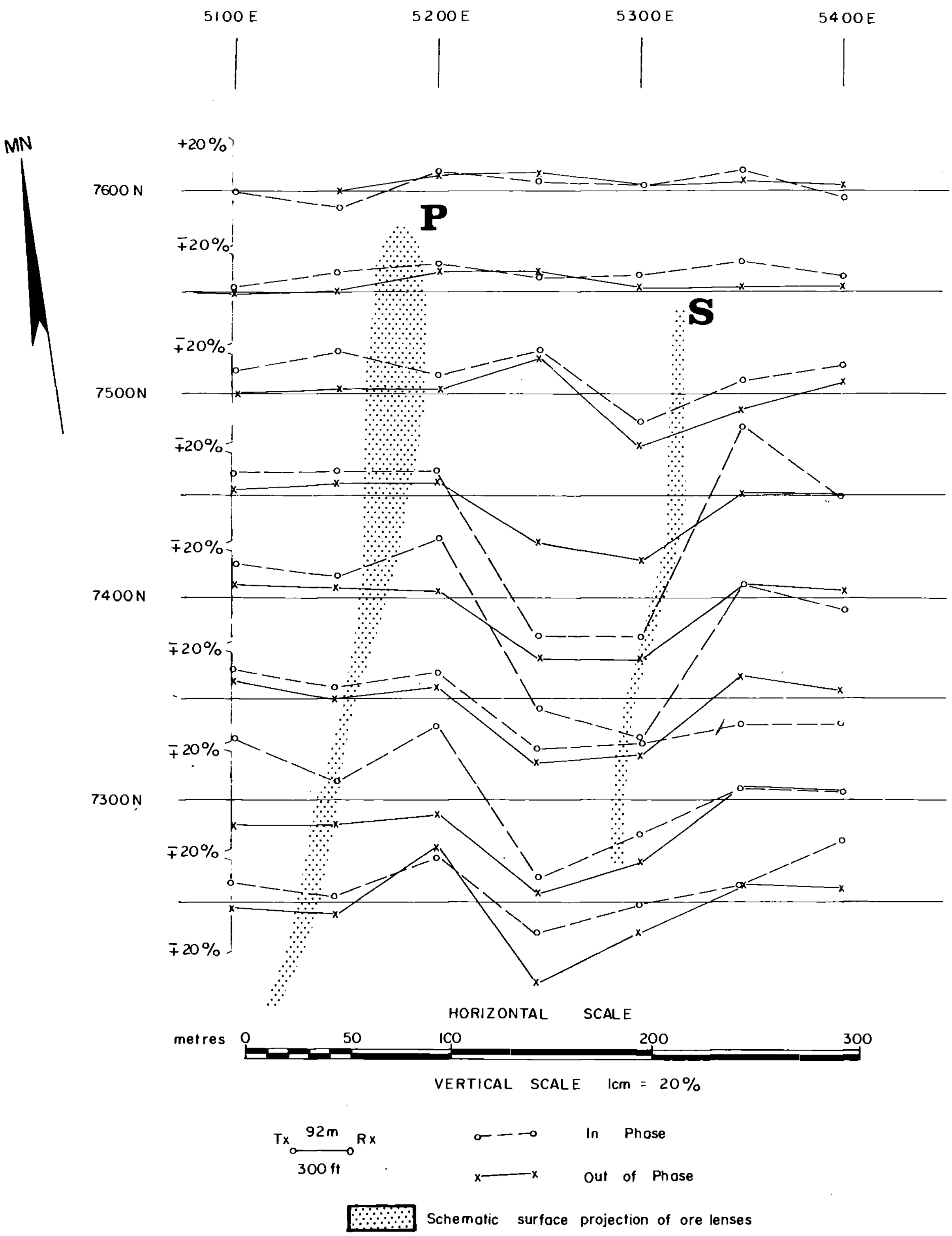

Channel 6
Channel 5
Channel 4
Channel 3
Channel 2
Channel 1
L-235BE
490
5
8/1·0
Black shale horizon
390
4
6/0·7
Que River Orebody
120
121
122
123
INPUT AIRBORNE E.M. DATA
OVER QUE RIVER DEPOSIT
TASMANIA

FIG. 17



INPUT AIRBORNE E.M. DATA OVER QUE RIVER DEPOSIT TASMANIA

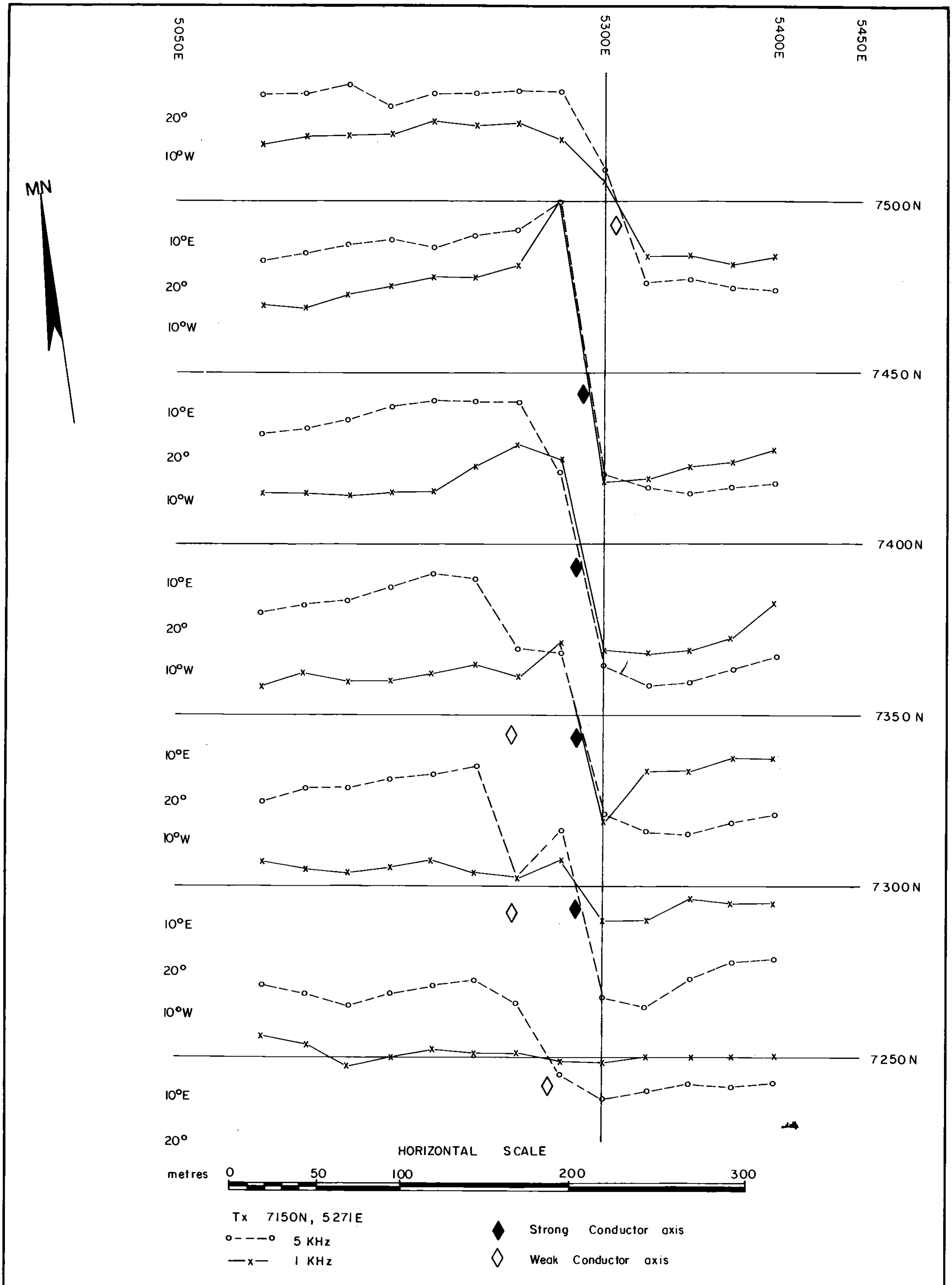
FIG. 17



QUE RIVER PROSPECT

Horizontal Loop E.M. Profiles

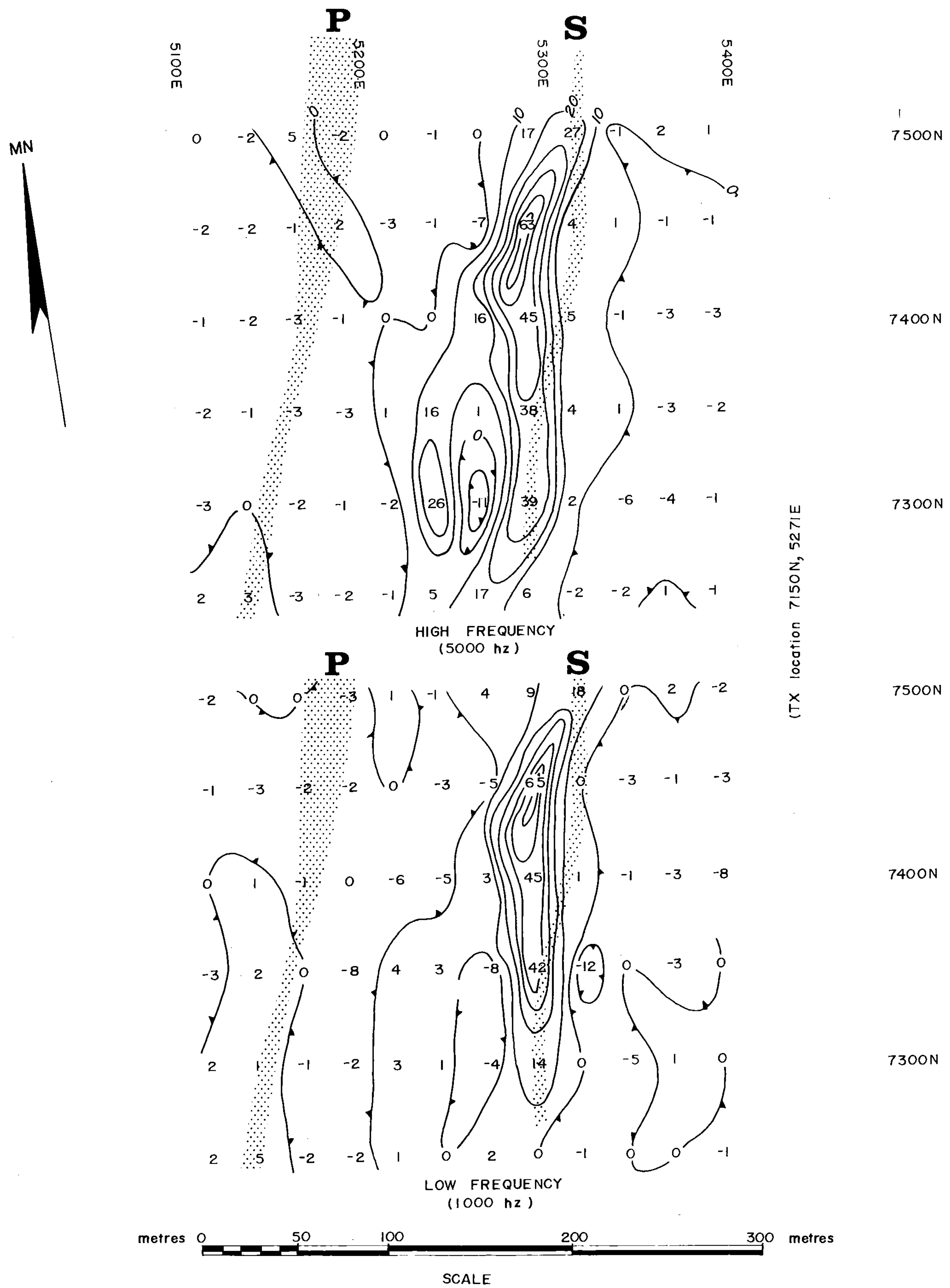
High Frequency (2400 Hz) data



QUE RIVER PROSPECT

Vertical Loop E.M.

FIG. 19



QUE RIVER PROSPECT

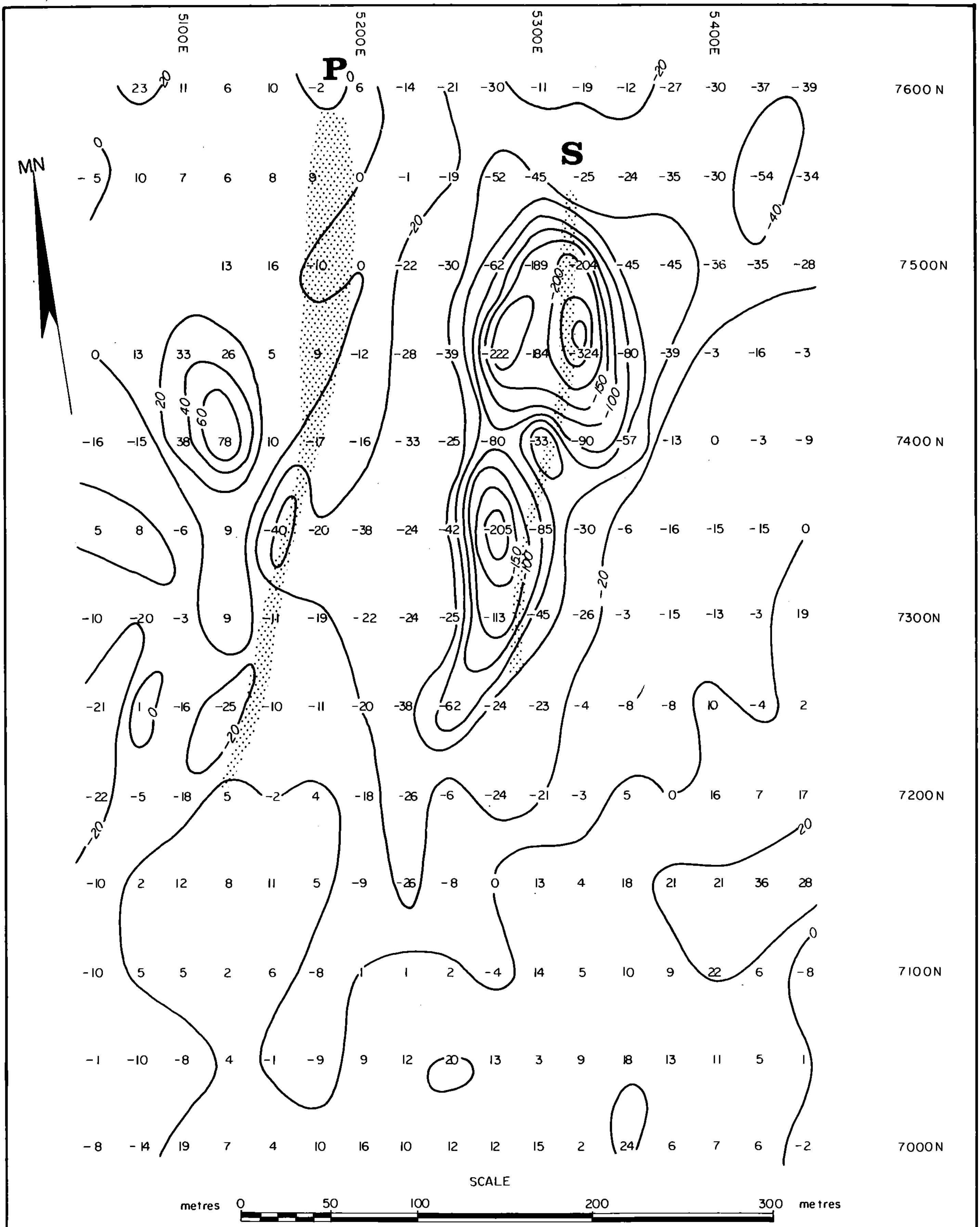
Vertical Loop EM Data

(Transformed and contoured after Fraser)
(1969)

Schematic surface projection of ore lenses

Contour Interval 10%/25m

FIG. 20



Contour Interval ± 20 mv to −100 mv thence 50 mv

QUE RIVER PROSPECT

Self - Potential Contours

Schematic surface projection of ore lenses

FIG. 21

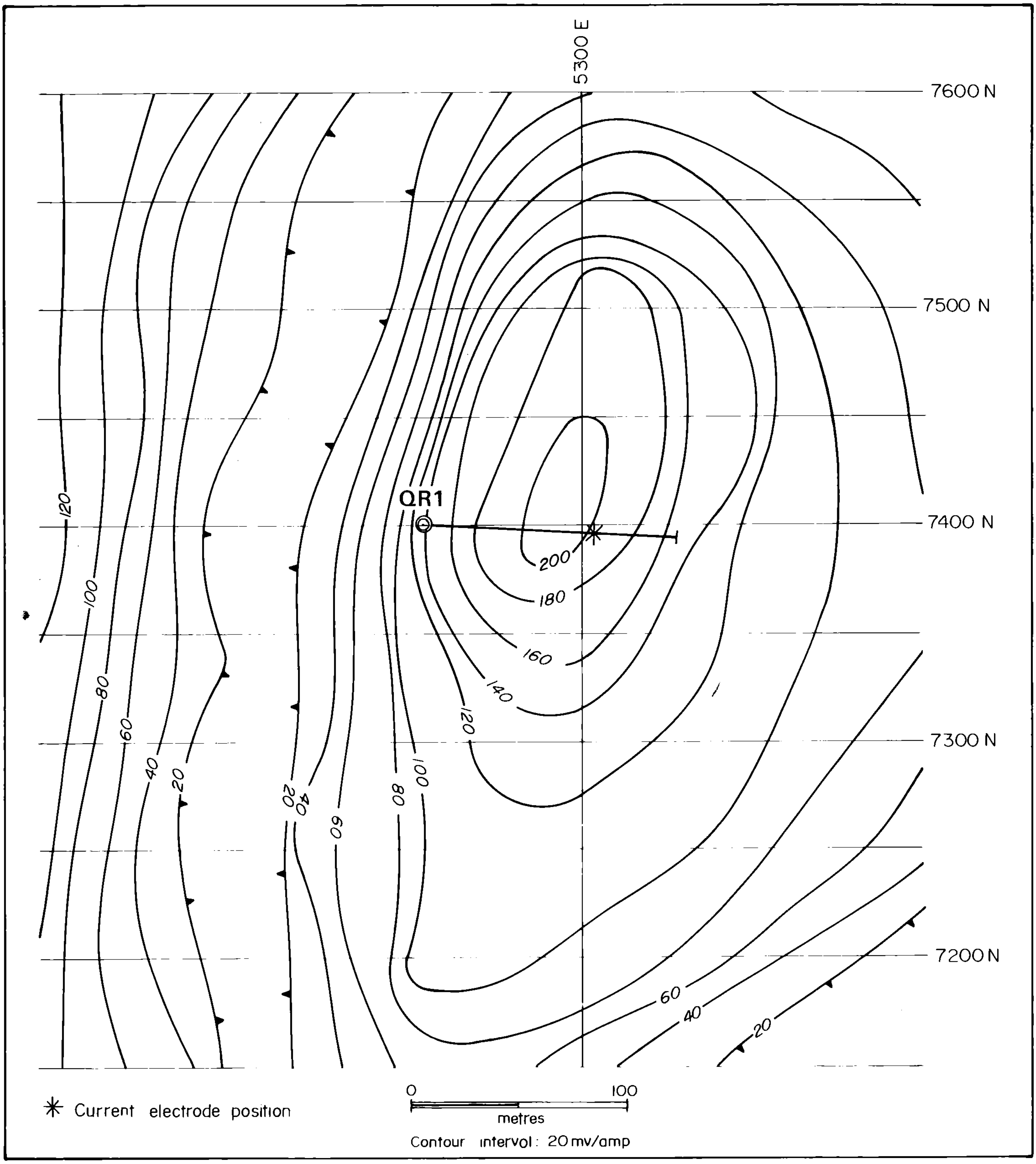
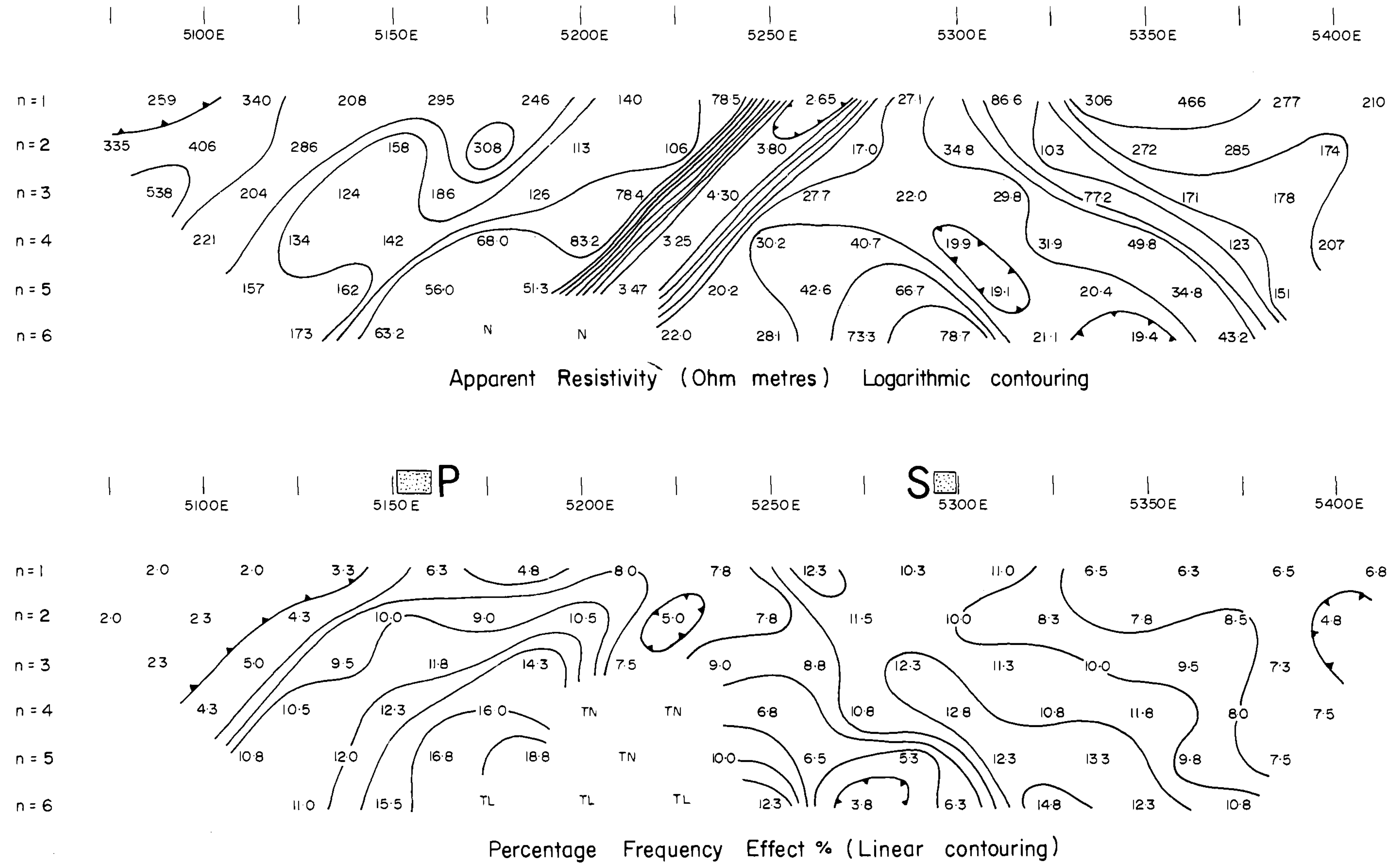


Figure 22. Mise a la masse survey - Que River

Current in eastern mineralisation via drill hole QR I



QUE RIVER PROSPECT

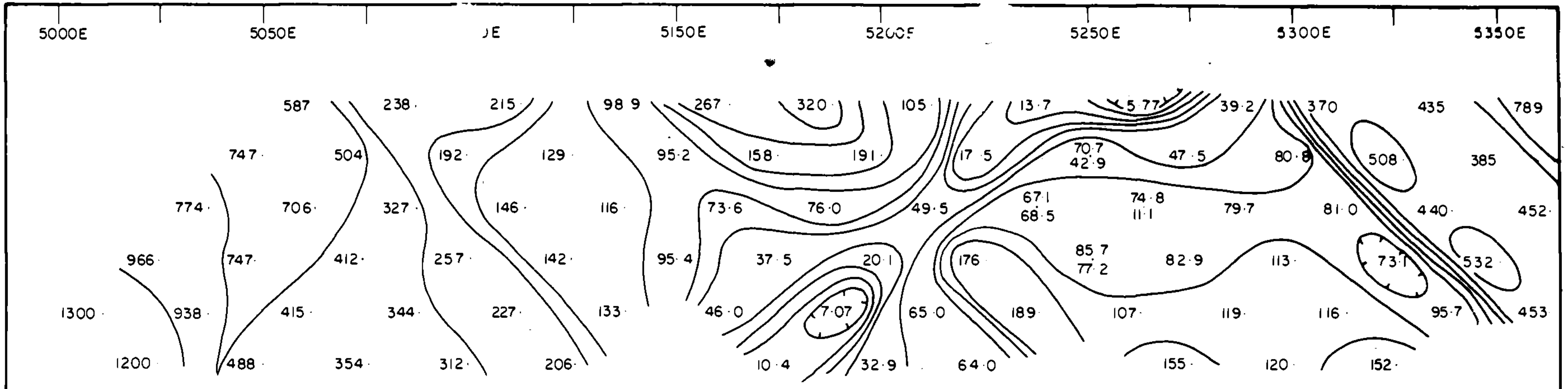
Resistivity and I.P. Survey - Traverse 7350N

Frequencies 2·5-0·3 Hz

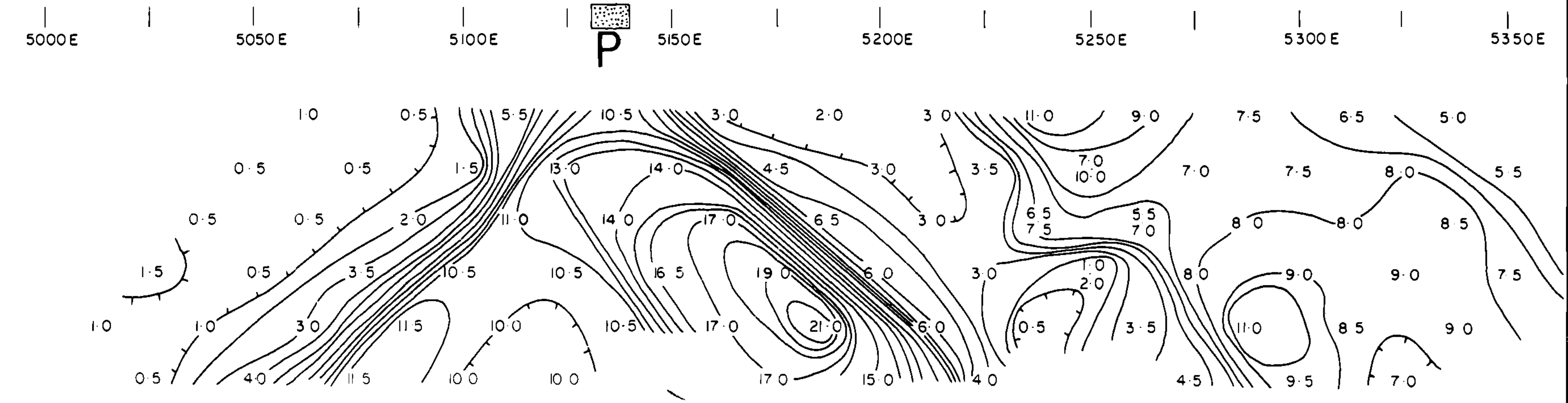
0 25 50 100 metres

TN,TL Readings either too noisy or voltage too low for measurement

FIG. 23



Apparent Resistivity (Ohm metres) Logarithmic Contouring



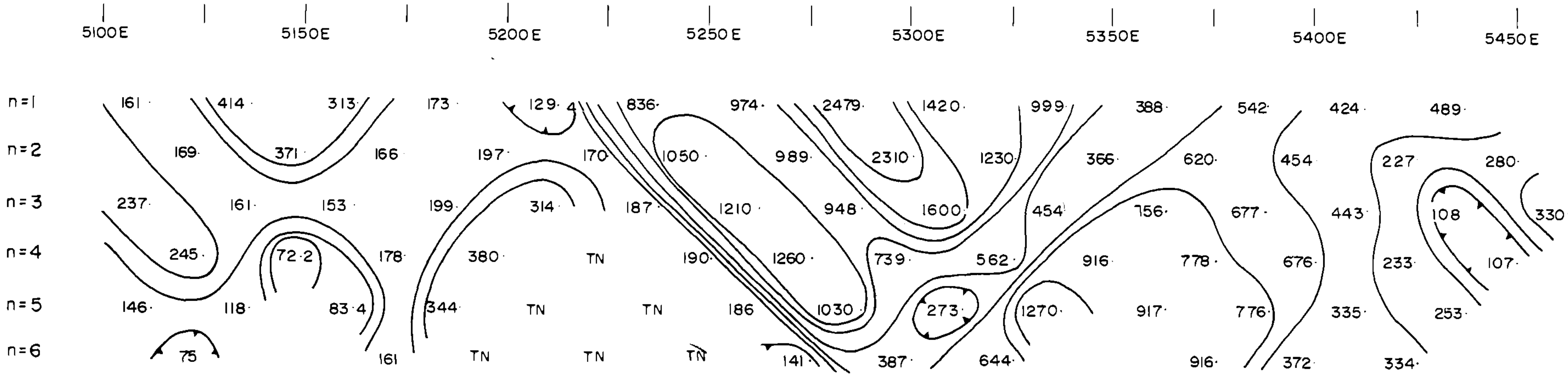
Percentage Frequency Effect % - (Linear Contouring)

QUE RIVER PROSPECT

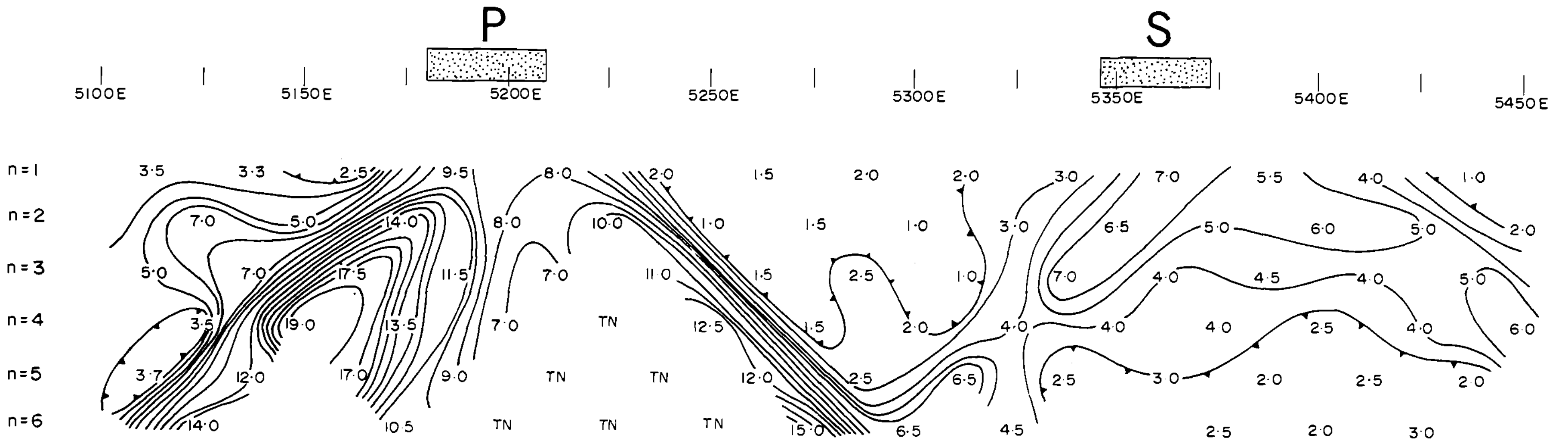
Resistivity and I.P. Survey - Traverse 7250N

FREQUENCIES 2.5 – 0.3 Hz

0 25 50 100 metres



Apparent Resistivity (Ohm metres) Logarithmic contouring



Percentage Frequency Effect % (Linear contouring)

QUE RIVER PROSPECT

Resistivity and I.P. Survey - Traverse 7800N

▲ Frequencies 2·5-0·3Hz

TN Readings not taken

0 25 50 100 metres

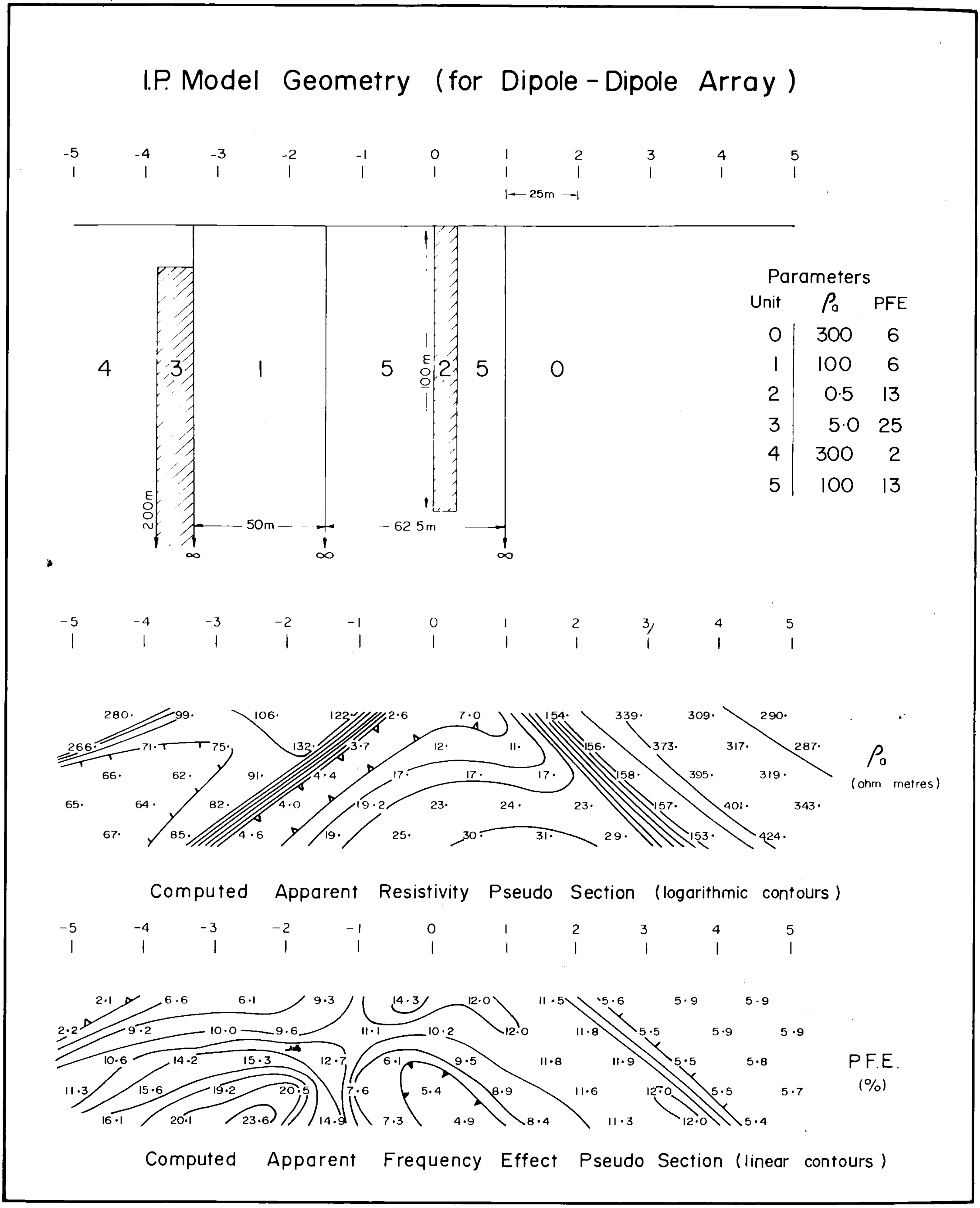

I.P. Model Geometry (for Dipole - Dipole Array)
25m
50m
62.5m
100m
200m
Parameters
Unit ρ_a PFE
0 300 6
1 100 6
2 0.5 13
3 5.0 25
4 300 2
5 100 13
ρ_a (ohm metres)
Computed Apparent Resistivity Pseudo Section (logarithmic contours)
P.F.E. (%)
Computed Apparent Frequency Effect Pseudo Section (linear contours)

FIG. 25

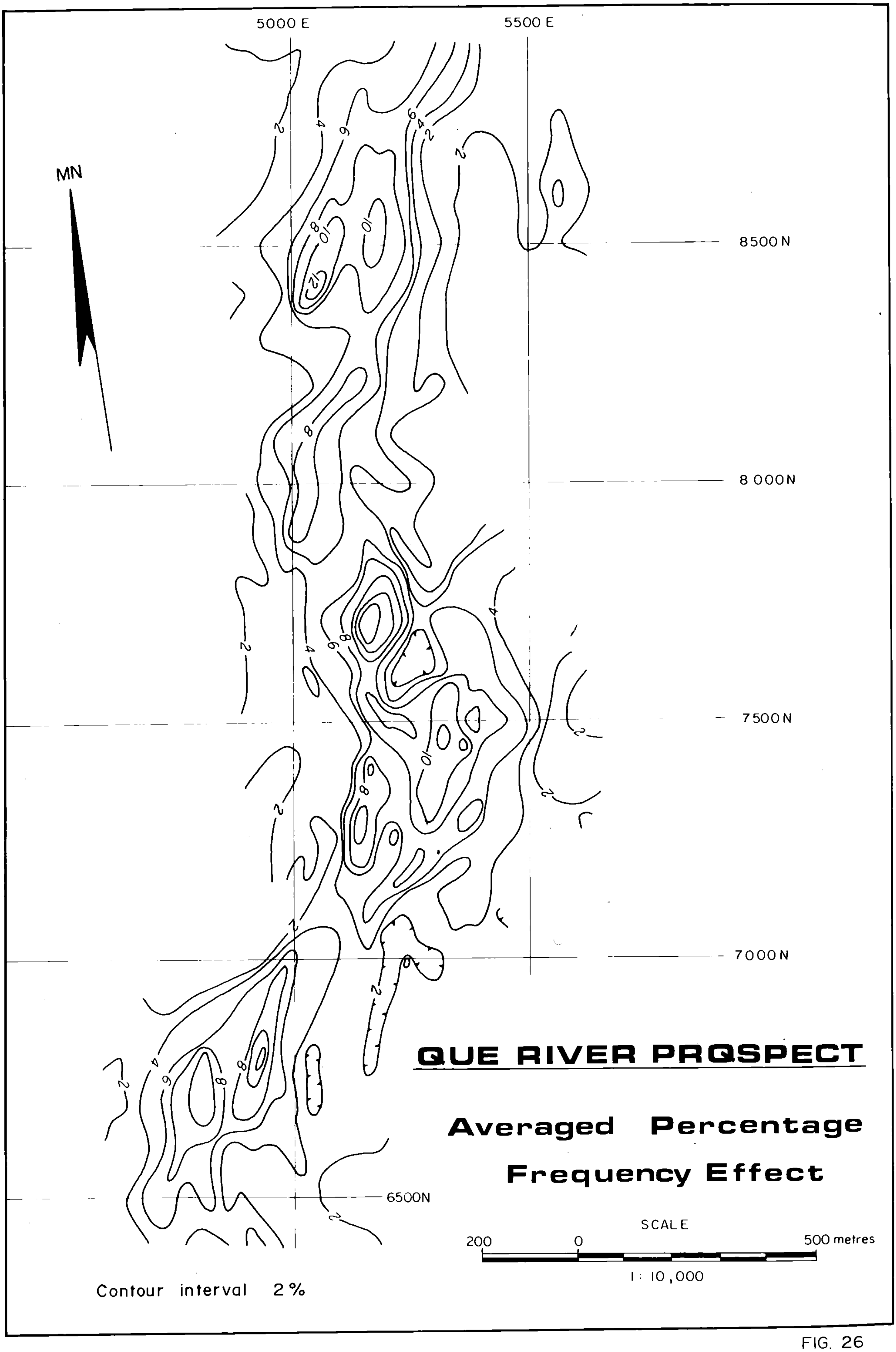
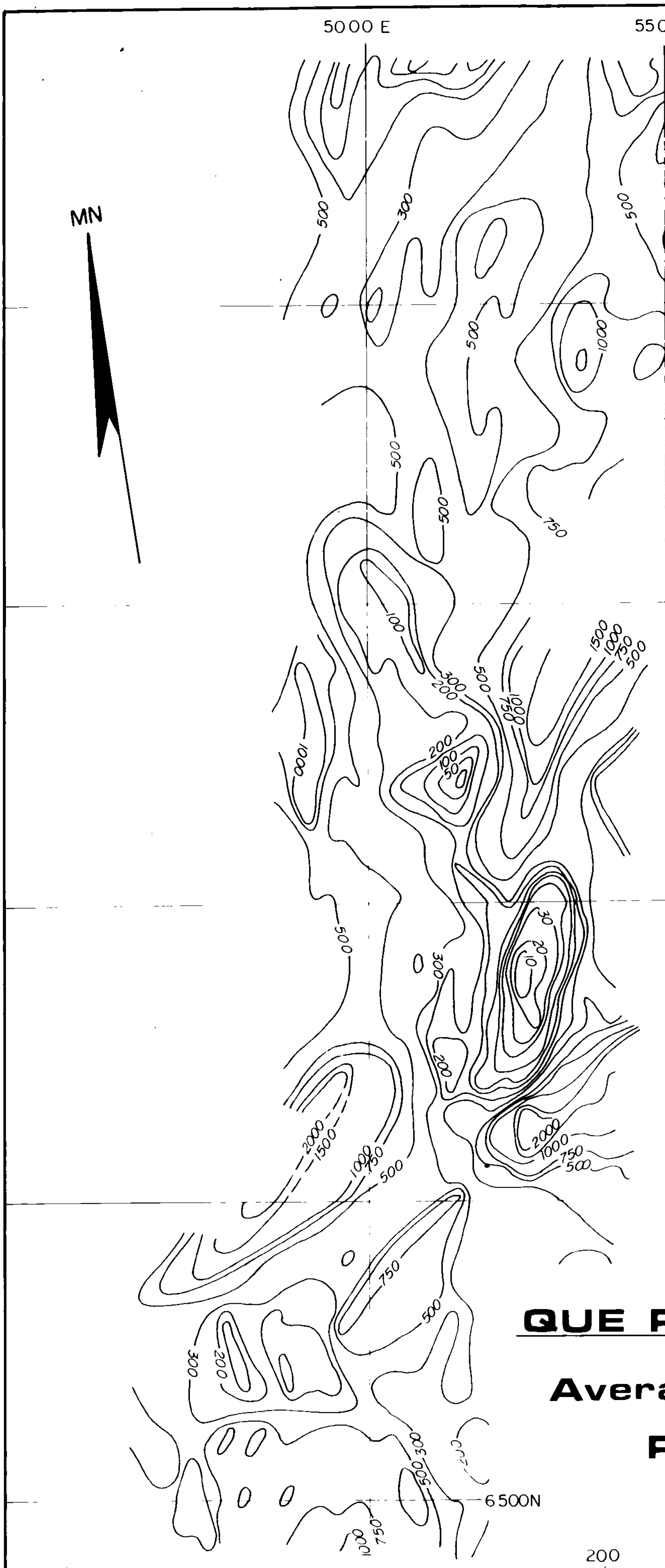

5000 E
5500 E
MN
8500 N
8 000N
7500 N
7000 N
6500N
QUE RIVER PROSPECT
Averaged Percentage Frequency Effect
SCALE
200
0
500 metres
1: 10,000
Contour interval 2%

FIG. 26



QUE RIVER PROSPECT

Averaged Apparent Resistivity (ohm. m.)

SCALE

200 0 500 metres

1 : 10, 000

Logarithmic Contour Interval

FIG. 27