33\. GEOPHYSICAL AND GEOCHEMICAL CASE HISTORY OF THE QUE RIVER DEPOSIT TASMANIA, AUSTRALIA

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Webster, S.S., Skey, E.H., Geophysical and geochemical case history of the Que River deposit, Tasmania, Australia; in Geophysics and Geochemistry in the Search for Metallic Ores; Peter J. Hood, editor; Geological Survey of Canada, Economic Geology Report 31, p. 697-720, 1979.

Abstract

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

The exploration area was selected within a well-mineralized belt of Cambrian calc-alkaline volcanics marking the eastern edge of the Dundas Trough. The initial reconnaissance involving geological traverses and stream sediment sampling covered an area of 60 km^2. Several areas of anomalous geochemistry were located in favourable rock types.

Progress of the reconnaissance program 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 polarization technique, combined with soil geochemistry, optimized drill target definition.

Résumé

Le gisement de la Que River dans le nord-ouest de la Tasmanie, découvert en 1974, comprend plusieurs lentilles distinctes de sulfures massifs dans une zone de 800 m sur 100 m. Les lentilles se trouvent dans une série de dacites pyriteuses et d'andésites, mesurant environ 300 m de large sur 4 km le long de la structure. Les lentilles sont verticales et ont une épaisseur moyenne de 9 m. Une lentille contient surtout de la pyrite et de la chalcopyrite, et les autres contiennent surtout de la pyrite, de la sphalérite et de la galène. Les affleurements de sulfures massifs sont inexistants. La zone d'exploration a été choisie à l'intérieur d'une zone bien minéralisée formée de roches volcaniques calco-alcalines du Cambrien, marquant la bordure orientale de la fosse de Dundas. La reconnaissance initiale, comprenant les cheminements géologiques et l'échantillonnage des dépôts fluviatiles, a couvert une surface de 60 km^2. Plusieurs zones d'anomalies géochimiques ont été découvertes dans des roches favorables.

Le programme de reconnaissance et les travaux ultérieurs ont été retardés à cause d'une forêt humide et dense et la topographie accidentée. Un levé électromagnétique aéroporté a alors été effectué. Même si cette méthode n'a jusque là pas permis de découvrir de gisements en Australie, le milieu géophysique en Tasmanie se prête à son application. Un conducteur a été immédiatement identifié dans une zone d'anomalies géochimiques à l'intérieur de sédiments fluviatiles. Le conducteur a été délimité par des techniques de levé géochimique des sols et de levé électromagnétique au sol. Un premier forage a montré que le conducteur était une lentille isolée contenant surtout des sulfures de fer et de cuivre. D'autres forages ont rencontré une zone relativement importante de sulfures de zinc, de plomb et de fer qui n'avait pas été détectée par les levés électromagnétiques, mais qui avait été signalée par la géochimie du sol. Une étude systématique a montré qu'en combinant la méthode de polarisation provoquée à l'exploration géochimique des sols, on pouvait très bien définir legisement.

INTRODUCTION

The Que River deposit, within the main mining district of northwestern Tasmania, is situated 2 km east of the Murchison Highway, approximately 25 km northeast of Rosebery (Fig. 33.1).

An Exploration Licence was acquired in 1970 within the Mount Read volcanics, a Cambrian calc-alkaline suite of pyroclastics, lavas and intrusives, which form an arcuate belt 10 km wide and 240 km long marginal to the Precambrian Tyennan nucleus. To the west is the Dundas Trough composed

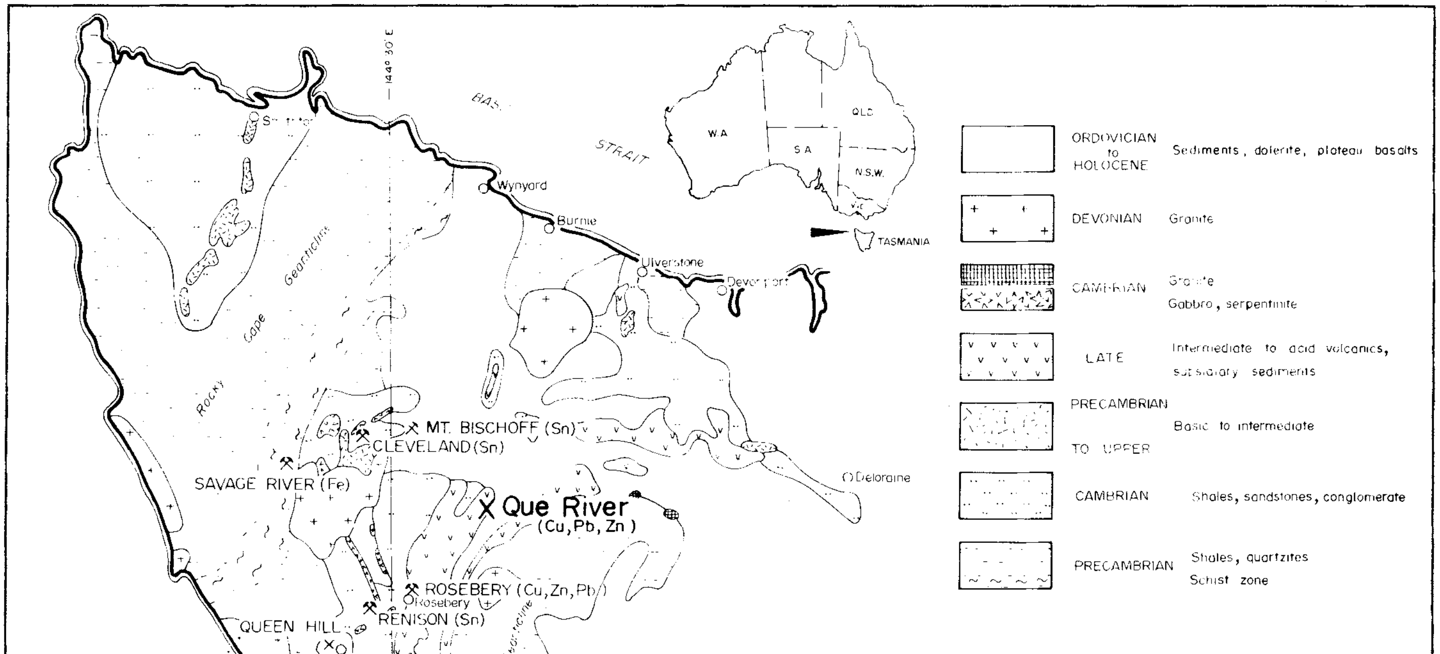

Figure 33.1.

Geology of northwest Tasmania (after Williams, 1976; Gee, 1967).

of late Proterozoic and early Palezoic sediments which are partly a facies equivalent of the volcanics (Corbett et al., 1974).

The Mt. Read volcanics were chosen for exploration as they host the Rosebery Zn-Pb-Cu deposit and the Mt. Lyell Cu-Au deposit. These deposits are important mineral producers in Tasmania and though they have been in production for most of this century, the volcanics have not been well prospected. This is mainly due to the dense vegetation and rugged terrain of the area, however improved access and modern geochemical and geophysical practices, have facilitated exploration of such difficult areas.

GEOLOGY OF THE QUE RIVER AREA

Geological mapping resulted in identification of three fundamental stratigraphic units from east to west, as shown in Figure 33.2.

The easternmost unit 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 overlie 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 northeast 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.

At the detailed scale (Fig. 33.3), the paucity of outcrop necessitates that a geological plan be substantially interpreted from the drilling results (Fig. 33.4). The subvertical 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" mineralization; heavily pyritized 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 mineralized pyroclastics containing the major galena-sphalerite ore lenses; hanging-wall andesitic-pyroclastics, unaltered and virtually devoid of sulphide mineralization. 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 composed 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.

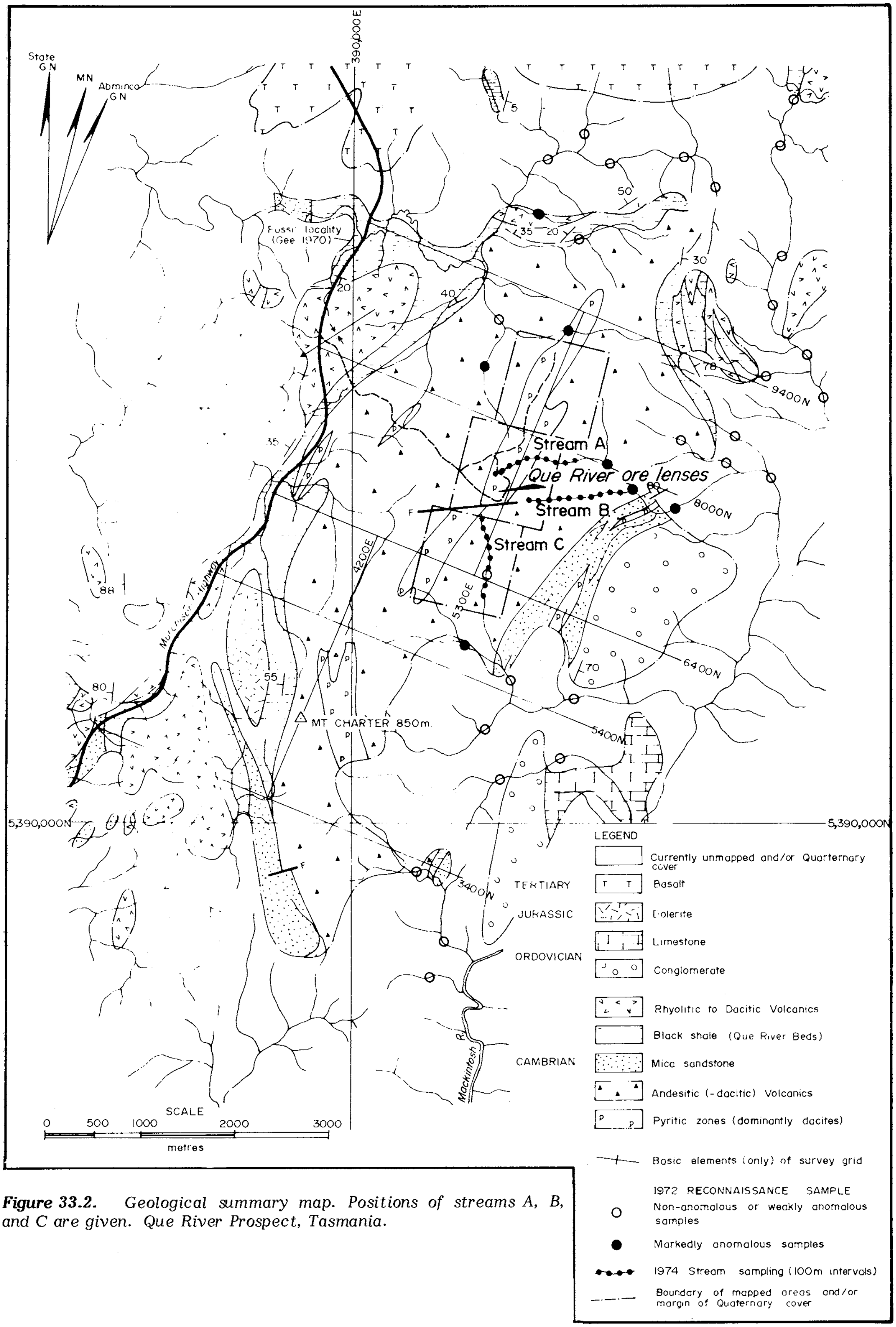

Figure 33.2. *Geological summary map. Positions of streams A, B, and C are given. Que River Prospect, Tasmania.*

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GEOCHEMICAL SURVEY PROGRAM

Stream Sediment Geochemistry

Regional Reconnaissance Program

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 pulverized and digested in hot perchloric acid, then analyzed by atomic absorption spectrophotometry (AAS) for copper, lead and zinc. Results from the vicinity of the Que River prospect are shown in Figure 33.5.

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 recognizably anomalous in a regional sense. Inspection of the metal values in adjacent samples within the volcanics revealed the 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.

Local Orientation Program

Three streams draining the prospect were sampled in detail for geochemical orientation purposes. This program 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 33.2. 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.

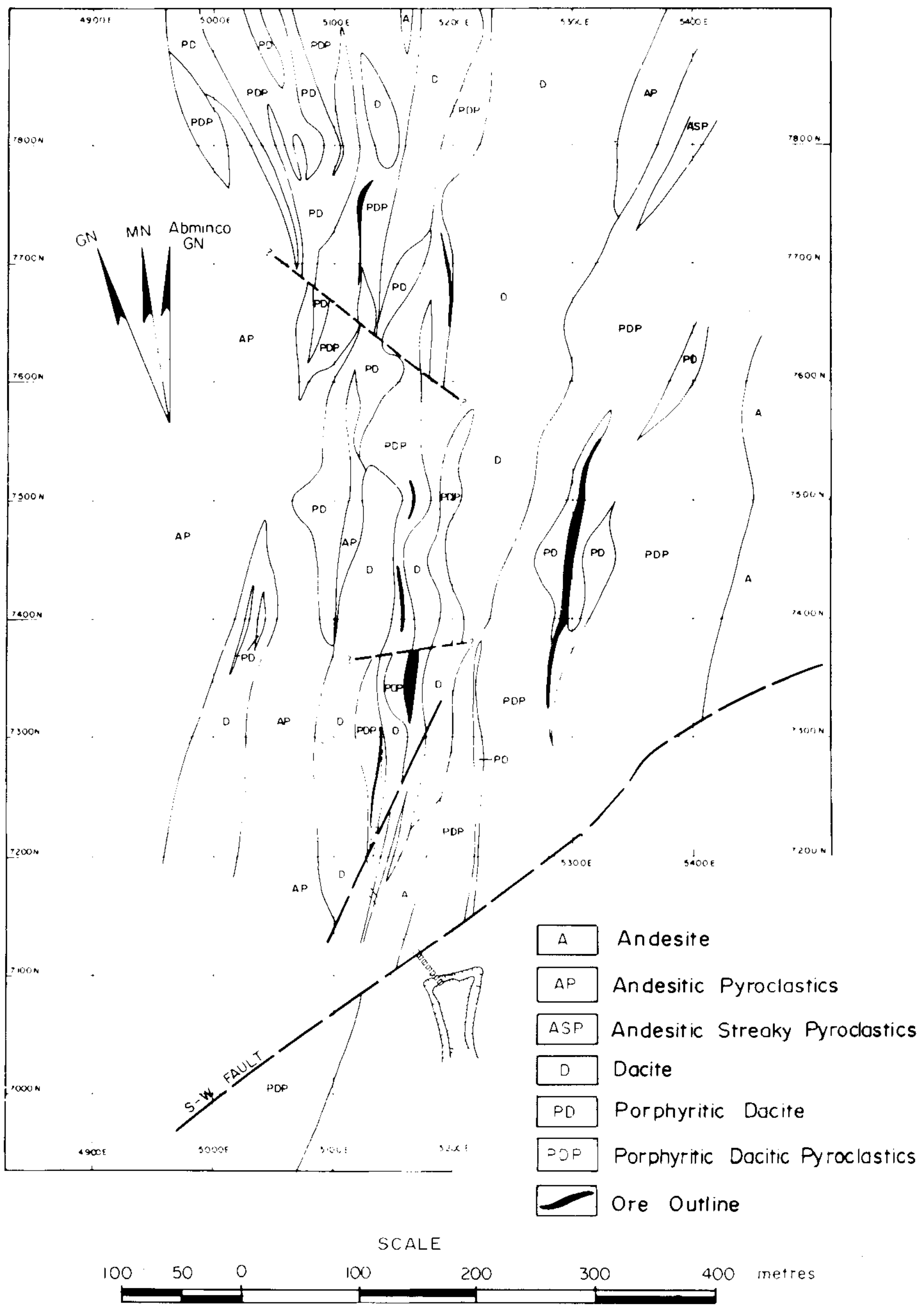

Figure 33.3. *Interpretetive surface geology, Que River Prospect, Tasmania.*

The range of results achieved for -200, -100 +200, -40 +100 and -40 (100%) mesh size fractions is shown in Figures 33.6, 33.7 and 33.8. 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.

Soil Geochemistry

During the preliminary program samples were collected at 50 m intervals from the A and C soil horizons using hand screw augers. After drying and sieving to obtain the minus 80 mesh fraction, (for analytical convenience) the samples were digested and analyzed in the same way as the stream sediments. Iron was analyzed 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 cm thick, is underlain by grey clays which are patchily ironstained and occasionally overlie massive gossan above fresh pyritic rock. This (C) horizon is typically 50 cm to 3 m in thickness and is usually underlain by rotten grey ironstained pyroclastics to a depth of 20 m 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.

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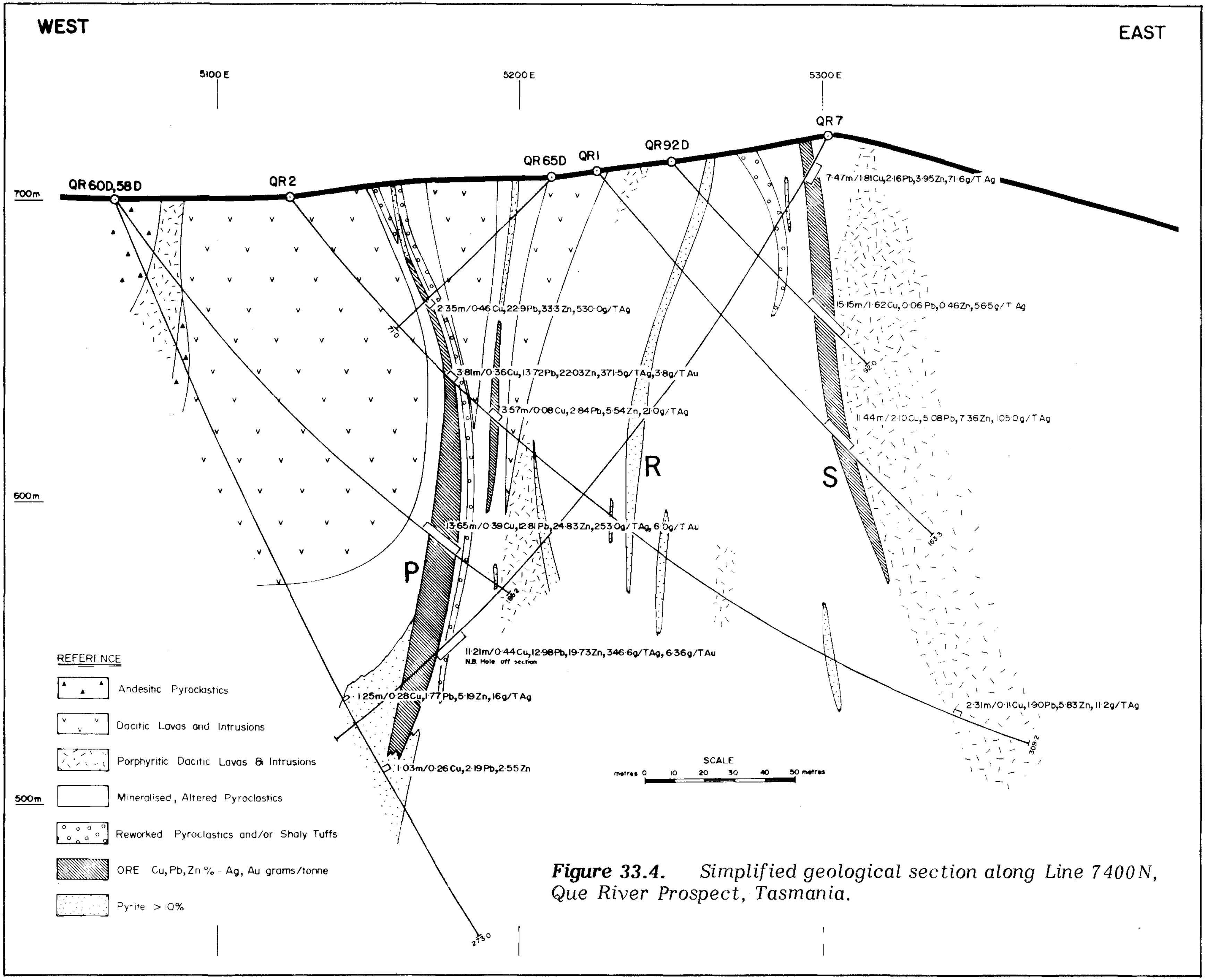

Figure 33.4. *Simplified geological section along Line 7400 N, Que River Prospect, Tasmania.*

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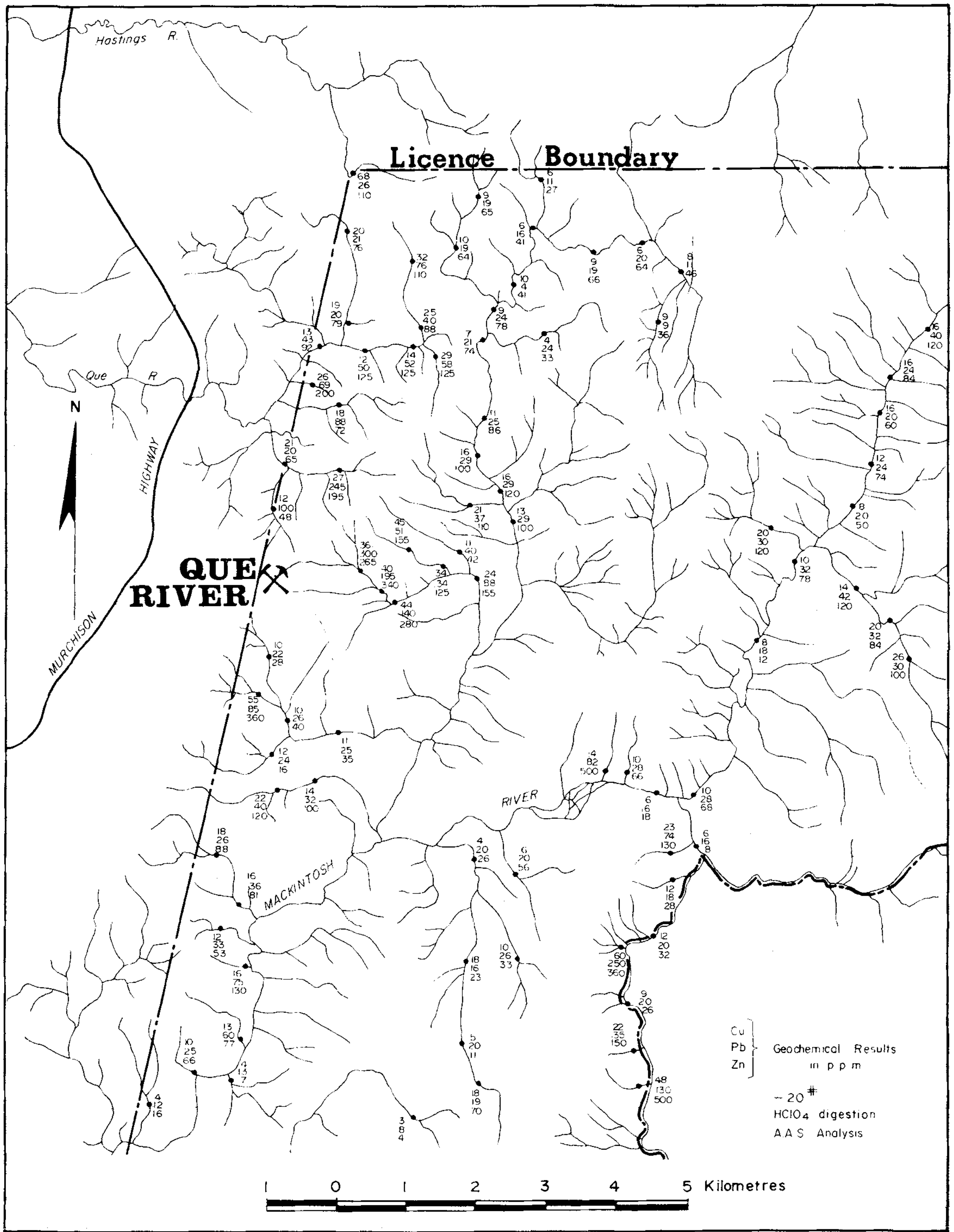

Figure 33.5. *Geochemical results for the 1970-71 stream sediment survey, Que River Prospect, Tasmania.*

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

The C horizon results for lead (immobile) and zinc (mobile) are illustrated by Figures 33.9 and 33.10. 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 50 m by 50 m was considered too broad to consistently identify a narrow source.

Iron values (Fig. 33.12) 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 southeastern sector of the grid was identified by mapping as outcropping and

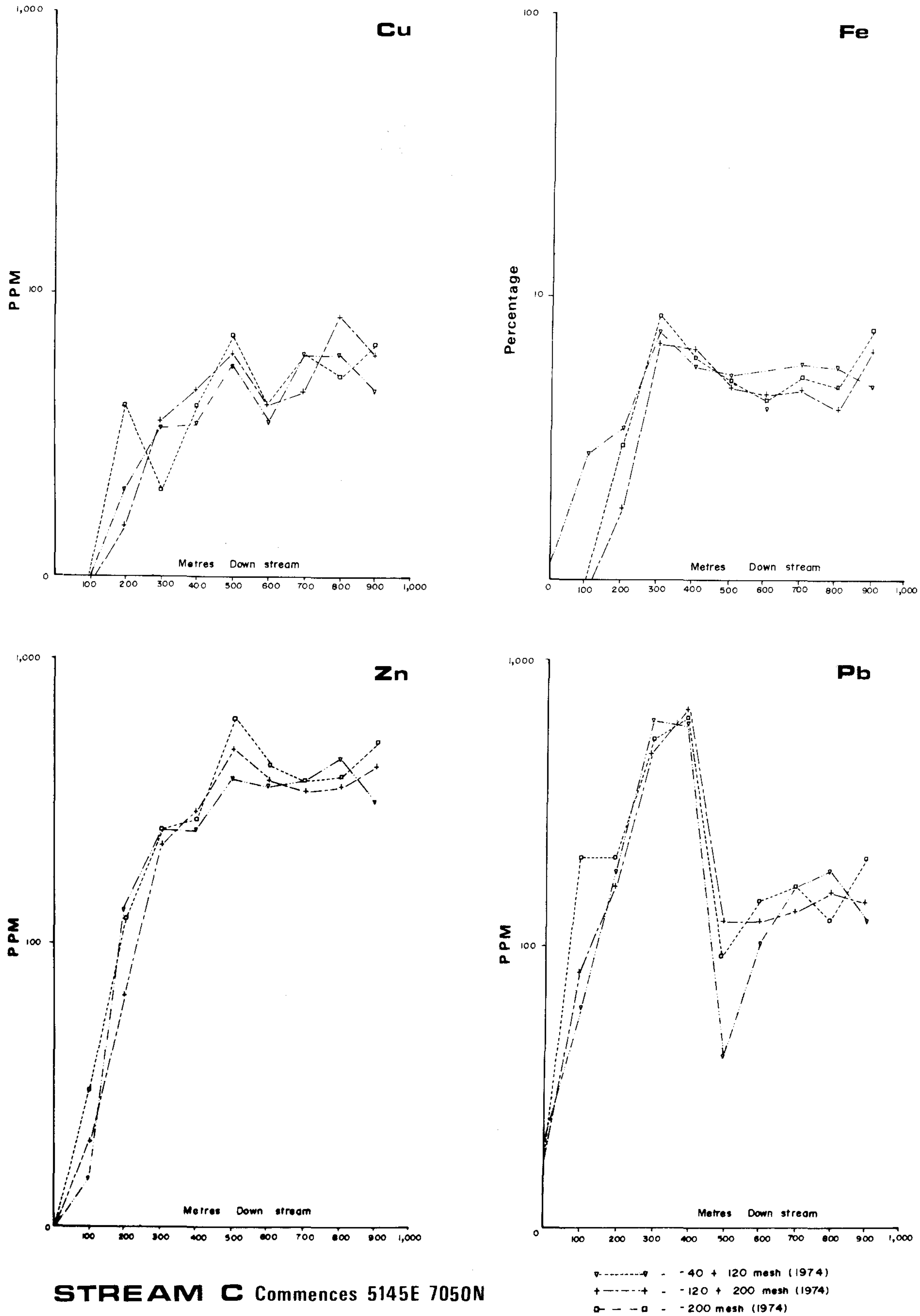

Figure 33.6. *Stream sediment geochemical results for Cu, Fe, Zn, and Pb from Stream C. Que River Prospect, Tasmania.*

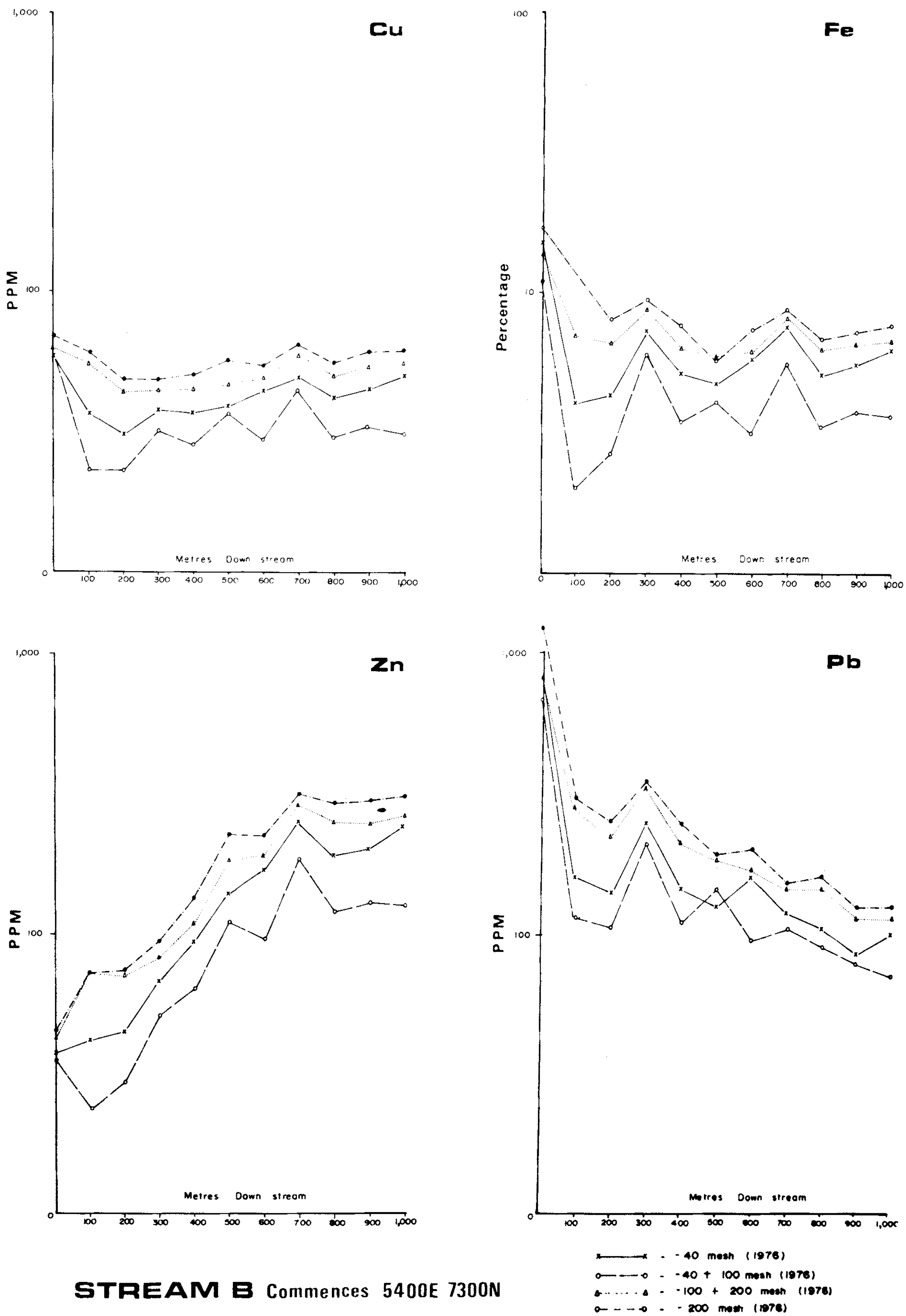

Figure 33.7. *Stream sediment geochemical results for Cu, Fe, Zn, and Pb from Stream B. Que River Prospect, Tasmania.*

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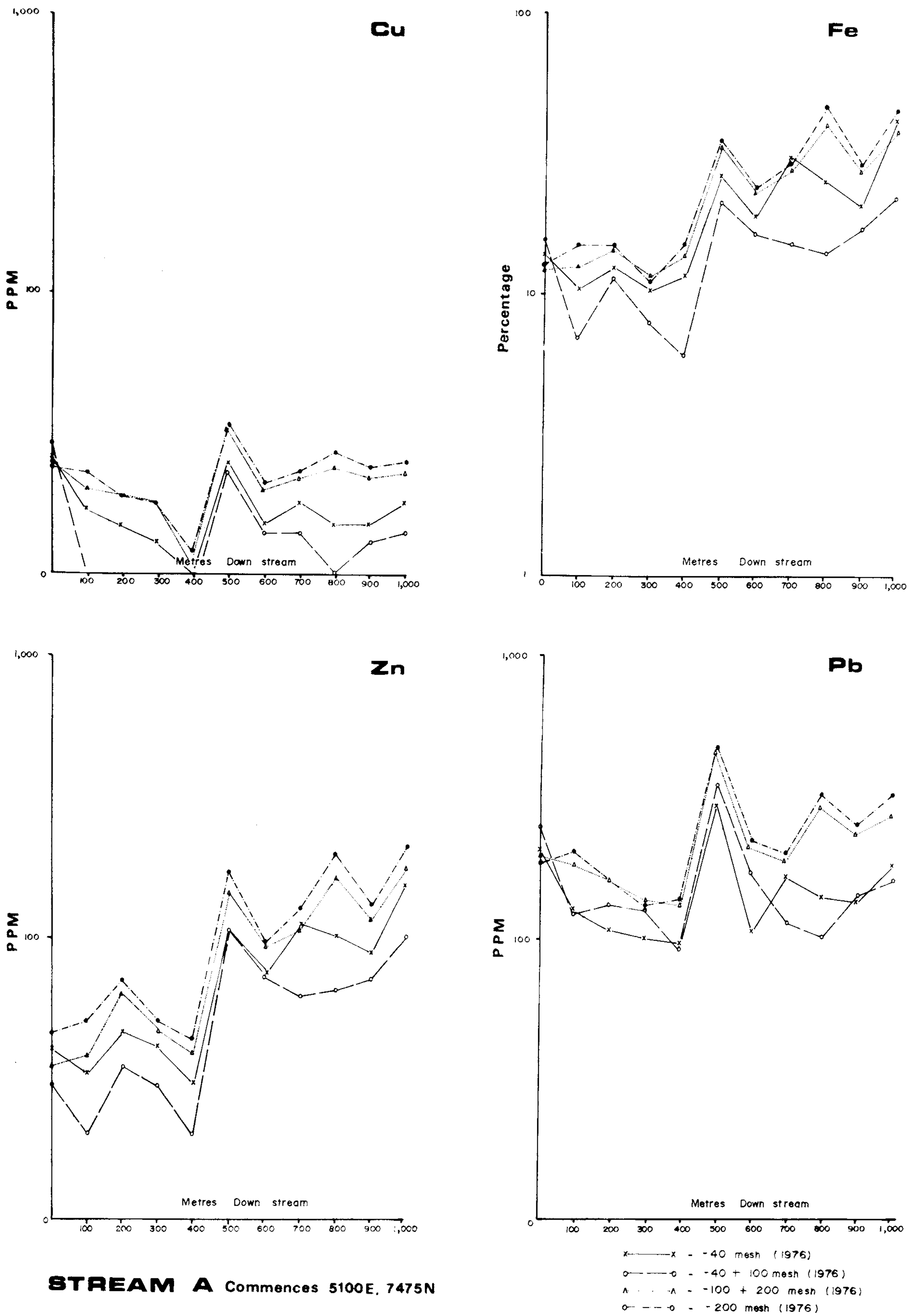

Figure 33.8. *Stream sediment geochemical results for Cu, Fe, Zn, and Pb from Stream A. Que River Prospect, Tasmania.*

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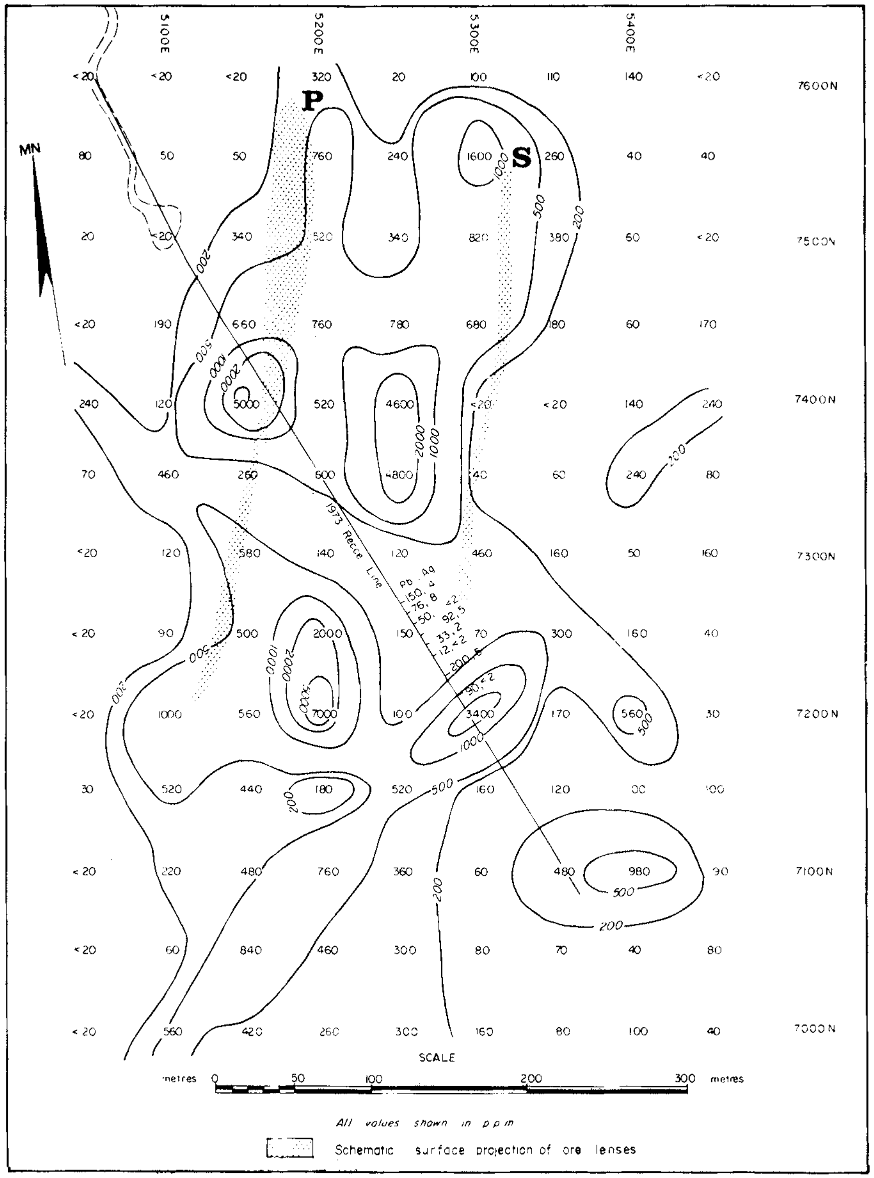

Figure 33.9. *Lead values in C horizon soils using a 50 x 50 m sampling grid. Que River Prospect, Tasmania.*

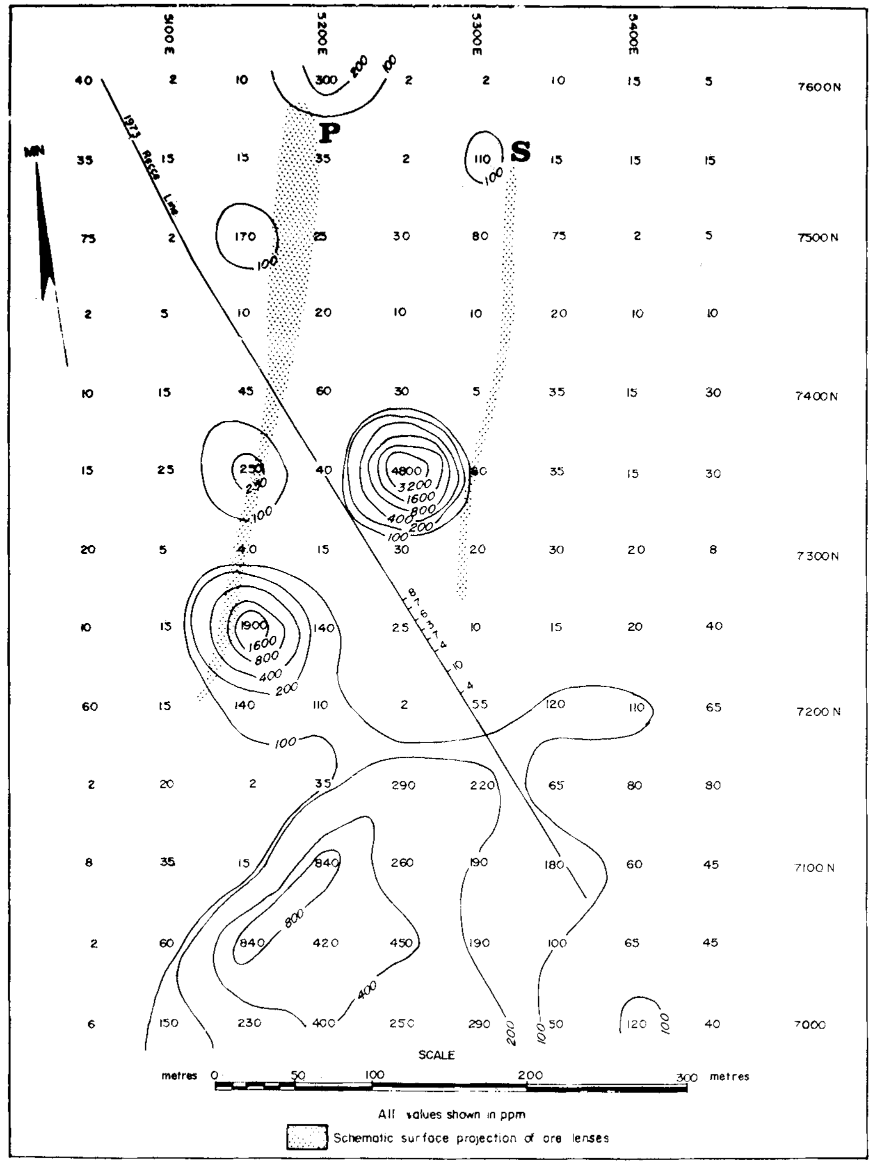

Figure 33.10. *Zinc values in C horizon soils using a 50 x 50 m sampling grid. Que River Prospect, Tasmania.*

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subcropping andesitic agglomerates with trace sulphides. The sharp termination of this geochemical zone to the northwest was inferred to be a fault of strike 045° grid, as shown in Figure 33.3.

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

Distribution patterns are broadly similar to those for the C horizon and delineate southeastern 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 transportation, 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 50 m sampling program, gossanous fragments and fresh sulphides in some auger samples prompted a pitting program. Sampling of soils form 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 mineralized 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, 10 500 ppm Zn and 15.5% Fe.

Auger samples collected from weathered bedrock had values up to 600 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 10 m spaced sampling was initiated.

As shown in Figures 33.11 and 33.12, several linear geochemical trends were indicated but these were 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 localized 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 compared to geophysical methods, but one metre-spaced samples were collected on line 7400N after drilling, for research purposes. Figure 33.13 shows stacked geochemical profiles of C horizon soil values for a 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 mineralized 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 GEOPHYSICAL SURVEY PROGRAM

In February 1972, a combined aeromagnetic/electromagnetic survey of a 400 km^2 area was flown by McPhar Geophysics Pty. Ltd. using a 320 m. 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 utilizing a large transmitter (horizontal dipole) to receiver (vertical dipole) separation of 130 m, 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 33.14, 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 the low frequency response to the 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 33.14 over the Que River deposit has an amplitude of 4 parts per thousand (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 (σt) 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 33.1.

The flight path recovery map for this survey (Fig. 33.15) shows that poor survey control in the vicinity of the ore lenses resulted 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 m line spacing. This detailed survey, utilizing 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 33.16 and indicate there is a recognizable response up to 245 m terrain clearance, which confairms the scale model results of Ward (1969), and the 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 33.17, 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.

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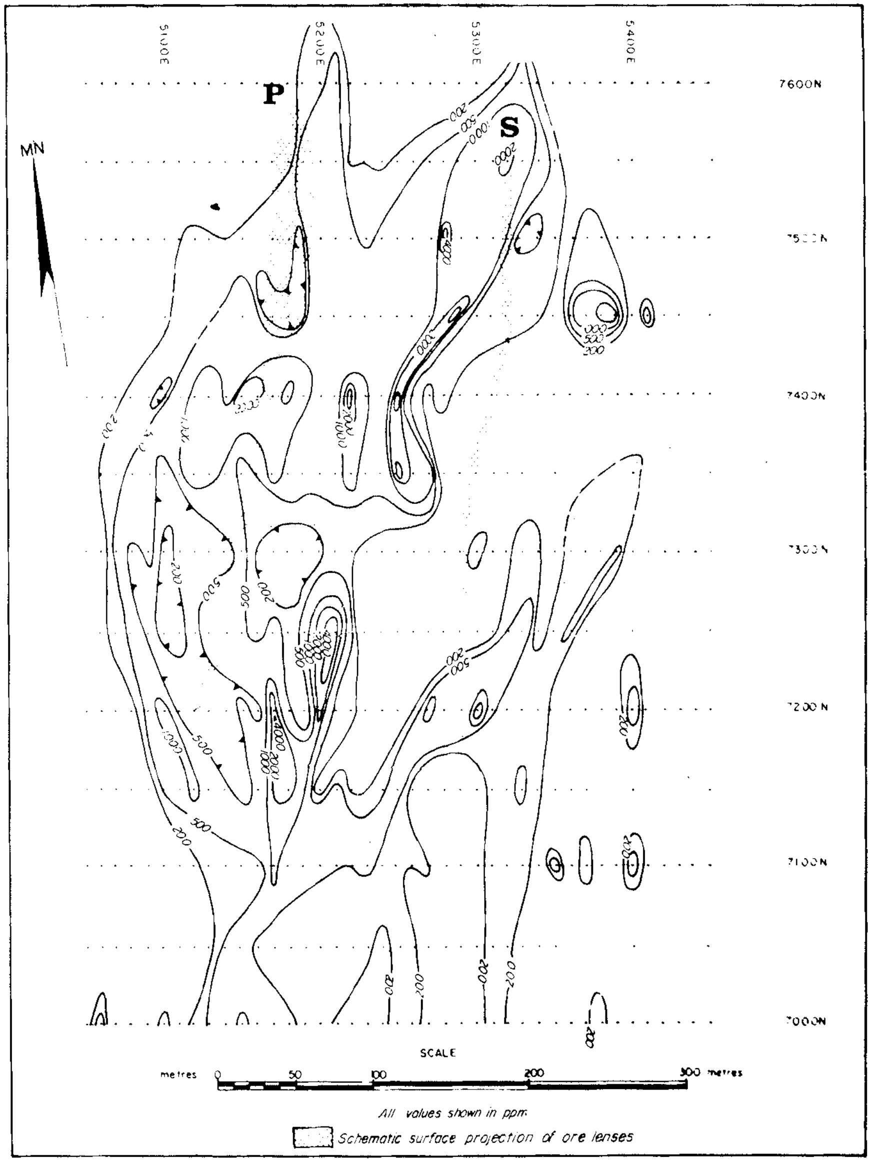

Figure 33.11. Lead values in C horizon soils using a 50 x 10 m sampling grid. Que River Prospect, Tasmania.

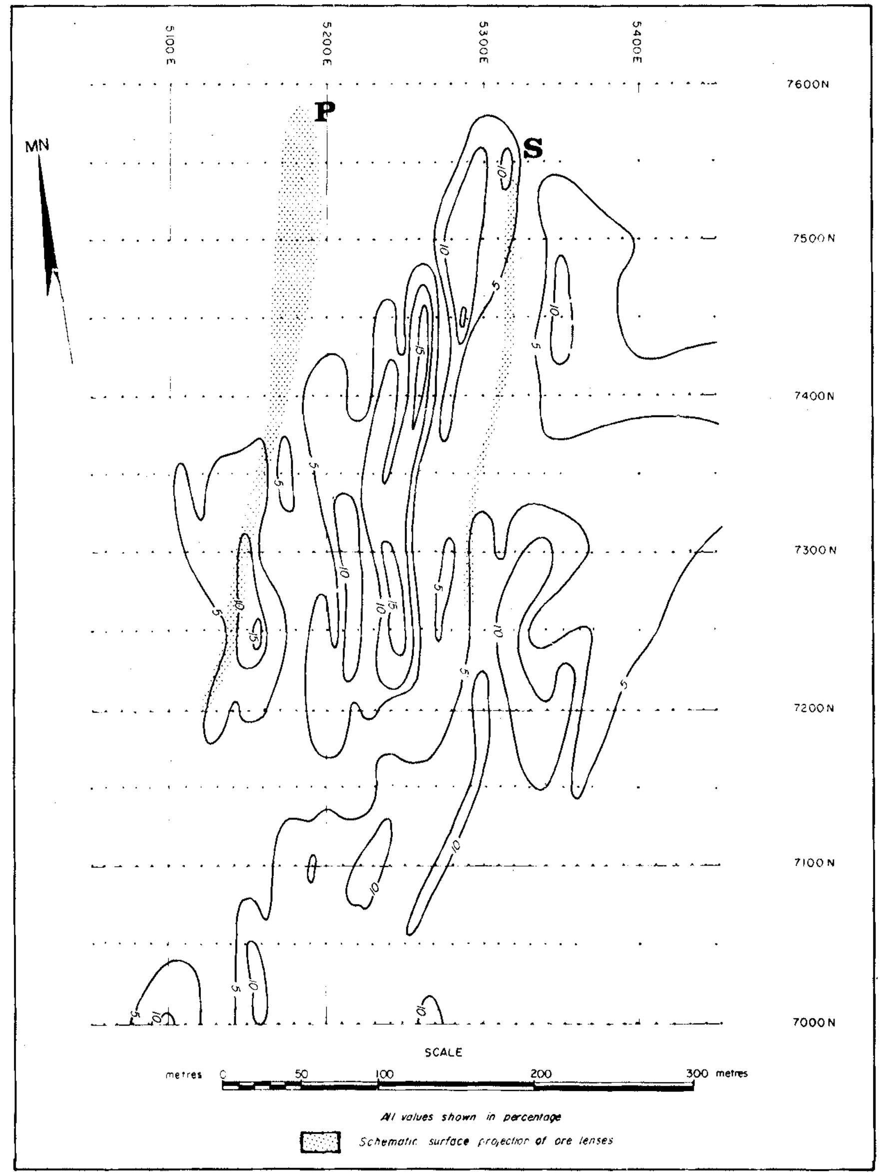

Figure 33.12. Iron values in C horizon soils using a 50 x 10 m sampling grid. Que River Prospect, Tasmania.

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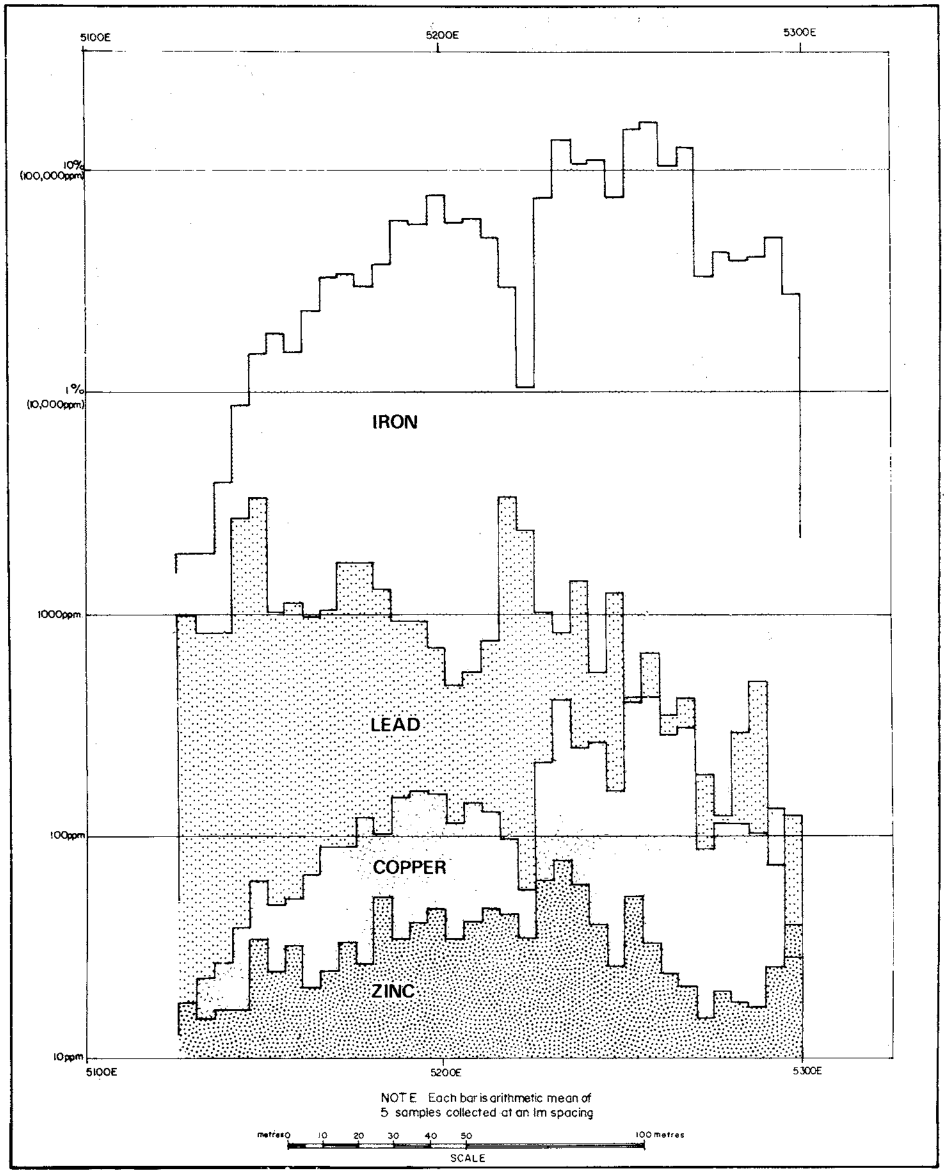

Figure 33.13. *Averaged iron, lead, copper and zinc values obtained from C horizon soil sampling at one metre intervals along Line 7400N. Que River Prospect, Tasmania.*

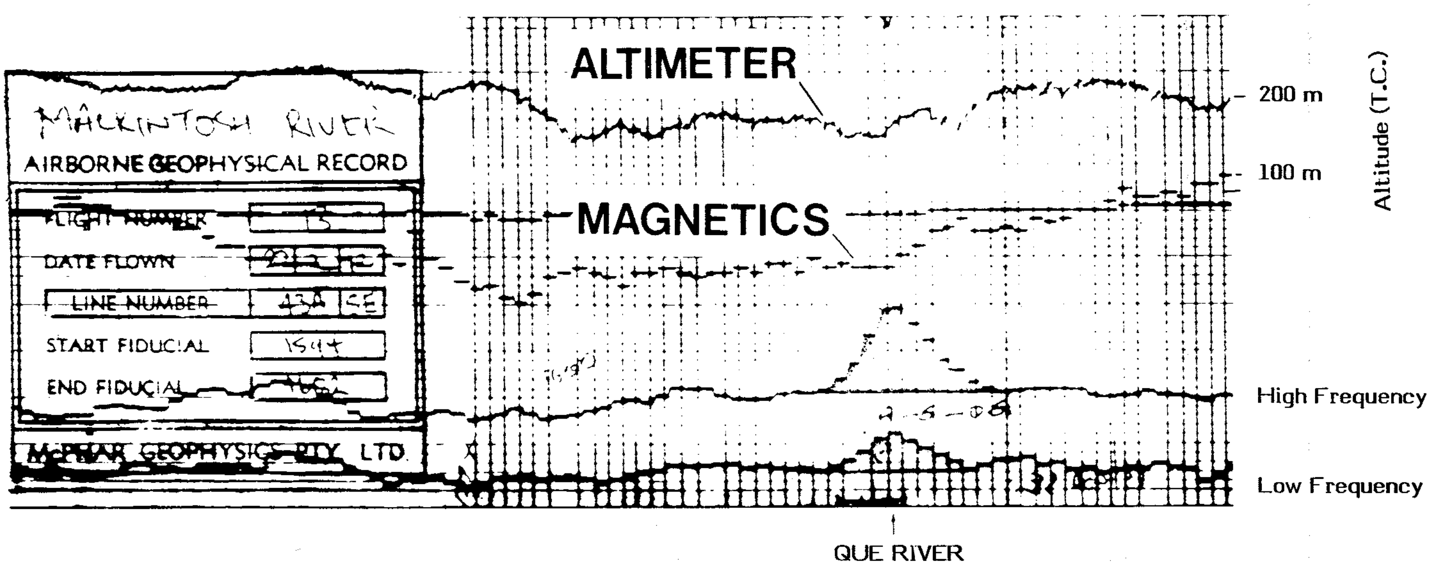

Figure 33.14. *Airborne electromagnetic discovery profile across the Que River Prospect using the McPhar H400 two-frequency quadrature system (1972).*

GROUND GEOPHYSICAL SURVEY PROGRAM

Ground Electromagnetic and Magnetic Surveys

To accurately locate and delineate the Que River airborne electromagnetic anomaly, a survey grid was established with cross lines, each 400 m long, cut every 50 m for a baseline length of 600 m over the position located during the 1972 survey. The grid was initially surveyed using the horizontal-loop electromagnetic method and a proton precession magnetometer. After the anomaly had been positively identified, the grid was surveyed using the vertical loop electromagnetic method in the broadside configuration, to accurately locate the axis of the anomalous source.

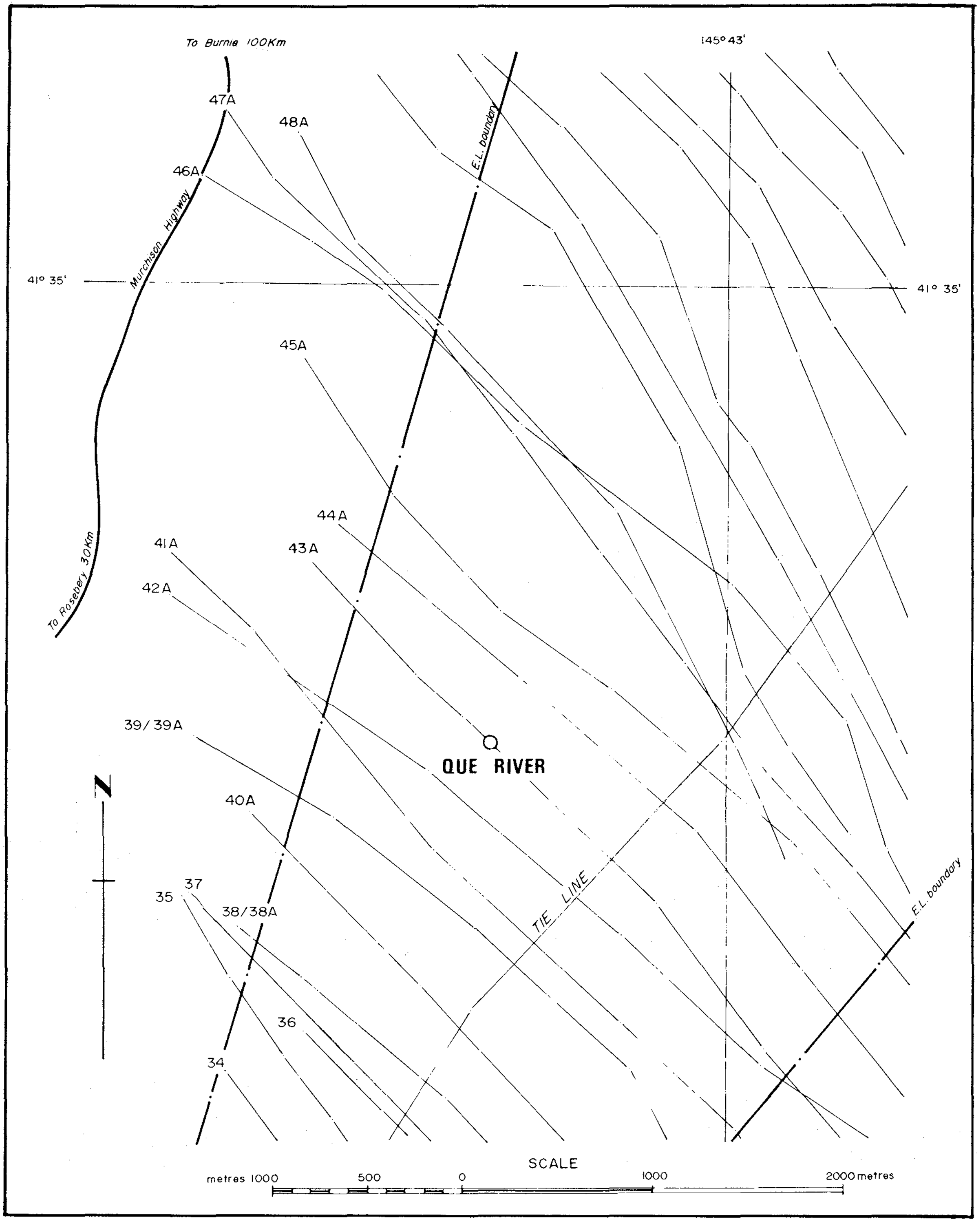

Figure 33.15. *Flight path map for the 1972 airborne EM survey by McPhar Geophysics Pty. Ltd. Que River Prospect, Tasmania.*

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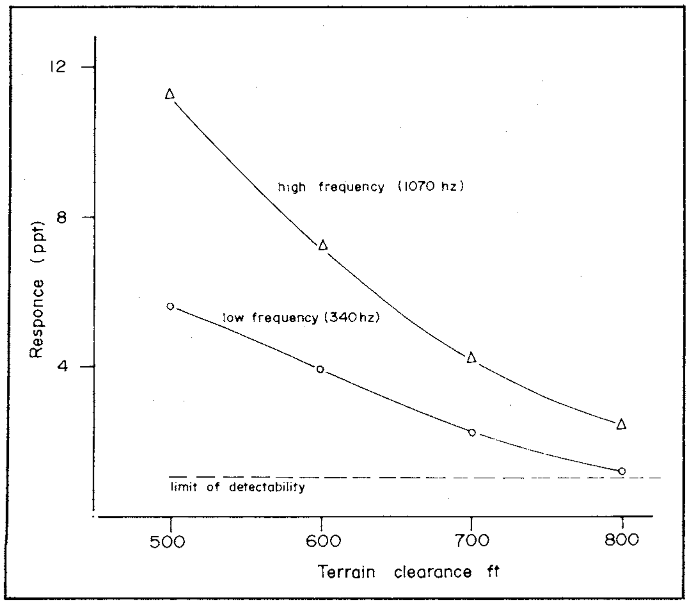

Figure 33.16. *Attenuation tests over the Que River anomaly using the McPhar H-400 airborne EM system flown by Geoex Pty Ltd. in 1975.*

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 m was used for the horizontal-loop EM survey (Fig. 33.18) 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-intensity magnetic field measurements were obtained with a McPhar GP 70 proton precession magnetometer which had a sensitivity of ± 1 gamma.

The vertical loop electromagnetic data were recorded by Geoex Pty. Ltd. utilizing a McPhar SS15 unit with a 5 m diameter vertical-loop which was positioned over the conductor axis and kept in maximum coupling with the receiver as the lines were traversed. The operational frequencies were 1000 Hz and 5000 Hz. The grid was surveyed with the McPhar SS15 vertical-loop EM from two transmitter locations 7150N, 5270E (Fig. 33.19) and 7400N, 5275E, thus covering the area of interest within the most effective range of the equipment.

Qualitative Analysis of Electromagnetic Data

The horizontal loop electromagnetic traverses (Fig. 33.18) 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 condutor. These EM anomalies are clearly due to the eastern (S lens) mineralization.

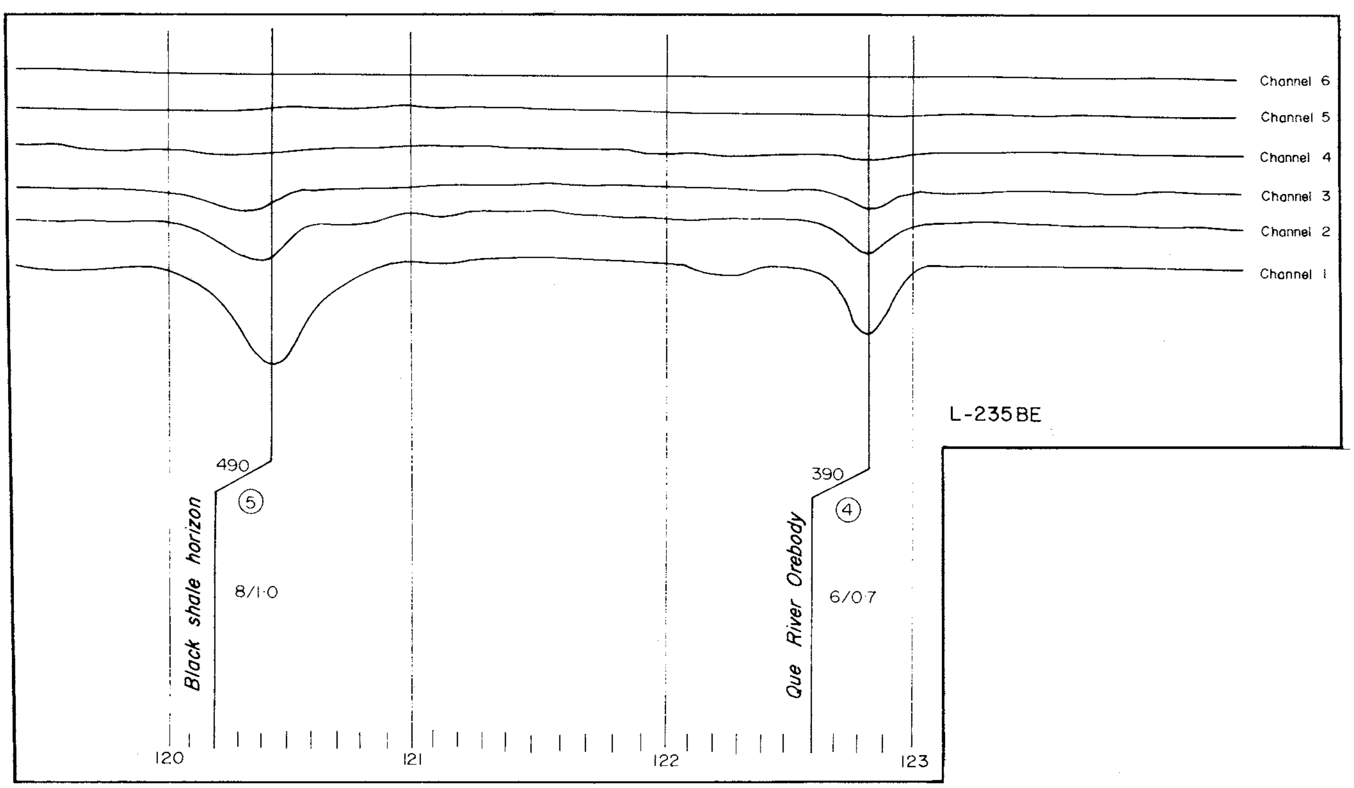

Figure 33.17. *INPUT airborne EM profiles across the Que River Prospect, Tasmania.*

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

A weak, but definite magnetic anomaly was detected on lines 7350N to 7550N, with a maximum relief of 200 gammas on line 7500N in the vicinity of 5150E. The magnetic data, however, proved to be of no value 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 vertical-loop electromagnetic (VEM) data have been transformed to their first derivatives by the procedure of Fraser (1969) and plotted in contour form in Figure 33.20. 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 (see Fig. 33.4). The main conductor can be classified as "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 horizontal-loop electromagnetic (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 lens system.

Quantitative Analysis of Electromagnetic Data

The horizontal-loop electromagnetic data recorded at Que River have been interpreted, 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 m along traverses, i.e. at approximately half-loop separation.

Table 33.1 lists the results of this analysis, and the classification of the conductivity-thickness parameters according to the system outlined in Table 33.1. 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 EM 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.

Self-potential Survey

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 (Fig. 33.21). This sharp anomaly was superimposed on a broad anomaly of -20 to -30 mv, which appears to delineate the pyritic suite. A weak northeast-southwest gradient crosses 5300E on line 7200N and marks the fault contact between mineralized pyroclastics and nonmineralized andesite.

Table 33.1

Classification of conductors detected by the horizontal-loop electromagnetic survey. σt is the conductivity-thickness product

Line	Anomaly	σt (mhos) High Frequency	Abminco Classification	σt (mhos) Low Frequency	Abminco 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. Abminco Classification of EM conductors.

Classification	σt mhos
Excellent	>15.0
Good	6.0 – 15.0
Fair	1.5 – 6.0
Poor	<1.5

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DRILLING PROGRAM – FIRST PHASE

A seven-hole diamond drilling program was designed to evaluate the prospect. The first hole encountered 11.4 m of sulphide mineralization which assayed 2.10% Cu, 5.08% Pb, 7.86% Zn and 105 grams/tonne 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 mineralized zone was intersected over 3.81 m which averaged 0.86% Cu, 13.72% Pb, 22.03% Zn, 371 grams/tonne Ag and 3.8 grams/tonne Au.

GROUND GEOPHYSICAL SURVEY PROGRAM – SECOND PHASE

Mise-a-la-masse Survey

As intersections of conductive mineralization were anticipated in the drilling program, provisions were made to survey the prospect with the mise-à-la-masse technique. The objective of this work was to attempt to ascertain the strike length of the eastern mineralization and its electrical conductivity, by placing a current electrode in drillhole QR 1 adjacent to the mineralization.

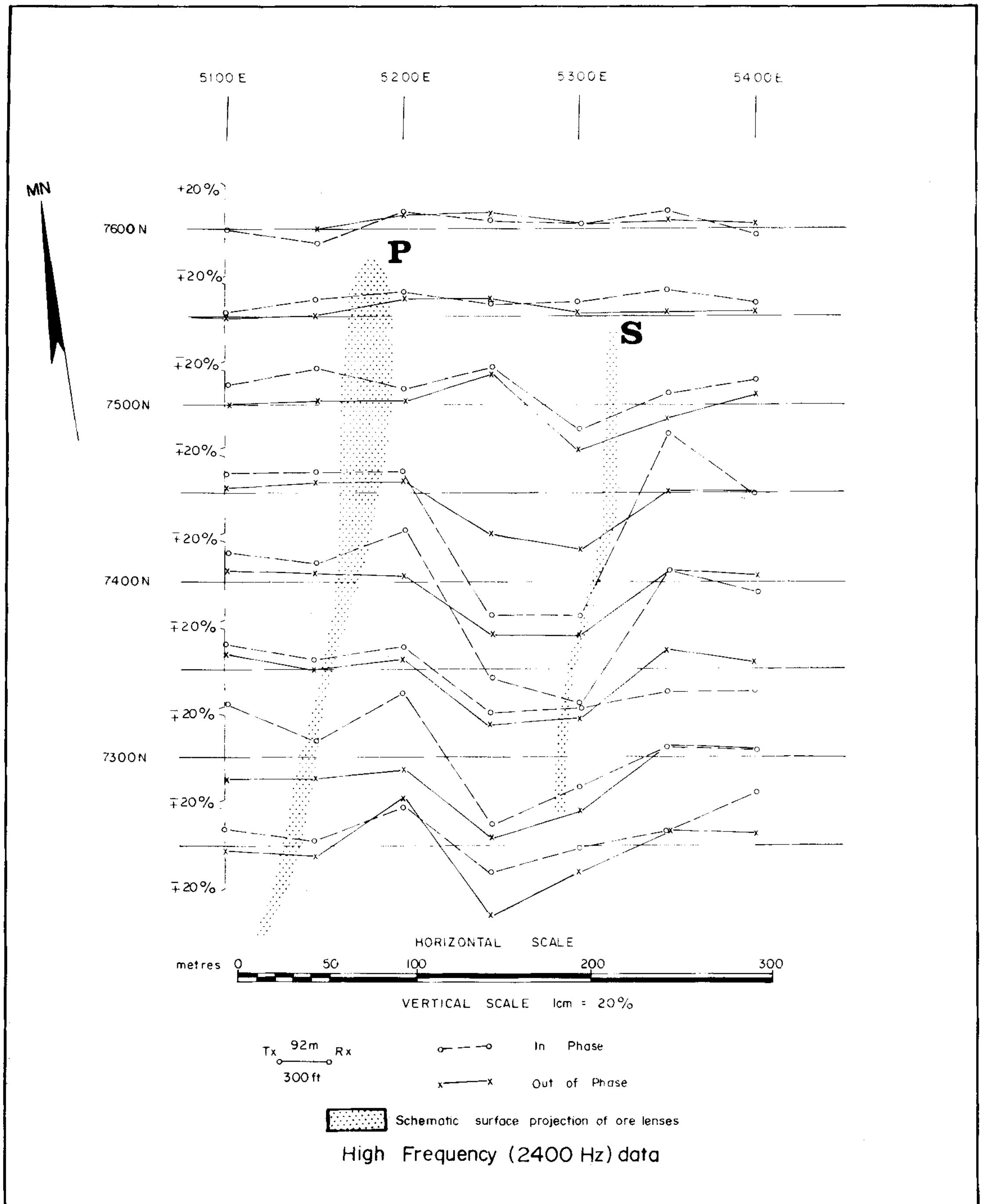

Figure 33.18. *Horizontal-loop electromagnetic profiles using McPhar VHEM equipment operating at 2400 Hz. Separation of transmitter/receiver was 92 metres. Que River Prospect, Tasmania.*

The surface potential mapped when this electrode was energized is shown in Figure 33.24 and indicates electrical continuity within the eastern mineralization 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 mineralization.

An attempt was made to energize the western mineralization via an electrode in QR 2, however, the resulting surface potential pattern suggested that the host pyroclastic unit was being energized in preference to the mineralization.

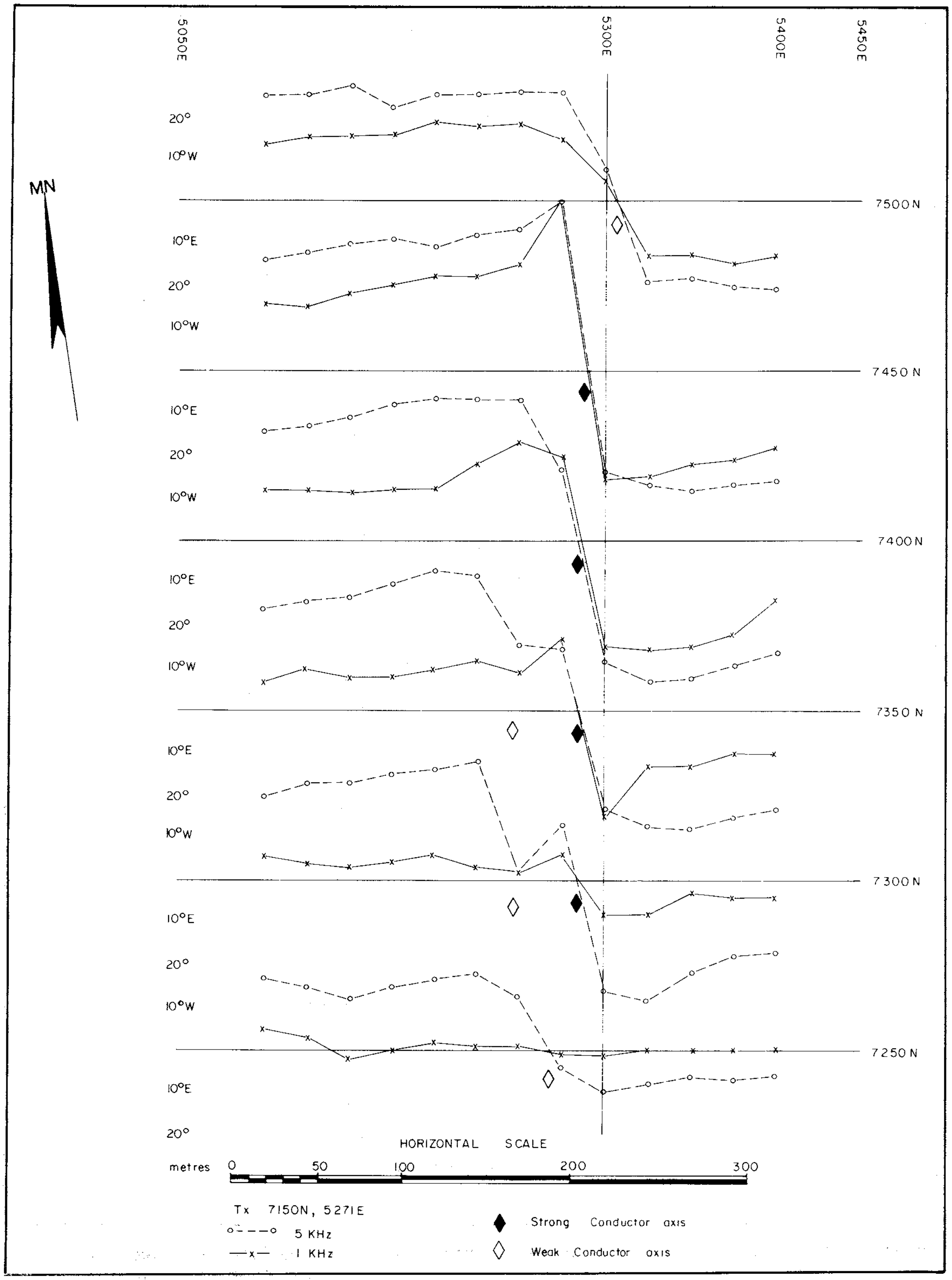

Figure 33.19. *Vertical-loop electromagnetic profiles obtained using the McPhar SS15 system. Transmitter located at 7150N, 5270E. Que River Prospect, Tasmania.*

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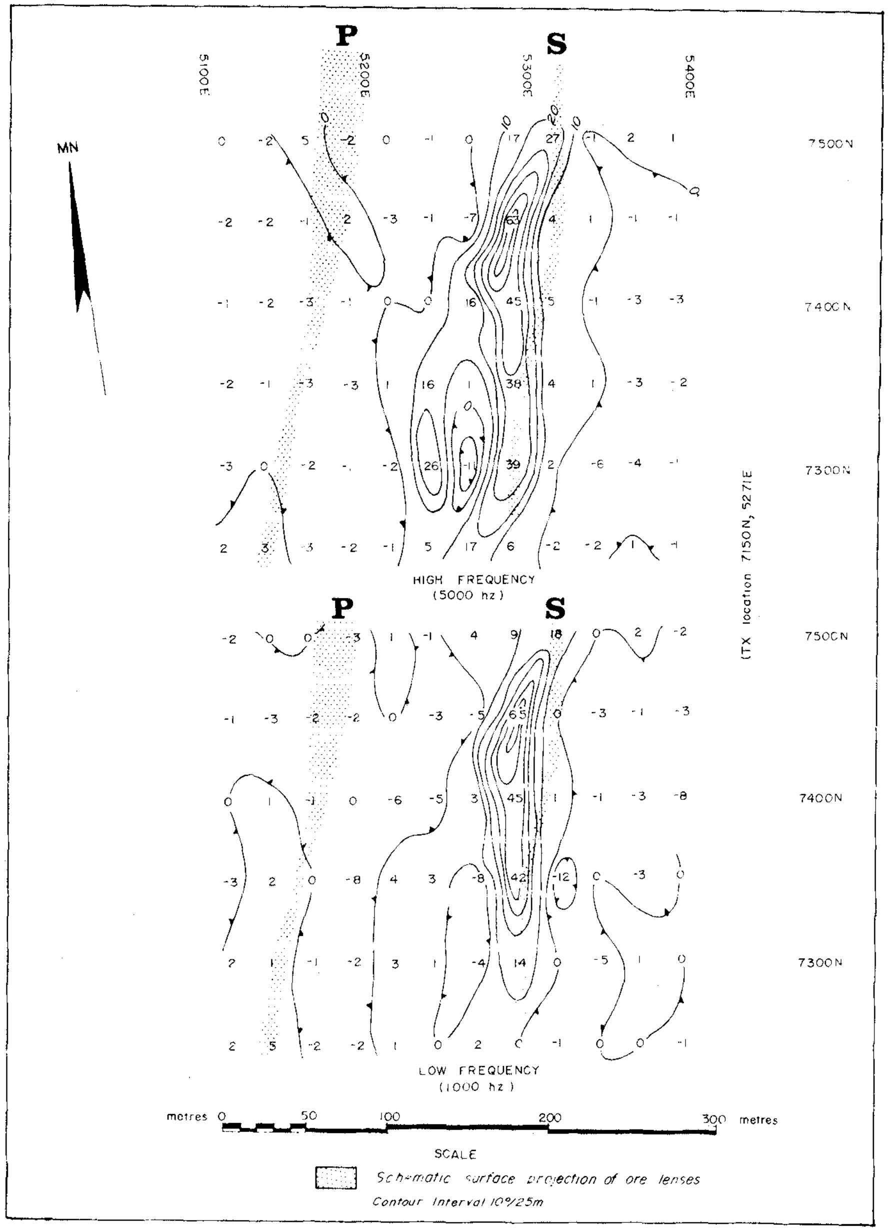

Figure 33.20. *First horizontal derivative map of vertical-loop EM data obtained using Fraser (1969) procedure. Contour interval 10°/25 m. Que River Prospect, Tasmania.*

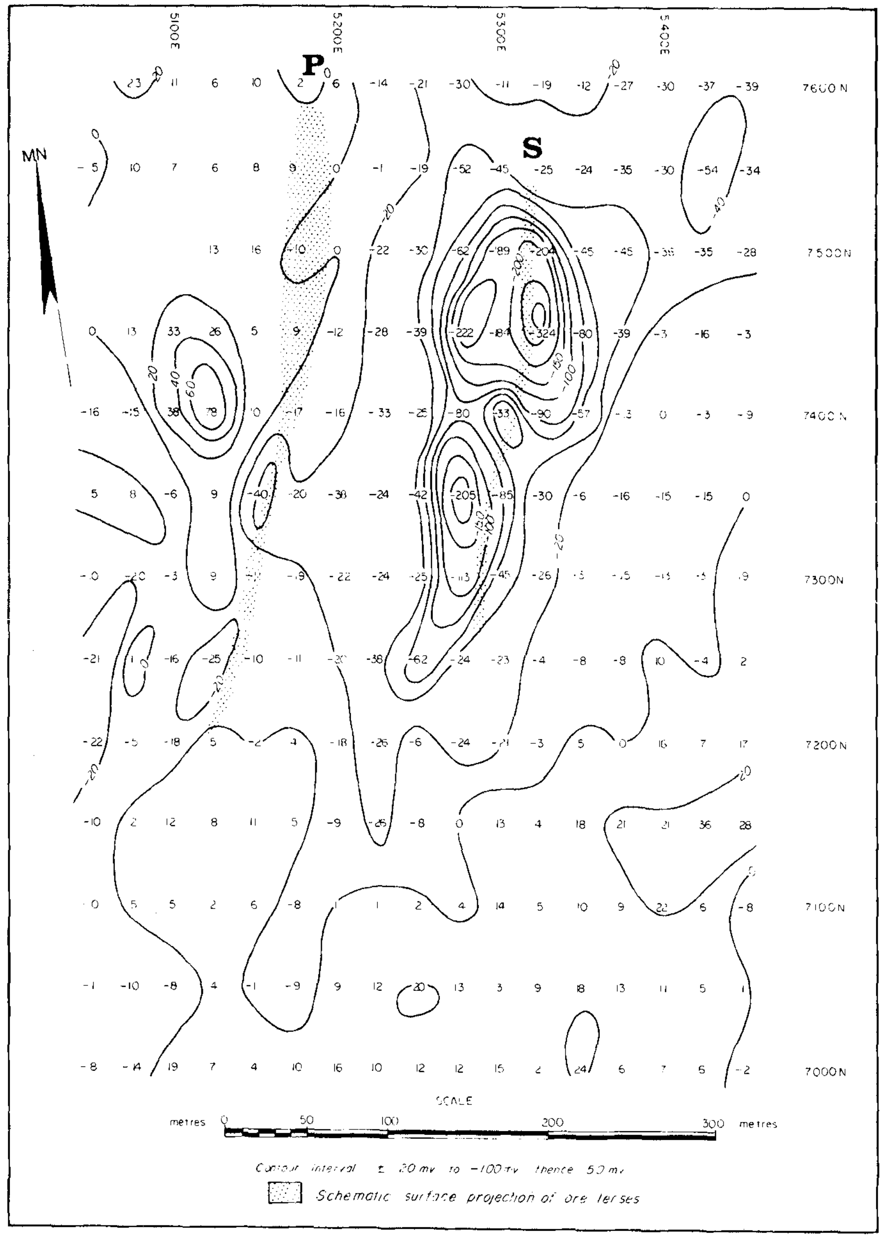

Figure 33.21. *Self-potential contour map. Que River Prospect, Tasmania.*

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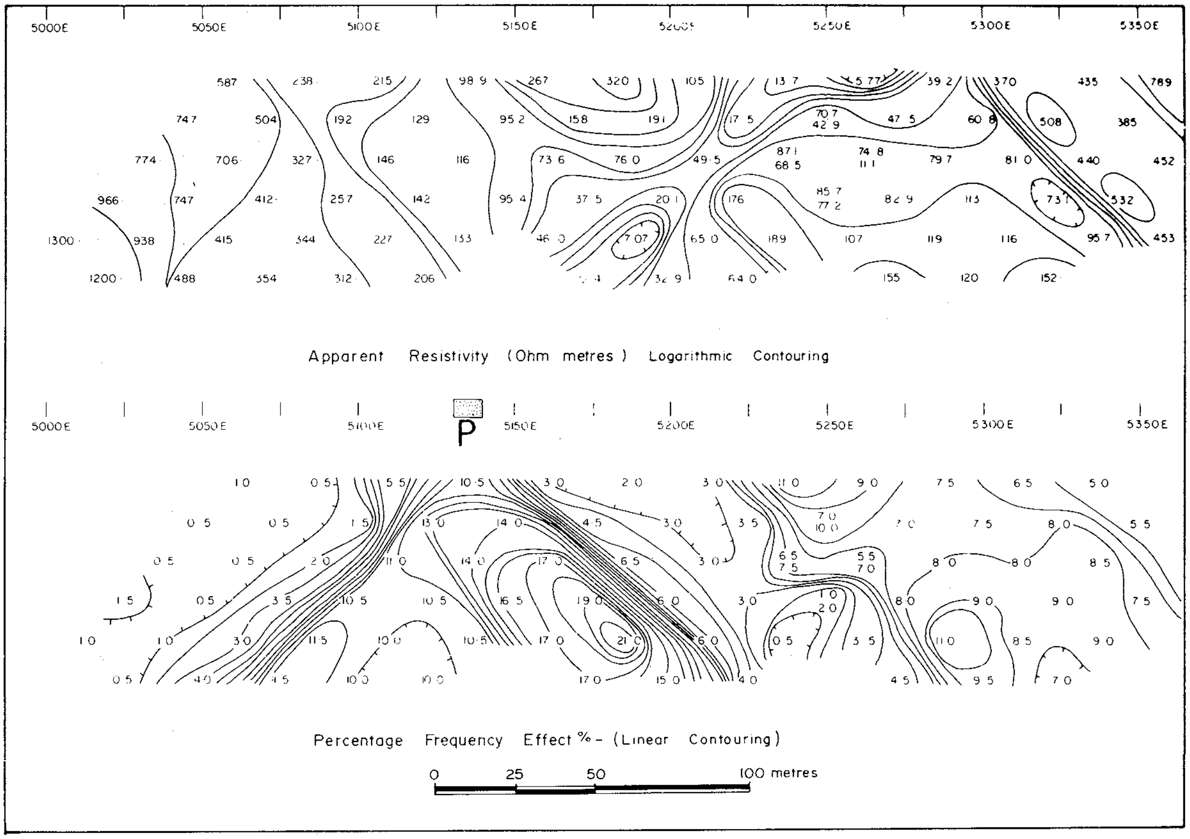

Figure 33.22a. *Resistivity and frequency domain IP results along Line 7250N using a dipole-dipole array. Frequencies used ranged from 0.3 to 2.5 Hz. Que River Prospect, Tasmania.*

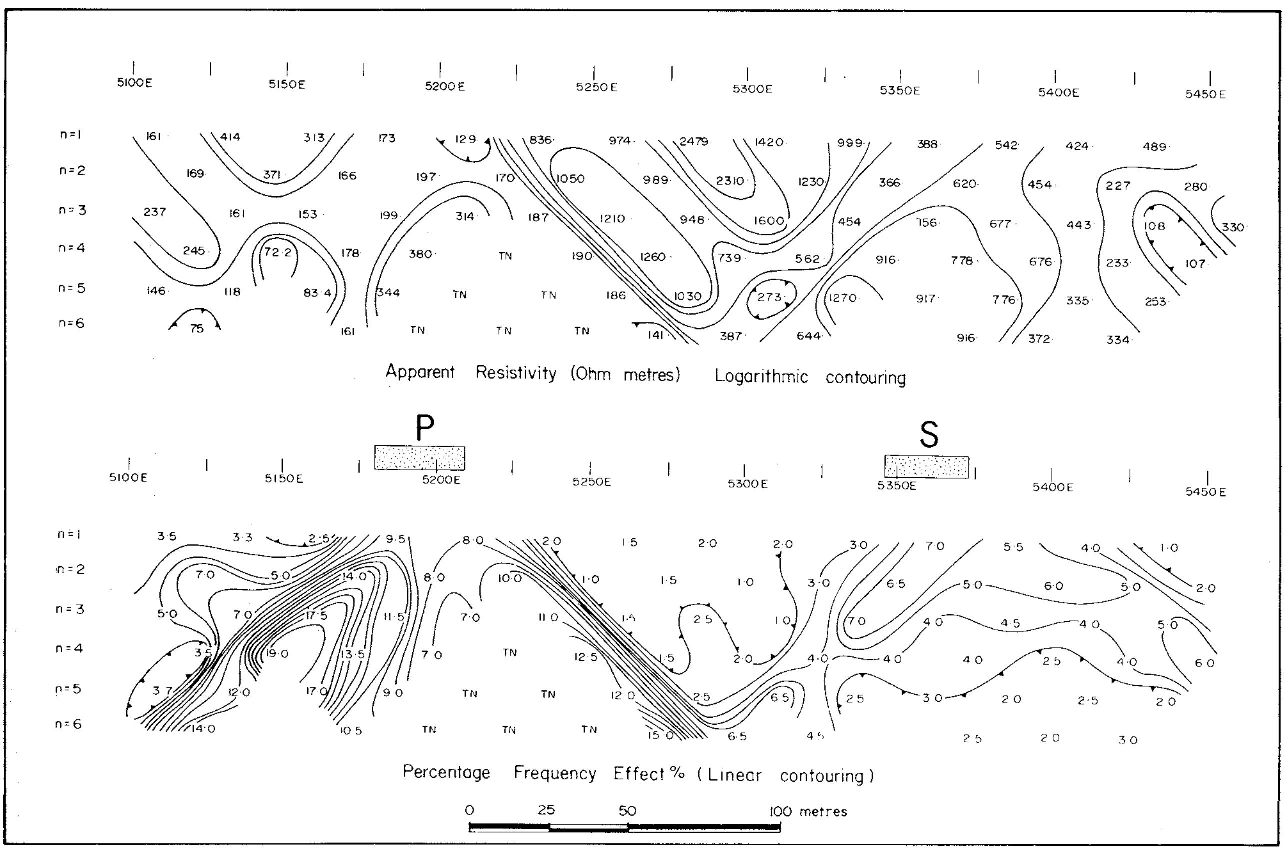

Figure 33.22b. *Resistivity and frequency-domain IP results along Line 7800N. Frequencies used range from 0.3 to 2.5 Hz. Que River Prospect, Tasmania.*

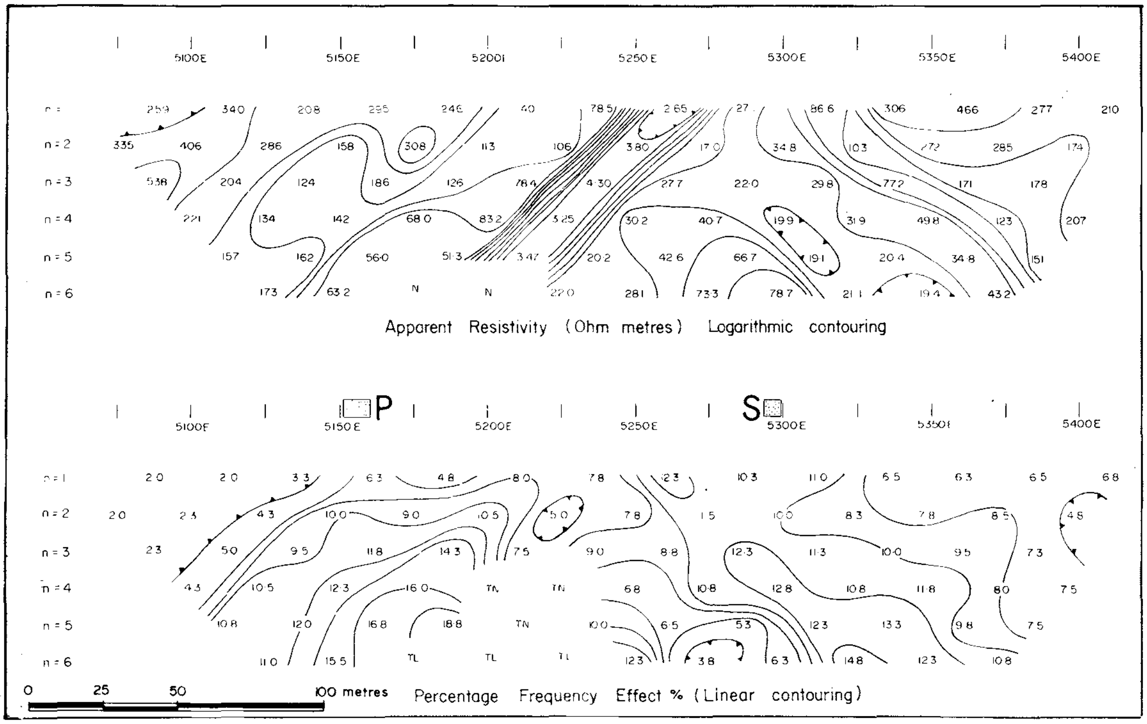

Figure 33.23. *Resistivity and frequency-domain IP results along Line 7350N obtained using a 25 m dipole-dipole array. Frequencies used ranged from 0.3 to 2.5 Hz. TN and TL indicates that readings were either too noisy or the voltage was too low for measurement. Que River Prospect, Tasmania.*

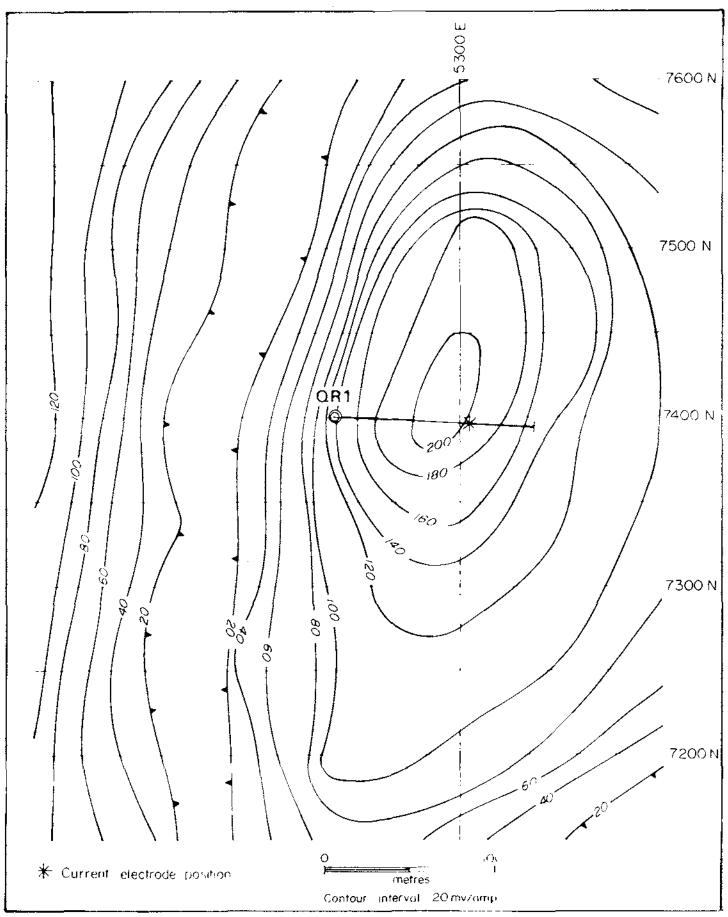

Figure 33.24. *Mise-à-la-masse map survey results using a current electrode located in the eastern mineralization in drillhole QR1. Que River Prospect, Tasmania.*

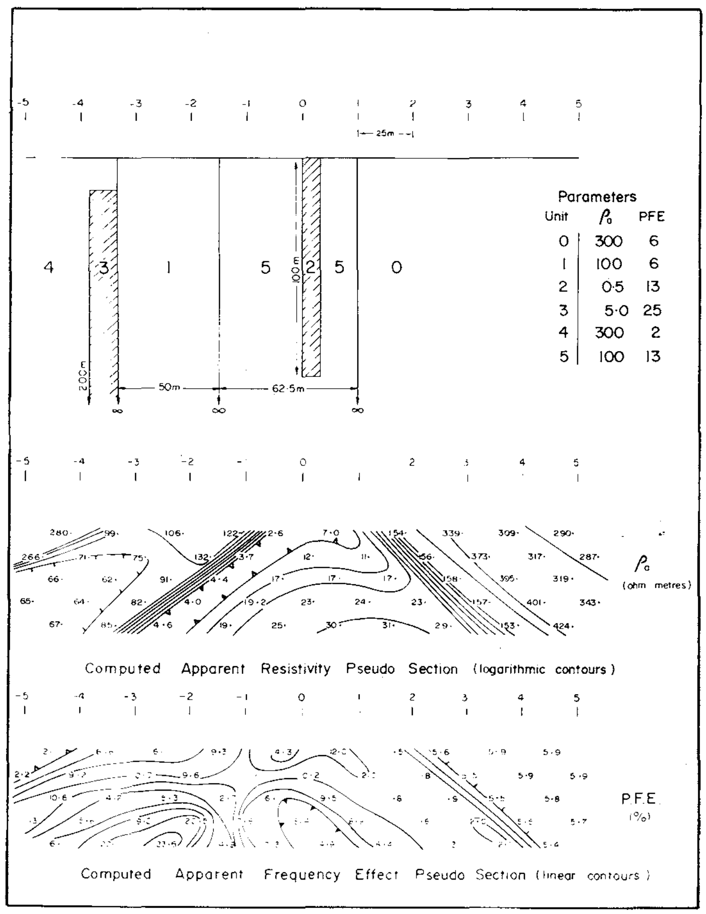

Figure 33.25. *Model results derived from the dipole-dipole array IP results along Line 7350N.*

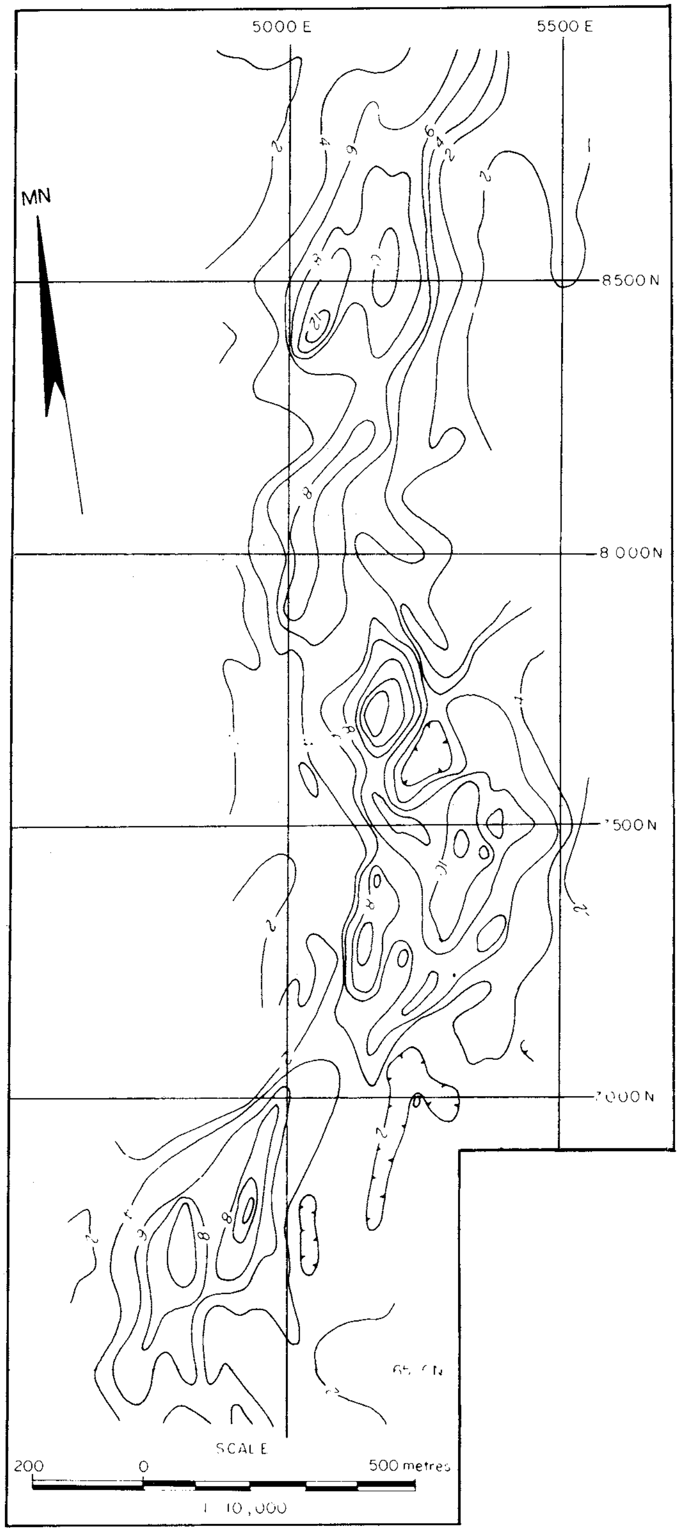

Figure 33.26. *Average percentage frequency effect (PFE) map. Contour interval 2%. Que River Prospect, Tasmania.*

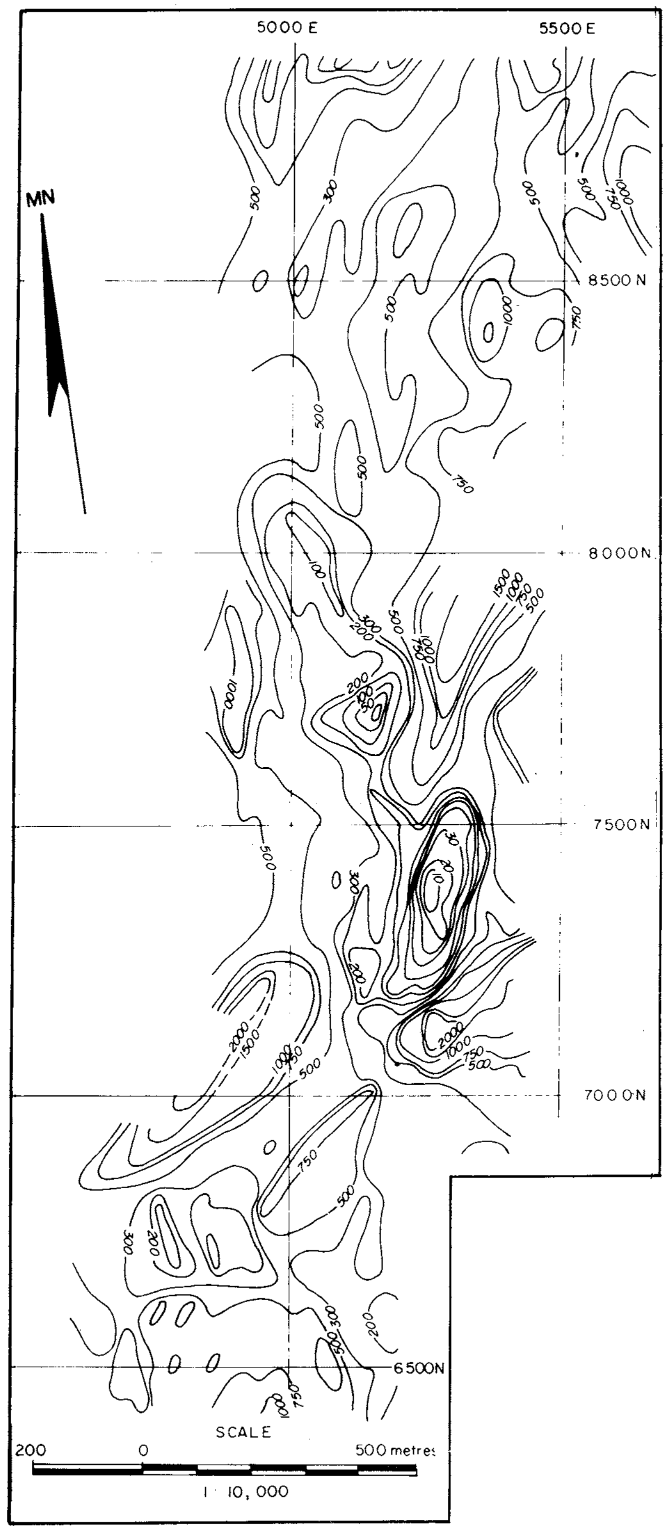

Figure 33.27. *Averaged apparent resistivity in ohm-metres using a logarithmic contour interval. Que River Prospect, Tasmania.*

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Downhole electrical logging of the mineralization and lithologies could not be undertaken due to poor ground conditions which prevented the holes from remaining accessible.

Induced Polarization Survey

Following the discovery of the western (P) ore lens in drillhole QR 2, a test induced polarization (IP) survey was undertaken to ascertain if this technique could detect the apparently nonconductive mineralization 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 m and 50 m on nine lines spaced 50 m apart.

The resistivity and frequency effect data for line 7350N, with 25 m spreads, are shown in Figure 33.23 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 mineralization, 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 mineralization, as is evident in data for line 7250N (Fig. 33.22a) and line 7800N (Fig. 33.22b).

An important feature of the dipole-dipole pseudo-section is the apparent depth control which indicates that the eastern mineralizaiton outcrops whereas 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 EM 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 33.25, 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 a 25 m dipole separation on lines spaced 100 m apart, compared with the discovery grid coverage of lines spaced 50 m apart. Plan presentation of these data (Fig. 33.26, 33.27) 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 mineralized "host" dacite over 2500 m strike length flanked by resistive barren andesite and dacite units. The barren dacite 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 (300 m) of the conductor which was detected in the airborne surveys relative to the strike length of the western mineralization (700 m) which was not detected.

DRILLING PROGRAM – SECOND PHASE

An ore delineation drill program of 108 drillholes totalling 25 500 m, 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. Of this total reserve, the eastern (S) mineralization comprises only 750 000 tonnes, the balance being in the western lens system.

CONCLUSIONS

The discovery of the Que River deposit resulted from the implementation of an integrated multitechnique exploration program. The ability to focus on a specific target, as defined by an airborne electromagnetic response coincident with a zone of anomalous stream sediment geochemistry, considerably reduced exploration expenditure. The exploration program demonstrated that broad spaced stream sediment geochemistry was a valid reconnaissance technique in the northwest 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 alone was found not to be generally acceptable for the selection of drilling targets due to secondary dispersion effects and the intermittent subcrop of ore lenses.

The application of several electrical and electro-magnetic ground techniques failed to indicate the presence of the significant western sulphide mineralization in the Que River deposit. That these ore lenses did not outcrop may partially explain the lack of responses, but effectively the mineralization is nonconductive. The same mineralization was however strongly responsive to the induced polarization technique.

It is therefore concluded that in this environment, a necessary criterion is that drill targets should exhibit both a soil geochemical anomaly and an induced polarization anomaly in close proximity.

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REFERENCES

Corbett, K.D., Reid, K.O., Corbett, E.B., Green, G.R., Wells, K., and Sheppard, N.W.
1974: The Mt. Read Volcanics and Cambro-Ordovician relationships at Queenstown, Tasmania; J. Geol. Soc. Aust., v. 21 (2), p. 173-186.

Dodds, A.R.
1976: A parametric study of induced polarisation models; Commonwealth Scientific and Industrial Research Organisation, Investigation Report No. 118.

Fountain, D.K. and Bottos, F.B.
1970: The McPhar 400 series dual frequency airborne EM system; McPhar Geophysics Ltd., Publication, 30 p.

Fraser, D.C.
1969: Contouring of VLF-EM data; Geophysics, v. 34 (6), p. 958-967.

Gee, C.E., Jago, J.B., and Quilty, P.G.
1970: The age of the Mt. Read Volcanics in the Que River area, western Tasmania; J. Geol. Soc. Aust., v. 16 (2), p. 761-763.

Ghosh, M.K.
1972: Interpretation of airborne EM measurements based on thin sheet models; unpubl Ph.D. thesis Univ. of Toronto, Toronto, Canada.

Seiberl, W.
1975: The F400 series quadrature component airborne EM system; Geoexploration, v. 13, p. 99-115.

Strangway, D.W.
1966: Electromagnetic parameters of some sulphide ore bodies; Soc. Explor. Geophys., Min. Geophys., v. 1, p. 227-242.

Ward, S.
1969: A model study of the McPhar F400 airborne EM method; Paper Presented 39th SEG Annual Meeting, Calgary.