27.

EXPLORATION CASE HISTORIES OF THE ISO AND NEW INSCO OREBODIES

W.M. Telford
McGill University, Montreal, Canada

Alex Becker
Ecole Polytechnique, Montreal, Canada

Telford, W.M. and Becker, Alex, Exploration case histories of the Iso and New Insco orebodies; in Geophysics and Geochemistry in the Search for Metallic Ores; Peter J. Hood, editor; Geological Survey of Canada, Economic Geology Report 31, p. 605-629, 1979.

Abstract

The Iso and New Insco base metal deposits, located in Hébécourt Township about 20 miles (32 km) northwest of Rouyn, Quebec, were both discovered by airborne EM in 1972, the former directly as a result of the Input survey of Rouyn-Noranda area made by the Quebec Ministry of Natural Resources, the latter by Dighem survey carried out shortly after. Although these bodies are relatively small, only limited magnetic and EM ground follow-up were necessary to locate drill targets which indicated economic grade mineralization at both sites.

Following the initial drilling, a relatively large amount of geochemical and geophysical work was carried out on both properties. Some of this work was done to establish possible lateral and depth extensions of the mineralization; much of it was done for test purposes and with the aim of preparing case histories. The geochemical work included B-horizon soil and basal-till analyses for various elements. There was a variety of geophysical surveys — magnetic, gravity, various EM, induced polarization, self potential, telluric, magnetotelluric and electrical logging of drill holes.

Geologically these deposits are located on the north edge of the rhyolite, dacite and andesite flows bounding the Dufault and Flavrian granodiorite intrusives. It is suggested that this geological environment is somewhat different from that of the typical Noranda-area orebody, which occurs near an original volcanic vent.

The two deposits differ in detail, Iso being larger, with a higher grade of Zn than Cu and no magnetic signature, while the New Insco mineralization is mainly Cu with a strong magnetic response due to pyrrhotite. Apart from size, they are similar in strike, dip, depth, and the character of host rock and overburden. Both are excellent targets for most geophysical and geochemical survey techniques, although the small dimensions of the New Insco body make quantitative EM interpretation difficult.

Résumé

Les gîtes de métaux de base de Iso et New Insco, situés dans le canton de Hébécourt à environ 32 km (20 milles) au nord-ouest de Rouyn au Québec, ont été tous deux découverts au cours d'un levé EM aéroporté en 1972; dans le premier cas, la découverte du gisement résultait directement du levé INPUT du secteur de Rouyn-Noranda, levé effectué par le ministère des Richesses naturelles du Québec, dans le second cas, la découverte résultait d'un levé DIGHEM effectué peu de temps après. Bien que ces corps minéralisés aient eu une taille relativement faible, quelques levés magnétiques et EM au sol ont ensuite suffi pour localiser des objectifs de forage, qui indiquaient une minéralisation d'intérêt économique sur les deux sites en question.

Du point de vue géologique, ces gisements se situent sur le rebord septentrional des coulées rhyolitiques, dacitiques et andésitiques qui limitent les masses granodioritiques intrusives de Dufault et Flavrien. On suggère que ce milieu géologique diffère quelque peu de celui qui caractérise la masse minéralisée typique du secteur de Noranda, qui se situe près de la cheminée volcanique initiale.

Après le forage initial, on a effectué sur les deux propriétés un nombre relativement élevé de travaux géochimiques et géophysiques. Une partie de ceux-ci ont servi à reconnaître des extensions possibles de la minéralisation, latérales et profondes, pour les forages d'essai, et aussi la préparation des études de cas types. Pour le dosage des divers éléments, l'analyse géochimique concernait l'horizon de sol B et le till de fond. On a effectué toute une variété de levés géophysiques – magnétiques, gravimétriques, divers levés EM, des levés de polarisation induite, de polarisation spontanée, des levés par les méthodes telluriques, magnétotelluriques, ainsi que la diagraphie électrique des trous de sondage.

Les deux gisements diffèrent dans les détails; celui d'Iso est plus vaste, et se distingue par une teneur du minerai plus élevée en Zn qu'en Cu, et par l'absence de signature magnétique, tandis que la minéralisation de New Insco consiste surtout en Cu, et estcaractérisée par une puissante réponse magnétique due à la présence de pyrrhotine. Excepté leurs dimensions, ils présentent des ressemblances du point de vue de la direction, du pendage, de la profondeur, et du caractère de la roche favorable et des terrains de couverture. Tous deux constituent d'excellents objectifs pour l'application de la plupart des techniques de levé, bien que les dimensions réduites du corps minéralisé de New Insco rendent une interprétation EM quantitative difficile.

Contents

INTRODUCTION

Location

The Iso and New Insco properties are situated on Lots 48 and 40-43, respectively, Range 1, Hébécourt Township, approximately 20 miles (32 km) northwest of Rouyn, Quebec, at the northwest end of Lac Duparquet. The Iso deposit lies about 1 mile (1.6 km) west of New Insco (Fig. 27.1).

Initial Discovery

Although there had been sporadic exploration with limited drilling in the area over a considerable time, both these deposits were airborne EM discoveries. The Iso anomaly appeared on the original data from the Input EM survey of the Noranda area, made public by the Quebec government in August 1972. New Insco, which has a very limited strike length, was first detected during a Dighem survey flown at a lower altitude in November 1972. Figures 27.2 and 27.3 display, respectively, sections of the original Input EM and Dighem anomaly maps; the cluster of anomalies south of Magusi River, obvious in both figures, marks the Iso zone, while the New Insco anomaly appears only in Figure 27.3.

Survey Sequence

Following the airborne EM surveys, limited ground geophysics, consisting of magnetic, vertical-loop and horizontal-loop EM surveys, were carried out to outline both mineral zones. Preliminary drilling in November 1972 indicated ore grade sulphides at Iso, while the discovery hole at New Insco was drilled in January 1973.

Considerable additional ground geophysical surveys and some geochemical work were done subsequently for two purposes. During 1973 basal-till geochemistry and frequency-domain IP surveys were undertaken primarily to determine possible lateral and depth extensions of the mineral zones on both properties. Later surveys, carried out to test new equipment and mainly to provide further data for case histories, included self potential, various types of EM, telluric, magnetotelluric, gravity, and seismic refraction surveys and electrical logging in diamond-drill holes.

Regional Geology

The rhyolites in the area west of Rouyn-Noranda are shown in Figure 27.4. Assuming that these define a depositional dome which was a volcanic seamount surrounded by lower areas in which pyroclastics, sediments and very fluid flows would be emplaced simultaneously with the volcanism on this 'Mount Noranda', the materials flowing outward in several directions were of widely varying composition, with felsic lavas being more common in the rocks which now underlie Hébécourt Township than in Duparquet Township to the east. The next peripheral area containing such large amounts of felsic material is 20 miles (32 km) to the east in the Clericy syncline.

The Noranda dome is cored by granodiorite batholiths which may represent subvolcanic intrusives associated with the volcanics. Because it was stiffened by thick rhyolite horizons and granodiorite batholiths, the dome remained undeformed whereas the intervolcanic tuff and sedimentary basins were isoclinally folded in the areas between it and other neighbouring volcanic centres of similar type. Both the Iso (Magusi River) and New Insco deposits are located on the north edge of the rhyolite, dacite and andesite flows which bound the Dufault and Flavrian granodiorite intrusives (Fig. 27.4).

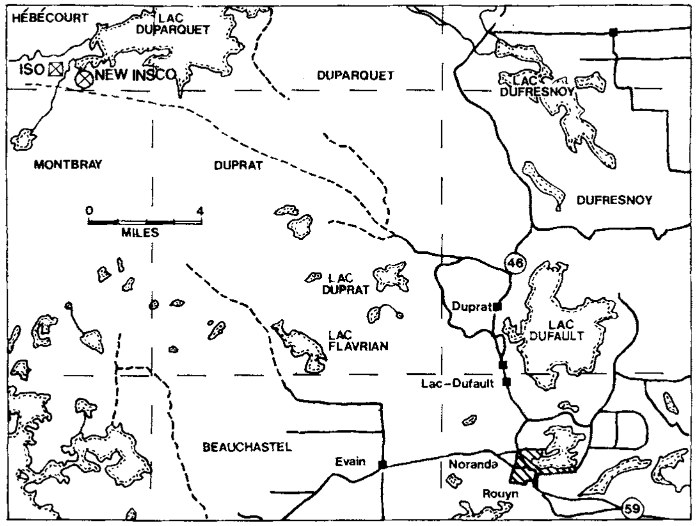


Figure 27.1. *Location map, New Insco and Iso base metal deposits, northwestern Quebec.*

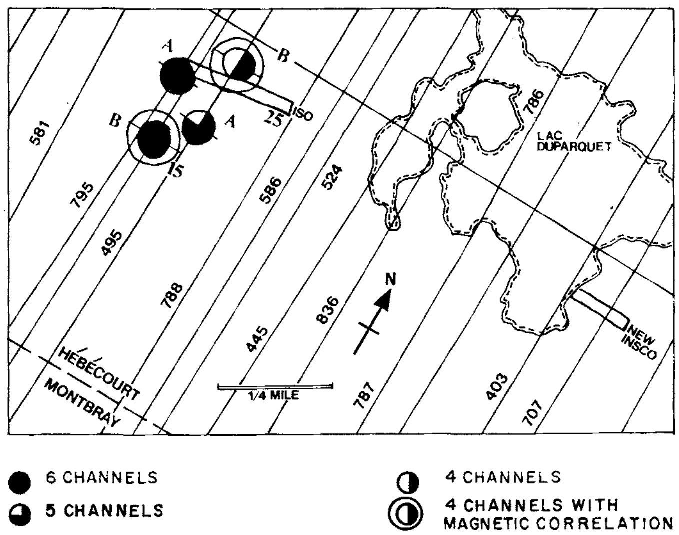


Figure 27.2. *Input-EM map, location of anomalies.*

Detail on Geophysical Methods

While most of the geophysical surveys — magnetic, gravity, IP, horizontal-loop EM, etc. — carried out on these properties are conventional, some of the less commonly-used techniques and the methods for displaying their data require explanation.

Dighem Survey

This helicopter-borne EM equipment (Fraser, 1972, 1974) is capable of detailed mapping with the flight lines being spaced 300-400 feet (90-120 m) apart and being flown at an altitude around 150 feet (45 m). In addition to the conventional coaxial vertical transmitter and receiver coils mounted fore and aft, the boom contained two additional receiver coils, one horizontal, the other with the plane vertical in the minimum coupling position (so-called fishtail configuration). The latter is called the strike-sensitive coil (see also Figures 27.3 and 27.11).

Contents

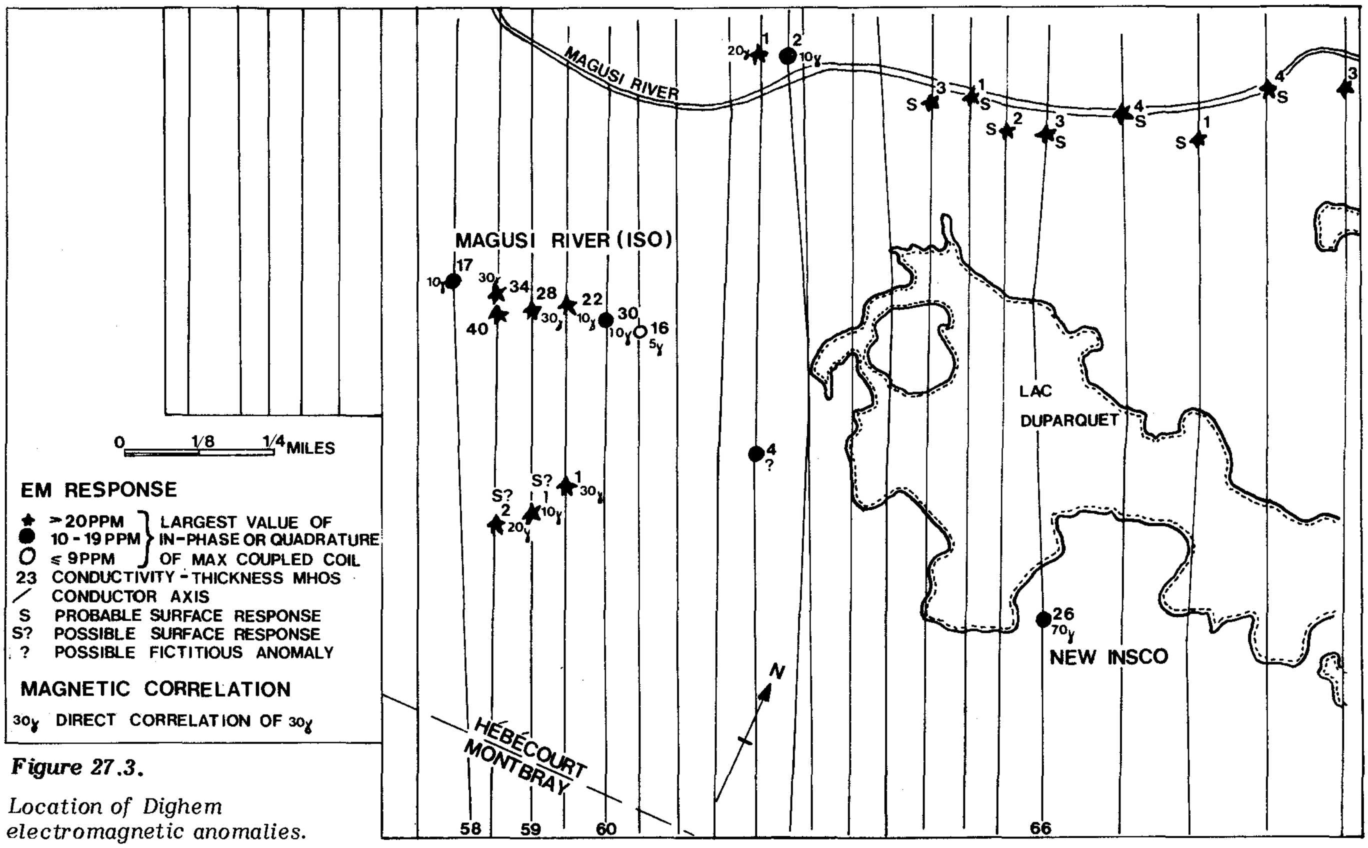


Figure 27.3.

Location of Dighem electromagnetic anomalies.

VLF-EM Survey

The contours in Figure 27.12 are obtained from a conventional VLF-EM survey by averaging the dip angles from several stations. If $\theta_1 \ldots \theta_4$ are dip angles at stations 1, ..4, the contour value is:

$$C_{23} = (\theta_3 + \theta_4) - (\theta_1 + \theta_2)$$

plotted midway between stations 2 and 3 (Fraser, 1969). The sign of C_{23} is positive in the vicinity of proper crossovers, negative for reverse crossovers. Negative values are discarded; in the process there is also a smoothing effect which reduces the geological noise inherent in the relatively high frequency VLF signals.

EM-25 Ground EM Survey

The Geonics EM-25 unit was originally designed for use in areas of highly conductive overburden (Paterson, 1973). It is a two-coil ground EM system operating at 50-70 Hz which may be employed in two survey configurations. With the fixed transmitter arrangement, a large single-turn rectangular transmitting loop is laid out with the long axis oriented more or less perpendicular to survey lines, similar to Turam EM. Readings are obtained with a small receiver loop in a vertical plane normal to the near side of the transmitter, being inclination in degrees and per cent (%) ellipticity of the polarization ellipse. These quantities correspond to the in-phase and quadrature components, respectively, of the secondary magnetic field produced by a conductor. Examples of this type of survey are found in Figures 27.18 to 27.22. In the moving transmitter configuration, the transmitter loop is a 100 foot (30 m) square or circular loop located at various stations along the traverse line. The receiver coil occupies several stations, varying between 400 and 1600 feet (120-480 m) from each transmitter set-up, again recording in-phase and quadrature readings.

Magnetotelluric and Telluric Surveys

Magnetotelluric data (Fig. 27.16) were obtained with a unit designed by Professor V.G. Pham and constructed at Ecole Polytechnique in Montreal. The equipment operates at a range of frequencies between 1 and 2000 Hz; four sharply-tuned channels may be used at one time. The magnetic field detector is a ferrite-core coil, bandwidth 1-2000 Hz, which is generally oriented to pick up the H_y (strike axis) component, while the telluric field E_x is measured with metal electrodes spaced 100 feet (30 m) apart along the profile line. Signals are integrated for 30 seconds (or longer to improve the lowest frequency response) and the apparent resistivity is derived from the relation:

$$\rho_a = |E_x/H_y|^2/5f$$

plotted midway between the electrodes. In some cases, generally to increase survey speed, only the telluric field is measured along the profile and the relative telluric field is plotted for the same station as above.

Drillhole EM Logging

The EM log in Figure 27.27 was obtained by John Betz with his DHEM unit, which has a multi-turn square transmitter coil mounted at surface and a ferromagnetic-core solenoid and receiver downhole. This equipment is used in two modes, known as min-coupled and max-coupled. In the former mode, the transmitter loop is rotated to obtain a minimum signal in the receiver; in the latter mode the Tx

Contents

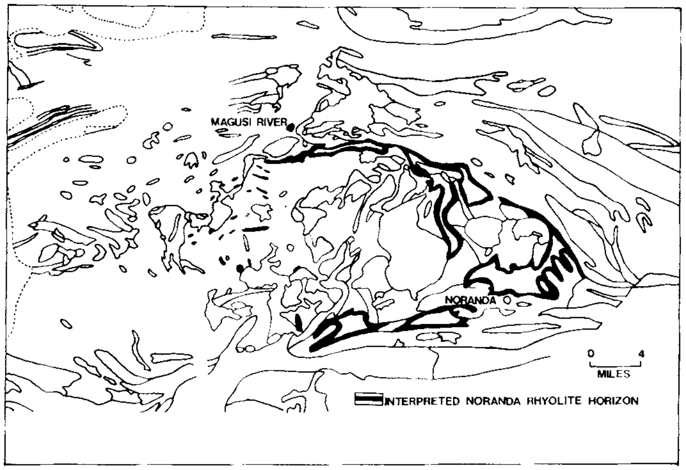


Figure 27.4. Simplified regional geology, Noranda area.

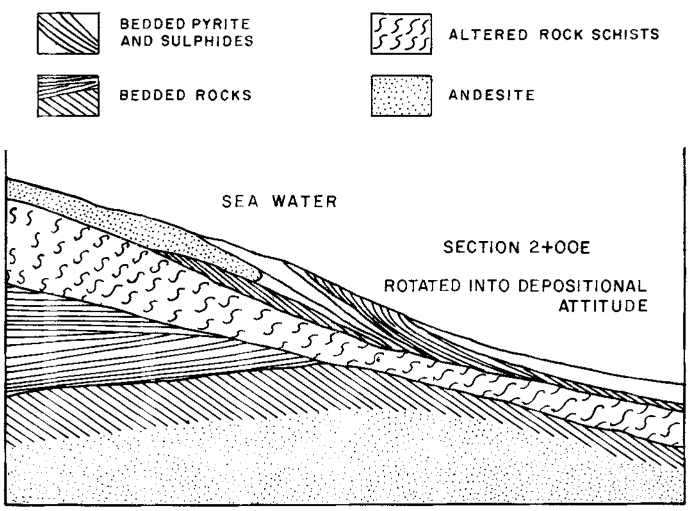


Figure 27.5. Idealized section of Iso-type deposition.

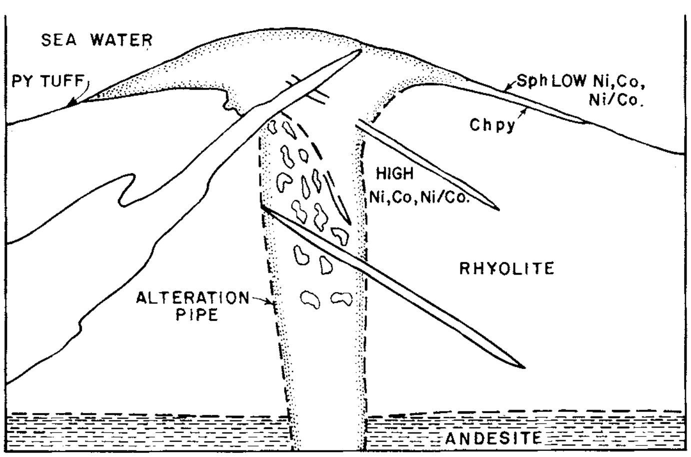


Figure 27.6. Idealized section of Noranda-type deposit (Vauze, Norbec, etc.).

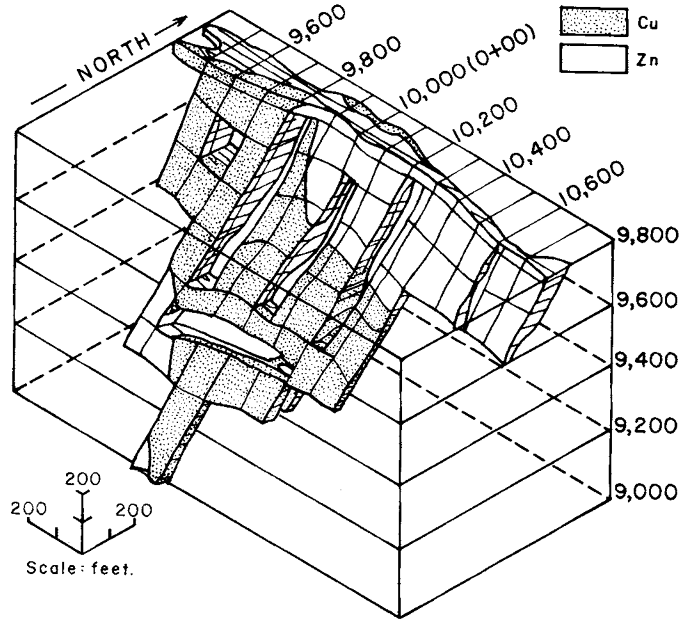


Figure 27.7. Isometric view of Iso Orebody.

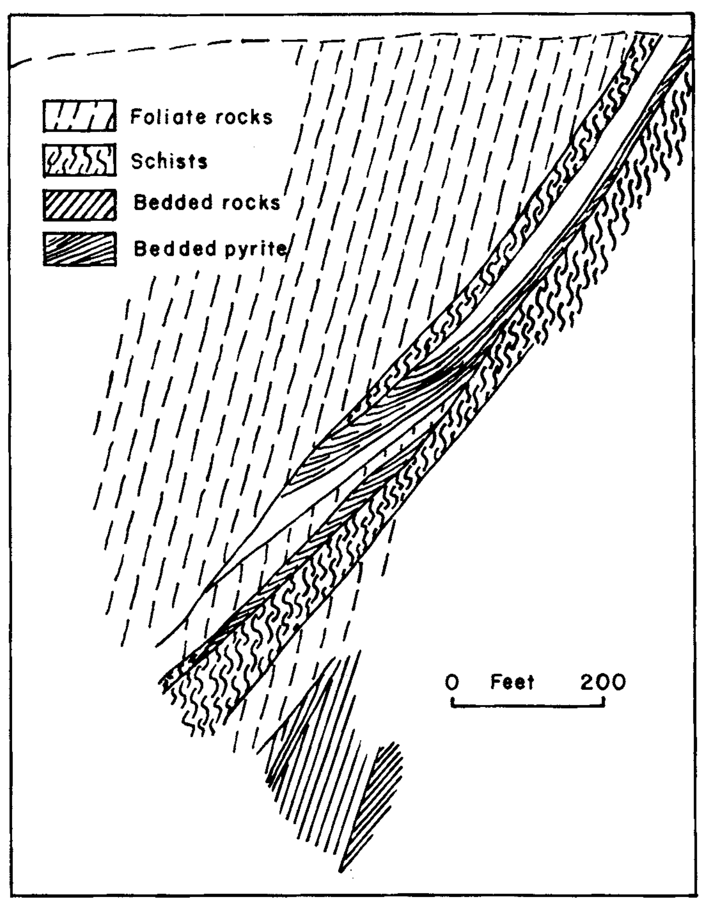


Figure 27.8. Fine layer and structure section, Line 2+00E, Iso Orebody.

loop is rotated for a maximum. System frequency is 735 Hz. In a barren area, the plane of the transmitter coil will contain the drillhole at minimum signal; when the downhole receiver solenoid is in the vicinity of zones of anomalous conductivity, the transmitter must be rotated about a horizontal axis and generally the minimum signal obtained is larger than in barren areas and is called the residual voltage (RV). Transmitter tilt angle and RV are related to the in-phase and quadrature components of the anomalous response respectively. The max-coupled mode is essentially a backup for the other measurement, to ensure that a conductive zone whose attitude provides poor coupling in the min-coupled position may not be missed.

ISO OREBODY

Following the discovery hole, pattern drilling outlined 5.8 million tons of ore averaging 1.13 per cent Cu, 2.72 per cent Zn, 0.82 oz/ton Ag, and 0.022 oz/ton Au contained in a tabular body striking east-west for about 1800 feet (550 m), dipping 50° south and extending more than 1000 feet (300 m) downdip. Clay and gravel overburden about 40 feet (12 m) thick covers the area.

Local Geology

Information on the geology of the Iso area is derived almost entirely from the excellent paper delivered by Hugh Jones at the Prospectors' and Developers' Meeting in Toronto in March 1973.

Rocks mapped by the Quebec Ministry of Natural Resources geologists, in the vicinity of the Magusi River north of the postulated extension of the Rouyn-Noranda district rhyolites, have been designated generally as dacites, although they may be more mafic than dacitic. Rocks from drill cores in the neighbourhood of the Iso deposit are flows and pyroclastic-sedimentary units of andesitic and rhyolitic composition which, compared to the thick flows in the main Rouyn-Noranda volcanic centre, are relatively thin. These flows may represent the periphery of 'Mount Noranda'. The sulphide mineralization is contained between two schistose units which are mainly sheared forms of andesitic lavas.

The sequence of deposition has been studied using samples from the deepest holes (e.g. M-19 on Line 2+00E). There is no evidence that the beds have been overturned, although some tilting may have taken place between the explosive events which provided the flows. An idealized section of deposition is shown in Figure 27.5. The pyroclastic-sedimentary units grade from coarse bottom layers to thin sedimentary caps, many of which contain considerable calcium carbonate. This is compatible with precipitation at some distance from the volcanic centre. Although the pyroclastic flows are thicker in the 'Clericy syncline', they are otherwise similar to the Magusi and in their relation to the rocks of the main Rouyn-Noranda centre, suggesting that the Magusi area is an extension of the 'Clericy syncline' about 20 miles (32 km) to the east.

Table 27.1

Process	Iso Deposit	Rouyn-Noranda Type Deposit
Deposition	Down flank of volcanic seamount	Nipples on a broad dome
Alteration	Schist envelope	Pipe extending considerably below ore zone, diameter ≃ orebody.
Dyking	Simple; semi-conformable gabbro	Several dyke compositions and orientations, cutting alteration pipe which seems to be locus of activity.
Layering Cu/Zn Zoning	Numerous layers rich in Cu, Zn sulphides	Piled to form equi-dimensional deposit; distinct Cu/Zn zoning, Zn on top, extending out on volcanic surface.

Analyses for major oxides of numerous samples of the volcanic rocks from DDH M-19 show that there are two definite groups, designated rhyolitic (70% silica) and andesitic (52% silica) and that rocks remote from the ore zone are sodic rhyolite above and tholeiitic basalt below it. It is concluded that the country rocks occur in a syncline north of the main Rouyn-Noranda centre, in an area where a tongue of felsic volcanics may have extended from the original topographic high into a depositional basin. This environment may be contrasted with that suggested for the typical deposits of the Rouyn-Noranda area such as at the Norbec and Vauze mines (Roscoe, 1965; Spence, 1966), where the sulphide bodies appear to lie on what was originally a gentle volcanic dome (Fig. 27.6). The rhyolitic flows may be as thick as 1800 feet (550 m) directly below the deposits, decreasing to a few hundred feet between them; pyroclastics and sediments are rare.

Iso Ore Zone

Overall the Iso deposit has a tabular shape within which the orebody, enriched in Cu and Zn, forms a thick portion of a more extensive sheet of Cu-Zn-bearing pyrite. This is illustrated in the isometric view of Figure 27.7, with some sections cut out to show the layering. The pyrite sheet is continuous, with no apparent gaps caused by faulting, folding or the intrusion of dykes. Thickness varies from a few feet at the edges to a maximum 110 feet (33 m). Abrupt variations in thickness occur along both strike and dip, indicating possible disruption by low angle faults, migration within an originally regular body, or an irregular mode of deposition. Some high grade ore sections coincide with thicker parts of the sheet.

Sulphide Composition

The economic sulphides in this pyritic body are chalcopyrite and sphalerite, with galena as a common accessory. Microprobe studies show that the Cu, Zn, and Pb are confined to their appropriate sulphides (as above) and are not present as solid solutions in pyrite or in one another. Pyrrhotite occurs as very minor disseminations within pyrite grains. Arsenopyrite has also been identified. Both magnetite and specularite are found in minor amounts, the former probably being the source of the weak magnetic anomaly associated with the orebody. Native gold and silver have been observed, associated with coarser and finer grained chalcopyrite respectively. However, it is thought that much of the silver occurs as a sulphide or sulphosalt.

The carbonate-quartz-chlorite gangue is rich in dolomite compared to the siliceous gangue of typical Rouyn-Noranda deposits, perhaps because of deposition in a carbonate-rich basin rather than the high silica environment of the volcanic centre.

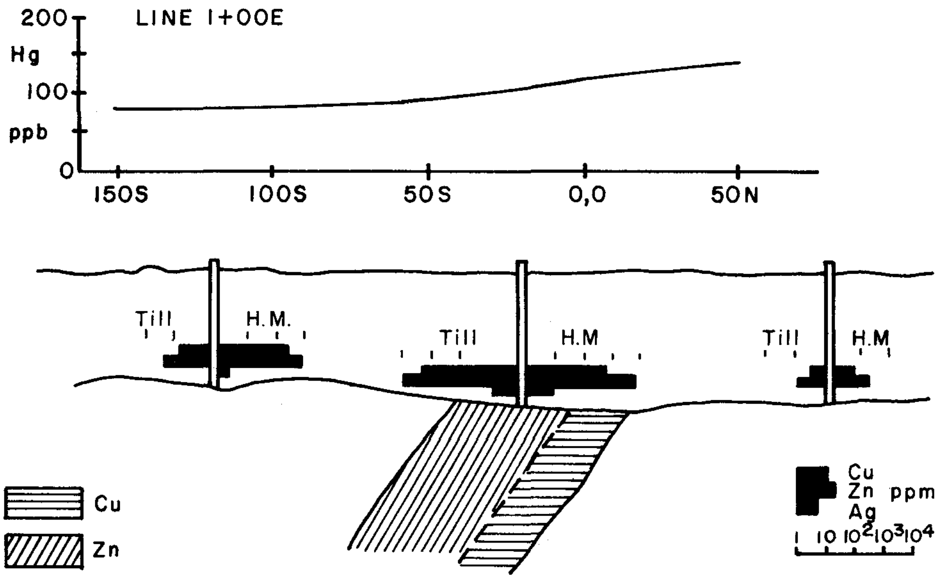


Figure 27.9. *Soil and basal-till geochemistry, line 1+00E, Iso Orebody.*

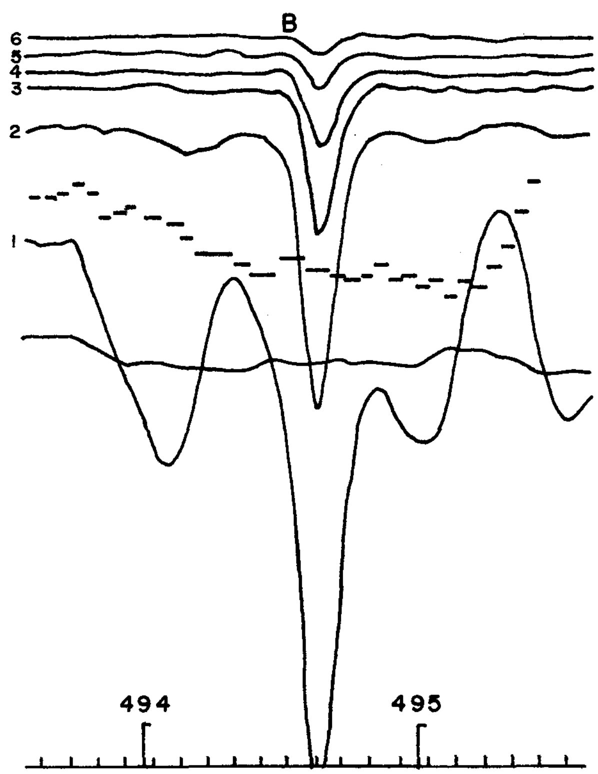


Figure 27.10. *Input data, flight record profile, Iso Orebody.*

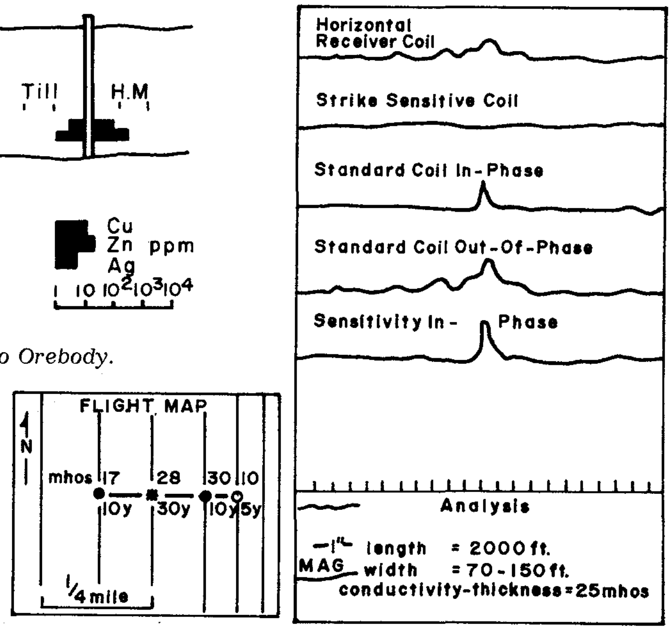


Figure 27.11. *Dighem data, flight record profile, Iso Orebody.*

Zoning and Layering

Chalcopyrite and sphalerite are confined to layers within the deposit, the thickness being in the order of tens of feet. The layers can usually be correlated from one drillhole to another. Copper-bearing layers may occur on either the hanging wall or footwall side and there may be more than one such layer present. Frequently a layer on the hanging wall downdip will cross over to appear on the footwall near surface (e.g. Fig. 27.8). Zn is predominant at both ends of the deposit, while Cu concentrates toward the centre.

On a small scale the major sulphides and gangue minerals are delicately layered and bedded. About 1 per cent of the sulphide mineralization is found in thin cross-cut veinlets or as fracture coatings; up to 10 per cent occurs in coarse interconnecting blebs. Both these fractions were mobile at a later date than the fine grained sulphides which comprise the bulk of the ore. The coarse and fine forms have somewhat different compositions and the coarse sulphides are associated with coarser carbonates in the gangue: the coarse sphalerite is deficient in iron compared to the fine grained variety.

In the fine grained part of the deposit, pyrite is the predominant mineral, with fairly consistent grain size and texture; the ore minerals occur as fine inclusions in the pyrite and as matrix for pyrite crystals and aggregates. There appear to be two distinct sizes, either 20 or 100 µm approximate diameter. Crystal and aggregate forms of pyrite include numerous agglomerations, some nodules and radial textures in which internal fine patterns are overgrown with coarser crystals. Inclusions of the other sulphides and gangue minerals are trapped in these aggregates. The nodules are similar to those found in pyritic black shale and in pyrite sands around recent fumaroles. A few 100 µm crystals in a matrix of spongy pyrite have been observed, resembling the Norbec ores. The existence of both delicate textures and the generally fine grained pyrite suggests little drastic reorganization during metamorphism.

From drill core measurements, the fine layering appears to be conformable with the sulphide body where the deposit is thin, whereas it is at a definite angle to the overall layering in the thicker sections. A schematic for the section on

Line 2+00E in Figure 27.8 illustrates this: the angle at which the fine layers are stacked as they cross the thick layering from hanging wall to footwall is the same as that of the thick layers crossing the sulphide section. This suggests the bedding of detrital material deposited in an active fluid environment.

Alteration

Nearby rocks in both the hanging wall and footwall sections of the Iso orebody have been altered to carbonate, chlorite and sericite schists. Occasionally, identifications of areas of former andesite or gabbro dykes can be made as a result of the presence of relict amygdules or leucoxene disseminations respectively. The altered rock is foliated with micaceous minerals and banded by the carbonates; core angles indicate the schistosity varies between the dip of the foliation (steeply south) and that of the strata (50°S). Within this schist zone, an early pervasive iron-rich chloritization and a later cross-cutting veined magnesian chlorite have been identified. Veinlets are confined to rocks within 100 feet (30 m) of the orebody. Soda and potash are significantly different (respectively leached and enriched) and disseminated sulphides are more common in the schist zone than in the wall rocks, whereas there is no enrichment of either magnesium or iron in the alteration zone. Perhaps the pyrite evolved in situ during creation of the schist.

The schist zone seems conformable with the sulphide body and the general stratigraphy. It is possible, however, that this zone of alteration and shearing could extend farther into the footwall, since numerous drillholes terminate in schist. Beyond this schist zone the rocks are quite fresh, with flow banding, amygdules and volcanic texture generally preserved. Here the foliation is weak and dips are steeply south.

Comparison with Other Deposits

The size of the Iso body is well within the range of other deposits in the Rouyn-Noranda, Joutel-Poirier and Mattagami mining camps. However, there appear to be fundamental differences between the Iso body and the so-called Rouyn-Noranda type. These are summarized in Table 27.1 (see also Figs. 27.5, 27.6).

Geochemical Surveys, Iso Orebody

The results of the basal-till geochemical sampling on Line 1+00E are presented in Figure 27.9. Mercury values from the top surface of the clay overburden are plotted over a distance of 200 feet (60 m) in the vicinity of the orebody. Values range from 85 to 145 ppb Hg, which appears to be rather high; however, there is no apparent relation to the ore zone. Basal-till Hg analysis gave maximum values of 150 ppb directly over the conductor, with a background of 60 ppb on the flanks. These are not particularly anomalous. Three sphalerite ore samples gave 540, 650, and 730 ppb Hg, whereas two samples of chalcopyrite contained 25 and 40 ppb.

Basal-till sampling results for Cu, Zn and Ag are illustrated by the horizontal bars at the bottom of the three holes located at 1+20S, 0+20S, 0+80N. Values to the left of the holes are for the complete till sample, to the right for the heavy mineral fraction. All three metals show high values over the orebody. At 1+20S they are still somewhat anomalous, although the decrease from 0+20S is rather large and is larger in the complete till samples than for the heavy mineral. The direction of glacial movement is north-south.

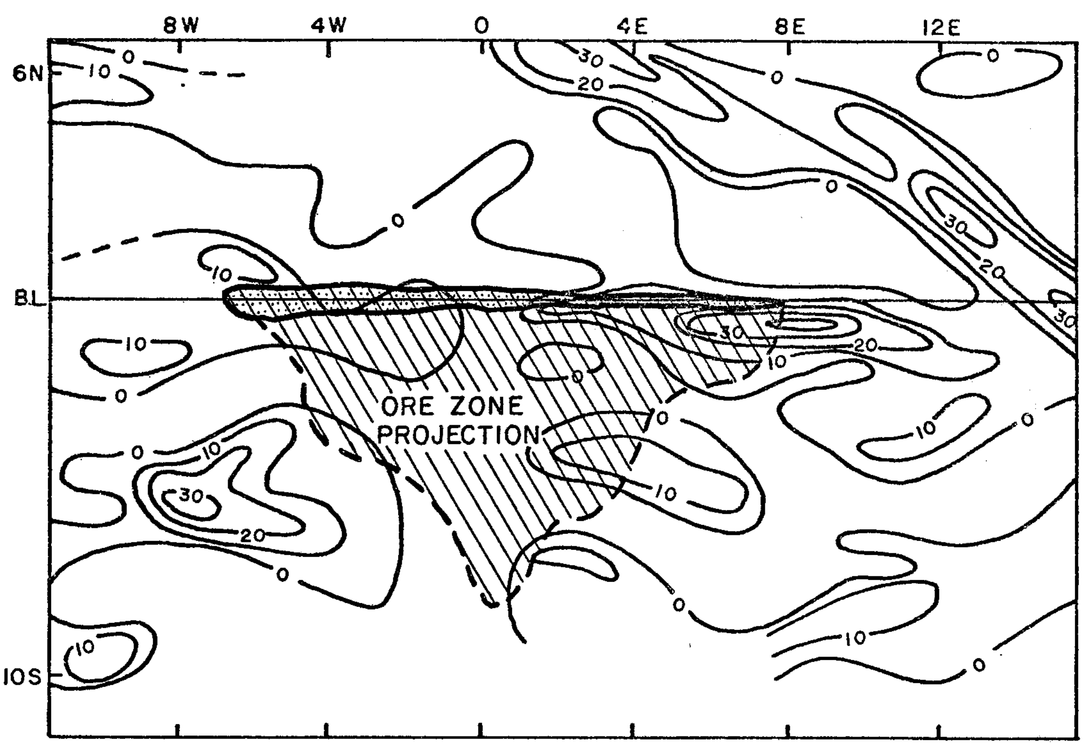


Figure 27.12. *VLF-EM contours; contours in degrees tilt angle, Iso Orebody.*

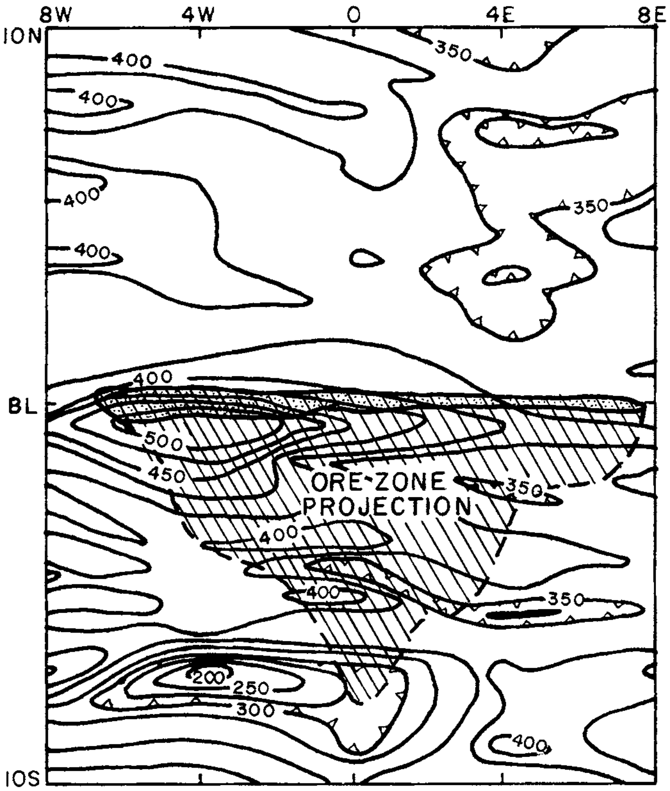


Figure 27.13. Vertical field magnetic contours; contour interval 25 gammas, Iso Orebody.

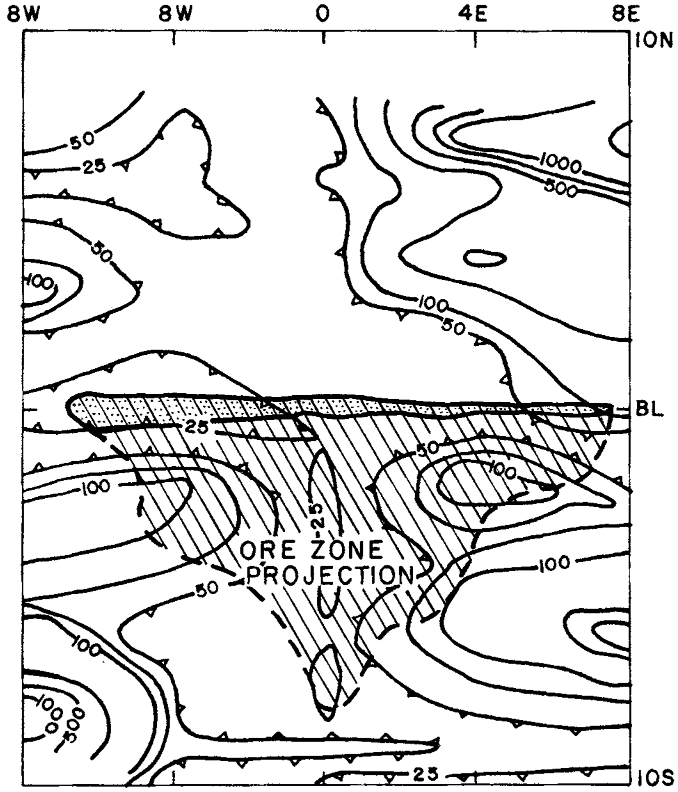


Figure 27.15. EM16R contours; contours of ρ_a Ωm. f = 18.6 kHz, Iso Orebody.

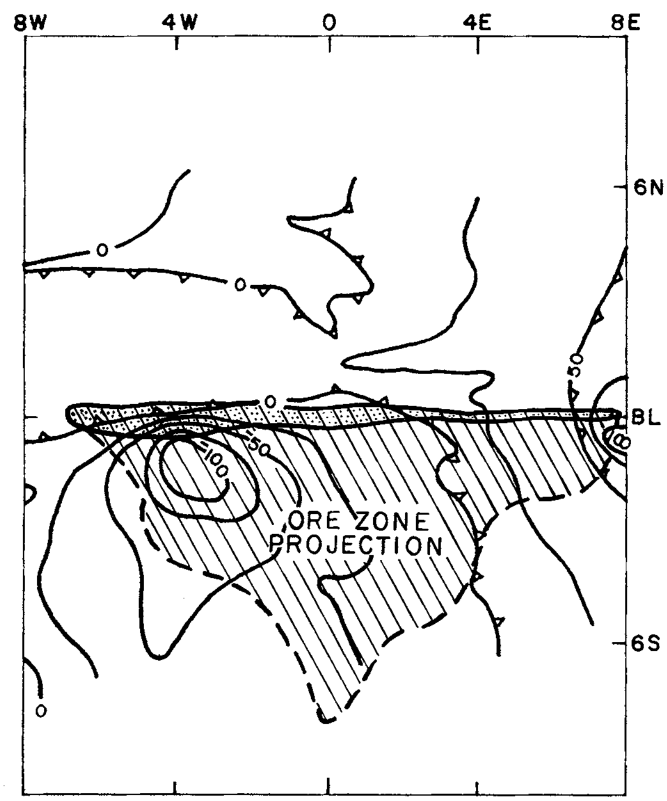


Figure 27.14. Self potential contours; contour interval 25 mV, Iso Orebody.

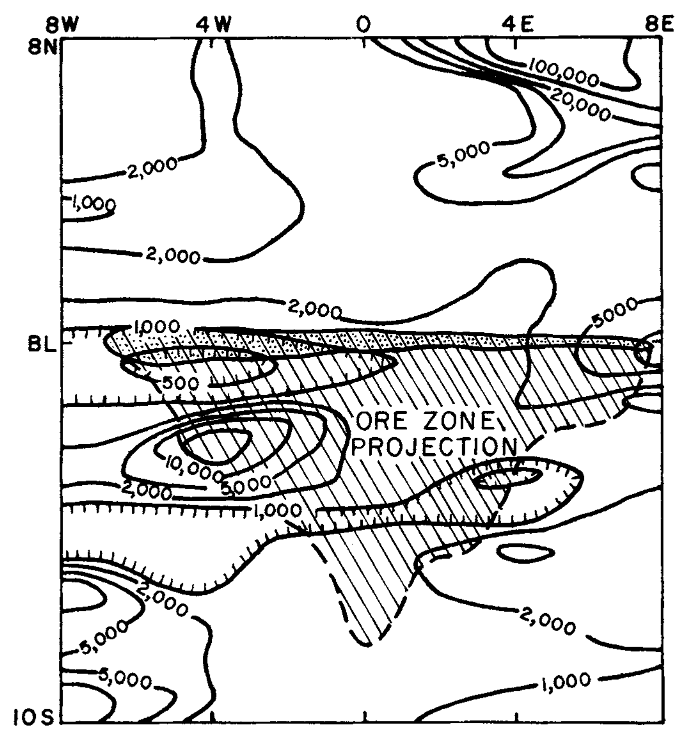


Figure 27.16. Magnetotelluric contours; contours of ρ_a Ωm. f = 250 Hz, Iso Orebody.

Geophysical Surveys, Iso Orebody

Input and Dighem (Airborne Electromagnetic) Profiles

Figure 27.10 presents Input EM (Mark 5) profiles of 6 channels from one flight line over the Iso ore zone. The AEM anomaly is clearly seen on all channels. The huge fluctuations in Channel 1 are doubtless a reflection of the varying thickness of the conductive overburden. The conductivity-thickness (σt) product obtained from the Input EM survey was 12 mhos, roughly the same as for New Insco (Lazenby, 1973).

A profile from the Dighem helicopter survey is displayed in Figure 27.11. The insert shows a section of the flight map for the area. Going from top to bottom are the quadrature profiles for the two minimum-coupled receiver-coils, then the in-phase and quadrature profiles from the standard coaxial maximum-coupled receiver coil and at the bottom the same in-phase profile for the coaxial receiver coil (labelled 'sensitivity in-phase') but amplified considerably. Analysis of these data indicated a conductor of about 2000 foot (610 m) strike length, 70-150 feet (20-45 m) thick, with a σt value of 25 mhos. The latter compares with 70 mhos obtained in the Dighem survey over the New Insco deposit.

VLF-EM Survey

Contoured data obtained from the VLF-EM survey carried out using the Crone Radem unit are presented in Figure 27.12. Except around Line 8+00E, where the ore zone is pinching out, there is no apparent correlation with the Iso conductor. The response is particularly weak in the west end of the zone. Anomalies centred at about 8+00W, 5+00S and 3+00E, 7+00N lie in areas of rather high surface resistivity, as determined later by a Geonics EM16R VLF survey (see Fig. 27.15). These anomalies appear to be mainly due to fluctuations in the thickness of the conductive clay overburden.

Ground Magnetic Survey

Contours of the vertical magnetic field, displayed on a 2000 by 1600 foot (610 by 490 m) grid in Figure 27.13, were obtained from the results of a fluxgate magnetometer survey (Fountain and Fraser, 1973). There is very little magnetic relief over the Iso deposit — the maximum variation is about 300 gammas — doubtless because of the lack of pyrrhotite and/or magnetite. Rock types change from rhyolite to diorite to andesite in a south-north sequence (see Fig. 27.17 to 27.22). Although the average magnetic susceptibilities of these rocks increase in the same order, they are not much different and there is no north-south gradient to indicate this. However, the axis of the conductor is quite well marked by mild maximum contours along the baseline, particularly in the west where a south dip is indicated. Magnetic lows in the south and northeast grid areas may be reflections of thicker overburden (see Fig. 27.21), but this is by no means definite.

Self Potential Survey

Data from the SP survey are contoured in Figure 27.14. There is a 100 mv negative anomaly near the baseline at 8+00E whose asymmetry indicates a south dip. The steep negative gradient of 100 mv on Line 4+00W between 1+50S and the baseline is characteristic of a vertical contact between rock types of different electrochemical properties, rather than a sulphide slab. Apart from these two features the SP map is featureless. Neither provides a satisfactory picture of the Iso deposit, which has practically pinched out on Line 8+00E.

EM16R and MT Surveys

Apparent resistivity contours obtained with the Geonics EM16R and MT units are presented in Figures 27.15 and 27.16 respectively. These surveys were carried out simultaneously. The EM16R data were obtained using the Seattle transmitter which operates at 18.6 kHz. Although the MT survey was made at four frequencies (3, 21, 250, and 1200 Hz) only the 250 Hz contours are shown in Figure 27.16, since the results were not sufficiently illuminating to warrant displaying all the data. MT readings showed a high noise level, particularly for the H-field at low frequencies.

Considering Figures 27.15 and 27.16 in conjunction with the VLF-EM contours of Figure 27.12, there are obvious similarities between the first two but very little correlation with the VLF-EM results. Both sets of ρ_a contours outline the Iso conductor along the baseline mainly on the west half of the grid and there is good correlation between the two resistivity zones in the southwest and northeast corners. Presumably the 18.6 kHz response reflects the conductive overburden much more than the 250 Hz MT, which may explain the less predominant east-west trend in the former.

Both EM16R and MT surveys measured only a single E- and H-component (E_x and H_y for MT, E_y and H_x for Seattle using the EM16R). Consequently, these contour plots are valid only for a layered geometry: lateral conductivity variations produce anisotropy. However, the VLF stations at Cutler, Maine and Panama were not available and lack of time prevented completion of the MT survey in two directions.

Detailed Geophysical Survey Profiles

Data from the four preceding ground geophysical surveys have been displayed in contour form, partly to condense the material, mainly because they were not particularly significant. In the following, IP, EM, gravity, and seismic refraction results are shown in profiles with accompanying vertical sections.

Line 8+00W

Vertical-loop and horizontal-loop EM (VLEM, HLEM) and induced polarization (IP) and apparent resistivity (ρ_a) profiles for Line 8+00W are illustrated in Figure 27.17, together with the incomplete vertical section. This line is beyond the end of the zone (see Fig. 27.7), which is predominantly rich in Zn in the western portion. DDH M-51 intersected 36.6 feet (11.2 m) of mineralization as shown. The other holes appeared barren.

The geophysical profiles generally reflect the presence of minor mineralization along Line 8+00W, apart from the vertical-loop EM profile, which has a clear crossover at 0+50S. This is to be expected, since VLEM usually responds for some distance beyond the end of a conductor when the transmitter loop is located on top of it. A mild HLEM anomaly at 0+50S suggests a rather poor conductor (σt = 24 mhos) at a depth of about 60 feet (18 m).

While the IP metal factor is anomalous at the same station, PFE values are insignificant. High resistivity to the south is clearly evident on the ρ_a profile; this correlates with the contours of Figures 27.15 and 27.16. Additional evidence that this resistivity high may be close to surface was seen in Figure 27.12, where the crossover at 5+00S on Line 8+00W suggests thinning of conductive overburden, or perhaps a shallow resistive bed.

Contents

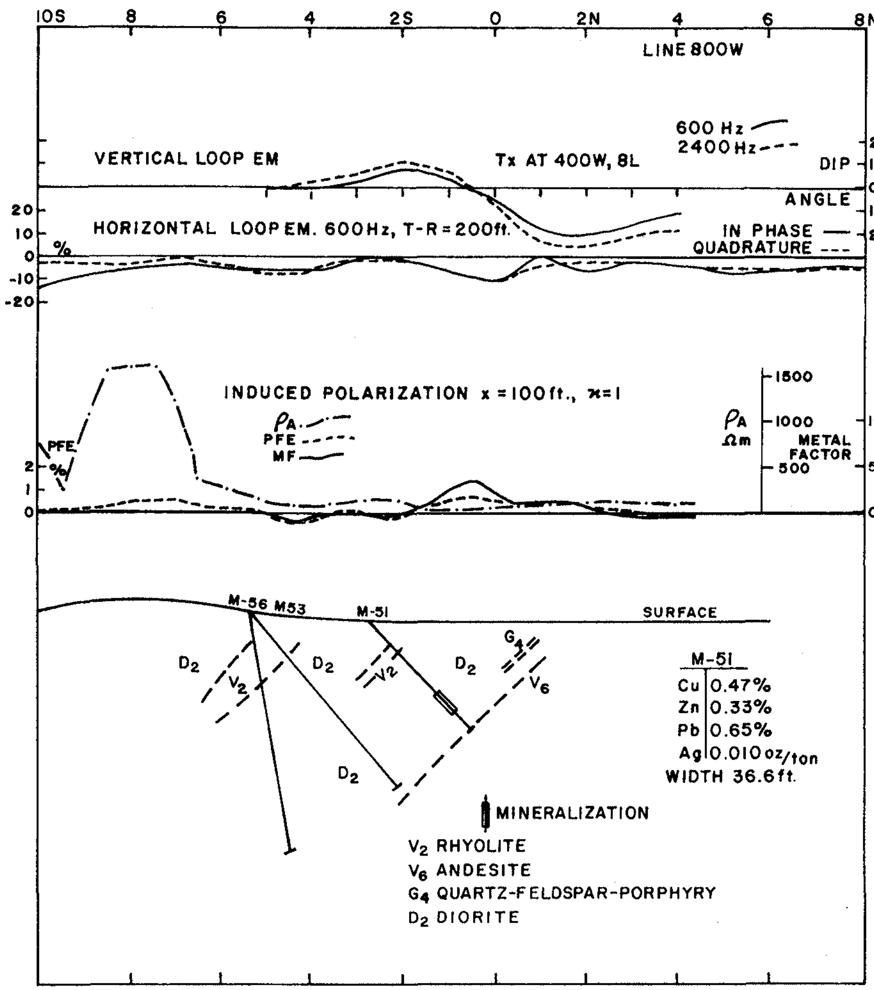
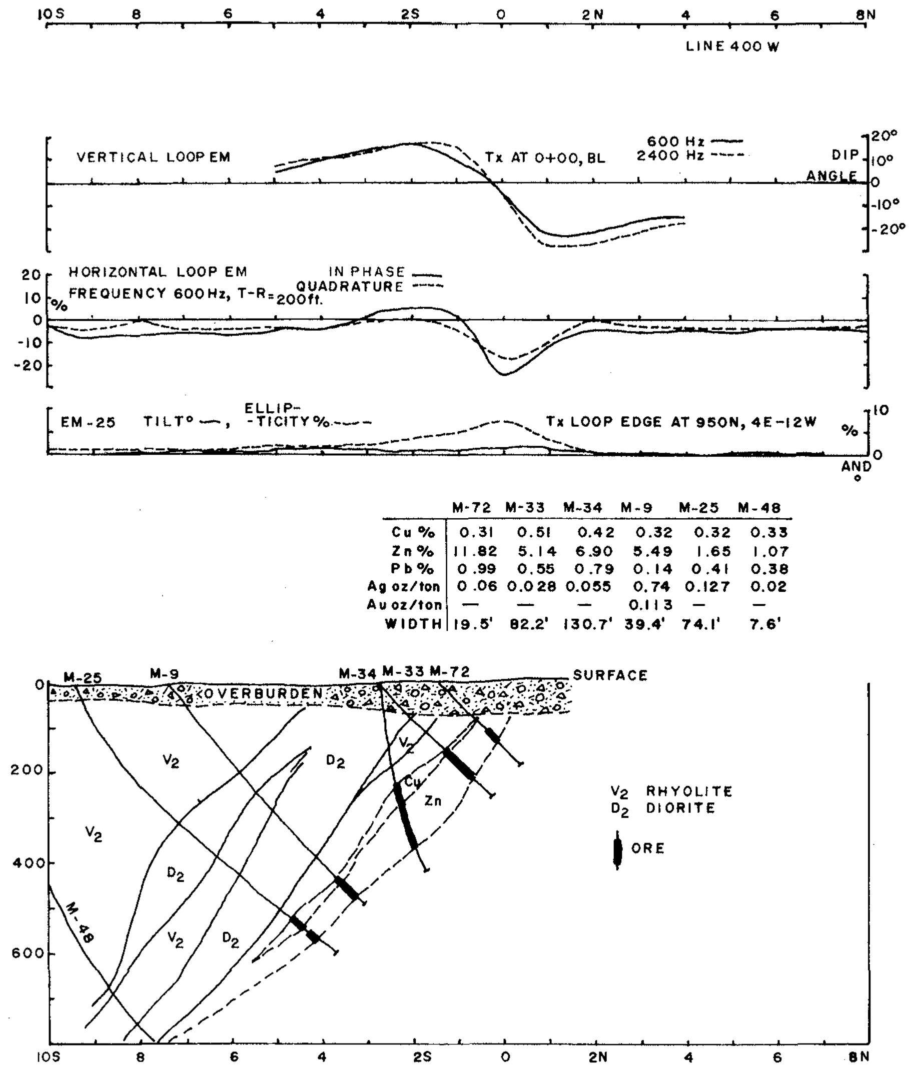
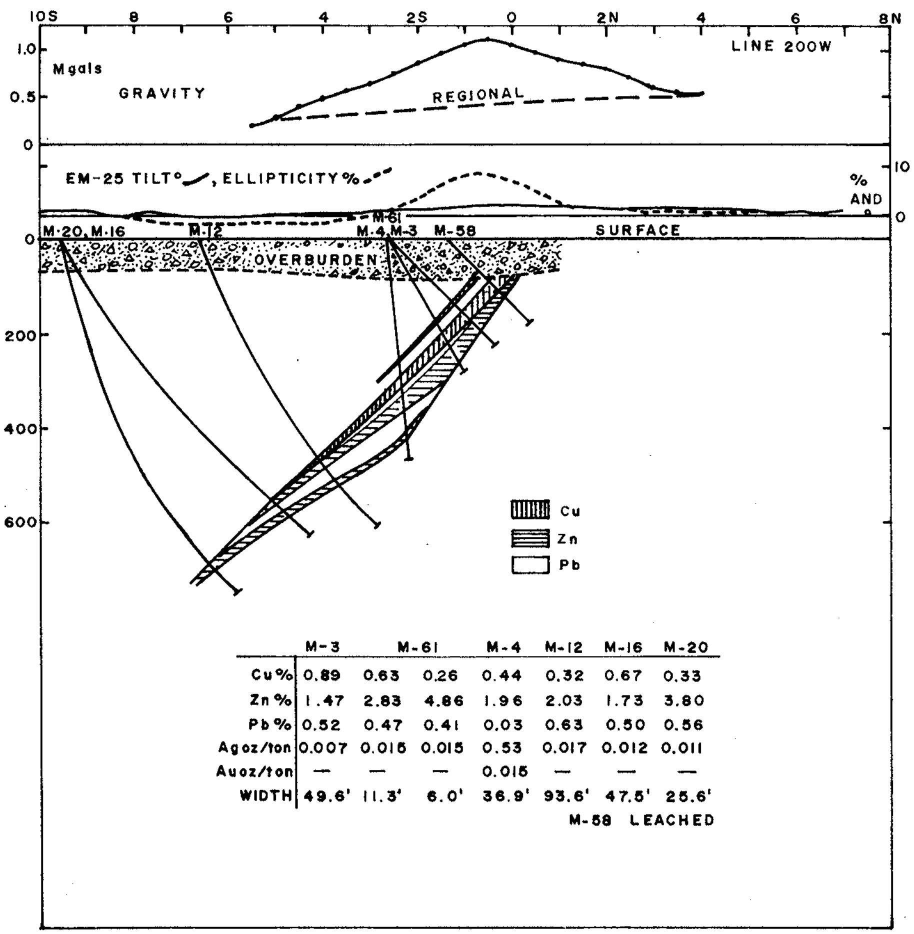


Figure 27.17. Various geophysical profiles and section, Line 8+00W, Iso Orebody.



	M-72	M-33	M-34	M-9	M-25	M-48
Cu %	0.31	0.51	0.42	0.32	0.32	0.33
Zn %	11.82	5.14	6.90	5.49	1.65	1.07
Pb %	0.99	0.55	0.79	0.14	0.41	0.38
Ag oz/ton	0.06	0.028	0.055	0.74	0.127	0.02
Au oz/ton	—	—	—	0.113	—	—
WIDTH	19.5'	82.2'	130.7'	39.4'	74.1'	7.6'

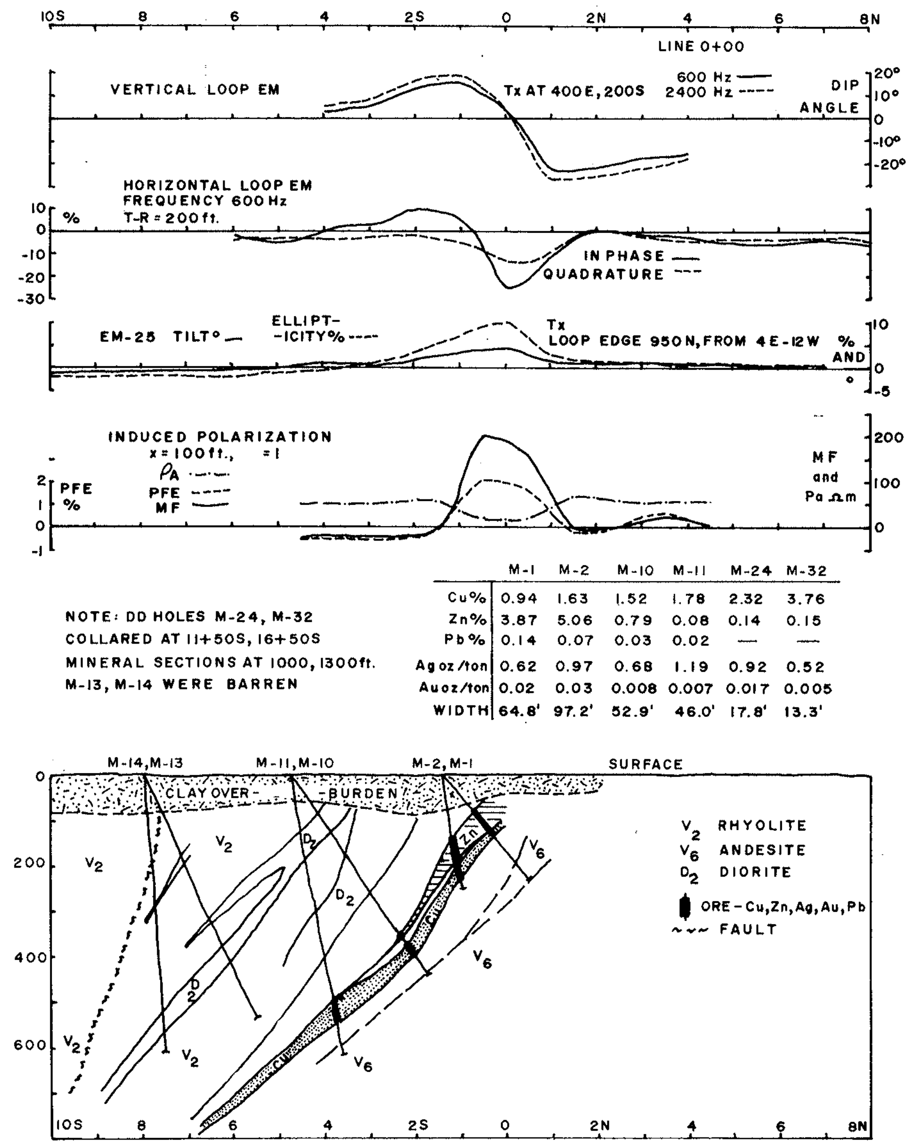
Figure 27.18. Geophysical profiles and section, Line 4+00W, Iso Orebody.



	M-3	M-61		M-4	M-12	M-16	M-20
Cu%	0.89	0.63	0.26	0.44	0.32	0.67	0.33
Zn%	1.47	2.83	4.86	1.96	2.03	1.73	3.80
Pb%	0.52	0.47	0.41	0.03	0.63	0.50	0.56
Agoz/ton	0.007	0.015	0.015	0.53	0.017	0.012	0.011
Auoz/ton	—	—	—	0.015	—	—	—
WIDTH	49.6'	11.3'	6.0'	36.9'	93.6'	47.5'	25.6'

M-58 LEACHED

Figure 27.19. *Gravity, EM-25 profiles and section, Line 2+00W, Iso Orebody.*



NOTE: DD HOLES M-24, M-32 COLLARED AT 11+50S, 16+50S MINERAL SECTIONS AT 1000, 1300ft. M-13, M-14 WERE BARREN

	M-1	M-2	M-10	M-11	M-24	M-32
Cu%	0.94	1.63	1.52	1.78	2.32	3.76
Zn%	3.87	5.06	0.79	0.08	0.14	0.15
Pb%	0.14	0.07	0.03	0.02	—	—
Agoz/ton	0.62	0.97	0.68	1.19	0.92	0.52
Auoz/ton	0.02	0.03	0.008	0.007	0.017	0.005
WIDTH	64.8'	97.2'	52.9'	46.0'	17.8'	13.3'

Figure 27.20. *Geophysical profiles and section, Line 0+00, Iso Orebody.*

Contents

Table 27.2

Parameters for Iso Conductor from HLEM Thin Sheet Curves

P	f	st	t	z	P	f	st	t	z	P	f	st	t	z
ft	Hz	mhos	ft	ft	ft	Hz	mhos	ft	ft	ft	Hz	mhos	ft	ft
200	222	130	0	55	400	222	175	20	60	600	222	130	50	55
"	444	150	10	55	"	444	105	20	50	"	444	80	50	50
"	888	122	5	60	"	888	60	40	40	"	888	35	60	30
"	1777	55	5	50	"	1777	22	60	40	"	1777	14	85	10
266	600	80	75	42	(from Figure 27.20)									

ℓ = coil spacing
σ = conductivity, mhos/m
t = conductor thickness
f = frequency of operation of HLEM unit
z = depth to top

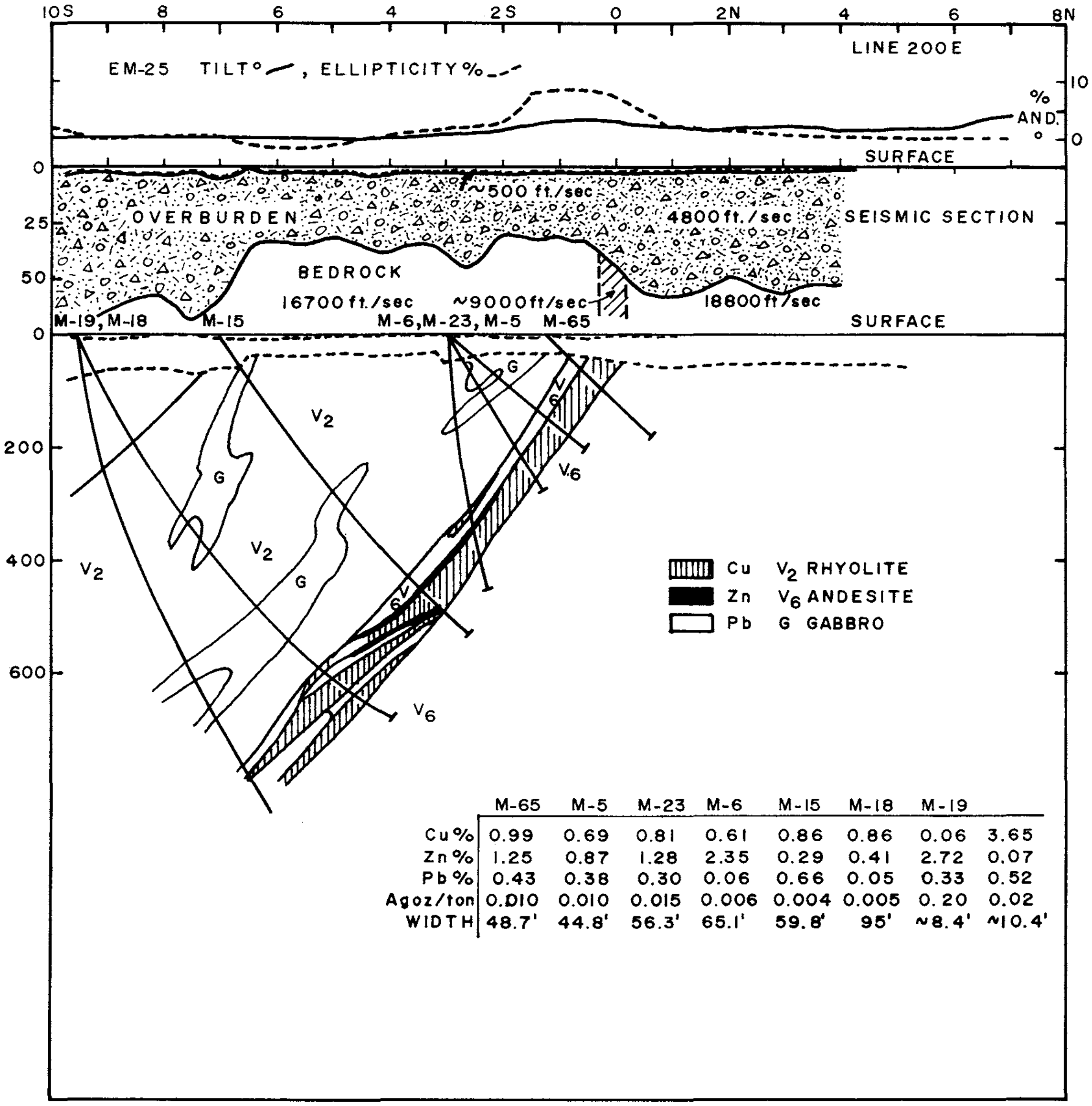


Figure 27.21. *EM-25, seismic data and section, Line 2+00E, Iso Orebody.*

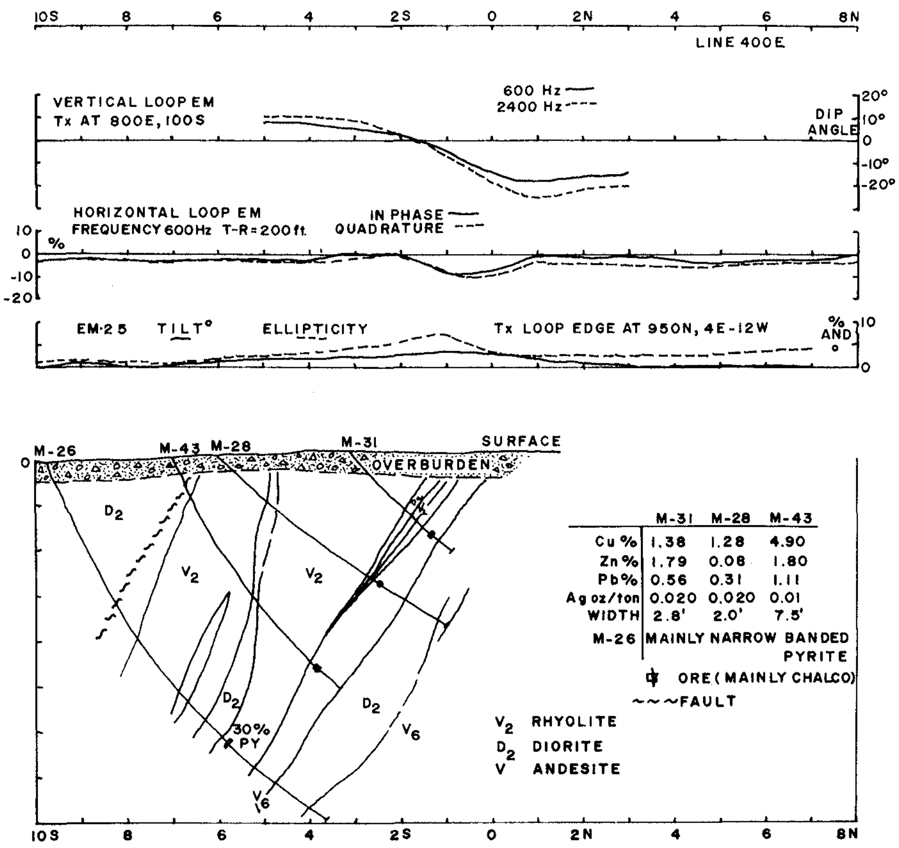


Figure 27.22. *Geophysical profiles and section, Line 4+00E, Iso Orebody.*

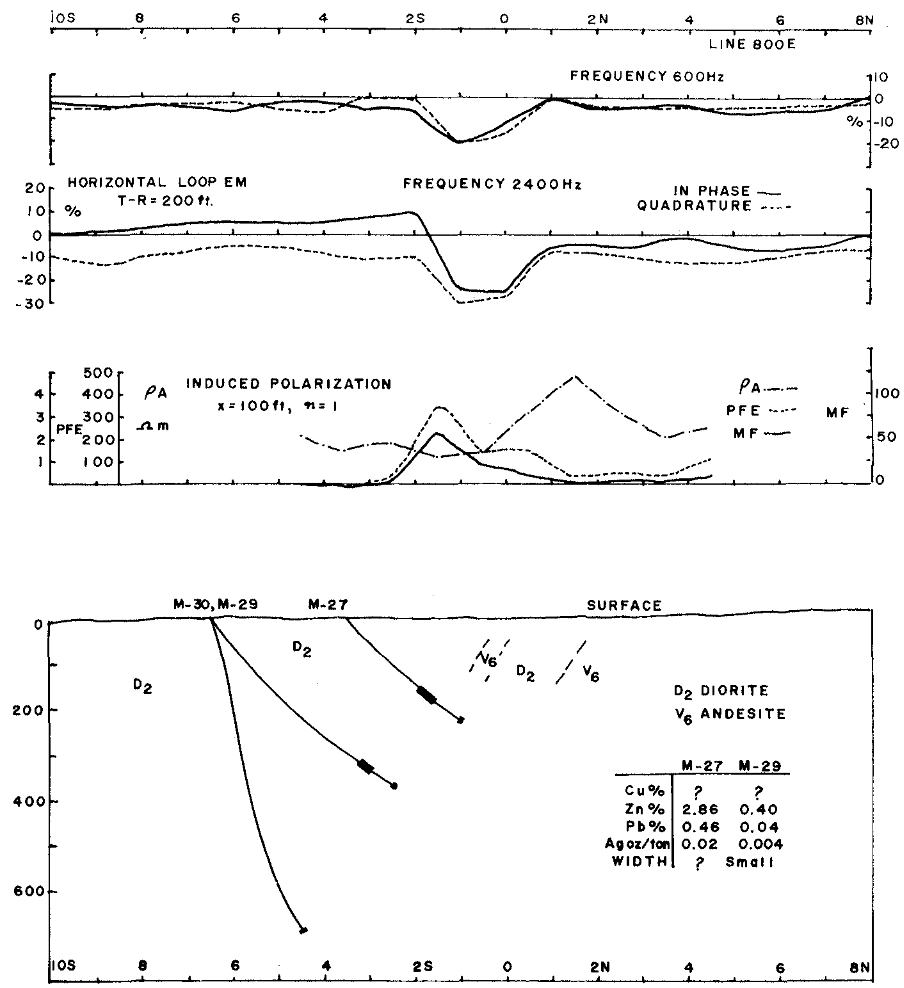


Figure 27.23. *Geophysical profiles and section, Line 8+00E, Iso Orebody.*

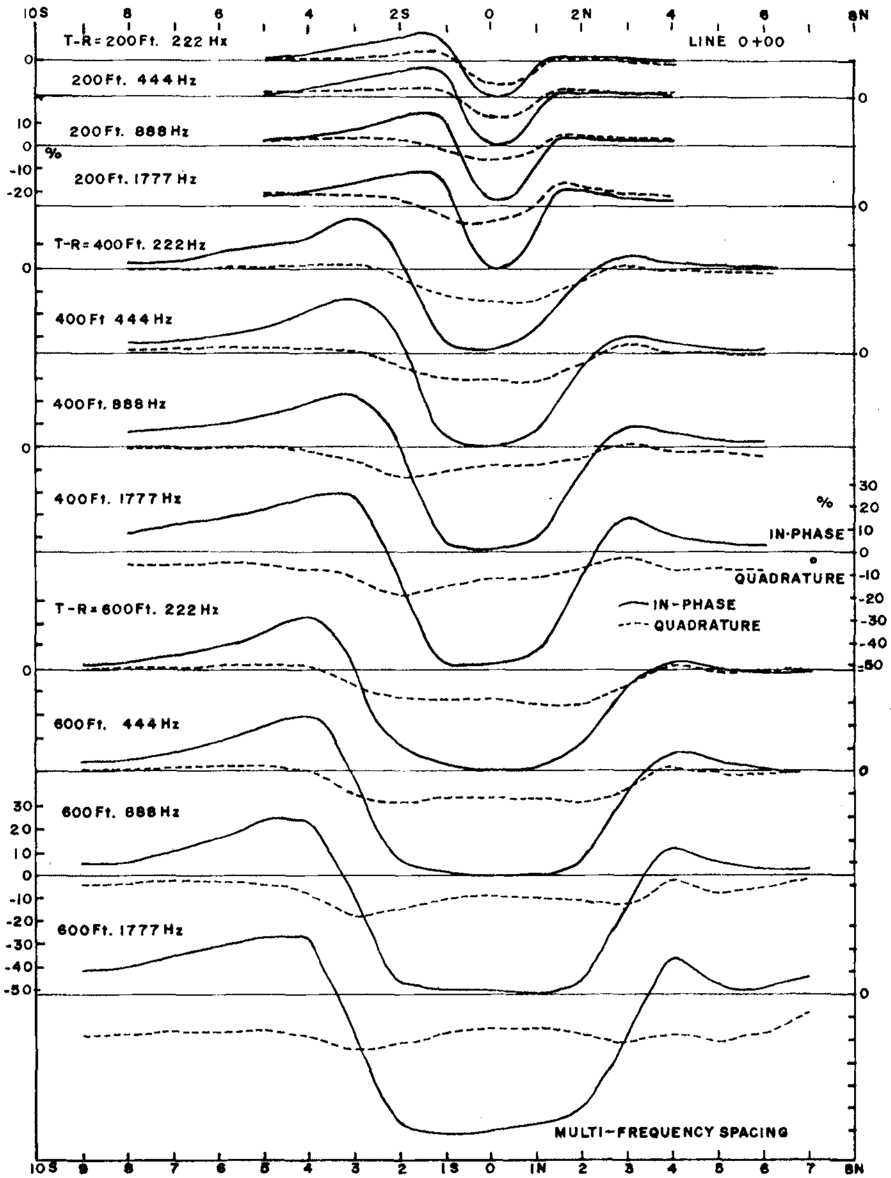


Figure 27.24. Horizontal-loop EM profiles, multifrequency-spacing, Line 0+00, Iso Orebody.

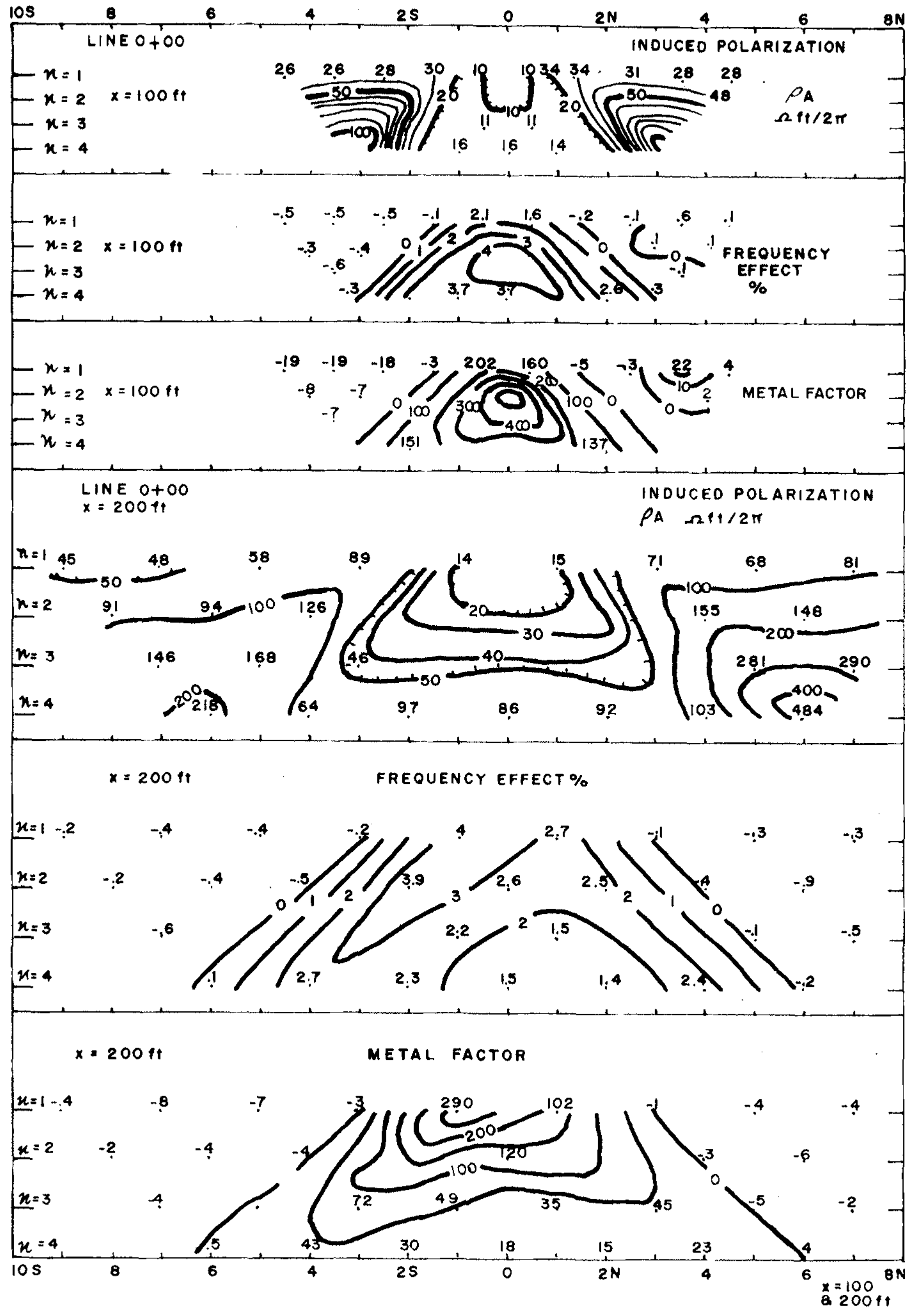


Figure 27.25. IP pseudo-depth plots, Line 0+00, double-dipole spread, Iso Orebody.

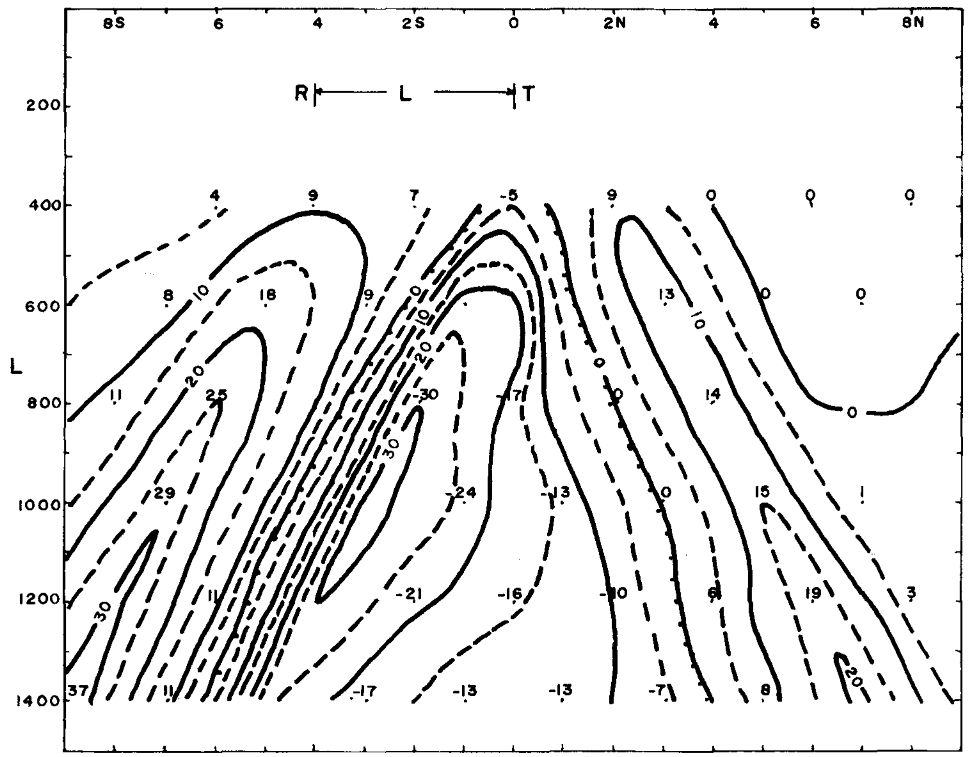


Figure 27.26.

EM-25 quadrature pseudo-section, Line 0+00; contours in per cent ellipticity, Iso Orebody.

Line 4+00W

Vertical-loop EM, horizontal-loop EM, and EM-25 profiles along Line 4+00W are presented in Figure 27.18. The vertical section shows Line 4+00W to be situated directly over the ore zone, which is covered by about 70 feet (20 m) of overburden. From the core logs in Figure 27.18, this is clearly the Zn-rich part of the mineralization. All three profiles are more or less anomalous in the area slightly south of the baseline. The HLEM data indicate a σt value of about 50 mhos and a depth of only 35 feet (11 m), when applied to the thin dipping sheet model characteristic curves.

Line 2+00W

Figure 27.19 shows a gravity profile along with EM-25 results over the vertical section of Line 2+00W, together with the mineralization observed in the drillholes. The gravity anomaly is about 0.7 mgals after removing the marked regional. Tonnage calculations based on this anomaly (Fountain and Fraser, 1973), are given as 3400 tons/linear foot, or 6.8 million tons for a strike length of 2000 feet (610 m). These are not necessarily all ore grade sulphides.

Line 0+00

The profiles and section for Line 0+00 are shown in Figure 27.20. Here the Cu and Zn concentrations have increased appreciably, particularly at depth; Zn decreases with depth and Pb is generally low.

The electrical profiles all show clear anomalies at 0+00 or slightly south, characteristic of a conductor with south dip. From the appropriate thin sheet model curves for the HLEM method, a depth of about 42 feet (13 m) and a σt product of about 80 mhos was calculated.

The IP profiles are quite conventional. Variation of IP and ρ_a response with depth is clarified in Figure 27.25, where it is evident that all three parameters peak in the section between n=2 and n=3 for x=100 feet (30 m), that is, 150-200 feet (45-60 m) below surface.

Line 2+00E

Figure 27.21 has been inserted mainly to illustrate the value of using the shallow seismic refraction technique to map the bedrock terrane. The EM-25 profile and vertical ore section are also shown. Interpretation of the seismic data was done by Hales' (1958) method. Velocities were quite uniform, averaging 4800 ft/s (1465 m/s) in the overburden and 18 000 ft/s (5485 m/s) in bedrock. There is a distinct low velocity zone in the bedrock averaging 11 000 ft/s (3350 m/s), which coincides generally with the ore zone and extends somewhat downdip.

The EM-25 profile is similar to those on adjacent lines, with the ellipticity anomaly predominating. In the 400 foot (120 m) section between Lines 2+00W and 2+00E the average ellipticity/tilt ratio indicates a σt product of 25-35 mhos and the asymmetry suggests a 60° south dip.

Line 4+00E

From the vertical section in Figure 27.22 and from Figure 27.7 it is clear the ore zone has grown thinner and extends only about 500 feet (150 m) downdip. The EM profiles reflect the decreased width of mineralization. The VLEM profiles locate the top of the conductor at 1+50S and indicate the south dip, while the maximum dip angles have decreased compared to Lines 2+00E and 0+00. The HLEM response has also decreased; modelling gives a depth of 55 feet (17 m) and a σt of 17 mhos. The EM-25 response is similarly smaller.

Line 8+00E

Geophysical profiles and vertical section are illustrated in Figure 27.23. Neither the depth of cover nor the detailed mineral zone section is known for this line, although it appears from Figure 27.7 that the latter is somewhat wider near surface and of the same depth extent compared to Line 4+00E. The 2400 Hz HLEM data suggest the south dip

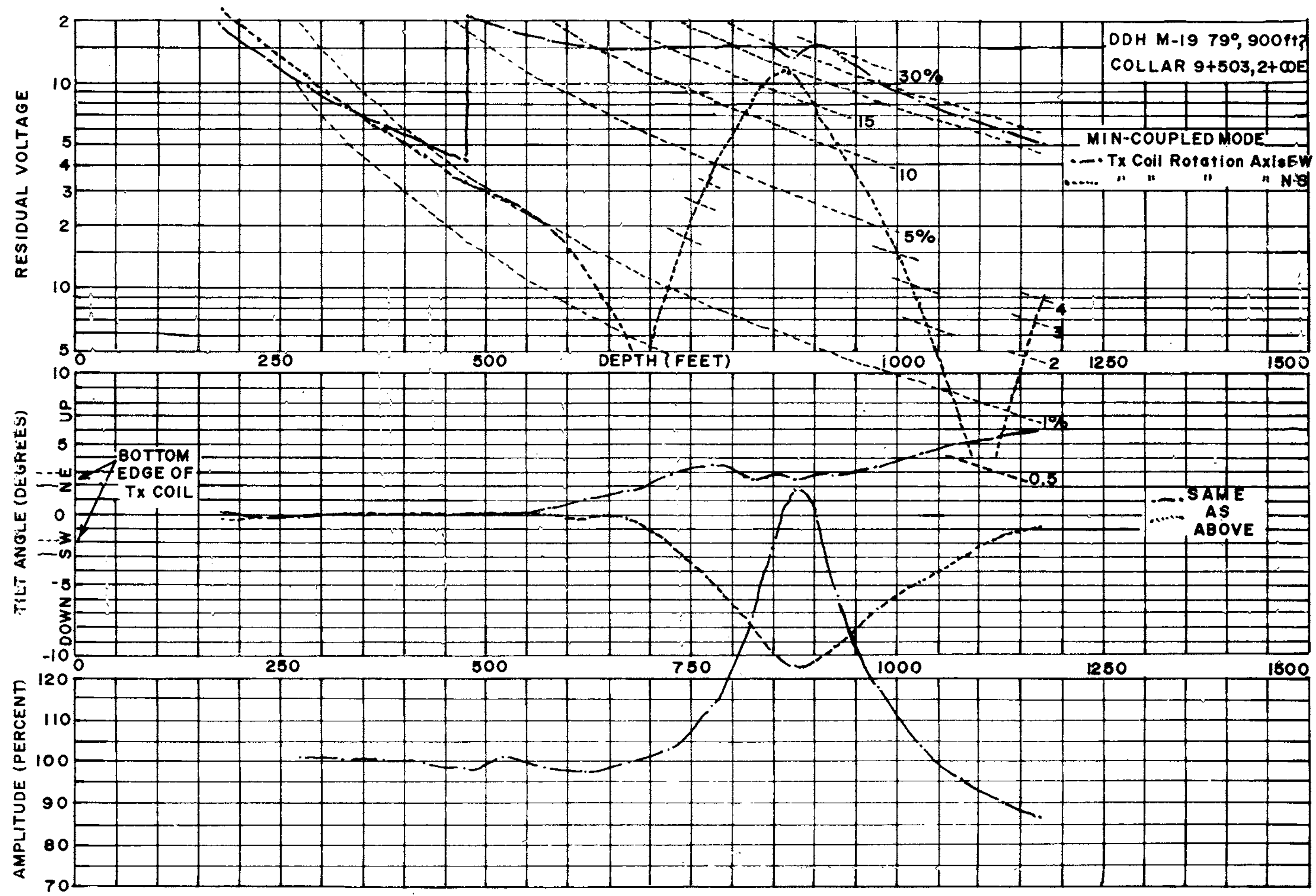


Figure 27.27. *EM logs in DDH M-19 (after Betz), Iso Orebody.*

more obviously than does the 600 Hz HLEM profile. The depths and σt products obtained from the thin sheet model are 25 feet (8 m) and 21 mhos at 600 Hz, about 10 feet (3 m) and 14 mhos for 2400 Hz.

The ρ_a profile from the IP survey also suggests a south-dipping conductor. At larger dipole spreads (x=200, 300 feet (60, 90 m)), the ρ_a values increase to the north. On this line the PFE anomaly is larger than on Lines 8+00W and 0+00. Furthermore, both PFE and metal factor increase more with expanded spreads than on the other two lines and shift the location of the ore zone somewhat south. Hence the IP data indicate possible disseminated mineralization at depth.

Maxmin Horizontal-Loop EM Profiles

A suite of horizontal-loop EM profiles obtained with the Apex Parametrics Maxmin unit at four frequencies – 222, 444, 888, 1777 Hz – and three coil separations – 200, 400 and 600 feet (60, 120, 180 m), is displayed in Figure 27.24 for Line 0+00. Parameters obtained from thin sheet characteristic curves (60° dip), using pertinent data from these profiles, are tabulated below. Estimates of σt, t and z from the HLEM profiles of Figure 27.20 are presented in Table 27.2; these should be closest to corresponding Maxmin values at ℓ = 200 feet (60 m), f = 444 Hz. The σt and z values are approximations, while the thicknesses (t) are merely crude estimates.

In general the agreement is not particularly good between the results of the two HLEM surveys, nor with the true values of σt, t and z. However, it is obvious that the cross-sectional geometry is not that of a thin sheet.

Pseudo-Depth Sections

IP and EM-25 pseudo-depth sections for Line 0+00 are shown in Figures 27.25 and 27.26 respectively. A shallow conductor of limited depth extent is indicated by the IP contours; the south dip is not apparent.

The EM-25 section in Figure 27.26 clearly has a more attractive appearance than the IP plot, although the depth of the anomaly appears too large. The absence of readings for L < 400 feet (120 m) is due to the minimum Tx-Rx spacing used, being 400 feet (120 m), with the moving transmitter mode of the EM-25. The transmitter coil was north of the receiver stations in all cases, since this configuration provides better coupling to a conductor dipping south. Note that the vertical scale in Figure 27.26 represents the full Tx-Rx spacing; it should be divided in half to be equivalent to Figure 27.25.

EM Logging

Results of the Betz DHEM survey in DDH M-19 are presented in Figure 27.27. The hatched scales accompanying the residual voltage (RV) log are a superimposed grid of per cent vs depth values used to convert the RV readings to the quadrature component of the response. Appropriate location of this grid is determined by calibration of the tilt angle vs receiver signal in a barren section of the hole.

There is a very strong response in the max-coupled (so-called AMP) signal, as well as for RV and tilt (Tx coil N-S), at about 875 feet (265 m). The RV and tilt logs for the E-W transmitter orientations are not so anomalous. Betz reports this as an indication of a large conductive zone within 25 feet (7.5 m) of the hole and probably to the west. DDH M-19 shows two rather thin mineral sections at an approximate depth of 900 feet (275 m).

NEW INSCO OREBODY

The New Insco deposit (see Fig. 27.1) is considerably smaller than Iso, being about 1 million tons averaging 2.5 per cent Cu, 0.25 oz/ton Ag, with very little Zn. The geometry, shown in Figure 27.28, indicates its limited depth extent (about 600 feet (180 m)), strike length (less than 400 feet (120 m)) and south dip. The overburden is similar to that at the Iso orebody. No information was available with regard to the local geology.

Geochemical and Ground Geophysical Surveys, New Insco Orebody

Line 0+00

The geochemical, magnetic, gravity and HLEM profiles along Line 0+00 are shown in Figure 27.29. From the vertical section, there is clearly little mineralization of appreciable width. The drill section shows 1.3 feet (40 cm) of 1.4 per cent Cu at 140 feet (43 m) in DDH H73-1; 6 feet (180 cm) of 1.8 per cent and 3 feet (90 cm) of 6.1 per cent Cu at 490 and 540 feet (150 and 165 m) respectively in H73-2. This mineralization has not been considered to be continuous over the intervening 275 feet (85 m) between the holes.

The magnetic and B-horizon soil geochemical profiles are quite uninteresting. No basal-till geochemical sampling was done on this line. There is a minor EM anomaly centred at 12+25N which, from its shape and from model curves, indicates a thin conductor dipping south from about 50 feet (15 m) below surface and having a σt product of 11 mhos. The broad gravity anomaly of 0.4 mgals, centred at 12+00N and persisting to the north, does not fit this interpretation. Nor would it appear to be due to either a density contrast in rock types – since dacite is generally of lower density than diorite – or an overburden anomaly. It may be due to disseminated mineralization. Thus the profiles on this line indicate that the main ore zone has pinched out slightly to the east.

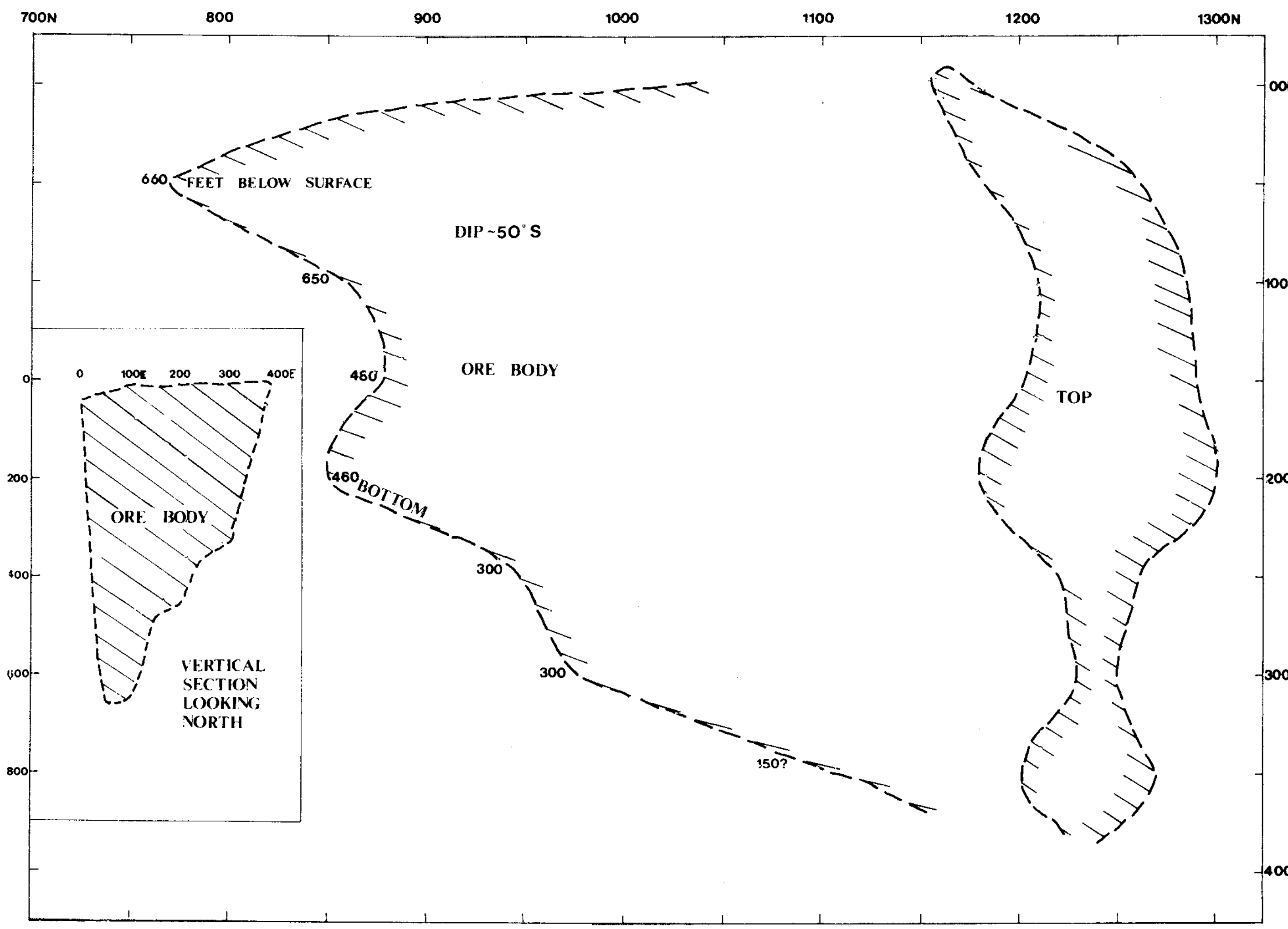


Figure 27.28. *Surface projection and vertical section, New Insco Orebody.*

Contents

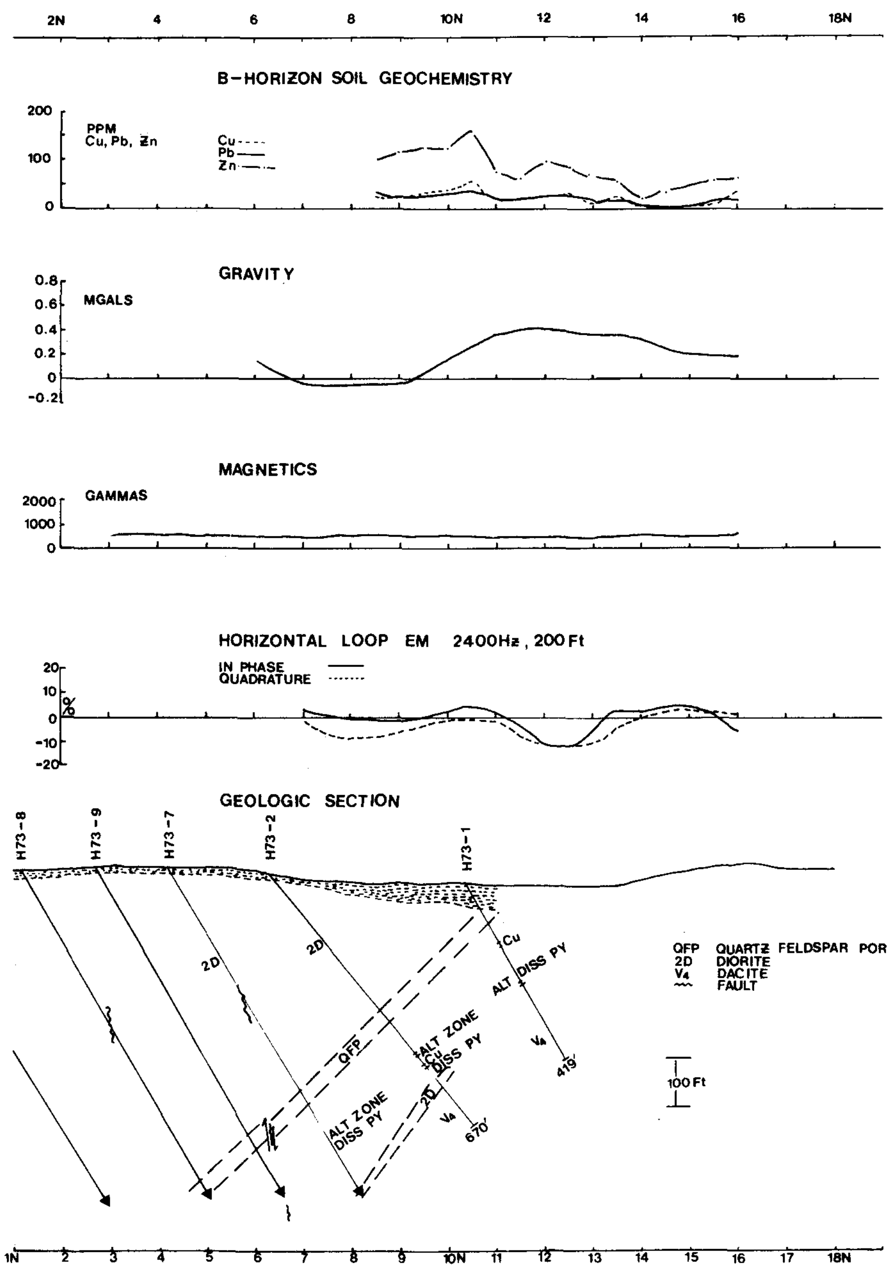


Figure 27.29. Various geochemical and geophysical profiles and section, Line 0+00, New Insco Orebody.

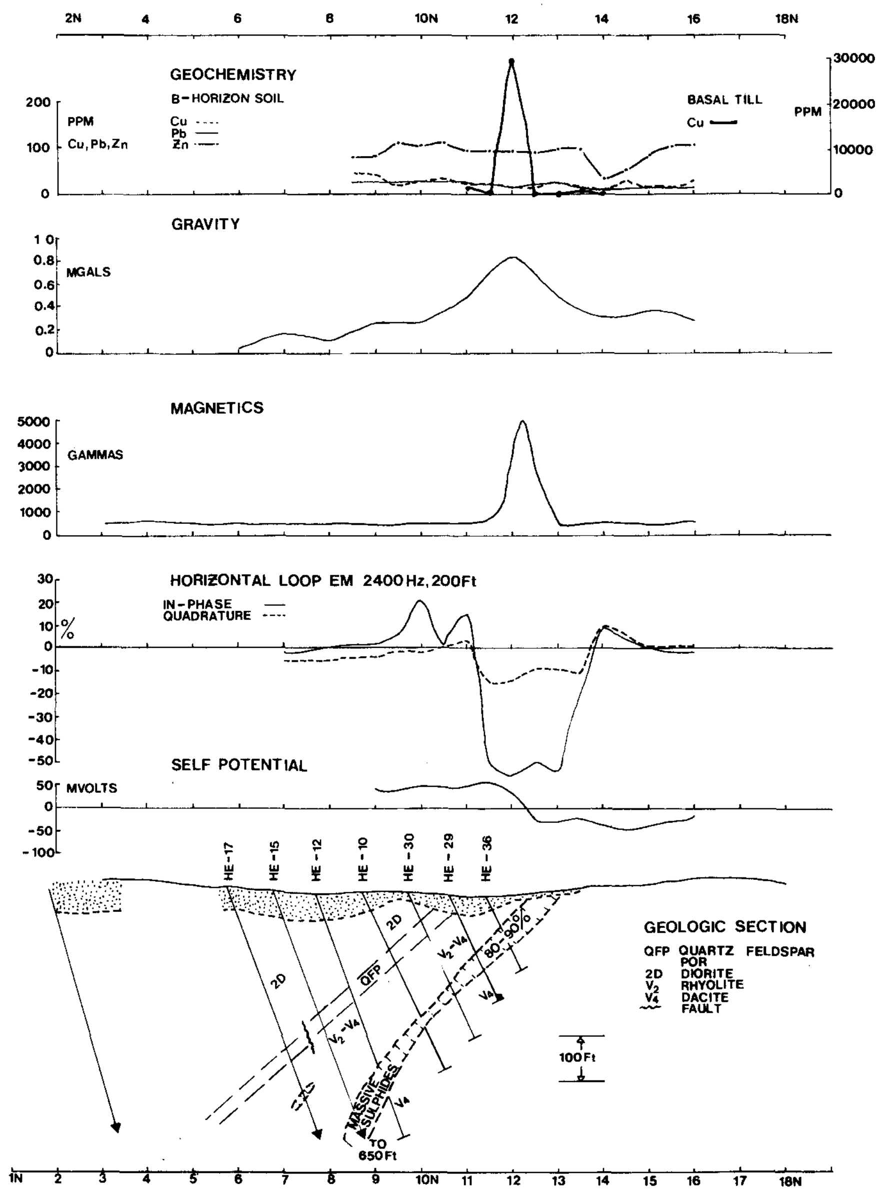


Figure 27.30. Various geochemical and geophysical profiles and section, Line 1+00E, New Insco Orebody.

Line 1+00E

Figure 27.30 displays the geochemical, magnetic, gravity, HLEM and SP profiles on Line 1+00E, with the section. Projected to surface, the top of the ore zone has a horizontal width of about 75 feet (23 m) and it bottoms out at 650 feet (200 m). The average grade is about 2.6 per cent Cu and there is a high concentration of pyrrhotite and pyrite throughout.

The SP response is surprisingly small for a massive sulphide at shallow depth. This may be due to the type of overburden. From soil sampling of the B-horizon, there appeared to be solid clay below about 10 inches (25 cm). Clay can have a masking effect on surface SP response, judging from previous surveys in this area and in the Quebec Eastern Townships.

The huge (2.9 per cent) basal-till Cu anomaly at 12+00N is on the south flank of the ore zone rather than directly over it. This is attributed by G.F. Archibald to the fact that the orebody subcrops 5-10 feet (1.5-3 m) above bedrock and may have been stripped off by glaciation. There is no reflection of this Cu anomaly in the surface soil geochemical profile.

The sharp magnetic anomaly peaking at 12+25N indicates a sheet or dipole type of causative body of limited depth extent and steep dip. Presumably the pyrrhotite in the ore zone is the source, although this is a large anomaly for pyrrhotite. The peak is sharper than would be produced by a uniform distribution of magnetic mineral across the ore section; its thickness could hardly be greater than 10 feet (3 m). However, there seems little doubt that the magnetic anomaly is associated with the ore zone, since it has practically disappeared on Line 3+00E and there is no indication of it on Line 0+00. There is no mention of pyrrhotite on the detailed drill section of Line 0+50E and none on 3+50E above a depth of 420 feet (130 m).

The HLEM profile indicates a good conductor dipping south and having a width of about 60 feet (18 m). From characteristic curves the depth to the top is more than 10 feet (3 m) and the σt value is about 55 mhos.

The gravity profile peaks somewhat south of the ore zone centre at bedrock, although if a meter reading had been taken at 12+50N the maximum might have shifted somewhat. In any case, the peak should be slightly downdip. However, the profile suggests a slab dipping north rather than south since the positive gravity persists to the north as on Line 0+00. Presumably this is due to disseminated mineralization.

Line 2+00E

Figure 27.31 presents additional profiles on Line 2+00E – multifrequency telluric, IP and apparent resistivity plots – along with those on the previous figures. On Line 2+00E the ore zone is 120 feet (36 m) wide at the top and has an average grade of 2.9 per cent Cu. There is also considerable massive pyrite and pyrrhotite through the section. DDH HE-42 intersects ore grade Cu at 350, 400 and 425 feet (107, 122, 130 m), the last appearing to be continuous as far as HE-14, that is, over 80 feet (24 m).

On Line 2+00E the basal-till Cu anomaly is on the north flank of the section. The 200 ppm soil anomaly at 11+00N presumably is a reflection of the bedrock anomaly caused by transport of material during north-south glacial movement.

There is a good SP anomaly of – 200 mv on Line 2+00E, with the peak at 13+00N corresponding to that for the basal-till Cu anomaly. Asymmetry of the anomaly indicates a south dip.

The IP profiles on Line 2+00E display the double-dipole traverse at x = 100 feet (30 m), n=1, the shallowest spread. There are strong IP anomalies at 12+50N. Although not evident on the scale used, the ρ_a profile has a minimum of about 9 Ωm at the same station and is generally less than 100 Ωm between 7+00N and 14+00N,

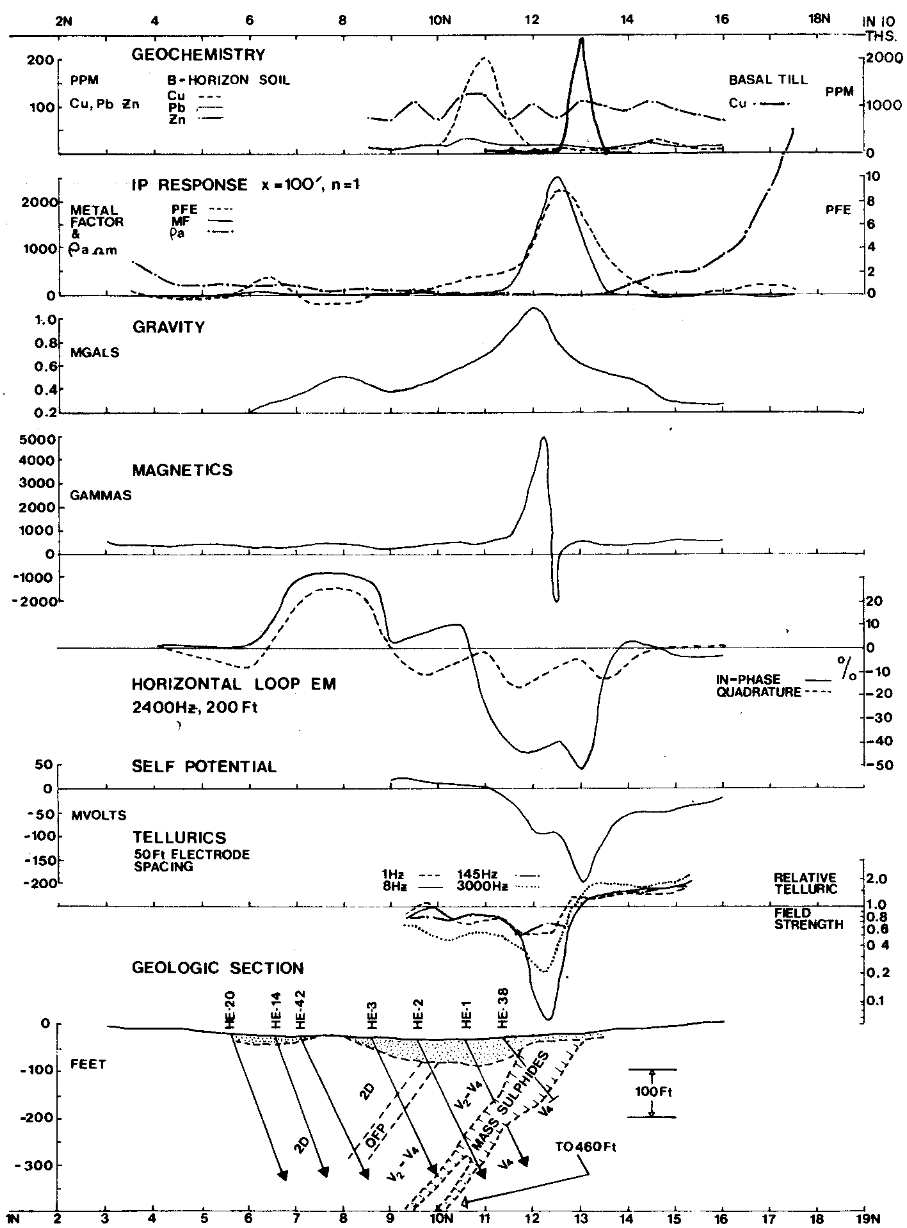


Figure 27.31. *Various geochemical and geophysical profiles and section, Line 2+00E, New Insco Orebody.*

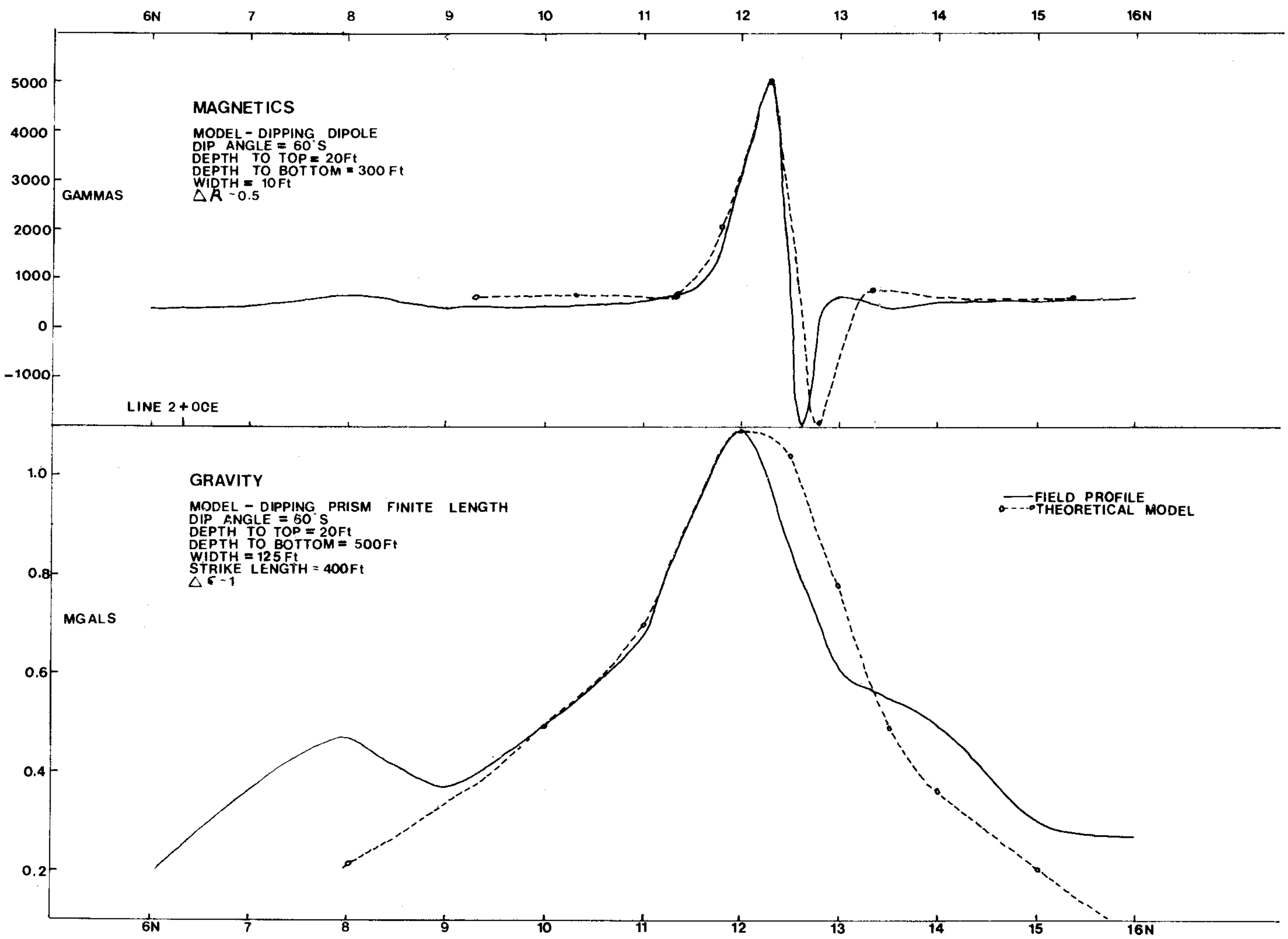


Figure 27.32. *Matching of magnetic and gravity profiles by model shapes, Line 2+00E, New Insco Orebody.*

reflecting the conductive clay overburden. Resistivity increases at both ends of the line, very sharply to the north. There is also a minor PFE peak at 6+50N which is not matched on either of the other profiles.

The telluric profiles on Line 2+00E also show a sharp anomaly over the top of the ore zone, particularly for 8 and 3000 Hz. Surprisingly the 145 Hz channel is least affected at this station: one would expect that the response to a conductor of limited depth extent such as this would vary directly with the frequency. Background noise, including conductive overburden, may be responsible. The asymmetry of the anomaly indicates a south dip, although the large telluric response north of station 14+00N may be mainly due to higher resistivity in the area.

As on Line 1+00E, there is a single 5000 gamma peak on the magnetic profile at 12+30N which, on this line, is followed immediately to the north by the characteristic negative tail associated with a thin sheet or dipole dipping south.

The HLEM response on Line 2+00E indicates a shallow zone of high conductivity at least 100 feet (30 m) wide. The shape of this anomaly is somewhat confusing, because the maximum negative value and the steep slope of the real component are on the north flank, while the positive overshoot is to the south. These characteristics conflict, suggesting north and south dips respectively. The rather peculiar anomaly shape may be due to the width and shallow depth of the conductor, that is, some saturation in the negative response. This argument is reinforced by the appearance of double peaks in both real and imaginary profiles, particularly the latter. From thin sheet model curves, a depth of about 12 feet (4 m) and a σt product of 40 mhos was calculated. Obviously the thin sheet is not appropriate as a model for the New Insco orebody.

On Line 2+00E, the gravity anomaly clearly indicates a prism section with south dip. The north flank response is less persistent here than on lines to the west. A minor positive excursion at station 8+00N is somewhat similar to the gravity anomaly on Line 1+00E. There is no obvious explanation for these features.

An attempt was made to match the magnetic and gravity anomalies of Line 2+00E, as shown in Figure 27.32. As mentioned earlier, the magnetic anomaly is so sharp that an extremely small cross-section is required to provide sufficiently steep slopes. Although the match is reasonably good, the strike length is unrealistic and the susceptibility too large. The latter could be improved by reducing the depth to 10 feet (3 m), which is nearer the actual value. On the other hand, if a strike length of 200 feet (60 m) is used, as it should be, the anomaly becomes too broad. In matching the gravity anomaly the problem is to make the model wide enough to

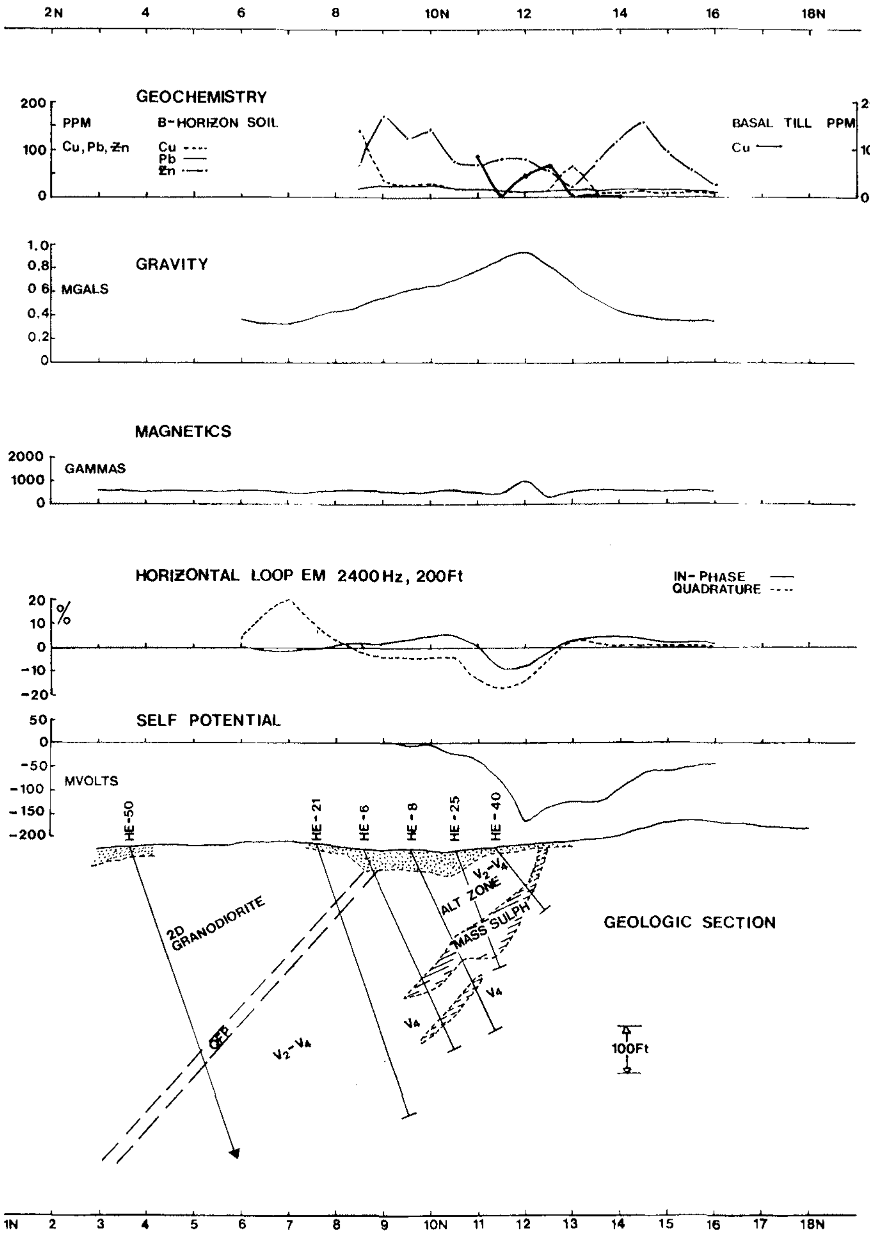


Figure 27.33. *Geochemical and geophysical profiles and section, Line 3+00E, New Insco Orebody.*

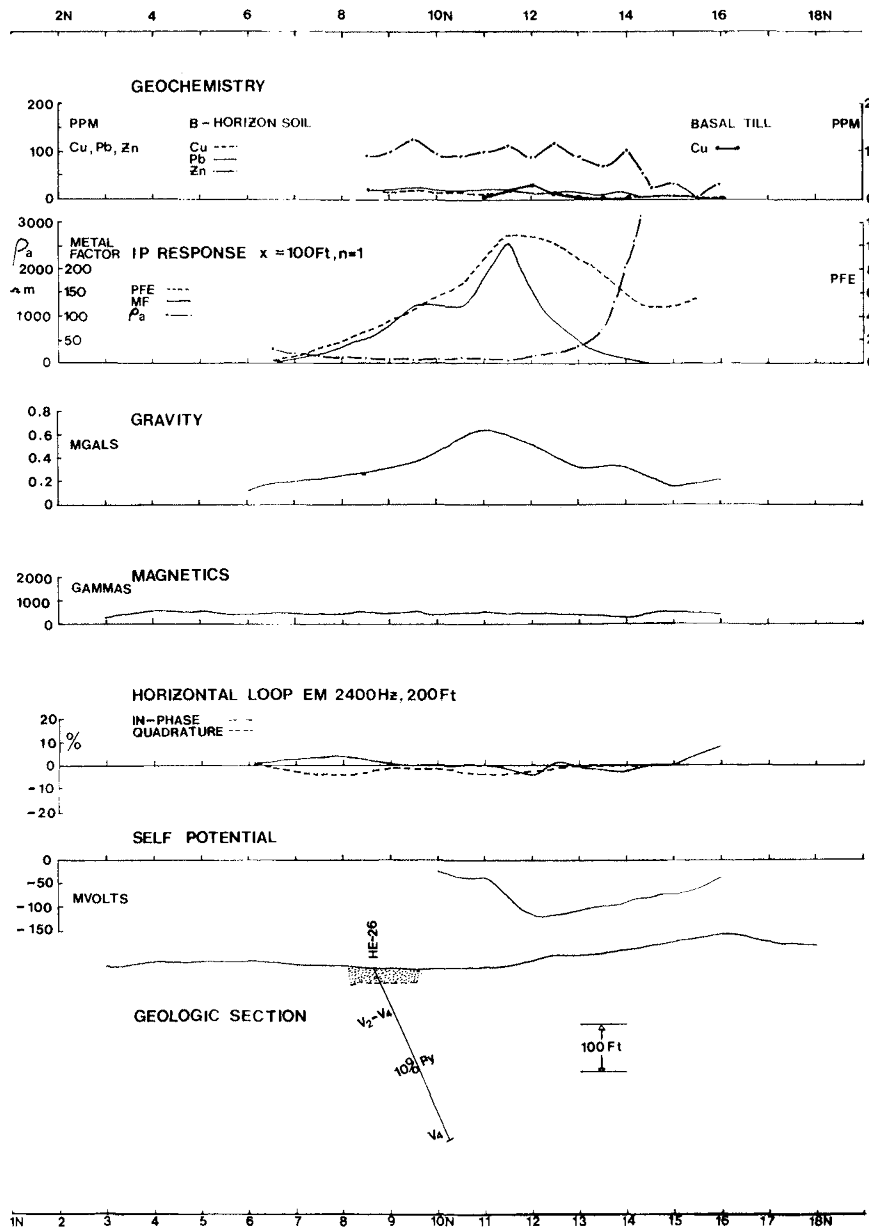


Figure 27.34. *Geochemical and geophysical profiles and section, Line 4+00E, New Insco Orebody.*

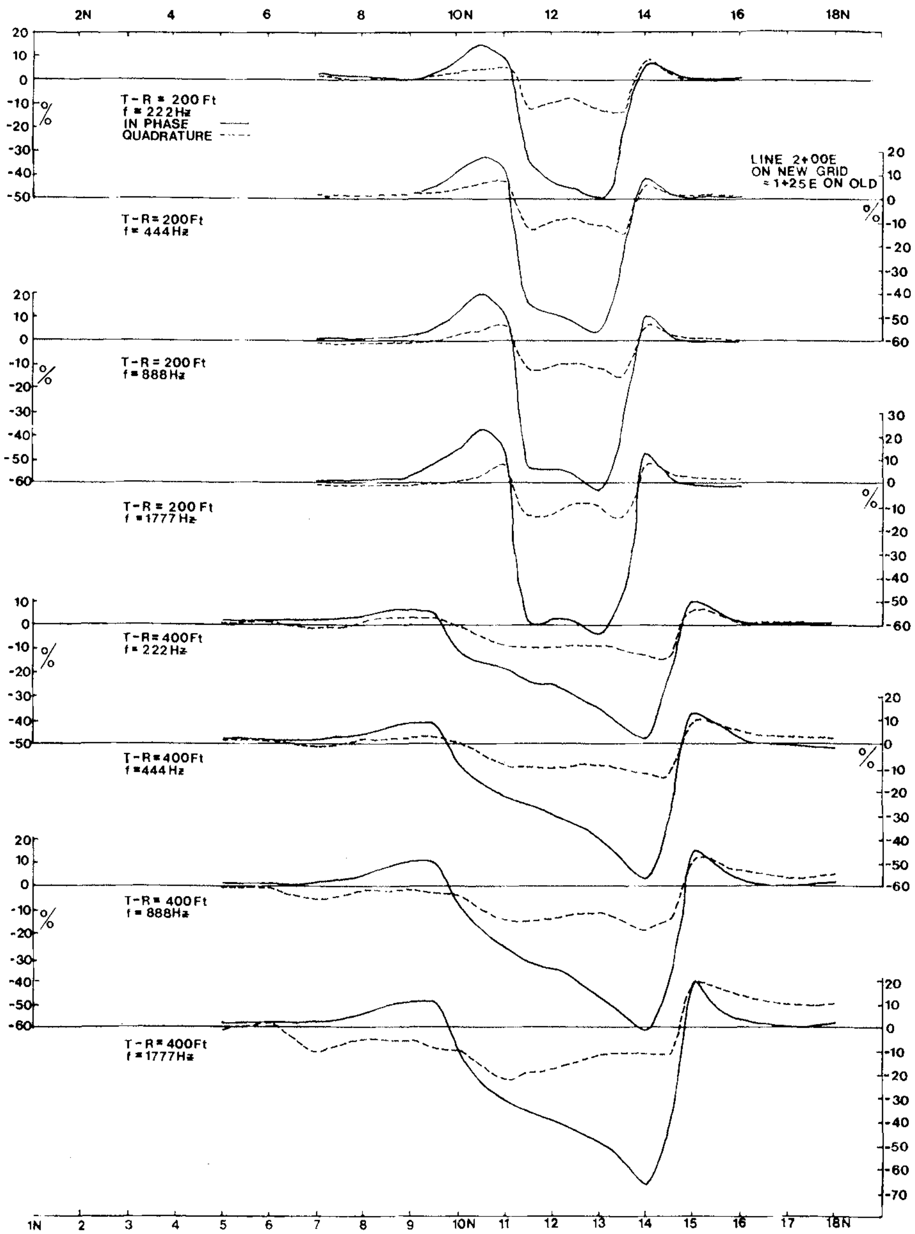


Figure 27.35. Horizontal-loop EM profiles, multifrequency-spacing, Line 1+25E, New Insco Orebody.

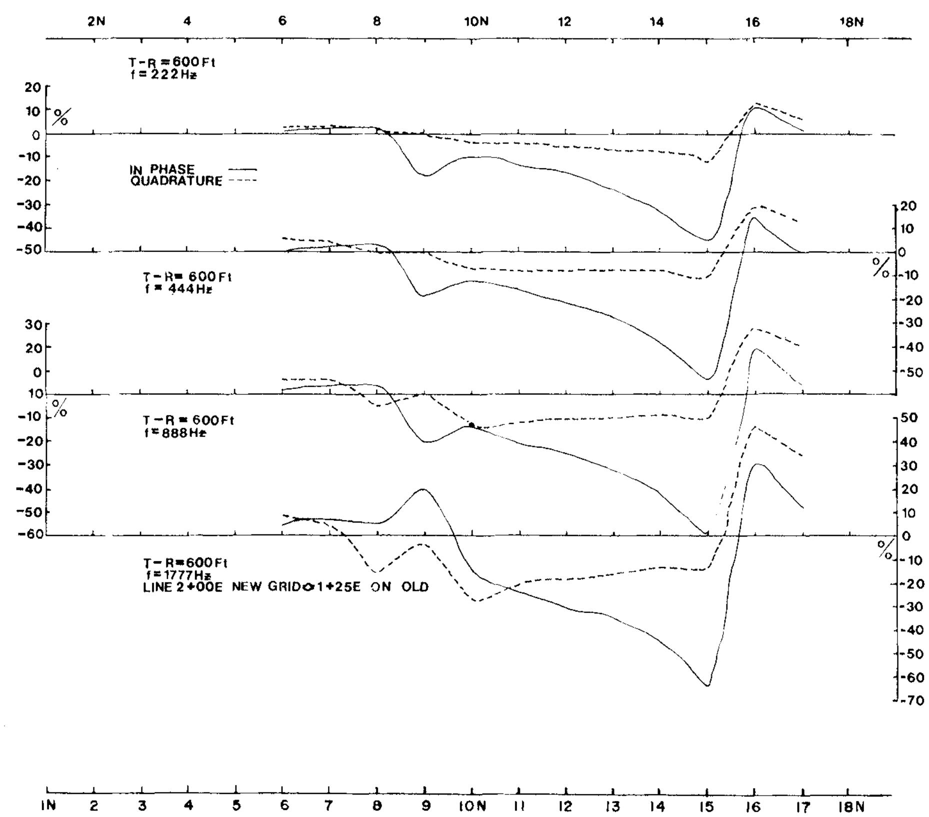


Figure 27.36. Horizontal-loop EM profiles, multifrequency-spacing, Line 1+25E, New Insco Orebody.

increase the slopes on the flanks. More heavy material is required than can be contained in the prism section. The rather high density contrast is not abnormal.

Line 3+00E

Figure 27.33 presents the geophysical and geochemical data obtained along Line 3+00E, where the ore cross-sectional area has shrunk and the average grade has decreased to 1.4 per cent Cu. A smaller section below the main zone, intersected by drillholes HE-8 and HE-6, averages 3.3 per cent Cu, but appears of limited extent. Also the amount of pyrrhotite in the sulphides has decreased, particularly in the shallow portion of the zone.

The basal-till Cu anomaly has decreased to 0.6 per cent at 12+50N on the north edge of the bedrock ore exposure. There is a second Cu peak at 11+00N. As on Line 2+00E, the soil geochemistry is anomalous for Cu about 400 feet (120 m) south. Glaciation is the probable cause of both these anomaly displacements.

The SP peak is quite strong, located 50 feet (15 m) downdip from the basal-till Cu maximum. The profile shape indicates a south dip. There is very little magnetic response, indicating the decrease in pyrrhotite.

The HLEM anomaly has also decreased and the profile shape reflects a very thin conductor dipping south. From model curves the depth is about 20 feet (6 m) and the σt product about 3 mhos — a surprisingly poor conductor. Gravity response, on the other hand, remains strong. The south dip is evident, but the gravity anomaly is wider than one would expect.

Line 4+00E

The drill section for Line 4+00E (see Fig. 27.34) shows little mineralization in the single drillhole HE-26. The ore zone appears to have pinched out 50 feet (15 m) west. However, only the barren magnetic and HLEM results support this assumption. The 0.3 per cent Cu basal-till anomaly at 12+00N is supported by an appreciable SP response. The IP profiles show a strong, broad PFE peak (larger than on Line 2+00E) and a metal factor maximum, both at 11+50N, although the latter is only 10 per cent of the maximum on Line 2+00E. This is due to the higher resistivity. A broad gravity anomaly is still present, reduced somewhat in amplitude from previous lines.

Maxmin Horizontal-Loop EM Profiles

Figures 27.35 and 27.36 display Apex Maxmin HLEM profiles from Line 1+25E. A new set of grid lines was offset 75 feet (23 m) west of the original; hence Line 2+00E on the new grid is actually 1+25E on the old and these profiles should resemble those of Line 1+00E.

Figure 27.35 shows eight profiles from Line 1+25E for four frequencies and three transmitter-receiver coil spacings. The fourth profile, 1777 Hz at 200 feet (60 m) spacing, should match most closely with the HLEM profile of Figure 27.30 on Line 1+00E.

The profiles for the 200 foot (60 m) spacing in Figure 27.35 have a conventional appearance at all four frequencies. However, at spacings of 400 and 600 feet (120, 180 m), (the latter appears in Fig. 27.36), they become increasingly distorted. This is due to the short strike length of the New Insco ore zone relative to such coil separations. An increasing fraction of the primary flux passes around the conductor rather than through it. The New Insco orebody is neither thin enough nor long enough to resemble a thin sheet model under these conditions. In Table 27.3, information obtained from HLEM data, when compared to thin sheet characteristic curves, is listed for the twelve profiles of Line 1+25E.

Clearly the thin sheet model becomes unrealistic as the coil separation increases. Estimates of thickness and depth, reasonably good for ℓ = 200 feet (60 m), become too large at 400 and 600 feet (120, 180 m), while the σt product and derived conductivity decrease steadily as ℓ increases. This subject has been discussed in some detail by West (1973) and Betz (1973). To realize a good estimate of σt for a conductor of the dimensions of the New Insco orebody, it would be necessary to use a coil separation of about 50 feet (15 m) and a much lower frequency — around 1 Hz. By extrapolation of the Maxmin survey data to these parameters, Betz has concluded that the true σt value should be about 9000 mhos.

Pseudo-Depth Sections

An assortment of pseudo-depth section plots is shown in Figures 27.37 and 27.38 for Lines 1+25E and 2+00E. Real-component horizontal-loop EM data appear in Figure 27.37. The upper four diagrams correspond to IP sections, both in the plotting arrangement and in general appearance. That is, they become broader at depth, show a steeper gradient on the north, and give no indication of the dip. The lower three

Table 27.3

Parameters for New Insco Conductor from HLEM Thin Sheet Curves

P ft	f Hz	t ft	mIP ohms	z ft	st mhos	s mhos/m	P ft	f Hz	t ft	mIP ohms	z ft	st mhos	s mhos/m
200	222	60	0.107	15	490	27	400	888	105	0.856	20	58	2
"	444	70	0.214	15	300	14	"	1777	100	1.712	20	28	0.9
"	888	70	0.428	10	175	8	600	222	145	0.321	60	170	4
"	1777	70	0.856	10	95	4	"	444	145	0.642	50	130	3
400	222	105	0.214	25	245	8	"	888	150	1.284	50	60	1.3
"	444	100	0.428	20	170	6	"	1777	5	2.568	30	14	9?

ℓ = coil spacing; t = conductor thickness; z = depth to top;
μ = permeability = $4\pi \times 10^{-7}$ h/m; $\omega = 2\pi f$; σ = conductivity

Contents

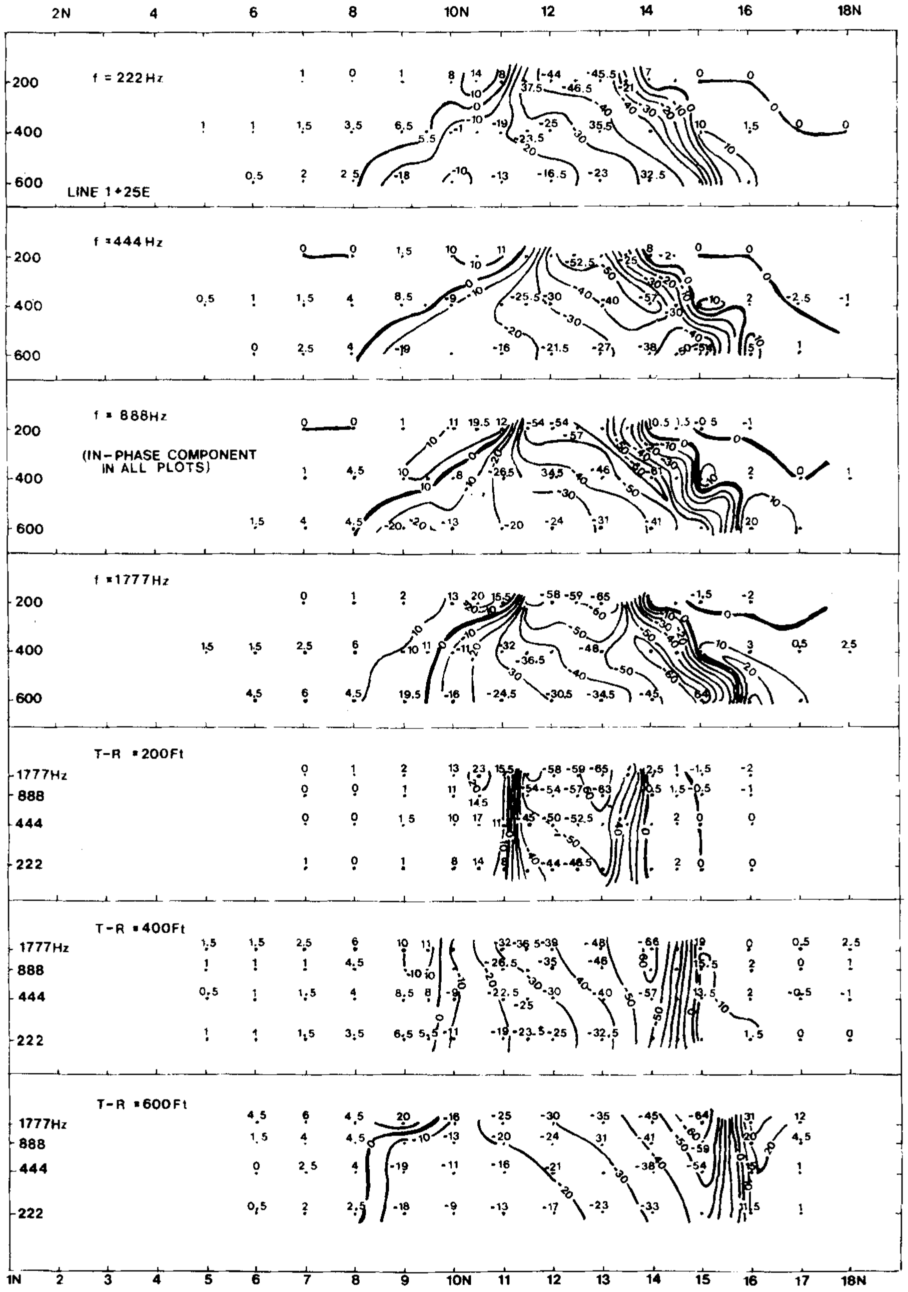


Figure 27.37. Horizontal-loop EM pseudo-depth sections, Line 1+25E, New Insco Orebody.

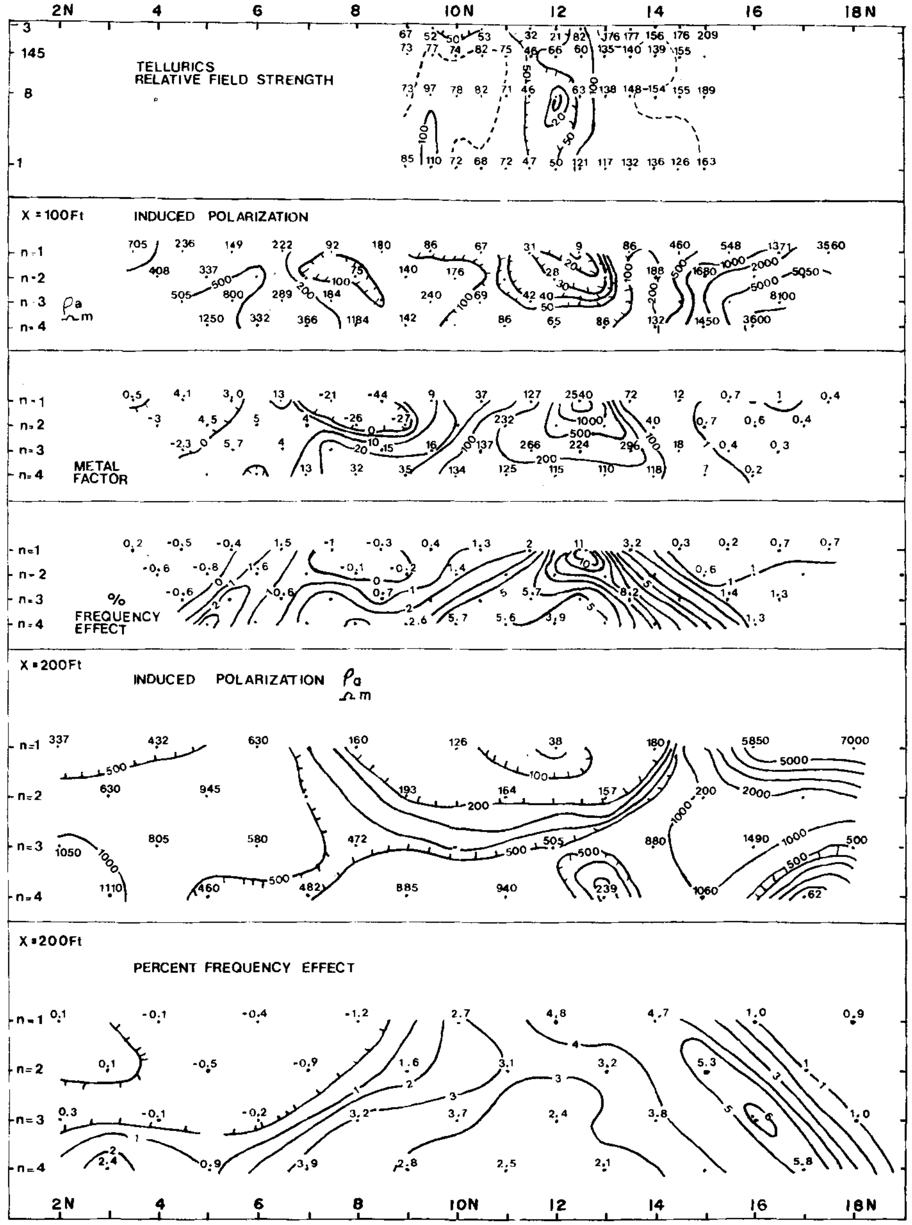


Figure 27.38. IP and telluric pseudo-depth sections, Line 2+00E, New Insco Orebody.

sections in Figure 27.37 use frequency for the ordinate as in MT plots. They are clearly reflections of the profiles, since the anomalous zone widens with increasing Tx-Rx separation and the dip appears to be north. There is some suggestion that the conductor is shallow and of limited depth extent.

IP and telluric pseudo-sections are shown in Figure 27.38. All the IP sections for x = 100 feet (30 m) locate the top of the zone correctly, but the direction of dip is not evident. There is some indication that the zone is of limited depth extent. In the next two sections (x = 200 feet (60 m)), however, the response is diffused to such an extent that the anomalous PFE zone is displaced about 300 feet (90 m) north of its real position. In the top diagram the telluric contours indicate a narrow conductor which appears to have its highest concentration at considerable depth, due to the 8 Hz low at station 12+00N.

DISCUSSION AND CONCLUSIONS

Detailed geological and geochemical studies of the Iso orebody have shown it to be fundamentally different from the conventional Rouyn-Noranda type deposit, both in its original deposition and subsequent alteration.

The lack of magnetic signature associated with the Iso orebody is due to the absence of pyrrhotite and magnetite, whereas for the New Insco orebody, the magnetic anomaly correlates closely with the richest section of the ore zone. Presumably this is due to the presence of massive pyrrhotite in the orebody.

The insignificant SP response over the Iso ore zone may be due to the conductive clay overburden or, more likely, the high Zn (sphalerite) content of the ore, particularly in the shallow portion. Correlation between SP and basal-till Cu values is excellent at New Insco on Lines 2+00E, 3+00E and 4+00E but not on Line 1+00E: between basal-till and soil geochemistry the correlation is only fair.

The EM-25 moving transmitter field system produced a highly interesting pseudo-depth section at Iso, while the IP survey results were fairly conventional. The MT survey, however, did not provide particularly good data, probably because of noisy signals.

The New Insco orebody is a poor target for IP, unless one were to use an abnormally small electrode spacing. Whether the IP anomalies on Lines 4+00E, 6+00E and 8+00E (the last two have not been included here) reflect appreciable disseminated mineralization is not known, since no drill data were available. The persistence of the broad gravity high to the east reinforces the IP results.

Variable spacing HLEM data are better at Iso than at New Insco because of the larger dimensions (particularly strike length) of the former. The New Insco deposit is something of a problem for interpretation by conventional electrical methods.

In general the wealth of geochemical and geophysical information provided by these studies supports the evidence obtained from pattern drilling of both the Iso and New Insco orebodies with regard to their geometry and to some extent their physical characteristics. That is to say, they are excellent targets for a variety of geophysical and geochemical survey techniques.

ACKNOWLEDGMENTS

We wish to thank all those who contributed survey data and other pertinent information to make this case history possible, including G.F. Archibald, J.E. Betz, Bondar Clegg & Co., D.C. Fraser, Geophysical Engineering Limited, R.D. Hutchinson, McPhar Geophysics, New Insco Mines, Noranda Exploration Ltd., J.E. Riddell, Salamis & Associates, SOQUEM, and Terraquest Surveys Ltd. The Mineral Exploration Research Institute (IREM/MERI) of Montreal financed the compilation through a grant from the Department of Energy, Mines and Resources, Ottawa.

REFERENCES

Betz, J.E.
1973-4: Test program of continuously portable EM systems; Profiles -- copyright 1973, text -- copyright 1974.

Fountain, D.K. and Fraser, D.C.
1973: Geophysical analysis of the Magusi River sulphide deposit; 43rd Annual Meeting, Soc. Explor. Geophys., Mexico City, October 1973 (Abs.).

Fraser, D.C.
1969: Contouring of VLF EM data; Geophysics, v. 34, no. 6, p. 958-967.

1972: A new multicoil aerial electromagnetic prospecting system; Geophysics, v. 37, no. 3, p. 518-537.

1974: Survey experience with the Dighem airborne EM system; Can. Inst. Min. Met. Bull., v. 67, no. 744, p. 97-103.

Hales, F.W.
1958: An accurate graphical method for interpreting seismic refraction lines; Geophys. Prosp., v. 6, no. 3, p. 285-314.

Johnson, A.E.
1966: Mineralogy and textural relationships in the Lake Dufault Ore, Northwest Quebec; Ph.D. Thesis, Univ. Western Ontario.

Lazenby, P.G.
1973: New development in the Input airborne EM system; Can. Inst. Min. Met. Bull., v. 66, no. 732, p. 96-104.

Paterson, N.R.
1973: Some problems in the application of ELF-EM in high conductivity areas; Symp. on EM Explor. Methods, KEGS-Univ. of Toronto, May 1973, Paper 28.

Roscoe, S.M.
1965: Geochemical and isotopic studies, Noranda and Mattagami areas; Can. Inst. Min. Met. Bull., v. 58, p. 965-971.

Spence, C.J.
1966: Volcanogenetic setting of the Vauze base metal deposit, Noranda District, Quebec; 68th Ann. Meet., Can. Inst. Min. Met., April 1966 (Abs.).

West, G.F.
1973: Some effects to look for in EM interpretation; Symp. on EM Explor. Methods, KEGS-Univ. of Toronto, May 1973, Paper 25.