29.

IZOK LAKE DEPOSIT, NORTHWEST TERRITORIES, CANADA: A GEOPHYSICAL CASE HISTORY

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Podolsky, G. and Slankis, J.A., Izok Lake deposit, Northwest Territories, Canada: A geophysical case history; in Geophysics and Geochemistry in the Search for Metallic Ores; Peter J. Hood, editor; Geological Survey of Canada, Economic Geology Report 31, p. 641-652, 1979.

Abstract

An exploration program in the Northwest Territories was begun by Texasgulf Inc. in 1971. The first encouraging results were found a year later in an area about 250 miles (400 km) north of Yellowknife. The field program, consisting of geological reconnaissance, airborne geophysics, intensive ground follow-up and drilling, resulted in the discovery of two small, high-grade massive sulphide deposits in an area just east of the southern end of Takiyuak Lake. Both these deposits had associated airborne EM anomalies.

Attention from this initial success was temporarily diverted by the investigation of gossan zones, often containing high-grade mineralization, which did not respond to electrical methods. By 1974, interest had shifted some 30 miles (48 km) to the south, where a mineralized showing and high-grade sphalerite boulders had been found on the shores of a small lake, subsequently named Izok Lake.

In the spring of 1975, a ground VLF EM survey over the lake ice detected a conductor, not far from the high-grade float. Subsequent drilling through the spring of 1977 established a high-grade, massive Zn-Cu-Pb-Ag sulphide body in excess of 12 million tons, the Izok Lake deposit. In addition to obtaining a very good picture of the deposit from geophysical work, the Izok Lake massive sulphide body has been used as a test case for several field techniques including the newly developed UTEM system.

Texasgulf's exploration program in the Northwest Territories commenced with the standard approach of geologic reconnaissance followed by airborne geophysics and then by ground surveys using conventional geophysical methods. In the six years culminating in 1976, many different geophysical methods were tried and some were found to be particularly suited to conditions prevailing in the Territories. Due to the relatively thin overburden and high resistivity of the country rock, electrical surveys often approximated the idealized case. Magnetic and gravity surveys also gave good results, but in all cases a thorough appreciation of the underlying geology was necessary to avoid an erroneous interpretation.

Résumé

La Texasgulf Inc. a entrepris en 1971, un programme d'exploration dans les territoires du Nord-Ouest. Elle a obtenu les premiers résultats encourageants une année plus tard, dans une zone située à environ 250 milles au nord de Yellowknife. Le programme d'exploration, qui consistait en une reconnaissance géologique supplémentaire, en levés géophysiques aériens, en travaux ultérieurs détaillés au sol, et en forages, a permis de découvrir deux petits gîtes sulfureux massifs, de teneur élevée, dans un secteur situé immédiatement à l'est de l'extrémité sud du lac Takiyuak. Ces deux gîtes ont été caractérisés par des anomalies EM décelées par levé aéroportée.

Lors de l'inspection de zones de chapeau de fer (gossan), souvent caractérisées par une minéralisation de teneur élevée, ou qui ne donnaient pas de réponses lors de l'utilisation de méthodes électriques, on a laissé de côté ce succès initial. En 1974, le centre d'intérêt s'est déplacé vers 30 milles au sud, où des indices de minéralisation et des blocs riches en sphalérite ont été observés sur les rives d'un petit lac.

Au printemps 1975, un levé EM-VLF au sol effectué au-dessus du lac englacé a permis de déceler un conducteur, non loin des débris minéralisés de forte teneur. Par la suite, des forages effectués pendant le printemps 1977 ont révélé la présence d'un corps sulfureux massif de teneur élevée, d'une capacité supérieure à 12 millions de tonnes, le gisement du lac Izok. Non seulement les travaux géophysiques ont donné une image très précise du corps sulfureux massif du lac Izok, mais encore, celui-ci a servi de cas-type, pour la mise à l'épreuve de plusieurs techniques d'exploration sur le terrain, en particulier le nouveau système UTEM!

Le programme d'exploration de la Texasgulf dans les territoires du Nord-Ouest a commencé par la méthode habituelle de reconnaissance géologique, suivie de levés géophysiques aéroportées, puis de levés au sol par des méthodes géophysiques conventionnelles. Pendant les six années précédant 1977, on a essayé diverses méthodes géophysiques, et constaté que certaines d'entre elles étaient particulièrement bien adaptées aux conditions régnant dans les territoires du

Nord-Ouest. En raison de la minceur relative des terrains de couverture, et de la résistivité élevée de la roche encaissante, les résultats qu'ont donnés les levés électriques se sont souvent rapprochés du cas idéal. Des levés magnétiques et gravimétriques ont aussi donné de bons résultats, mais dans tous les cas, il a été nécessaire de faire une évaluation approfondie des conditions géologiques.

INITIAL DISCOVERIES – TAKIYUAK LAKE REGION

A geological reconnaissance of the southeastern area of Takiyuak Lake, some 250 miles (400 km) north of Yellowknife (Fig. 29.1) was initiated by Texasgulf Inc. in 1971. The program concentrated on mapping and sampling gossan or stain zones over an area previously depicted as metasediments on published maps, but reinterpreted as metavolcanics by Texasgulf geologists. An airborne EM survey was flown early in 1973 and produced numerous EM anomalies, some of which even corresponded to a few of the sampled gossans. However, the gossan yielding the best assays resulted in a one line EM anomaly at only twice the background response. Subsequent ground geophysical surveys gave a more complete picture of this anomaly designated as Hood River (H.R.) 10, showing it to be due to a complex, narrow, Y-shaped sulphide body of limited length. The work included VLF EM, magnetic, horizontal-loop EM at three coil spacings, and gravity surveys (Fig. 29.2a-d). Of note is the excellent correlation between all the geophysical data. The magnetic response proved to be characteristic of the stronger sulphide conductors encountered. Estimated tonnage is less than 1 000 000 tons, but the grade is high.

The first truly geophysical success, designated as H.R. 41, proved to be an even smaller sulphide body which, nevertheless, produced an airborne EM response similar to that of H.R. 10. The correlation between the various sets of geophysical (Fig. 29.3a, b) is not as good, probably due to the presence of a granite intrusive.

By the summer of 1974, after having tested a number of other barren conductors, more attention was devoted to mineralized zones which did not respond to airborne EM, ground EM, or even VLF EM methods. One typical example, H.R. 46, is just north of H.R. 10. Here, grab samples from scattered surface gossans assayed at better than 2 per cent combined copper-zinc. Magnetic and horizontal-loop EM surveys showed nothing and a VLF EM survey produced only minor crossovers (i.e. 4° peak to peak). However, gradient IP surveys (Fig. 29.4a), in which surprisingly no problems were encountered in getting sufficient current into the ground, produced chargeability and resistivity anomalies that corresponded to a zone of minor, but interesting mineralization. A telluric survey (Fig. 29.4b) using a Texasgulf-built receiver operating at 8, 145, and 5000 Hz, showed comparable apparent resistivity profiles. Only small differences existed between the 5000 Hz and 8 Hz responses so, for clarity, only the latter is shown in Figure 29.4b. With little or no overburden and high host rock resistivities, it was apparent that resistivity profiling at VLF frequencies would be a practical exploration technique.

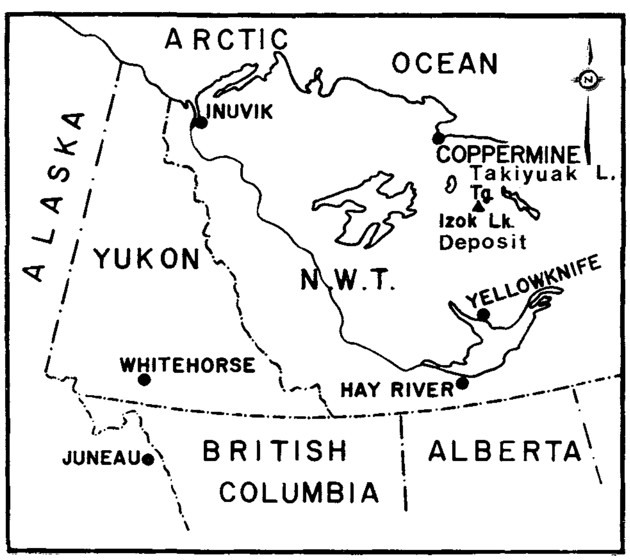


Figure 29.1. *Map showing location of Takiyuak Lake area and the Izok Lake deposit, Northwest Territories.*

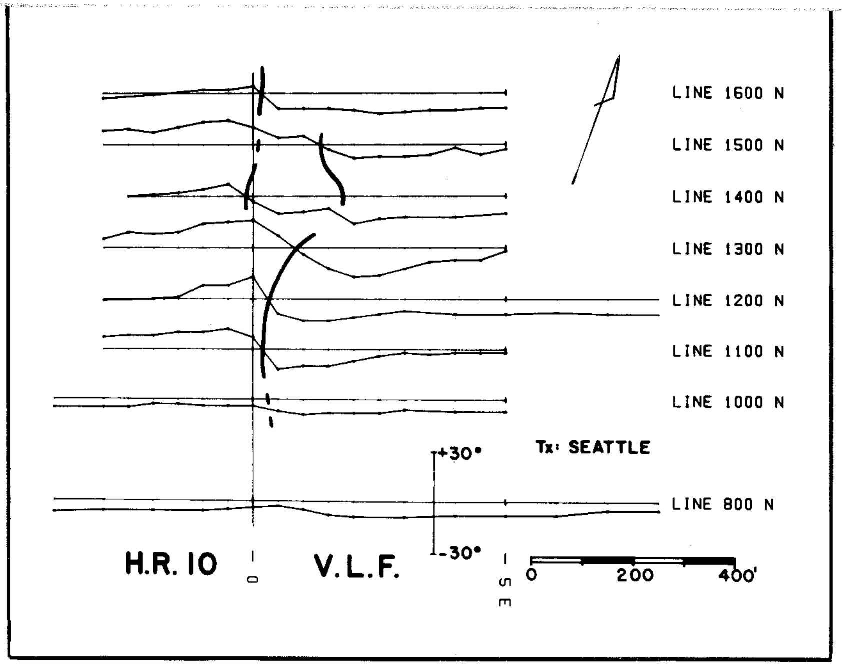
Farther to the west, the VLF EM technique (Fig. 29.5a) was utilized to outline a long, apparently narrow northeasterly trending conductor (anomaly H.R. 462) which occurred along a geological contact zone. The horizontal-loop EM responses were not encouraging and were complicated by topography. Magnetic surveys confirmed the trend, but showed no anomaly over the conductor. A drillhole at 65W on line 26S penetrated a short section of high-grade, stringer copper mineralization, but additional holes in the immediate area were disappointing. A subsequent VLF EM resistivity survey (Fig. 29.5b) probably gave the best picture of sulphide distribution along this conductor.

Up to this time, little more than technical success had been obtained. It was obvious that massive sulphides were to be found in the area, but they tended to be small and were generally poor EM targets (except for EM systems capable of high definition). The examples discussed might have merited greater priority had they been within several miles of an operating mine, but the fact they were discovered at all, and followed up with drilling, is due largely to the geological control afforded by the extensive outcrop.

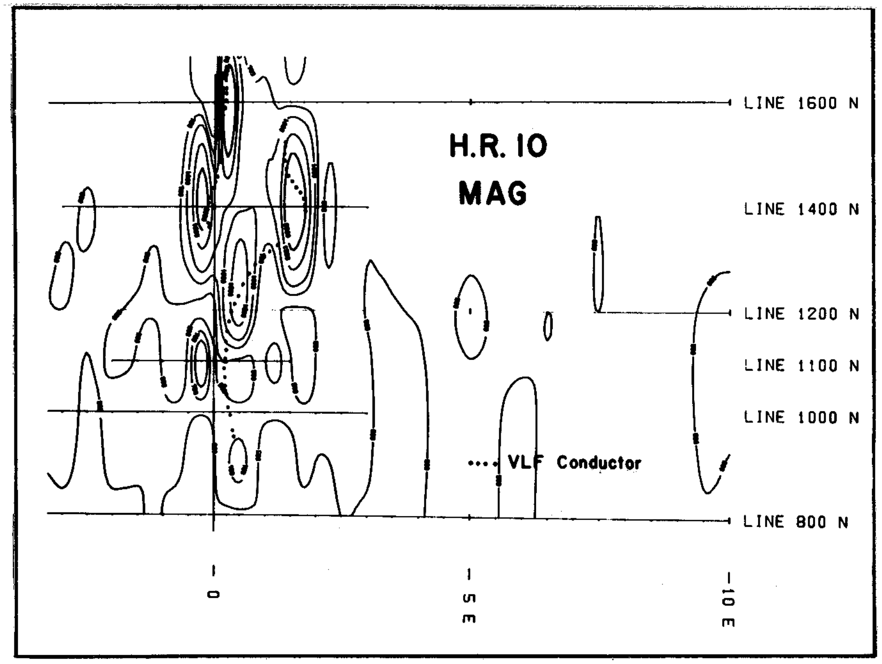
It was considered that the rather low apparent conductivity of the sulphide systems was due to their small size, the high metamorphic grade of the country rock, and its consequent high resistivity. The VLF EM technique proved to be very effective as a reconnaissance tool, but could not be relied upon for consistent data (in a qualitative sense). Also, magnetic anomalies correlated well with the more massive sulphide occurrences, but not with stringer mineralization. Up to the fall of 1974, all geophysical survey work had been carried out in the summer.

IZOK LAKE DEPOSIT, NORTHWEST TERRITORIES

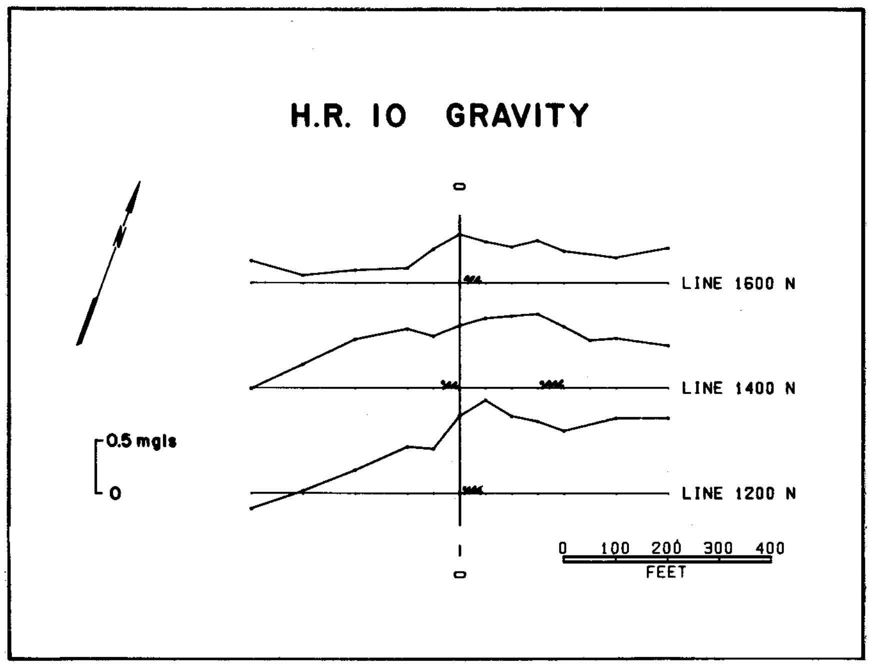
Fortunately, while the geophysical crews were involved in follow-up work, the geologists carried out a reconnaissance mapping, sampling, and staking program. These endeavours resulted in interest being focused on an area about 30 miles (48 km) south of Hood River. In the course of staking claims around one of the weakly mineralized showings, a geologist and his assistant located high-grade sphalerite boulders on the shore of what subsequently became known as Izok Lake. The size and distribution of these boulders and their grade of mineralization suggested that the source had to be either beneath, or in the immediate vicinity of the lake. With this indication of the presence of mineralization and other encouraging geological evidence, an airborne EM survey using the Kenting in-phase/out-of-phase vertical coaxial system operating at a frequency of 390 Hz was planned for the spring of 1975 to be complemented by ground follow-up, prior to break-up, of all targets not entirely on land.



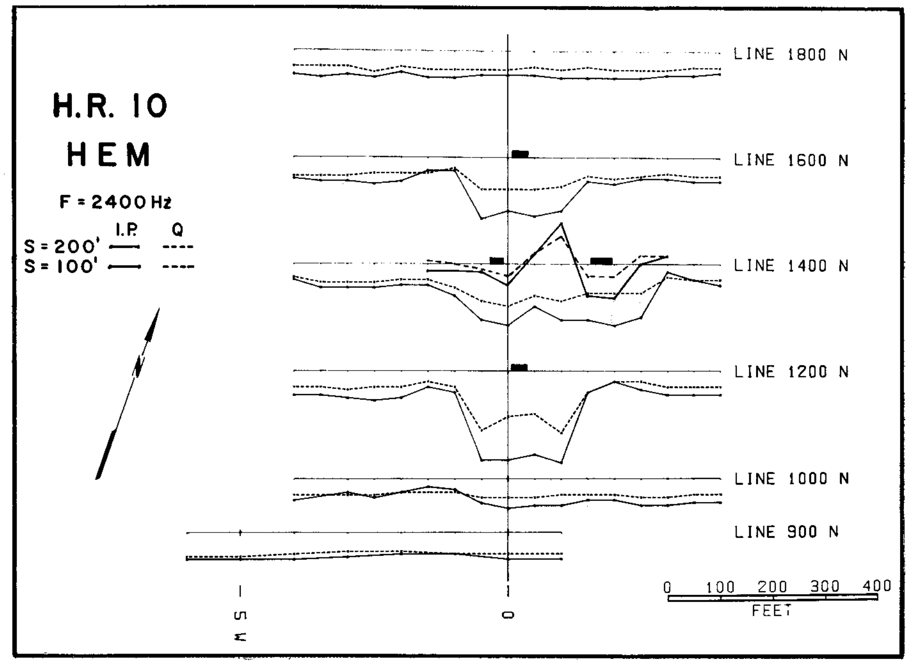
a. *VLF EM Survey.*



b. *Magnetic Survey.*

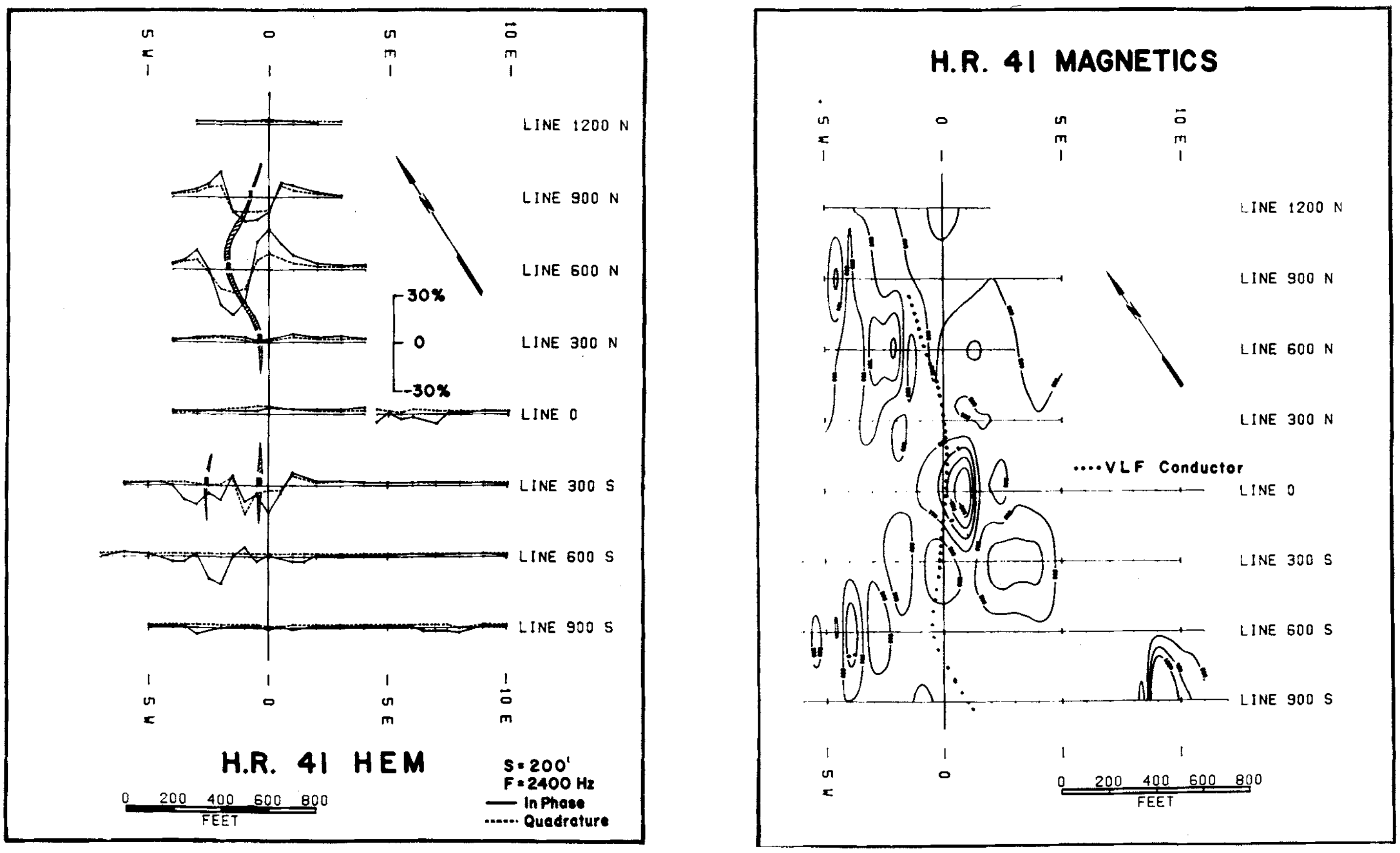


c. *Gravity Survey.*



d. *Horizontal-Loop EM Survey.*

Figure 29.2. *Ground geophysical surveys carried out on the Hood River 10 Anomaly.*



a. *Horizontal-Loop EM Survey.* b. *Magnetic Survey.*

Figure 29.3. *Ground geophysical surveys carried out on the Hood River 41 Anomaly.*

1975 Geophysical Surveys

The first area to be ground checked in 1975 was the possible eastward extension onto Izok Lake of an onshore zone of weak mineralization opposite the area of the high-grade boulders. This resulted in the detection of a very strong VLF EM conductor towards the middle of the lake, but well beyond any apparent extension of the conductor previously located on shore. A grid was then laid out across the lake ice and surveyed by a number of geophysical methods including VLF EM, the Geonics EM-16R VLF resistivity system, horizontal-loop EM at 100 and 200 foot (30 and 61 m) spacings, and fluxgate magnetometer. The work was curtailed by deteriorating lake ice conditions and the need to cover other areas, but only after enough data had been obtained to outline a drill target. On May 27, 1975 from the first drill location spotted at 6 + 50S, line 22E on the grid, the discovery of the Izok Lake orebody was established with the intersection of about 20 feet (6 m) of 14 per cent zinc. Ironically, the airborne EM program, hampered by bad weather and by snow cover which persisted longer than anticipated, did not cover the area of Izok Lake until the third hole was in progress. Of the major massive sulphide volcanogenic deposits discovered in the Archean of North America since the mid-fifties, Izok Lake can be said to be an exception in that it was not located as a direct result of the follow-up of an airborne EM survey. It missed this classification by two weeks.

VLF EM Survey

The VLF EM survey (Fig. 29.6a), using the Seattle transmitter (NPG 18.6 kHz), detected what appeared to be two major conductors running parallel to one another generally south of the base line. Two other minor conductive zones were also mapped approximately 800 and 1200 feet (240 and 370 m) south of the base line. Vertical field strengths as well as dip angles were recorded. Figure 29.6a shows essentially the interpretation made in the field. The open circles indicate weak conductors, generally from minor inflections.

Of the conductors shown, only the southernmost extends onto the mainland; the others, apart from the portions crossing two small islands, are entirely under water. Note that a weak conductor has been indicated (by open circles) starting at 9 + 00N on line 16E and ending at approximately 16 + 00N on 28E. Apart from the latter and the crossover at 2 + 50S on 8E, all the conductor trends shown on this map are due to sulphide mineralization. These conductors eventually became identified as the Main or Central Zone, North Zone, South Zone, and Northwest Zone (Fig. 29.6b).

VLF Resistivity Survey

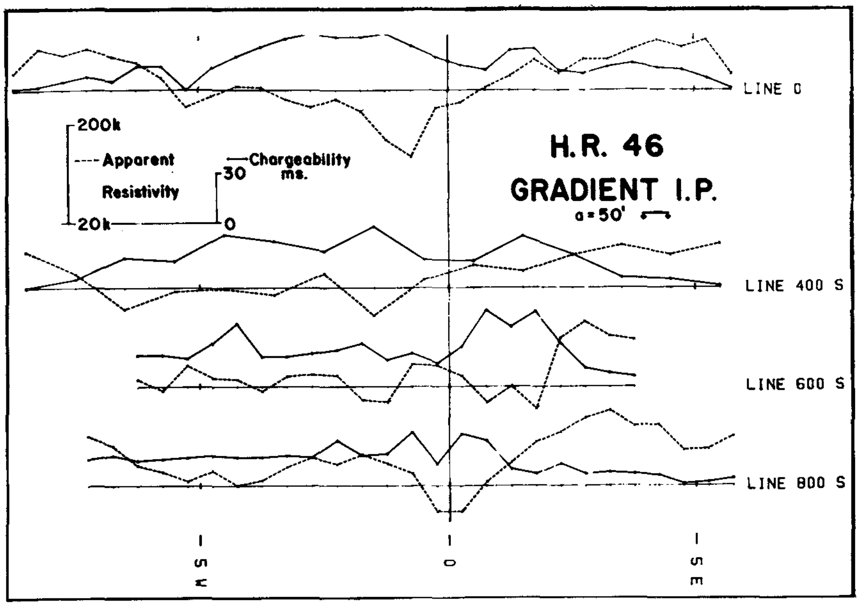
This was the first time that the Geonics EM-16R system was utilized by Texasgulf and this might not have occurred under normal circumstances. Fortunately, the survey was carried out by a graduate student who used the technique as part of his thesis work. Although considerable success had been attained in prior years with low frequency telluric surveys, it was felt that the unit utilized had an input impedance too low to get results over the lake ice. The input impedance of the EM-16R is rated at 100 megohms.

Measurements were made of both resistivity and phase-angle over a limited portion of the grid. The results (Fig. 29.7a, b) show a pattern similar in configuration to the

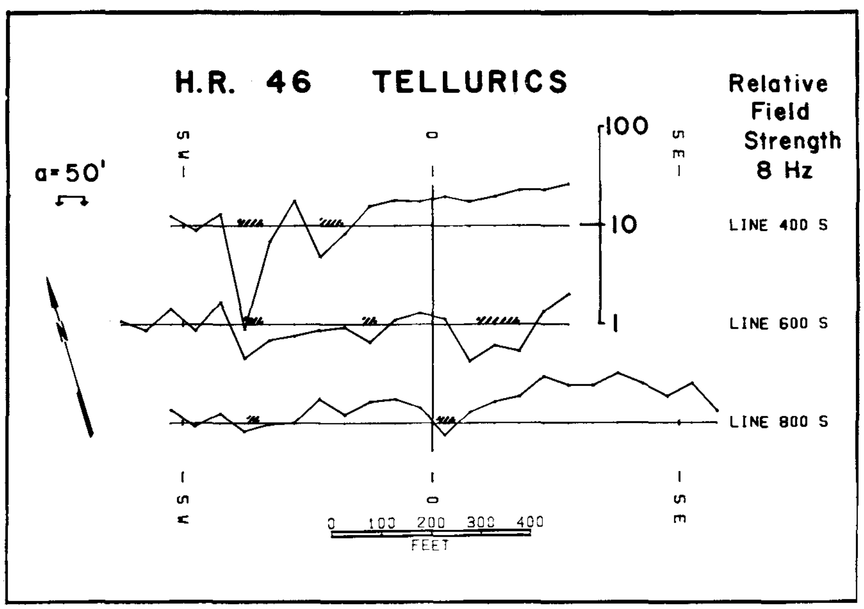
VLF EM survey. The Central and North Zones, particularly the Central Zone, now show appreciable width and continuity. From this data, the Northwest Zone appears to be a separate entity.

The resistivity anomalies are quite sharp and well defined. Average background resistivities appear to be around 2000 ohm-m, but vary throughout from about 1500 to 6000 ohm-m. The lower figure probably represents a water resistivity although this measurement was never actually made.

Anomalous resistivities are as low as 2 ohm-m. The hachured area in Figure 29.7a includes zones having 50 ohm-m resistivity or less. The reader should note that in all cases, apart from the South Zone where resistivities equal 500 ohm-m or greater, the phase angle remains high (i.e. 45°) over the entire span of the 500 ohm contour. This feature assumed increasing significance, though for a time the anomaly was ascribed to the presence of lake bottom sediments. As it happened, this method resulted in the production of one of the better maps of the deeply buried sulphides.



a. *Gradient Array IP Survey.*



b. *Telluric Survey – 8 Hz.*

Figure 29.4. *Ground geophysical surveys carried out on the Hood River 46 Anomaly.*

Horizontal-Loop EM Survey

The grid was next surveyed with a horizontal-loop EM unit using a coil spacing of 200 feet (61 m) and frequency of 2400 Hz. The most encouraging aspect of this survey was that it not only indicated very high conductivity for the North and Central Zones, but also showed substantial widths to each zone, especially on lines 22E on the Central Zone and 26E on the North Zone. The Central Zone appears to lack the continuity established by the VLF EM data at both east and west ends whereas the North Zone shows up as a minor conductor of fairly high In-phase Quadrature ratio.

To check the continuity and apparent widths of the strong conductors, a portion of the grid was resurveyed with a 100 foot (30 cm) coil separation. The resultant data provided greater definition, but essentially confirmed the 200 foot (61 m) work (see 1975 compilation-Fig. 29.8a).

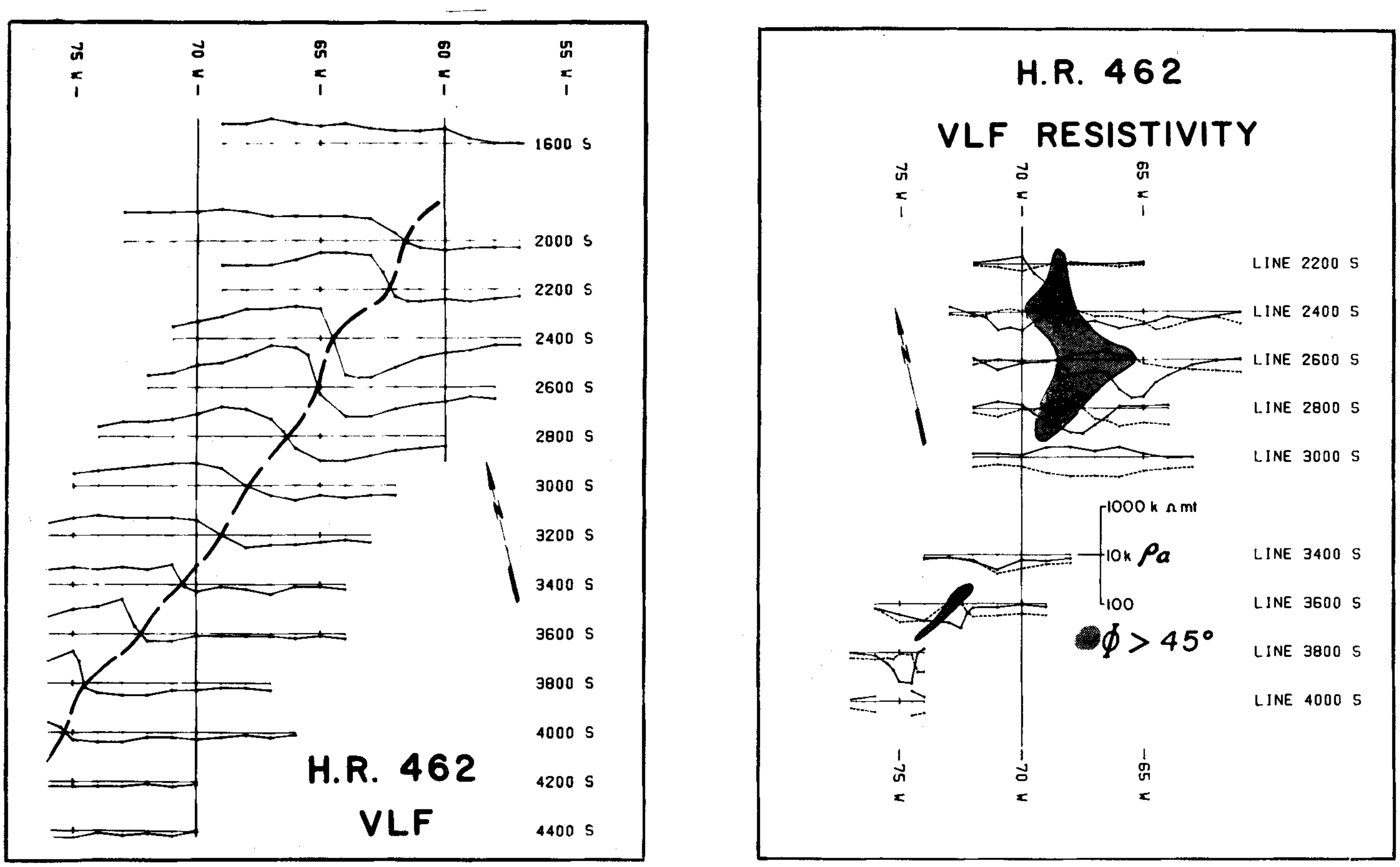
On the basis of the data from these surveys, the geophysicist on the project located the first hole at 6 + 50S on line 22E to drill at -60° to the north.

Magnetic Surveys

The 1975 magnetic survey was done with a vertical field fluxgate magnetometer. Previous experience with the small sulphide bodies to the north indicated that appreciable percentages of magnetite and/or pyrrhotite could be expected to occur with ore grade sulphides.

Due to the pressure of time, and deteriorating ice conditions, magnetic survey coverage was quite erratic and generally not too satisfactory. A number of anomalies were recorded, but their full significance was not appreciated until a proper interpretation was made late in the summer. Figure 29.9a is actually a computer contour plot produced in 1976, but it corresponds closely with the final hand drawn version of the 1975 magnetic survey results. When the strong correlation between magnetic anomalies and sulphides became apparent, susceptibility measurements were obtained on the sulphide sections from several of the holes. This not only proved that magnetic susceptibilities, even within the massive sphalerites, were anomalously high throughout the sulphides, but showed a distinct variation in susceptibilities between the sulphide lenses comprising the Central Zone.

Several other anomalous areas were mapped apart from the Central Zone. The reader should note that no distinct magnetic anomaly was recorded for the North Zone although a narrow anomaly was traced out north of the base line. The anomaly to the northwest indicated a target somewhat deeper than the Central Zone and possibly larger in areal extent. The high readings along line 36E were thought to be the result of a mistie until it was noted that this corresponded to a narrow diabase dyke mapped on shore.



a. *VLF EM Survey.* b. *VLF Resistivity Survey.*

Figure 29.5. *Ground geophysical survey carried out on the Hood River 462 Anomaly.*

Airborne EM Survey

Despite the fact that the airborne EM survey was flown during the drilling program, the AEM results at least gave the assurance that the target had been fairly well delimited by the ground work. From previous experience at Hood River, there was some concern about the magnitude of the AEM anomaly that would be obtained, but the anomaly over the Izok Lake deposit was in excess of ten times background.

The airborne EM survey had originally been laid out to cover this particular area in two directions, an indication of the importance that was attached to this area and the complexity of the geology, and it is interesting to report that the stronger AEM responses were recorded on lines flown approximately parallel to the grid lines.

Although coincident airborne magnetic anomalies were recorded, the overall magnetic picture is dominated by the effect of a series of northwest-trending diabase dykes, one of which cuts the Izok Lake deposit at the east end.

Geology

A paper was published by P.L. Money and J.B. Heslop (1976) of the exploration staff of Texasgulf, which essentially dealt with the geology of the Central Zone. The data presented are applicable to the other zones with only minor changes in zinc-copper ratios.

In summary, the Izok Lake sulphide deposit is a fairly straightforward example of a volcanogenic copper-zinc-lead deposit. The rocks are highly metamorphosed and recrystallized, but what was formerly mapped as amphibolite is now considered to be a meta-andesite, the siliceous metasediments (i.e. gneisses) include felsic metavolcanics, and the hybrid "lit-par-lit" gneisses are a mixed metasedimentary-metavolcanic sequence intruded by numerous granitic bodies.

Drilling Program

By the end of the first week in June 1975, the drill had to be moved off the ice onto the southern island in the lake. Drilling continued into the summer on the Main Zone from the island as well as the South Zone from the south shore. At the conclusion of the summer season, approximately 7 million tons of high-grade copper, zinc, lead, and silver mineralization had been indicated. Most of the North Zone remained untested and the anomaly to the northwest had not been touched.

Despite the extremely encouraging results and the remarkable correlation between some of the geophysical work and the drill data, it was felt that more geophysical survey coverage, particularly ground electromagnetic surveys to obtain greater depth penetration than could be obtained from a 200 foot (61 m) horizontal-loop EM survey, was needed. Magnetic survey coverage was neither uniform nor consistent and with the correlation that had been obtained between massive sulphides and magnetic survey results, it was felt that a higher order of accuracy would provide a greater potential to detect sulphides at depth. Accordingly, a very comprehensive program of EM, magnetic, gravity, and some experimental surveys (mise-à-la-masse) was planned and carried out during the spring of 1976 prior to a second phase of diamond drilling.

Contents

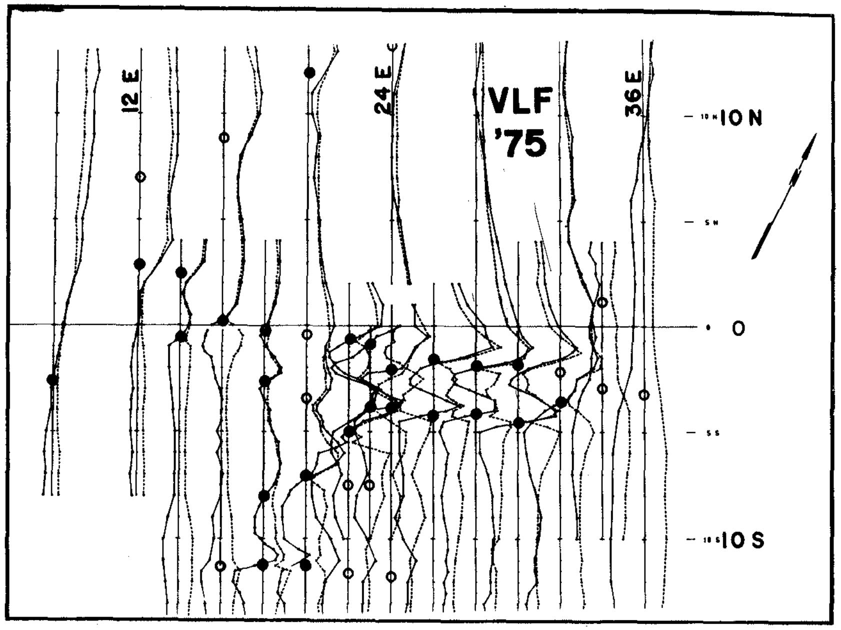


Figure 29.6a. *1975 VLF EM survey of Izok Lake using the Seattle (NPG) transmitter.*

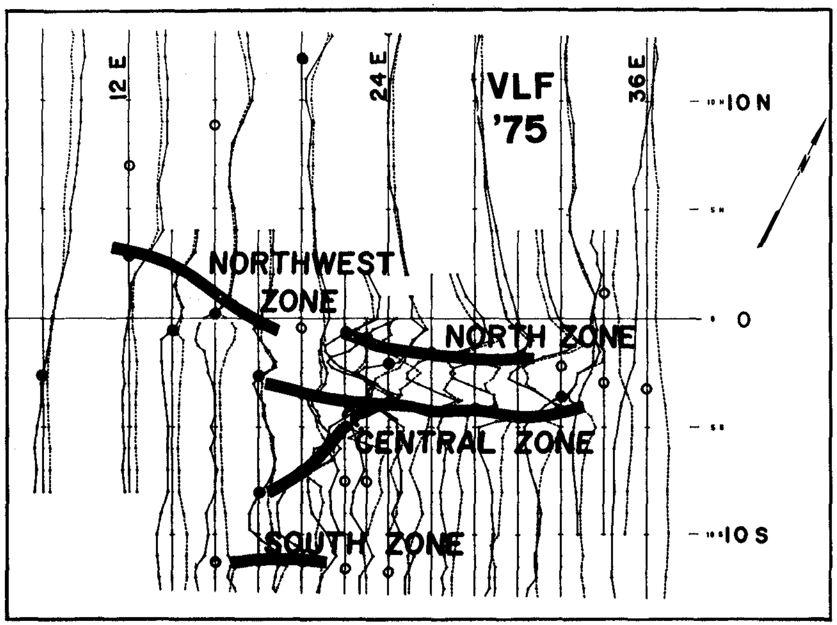
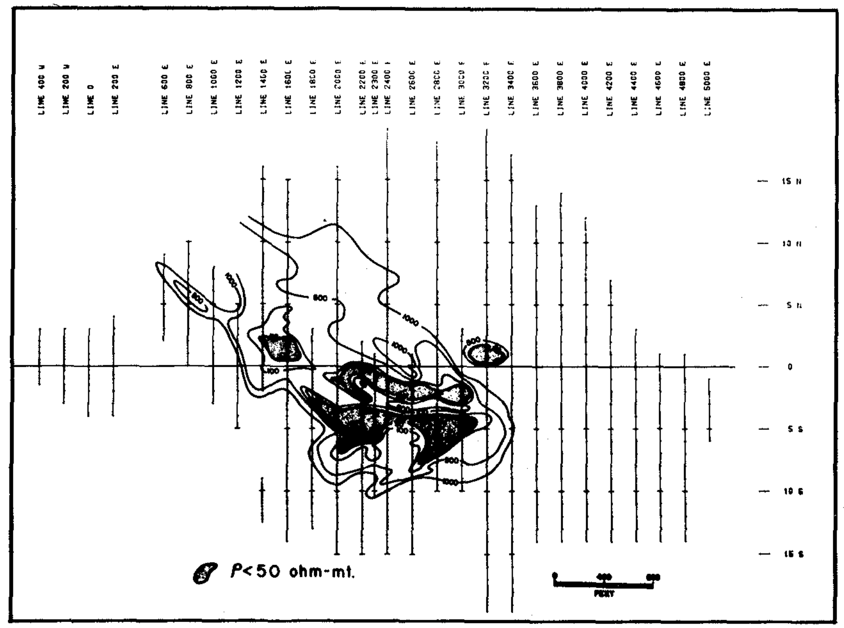
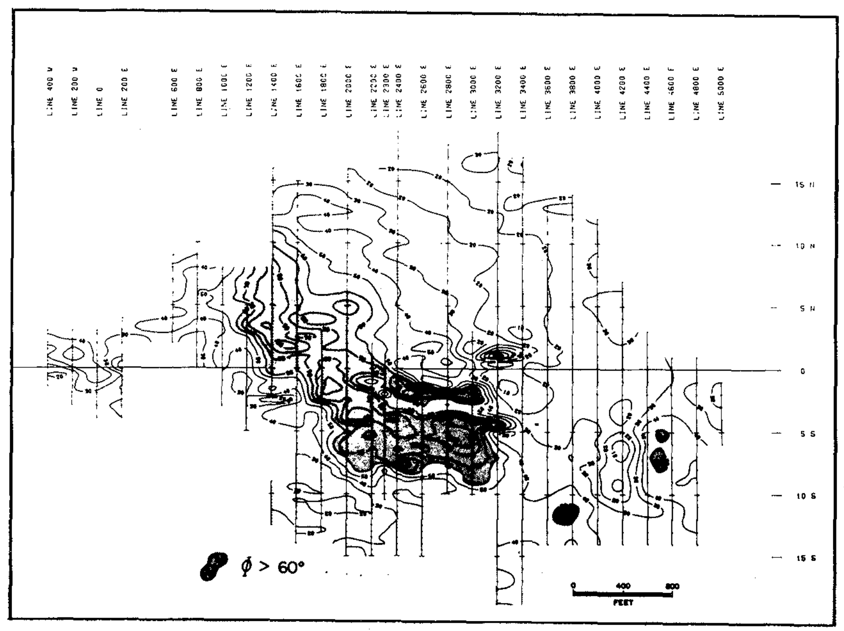


Figure 29.6b. *Same VLF EM results as Fig. 6a but showing principal conductive zones. Open and solid circles are poor and good conductors respectively.*

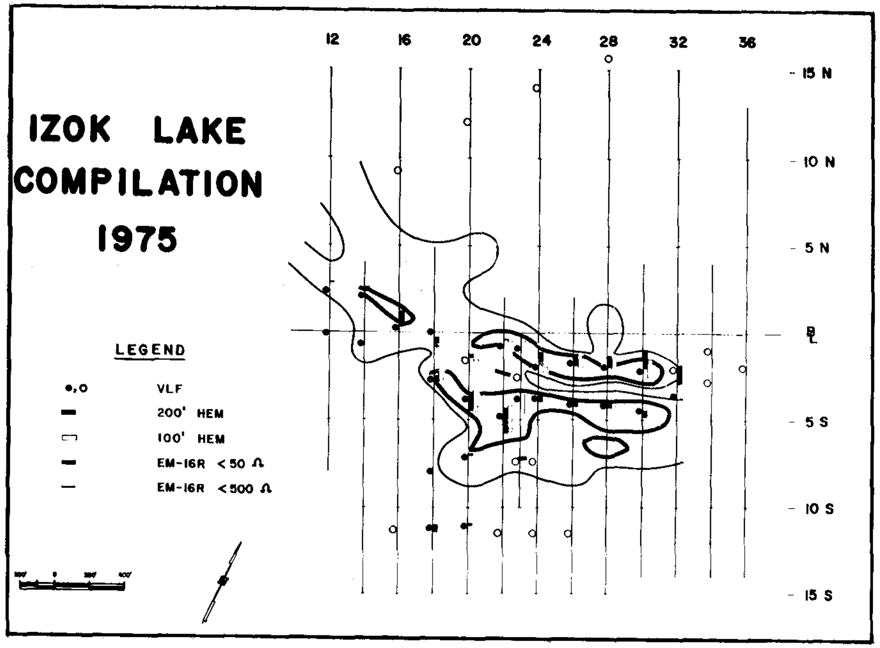


a. Apparent resistivity contours.

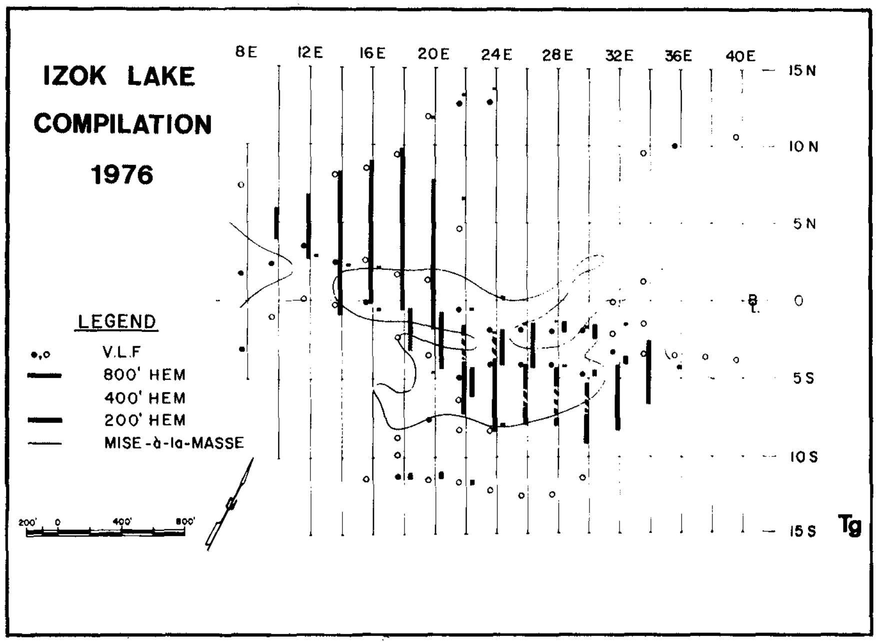


b. Phase angle contours.

Figure 29.7. *VLF resistivity survey of Izok Lake, NWT.*

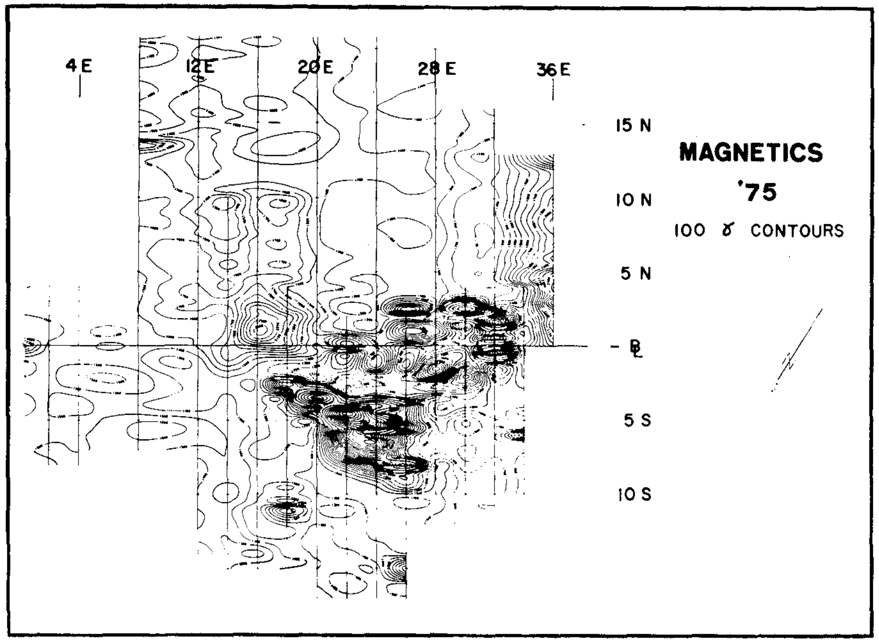


a. 1975 Compilation.

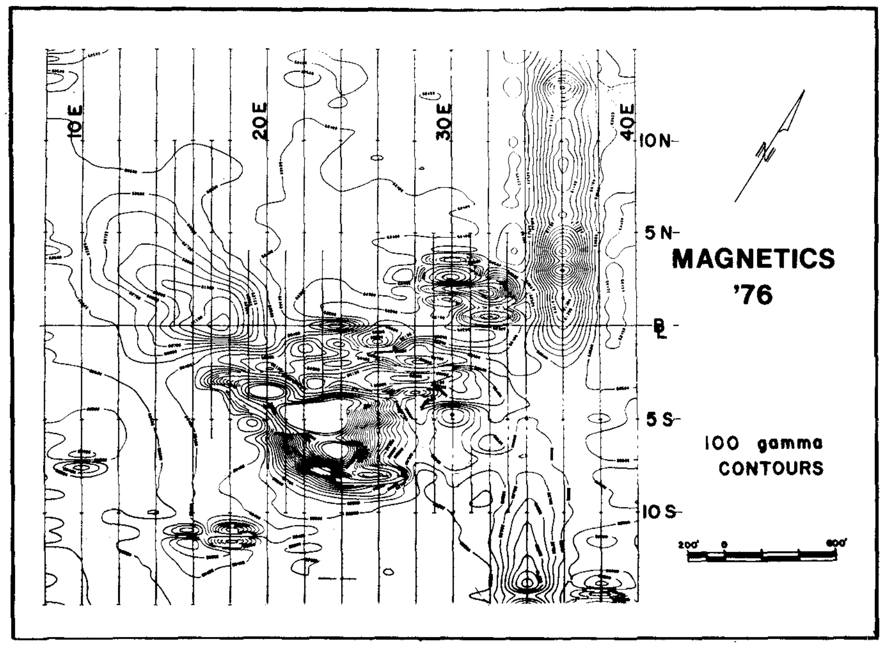


b. 1976 Compilation.

Figure 29.8. *Electrical surveys of Izok Lake, NWT.*



a. 1975 Survey.



b. 1976 Survey.

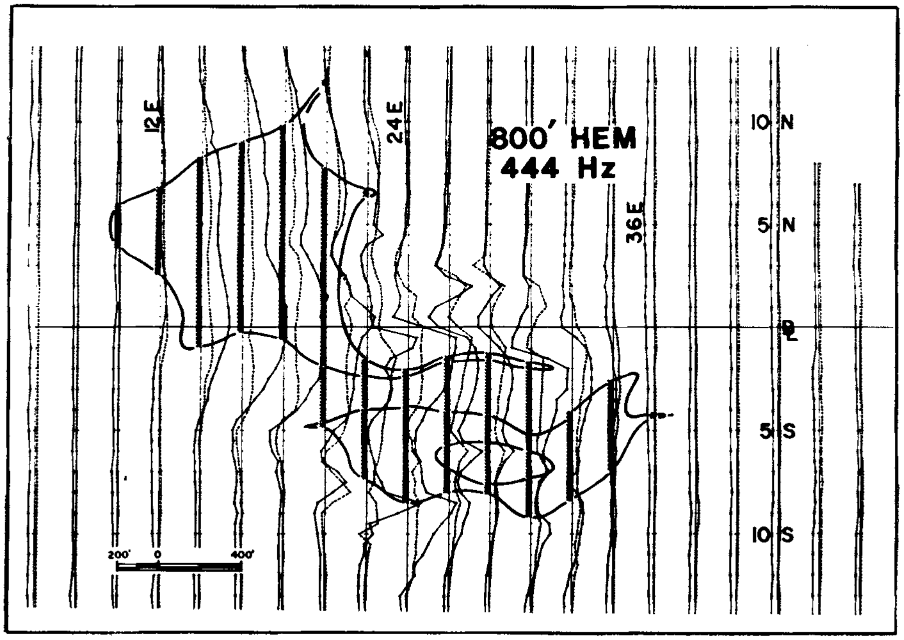
Figure 29.9. *Magnetic surveys of Izok Lake, NWT.*

Contents

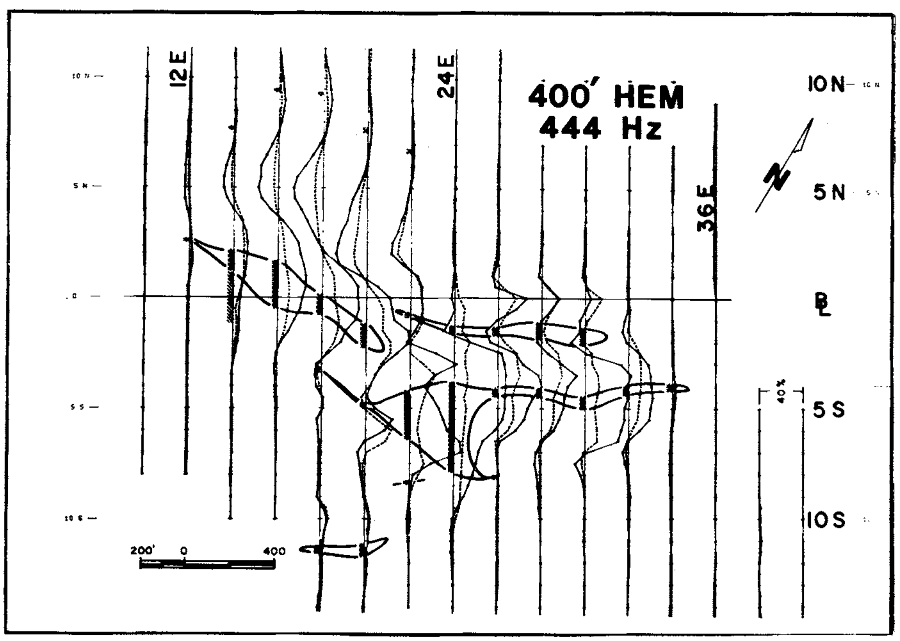
1976 EXPLORATION PROGRAM

The 1976 exploration program was quite unusual in that there had been time to digest all the results from 1975, to evaluate the geological and geophysical parameters, and to take a second approach to the project. The work, therefore, benefitted from more planning, more people, a greater redundancy of equipment, and more time allotted for the program.

The actual field work began in mid-March 1976 with the re-establishment of the survey grid from the previous year. The field work was scheduled so that the priority geophysical surveys, that is the 400 foot (122 m) 800 foot (244 m) horizontal-loop EM, gravity and magnetic surveys were carried out by mid-April 1976, before the resumption of drilling. By early May, the program had been essentially completed, including the drilling of about 700 holes through the six-foot (1.8 m) thick ice to measure the water depths and to spot electrodes from ice surface to lake bottom at each point.



a. 1976 survey using 800 foot (244 m) coil spacing.



b. 1976 survey using 400 foot (122 m) coil spacing.

Figure 29.10. *Horizontal-Loop EM survey of Izok Lake, NWT.*

Horizontal-Loop EM Surveys (see 1976 compilation Fig. 8b)

In the initial review of the results of the 1976 horizontal-loop EM work, two aspects of the data were considered significant. First of all, although this was admittedly viewed with the clearer vision of hindsight, it was felt that the combination of 200, 400, and 800 foot (61, 122 and 244 m) coverage would have permitted a better understanding of the Central Zone sulphides had this work been carried out in 1975. More importantly, the similarities in the data, allowing for differences in amplitudes, for the Central Zone and Northwest Zone strongly indicated the presence of another sulphide body in the Northwest Zone of even greater areal extent than, and possibly of equal thickness to the Central Zone.

The differences in response between the 800 and 400 foot (244 and 122 m) curves (Fig. 29.10a, b) on lines 16E and 14E could only be accounted for by the occurrence of a relatively flat-lying body at a depth greater than 160 feet (50 m), but probably less than 240 feet (73 m). Furthermore, the response from shallow penetration geophysical methods indicated the presence of a sheet, which subcropped along its south margin, was relatively narrow along this margin, and dipped moderately (say 30-40°) to the north from the subcrop edge.

Considerably more horizontal-loop EM surveying of a detailed nature was done than can be presented in this paper. In general, the 1777 Hz response was stronger than that obtained at 444 Hz, but the two showed an identical pattern. It is debatable whether one may have interpreted this as evidence of a thin sheet response since this observation holds for even the thickest sulphides (e.g., section 24 E). A series of east-west profiles tended to suggest a northeasterly trend which was not borne out by the drilling. Based on the high shoulders for the profiles, a much deeper sulphide sheet had been postulated to the north of the base line, east of line 22E. Limited drilling has not confirmed this interpretation.

It was disappointing that the field work did not extend the Central Zone beyond 34E. One interesting facet to the 800 foot (244 m) horizontal-loop EM coverage is that the South Zone cannot be detected because of the coil spread used, body size, and depth extent. Perhaps the most startling fact brought out by this work was the remarkable correlation between the 800 foot (244 m) HEM and EM 16R data, particularly in reference to the 500 ohm-m resistivity contour. This is apparent from a comparison of the 1975 and 1976 compilations (Fig. 29.8a, b).

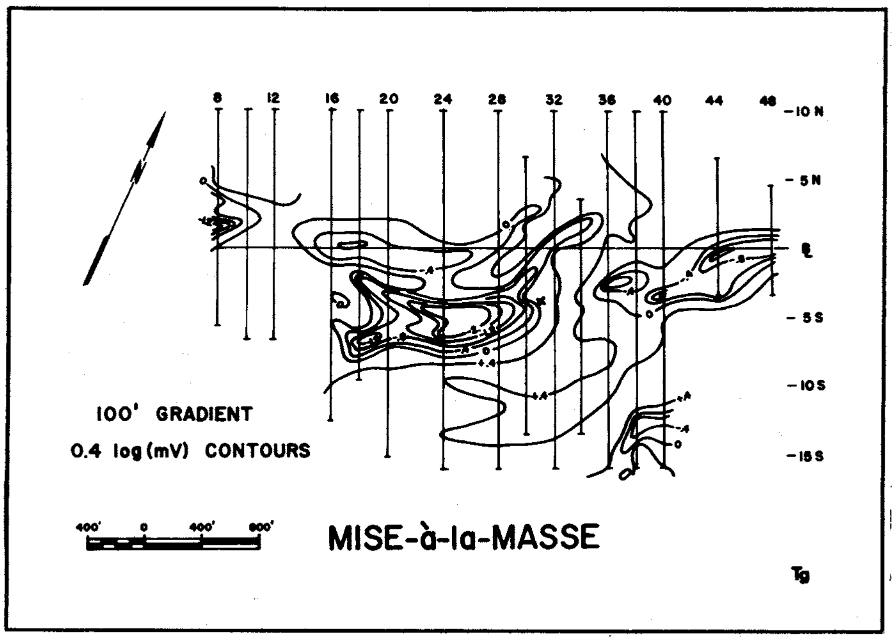


Figure 29.11. *Mise-à-la-masse survey of Izok Lake, NWT.*

1976 VLF EM Survey Results

The VLF EM survey was rerun in 1976 in an attempt to achieve more uniform and more extensive coverage. The 1975 and 1976 VLF EM results are almost identical, but additional weak anomalies were recorded off the east end of the Central Zone. The persistence of the anomalous trends appears to be more related to structure than to mineralization, but much remains to be done in correlating this information with the geology.

VLF Resistivity Survey

The 1975 VLF resistivity survey was filled in and expanded during 1976, but the new data did not improve the previous interpretation. It was gratifying to obtain a good correlation with repeated profiles over anomalous areas. The major change appeared to be a higher background resistivity due, probably to different ice conditions.

Gravity Survey

The gravity work enhanced the possibilities of mineralization being associated with the Northwest Zone. The free air data not only showed the two-lobed nature of the Central Zone, but also indicated a gravity high beneath the Northwest Zone. When one considered the greater depth to sulphides and the fact that water depths in this area were generally greater than 30 feet (9 m), it seemed that a total excess mass roughly equal to that of the Central Zone was present. It was subsequently found that the interpretation of the geophysical results was correct, but the geological inferences were presumptuous.

Magnetic Surveys

The 1976 ground magnetic survey (Fig. 29.9b) was designed to cover the entire grid over the lake as uniformly and intensively as possible. The results from the 1975 magnetic survey and susceptibility measurements on drill core were encouraging, and it was felt that magnetic surveys were probably the best and most sensitive tool to use to delineate the extent of known sulphides and detect new ones at depth. A proton magnetometer was used to achieve the high order of accuracy considered necessary.

After the second day of the survey, severe magnetic storms were detected with fluctuations exceeding 40 gammas over a period of two or three minutes and occurring at random intervals during a span of several hours. Thereafter, magnetic activity was monitored with a station magnetometer, and readings taken during magnetic storms were simply discarded.

Several factors are readily apparent in comparing the 1976 results to those obtained in 1975. There is no doubt about the existence of the diabase dyke at the east end of the grid. The apparent "gap" south of the base line was checked with traverses along 4S and 6S between lines 34 and 36E, and it was determined that the dyke had a true width of 25 feet (7.6 m) or less. The northwest magnetic anomaly is more regular in shape, and in fact, gives an excellent representation of the subsurface extent of the sulphides, probably better than the EM results. Again, there is little evidence of deeply buried sulphides to the east of line 34E, although more detailed work away from the influence of the diabase dyke might have shown some trends. The magnetic anomalies in the area of North Island (i.e., lines 28E to 34E, just north of the base line) were found to be due to magnetite stringers within the metavolcanics.

Mise-à-la-masse Survey

A mise-à-la-masse survey (Fig. 29.11) gave the same anomalous pattern as did the other electrical methods over the Central and North Zones, but the Northwest and South Zones were not as well defined. It is suspected that the latter response might have been improved by a better placement of the in-body current electrode, but only the drillholes that were available could be utilized. The operating frequency was 100 Hz and electrical contact to lake bottom was achieved by wires suspended from the surface ice. Measurements were made with General Radio wave analyzers with an input impedance of approximately 500 megohms.

The strong anomaly on line 8E, and the strong trend near the base line from 36E to 48E are probably due to weak, near-surface conductors of structural origin. Drilling in the vicinity of the northernmost anomaly on line 40E did not intersect mineralization. To the south, along the same line, a small disseminated sulphide lens was confirmed by the 1975 drilling program. It was noted during the survey that the induced response, that is, with the 100 foot (30 m) surface dipole not connected to the electrode wires, was about half the measured electrical potential. A similar phenomenon was noted during the VLF resistivity survey.

UTEM Survey

The University of Toronto EM system (UTEM) was tried in the spring of 1977, with excellent results. Figure 29.12a shows the overall interpretation and provides good definition of the Central and Northwest Zones as well as distinct UTEM anomalies for the North and South Zones. Line 12E is reproduced in Figure 29.12b to show the UTEM response over a deeper portion of the Northwest Zone. The interpreted depth of just over 300 feet (91 m) is shown in the small sketch above the profiles.

Contents

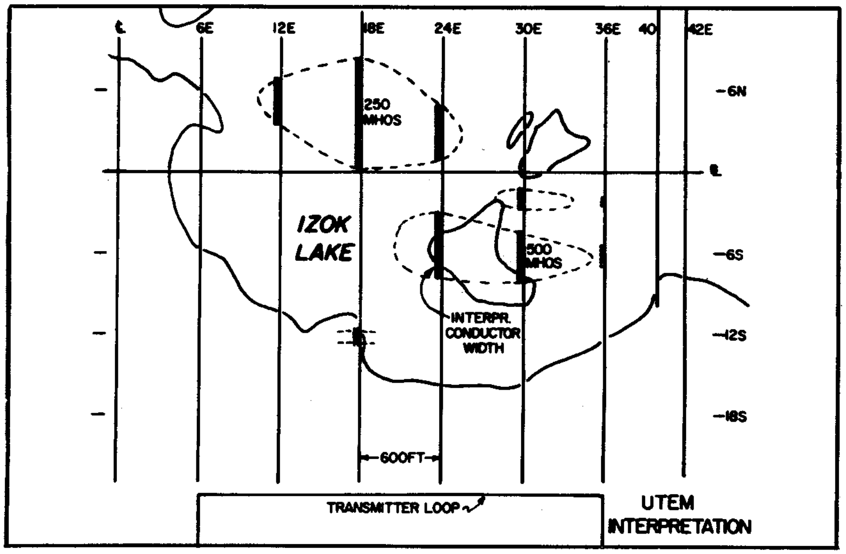
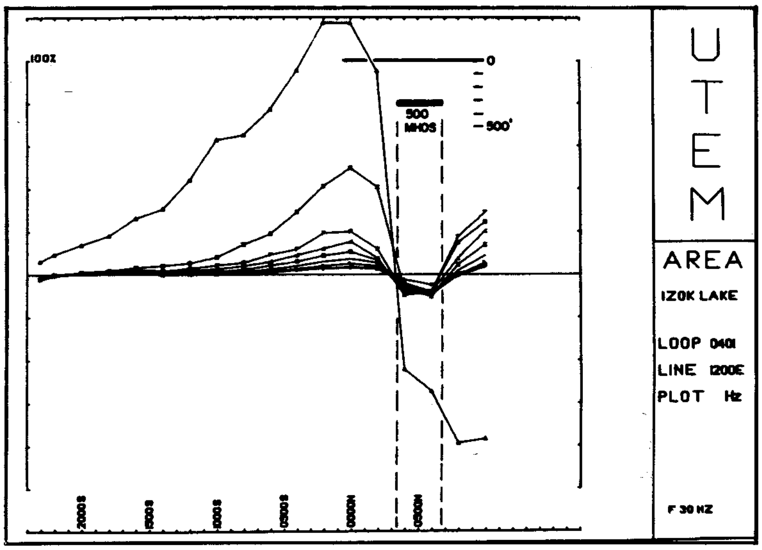


Figure 29.12.

1977 UTEM survey of Izok Lake, NWT.

a. Interpreted results.



b. Profile 12E.

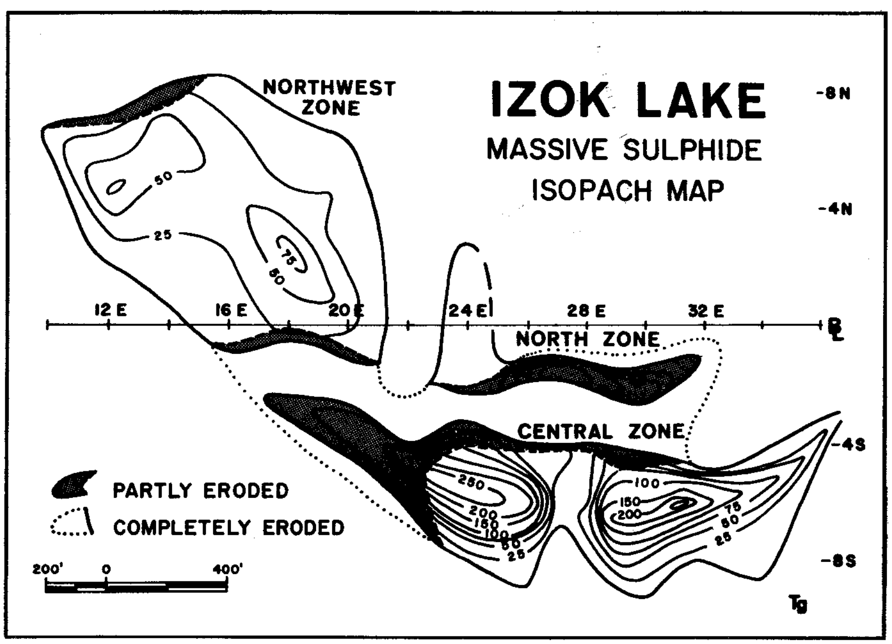


Figure 29.13.

Isopach Map of Izok Lake deposit showing total thickness of massive sulphide lenses.

DRILLING RESULTS

Figure 29.13 is an isopach map of the massive sulphides froming the Izok Lake deposit obtained from the drilling results. The reader should note that the average depth to sulphides within the Northwest Zone is greater than 200 feet (61 m). The summary report on the work that was completed just prior to the start of the 1976 drilling program (i.e. everything but the mise-à-la-masse survey and some magnetic coverage), accurately predicted the ultimate configuration of the Northwest Zone. However, the estimate of the overall thickness of the Northwest Zone was somewhat exaggerated. In drilling the Northwest Zone it was found that, rather than the expected average sulphide thickness of 120 feet (37 m), only a 40 foot (12 m) sheet was intersected that was overlain by up to 200 feet (61 m) of amphibolites whose average specific gravity was about 3.05 g/cm^3 (or 0.33 to 0.35 higher than the country rock). These amphibolites had been mapped around the lake, but had not been encountered in our 1975 drilling, and consequently were an unpleasant surprise. The effect of the amphibolites is illustrated by a gravity profile along line 12E (Fig. 29.14a) wherein a simple two-dimensional model was used. This may be contrasted to a profile along line 24E (Fig. 29.14b) where the gravity anomaly is entirely due to sulphides.

From the drilling completed to the end of 1976, the estimated tonnage figure for the Izok Lake deposit was approximately 12.2 million tons grading 13.73 per cent zinc, 2.83 per cent copper, 1.43 per cent lead, and 2.05 oz./ton silver (with minor values in gold).

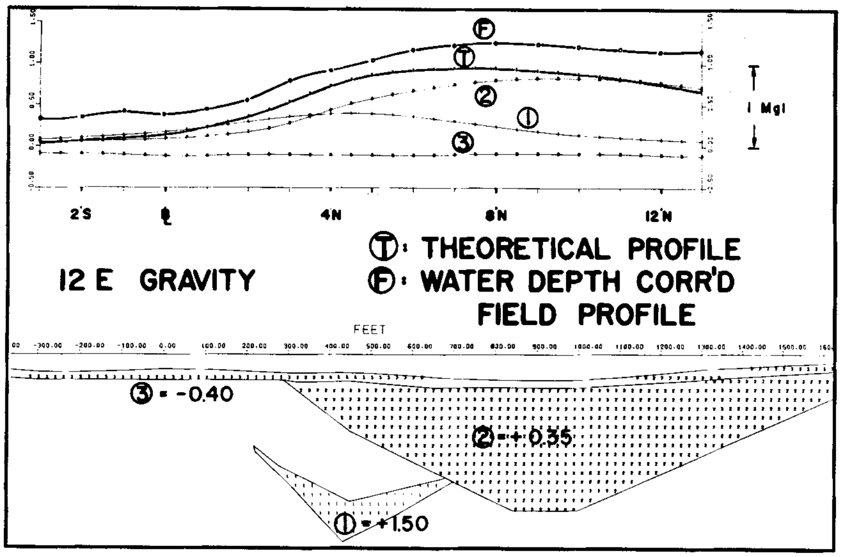
CONCLUSIONS

In retrospect, one might conclude that the Izok Lake deposit was subjected to a surfeit of geophysical investigations, but the temptation, on a target such as this, was too strong to resist. Within the rather stringent constraints of time, weather, operating conditions, and the need to provide the geologists with the guidelines for a drilling program subject to the same constraints, it is felt that the work carried out was totally successful. In addition, a wealth of experience was accumulated in applying geophysical methods in the Arctic, and on this particular type of volcanogenic massive sulphide deposit.

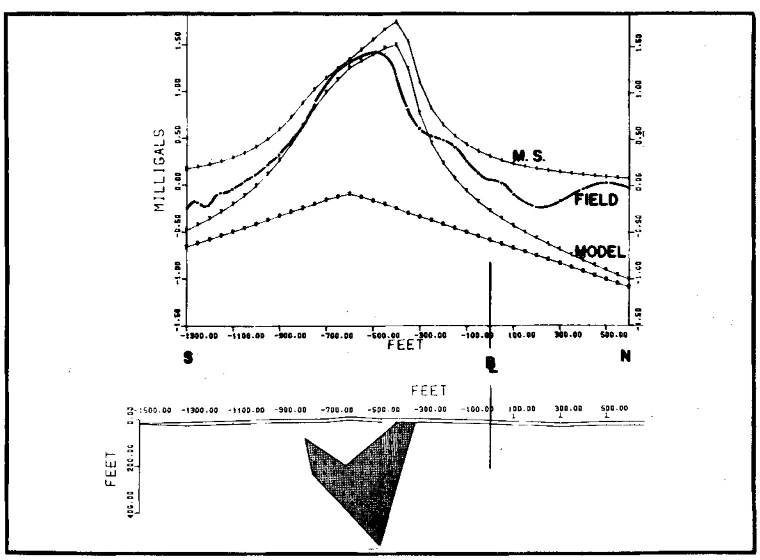
Quite obviously, the high frequency VLF EM technique works extremely well in this high resistivity environment, but is still prone to misleading anomalies. The horizontal-loop EM systems are very effective within the limitations imposed by their geometry and such EM surveys should not be limited to a single coil spacing in the ground follow-up of airborne EM anomalies. Magnetic surveys are essential for both the geophysical the geological interpretations. A gravity survey may be very decisive in delineating high density massive sulphides, but can also be misleading if the geology is not fully appreciated and density contracts exist within the country rock.

The mise-à-la-masse method works very well, but is subject to the same shortcomings as the VLF EM technique with the minor near-surface conductors tending to be accentuated. The response provided by IP is only marginally better than with the telluric technique (or VLF Resistivity) except for deep-seated targets. The gradient IP array poses no problems and provides the fastest and most efficient geophysical survey coverage.

One could justifiably feel quite proud of the contribution that geophysics has made to the discovery and evaluation of this very significant massive sulphide deposit, and equally proud of the people, both staff and students, who did the work. The authors wish to thank the management of Texasgulf Inc. for allowing publication of this paper, and for providing the encouragement to prepare it.



a. Profile 12E with interpretation.



b. Profile 24E with interpretation.

Figure 29.14. *Gravity profiles across Izok Lake, NWT.*

REFERENCE

Money, P.L. and Heslop, J.B.
1976: Geology of the Izok Lake massive sulphide deposit; Can. Min. J., v. 97(5), p. 24-27.