STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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EVALUATION OF GEOPHYSICAL METHODS IN THE FAIRBANKS MINING DISTRICT

By

Eugene M. Wescott

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EVALUATION OF GEOPHYSICAL METHODS IN THE FAIRBANKS MINING DISTRICT

By
Eugene M. Wescott[1]

ABSTRACT

As a contribution to the appraisal of the mineral resources in the Fairbanks mining district, classical geophysical profiles were run across four types of mineral deposits to evaluate their effectiveness. The Spruce Hen tungsten skarn deposit was surveyed with a gravimeter, a Max-Min duo-coil electromagnetic system at 100- and 200-ft coil separations, a VLF electromagnetic EM-16 system, and a total-field magnetometer.

To determine auriferous gravel depth, a long seismic refraction line was run near Sheep Creek and older work on galvanic resistivity and magnetic methods was reevaluated.

On Ester Dome, two shear-zone gold vein deposits were traversed with the Max-Min electromagnetic equipment at 200- and 400-ft coil spacings and with VLF magnetotelluric resistivity.

Finally, a Max-Min traverse was made over a zone of massive to disseminated sulfides near Cleary Creek and the time-domain induced polarization technique was used on a deposit on the southwest flank of Pedro Dome.

Some methods were found to be promising and others not useful (see Summary and Conclusions, p. 21). Overall, geophysical methods appear to be useful projecting tools in the Fairbanks mining district.

TUNGSTEN SKARN DEPOSIT

Tungsten occurs in skarns in a linear zone near Tungsten Hill, northeast of Fairbanks (fig. 1). Several classical geophysical methods were tried on a profile across the Spruce Hen project to determine if there is a geophysical signature useful for exploring for skarn zones. Methods used included gravimetric, EM-16 VLF electromagnetic system, Max-Min duo-coil horizontal-loop electromagnetic unit, and total-field magnetic surveys along a profile line (fig. 2)

Gravimetric Method

Density measurements of two skarn samples provided densities of 3.24 and 2.89 gm/cc. A schist background sample measured 2.66 gm/cc. The skarn zone exposed in the cut (fig. 3) dips about 45° NE. Model calculations indicated that if there was a zone 10 m thick of the high-density ore, it could easily be detected with a gravity survey. Figure 3 shows the model calculation with a density contrast $\Delta\sigma$ of 0.57 g/cc and the simple Bouguer anomaly ($\sigma = 2.67$) along the traverse line from 90 m south to 150 m northwest. Elevations were surveyed with rod and transit. There is no clearly defined anomalv associated with the skarn zone.

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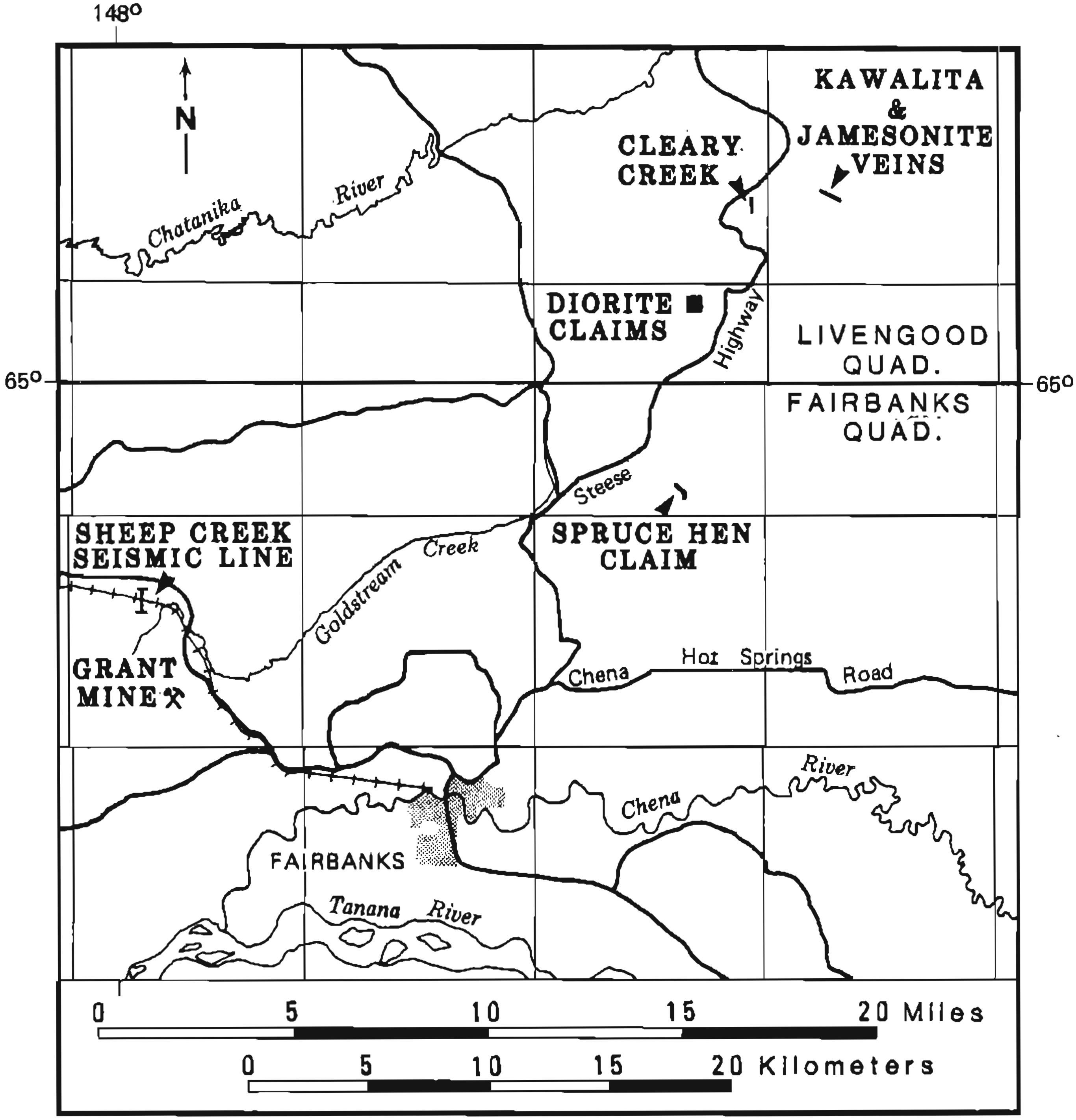

Figure 1. Location of survey sites.

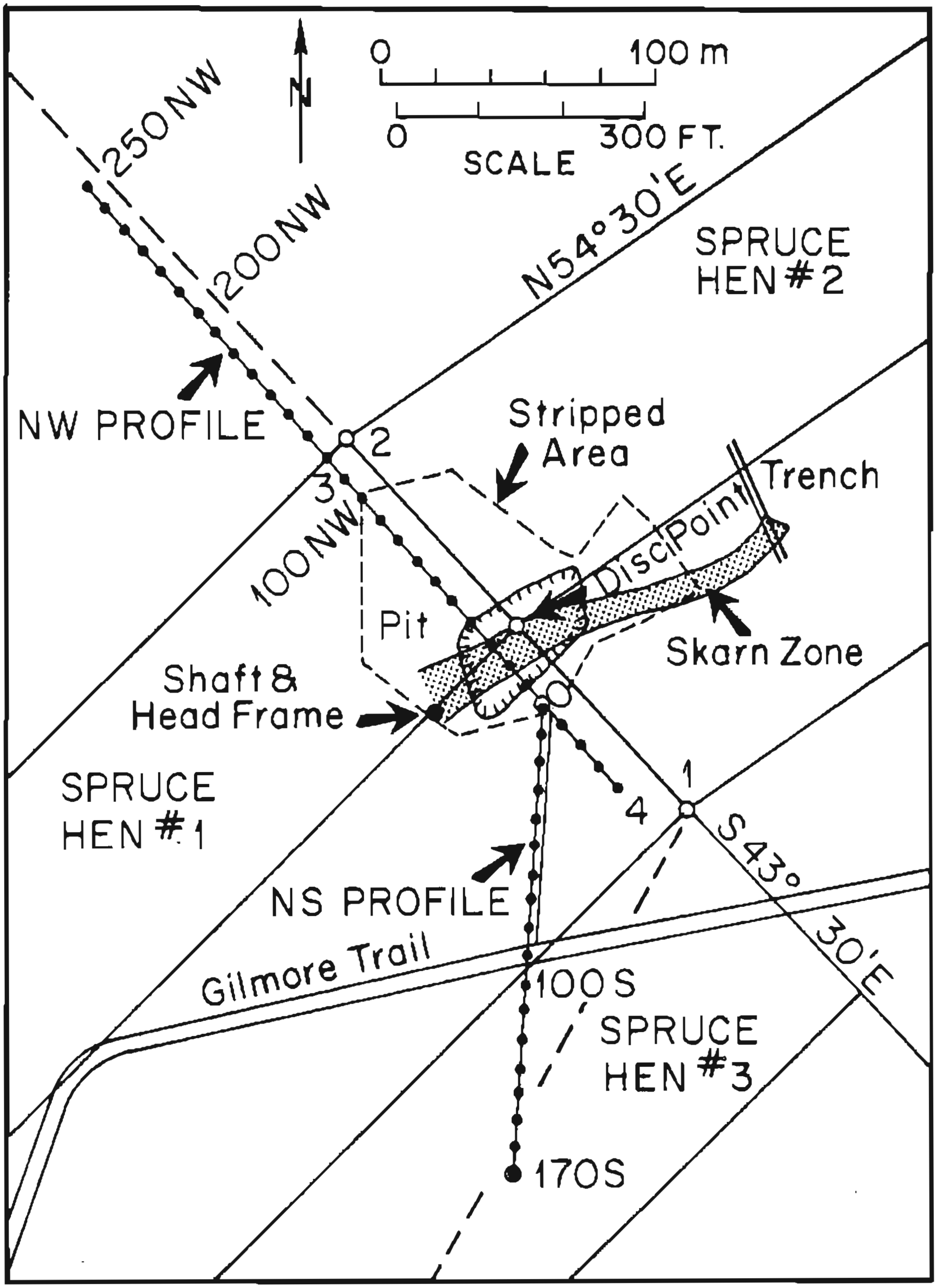

Figure 2. Map of the Spruce Hen Mine vicinity off Gilmore Trail, NE ¼, sec. 34, T. 2 N., R. 1 E., Fairbanks Meridian. Geophysical measurements were made along the north-south and northwest profiles. Dots are station locations 10 m (32.8 ft) apart. The approximate tungsten skarn zone is shaded.

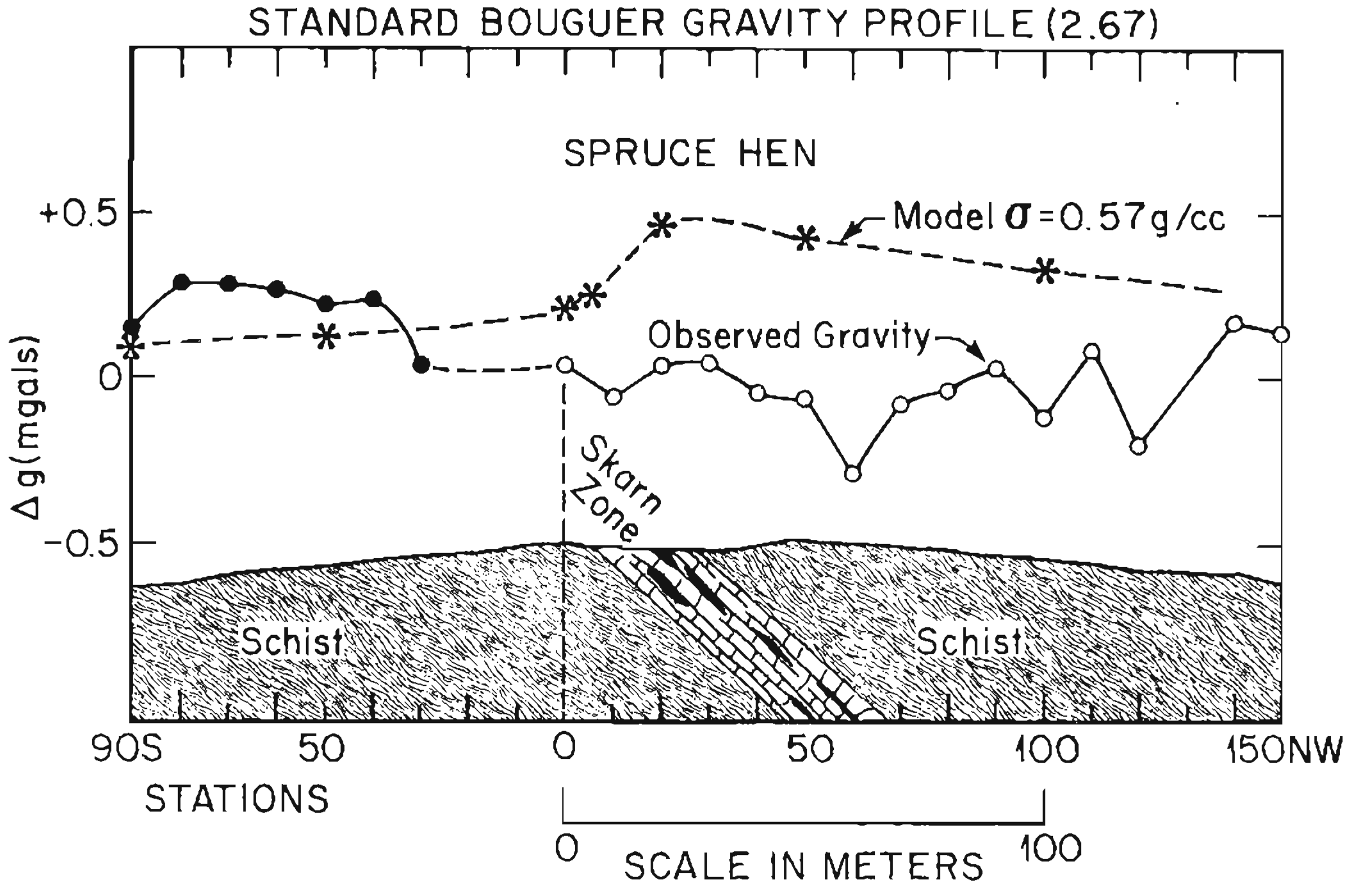

Figure 3. Simple Bouguer gravity anomaly profile over Spruce Hen skarn zone from 90 m S (solid circles) to station 0, and 0 to 160 northwest (open circles). A calculated gravity profile based on a dipping body 10 m thick with density contrast of 0.57 g/cc is shown with asterisks. The generalized geologic cross section has no vertical exaggeration.

Magnetic Method

A total field magnetometer traverse was run extending the profile in both directions. Corrections for magnetic activity were made using the College Observatory three-component magnetograms and checked for consistency by looping stations. All values were consistent to ± 1.5 gammas. There is no characteristic anomaly associated with the narrow skarn zone (fig. 4). A positive anomaly of about 75 gammas occurs near Gilmore Trail Road. Although there is some contamination in the data because of iron gates and so forth, the anomaly is too broad to be due to those. The most probable source of the anomaly is the amphibolite unit indicated in the cross section (fig. 4). If the unit is parallel to the skarn zone in a continuous fashion, it would be a useful marker in tracing the approximate position of the favorable zone along strike.

VLF Electromagnetic Method

An EM-16 VLF instrument, used to run a traverse across the skarn zone, has been widely used by mining companies in exploration for conductive zones in recent years in the Fairbanks district. It measures the in-phase and quadrature-phase components of the vertical magnetic field as a percentage of the horizontal primary field from one or more of the high-power U.S. Navy VLF transmitters; the two stations nearest to central Alaska are NLK in Seattle and NPM in Hawaii. For optimum use, the strike should be in the direction of the transmitter and the profiles run at right angles to the strike. The direction to NLK is 127.5° and to NPM is 193.6°. The average strike in the skarn zone is about 225°, and the Hawaiian station, NPM, is the best choice. However, NPM was off the air the day the survey was run. Station NAA in Cutler, Maine, at azimuth 27° is fairly well aligned along the strike but is very weak, and it was difficult to detect the null point.

Figure 5 shows the results of the survey. At the top the raw field data, in-phase (R) and quadrature (Q) are plotted. In the middle, the Fraser filter method has been used to locate zones of maximum slope of the in-phase component (Fraser, 1969). A geologic cross section is shown below.

There are very large changes obvious in the quadrature component for which we have no explanation. Several suggestive zero crossings in the in-phase data occur in the skarn zone near station 20 NW and near station 150 NW (fig. 2). We have not attempted to model the data, but the anomaly near station 150 NW is similar to model curves over conductors dipping parallel to the beds in the schist; the anomaly may be due to graphite in the schist.

One profile cannot fully define the usefulness of the VLF method; thus a complete feasibility study should include a series of parallel profiles, correlation checks, and use of the Fraser filter method to contour the data. The VLF method looks promising for this type deposit.

Duo-coil Electromagnetic Method

A Max-Min II duo-coil electromagnetic unit, with the coils separated by 100 and 200 ft in the horizontal maximum-coupled mode, was used to look for deeper conductors than the VLF method could detect. The Max-Min II has five operating frequencies: 222, 444, 888, 1777, and 3555 Hz. The in-phase and quadrature components are read directly from dials as a percentage of the transmitted signal. The spacing between the coils is critical, because errors of as little as 1 ft can cause spurious indications of anomalies. Therefore, the transmitter and receiver stations are usually carefully surveyed prior to running the profiles.

Figure 6 shows the 100-ft spacing results. There is little variation in the out-of-phase (OP) component at any frequency and a rather noisy profile in the in-phase component. With the Max-Min duo-coil system, a vertical or steeply dipping conductor produces a double maximum anomaly separated by a minimum with the two zero crossings separated by about the coil separation difference. This type of anomaly was not seen in the data. The anomaly between 70 and 100 NW does not cross the zero line in the 3555 channel, but the peaks and zeros are too close together for a typical 100-ft coil spacing anomaly over a single conductor.

We also ran a Max-Min traverse at 200-ft coil spacing, but it did not show anomalies typical of a dipping conductor.

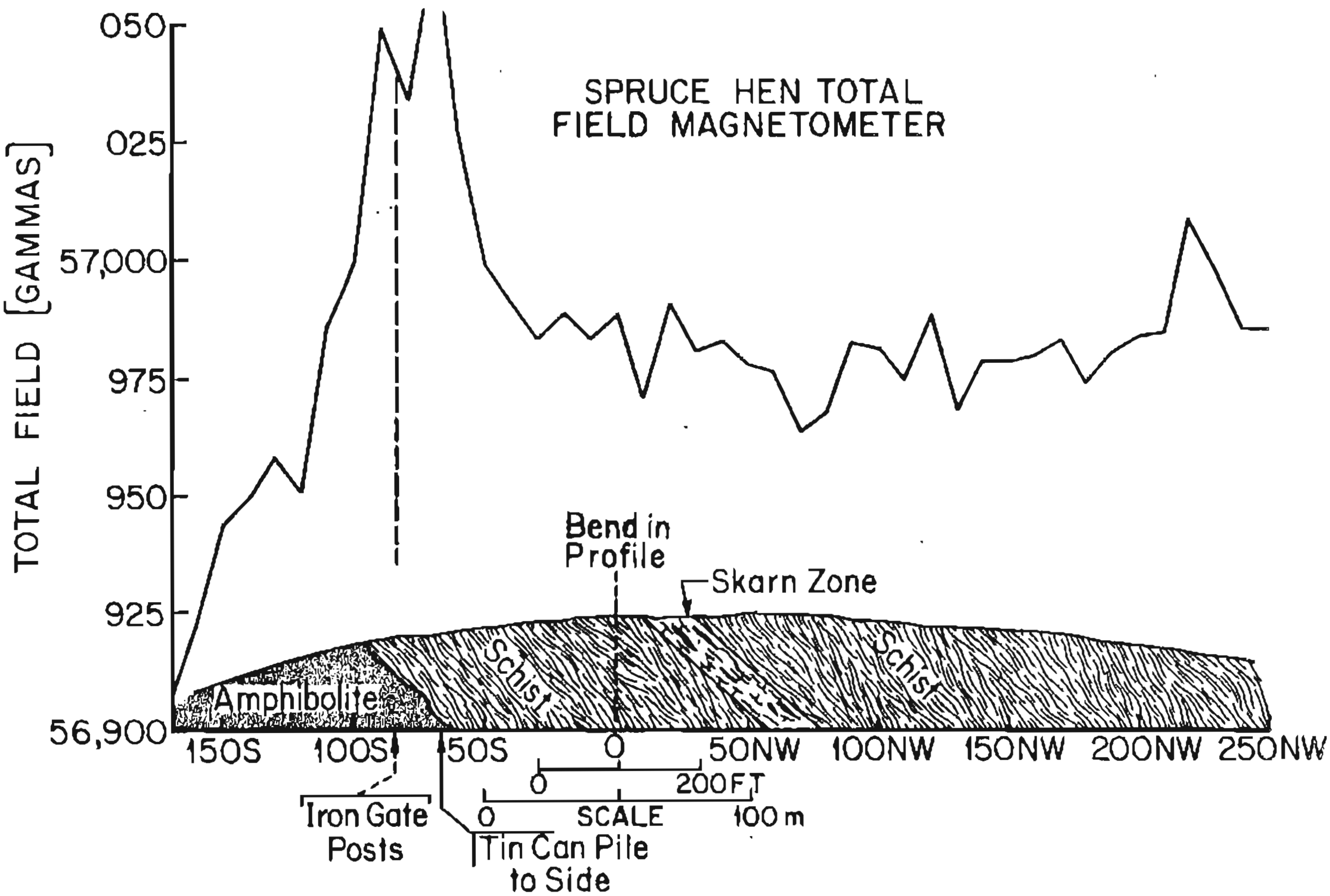

Figure 4. Total-field magnetometer profile over Spruce Hen Mine skarn zone, showing the generalized geologic cross section with no vertical exaggeration. The amphibolite-schist contact is only approximate. See figure 2 for profile location.

Conclusions

There does not appear to be any classical geophysical signature to the skarn zone that was investigated with various methods. Because the area had been cleared of overburden with a bulldozer, it would have been difficult to use galvanic-resistivity or induced-polarization techniques. From our work, it seems that the amphibolite unit on the south side of the skarn zone may be traceable with a ground or aeromagnetic survey. In the VLF and Max-Min data are suggestions that units in the host-rock schist on either side of the skarn zone may have conductors, which might also be useful in tracing the zone. The skarns appear to occur in pods and do not represent enough excess mass to produce an interpretable gravity anomaly.

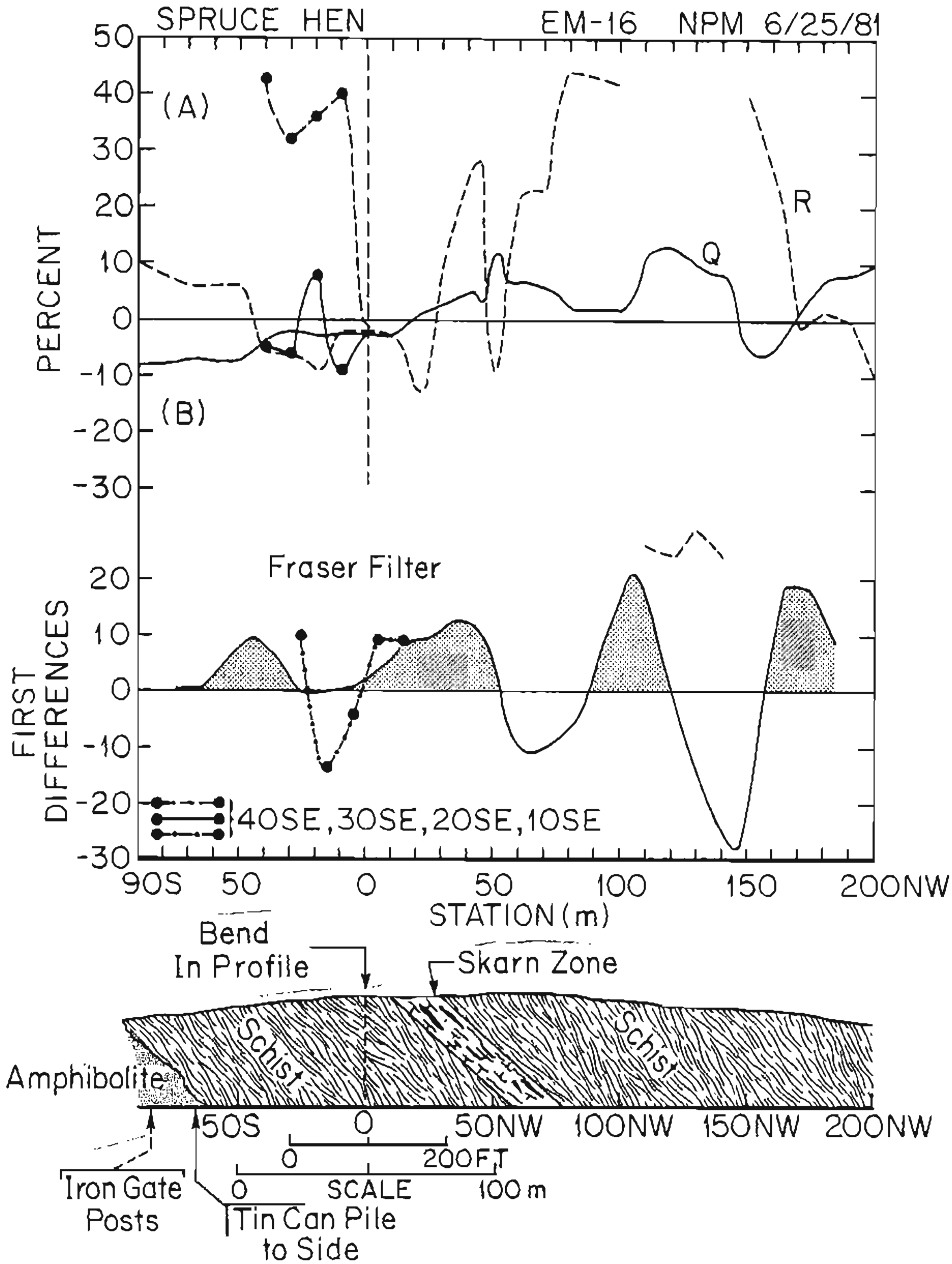

Figure 5. Results of VLF electromagnetic survey A - In-phase (R) and out-of-phase (Q) vertical magnetic components of the VLF signal from 18.6 KHz station NLK, Seattle. B - First difference of alternate sums, Fraser filter values of the in-phase component. Maxima and minima show the zones of steepest gradient.

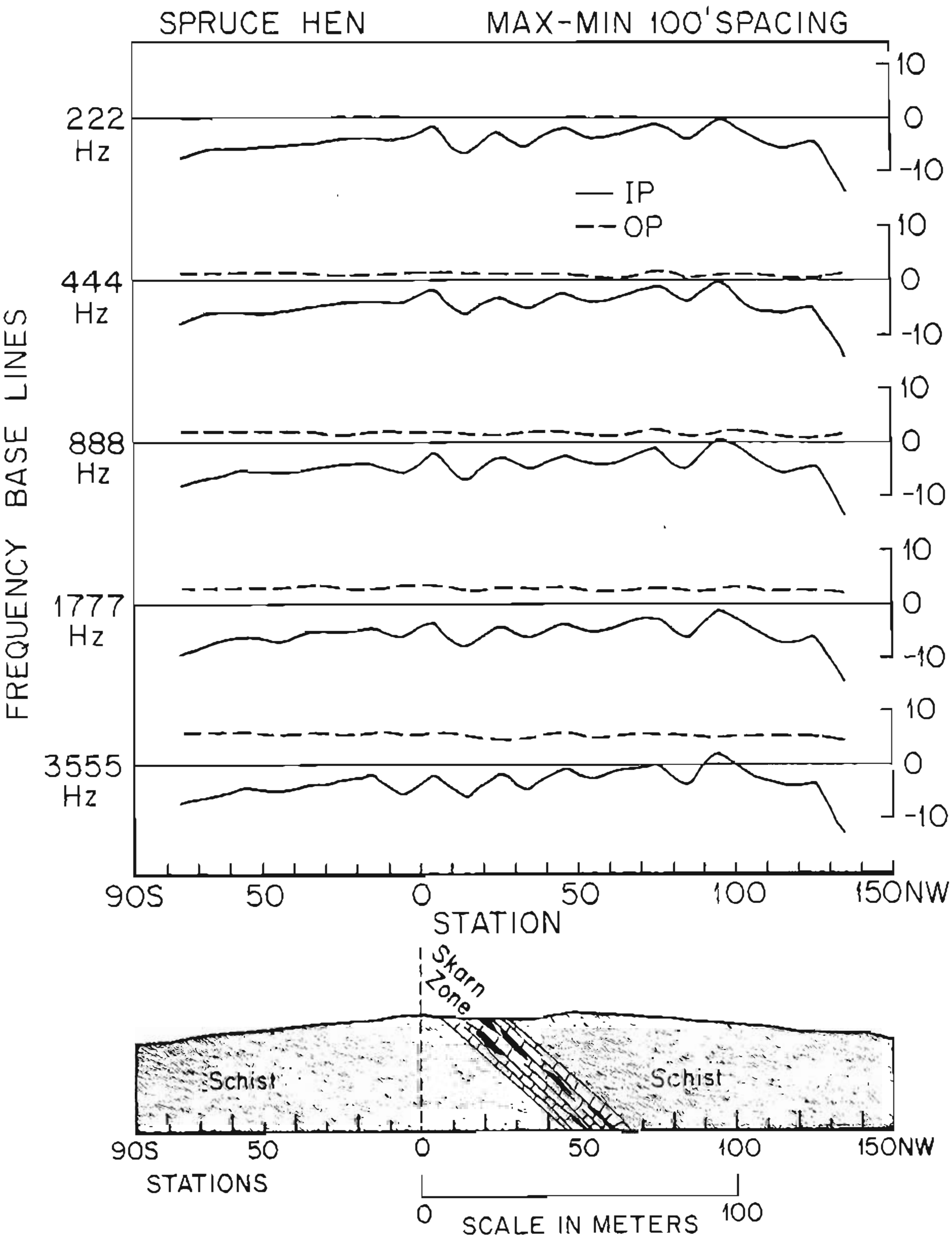

Figure 6. In-phase and out-of-phase components from a duo-coil horizontal-loop Max-Min II EM profile over the Spruce Hen tungsten skarn zone. There are no classical anomalies that can be interpreted simply.

AURIFEROUS GRAVELS

Many of the stream valleys in the Fairbanks district contain gold-bearing gravel deposits in ancient stream channels. The gravels vary in thickness and are overlain by younger sediments such as silts, sands, reworked loess, and peat, which in most areas are permanently frozen. The Fairbanks district is historically famous for extensive dredging operations of the most accessible and economic gravels. The usefulness of geophysical methods in determining the depth of valley fill over bedrock and locating buried stream channels was investigated. Field measurements were made with a refraction seismograph and earlier galvanic resistivity magnetic data were reevaluated.

Refraction Seismic Profiling

Two days were spent using a pair of Geometrics Nimbus-12 twelve-channel digital memory seismographs to run a profile across part of Goldstream Valley near Sheep Creek (fig. 1). The profile was run along the access road into the Alaska Gold Company Sheep Creek dredge, beginning 139 m (457 ft) north of the Goldstream Creek Road crossing where the road bends, and extending north along the east side of the road. Four loads of Nitromon seismic explosives were shot in 4-in. auger holes drilled as deeply as possible (about 4-5 ft) in permafrost. Because it was expected that several hundred feet of sediments lay over the bedrock, a long seismometer-seismometer spacing of 15 m (49 ft) with a total spread of 545 m (1,788 ft) was used between shot points with one intermediate shot point. As it turned out, the depth to bedrock in a line of drill holes nearby varied from about 3 to 18 m (10-60 ft), so a smaller seismometer spacing could have been used. However, the use of long spreads allowed more sophisticated analysis of the bedrock topography.

Figure 7A shows the travel-time curves for the first arrivals of the four shots. There was difficulty in triggering the two seismographs simultaneously; one had to be triggered by hand. For the hand-triggered spreads, a Δt was added to or subtracted from all arrival times to align the curve with the precision-timed data. The only apparent break in the travel-time curves was from 1,376 to 3,746 m/sec. This was originally attributed to a frozen silt-frozen gravel interface, and the longer shots (Nos. 2 and 4) were made in search of a deeper refractor. However, drill-hole information acquired after the survey (fig. 7D) indicates that bedrock is much shallower than was thought, and the break in travel time represents the interface between silt-gravel and bedrock.

The depth and dip of the refractor were analyzed by three methods: dipping refractor (Mooney, 1977; Campbell, 1977), delay times (Telford and others, 1976), and generalized reciprocal method (Palmer, 1981).

Figure 7B shows a cross section, with no vertical exaggeration, using the dipping-refractor method (Campbell, 1977). This assumes that the velocity in each dipping layer is constant, that the dips are constant, and that all layer velocities increase with depth. A depth under shot 1 (at the south end) was found to be 21.1 m (69.2 ft) and 10.2 m (33 ft) under shot 3, which was 365 m (1,197 ft) to the north. The upper velocity of 1,376 m/sec (4,513 ft/sec) is reasonable for frozen sediments (Johnston, 1981), and the underlying velocity of 3,746 m/sec (12,287 ft/sec) is reasonable for bedrock. The method of delay times (Telford and others, 1976) provided similar results, with some low-velocity zones near the surface and some slight basement topography, as indicated in figure 7B.

Figure 7C shows the profile obtained using the generalized reciprocal method (Palmer, 1981). This method is particularly good in eliminating the effects of ghost layers and other velocity variations in the layers above the basement rocks. It clearly brings out the topography in the basement refractor. The depth to bedrock is shallower at the north end than at the south end in both B and C profiles. However, this does not agree exactly with the drill-hole information in figure 7D. The drill-hole line is at an angle to the road along which our profile was run and is about 100 ft away at shot point 1 and about 340 ft away at shot point 3. Data supplied by Alaska Gold Company shows that about 90 m (300 ft) of the south end of the seismic profile was dredged and refilled with tailings. The dredge probably cut into the bedrock to provide the minimum depth for flotation, which would explain much of the difference between profiles C and D.

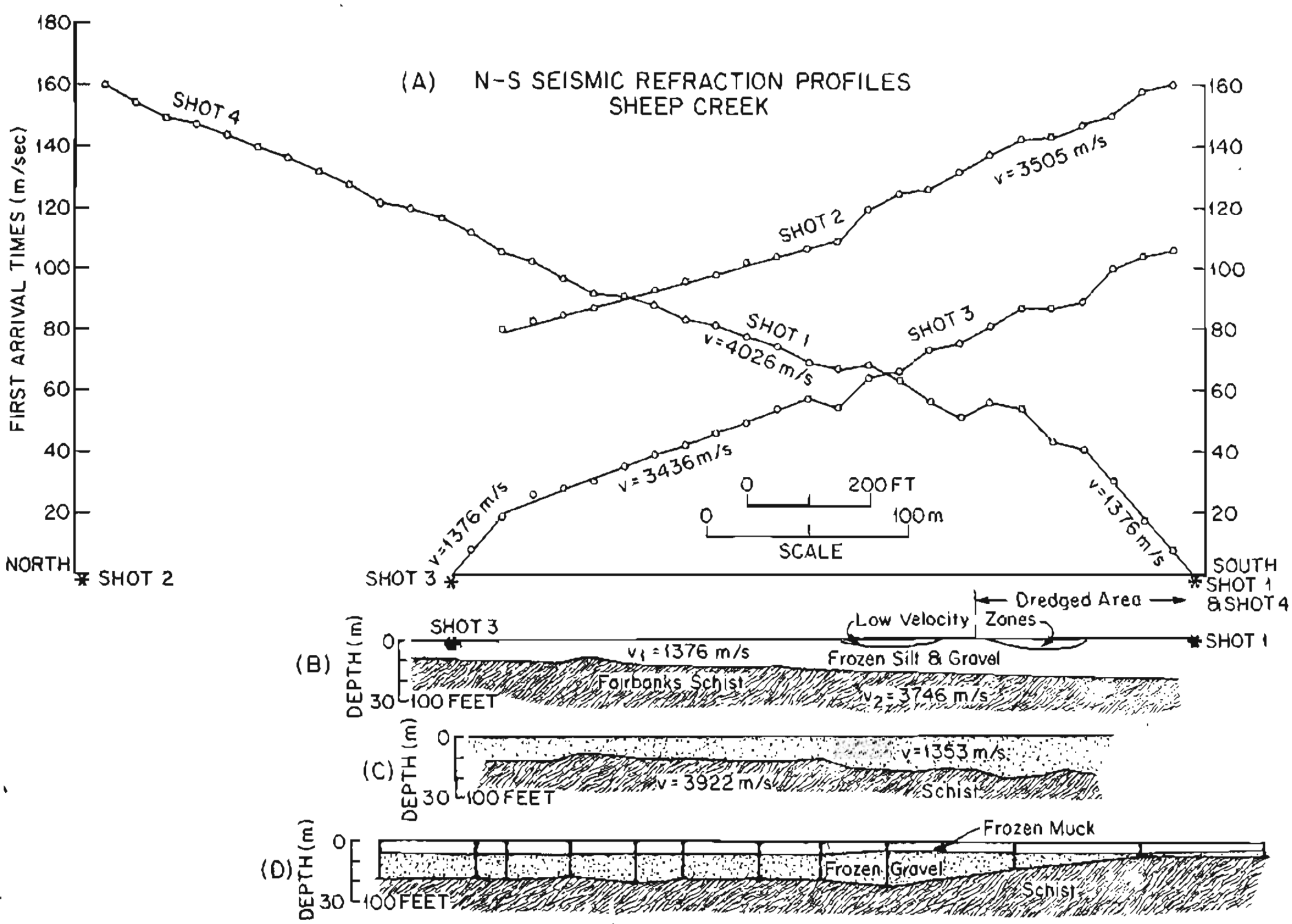

Figure 7. Refraction seismic profiles, Goldstream Valley near Sheep Creek. 7A - First-arrival travel-time curves for seismic line across Goldstream Valley near Sheep Creek dredging area. 7B - Computed cross section using the dipping refractor and delay time methods, no vertical exaggeration. 7C - Computed cross section using the generalized reciprocal method. 7D - Drill-hole cross section on line west of seismic profile. The southernmost 300 ft of the seismic profile was dredged after the drilling, which may explain the deeper bedrock indication on the seismic profiles.

If weathering correction shots along the profile using the multiple hammer-stroke technique or smaller geophone spacings had been used, the interface between frozen silt and gravel might have been resolved.

Galvanic Resistivity

A second geophysical technique that, in principle, can be used to explore the layers vs depth in sediment-filled valleys, is galvanic- resistivity vertical electric soundings (VES) (Keller and Frischknecht, 1966). Direct or alternating square-wave current is put into the ground via a pair of electrodes, and the voltage drop is measured across another pair of electrodes. Wider electrode spacing results in deeper effecting soundings. Various electrode configurations have been used. The Schlumberger array is the most popular because it involves moving only the current electrodes and minimizes effects caused by lateral inhomogeneities near the surface. Much earlier American work used the Wenner array, where the spacing between the two current electrodes is always kept at three times the spacing between the potential electrodes.

Anderson and Johnson (1970a) carried out seven Schlumberger vertical electrical soundings along Miller Hill Road and Sheep Creek Road in the Cripple Creek-Ester-Goldstream Valley area and on Ester Dome Road. They concluded,

> "In areas free of permafrost, bedrock depths determined from resistivity data compared favorably with drill hole data. However, resistivity soundings made over permafrost were useful only for determining the depth to the top of the permafrost. The electrical current can be made to penetrate the permafrost by use of very large electrode separations but the underlying layers are then detected as a single layer having a resistivity which represents an average of the individual layers."

They speculated that if the resistivity of the bedrock were extremely high, the depth to bedrock might be determined. The Anderson and Johnson (1970a) work shows that the Birch Creek Schist Formation had resistivities ranging from 70 Ω-m to very high, with a typical value of about 350 Ω-m.

Wescott and Hessler (1962) made 18 vertical electric soundings in the Fairbanks district using the Wenner array. They found the true resistivity of the schist to vary between 579 and 3,000 Ω-m where it was not frozen. The resistivity of permafrost also varies considerably, depending on the ice content. Wescott and Hessler (1962) found permafrost resistivity ranging from 4,420 to 30,487 Ω-m, with an average typical value of about 7,400 Ω-m. Thus, resistivity contrasts would be suitable for determining depth to bedrock in some permafrost areas.

Joesting (1941) used a Wenner array to make vertical electric soundings in placer areas in the Fairbanks district where drill information was available. At the time of his work, interpretation of VES curves was not very advanced. Some of his data were scaled to use a modern automatic curve-fitting program to determine if bedrock could be found with his data. A modified version of a program by Zhody (1973) to use the Wenner array was employed and run on a VAX computer. Figure 8 shows the apparent resistivity vs 'a' spacing curve and the calculated true resistivity vs depth data as well as the drill log for a location in the Tanana Valley near College. The sediments were frozen to a depth of 27 m (90 ft). The calculated values predict the bottom of the permafrost to be 34 m (108 ft). A second VES curve in partially frozen overburden in the Tanana Valley east of Fairbanks is shown in figure 9. The driller's log shows the bottom of permafrost to be at 27 m (88 ft), with a thawed zone from 19-23 m (62-77 ft), and bedrock at a depth of about 98 m (320 ft). The automatic curve-fitting program had difficulty fitting the data between 'a' spacing of 35 and 100 ft. The fitted model suggests a bottom of the permafrost at 120 ft and low resistivity bedrock at 58 m (189 ft). In this example, the permafrost has a very high resistivity of 17×10^6 Ω-m. In these two cases there was a thawed zone of sediments above bedrock, and the results are encouraging. Joesting (1941) concluded that it was possible to determine the location and approximate depth of water-bearing gravel under permafrost wherever the method had been tried, but that determination of depths to bedrock was not entirely satisfactory because of the frequent lack of lateral uniformity in the overburden and in bedrock.

Magnetic Surveys

The third geophysical technique for locating buried stream channels containing gold is the use of vertical or total-field magnetometer profiling. The most important magnetic minerals, magnetite and illmenite, are also fairly dense: 5.2 and 4.3-5.5 gm/cc, respectively. Thus, these minerals tend to be concentrated in stream deposits where gold is deposited. Joesting (1941) examined 110 samples of placer concentrates from 54 creeks, and found magnetic-mineral concentrations in all of the samples. In the Fairbanks district, he found magnetite ranged from 6 to 58 percent, with a mean of 14 percent in placer deposits. He ran a number of vertical field-magnetometer profiles across placer deposits that had been drilled but not mined. Figure 10 shows a classic profile across a narrow-bench paybreak on Deadwood Creek, Circle district, where there is almost 1:1 correlation between gold content and magnetite anomaly. Figure 11 shows a more typical profile of magnetic anomaly vs gold content. The correspondence between gold and magnetic values is influenced by the topography and the thickness of gravel. Thus, Joesting (1941) concluded,

> "Gold and magnetite occur in roughly proportionate amounts only where there is a well-defined, fairly uniform paystreak. Where values are spotty and the gravel is poorly sorted there is often little or no correspondence between the amounts of gold and magnetite."

Anderson and Johnson (1970) also made vertical-intensity magnetic measurements in the Fairbanks district that coincided with a series of drill holes that penetrated bedrock. They found magnetic anomalies over sections near Happy and across Goldstream Valley where auriferous gravels occur below the operating depth of existing dredges. They concluded that magnetic-mineral concentrations in buried stream channels can be detected rather easily by conventional magnetic ground methods. At great depths, the recognition is more difficult but possible. They suggested the usefulness of airborne magnetic surveys at altitudes of about 100-200 ft above the ground in areas where the

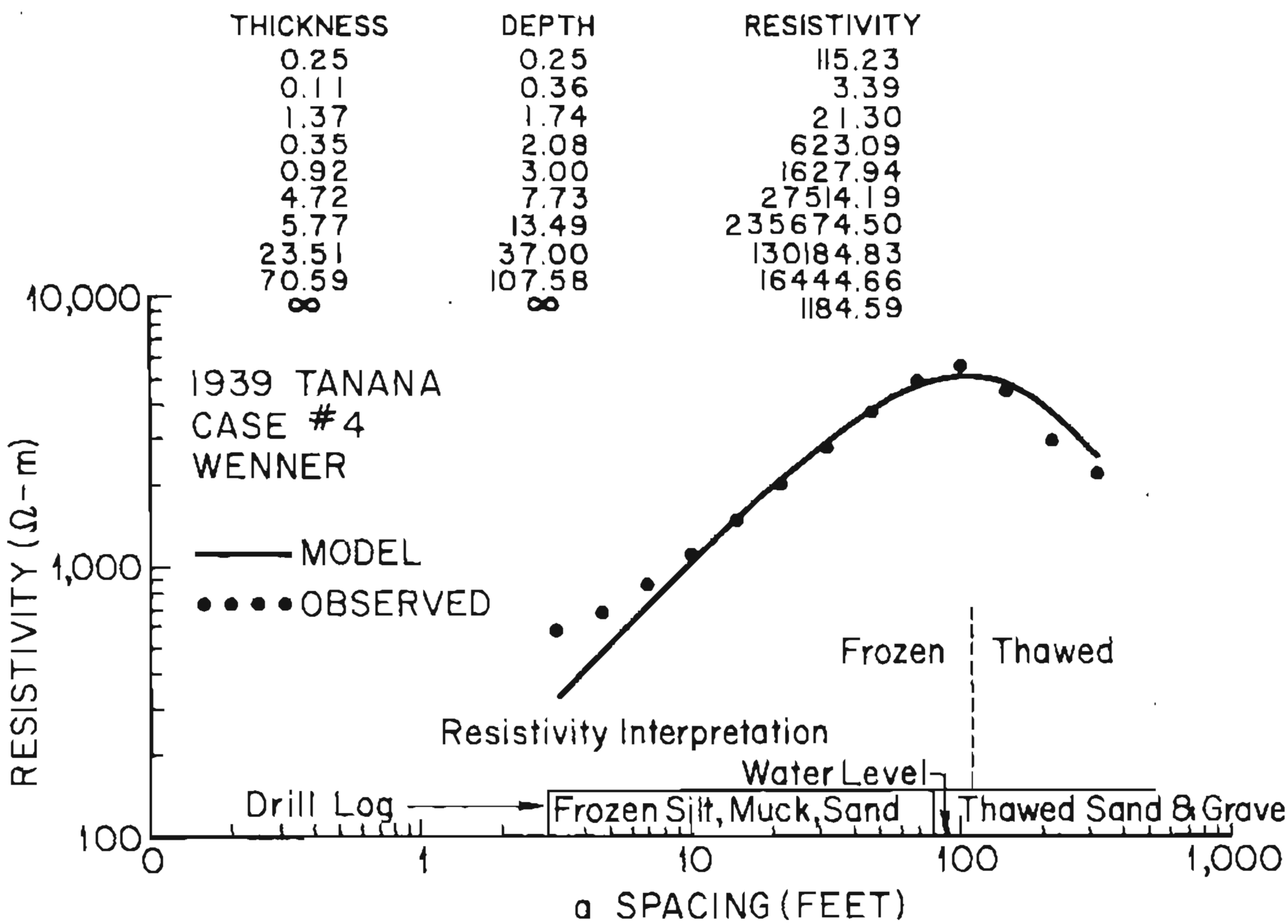

Figure 8. Apparent Wenner resistivity vs 'a' spacing or depth (after Joesting, 1941) for a location in the Tanana Valley. A computer-generated model to best fit the data points is shown as a solid line. Model and drill-log base of permafrost differ by about 20 ft.

depth to bedrock is less than 150 ft. They stressed the need to filter out high-frequency components of the ground-magnetic data to see the placer mineral distribution.

Conclusions

Three methods were considered for exploration of auriferous gravels prior to drilling programs. The seismic method probably can determine accurately the depth to unweathered bedrock, even in deep permafrost areas. Galvanic resistivity is useful in finding water-bearing gravels and bedrock in non-permafrost areas. When frozen muck covers the gravels, the depth to water-bearing gravels can probably be determined, but depth to bedrock is less certain. The work of Joesting (1941) and Anderson and Johnson (1970a) indicates that vertical or total-field magnetic surveys are a useful indicator of concentrations of dense magnetic minerals in stream-deposited gravels. In poorly sorted gravels or colluvial debris, however, the presence of magnetite may not correspond with gold concentrations.

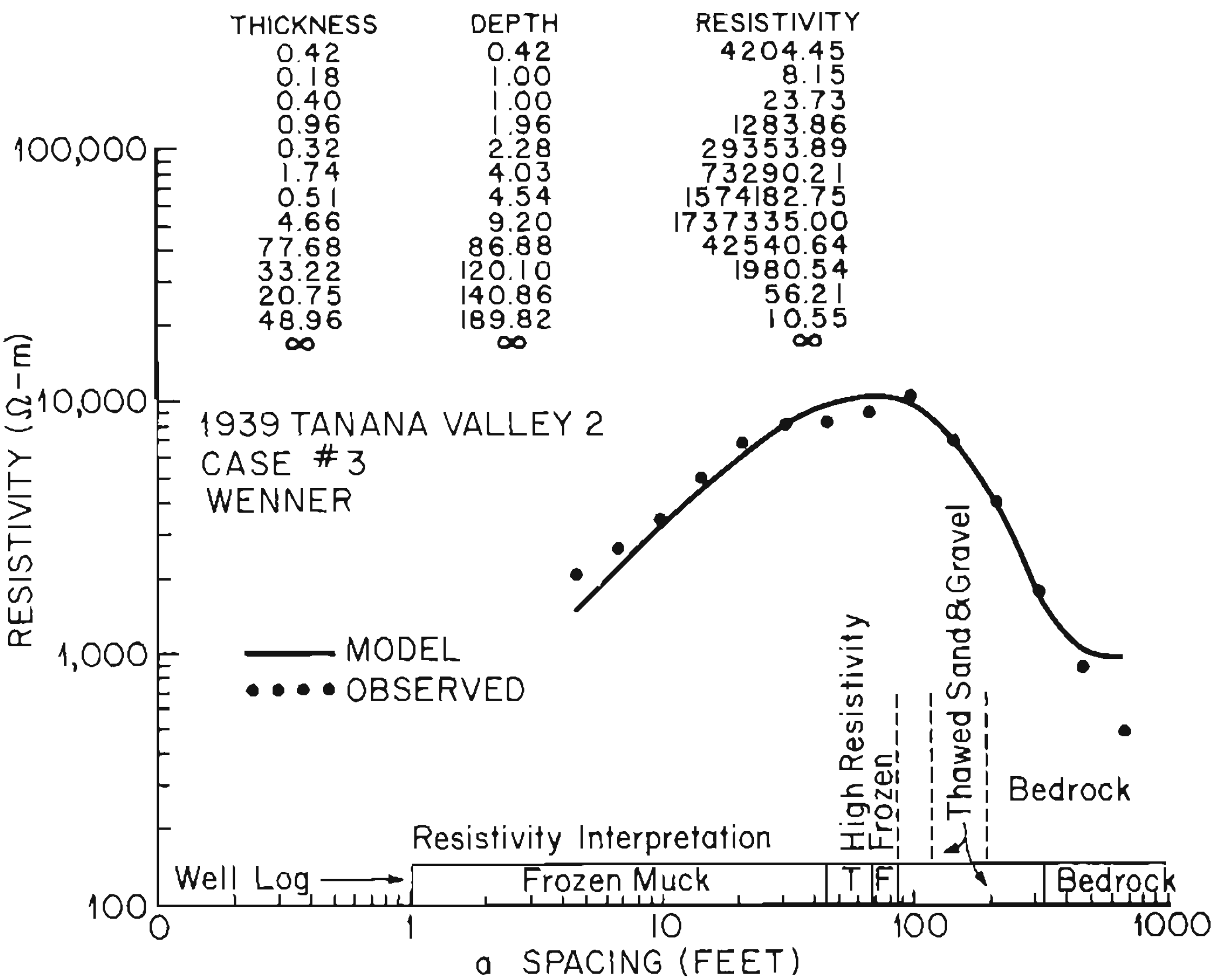

Figure 9. Apparent Wenner resistivity vs 'a' spacing or depth (after Joesting, 1941) for a second location in Tanana Valley. The computer-generated-model fit to the data is shown as a solid line. The well-log and basic-model interpretation are shown below.

ESTER DOME SHEAR ZONE

The usefulness of several classical geophysical techniques was investigated in locating two structurally controlled, auriferous vein-fault deposits on the southeast flank of Ester Dome. The Grant Gold Mine deposits have been intermittently explored and mined since the 1920s (fig. 1). Tricon, Inc. is currently actively developing two veins: the Irishman and O'Dea zones. Host rocks for the deposits are polymetamorphic schist and quartzite of undetermined age (Bundtzen and Kline, 1981). The water level is about 30 ft below the level of the current workings in the mine. Inspection of the veins showed that only the presence of thin fault gouge in mineralized fault zones is likely to contribute to anomalous conductivity.

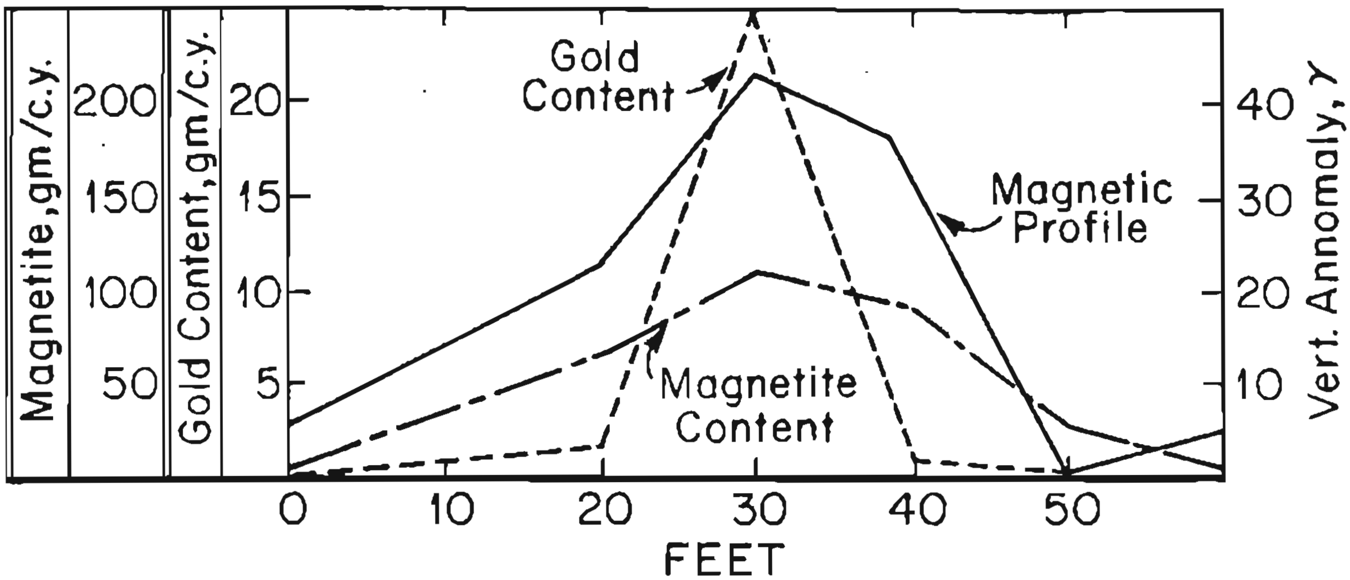

Figure 10. Profiles of vertical magnetic component, magnetite, and gold content across narrow-bench paystreak on Deadwood Creek, Circle district, from Joesting (1941).

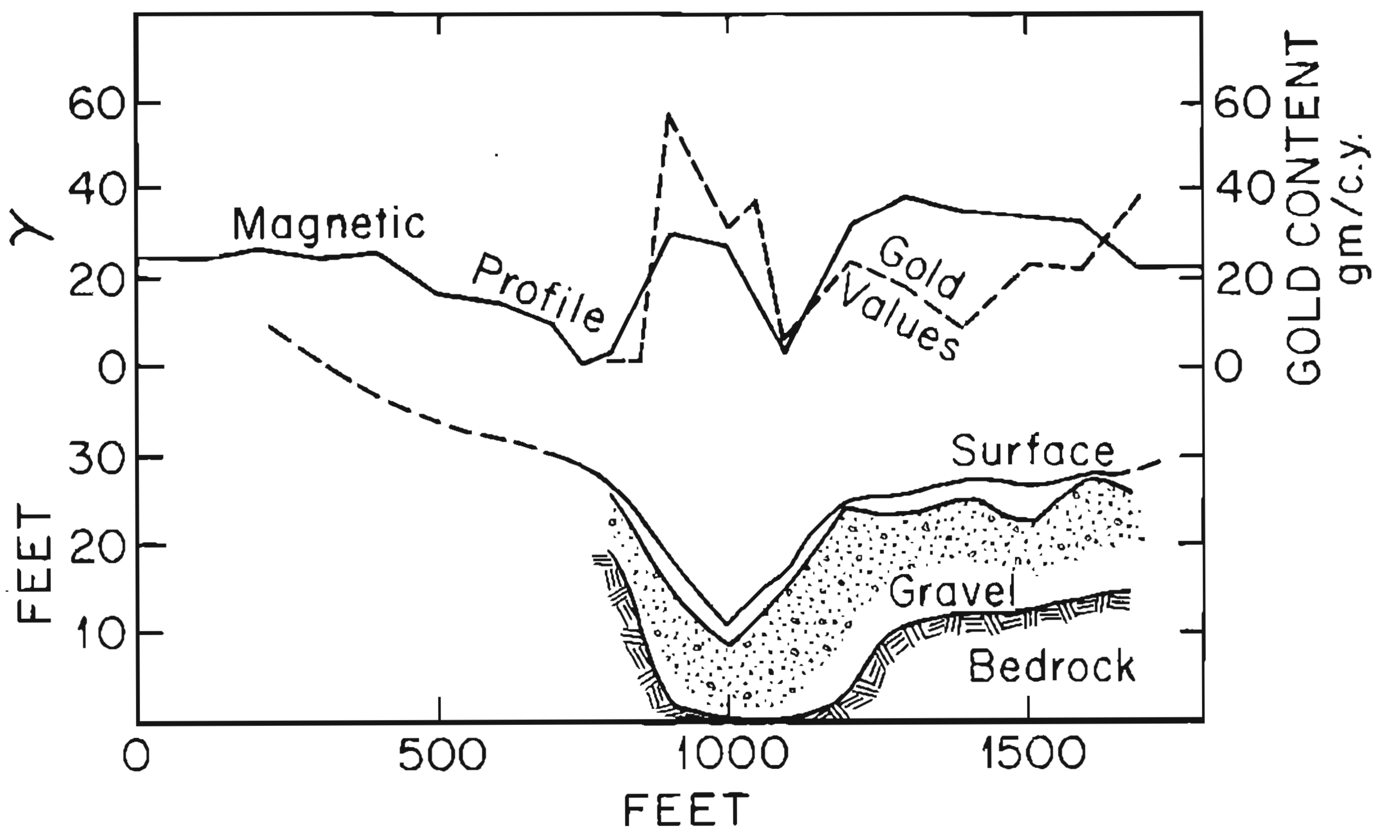

Figure 11. Profiles of vertical magnetic component, gold values, and geologic cross section, Portage Creek, Circle district, from Joesting (1941).

Contouring of EM-16 VLF Fraser filtered data has proven very useful for mapping structural and geological trends on Ester Dome, but has not actually shown the extension of the Irishman and O'Dea veins beyond the mine area (J. Burton, Tricon, Inc., personal commun.). Several geophysical instruments were run along a 2,000-ft profile as shown in figure 12. In June 1981, an EM-16R resistivity profile and Max-Min electromagnetic profile at 200- and 400-ft spacing were run before drifting in the 200-ft O'Dea zone had reached the profile area. In October 1981, the Max-Min profiles were extended because new information on the vein location indicated that it intercepted our line beyond the northwest end. Because the drift was then under and beyond the profile line, some manmade 'noise' may be present in the data.

EM-16R Resistivity

The EM-16R unit is an attachment to the EM-16 VLF electromagnetic unit to measure the electric field corresponding to the magnetic component and the phase angle between them. Thus, the apparent resistivity at a single frequency can be measured using the magnetotelluric formula. The EM-16R resistivity and phase are read from dials that are set to produce a null in an audio tone. Figure 13 shows the EM-16R profile and a geological cross section using station NLK in Seattle at 18.6 KHz. The combination of an apparent resistivity less than 100 Ω-m and a phase angle greater than 45° between 600 and 100 ft southeast is interpreted as a low resistivity layer overlain by a higher resistivity layer. The general increase in apparent resistivity from the southeast to near station 0 suggests a thinning out of the low-resistivity layer. Between 500 ft southeast and 200 ft northwest, the phase angle 45° suggests that the underlying resistivity is greater than that of the surface. There is a relatively low resistivity zone near station 300 NW where the O'Dea breccia zone projects to the surface, but there are other similar anomalies farther to the northwest. Parallel profiles should be run to answer the question of the significance of the anomaly.

Max-Min Duo-coil Horizontal Loop EM

In June 1981, a horizontal maximum coupled electromagnetic profile was run with 200-ft coil separations from station 0 SE along the profile line shown in figure 14 as open circles. There was no indication of any significant anomaly. In November 1981, when it was learned that the O'Dea zone projected to the surface at about 350 ft northwest of station 0, part of the line was run again and the coverage was extended to 900 ft northwest. The in-phase component at station 100 SW was substantially different from the earlier survey, changing from a few percent negative to nearly 10 percent positive. It is suspicious that the Max-Min readings changed between June and November when the mine workings were extended. However, the anomaly is not what would be produced by a long conductive cylinder 200 ft deep (which the mine rail line and air piping would resemble). The new data points (solid circles) show a typical EM anomaly for a thin sheet dipping at 45° (Frischknect and Mangan, 1960). This would correspond to the approximate location of the projection of the Irishman vein, not the O'Dea zone.

The Max-Min horizontal loops were also run with 400-ft spacing from 1,000 ft southeast to 800 ft northwest along the same profile as figure 12. The

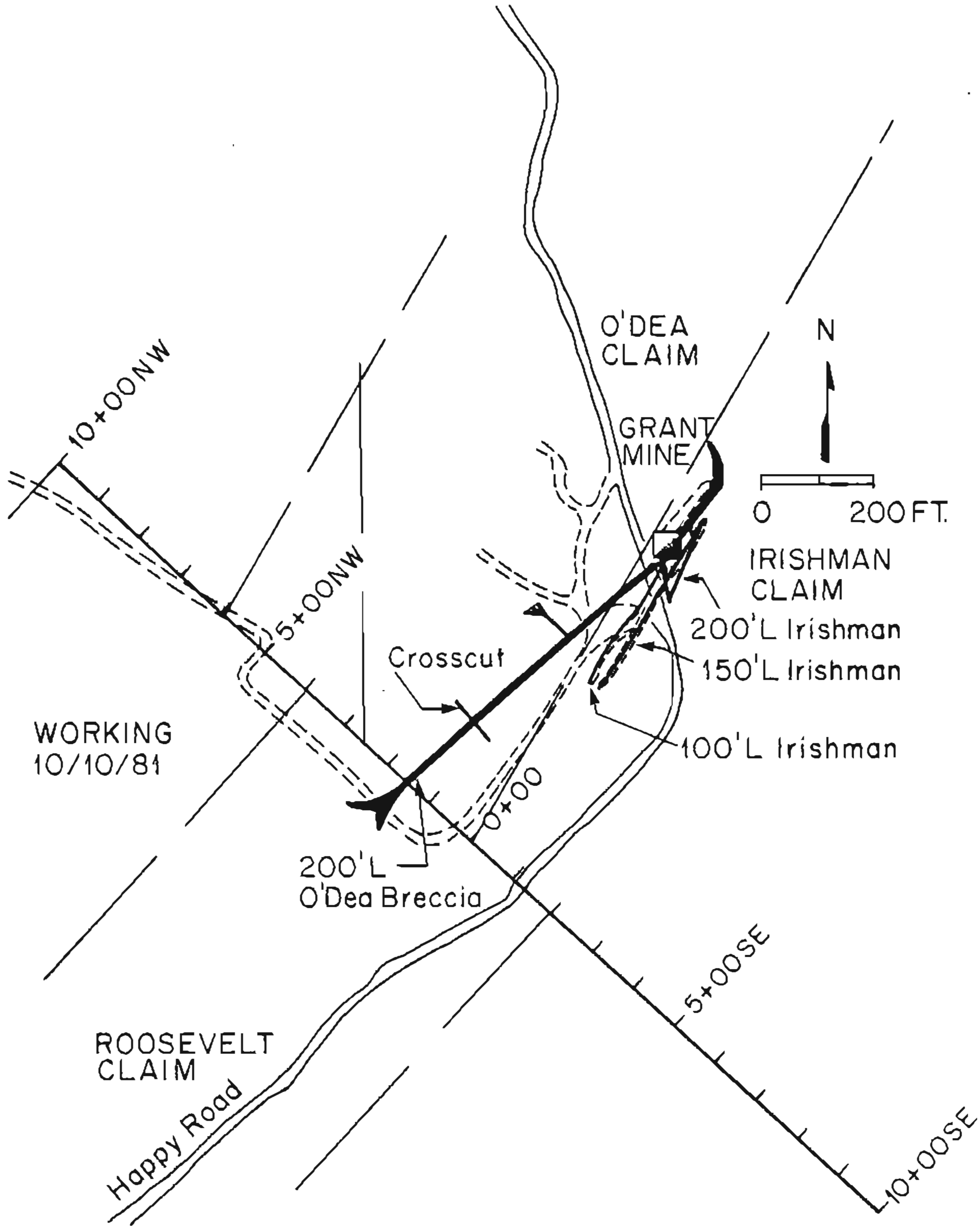

Figure 12. Map of Grant Gold Mine on Happy Road, Fairbanks mining district, SE ¼, sec. 28, T. 1 N., R. 2 W., Fairbanks Meridian. Approximate surface projections of the 100-, 150-, and 200-ft levels of the Irishman vein and on the 200-ft level of the O'Dea breccia zone as mapped by Bundtzen and Kline (1981) are shown. Geophysical measurements were taken along the profile line from 1,000 ft southeast to 1,000 ft northwest as shown.

data did not show any definite classical anomaly signature. There was some effect due to the powerline just beyond the southeast end of the line.

Induced Polarization

An induced-polarization profile could not be run before freezeup. IP could be effective in locating the Irishman vein and O'Dea breccia zone. Bundtzen and Kline (1981) mention the presence of arsenopyrite in the Irishman and O'Dea vein faults, and both veins have clay-gouge mineralization, which is likely to produce IP effects.

Conclusions

The Irishman vein and O'Dea breccia zone exposed in the Grant Mine do not appear to have a significant effect on the conductivity. The clay mineralization is probably the biggest contributor to conductivity, and it is only present intermittently. A possible EM anomaly corresponding to the

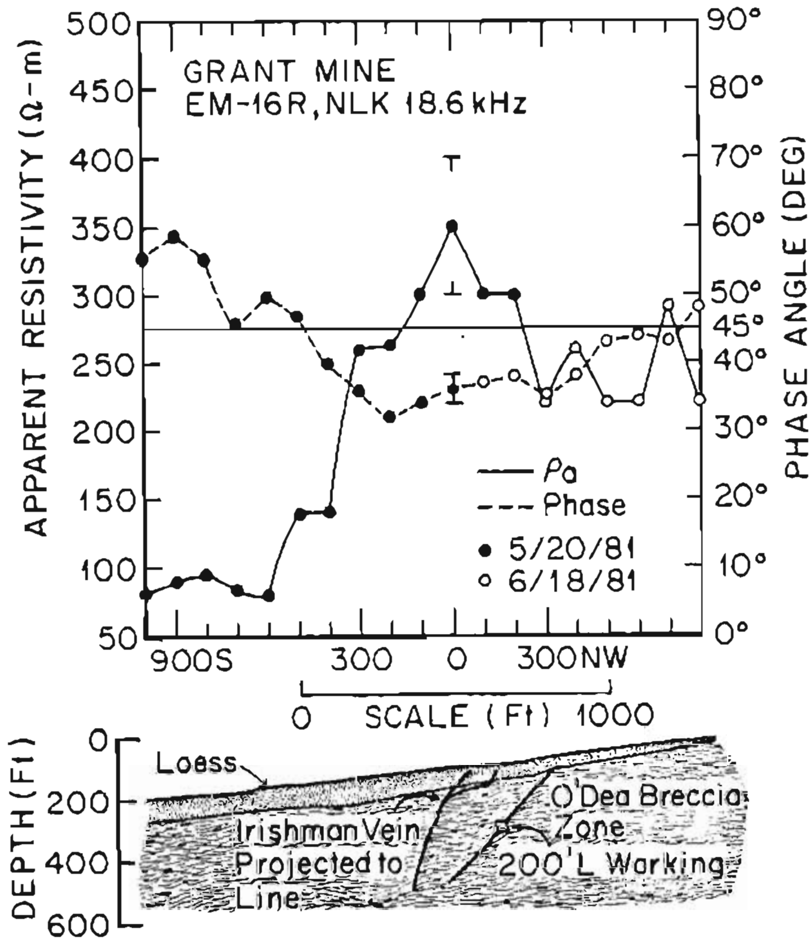

Figure 13. EM-16R VLF magnetotelluric apparent resistivity and E/H phase angle on Grant Gold Mine along profile line shown in figure 12. Generalized geological cross section based on mapping by Bundtzen and Kline (1981) is shown below. The O'Dea-breccia-zone position extends under the profile; the Irishman vein is by extension.

projection of the Irishman vein was found with 200-ft coil spacings. Also, there may be an apparent resistivity effect in the VLF EM-16R data in the vicinity of the surface trace of the O'Dea breccia zone.

MASSIVE AND DISSEMINATED SULFIDES ON WILLOW CREEK AND PEDRO DOME

A zone of massive and disseminated Pb-Zn-Ag sulfides crosses Willow Creek near its junction with Cleary Creek. Fresh, unoxidized sulfide minerals can be seen in hand samples from a rubble pile in Willow Creek. A Max-Min profile was run across this zone. Sulfide mineralization is also found in claims on the flank of Pedro Dome, that were investigated with induced polarization.

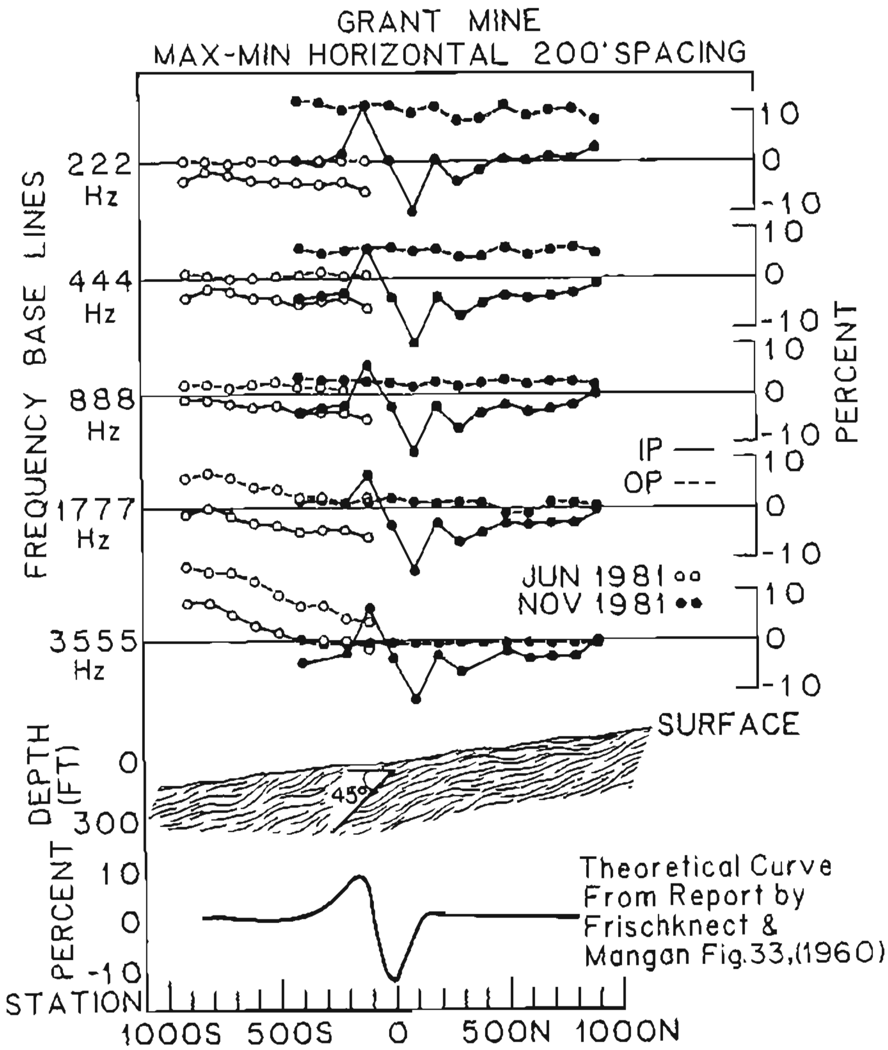

Figure 14. Max-Min II 200-ft duo-horizontal coil profile of Grant Gold Mine along line shown in figure 12. Open circles represent data taken in June before 200-ft level drift in O'Dea zone reached profile; solid circles represent data rerun and extended after the drift reached the profile. The cross section shows the curve of a 45°-dipping sheet-conductor model that fits the in-phase anomaly located where the Irishman vein would project to the line.

Max-Min Electromagnetic Profile

Only a preliminary 800-ft profile (fig. 15) using horizontal loops (100-ft coil separation) was run parallel to Willow Creek, starting from the Cleary Creek bed (fig. 1). The topography is rugged because of previous mining. Station 0 is located on a pile of sulfide-rich rocks at the side of Willow Creek. Station 400N is in the bed of Cleary Creek, and 400S is up Willow Creek. There is no obvious anomaly centered near the sulfide-rich rocks at station 0. The actual sulfide-bearing zone was not mapped from outcrops. One significant anomaly, present from about 50 to 350 ft north, closely resembles the in-phase response of a flat, horizontal sheet conductor at a depth of about 40 ft with an edge at 150 ft north and extending north under Cleary Creek. There is, however, no corresponding anomaly in the out-of-phase component, and the separation between maxima is too large for the 100-ft coil separation. No attempt was made to devise a more complicated model to fit the data, because the anomaly does not seem to be due to the massive-sulfide zone, which has a steep dip. Unfortunately, scheduling and access restrictions precluded further work; induced polarization might have proven effective.

Induced Polarization on Pedro Dome

Several sulfide-bearing mineralized zones containing gold anomalies occur on the southwest flank of Pedro Dome. A preliminary time-domain induced-polarization profile was run across the Diorite 2 and 4 claims (fig. 1) with a 100-m linear dipole-dipole array. The transmitter was a 4-amp Geotronics FT-4 transmitter and generator; the receiver was a Zonge GDP-12 two-channel geophysics receiver. We completed n = 1 to 4 with the transmitter between 100 and 200 ft southwest.

Figure 16 (top) shows the apparent resistivities plotted in pseudosection form. The resistivity generally increases with depth from 244 Ω-m at n = 1 and 359 Ω-m at n = 4. In the center, also in pseudosection, are the values of chargeability M (in milliseconds), which are in the low range for rocks. At the bottom are plotted the Fraser filtered values from an EM-16 survey (R.C. Swainbank, personal commun., 1981). There is general agreement between the higher values of chargeability and the positive filter values.

Previous Induced-polarization Surveys

Anderson and Johnson (1970b) ran three frequency-domain IP pseudosections across the Kawalita and Jamesonite veins on the north flank of Cleary Summit (fig. 1). They used a pole-dipole array with a 100-ft dipole to a distance of n = 5, or 500 ft. They found significant values of percent-frequency effect (PFE) defining zones of disseminated-sulfide concentrations of possible economic interest. The Jamesonite vein had a very well defined low-resistivity anomaly associated with the vein gouge, but had a smaller PFE than the Kawalita vein.

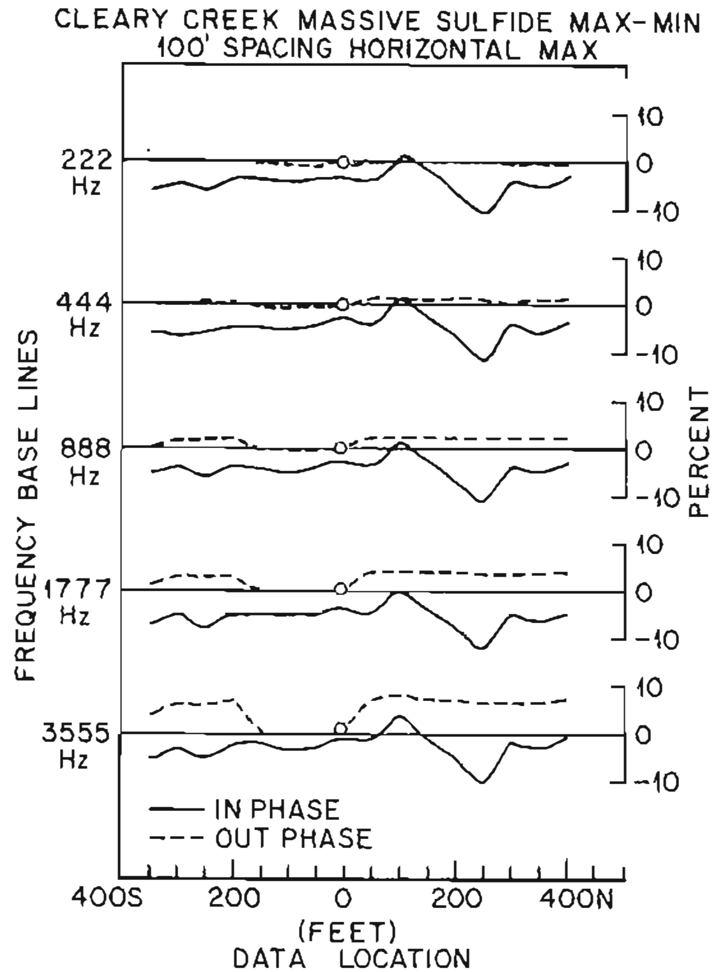

Figure 15. Max-Min II 100-ft duo-coil horizontal-loop profile across a massive disseminated sulfide zone near the junction of Willow and Cleary Creeks. The zone is believed to be near station 0.

Conclusions

Our work on this study was very limited. Truly massive-sulfide deposits with unoxidized, connecting conductors apparently are not known in the district. The sulfides we observed, and also those studied by Anderson and Johnson (1970b), are typically disseminated and badly oxidized near the surface. Induced-polarization techniques are likely to be useful in exploring for deposits with disseminated sulfides. The use of Max-Min electromagnetic surveys is less likely to be effective because of the apparent absence of truly massive-sulfide conductors. Many other geophysical techniques that might prove useful in sulfide exploration should be considered on a case-by-case basis.

SUMMARY AND CONCLUSIONS

Because the work described in this report was necessarily limited, this must be treated as a pilot study. Any proposed use of geophysical techniques in the district should be considered on a case-by-case, prospect-by-prospect basis.

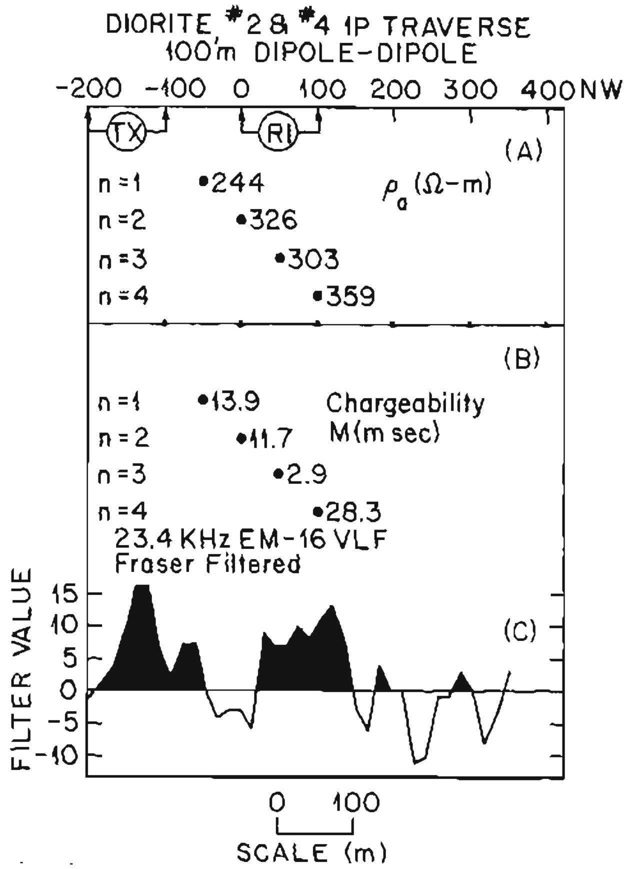

Figure 16. Resistivity, chargeability, and EM-16 VLF data, Pedro Dome. 16A - Pseudosection plot of apparent resistivity across mineralized zones on the Diorite 2 and 4 claims, NE ¼, sec. 3, T. 2 N., R. 1 E., Fairbanks Meridian. 16B - Time-domain induced polarization chargeability values corresponding to the resistivity points. 16C - Fraser filtered VLF EM-16 values along the same profile as the induced-polarization data. Positive second-difference values are shown shaded for comparison (R.C. Swainbank, personal commun., 1981).

No useful geophysical signal of a tungsten skarn zone was found on the Spruce Hen Mine. However, there appears to be a magnetic anomaly (on the south side of the zone) associated with an amphibolite unit that could be traced across country, and there may also be fair conductors in the schist that might also be useful structural tracers.

Seismic-refraction profiling, galvanic-resistivity vertical electrical soundings, and magnetic surveys seem to be useful in exploration of auriferous gravel deposits. These methods can be used to estimate depth of bedrock beyond present economic recovery.

Shear zones and veins on Ester Dome seem to be characterized by subtle resistivity contrasts. A small Max-Min anomaly characteristic of a dipping conductor, which might represent a vein fault in the Grant Gold Mine, was found. The very careful surveying of transmitter and receiver sites necessary for Max-Min surveys hinders its use in other than flat terrain. VLF EM-16 surveys are useful for tracing conducting units (probably graphitic schists) and possibly locating the general locations of shear zones. The addition of EM-16R measurements of apparent resistivity seems to be useful in locating near-surface conductors and interpreting structures. Induced-polarization techniques are probably also useful where the shear zones have disseminated sulfides and clay mineralization.

Sulfide deposits on upper Cleary Creek and Pedro Dome were briefly investigated with Max-Min EM and time-domain induced polarization, respectively. There does not appear to be enough conductivity associated with the sulfide zones for the Max-Min to be useful. However, induced polarization is probably a useful technique.

ACKNOWLEDGMENTS

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