GEOLOGICAL SURVEY OF CANADA

OPEN FILE 2503

Helicopter geophysical surveys at the Val Gagné test site, District of Cochrane, Ontario

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1992

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MINERAL RESOURCES DIVISION

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HELICOPTER GEOPHYSICAL SURVEYS AT THE VAL GAGNÉ TEST SITE, DISTRICT OF COCHRANE, ONTARIO[1]

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August 1992

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Map 2: Total-field VLF map (f = 21.4 kHz)

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Map 5: Apparent conductivity map (horizontal coplanar coils, f = 32 kHz).

ABSTRACT

This Open File presents five geophysical maps of the Val Gagné test site, District of Cochrane, Ontario (scale 1:10,000). The maps resulted from a helicopter geophysical survey carried out by Aerodat Limited of Mississauga, Ontario, under contract to Supply and Services Canada. The following maps are included in the package: 1) magnetic total field (contour interval 5 nT); 2) VLF total field at 21.4 kHz (transmitter NSS Annapolis); 3) VLF total field at 24 kHz (transmitter NAA Cutler); 4) apparent conductivity calculated from horizontal coplanar coil electromagnetic data at 4175 Hz; 5) apparent conductivity calculated from horizontal coplanar coil electromagnetic data at 32 kHz.

The test area is covered by 20 to 40 m of highly conductive varved clays (average resistivity 30 Ω.m). To obtain detailed information about the Quaternary geology at the site, ground geophysical measurements were carried out at the site by the staff of the Geological Survey of Canada. Previously, the Ontario Geological Survey drilled two boreholes at the site. Comparison of ground and airborne geophysical data with the results of drilling shows that penetration of airborne VLF and electromagnetic methods is limited by thick, highly conductive overburden. Total-field VLF maps did not provide useful information. Conductivity maps compiled from horizontal coplanar coil electromagnetic data provided good estimates of overburden conductivity and qualitative outline of bedrock topography. The magnetic map outlined mafic volcanic flows.

1. INTRODUCTION

Highly conductive overburden can negatively affect the usefulness of electromagnetic methods in mineral exploration. The most difficult area in Ontario is the Abitibi clay belt, where conductive lacustrine clays deposited in the former Lakes Barlow and Ojibway can reach a thickness of 60 m (Veillette, 1989). In the past 30 years, many ground and airborne electromagnetic instruments were designed to overcome the problem of conductive overburden. The manufacturers of these instruments expressed interest in documented sites, where they could test their equipment (Palacky, 1986).

After consultations with the private sector, the Geological Survey of Canada (GSC) and the Ontario Geological Survey (OGS) concluded that it would be desirable to establish a test site, where the ability of geophysical instruments to outline buried bedrock topography could be tested. R.B. Barlow of the OGS suggested an area east of Val Gagné, where buried bedrock valleys were known from previous geophysical surveys and drilling. A large area east of Timmins had previously been surveyed with a time-domain airborne electromagnetic system (INPUT) and selected features were followed up on surface with Geonics EM-31 and EM-34 equipment and drilled. The results of the Black River-Matheson program (BRIM) have been described by Pitcher et al. (1984).

The Val Gagné test site was outlined in 1985 after reconnaissance by the staff of Geophysics and Geochemistry Section of the OGS and Electrical Methods Section of the GSC. Later in the year, the GSC staff carried out resistivity soundings along selected profiles and OGS geophysicists used ground time-domain electromagnetic equipment. In the following year, several geophysical techniques were used by GSC scientists; apparent conductivity of the ground was measured by the staff of Electrical Methods Section using Geonics EM-16R, EM-31 and EM-34 equipment, and high-resolution optimum-offset seismic reflection surveys were carried out by the Terrain Geophysics Section (Pullan et al., 1987). In 1987-1988, the Electrical Methods Section surveyed the site with horizontal-loop APEX MaxMin I electromagnetic equipment. Detailed airborne electromagnetic measurements were carried out at the site in 1986 (time-domain, towed-bird GEOTEM surveys) and in 1987 (multifrequency, multicoil helicopter surveys). Interpretation of field results using a variety of data processing techniques continued until 1991. A summary of the project has been published by Palacky et al. (1992).

2. TOPOGRAPHY AND GEOLOGY OF THE TEST SITE

The Val Gagné test site is located 3 km east of the village of Val Gagné in the District of Cochrane in northeastern Ontario. The nearest city with an airport is Timmins, about 60 km to the west. The test site lies at latitude 48°35'N and longitude 80°35'W (NTS Reference 42A/10). The rectangular test site measures 2.7 km east-west and 6.1 km north-south (Figure 1). The area selected for investigation includes two distinct environments; in the south, the terrain is mostly flat and the is overburden thick; in the north, the rivers are deeply incised and the overburden is believed to be thinner. Black River flows north-northwest through the designated site.

The most important geological feature is the Pipestone Fault which crosses east-west through the area. Several gold deposits are associated with this fault in the Timmins area. Bedrock geology at the site is formed by pyroclastic rocks to the north of the fault and Precambrian sedimentary rocks (mostly siltstone) in the south. Mafic volcanic flows have been identified in the area by interpretation of aeromagnetic data.

Overburden consists of a thick layer of varved clays deposited circa 9000 years BP on the floor of the glacial Lake Barlow. In valleys buried by the lacustrine clay layer, glacial tills and glaciofluvial sands are known to exist. The Quaternary stratigraphy of northeastern Ontario and western Quebec has been summarized by Veillette (1989). Two boreholes drilled at the Val Gagné test site by the OGS intersected in excess of 30 m of varved clay, underlain by 2 to 4 m of glacial till. In one borehole, sand was also found (Palacky et al., 1992).

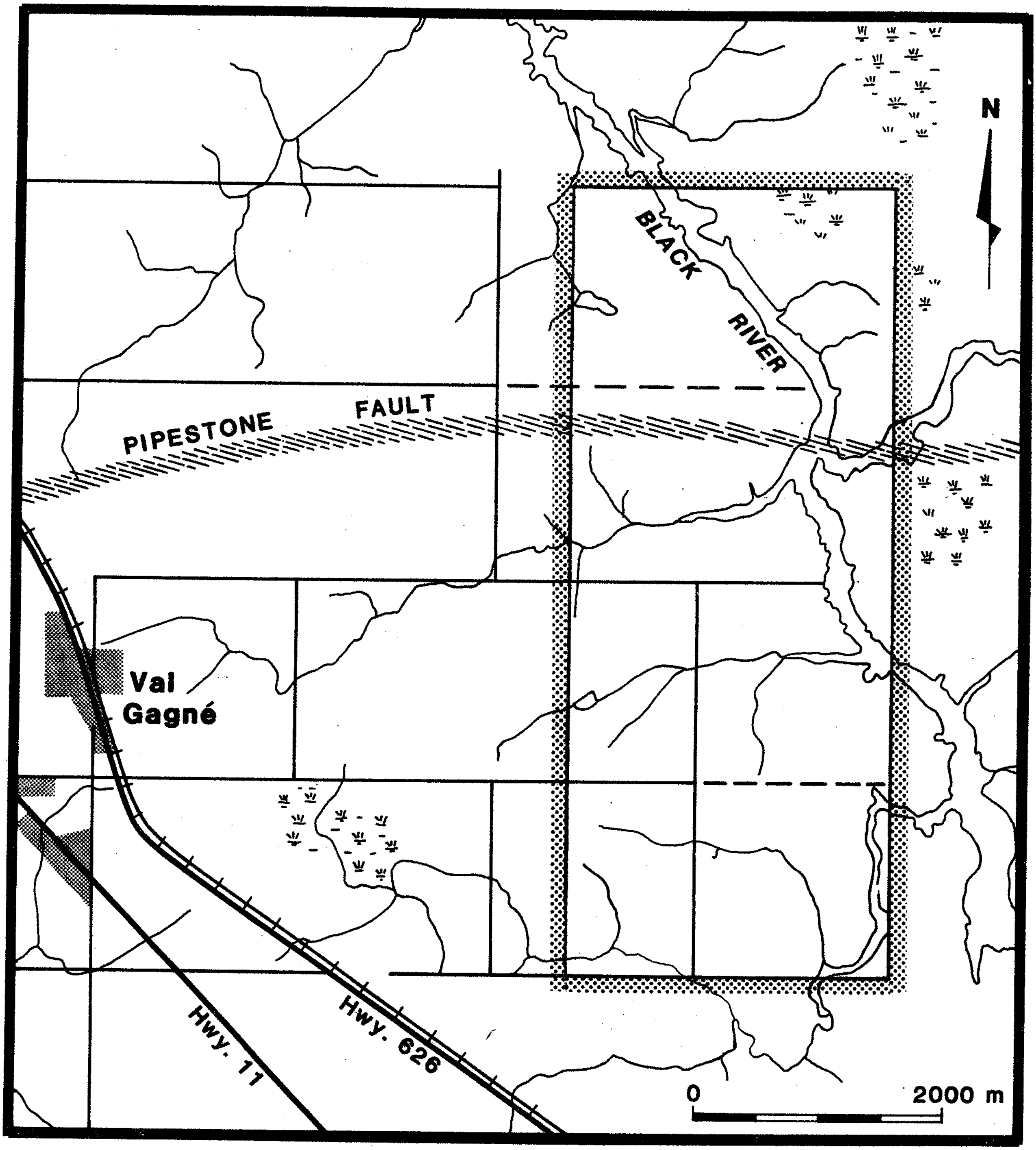
N
BLACK RIVER
PIPESTONE FAULT
Val Gagné
Hwy. 11
Hwy. 626
0
2000 m

FIGURE 1

3. AIRBORNE GEOPHYSICAL SURVEYS

3.1 Data Acquisition

Aerodat Limited of Mississauga, Ontario, carried out helicopter geophysical measurements at the test site in February 1987. The base station for the operations was the town of Matheson, 12 km to the southeast. The survey was flown along north-south lines with a spacing of 100 m. An Aerospatiale ASTAR 350 helicopter flew at an average speed of 100 km/h. The mean flight height was 60 m with a permitted tolerance of 5 m. The output of a Hoffman HRA-100 radar altimeter was recorded at 0.25 s intervals with an accuracy of 1 %. The navigation was aided by a Motorola Mini-Ranger system and helicopter positions were recorded at 0.1 s intervals. The recovery accuracy was ± 15 m. Technical details of the survey and flight records were included in the operation report (Lechow, 1987).

The main sensor was a multifrequency, multicoil electromagnetic system which was described in detail by Palacky and West (1991). Two pairs of vertical coaxial coils (spacing 6.5 m) were operated at frequencies of 935 and 4600 Hz, two pairs of horizontal coplanar coils at 4175 and 32,000 Hz. The measured parameters were in-phase and quadrature components at the four frequencies. Electromagnetic data were recorded every 0.1 s with a resolution of 0.1 ppm (parts per million of the ratio secondary to primary magnetic field). The effect of electrical transmission lines was monitored using a special 60 Hz channel. The nominal terrain clearance of the bird in which the transmitting and receiving coils were rigidly mounted was 30 m.

Simultaneously with electromagnetic measurements, magnetic and VLF data were acquired. Total-field magnetic data were measured using a Geometrics G-803 proton precession magnetometer. The recording interval was 0.25 s and the resolution 0.5 nT. The mean terrain clearance of the bird with the magnetic sensor was 40 m.

VLF data were acquired by means of the Totem-2A Herz system (Herz, 1986). Total-field and quadrature components were measured at two frequencies (21.4 kHz, transmitter NSS Annapolis, Maryland; 24 kHz, transmitter NAA Cutler, Maine). The data were recorded at an interval of 0.25 s and with a resolution of 0.25 %. The nominal terrain clearance of the VLF bird was 50 m.

Two instruments were used at a base station: a Geometrics proton precession magnetometer and a VLF Totem-2A Herz receiver. The output of the monitoring instruments was recorded digitally at 1 s intervals.

3.2 Data Processing

After the flight, the recorded data were transcribed into a database. The magnetic data were levelled and a preliminary contour map was generated to assess the need for additional levelling and filtering. The levelled and filtered data were gridded at 20 m interval. Electromagnetic data were calibrated, levelled and filtered using a statistical filter to reject sferics caused by distant thunderstorms. During the survey, sferics activity was low. VLF data were filtered to remove the effect of bird swing, which was substantial because of windy weather during the survey. The period of the bird swing (11.4 s) was determined experimentally. Subsequently, the VLF data were gridded using the same grid size as for magnetic data.

Proprietary software developed by Prof. R.N. Edwards of the University of Toronto was used to compile conductivity maps from electromagnetic data. Measured in-phase and quadrature values were fitted to precalculated responses of a 200 m thick horizontal layer. This model is considered equivalent to the homogenous half-space. (Penetration of the helicopter system with the frequencies used is less than 200 m.) As conductance (conductivity-thickness product) is the best determined parameter in electromagnetic surveys, the assumption of an unrealistically thick upper layer (overburden) would result in underestimating conductivity when compared with the true value or the results of surface electromagnetic measurements. Apparent conductivity data (units mS/m - milliSiemens per metre) were gridded (cell size 20 m) and contoured using logarithmic intervals (5 contours per decade).

The results of the survey were presented as stacked profiles of all measured and calculated parameters and contour maps. A set of five maps at a scale 1:10,000 is included in this Open File report:

- Map 1: magnetic total field (contour interval 5 nT);
- Map 2: VLF total field at 21.4 kHz (contour interval 0.5 %);
- Map 3: VLF total field at 24 kHz (contour interval 0.5 %);
- Map 4: apparent conductivity calculated from coplanar data at 4175 Hz (contour interval logarithmic, 5 per decade);
- Map 5: apparent conductivity calculated from coplanar data at 32 kHz (contour interval logarithmic, 5 per decade).

3.3 Comments on the Enclosed Maps

The **magnetic map** (Map 1) is useful for definition of bedrock geology. Several well-defined magnetic highs were detected in the course of the survey. Most likely, the anomalies are caused by mafic volcanic flows. Two parallel anomalies in the southern half of the area strike west-southwest - east-northeast. A well defined feature coincides with the Pipestone Fault. A parallel magnetic high was detected near the northern edge of the survey area. A north-south anomaly is visible in the centre of the test site. As expected, aeromagnetic data did not yield any information on Quaternary geology.

In **VLF total-field maps** (Maps 2 and 3), the only clear anomaly detected with both NAA and NSS stations coincides with the Black River. Because of thick overburden, the Pipestone Fault was not clearly defined by the measurements. However, on the NAA data, weak anomalies were detected approximately in the fault area.

The most useful products of the helicopter geophysical survey for overburden mapping are **apparent conductivity maps** (Maps 4 and 5). Conductivity patterns over the northern third of the area (north of the Pipestone Fault) differ from the remaining portion. In the north, an elongated anomaly of low apparent conductivity is associated with the Black River. The thickness of lacustrine clays is thought to be much smaller under the incised valley of the river. (However, no drilling information was available to confirm this interpretation.) The interpretation model used (thick layer of a constant thickness) causes a reduction in overburden thickness to appear on the map as lower apparent conductivity. Apart from the river, apparent conductivity values north of the Pipestone Fault average 10 mS/m (on the 4175 Hz map). In the south, the average apparent conductivity increases to about 20 mS/m. The values are about twice higher on the 32 kHz map. Compared with the conductivity values determined by ground measurements (Palacky et al., 1992), the high-frequency data provide a better match. This difference is most likely caused by the deeper penetration of the system at the lower frequency, thus including more resistive basement in the apparent conductivity estimate.

4. CONCLUSIONS

The contractor used state-of-the-art technology in the airborne geophysical survey and the results are of high quality. Predictably, aeromagnetic data provided information on bedrock geology. The VLF results were disappointing; because of thick overburden cover at the test site, even the prominent Pipestone Fault could not be clearly detected. Conductivity maps compiled from horizontal coplanar coil electromagnetic data provided conductivity estimates consistent with ground investigations (Palacky et al., 1992). The lesser thickness of overburden in the northern third of the test site (north of the Pipestone Fault) could be interpreted qualitatively from the conductivity maps.

ACKNOWLEDGMENTS

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