REPORT ON

AEROMAGNETIC DATA INTERPRETATION

BAUDETTE AREA, MINNESOTA

for

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

by

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TORONTO CANADA

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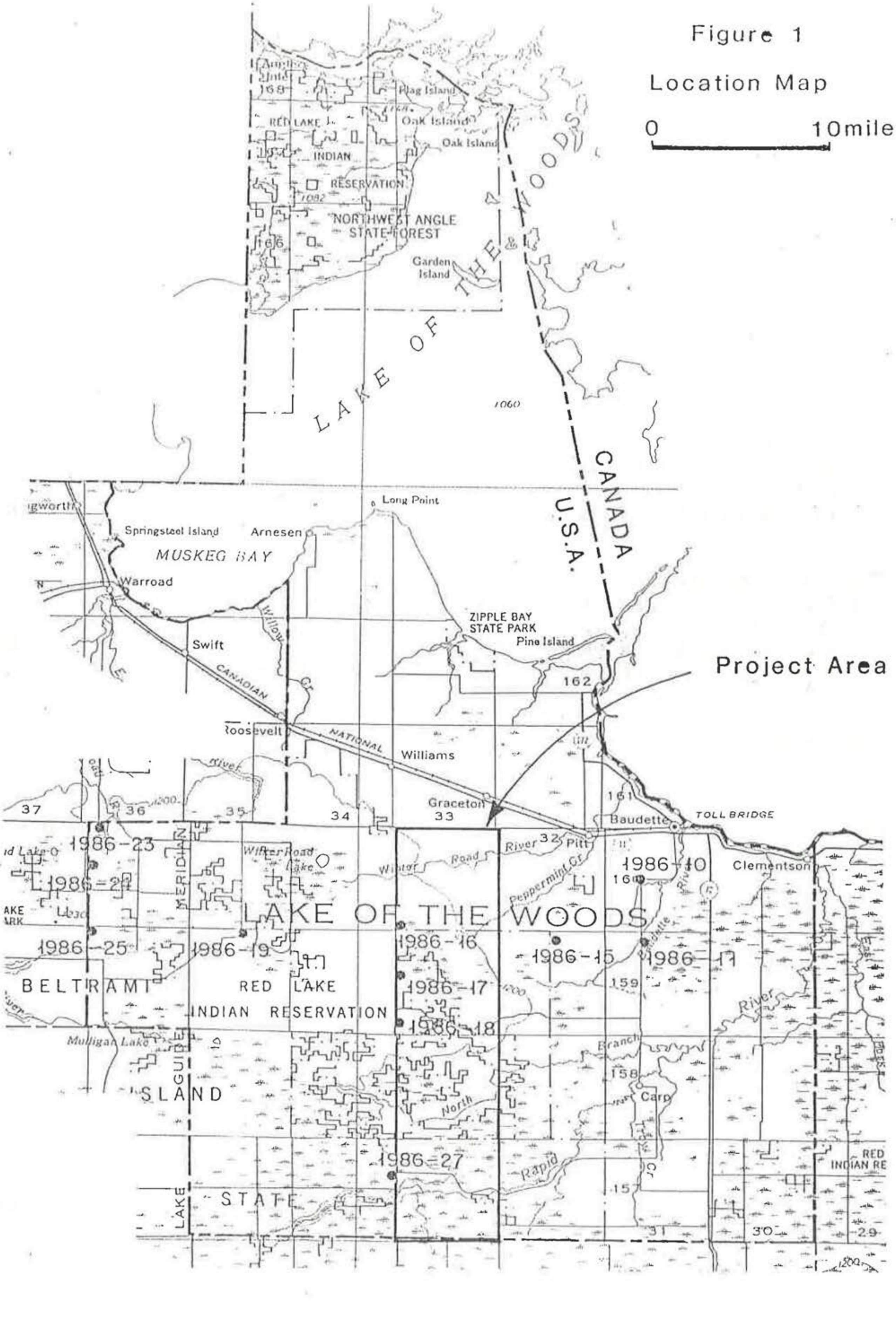
Figure 1

Location Map

0 10miles



1. INTRODUCTION

1.1 The Project Area

This report contains the results of an analysis of aeromagnetic data in an area located in Lake of the Woods County, as shown in Figure 1. Four townships are included; T157 to T160N, R33W; an area of 216 square miles. The area is mainly covered by swamp, with elevations ranging from 1100 to just over 1300 feet.

Principal objective of this work is geological mapping; to analyze and interpret aeromagnetic data in conjunction with all other available data, to elucidate the geology of buried Precambrian crystalline rocks with regard to structure, depth of burial and lithology.

1.2 The Aeromagnetic Data and Its Analysis

Aeromagnetic data analyzed in this study were taken from a relatively detailed survey conducted by the USGS in 1985. The survey replaces a previous 1949 USGS survey described by Meuschke et al (1957). That survey consisted of north-south lines at one mile spacing and 1000 foot altitude. The 1985 survey consisted of north-south lines at 1/4 mile spacing and 300 foot altitude.

A 9-track digital tape recording of the 'new' aeromagnetic data was supplied for this study by Dr. Bruce Smith of the USGS.

Figure 2 shows the location of the survey lines, as plotted from the digital tape recording, that cross the project area; lines 3471 to 3723. No east-west cross/tie lines were flown in the vicinity of the project area. According to the USGS, some difficulty was encountered in positioning of the survey lines because of the featureless topography.

A 1:50,000 scale contour map compilation of the data was also supplied.

For purposes of this study, profiles of the magnetic survey data (minus Geomagnetic Gradient) and aircraft altimeter data were constructed at 1" = 50 and 500 gammas and 1" = 600 feet scales.

About 650 line miles of aeromagnetic data were analyzed in this study.

The magnetic data analysis was done with reference to model anomaly profiles, shown in Figures 3a and 3b. The profiles simulate anomalies created by prismatic bodies as seen in north-south lines. Magnetic field characteristics for the area in 1985 are described as follows (see USGS Geophys. Invest. Maps 9P-986-D,I and F);

declination: 5% E
inclination 76% N
intensity 59,800 gammas

The model curves have been generated for a declination of 5%E and inclination of 76%. They provide a basis for determining the location of magnetic contacts, magnetic bedding attitude, and depth of burial of a magnetized unit.

In Figure 3c, a plan view is given of a typical anomaly in contour form. This figure is taken from Vacquier et al(1951) who give a series of model anomaly maps for various model shapes and orientations. They also provide methods for magnetic susceptibility estimation. From susceptibility determinations, estimates of magnetite content may be obtained using an empirical relationship derived by Mooney and Bleifuss (1953) using a suite of 75 rock samples from Minnesota. The least squares relationship is shown in graphical form in Figure 3d.

The analysis included a correlation with the radar altimeter data to determine which magnetic features had been amplified or attenuated by variations in aircraft/ground clearance.

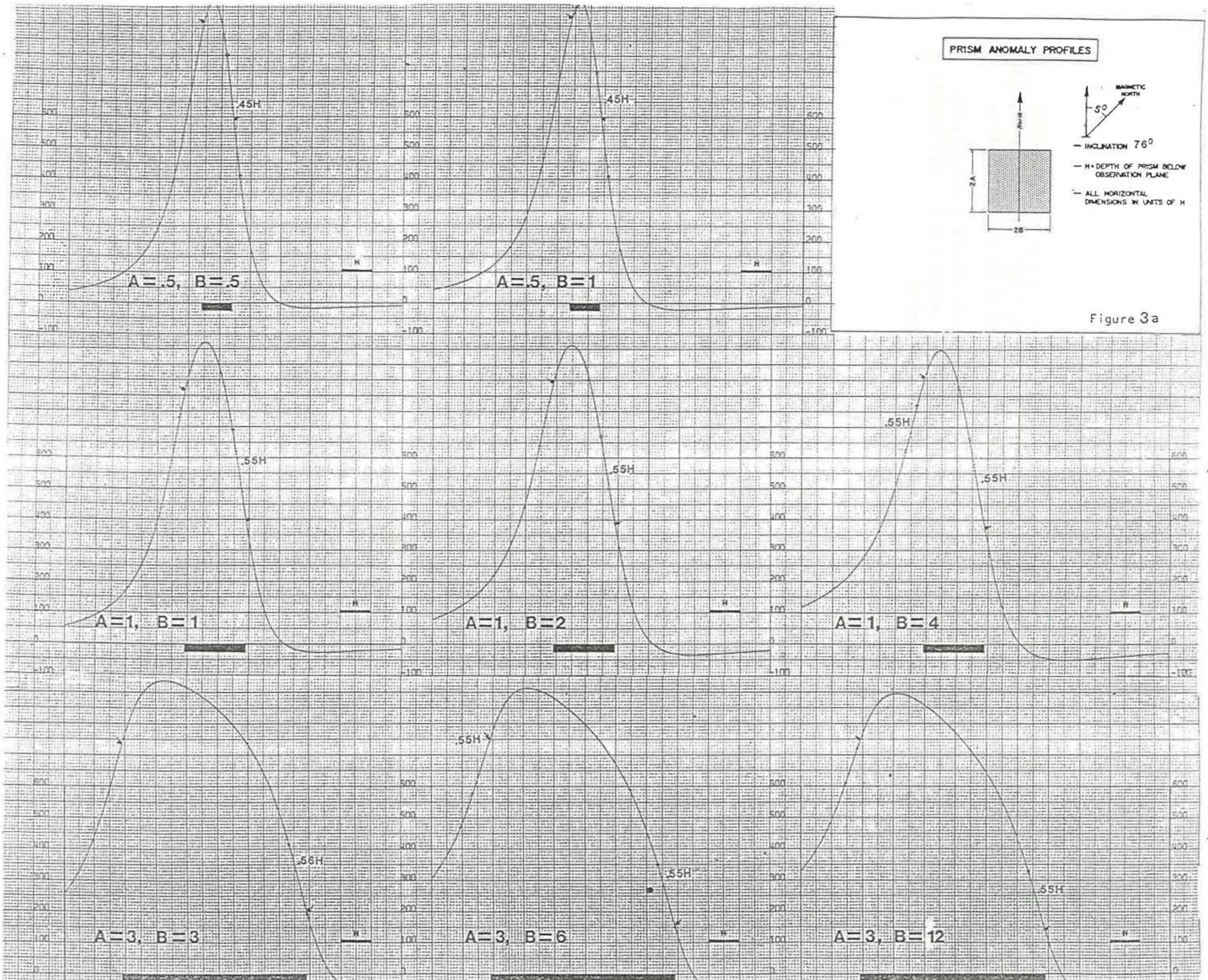
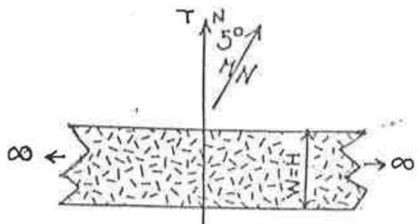

PRISM ANOMALY PROFILES
MAGNETIC NORTH
5°
— INCLINATION 76°
— H = DEPTH OF PRISM BELOW OBSERVATION PLANE
— ALL HORIZONTAL DIMENSIONS IN UNITS OF H
2A
2B
A=.5, B=.5
A=.5, B=1
A=1, B=1
A=1, B=2
A=1, B=4
A=3, B=3
A=3, B=6
A=3, B=12
.45H
.55H
.56H
H
600
500
400
300
200
100
0
-100

Figure 3a

Figure 3b

DIPPING PRISM ANOMALIES

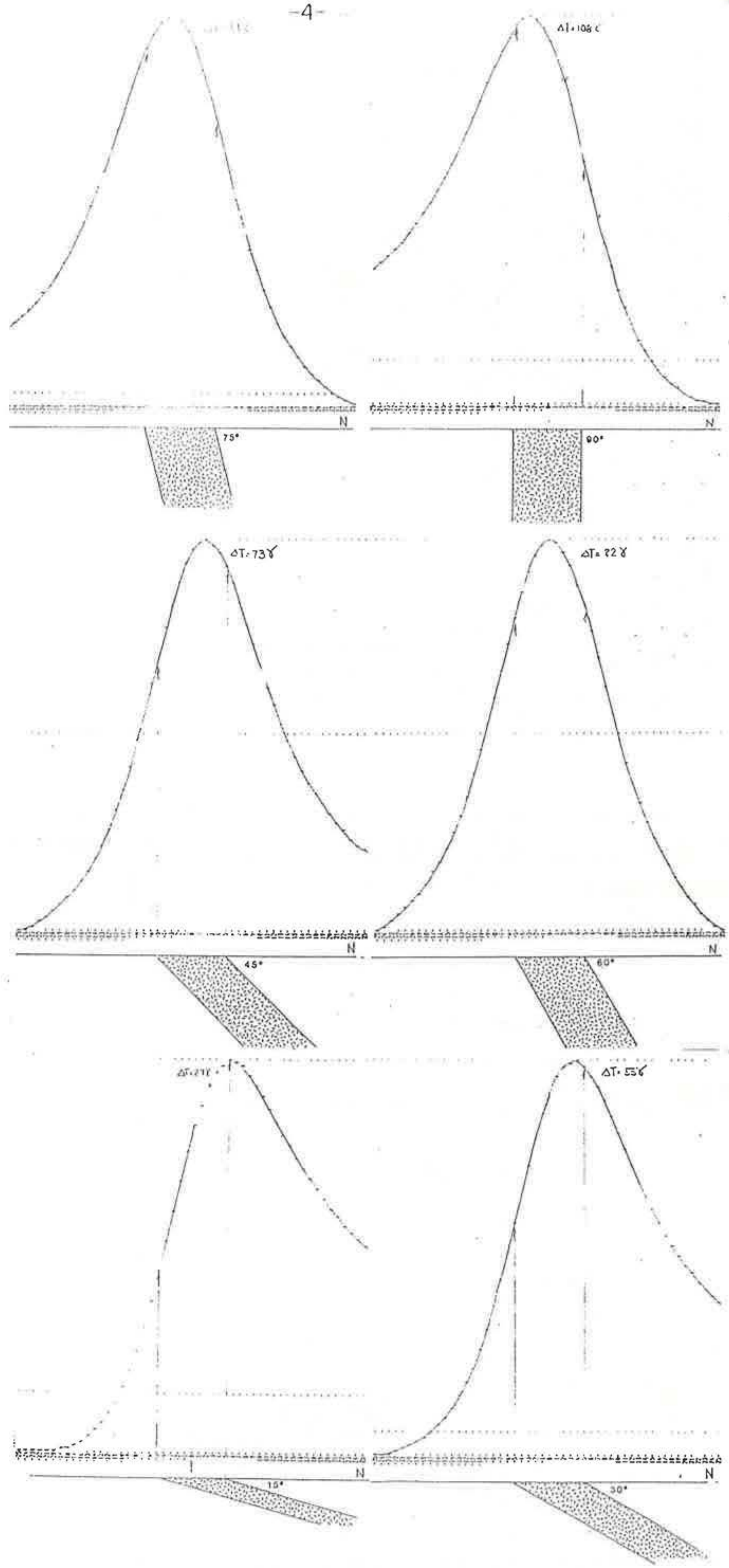


field inclination: 76°

field intensity: 59800 γ

prism depth: 10Δ (Δ=50')

susceptibility: 1000×10^{-6} cgs



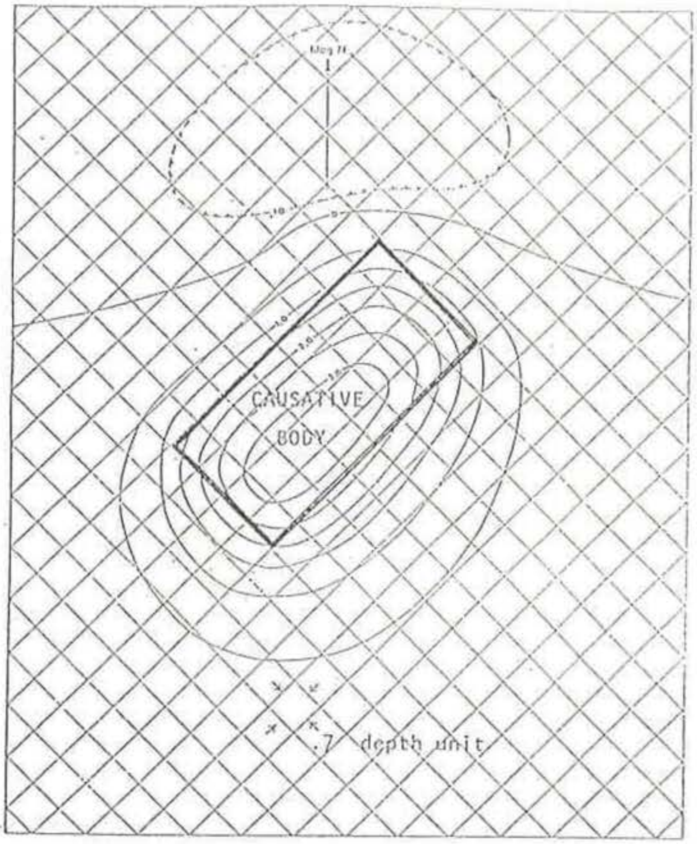


Figure 3c Prism Model Anomaly

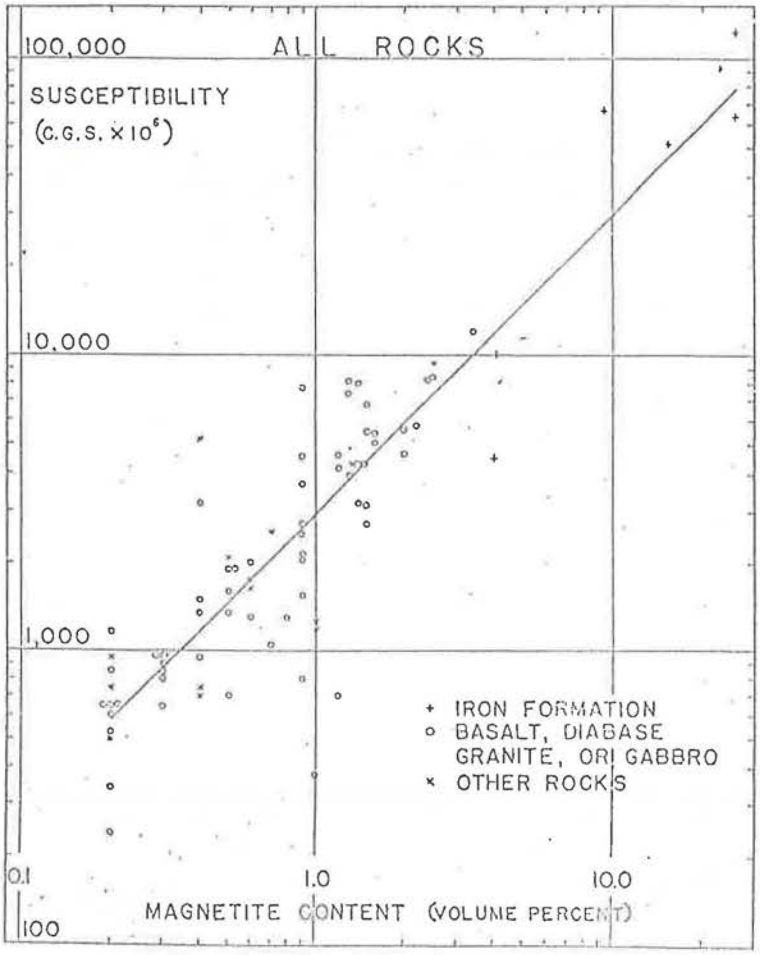
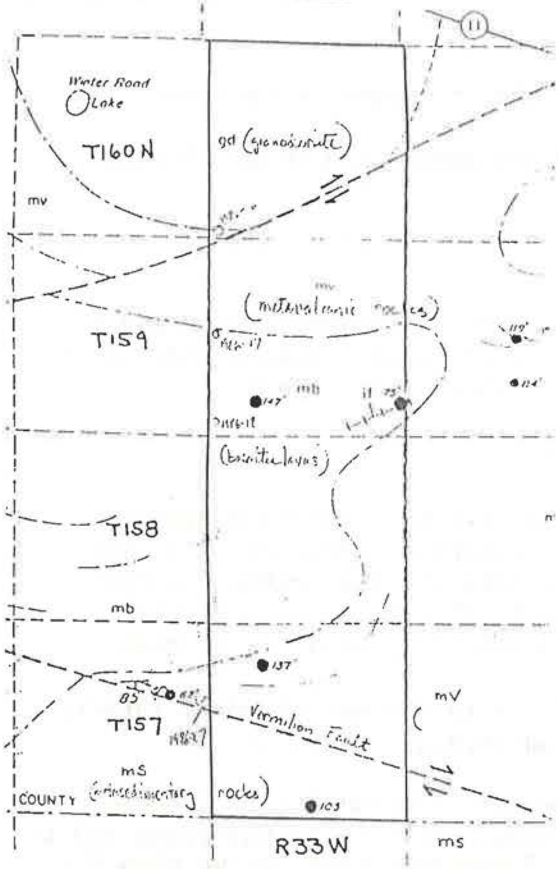


Figure 3d Magnetite and magnetic susceptibilit

1.3 Geological Setting



According to Sims and Ojakangas (1975) there are no known bedrock exposures in the project area. They produced a pseudo-geological map of the area using some rather widely scattered drill hole data and the 1949 aeromagnetic data supplemented by gravity data published by McGinnis et al (1973). Their map is seen across. Three principal lithologic units were discerned;

- granodiorite to the north,
- metavolcanic rocks (mv) and mafic units (mb), and iron formation.
- metasedimentary rocks (ms) to the south.

Right-lateral faults are shown to cross the southern part of the area.

As part of Minnesota's contribution to the USGS CUSMAP project in the Roseau Quadrangle, four drill holes were completed in 1986 (1986-16,17,18 and 27). Their locations are shown in Figures 1 and 2, in relation to the aeromagnetic survey. A summary of the logging, taken from Mills et al (1987) is given below;

drill hole	depth to bedrock	bedrock	comments
1986-16	300'	gneissic tonalite	
-17	190'	gabbro	magnetic rock
-18	335'	plagioclase porphyry	highly weathered
-27	30'	hornblende schist	

Prospecting interest is directed to metavolcanic or 'greenstone' rocks because they host massive sulfide basemetal deposits, particularly to the northeast, in Canada. For example, the Mattabi orebody at Sturgeon Lake consists of 13 million tons of 0.9% copper and 7.6% zinc. The orebody is associated with a conspicuous 300 gamma aeromagnetic anomaly observed at 500 foot altitude.

1.4 Correlation With Gravity Data

The gravity map of the area (McGinnis et al, 1973) shows -30 mgal gravity anomalies in the north and south halves of the area. These negative effects may be attributed to the lower density of granitic rocks and metasedimentary rocks, respectively. The metavolcanic rocks occupying the central part of the area are associated with a relatively positive effect.
This gravity data was collected in the course of a reconnaissance survey of Minnesota, involving measurements at one mile interval along roads or section corners where elevations were known from published topographic maps. Further gravity surveying is necessary to detail many of the features that are prominent in the data.

2. GEOLOGICAL INTERPRETATION

The results of the analysis and geological interpretation of the aeromagnetic data are presented at 1:62500 scale as Figure 4.
The map shows the location of magnetized rocks, their depth below ground and their structure.

2.1 Magnetic/Lithological Units

Areas of similar magnetization were distinguished and outlined in the interpretation map as 'magnetic units'. On the basis of drill hole data and recognized characteristics of rock units in published geological mapping the magnetic units are given a lithological identity.

Metavolcanic and associated units

10 to 3000 gamma anomalies that reflect long, rather linear, mainly west-trending magnetic zones. These rather narrow zones are separated by non-magnetic intervals. Metavolcanic rocks are associated with these anomalies that occupy a 10 mile wide interval that extends across the map area in an arcuate-shaped pattern. The metavolcanic rock interval is also marked in the published gravity map as a 30 mgal. increase over areas underlain by granitic or metasedimentary rocks.
We may further divide this interval into 3 sub-units, in addition to the non-magnetic intervals which probably reflect volcanoclastic and/or felsic volcanic units, e.g., rhyolite.

mv — Moderately magnetic zones are associated with relief of from 10 to 200 gammas. From modelling, the susceptibility contrast of these units is in the range 100 to 1000 x 10^{-6} cgs units and according to Mooney and Bleifuss, these rocks have 0.1 to 0.3% minimum magnetite content.

mvb — a much more magnetic volcanic facies is evident by magnetic relief of from 300 to 3000 gammas (1 to 10% minimum magnetite content). Two or three of these zones appear to be involved in a west-trending synclinal structure near the boundary of T157 and T158. Probable lithology is metabasalt.

IF — a 4000 to 7000 gamma anomaly dominates the central part of the map. According to Sims and Ojakangas (1973), the anomaly is due to iron formation. Estimated magetite content is 20 to 30%. The iron formation is seen to be intimately associated with the mafic metavolcanics.

Metasedimentary Rocks

ms — metasedimentary rocks are associated with depressed levels in magnetic intensity in the aeromagnetic data. Drill hole 1986-27 encountered hornblende schist (with high copper and zinc grades). These rocks also appear to have lower bulk density as compared to the metavolcanic sequence to the north.

Intrusive Rocks

magnetic intensity levels in the north third of the area which is underlain by granodiorite, are observed as much more uniform or less erratic than levels over the metavolcanics. In comarison to metasedimentary rocks, the granodiorite is associated with a 50 to 250 gamma increase in magnetic intensity. This is indicative of a 0.1 to 0.3% increase in magnetite content.The south contact of the granodiorite with the metavolcanics appears to be fairly well definable.
A stock-like granitic intrusive is outlined in T157N, in contact with metasedimentary rocks.
It exhibits magnetization quite similar to that associated with the granodioritic rocks.

narrow, dyke-like anomalies are conspicuous in the north half of the area against the uniform magnetic background of the granodiorite. The anomalies are mostly negative in polarity; -50 to -200 gammas in amplitude. A NNW-trending swarm of these dykes appears to cross the area, apparently in association with a parallel fault zone.

2.2 Structure

A number of structures may be deduced from the aeromagnetic data;

(a) synclinal fold structure. Magnetic anomalies linked to the metavolcanic assemblage, invariably display asymetry indicative of northerly dipping, as opposed to vertically dipping attitude. A synclinal structure is deduced from the distribution of the mafic metavolcanic units. The axial plane of the syncline appears to have been rotated and is now dipping northerly. This rotation may help to explain the 1 to 2 mile displacement between the synclinal axis and the gravity anomaly peak.

(b) West-trending faults. The contact between the metavolcanic and the metasedimentary rocks to the south appears to be a fault zone as judged by the linearity of the contact and the strong gravity gradient across it.
A second west-trending fault may be coincident with the contact between the metavolcanic rocks and the granodioritic rocks to the north.

(c) NNW-trending faults. Granodioritic rocks and metavolcanic units appear to have been dislocated or sheared by NNW-trending faults. This structure appears to be associated with a dyke swarm. Similar deformation appears to have affected the granitic stock in T157N.

(d) Other faults. The WSW-trending Quetico Fault is associated with a magnetic contact that is located in granodioritic rocks.
A major northerly-trending fault zone is suggested by the abrupt termination or dislocation of magnetic anomalies near the east border of the project area.

2.3 Depth to Magnetic Basement

Magnetic basement in this area is covered by unconsolidated surficial deposits of Quaternary age and highly weathered non-magnetic Precambrian rocks or regolith. Contours of depth to magnetic basement below ground are included in Figure 4, at 100 foot interval.
Depth determinations were made at most magnetic contact locations. The determinations are considered to have an accuracy of +/- 20%. Thus a determination of 200 feet (plus 300 feet aircraft height) would have a reliability of +/- 100 feet.
To avoid obscuration of other aspects of the aeromagnetic interpretation, individual depth determinations were not included in Figure 4.
Depth determinations were found to vary from less than 100 to over 400 feet. Two basement depressions (depths greater than 400 feet) are expressed;

- in the northeast part of the map, over granodiorite,
- near the south border of the area.

Elsewhere, magnetic basement, for the most part, appears to be at depths of 200 +/- 100 feet.

2.4 Summary and Recommendations for Follow-Up Investigation

A 10 mile wide 'greenstone' belt is delineated from the aeromagnetic and gravity data. The belt includes magnetized volcanic members of intermediate and mafic composition and iron formation. Intervening non-magnetic, possibly felsic members attract interest as preferred mediums for massive sulfide, base metals mineralization.

Certain structural environments may be attractive in terms of potential gold mineralizion;
(1) the axial part of the synclinal fold structure involving mafic metavolcanic units,
(2) along west trending fault zones that border the metavolcanic belt on its north and south flanks,
(3) along the NNW-trending fault zone that crosses the metavolcanic belt.

VLF electromagnetic surveying may be considered as an economical means for testing for conductivity anomalies along some of these structures. However the thick cover of Quaternary and regolith cover may make it difficult to achieve penetration by this prospecting method.

Additional gravity surveying is necessary in the area. There is a good correlation between some of the aeromagnetic structures and gravity features, but the gravity coverage to date must only be considered as reconnaissance in scope.

The analysis of the survey data embodied in this report is essentially a geophysical appraisal of the area. As such, it can incorporate only as much geological and geophysical information as the interpreter has available at the time. It should be judiciously used therefore as a guide only by geologists thoroughly familiar with the area and who are in a better position to evaluate the significance of any particular feature. With additional information, such as that provided by other surveys and eventually drilling, it may be possible to revise the significance of features identified in this study.

Respectfully submitted,

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