A Detailed Magnetic Survey of the St. Lawrence River: Oak Point to Lake Ontario, New York

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OF THE
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ABSTRACT

Measurements of the total intensity of the earth's magnetic field in the St. Lawrence River between Oak Point and Lake Ontario indicate magnetic anomalies of high magnitude and steep gradients due to rocks of varying magnetic susceptibility in the Precambrian basement complex. The anomalies and magnetic contours that trend continuously across the river indicate no large lateral offset in this area. Also, magnetic anomalies associated with diabase dikes in the Gananoque, Ontario, and Grindstone Island areas indicate no lateral offset in that area.
MAGNETIC MAP OF THE ST. LAWRENCE RIVER

Oak Point to Lake Ontario

by

Frank Revetta
John Cardinal

This map is based on a magnetic survey, conducted by the Department of Geology, SUNY, Potsdam, NY, during summer 1976 with the support of a grant from the New York Sea Grant Institute. Measurements of the total intensity of the earth's magnetic field were made with a proton precession magnetometer. A 57,000 gamma regional magnetic field value was subtracted from each total intensity measurement and the difference plotted on a base map for contouring. Hachured contour lines indicate lower magnetic intensity and lines are dashed where data are incomplete. No correction was made for regional variation.
INTRODUCTION

This report presents the findings of a detailed magnetic survey of the St. Lawrence River conducted during summer 1976 under a grant by the New York Sea Grant Institute. We investigated a possible major geologic structure running along the St. Lawrence River into Lake Ontario. Some researchers have suggested a possible geologic alignment connecting the seismically active northeastern St. Lawrence River Valley in Canada and the seismic activity in the Attica, NY area (Dames and Moore 1974). We undertook this investigation to determine whether any such geologic structure might be revealed by a detailed precision magnetic survey.

The approach used in this investigation was to determine whether a highly magnetic dike swarm mapped in the Gananoque, Ontario, and Grindstone Island areas continued to cross the river to the US mainland. The dikes in the St. Lawrence River are covered by Paleozoic rocks and water so they are not able to be mapped by conventional field geologic methods. We made magnetic measurements to determine whether the dike swarm could be traced into the New York side of the river without offset. If so, then the possibility of strike-slip movement would be locally eliminated.

A total of 170 traverses were made at intervals of one-quarter mile (402 m) across the St. Lawrence River from Oak Point to Lake Ontario, NY (Figure 1). Over 3,500 total magnetic field measurements were made along the traverses at 200 to 400 feet (61 to 122 m) intervals. These measurements were plotted on a base map with a scale of 1:30,000 and contoured at intervals of 100 and 200 gammas (Plate 1).
FIELD PROCEDURE

We made measurements in a 15 foot (4.6 m) nonmagnetic fiberglass boat. Preliminary measurements on the boat indicated that the boat had no magnetic effect. The proton sensor was placed in the front of the boat away from the motor and connected to the magnetometer with a 6 foot (1.9 m) sensor cable. The sensor was free from any stray magnetic materials.

The magnetic stations were located on the most recent National Oceanic and Atmospheric Administration maps of the St. Lawrence River with a scale of 1 inch equal to 2,500 feet (l in equal to 760 m). Station locations were established by running straight line traverses by dead reckoning. Boat velocity was constant and measurements were made at equal time intervals to enable us to establish the location of the station on the traverse.

EQUIPMENT

A Varian M-50 Portable Proton Precession Magnetometer with a sensitivity of $\pm 1$ gamma was used for all magnetic measurements. This instrument measures in gammas the total intensity of the earth's magnetic field. The instrument is ideally suited for this project because of its compact size and light weight. The instrument requires no leveling.

The instrument requires three 18v DC rechargeable lead acid batteries, which were recharged each night to assure best operation of the instrument. The field intensity range of the instrument is 25,000 to 85,000 gammas. All measurements in this project were between 56,000 and 60,000 gammas. The operating range of the instrument is 14°F to 120°F, well within the temperature variation recorded in the field. The accuracy of the instrument is reported as $\pm 3$ gammas.
REDUCTION OF OBSERVATIONS

The total intensity magnetic measurements were not corrected for any diurnal variations of the earth's magnetic field and instrumental drift. A correction for the diurnal variation assumes the earth's magnetic field varies linearly with time; this assumption is not true. There is no instrumental drift associated with the instrument, so this correction was not made. It was not necessary to correct the observed magnetic intensity values for latitude since inspection of the Total Magnetic Intensity Map of the United States indicates that the 58,000 gamma contour runs along the St. Lawrence River. A 57,000 gamma regional magnetic value was subtracted from each total field magnetic measurement and the difference plotted on a base map for contouring.

GEOLOGY OF THE AREA

The location of the magnetic survey is shown in Figure 1. It includes the Upper St. Lawrence River Valley between Oak Point and Lake Ontario. It is bounded on the northwest by the Canadian Shield, on the southeast by the Adirondack highlands, and in the southwest by Lake Ontario. The dominant feature of the upper St. Lawrence region is the Frontenac Axis, a ridge of uplifted basement which crosses the area from northwest to southeast, connecting the Adirondacks with the Canadian Shield (Dames and Moore 1974). For the most part, the Frontenac Axis is underlain by high grade metamorphic rocks of the Grenville Group. The Precambrian basement rocks in the area of the survey are alaskites, granite gneisses, marbles, paragneisses, quartzites, and diabase dikes. These rocks are unconformably overlain by the Paleozoic sequence of the Cambrian Potsdam Sandstone and Theresa sandy dolomite (Arshing 1910).
FIGURE 1 Location of Magnetic Survey
Discussion of Magnetic Anomalies

Magnetic anomalies reveal the location and configuration of various types of geologic structures. When the structures are buried, the magnetic method provides an economic means for detecting and examining them. Magnetic anomalies in the St. Lawrence River between Oak Point and Lake Ontario, NY are shown in the accompanying magnetic map series.

The magnetic data on this series of maps were compiled along straight line traverses as shown on the maps. The anomalies expressed by the magnetic contours are due to rocks of variable magnetic intensity in the underlying basement. The high magnetic anomalies probably indicate the presence of:

1. basic rocks such as diabase, gabbro or serpentine;
2. concentrations of magnetic minerals in granite or granite gneisses;
3. diabase dikes;
4. faults;
5. lithologic contacts of rocks with different intensities of magnetizations.

The magnetic anomalies on the map series are discussed in the following paragraphs under the geographic areas: Holmes Point to Deer Island (Chart 15); Whiskey Island Shoal to Bartlett Point, NY (Chart 16); and Bartlett Point to Cape Vincent, NY (Chart 17).

Holmes Point to Deer Island (Chart 15)

The Holmes Point to Deer Island sheet extends from 75° 40' to 75° 54' west longitude. The magnetic contours in this area extend continuously across the river without any evidence of lateral displacement. The anomalies are of low magnitude and gentle gradient. In the northeast at Birch Point, there are three elliptically shaped magnetic highs extending across the river.
Between Oak Point and Grenadier Island, the magnetic contours are widely spaced indicating low magnetic gradients. This suggests the basement has little variation in its intensity of magnetization in this area. South of Grenadier Island, the magnetic anomalies have large magnitudes (2,000 gammas) and gradients (1,000 gammas/mi). These magnetic anomalies may be due to basic volcanic rocks that outcrop along the south short of Grenadier Island and extend southeastward beneath the river. Another possibility is that the anomalies are due to variations in the concentrations of magnetite or other magnetic minerals in alaskite in the basement complex.

Whiskey Island Shoal to Bartlett Point, NY (Chart 16)

This map extends from 75° 54' to 76° 6' west longitude. It includes Alexandria Bay, Wellesley Island, Hill Island, and One Island. A series of elliptically shaped magnetic highs ranging from 800 gammas to 1,600 gammas extend southwestward between Wellesley Island and the Canadian mainland. Between Wellesley Island and the US mainland are a series of elliptical to circular shaped magnetic highs and lows with very steep gradients. These anomalies may be accounted for by variations in concentrations of magnetite in the alaskite that outcrops between Alexandria Bay and Fishers Landing. Southwest of Wellesley Island, the magnetic anomalies have high magnitudes (2,000 gammas) and steep gradients. Most of the small islands in this area are mapped as alaskite. If we assume the basement complex beneath the river is alaskite, then the most reasonable explanation for these anomalies are variations in the concentration of magnetite within the alaskite basement rocks.
This map is located between 76° 6' and 76° 20' west longitude. It includes Gananoque, Ontario, Grindstone Island, Howe Island, Wolfe Island, and Carleton Island. This sheet contains a great number of magnetic anomalies with large magnitude and steep gradients (Wolfe Island, Ontario, map no. 84146, 1970). The anomalies in this sheet may be due to faults, diabase dikes, concentrations of magnetite in alaskite, and lithologic contacts.

Most of the small islands in this area are mapped as alaskite. If we assume this rock makes up the Precambrian basement below the water level, then a most likely explanation for the anomalies would be concentrations of magnetite in the alaskite.

Aeromagnetic profiles have been constructed from the aeromagnetic map of the Gananoque, Ontario, area (Dames and Moore 1974). Some of these aeromagnetic anomalies on the profiles were interpreted as faults. An example of such a fault is shown as A-A' (Charts 16 and 17) between Grindstone Island and the Canadian mainland. Where the fault leaves the bed of the St. Lawrence River and continues on land in a northeast direction, it is associated with a known fault in Precambrian terrain. This fault (A-A') has a series of magnetic highs along its southeast side. Other faults, such as B-B', C-C', and D-D', seem to cut directly across some magnetic anomalies and show no correlation with the anomalies.

The bedrock or Grindstone Island is Precambrian hornblende granitic gneiss and quartzite. These units are unlikely to cause the magnetic anomalies unless they have concentrations of magnetic minerals in them. The legend of the New York State Geologic Map (Fisher 1961) indicates no magnetite found in these units. A likely explanation for some of the anomalies in this
region is highly magnetic diabase dikes. These dikes are discussed in the following paragraphs.

The remainder of the Bartlett Point-Cape Vincent sheet contains many elliptically shaped magnetic anomalies due to the basement rock underlying the St. Lawrence River and Paleozoic sediments. These anomalies may be due to concentrations of magnetic minerals in alaskite. Alaskite is known to outcrop in many of the island and along the shores of the St. Lawrence River. Magnetic traverses of some alaskite bodies indicate magnetic highs of 2000 gammas associated with them. Another possibility is that magnetic highs are due to basic volcanic rocks. Basic volcanic rocks have been mapped in at several locations (Hewitt 1964) along the river. Basic rocks tend to produce high magnetic anomalies.

**Diabase Dikes**

Many diabase dikes have been mapped by conventional geologic field mapping in the area of this survey. A northwest set of dikes occurs at Gananoque, Ontario (Figure 2). Seven have been located on Grindstone Island and are mostly of large size, ranging from 20 to 100 feet wide. Two have been found on Wellesley Island and several have been found in the Alexandria Bay quadrangle.

The northwest trend of the dike swarm at Gananoque suggests they extend from Gananoque, Ontario, across Grindstone Island and into the Clayton area of mainland United States. If this dike swarm can be traced across the river into New York without offset, then the possibility of lateral strike slip movement along the St. Lawrence River would be locally eliminated.

Magnetic traverses were carried out across five similar Precambrian diabase dikes in the Alexandria Bay quadrangle. These traverses indicated large
FIGURE 3  Magnetic Profile across Diabase Dike near Redwood, NY
magnetic anomalies ranging from 1,100 to 5,600 gammas (Table 1) produced by dikes.

<table>
<thead>
<tr>
<th>Dike</th>
<th>Magnetic Anomaly (gammas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,000</td>
</tr>
<tr>
<td>2</td>
<td>5,600</td>
</tr>
<tr>
<td>3</td>
<td>1,100</td>
</tr>
<tr>
<td>4</td>
<td>3,800</td>
</tr>
<tr>
<td>5</td>
<td>2,100</td>
</tr>
</tbody>
</table>

TABLE 1 Magnetic Anomalies Across Diabase Dikes

A typical magnetic profile of a dike located 1.5 miles southwest of Redwood is shown in Figure 3. The large magnetitudes produced by these dikes indicate they are capable of being detected by ground magnetic measurements whenever they are not deeply buried.

A study of the Canadian aeromagnetic map (Gananoque, Ontario, Map No. 8393G 1970) indicates no large magnetic anomalies in the river just south of Gananoque that could be due to diabase dikes. Our magnetic measurements in the area between Gananoque and Grindstone Island indicate that the magnetic field is rather uniform, with no evidence that diabase dikes lie below the St. Lawrence River in that area. However, just southeast of Grindstone Island a magnetic high of 2,000 gammas occurs. This magnetic high is aligned with diabase dikes on Grindstone Island and is probably due to diabase dikes in the basement below the river. A series of magnetic highs also extends eastward from Grindstone Island along the 44° 16' parallel. These anomalies may also be due to diabase dikes.

A study of the geologic map of the Clayton quadrangle, NY, (Cushing, 1910) indicates no diabase dikes. In this area, most of the Precambrian basement complex is covered by Paleozoic sediments so they would not be mapped by
conventional methods. A study of an aeromagnetic map of the Ogdensburg, NY (L.K.B. Resources, Inc. 1974), area for the USGS indicates a series of northwest trending magnetic highs with magnitudes of over 1,000 gammas. These magnetic highs could be due to an extension of the diabase dikes from Gananoque through Grindstone Island and onto the US mainland near Clayton, NY. There is probably one dike, or possibly more, between Grindstone Island and Clayton, NY, on the mainland. The presence of three magnetic highs in the Clayton Quadrangle could indicate dikes. The evidence seems to indicate that the dikes extend from the Canadian mainland (Gananoque), across the St. Lawrence River, to the Clayton quadrangle without offset, thus eliminating the possibility of strike slip movement in this region.

CONCLUSIONS

The Precambrian basement rocks cause magnetic anomalies over the St. Lawrence River between Oak Point, NY, and Lake Ontario. The magnetic anomalies and contours trend continuously across the river indicating no large lateral offsets have occurred in the Precambrian basement complex beneath the river. Also, the magnetic anomalies indicate that a diabase dike swarm in the Gananoque, Ontario area extends across the river through Grindstone Island and into the Clayton Quadrangle without offset to indicate no lateral strike slip movement.

The magnetic anomalies in the area have rather high magnitudes and steep gradients. This is due to the basement rocks of the Frontenac Axis being at shallow depths and having variable magnetic susceptibilities.
REFERENCES


APPENDIX

The following pages comprise an enlargement of the map at page 2.
The pages correspond to this grid below.
EXPLANATION

MAGNETIC CONTOURS--
CONTOUR INTERVAL -- 100 AND 200 GAMMAS
STATION LOCATION -- •
DIABASE DIKES -- ||
FAULTS OR LINEAMENTS -- -- --

SCALE

FEET

METERS

STATUTE MILES
EXPLANATION

MAGNETIC Contours —
CONTOUR INTERVAL — 100 AND 200 GAMMAS
STATION LOCATION — •
DIABASE Dikes — I
FAULTS OR LINEAMENTS — — — — — —

SCALE

FEET

METERS

STATUTE MILES
EXPLANATION

MAGNETIC CONTOURS —
CONTOUR INTERVAL — 100 AND 200 GAMMAS
STATION LOCATION — ●
DIABASE DIKES — ||
FAULTS OR LINEAMENTS — — —

SCALE

FEET

METERS

STATUTE MILES
EXPLANATION

MAGNETIC CONTOURS - ○
CONTOUR INTERVAL - 100 AND 200 GAMMAS
STATION LOCATION - ●
DIABASE DIKES - —
FAULTS OR LINEAMENTS - — — —

SCALE

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STATUTE MILES
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MAGNETIC CONTOURS

CONTOUR INTERVAL - 100 AND 200 GAMMAS

STATION LOCATION - ●

DIABASE DIKES - □

FAULTS OR LINEAMENTS - — — —

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STATUTE MILES
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MAGNETIC CONTOURS —
CONTOUR INTERVAL — 100 AND 200 GAMMAS
STATION LOCATION — •
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MAGNETIC CONTOURS
CONTOUR INTERVAL — 100 AND 200 GAMMAS
STATION LOCATION — ●
DIABASE DIKES — □
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STATUTE MILES
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CONTOUR INTERVAL — 100 AND 200 GAMMAS
STATION LOCATION — •
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FAULTS OR LINEAMENTS — — —

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STATUTE MILES
EXPLANATION

MAGNETIC CONTOURS

CONTOUR INTERVAL — 100 AND 200 GAMMAS

STATION LOCATION — •

DIABASE DIKES — 11

FAULTS OR LINEAMENTS — — —

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EXPLANATION

MAGNETIC CONTOURS - ○ ○ ○
CONTOUR INTERVAL - 100 AND 200 GAMMAS
STATION LOCATION - ●
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