Open File Report OF2001-7

Summary of geophysical data from open assessment files of the Fox River Sill area, Manitoba (part of NTS 53N, 53M and 54D)

By I.T. Hosain

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Winnipeg, 2003

Industry, Trade and Mines

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360–1395 Ellice Avenue
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Telephone: (800) 223-5215 (General Enquiry)
(204) 945-4154 (Publication Sales)
Fax: (204) 945-8427
E-mail: minesinfo@gov.mb.ca

Website: http://www.gov.mb.ca/itm/mrd

ABSTRACT

The Fox River Sill (FRS) is an ultramafic-mafic complex, approximately 250 km in length and 2 km in width, within the Paleoproterozoic Fox River Belt at the northern margin of the Archean Superior Province. Since 1955, companies have explored the Fox River Belt for base-metal deposits and, more recently, for platinum-group elements. This report summarizes the geophysical data of the area submitted to the Mines Branch of Manitoba Industry, Trade and Mines for assessment purposes. Recommendations for future exploration work are included.

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INTRODUCTION

A very important aspect of any mineral exploration program is the compilation of previous assessment work and government reports. The objective of this report is to present geophysical data, contained in open assessment files of the Mines Branch of Manitoba Industry, Trade and Mines, in a format that will serve as a guide for mining companies contemplating or currently carrying out exploration in the Fox River Belt (Fig. 1).

This report summarizes geophysical data from open assessment files and contains tabular information on how various anomalies were interpreted and on ground follow-up that has been completed, including geophysics and drill logs.

BACKGROUND

In mineral exploration, both anomalously high and low magnetic trends can be of significance. Magnetic lows may reflect felsic volcanic rocks, the most common host rocks for base-metal mineralization, or zones of silicification and attendant destruction of the magnetic signature of the host rocks. Magnetic and gravity highs could indicate iron formations, mafic volcanic rocks and ultramafic rocks. High magnetite concentrations would produce strong magnetic anomalies.

Magnetic maps can be used confidently to interpret faults, folds, intrusions and contacts. Fault zones can usually be recognized by the destruction of magnetite, which results in featureless contours as well as offsets of magnetic signatures.

Electromagnetic (EM) surveys outline conductors, which could be produced by base metals and graphite. High-frequency EM surveys assist in outlining faults and formational conductors, which are of interest in exploring for gold (Palacky, 1989).

REGIONAL GEOLOGY

An overview of the geology of the Fox River Belt was published by Davies et al. (1962). Geology of parts of the area is described in reports by Scoates (1981, 1987, 1990), Schwann and Scoates (1988), Schwann et al. (1989), Peck et al. (1999) and Desharnais et al. (2000).

The Fox River Belt forms one of several Paleoproterozoic supracrustal belts that occur on the margin of the Archean Superior Province (Fig. 1; Baragar and Scoates, 1980). The belt borders the northeastern edge of the Superior Geologic Province in Manitoba for approximately 250 km, within the Superior Boundary Zone. It consists of sedimentary rocks, large differentiated mafic and ultramafic sills and ultramafic to mafic volcanic rocks, which together form a north-facing homoclinal sequence that is interpreted to have been deposited on Superior Province crust (Fig. 2; Scoates, 1990). Fox River Belt rocks have suffered low- to very low grade metamorphism. Metamorphic grade increases to the south, with stratigraphic depth (Scoates, 1990).

The Fox River Sill, a stratiform ultramafic-mafic intrusion, forms an integral part of the Fox River Belt. The intrusion is predominantly ultramafic in composition. In the western part of the belt, the sill comprises two lobes or segments, each approximately 70 km long and separated by a gap of 12 km. Distinctive aeromagnetic (Geological Survey of Canada, 1984) and gravity (Geological Survey of Canada, 1991) anomalies, east of the eastern segment, indicate that ultramafic rocks extend for another 120 km eastward, beneath Paleozoic cover rocks of the Hudson Bay Lowlands (Fig. 3). The thickness of the western segment averages slightly more than 2 km, at the present erosional surface. The sill intrudes the Middle Sedimentary Foundation, a sequence of siltstone, sandstone, argillite and shale (Scoates, 1990).

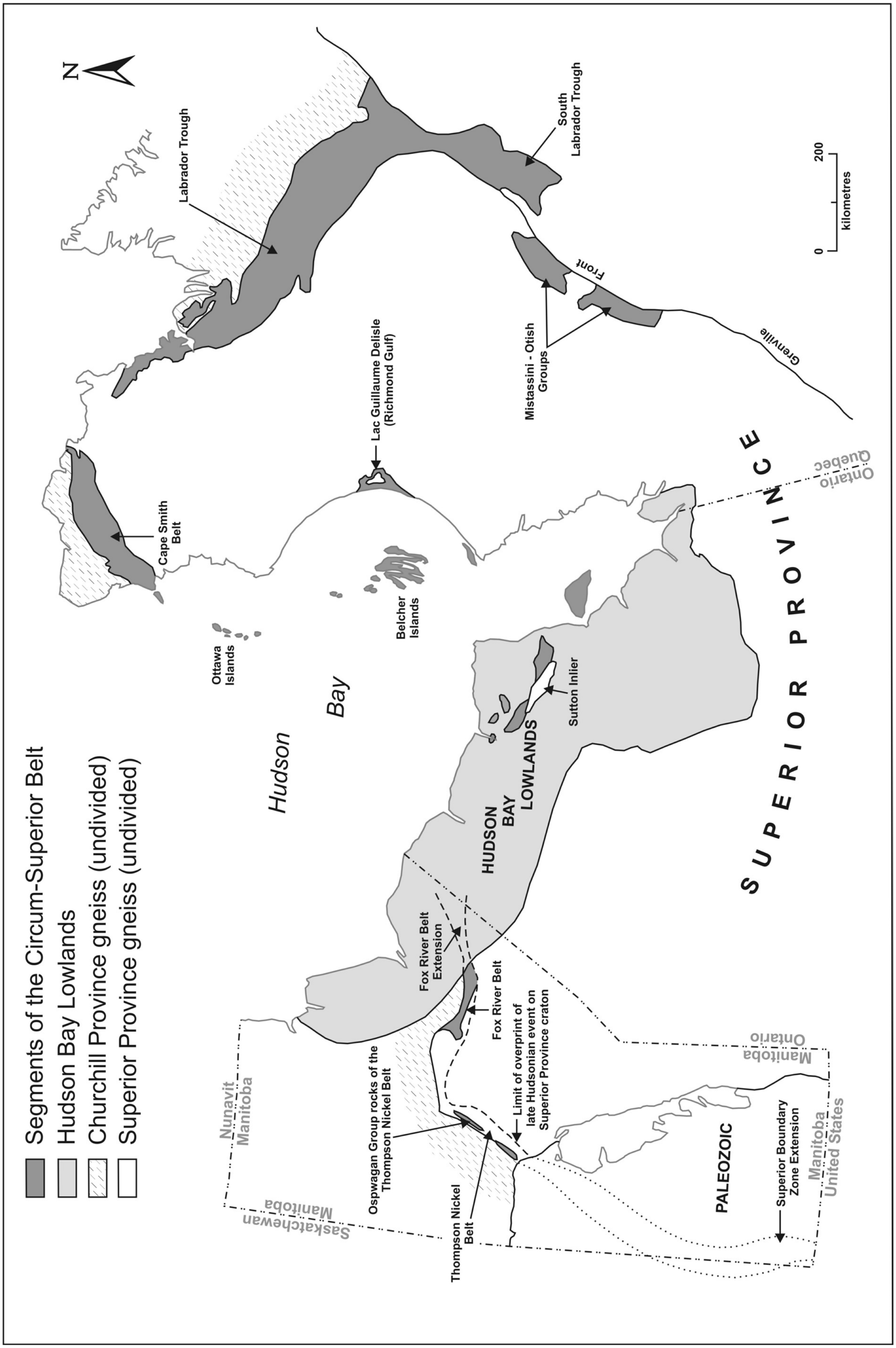

Figure 1: Relation of the Fox River Belt to the northern part of the Circum-Superior Belt.

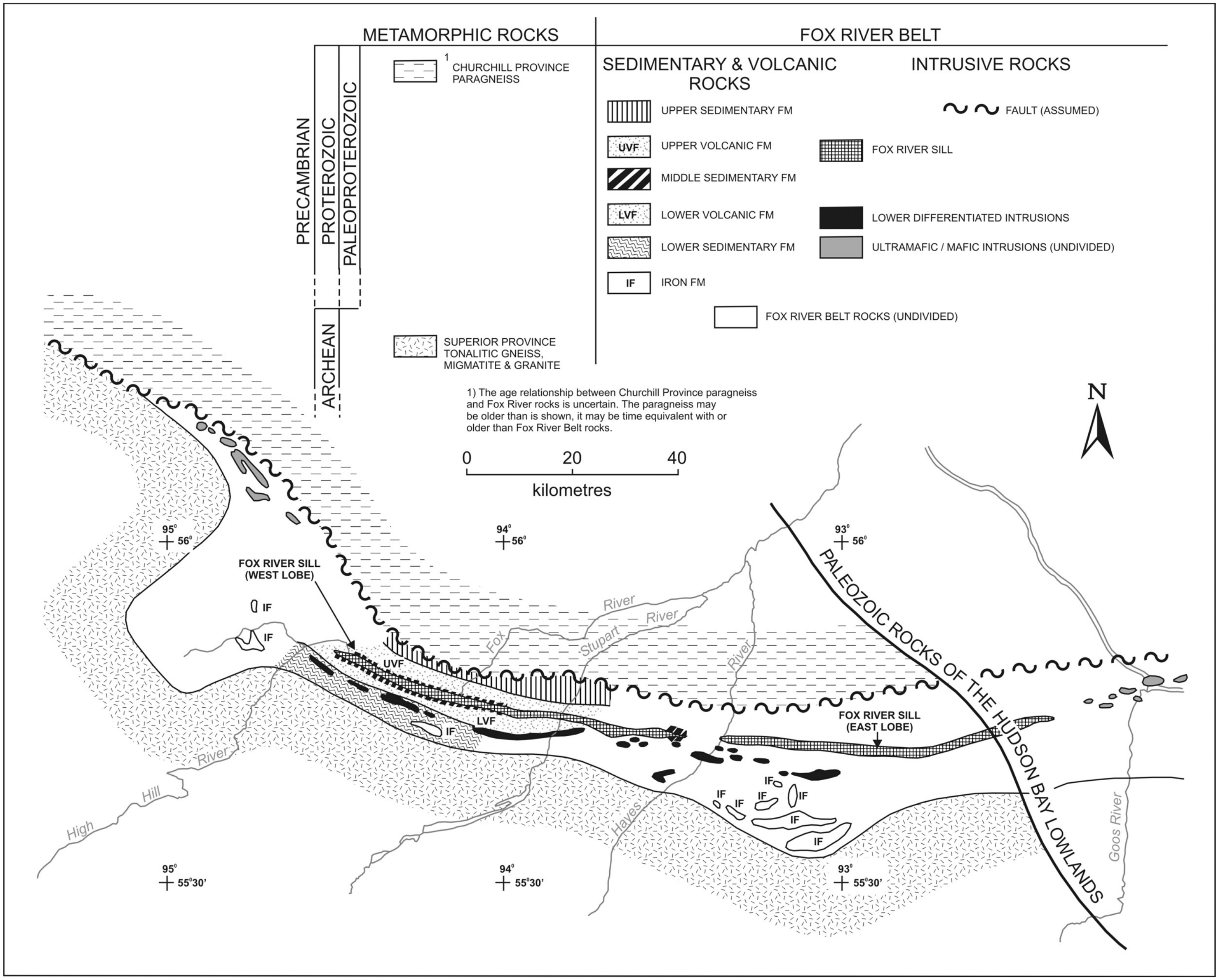

Figure 2: General geology of the Fox River Belt (from Scoates, 1990).

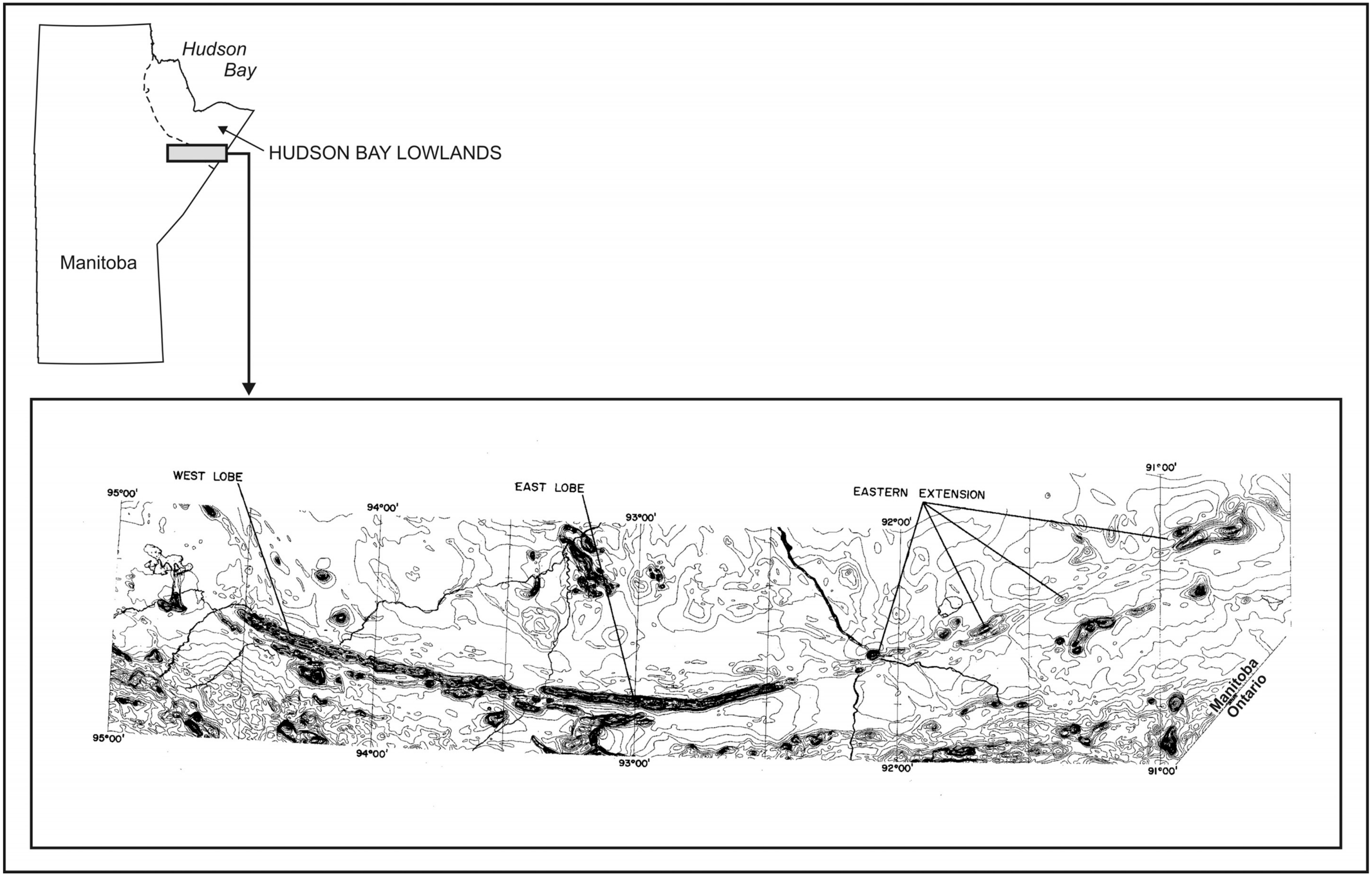

Figure 3: Aeromagnetic expression of the Fox River Sill (after Scoates, 1990).

Two sequences of komatiitic to basaltic volcanic rocks underlie and overlie the Middle Sedimentary Formation into which the sill is intruded (Scoates, 1990). They range in composition from komatiite to komatiitic basalt to basalt. The 250 m thick upper volcanic sequence varies from komatiitic composition at the base to basaltic at the top (Scoates, 1981).

Outcrops are mainly confined to rivers, lakeshores and islands. Overburden thickness in the area ranges from more than 50 m in the western part to more than 80 m in the east. The supracrustal rocks are underlain by two types of granite gneiss: quartz-feldspar-biotite gneiss with less than 10% mafic minerals and hornblende-plagioclase-biotite gneiss with more than 10% mafic minerals. South of Atkinson Lake (NTS 53M15), there are outcrops of volcanic rocks that probably represent narrow volcanic bands in a dominantly gneissic terrain. Throughout the southern gneissic terrain, there are gabbro dikes up to 13 m in thickness. Most strike northeast, but a few strike northwest (Assessment File 91659, Manitoba Industry, Trade and Mines, Winnipeg). To the north, amphibolite-grade metasedimentary rocks overlie the belt. Contacts between the Fox River Belt and the upper and lower gneissic terrains are apparently thrust controlled (Scoates, 1990; Assessment File 93695, Manitoba Industry, Trade and Mines, Winnipeg).

PREVIOUS EXPLORATION

The largest exploration program over the region was conducted between 1955 and 1957 (Assessment File 90222, Manitoba Industry, Trade and Mines, Winnipeg) and between 1969 and 1972 (Assessment Files 91662 and 91678, Manitoba Industry, Trade and Mines, Winnipeg) by the Canadian Nickel Co. Ltd. (now Inco Ltd.) and, to a lesser extent, by Sherritt Gordon Mines Ltd. Inco flew extensive magnetic and EM surveys, mapped river outcrops and drilled in excess of 130 diamond-drill holes. Many of these holes (49) were drilled into the Fox River Sill, as well as parts of the Upper and Lower Volcanic formations. Sherritt Gordon drilled 8 holes in the area in 1956 and 1957 (Assessment File 93695, Manitoba Industry, Trade and Mines, Winnipeg). Icon Syndicate flew an airborne magnetic and EM survey in the Hayes River area in 1962 (Assessment File 91637, Manitoba Industry, Trade and Mines, Winnipeg). In 1968, McPhar Geophysics Ltd., in conjunction with Amax Exploration Ltd., carried out an airborne EM and magnetic survey in the western part of the area (Assessment File 91665, Manitoba Industry, Trade and Mines, Winnipeg).

Geochemical and geophysical surveys were conducted over a 4 km section of the western portion of the Fox River Sill in 1976 by the Exploration Operations Branch of the Manitoba Department of Mines, Resources and Environmental Management (Clue, 1976). Vertical-loop EM bedrock conductors were found to coincide with anomalous concentrations of sulphide minerals that had little or no enrichment in Cu, Ni and Cr. This pattern was interpreted as reflecting the presence of barren sulphide mineralization in the area (Scoates, 1990).

From 1985 to 1987, Platinum Exploration Canada Inc. and BP Resources Canada Ltd. conducted platinum exploration, focusing on the Fox River Belt. Detailed airborne magnetic-VLF surveys were flown over the entire known length of the sill, with lines extending north and south to include the basal sections of the Lower and Upper Volcanic formations. BP Resources drilled 15 holes, most within areas previously defined by the Inco work, as well as 3 to 5 holes within the eastern lobe of the sill (Assessment File 93695, Manitoba Industry, Trade and Mines, Winnipeg).

Falconbridge Nickel Mines Ltd. conducted nickel exploration at the extreme northwestern edge of the belt in 1977 and 1979, focusing on magnetic highs that were thought to represent magnesian ultramafic units along strike from the Fox River Sill. Results were discouraging (Assessment File 93695, Manitoba Industry, Trade and Mines, Winnipeg). Falconbridge carried out exploration in the western part of the sill in the 1990s, but the data are still confidential.

METHODOLOGY

Geophysical surveys have been assessed only in a qualitative manner due to the variable quality of geophysical information extracted from assessment files. This methodology is considered sufficient to give an indication of the relative importance of an anomaly (Hosain, 1999). Qualitative analysis of an EM anomaly involves determination of strike length and strength of a conductor. A more comprehensive quantitative analysis would include determination of the angle of dip, depth, width and conductivity. In some of the older surveys, quantitative analysis cannot be undertaken because of incomplete data. More recent surveys provide a better database. Quantitative analysis of the magnetic data would involve computer modelling to determine the susceptibility, location and combination of various bodies that produce the closest fit to the measured data. Digital magnetic data were not recorded in the older surveys and are not usually submitted in the more recent surveys.

AIRBORNE SURVEYS

Airborne surveys are essentially a reconnaissance method, so qualitative interpretation is sufficient for handling the data. Most of the airborne geophysical data in the assessment files have been obtained from magnetic or EM surveys. In classifying the EM anomalies as strong, medium or weak, the system and the frequencies employed have been taken into consideration.

In this report, the airborne EM anomalies from company maps have been transferred to half-tone aeromagnetic 1:50 000-scale base maps. These maps show all the relevant geophysical surveys, and Table 1 lists the assessment file number, area location, name of the company for whom the survey was carried out, year the survey was flown, flight altitude and line spacing, system and specifications employed, anomalies and their characteristics, ground follow-up activity and relevant comments. Magnetic surveys constitute a passive method, so they are directly comparable and conform with the Federal Government's aeromagnetic maps. These latter maps were used as a base because they have continuous coverage over the area, and the flight altitude, line spacing and contour interval are constant.

GROUND SURVEYS

The method of handling the ground data in the assessment files involved direct interpretation from maps, which are transferred to the above-mentioned aeromagnetic base maps. These latter maps show all relevant geophysical information, drillhole locations, rock types intersected and possible cause of anomalies. The assessment file number and the areas covered by the surveys are further defined in Table 1. Recommendations on whether further work is warranted are included in the comments.

The depth of exploration reached by an EM survey is dependent on the instrument's specifications, method of conducting the survey, and the geological and topographic environments. For example, the higher the frequency employed, the less the penetration of the EM waves; and the lower the resistivity of the material, the less the depth of penetration. As a result, a high-frequency unit may produce false conductors in swampy areas. Coil separation also affects the depth of penetration: a large coil separation will increase the depth of penetration of EM waves.

The coil configuration plays a very important part in determining how well the EM waves couple with conducting bodies. The primary electromagnetic waves emanating from a horizontal transmitter will couple very well with flat-lying conducting bodies, which makes the horizontal-loop EM method very susceptible to the effect of lake bottom clay and conductive overburden. Therefore, in surveying over lakes, the vertical loop would be a more effective exploration method. On the other hand, the ratio of in-phase to quadrature component (obtainable with the horizontal loop) would be a better method of interpreting the strength of the conductor.

Table 1: Geophysical data from open assessment files, Fox River Belt area.

Assess. file no.	NTS area	Company	Year	Altitude	Line spacing	Electromagnetic	Magnetic	Probable cause of anomaly, follow-up drilling, etc.	Comments and geology
91659	53M15, 16, 54D2	Sherritt Gordon Mines Ltd.	1967	135 m	800 m	Two-frequency quadrature (385 and 1700 Hz.): coil sep 150 m Many str and med condrs.	Proton precession	Some condrs have been drilled; holes on 54D2 - gf sch	Gf sch and gf tuff in both holes; also per in southern hole
								Central holes on 53M15 gf sch	Gf sch and IF
								Holes on eastern 53M15 and 53M16 gf sch	Gf sch and gf tuff; and and per on the northern magnetic anomaly; most northerly hole IF
93695	54D2, 53M15, 16, 53N	Westminer Canada Ltd.	1992			MaxMin II® (444 and 1777 Hz.): coil sep 200 m Grid A (53M16): many str condrs. Grid B (53M16): one str condr.		10 holes drilled to test condrs; bas, per, IF and sl.st; low Ni, Cu, Co assays	Limited IP carried out on both grids and confirmed the MaxMin® condrs Reprocessed GSC and BP Resources airborne magnetic data.
91662	54D2, 53M15, 16	Canadian Nickel Co. Ltd.	1968	150 m	400 m	INCO system: 54D2 and a narrow strip of 53M15 and 16 were flown Same condrs as 91659			
91678	53M 15, 16 53N 9 to 16	Canadian Nickel Co. Ltd.	1970	150 m	400 m	INCO system: ratio of response amplitude to coplanar quadrature signal and coaxial quadrature signal respectively; P.A. = response on quadrature channel only Many long str and med condrs A few wk condrs			
90222	53M15, 16	Canadian Nickel Co. Ltd.	1957				Sharp and Askania		Data not included
90229	53M15, 16	Sherritt Gordon Mines Ltd.	1956			VLEM (1200 Hz.) 2 med and a few wk condrs		A few holes drilled	Red/brown ferrigenous material in western hole
								Central holes near river: po, py, tr cp	And, dio (IF in one hole); per in one hole
								Eastern holes: po, py	Alt volcs (mostly and)
93520	53M15, 16 and 53N13	BP Resources Canada Ltd.	1987	75 m	200 m	Aerodat VLF-EM Data not submitted	Scintrex Cesium		Computer tape filed VLF-EM not filed Calculated vertical gradient
91777 91778	53M16 53N13	Canadian Nickel Co. Ltd.	1971-72			INCO Mark 3 VLEM (1000 Hz.) Many long str and med condrs	Sharp MF-1 Many str anomalies	Some of the condrs have been drilled	Mostly serp volcs (bas) Gab and some diss py, po
93499	53N13 (Stupart River)	BP Resources Canada Ltd.	1987				EDA OMNI IV One 6000 nT anomaly	Holes near Stupart River: per, gab containing po, py, tr cp (93501)	Per, gab
	53M16						One 7000 nT and one 3000 nT anomaly	Hole on 53M16 (93501)	Per, gab
93508	53M16 (Fox River)	Platinum Exploration Canada Inc.	1986			VLF-EM 16, MaxMin® II HLEM 5 condrs not plotted	PPM500: mag and vertical gradient A few coincident magnetic anomalies with the condrs	7 holes drilled (no logs); report states condrs caused by faults or up to 3% sulphides	Not plotted as too busy; only outline plotted

Table 1: Geophysical data from open assessment files, Fox River Belt area. (continued)

Assess. file no.	NTS area	Company	Year	Altitude	Line spacing	Electromagnetic	Magnetic	Probable cause of anomaly, follow-up drilling, etc.	Comments and geology
93081	53N10 to 15 (eastward continuation of 93520)	Selco-BP Resources Canada Ltd.	1986	60 m	115 m	Totem 2A VLF-EM Data not submitted	Questor mag and vertical gradient		
91780	53N11	Canadian Nickel Co. Ltd.	1971			INCO Mark 3 VLEM (1000 Hz.) 1 wk condr in each grid	MF1 No anomalies		
91781	53N11, 14, 15	Canadian Nickel Co. Ltd.	1971			INCO Mark 3 VLEM (1000 Hz.) A few wk condrs in the southern large claim block and 2 small claim blocks; no condrs in the large northern claim block	MF1 Many str anomalies	Many holes drilled on both large claim blocks: serp, per, mvvw	Serp, Per.
91637	53N11 to 14	Icon Syndicate Ltd.	1962	35 to 50 m	300 m	Canadian Aero (320 Hz.): tx and Rc in wing tips with 20 m sep; in-phase and quadrature recorded Same condrs as other surveys	Magnetic data not submitted		Ground follow-up warranted on the southern condrs
91694	53N11, 12	Canadian Nickel Co. Ltd.	1972	150 m	800 m	INCO system 1st to 4th priority condrs same as other surveys			
91803	53N14 NE	Canadian Nickel Co. Ltd.	1972			INCO Mark 3 (1000 Hz.) No condrs	MF1 No anomalies		
91752	53N, 54C, D, E and F	Aquitaine Sogepet Group	1967						Much useful information, including pyrope garnets recovered from area north of Fox River
91779	53N11 to 14	Canadian Nickel Co. Ltd.	1969			INCO Mark 3 (1000 Hz.) 2 claim blocks No condrs	MF1 Many magnetic anomalies	A few holes drilled: mvvw	Serp, gab, seds
91783	53N16	Canadian Nickel Co. Ltd.	?			INCO Mark 3 (1000 Hz.) No condrs	MF1 A few anomalies	3 holes drilled. log of 1 hole: mvvw	Pyrox, serp, gn
91665	53M15, 16 54D2	Amax Exploration	1968	Tx: 130-150 m Rc: 45 m	400 m	McPhar F 400 (340 & 1070 Hz.): quadrature Same condrs as other surveys	Varian nuclear precession		Survey outline is omitted
93699	54D2	Manitoba Mineral Resources and Falconbridge Nickel Mines Ltd.	1977		200 m	Aerodat Many condrs, mostly the same as from other surveys (report missing)			
92956	54D2	Falconbridge Nickel Mines Ltd.	1979			MaxMin® II (444 and 888 Hz., 1777 Hz and 444 Hz on grid G): coil sep 200 m Grid G: one str and two med condrs with coincident 400 and 200 nT magnetic anomalies	Geometrics G816 proton precession and Barringer GM 122 proton precession	One str and 2 med condrs drilled Westernmost hole: gf seds; nil Ni, Au Po, py, nil Ni, Au (93741)	Westernmost hole: ser sch, gf seds, arg Bas, amp, arg, serp in str condr IF in one hole

Table 1: Geophysical data from open assessment files, Fox River Belt area. (continued)

Assess. file no.	NTS area	Company	Year	Altitude	Line spacing	Electromagnetic	Magnetic	Probable cause of anomaly, follow-up drilling, etc.	Comments and geology
						Grid B: 1 str condr with 2000 nT magnetic association		Condr drilled: gf, po, py (93741)	Seds, bas
						Grid C: 2 str condrs, one located on flank of a 5000 nT magnetic anomaly and one that has a 300 nT magnetic association; 1 med condr with 300 nT magnetic association		One str condr drilled: py in places, nil Ni, Au (93741)	Bas, amp, serp, seds
						Grid E: no condrs			
						Grid F: 1 med condr, no magnetic association		Condr drilled: gf, py, nil Ni, Au (93741)	Bas., peg, seds, bio gn
						Grid D: 2 str condrs on the flank of a 2000 nT magnetic anomaly		One condr drilled: gf, po, py in places (93741)	Amp, bas, seds, peg and 2 m IF intersection

Abbreviations:

alt	altered
amp	amphibolite
and	andesite
arg	argillite
bas	basalt
bio	biotite
condr	conductor
dio	diorite
diss	disseminated
gab	gabbro
gn	gneiss
gf	graphite
IF	iron formation
med	medium
mvvw	mineralization very very weak
peg	pegmatite
per	peridotite
pyrox	pyroxenite
sch	schist
seds	sediments
ser	sericite
sep	separation
serp	serpentinite
sl.st	siltstone
str	strong
tr	trace
volcs	volcanics
wk	weak

All or most of these factors have been taken into consideration before assigning an anomaly to one of several arbitrarily chosen levels of intensity, namely strong, medium or weak.

HIGHLIGHTS AND RECOMMENDATIONS

The only outcrops in the area are along creeks and rivers. Therefore, exploration in the area would depend entirely on geophysics and geochemistry. Drilling is limited to a small segment of the sill, so most of the sill can be considered relatively unexplored. Airborne surveys have been conducted over a larger area but with limited ground follow-up.

NTS 54D2

This map sheet was covered with airborne magnetic and EM surveys by Sherritt Gordon Mines Ltd. and Inco Ltd. in 1967 and 1968, respectively, and the magnetic trend north of Atkinson Lake was flown for Falconbridge Nickel Mines Ltd. in 1977. The conductors outlined on the maps were located by all three systems. Strong airborne conductors are associated with the northwest-southeast magnetic (up to 2000 nT) trend. Ground follow-up using the MaxMin® II unit has been carried out by Falconbridge and some of the conductors have been drilled. The thickness of the overburden in the area is more than 50 m. The rocks intersected were mostly basalt, argillite, graphitic schist and amphibolite. Pegmatite and iron formation were intersected in a few holes. The Ni and Au values were disappointing. The sedimentary rocks contained pyrite and pyrrhotite in places. A few weak conductors were located away from the magnetic trend. Due to the presence of the deep overburden, these weak conductors could be important and should be investigated.

NTS 53M15, 16 and 53N12 and 13

The 2000 nT magnetic anomaly in the north-central part of NTS 53M15 has been drilled and found to be caused by iron formation in gneiss and schist. The airborne conductors outlined by the surveys of Sherritt Gordon and Inco are caused by graphite in the schist.

The western part of the sill, which is located within the east-west magnetic trend, has received much exploration activity. Airborne EM and magnetic surveys were carried out by Sherritt Gordon in 1967, Inco in 1970, Falconbridge in 1977, BP Resources in 1987 and Falconbridge in the 1990s (the latter Falconbridge data are still confidential). Westminer Canada Ltd. reprocessed the airborne magnetic data of the Geological Survey of Canada and BP Resources for their program in 1992.

Numerous strong and medium airborne conductors are associated with the magnetic trend. Many of the conductors have been followed up on the ground and drilled. The northern magnetic trend (up to 2000 nT) is caused by the sill. The magnetic contours outline the sill as being generally stratiform. Toward the western end, there is some offsetting of the contours that may reflect flexures in the sill. It is here that the greatest amount of exploration activity has been conducted. Drillholes have intersected predominantly mafic and ultramafic rocks (peridotite, serpentinite, gabbro and andesite) containing varying amounts of pyrite and pyrrhotite. A few holes were drilled north of the sill and intersected volcanic rocks. Farther north, the holes intersected sedimentary rocks (siltstone, sandstone and argillite). Drillholes to test conductors toward the east, along the magnetic trend, intersected rocks similar to those in the western part.

The conductors associated with the southern magnetic trend were drilled and found to be caused by peridotite, basalt, graphite schist and tuff. The Cu and Ni values were disappointing.

In the south-central part of NTS 53M16, there is an ellipsoidal magnetic anomaly that is generally similar to the north-central anomaly in NTS 53M15. Drillholes within this anomaly encountered rocks similar to those intersected in NTS 53M15, with iron formation being the cause of the 2000 nT anomaly. A long formational conductor south of the magnetic trend is similar to the one located north of the magnetic trend. There are also two circular magnetic anomalies, of 1000 and 2000 nT, north of the sill. One hole drilled on the flanks of the southern anomaly intersected sedimentary rocks. More work is warranted in the area. The holes drilled to determine the cause of the conductor at the eastern end of the western lobe or segment of the sill intersected trace Ni, Cu, Pd, Pt and Au. The host rocks were gabbro, serpentinite and peridotite.

NTS 53N9 to 11 and 14 to 16

The eastern lobe or segment of the sill has received limited exploration. The area has been covered with airborne magnetic and EM surveys by Inco in 1970 and 1972, and by Selco–BP Resources in 1986. The western part was flown by Icon Syndicate in 1962. Limited ground follow-up was carried out by Inco in 1971. A few holes were drilled to test some conductors and intersected peridotite, dunite and serpentinite with traces of Ni, Cu, Pb, Pt and Au. The overburden in the area is approximately 70 m thick. South of the main east-west magnetic trend, there is an area of high magnetic values (up to 12000 nT). One hole (in NTS 53N11) was drilled to determine the cause of this high and intersected biotite schist and iron formation.

According to the assessment files, very limited work has been carried out on the eastern part of the eastern lobe of the sill. A few holes have been drilled (NTS 53N15) by Inco, but their logs were not been submitted. The log of the only hole submitted (in NTS 53N16) reported pyroxenite, serpentinite and gneiss with very low mineralization.

The thickness of the overburden in the area was approximately 100 m. There is an isolated magnetic anomaly at Shamattawa, with an associated weak airborne EM conductor, that requires further investigation.

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