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Article abstract

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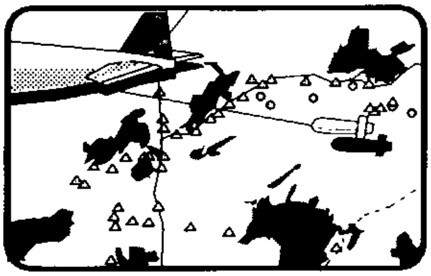
The mapping tools are aeromagnetic total fields, vertical gradient surveys, and diamond drill core. The geophysical data have been used to create a magnetic domain map for the sub-Paleozoic region. Geological data from drill core and exposed Pre-cambrian rocks will be used to transform the magnetic domain map into a pseudo-geological map of the covered basement rocks.

A U-Pb zircon age of 1845 +107-8 Ma has been obtained from the large central granitoid domain beneath Paleozoic cover rocks, comparable with ages of plulons in the Flin Flon belt.



Project Cormorant: Interpretations of Sub-Paleozoic geology of the Cormorant Lake map area from geophysical and drill core data

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Summary

The Flin Flon-Snow Lake greenstone belt trends southwesterly and is bounded on the north by the Kisseynew gneiss belt and on the south by Paleozoic carbonate rocks. Airborne geophysical surveys indicate that the greenstone belt extends south beneath a thin (< 100 m), shallow-dipping cover of Paleozoic rocks. Precambrian mineralization discovered in the greenstone belt north of the Paleozoic rocks should also be found beneath them. Project Cormorant is designed to map Precambrian geology beneath the Paleozoic cover to assist exploration for sub-Paleozoic mineral deposits.

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Geological Survey of Canada Contribution No. 39887

Introduction

In November 1983, the governments of Canada and Manitoba negotiated a Mineral Development Agreement under the federal government's Economic and Regional Development program. Throughout the five-year term of this agreement, the two governments agreed to carry out a series of complementary programs to stimulate exploration, mining and mineral processing activity in the province.

The Flin Flon-Snow Lake belt and adjoining areas were selected as one of the regions targeted by these programs. This greenstone belt is one of the most productive belts in the Canadian Shield. Since 1930, 2.5 million tonnes Cu, 3.5 million tonnes Zn, 81 million ounces Ag and 6 million ounces Au have been produced from several massive sulphide and gold deposits. The major structures in the belt strike southwesterly to southerly and can be extrapolated to the south on the basis of aeromagnetic trends. Mineral exploration in the area south of the Flin Flon belt began in the 1960s, mainly by drilling EM anomalies. The Namew Lake orebody (Pickell, this issue, p. 120), and several significant massive sulphide deposits have been discovered by industry exploration programs. Project Cormorant (Weber and Gordon, 1987) is designed to map Precambrian geology south of the greenstone belt beneath Paleozoic cover to assist exploration for sub-Paleozoic mineral deposits.

Project Cormorant covers an area of 8000 km² in the southern portion of NTS 63K (Figure 1), west-central Manitoba, extending from the Paleozoic-Precambrian boundary southward to the 54th parallel. The Paleozoic cover reaches a maximum thickness of about 100 metres at the southern margin of the map area. These shallow-dipping Paleozoic carbonate rocks are magnetically transparent, hence airborne geophysical surveys may be used to obtain the magnetic signatures of the underlying Precambrian basement rocks.

Aeromagnetic Vertical Gradiometry

The magnetic vertical gradient is the rate of change of the earth's total magnetic field in the vertical direction. Two vertically separated magnetometers mounted in the aircraft record total field measurements. The vertical gradient is computed from the difference between the two readings. In northern latitudes, the points of inflection in the vertical gradient profiles are located directly above vertical contacts. This fact, plus the relative insensitivity of the instrumental readings to diurnal variation, makes vertical gradient surveys particularly useful in geological mapping.

Aeromagnetic vertical gradient surveys were flown over the project area from 1980 to 1986, and are illustrated in Figure 1. The surveys presently cover 85% of the project area, with 82% of these data having been released to date.

Data Sources

The sub-Paleozoic geological compilation is being based on geophysical data from the gradiometer surveys, geological data obtained from the exposed Precambrian north of the Paleozoic cover rocks, and on observations of drill core. Drill hole data come from three sources: the exploration industry; the Manitoba Geological Services Branch's (MGSB) "scout" drill program; and the Geological Survey of Canada's (GSC) 1987 winter drill program.

The largest source of drillcore data is the exploration industry. In 1986, Taiga Consultants Ltd. compiled logs from approximately 1000 drill holes within the project area (Taiga Consultants Ltd., 1986). The majority of these data were obtained from the provincial government assessment files. These drill logs, however, lack the consistency required for a regional study because they were logged by many geologists using different exploration models. A drill core re-logging program, undertaken jointly by the GSC and the MGSB, re-examined 51 of the industry holes in 1987 to establish a lithologic legend for the project area.

The second source of drill core data comes from 59 holes of the MGSB "scout" drill program (Figure 1). The MGSB has been testing a variety of magnetic responses in the map area wherever they could gain access with their trailer-mounted Schmidt 300 drill rig. Eight of these holes were completed during the 1987 summer field season in the south-central and southwestern portion of the map area. They were located on magnetic highs and lows associated with strong, linear, magnetic features. The majority of the sub-Paleozoic rocks encountered were mafic meta-igneous rocks, with a small granitoid component.

The third source of drill core data is the GSC's winter drill program, which was designed to test magnetic features not accessible to the MGSB drill rig. Eight holes were completed in the north-central and northeastern portion of the map area (Figure 1). The holes tested several magnetic domains of which four were oblate magnetic highs (domains 1, 2, 3 and 4; Figure 2) and proved to be gabbroic intrusive bodies (Blair *et al.*, 1987).

In Figure 1, the shaded area represents the coverage of the re-logged industry holes, the triangles locate the MGSB drill holes and the circles locate the GSC drill holes.

The gradiometer surveys have not been restricted to the project area, but also cover areas north of the Paleozoic cover. The geophysical responses of known lithologic units provide important controls for interpretation of geophysical data from covered areas.

Magnetic Domain Map

As a first step in interpretation, a magnetic domain map (Figure 2) was derived from all aeromagnetic verical gradient and total field surveys in the project area. An earlier interpretation of the northern third of the area was prepared by Hosain (1984). Domain boundaries on Figure 2 are defined by changes in the orientation, configuration, regional extent, intensity and degree of homogeneity of the magnetic field. Smaller, more local perturbations in the magnetic responses are recorded as sub-domains within the major domains. The geological data obtained from the drillcores are being related to the geophysical data to create a pseudo-geological map.

Regional changes in magnetic signatures that are very abrupt have been interpreted as large structural breaks. A good example of this is the Sturgeon Weir Fault on the western edge of the domain map (Figure 2). Linear magnetic trends north of the break, in both the total field and vertical gradient, are truncated by the fault. This structure has high magnetic relief with rocks of higher magnetic susceptibilities to the north and lower susceptibilities to the south.

The main features of the pseudo-geological compilation shown in Figure 2 reflect the nature of the various magnetic domains. There is a large, quiet, magnetic low in the central portion of the map sheet (domain 5, Figure 2). This is interpreted to be a granitoid complex, as indicated by drillcore data. A U-Pb zircon age of 1845 + 10/-8 Ma has been obtained for this complex (P. Hunt, pers. comm., 1987). This coincides with a 1847 Ma age of plutonism in the Flin Flon belt reported by Syme *et al.* (1987).

The small, well-defined, magnetic highs in the north-central and northeast parts of the map sheet (domains 1, 2, 3 and 4; Figure 2) are underlain by gabbroic rocks. The vertical gradient data identifies concentric to sub-parallel contacts within these gabbroic bodies. These internal contacts are interpreted as resulting from layering or zoning within mafic intrusions.

Linear, southwest-striking magnetic features flank the central granitoid complex on the east and west. In the western portion of the project area, and further west into Saskatchewan, large magnetic domains are truncated along magnetic lineaments. These truncations are interpreted as evidence of large-scale block faulting, readily identified by the sudden change in regional magnetic character and orientation. The magnetic orientations within each domain are interpreted to have been modified by large intrusive bodies.

Drill core data indicate that, with the exception of the domains described above, the covered basement rocks are largely

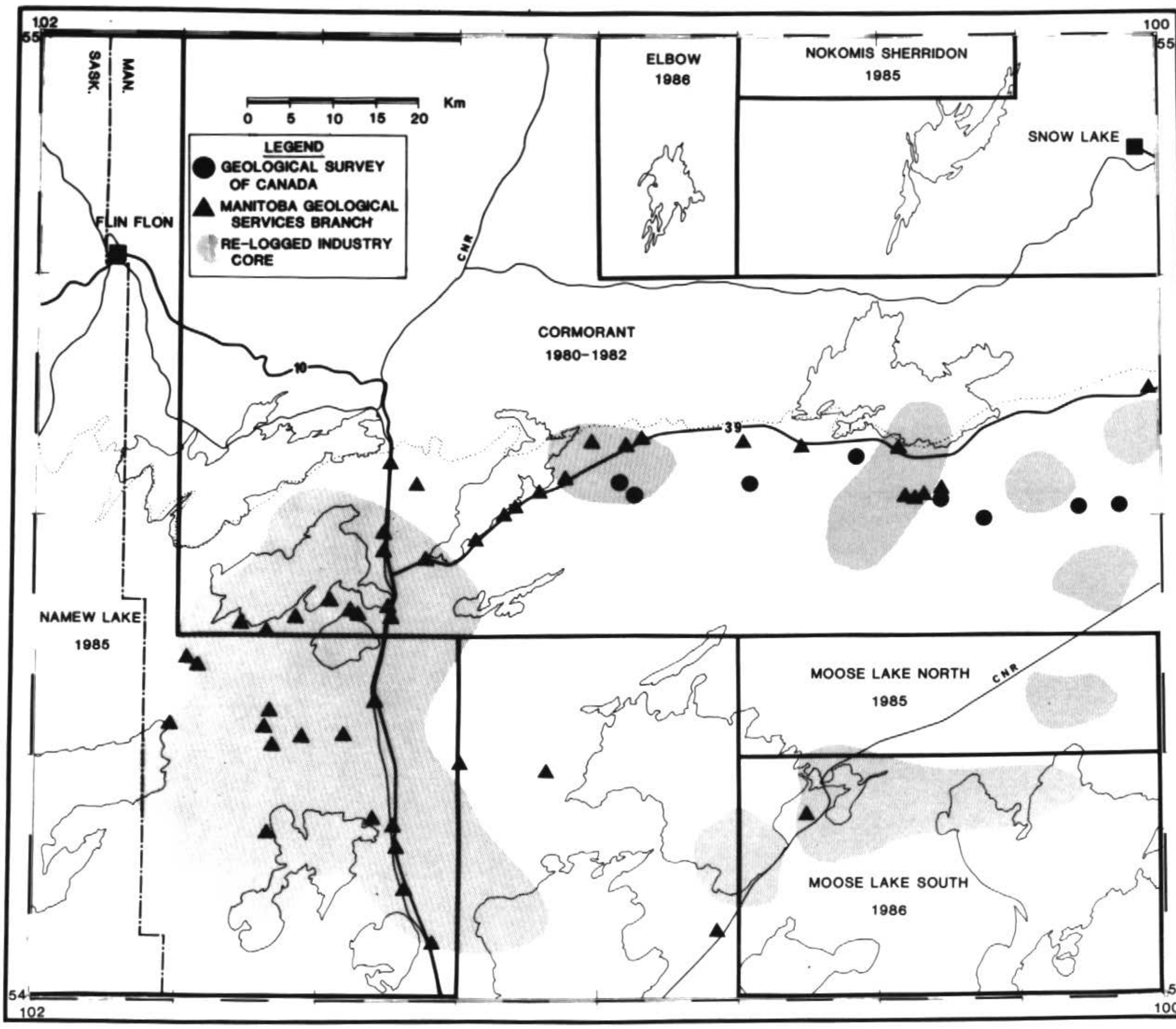

Figure 1 Project Cormorant location map (NTS 63K). The dashed line marks the northern limit of the Paleozoic cover rocks. The heavy lines define the aeromagnetic survey areas, labelled by name and the year the survey was flown. Shaded zones indicate the area covered by the drillcore re-logging program. The MGSC "scout" drill holes are marked with triangles and the GSC drill holes are marked with circles.

gneisses. They are predominantly of garnet-amphibolite grade, indicating an increase in metamorphic grade southward from the Flin Flon region. Metasediments of the north-central portion of the project area were found to be staurolite- and andulasuite-bearing.

On the eastern flank of the granitoid complex (domain 5, Figure 2), the metamorphic grade appears to increase from greenschist in the north to almandine-amphibolite facies in the south. Concomitantly, the anorthite content of plagioclase increases from oligoclase to labradorite. A petrographic study on samples collected across the project area is in progress.

The GSC is planning a ten-hole diamond drill program for the winter of 1988 to cover the southeastern and south-central portions of the map sheet. The MGSB will continue their "scout" drill program during the summer of 1988.

Products

The report and accompanying map of the sub-Paleozoic geology of the Cormorant Lake map sheet will be published in 1989. The report will include the following:
(i) geological report of the sub-Paleozoic basement rocks; (ii) 1:250,000 geological compilation map sheet NTS 63K showing both exposed and sub-Paleozoic basement geology; (iii) 1:250,000 blackline contour map of the main gradiometer and INPUT features; (iv) 1:250,000 map showing basement contours and drill hole density.

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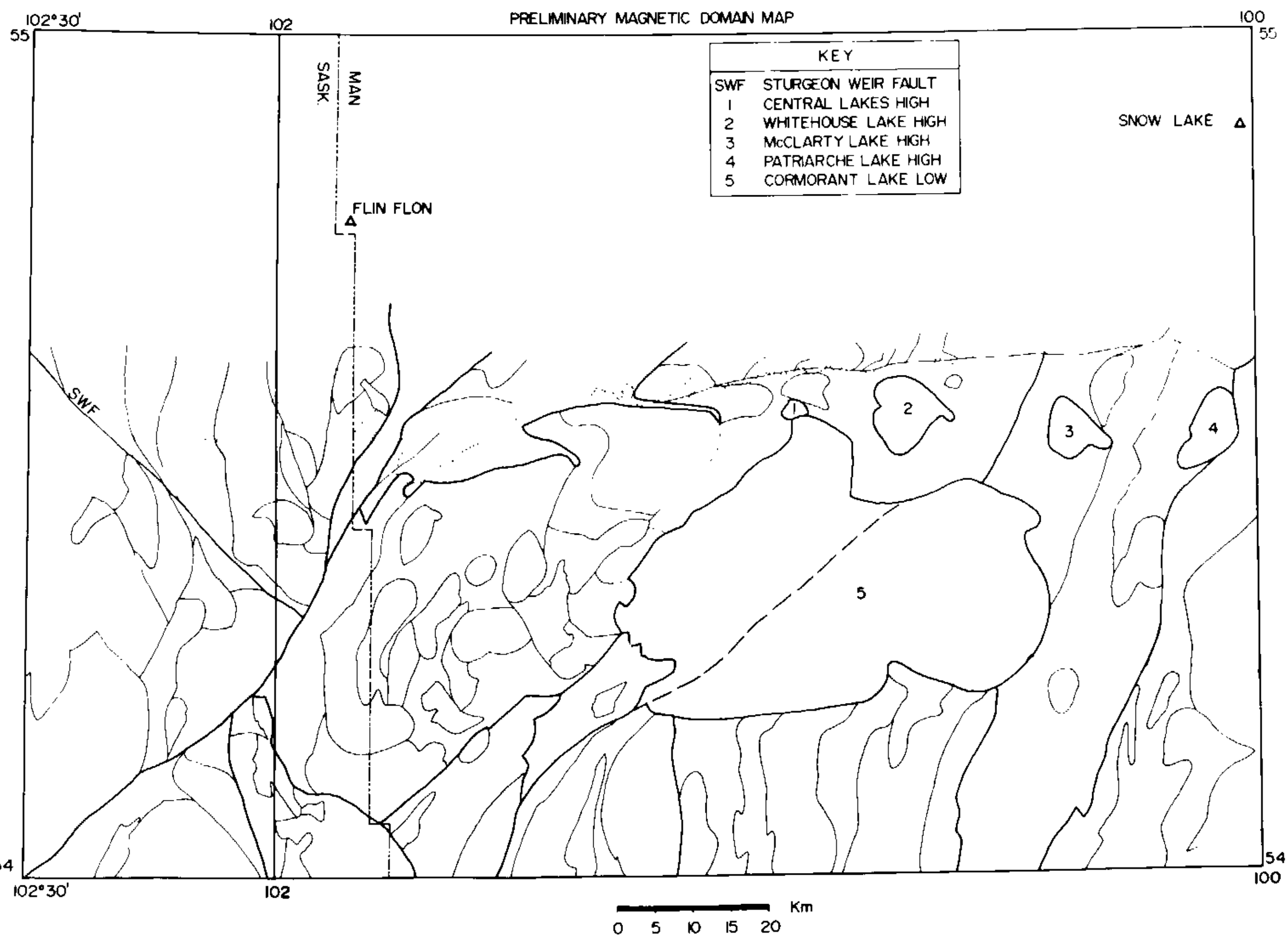

Figure 2 *Preliminary magnetic domain map as interpreted from aeromagnetic survey shown in Figure 1. The numbered domains are referred to in the text. Domains 1 to 4 are underlain by gabbroic rocks; domain 5 by a granitoid complex. The thick lines are domain boundaries, whereas the thinner lines are sub-domain boundaries.*