FIGURE A

Geology of the Edwards Lake Area

Legend

LOWER PROTEROZOIC

Amisk intrusive rocks, intrusions of unknown age

- 9 Mafic intrusions
- 9a a) fine grained, medium grained and plagioclase-phyric
- 9b b) pyroxene-phyric
- 9c c) composite: mafic margin, felsic core
- 8 Pyroxenite
- 7 Quartz-plagioclase porphyry, phenocrysts up to 6 mm in diameter
- 6 Fine grained quartz-phyric intrusions, phenocrysts up to 2 mm in diameter
- 5 Aphyric and plagioclase-phyric felsic intrusions

Amisk Group

- 4 Heterolithic , mixed mafic and felsic volcaniclastic rocks
  - a) breccia of mainly mafic clasts, q quartz phenoclasts up to 1 cm in diameter
  - b) wacke, bedded
- 3 Mafic volcaniclastic rocks
  - a) pyroxene-phenocryst-rich wacke, massive
  - b) fine grained, massive and bedded
  - c) plagioclase-phenocryst rich wacke and breccia
- 2 Felsic volcanic breccia and wacke
- 1 Mafic flows
  - 1a a) pyroxene plagioclase-phyric, pillowed and massive
  - 1b b) pyroxene-phyric, pillow-fragment breccia
  - 1c c) plagioclase-phyric, pillowed and massive
  - 1d d) aphyric, pillowed
  - 1e e) aphyric, massive
  - 1f f) aphyric, pillow-fragment and isolated-pillow breccias

SCALE 1:2000

0 50 100 150 200 m

Geology by R. G. Skirrow, 1985-1986

Magnetic declination approximately 11° 56' East, decreasing 5' annually

Symbols

- Geological contact: accurate; approximate; inferred
- Flow facies contact: accurate; inferred
- Stratigraphic division boundary
- 40 Strike and dip of bedding
- 71 Cleavage orientation
- 51 Plunge of minor fold
- Fault: accurate; inferred
- Facing direction
- Limit of outcrop
- MX1 Stratigraphic unit

DESCRIPTIVE NOTES

INTRODUCTION

The map area is located about 2 km south of the Chisel Lake Zn-Cu massive sulphide deposit, near Snow Lake, Manitoba. Mapping was undertaken to document part of an extensive zone of silicified, epidotized and Fe-metasomatized rocks, and to examine the possible relationship of the alteration to nearby volcanic-associated massive sulphide deposits.

The geology of the Snow Lake region has been described most recently by Froese & Moore (1980) and Walford & Franklin (1982). Williams (1966) described the geology of an area to the north of Edwards Lake, and Bailes (1986, 1987, 1988) mapped the Chisel-Morgan Lakes area at a scale of 1:5 840, including the Edwards Lake area. In addition geologists of Hudson Bay Exploration and Development Company have been active in the area (Ziehlke, unpublished company report, 1982). More comprehensive descriptions of the geology can be found in Skirrow (1987) and Bailes et al. (1987), Bailes (1988).

The Edwards Lake area lies near the axis of the north-northeast-trending Threehouse syncline, and the rocks have undergone relatively mild ductile deformation. The north-facing volcanic sequence constitutes part of the Amisk Group. The rocks are in, or at sightly lower grade than, the chlorite-biotite-staurolite zone of metamorphism that was delineated by Froese & Gasparrini (1975) and Froese & Moore (1980). A U/Pb zircon age of the subvolcanic Richards Lake tonalite (1889 ± 8 Ma), which intrudes the volcanic sequence, indicates that the rocks are early Proterozoic (Gordon, 1988).

GENERAL GEOLOGY (Figure A)

The volcanic strata form part of a homoclinal succession of submarine volcanic rocks striking west to northwest and dipping 30°-80° to the northeast. The succession can be divided into a lower sequence of mafic flows, related breccia and minor intercalated felsic volcaniclastic rocks and an upper sequence composed of dominantly mafic heterolithic volcaniclastic units.

Three texturally distinct tholeiitic mafic lava types are present in the lower sequence. Aphyric pillowed and massive basaltic-andesite flows occur towards the base of the section and include intervals of pillow-fragment and isolated-pillow breccia. Plagioclase-phyric basaltic-andesite flows contain 5-10% phenocrysts, 2-5 mm in length, and are present mainly to the east of a quartz-plagioclase porphyry stock that occupies the central part of the map area. Pyroxene-phyric basalt flows containing hornblende pseudomorphs of pyroxene phenocrysts (5-10%, 1-6 mm in diameter) are prominent to the west of the quartz-plagioclase porphyry. A sharp facies change from east to west is inferred at the approximate position of the porphyry intrusion, west of the access road, in order to account for the distribution of plagioclase- and pyroxene-phyric flows.

Stratified heterolithic and monolithic felsic (trondhjemite-tonalite) volcanic breccia and wacke, and minor mafic wacke and sediments, form a distinctive marker horizon (FMVC1) between aphyric and plagioclase-phyric flow units MA and MP3. Other thin felsic volcaniclastic units occur higher in the sequence. The breccias were deposited from subaqueous debris flows, whereas the volcanic wacke beds probably were deposited from turbiditic density currents (Bailes, 1986; Skirrow, 1987).

The upper part of the sequence in the map area consists of a mafic volaniclastic unit (MVC) overlain by a mixed mafic and felsic volcanic breccia and wacke unit (HVC). MVC comprises a lower interval rich in hornblende pseudomorphs of pyroxene phenocrysts, overlain by fine- to medium-grained mafic volcanic wacke, and an upper interval of plagioclase-phyric mafic wacke and breccia. The appearance of felsic clasts marks the lower contact of the heterolithic unit HVC. This unit consists of mainly breccia deposits, up to 60 m in thickness, that are the products of subaqueous debris flows (Bailes, 1986; Skirrow, 1987).

The volcanic sequence has been intruded by a variety of mafic and felsic bodies, including: pyroxenite; gabbroic and basaltic-andesite dykes; quartz-phyric, plagioclase-phyric and aphyric felsic intrusions; and a quartz-plagioclase porphyry stock. These intrusions were metamorphosed and deformed together with the supracrustal rocks, and many are compositionally and texturally similar to volcanic rocks in the sequence, suggesting a synvolcanic origin for these bodies (Skirrow, 1987). The aphyric and plagioclase-phyric felsic intrusions, in particular, are probably the subvolcanic equivalents of the felsic volcaniclastic rocks that directly underlie the Chisel Lake massive sulphide deposit, about 2 km to the north.

HYDROTHERMAL ALTERATION (Figure B)

About 30% of the volcanic rocks in the map area have been hydrothermally altered. Silicification, characterized by net addition of Si and Na and loss of Fe-Mg-Mn+Ca+Zn, typically resulted in light grey or white weathering fine grained quartz-plagioclase-rich rocks (Skirrow, 1987). Laterally extensive zones of alteration in aphyric flow unit MA are defined by silicification at the margins of pillows and in zoned patches with epidosite cores in massive flows. In the volcaniclastic rocks, silicification occurs as a large semiconformable zone and exhibits a variety of forms - for example: adjacent to aphyric and plagioclase-phyric felsic intrusions; at the margins of clasts; and as discordant zones in some bedded intervals.

Pervasive epidotization (clinozoisite-rich alteration) is most prominent in mafic volcaniclastic rocks below the large zone of silicification, in the eastern part of the map area. Epidotization led to net gains of Ca and Sr, and losses of Na, Fe and, in some places, Mg and base metals (Skirrow, 1987).

Garnet-chlorite alteration, or Fe-metasomatism, shows a crude increase in extent and intensity northwestwards in the breccia unit HVC. In the map area, almandine-rich garnet and Fe-rich chlorite commonly occur in the matrix of breccias, but further northwest, nearer the Chisel Lake deposit, the silicified clasts themselves are altered to garnet-chlorite-biotite-staurolite assemblages. Large net gains of Fe, and lesser Mg, and losses of Na, Ca and Si have been inferred for this type of alteration, based on evidence of immobility of Ti, Zr and Al in Fe-metasomatism and in the other alteration processes (Skirrow, 1987).

Plagioclase-quartz-bordered fractures cut the other alteration types and appear to be spatially and temporally related to the quartz-plagioclase porphyry.

MODEL OF ALTERATION (Figure C)

Field, mineralogic and geochemical evidence point to the existence of a fossil sub-seafloor geothermal system in the Edwards Lake - Chisel Lake area (Skirrow, 1987). Possible heat sources for the system include: (i) a large tonalite sill located 2-3 km south of the map area, which has been interpreted by Walford & Franklin (1982) and Bailes (1986) as a synvolcanic pluton; (ii) cooling lava flows, and (iii) local intrusions. Si-rich fluids may have been derived during interaction of seawater with mafic volcanic rocks in the (unidentified) intake areas of the system, although a direct magmatic source of the silica can not be dismissed.

Shortly before deposition of the Chisel Lake sulphides, emplacement of aphyric and plagioclase-phyric felsic dykes into a sub-seafloor fluid reservoir probably led to heating of fluids adjacent to the dykes to temperatures of greater than 350°C, causing deposition of Si and Na and leaching of Fe, Mg, Mn and in some places Zn. Where no local heat source is obvious, such as in much of the breccia unit HVC, the exchange reactions may have taken place without an increase in temperature, but the actual physico-chemical conditions during silicification remain unclear.

The zones of Fe-addition and silicification are spatially separated; furthermore, rocks marked by Fe-addition have lost silica and vice versa. Thus some of the metals released during silicification were precipitated both locally in the breccias and, at more distant sites in the alteration zone (Bailes, 1987) nearer the Chisel Lake massive sulphide deposit. A crude zonation in this semiconformable alteration from distal, deeper silicification to Fe-metasomatism near the deposit and the continuation of Fe-Mg-rich alteration upwards to the deposit itself (D. Ziehlke, pers. comm., 1986) further suggest that silicification may have been directly involved in generating an ore fluid (Skirrow, 1987; Franklin et al., 1981).

MacGeehan (1978) proposed a similar role of silicification in massive sulphide genesis at Matagami, Quebec. However, Gibson (1979) and Gibson et al. (1983) contended that silicified rocks near Noranda, Quebec acted in a passive role by creating an insulating, impermeable 'cap rock' at the top of the massive sulphide - producing geothermal systems. Thus, although silicification may have had more than one role in massive sulphide development, it is apparent that this alteration is spatially associated with at least some of these deposits in Precambrian terranes, and is therefore an important guide to exploration for environments of massive sulphide deposition.

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