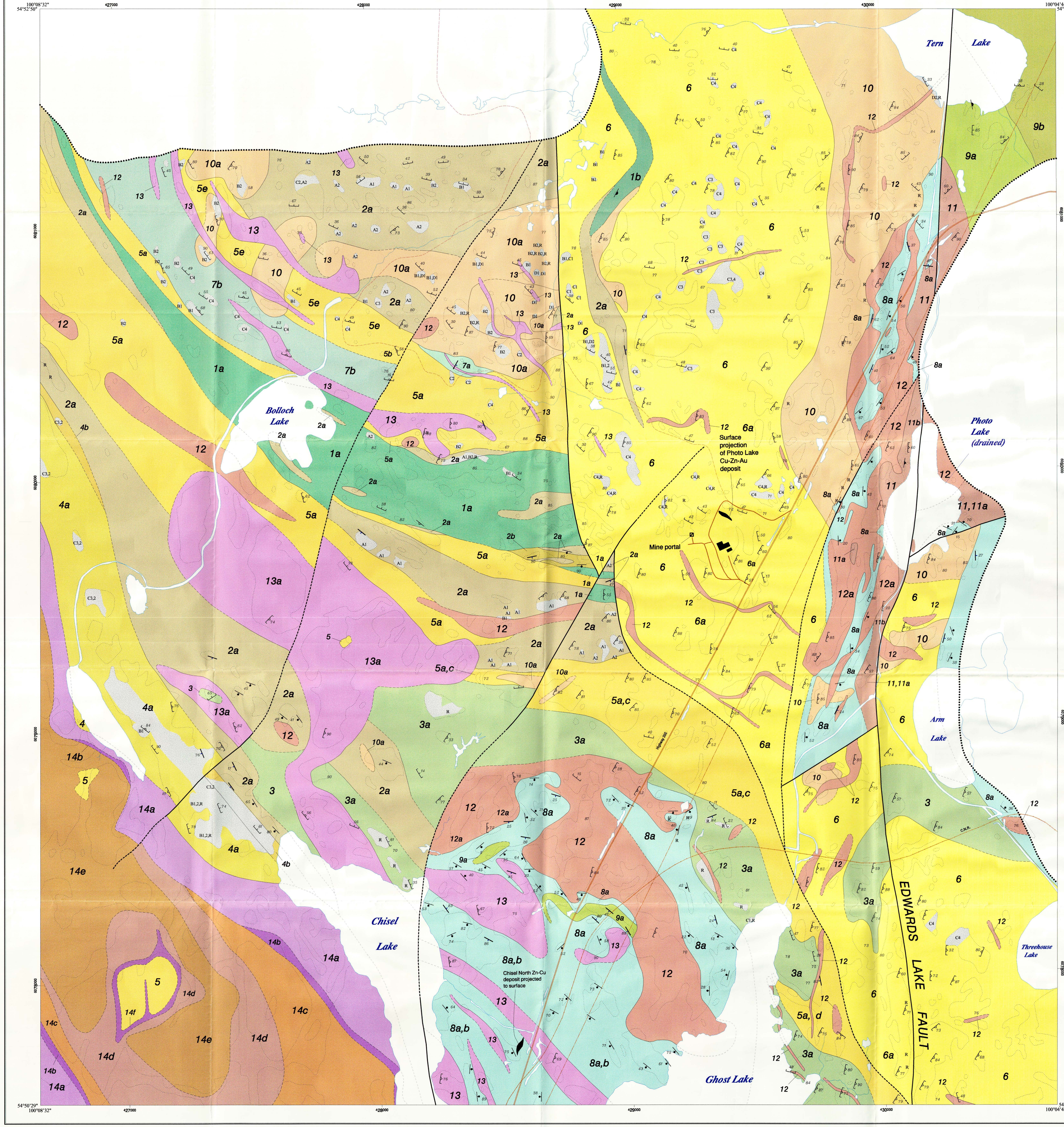
GEOLOGICAL SETTING OF THE PHOTO LAKE VOLCANIC-HOSTED MASSIVE SULPHIDE DEPOSIT, SNOW LAKE, MANITOBA

NTS 63K/16SE (part)

Open File OF97–5



LEGEND

PALEOPROTEROZOIC

INTRUSIVE ROCKS

SYNKINEMATIC INTRUSIVE ROCKS

14 (a–f) 14. Chisel Lake pluton
- a) lower peridotite
- b) pyroxenite
- c) lower gabbro
- d) middle gabbro
- e) upper gabbro
- f) upper margin zone, gabbro-pyroxenite

13 13. Fine– to medium–grained gabbro
- a) medium– to coarse–grained gabbro and quartz diorite

SYNVOLCANIC INTRUSIVE ROCKS

12 12. Plagioclase and plagioclase–pyroxene phyric gabbro
- a) amygdaloidal

11 11. Pyroxenite, melagabbro and gabbro
- a) pyroxene phyric gabbro
- b) amygdaloidal

10 10. Quartz porphyry, quartz–plagioclase porphyry
- a) aphyric to sparsely porphyritic, may include extrusive rocks

JUVENILE ARC VOLCANIC ROCKS

'YOUNGER' VOLCANIC ROCKS

9 (a, b) 9. Threehouse basalt and basaltic andesite
- a) plagioclase phyric flows
- b) pyroxene and pyroxene–plagioclase phyric flows

8 8. Threehouse mafic wacke and breccia
- a) mafic volcanic wacke and tuff
- b) mafic breccia

'OLDER' VOLCANIC ROCKS

7 (a, b) 7. Heterolithologic felsic breccia
- a) abundant plagioclase phyric clasts
- b) abundant quartz phyric clasts

6 6. Photo Lake rhyolite, felsic metavolcanic gneiss
- a) amygdaloidal

5 5. Rhyolite, dacite and felsic metavolcanic gneiss
- a) aphyric to sparsely porphritic
- b) quartz phyric
- c) monolithologic breccia
- d) amygdaloidal
- e) plagioclase phyric

4 (a, b) 4. Dacitic volcaniclastic rocks, possibly euqivalent to Powderhouse dacite
- a) tuff and lapilli tuff
- b) heterolithologic felsic and mafic breccia

3 3. Ghost Lake 'andesite', mainly altered felsic flows
- a) amygdaloidal

2 2. Heterolithogical mafic volcaniclastic rocks
- a) mafic breccia
- b) mafic wacke and tuff

1 1. Bolloch Lake basalt and fine–grained amphibolite, minor undivided basalt
- a) aphyric
- b) porphyritic

▨ HYDROTHERMALLY ALTERED ROCKS

Quartz + plagioclase–rich rocks

A1	>50% domains of quartz + albite ± epidote in a matrix of 5–25 garnet
A2	10–50% domains of quartz + albite ± epidote in a matrix of 5–15% garnet, 30–50% amphibole and 0–3% magnetite

Chlorite–rich rocks

B1	20–100% chlorite + garnet ± staurolite ± biotite ± amphibole
B2	irregular veins and seams of chlorite + garnet
B3	abundant disseminated chlorite ± amphibole
B4	minor disseminated chlorite ± amphibole

Amphibole–rich rocks

C1	>50% coarse amphibole ± chlorite in a fine–grained mafic groundmass
C2	10–50% coarse amphibole in a fine–grained mafic groundmass
C3	10–30% acicular amphibole ± garnet
C4	< 10% acicular amphibole ± garnet

Other Alteration Types

D1	pyritization (0.5–5%, ± pyrrhotite ± chalcopyrite) ± sericitization
D2	disseminated sulphides (py = pyrite, po = pyrrhotite, cp = chalcopyrite)
R	rusty weathering

Symbols

Map limit

Area of outcrop

Geological boundary: defined/approx, assumed, underwater

Fault: defined, assumed

Foliation: age unknown, S_{1-2}, S_3

Bedding: top unknown, known, overturned

Flow contact: top unknown

Pillows: top known

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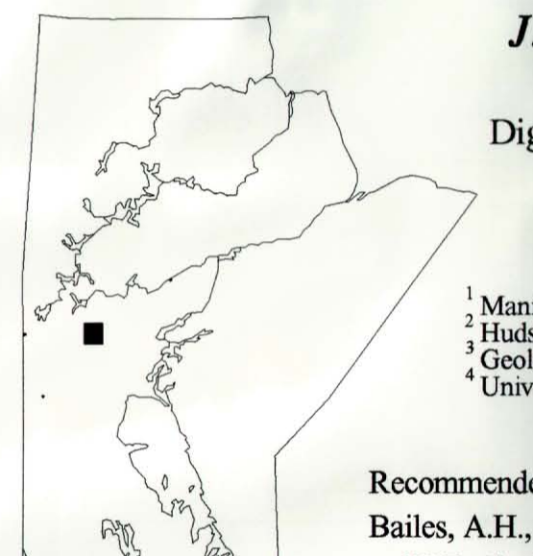
J. Young (1987)[4]



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1997: Geological setting of the Photo Lake volcanic–hosted massive sulphide deposit, Snow Lake, Manitoba (part of 63K/16SE); Manitoba Energy and Mines, Open File OF 97–5, annotated 1:5000 colour map.

Scale 1:5000

100 0 100 200 300 400 500

METERS

Projection:
Universal Transverse Mercator
Zone 14 NAD 27

Manitoba
Energy and Mines

DESCRIPTIVE NOTES

INTRODUCTION

The Snow Lake area at the east end of the Paleoproterozoic Flin Flon Belt contains 11 of the belt's 25 producing and past producing base metal mines (Syme *et al.*, 1996). Two deposits, the currently producing Photo Lake Cu-Zn-Au mine and a potential producer (Chisel North Zn-Cu deposit), occur in the Photo Lake map area. Photo Lake is the only currently producing base metal mine in the Snow Lake area.

This 1:5000 scale map of the Photo Lake area is one of a series of 1:5000 to 1:50 000 scale maps produced to place volcanic-hosted massive sulphide (VMS) deposits and occurrences near the town of Snow Lake into a comprehensive geological setting (Bailes and Galley, 1992; Bailes and Galley, 1993; Bailes *et al.*, 1994; Bailes *et al.*, 1996). This open file map is the product of a cooperative endeavour of Manitoba Energy and Mines and Hudson Bay Exploration and Development.

GEOLOGY OF THE PHOTO LAKE AREA

The Photo Lake map area is underlain by volcanic rocks (units 1 to 9) and synvolcanic intrusive rocks (units 10 to 12) that belong to the 'mature' arc portion of the Snow Lake arc assemblage as defined by Bailes and Galley (1996). They are intruded by synkinematic gabbro (unit 13) and the Chisel Lake layered mafic to ultramafic pluton (unit 14). Although all rocks have been recrystallized to almandine amphibolite facies metamorphic mineral assemblages, those that have recognizable primary features are referred to by their original names without metamorphic prefixes.

The volcanic rocks in the eastern half of the Photo Lake area include an 'older' and 'younger' sequence. The 'older' sequence consists largely of felsic flows, volcaniclastic rocks and derived gneisses (units 1 to 7). The 'younger', stratigraphically overlying sequence includes dominantly mafic volcaniclastic rocks (unit 8), related basalt (unit 9) and subvolcanic intrusions (units 11 and 12) of the Threehouse formation. In the western half of the map area this subdivision into 'older' and 'younger' successions is not as clear because the section is more heterogeneous and includes intercalated mafic and felsic sequences. The relationship between the eastern and western domains at Photo Lake is further complicated by a north-trending fault down the centre of the map area. The fault truncates over 2 km of stratigraphic section to the west that is not repeated to the east, and separates a southwest facing domain to the west from an east and northeast topping section to the east.

Both VMS deposits in the Photo Lake area are spatially associated with a large rhyolite flow complex (unit 6). The Chisel North deposit is along strike from and at the same stratigraphic interval as both the rhyolite complex and the Chisel Lake VMS deposit. It is directly overlain by 'younger' Threehouse mafic volcanic wacke (unit 8a). The Photo Lake VMS deposit occurs in the middle of a >2 km thick sequence of unit 6 rhyolite flows that are overlain to the east by Threehouse mafic volcanic wacke.

Both the Chisel North and Photo Lake VMS deposits are coarsely recrystallized and strongly deformed. The host volcanic rocks display a layer parallel F_1-F_2 schistosity overprinted by a weak F3 NNE-trending biotite foliation (deformation events as defined by Krause and Williams, 1995). The paucity of top direction indicators in the dominant felsic lithologies of the Photo Lake map area preclude ready recognition of earlier layer parallel F_1-F_2 structures, but the available top direction indicators suggest that prominent isoclinal F_1-F_2 structures are unlikely to be present in the Photo Lake map area. Nevertheless these structures are important as orebodies are typically alligned parallel to a prominent F_{1-2} - F_3 stretching lineation (Galley *et al.*, 1993).

Description of 'older' volcanic rocks

The 'older' volcanic sequence at Photo Lake consists mainly of massive felsic flows with lesser amounts of intercalated mafic flows, heterolithologic mafic and felsic breccia, with local synvolcanic bodies of quartz and quartz-feldspar porphyry. In the absence of a well defined stratigraphy, the legend for 'older' strata is arbitrarily given in order from mafic to felsic compositions. The following description of units is also given from mafic to felsic, without regard to stratigraphic order.

Bolloch Lake basalt and fine-grained amphibolite, minor undivided basalt (unit 1): Bolloch Lake basalt (unit 1a), a >600 m thick unit of massive aphyric basalt and basaltic andesite flows with lesser pillowed flows and amoeboid pillow breccia, is the only volumetrically significant mafic flow unit in the Photo Lake area. It typically contains 1-10%, 2-30 mm quartz amygdales and is locally intercalated with minor, thin volcaniclastic units, including heterolithologic mafic breccia, mafic scoria lapilli tuff and mafic wacke. Bedding in the mafic wacke indicates that the Bolloch Lake basalt is steep dipping and south- to southwest- facing. The presence of large amygdales in the basalt and intercalation with scoria lapilli tuff suggests that it was likely deposited in a moderately shallow water environment. Porphyritic pillowed basalt (unit 1b), unrelated to the Bolloch Lake basalt, is exposed in a single tiny exposure 1.5 km north-northwest of the Photo Lake mine; it is significant as it provides the only reliable facing direction (SE) in the otherwise monotonous felsic sequence (unit 6) that hosts the Photo Lake VMS deposit.

Heterolithologic mafic volcaniclastic rocks (unit 2): Thick units of mafic heterolithologic breccia and wacke (unit 2) occur in three localities: a >600 m thick unit northeast of Bolloch Lake, a <200 m thick unit stratigraphically overlying the Bolloch Lake basalt, and a <90 m thick unit stratigraphically overlying the Photo Lake mine 'horizon'. The >600 m thick mafic breccia unit northeast of Bolloch Lake is composed dominantly of plagioclase phyric mafic volcanic fragments and is commonly silicified and feldspathized. Altered breccia has a bleached appearance with nebulous fragments, resembles an intermediate to felsic rock, and contains 10-40% acicular 2-7 mm amphibole porphyroblasts. The < 200 m thick unit of mafic heterolithologic breccia south of, and stratigraphically above, the Bolloch Lake basalt (unit 1a) is composed mainly of aphyric basalt fragments, with minor aphyric mafic scoria, rare angular rhyolite and porphyritic basalt clasts. Many of the aphyric basalt clasts contain large quartz amygdales, and are identical in appearance to stratigraphically underlying Bolloch Lake basalt flows. Portions of the mafic breccia are silicified and feldspathized, varying from selective alteration of individual fragments to widespread alteration of sections up to 70 m thick. The <90 m thick, north-trending unit of heterolithologic mafic breccia in the middle of unit 6 north of Photo Lake VMS deposit has a highly variable clast population that is dominated by aphyric and plagioclase phyric basalt and basaltic andesite. This unit of mafic breccia is relatively unaltered, in contrast to strong alteration of felsic rocks to the west, indicating that the hydrothermal event that affected the felsic rocks to the west ceased before its deposition. The latter alteration was likely produced during the hydrothermal event responsible for the Cu-Zn-Au sulphide mineralization at the Photo Lake mine. A corollary of this interpretation is that the unexposed interval between the unaltered mafic breccia and the altered felsic rocks is the Photo Lake 'mine horizon'.

Ghost Lake 'andesite' (unit 3): Medium to dark grey green weathering, massive, aphyric, quartz amygdaloidal volcanic rocks occur within the dominantly felsic domain directly east and northwest of Ghost Lake. They display irregular and often gradational contacts with the felsic rocks, and are internally variable in colour and composition. In the past these rocks have been mapped as mafic to intermediate flows (Harrison, 1949; Williams, 1966; Bailes and Galley, 1992) but chemical analyses indicate that they are typically andesitic to dacitic in composition (Bailes, 1997). Their irregular distribution, gradational contacts and internal variability are consistent with them being altered rocks; one interpretation is that they are simply chloritized equivalents of the bounding rhyodacite and rhyolite lithologies, in accord with their high alkali contents.

Dacitic volcaniclastic rocks (unit 4): A unit of plagioclase phyric dacite tuff and lapilli tuff (unit 4a) and heterolithologic breccia (unit 4b) >250 m wide outcrops 600 m southwest of Bolloch Lake. Hydrothermally altered domains are common and characterized by 5-30% garnet, 10-60% amphibole porphyroblasts and up to 5% disseminated pyrite.The dacite tuff and lapilli tuff (unit 4a) is typically massive, pale buff weathering and characterized by 5-15%, 0.5-3 mm plagioclase phenocrysts and small plagioclase phyric felsic fragments. The >60m wide unit of breccia (unit 4b) to the northeast is composed of a mixture of felsic and mafic clasts. Felsic fragments in this breccia are commonly plagioclase phyric and texturally identical to the fine grained massive dacite tuff. Although no facing directions were identified in the dacite, unit 4 likely tops to the southwest because bounding mafic wacke units face southwest. Although unit 4 dacite is texturally similar to the 'Powderhouse dacite', a unit that stratigraphically underlies Chisel Lake area Zn-rich VMS deposits, it displays lower lower Zr values (42-102 ppm compared to 131-152 ppm) and much lower contents of LREE (Bailes, 1997).

Rhyolite, dacite and felsic metavolcanic gneiss (unit 5): The 'older' volcanic sequence at Photo Lake is dominated by felsic volcanic rocks. Most of these felsic rocks are aphyric to sparsely porphyritic massive units that locally include phases that are quartz phyric, fragmental or quartz amygdaloidal. The two largest domains of unit 5 felsic volcanic rocks occur in the vicinity of Bolloch Lake and northwest of Ghost Lake. The relationship of unit 5 felsic rocks to the Photo Lake rhyolite (unit 6), host to the Photo Lake Cu-Zn-Au and Chisel North Zn-Cu VMS deposits, is uncertain as they are separated by faults with indeterminate offsets; they do, however, display significant geochemical differences (Bailes, 1997). At Bolloch Lake the unit 5 felsic rocks form approximately half of a >1.3 km thick sequence, with the remainder of the sequence consisting of intercalated units of Bolloch Lake basalt (unit 1a) and a variety of heterolithologic mafic volcaniclastic units (unit 2). Rare facing directions in this section are consistently to the southwest. Primary structures and phenocrysts are typically not well preserved in massive felsic units north of Bolloch Lake due to strong recrystallization. However, northwest of Ghost Lake, in less strongly recrystallized equivalents, they locally consist of domains (lobes?) of massive rhyolite and intervening domains of monolithologic breccia (microbreccia?). Alteration of unit 5 felsic volcanic rocks is common, but is most prominent in the area just north of Bolloch Lake.

Photo Lake rhyolite, felsic metavolcanic gneiss (unit 6): The Photo Lake rhyolite (unit 6) consists of a monotonous sequence of massive aphyric to sparsely porphyritic felsic rocks and derived felsic gneisses. It includes rhyolites north of Ghost Lake that were previously referred to as Ghost Lake rhyolite. The rhyolites locally contain quartz amygdales, quartz-filled gas cavities and massive lobes with intervening microbreccia, and are interpreted to be mainly flows. They host the Cu-Zn-Au rich Photo Lake VMS deposit and are along strike from the Chisel North Zn-Cu VMS deposit. No internal subdivisions of the Photo Lake rhyolite were mapped and no facing directions were identified. The only indication of the strike of units in the domain hosting the Photo Lake VMS deposit is provided by an intercalated, north-northwest-trending unit of heterolithologic mafic breccia (unit 2a) northwest of the Photo Lake mine. This domain of rhyolites is interpreted to top to the east-northeast on the basis of a pillow top in unit 1b, strong alteration of felsic rocks west of the unaltered heterolithologic mafic breccia (unit 2a), and the presence of strongly altered 'footwall' rocks on the southwest side of the Photo Lake VMS deposit (pers. com. HBED geologists, 1994). A prominent zone of altered rhyolite occurs 700 m northwest of the Photo Lake mine. These altered rocks typically contain 15-30%, 2-12 mm garnet and 5-40%, 1-6 mm dark green amphibole porphyroblasts in irregular patches and anatomosing veins. They also contain 2% sulphides, mainly pyrrhotite with some pyrite and rare chalcopyrite. This zone of alteration has been traced over 1 km to the north in a series of widely spaced, generally small outcrops. Rocks in three small outcrops in this zone, at the north edge of the map area, consist entirely of garnet, chlorite and biotite; they closely resemble 'pipe-like' alteration that is normally found only in the immediate footwall of massive sulphide deposits elsewhere in the Snow Lake area. Other zones of altered rocks, north and west of the Photo Lake deposit, are much weaker, typically composed of sucrosic felsic rocks with 1-3%, 0.5-1 mm garnet and 2-8%, 1-4 mm pale green amphibole porphyroblasts.

Heterolithologic felsic breccia (unit 7): This 150 m wide unit outcrops northwest and east of Bolloch Lake, and is bounded to the northeast and southwest by undivided felsic rocks. It is composed dominantly of felsic clasts, most of them coarsely quartz phyric, but including up to 10% mafic clasts. The quartz phyric clasts, which contain 5-7%, 1-5 mm quartz phenocrysts, texturally resemble quartz porphyry intrusions (unit 10) that outcrop down section to the northwest.

Description of 'younger' volcanic rocks:

The 'younger' volcanic sequence consists of Threehouse mafic wacke, mafic breccia and pillowed porphyritic basalt/basaltic andesite (units 9 and 10) that are exposed along the south and east margins of the map area. At the south margin of the map area they occur in a northwest-trending synclinal fold interference structure, 6 km long and 2.5 km wide (locally known as the 'Chisel basin'). Those exposed east of the Photo Lake mine site are at the base of a >0.5 km thick homoclinal sequence that mainly outcrops east of the map area. In both domains, Threehouse mafic rocks are relatively unaltered, and thus postdate the prominent synvolcanic hydrothermal event that effected the underlying 'older' volcanic rocks. Since the hydrothermal event is interpreted to be related to the mineralizing episode that produced the Chisel Lake and Photo Lake area base metal sulphide deposits, the Threehouse formation in the Photo Lake map area is not considered prospective for VMS deposits. At Chisel Lake the Threehouse mafic wackes directly and conformably overlie the Chisel Lake mine horizon. Near Photo Lake they appear to unconformably overlie and possibly truncate the Photo Lake ore-hosting stratigraphy (Bailes and Simms, 1994).

Threehouse mafic wacke and breccia (unit 8): Well bedded mafic wacke (unit 8a) forms almost all of the Threehouse formation in the 'Chisel basin', whereas it composes only the basal 100 m of this formation east of Photo Lake. The mafic wacke displays excellent graded bedding, load structures, scour channels and A, AB and ABE Bouma bed zonation, consistent with deposition in a subaqueous environment from turbulent density currents.

Threehouse basalt and basaltic andesite (unit 9): Pillowed basalt and basaltic andesite flows (unit 9) dominate the upper part of the Threehouse section east of Photo Lake, but only occur sporadically west and north-west of Ghost Lake in the 'Chisel basin' section. They include both pyroxene (unit 9a) and pyroxene-plagioclase (unit 9b) phyric flows that are texturally identical to clasts preserved in breccia beds in Threehouse mafic volcaniclastic rocks, suggesting a common magmatic source for both lithologies. East of Photo Lake the Threehouse section is dominated by mafic flows, whereas in the 'Chisel basin' section it is dominated by mafic volcaniclastic rocks. One interpretation is that the section east of Photo Lake preserves a more proximal portion of this unit than that in the 'Chisel basin'.

Description of synvolcanic intrusive rocks

Quartz porphyry, quartz-plagioclase porphyry (unit 10): Plugs and sills of quartz and quartz-feldspar porphyry occur throughout the Photo Lake area. The largest single body is a sill-like intrusion >350 m wide and >2 km long located north of the Photo Lake VMS deposit. It is a massive, featureless, fine grained rock with 4-8%, 1-6 mm quartz and 1-4%, 0.5-3 mm plagioclase phenocrysts. Most other intrusions occur north of Bolloch Lake where they form bodies up to 300 m in diameter. Although the quartz porphyry and quartz-plagioclase porphyry bodies may vary in age, most of them appear to be early, possibly synvolcanic, as they are cut by gabbro intrusions that can be linked to overlying extrusive volcanic rocks and because clasts of these intrusions locally occur in heterolithologic felsic breccias (unit 7). Zones of disseminated pyrite are common in these intrusions; some have prominent exploration trenches. The origin of massive fine-grained felsic rocks (unit 10a) spatially associated with the quartz porphyry and quartz-feldspar porphyry intrusions north of Bolloch Lake is uncertain. Although these rocks are indistinguishable from extrusive aphyric to sparsely porphyritic felsic volcanic rocks (unit 5), their irregular contacts and apparent cross-cutting distribution suggest that they may be in part intrusive. They contain zones of disseminated pyrite comparable to those that occur in the porphyritic intrusions (unit 10).

Pyroxenite, melagabbro, gabbro and porphyritic gabbro (units 11 and 12): Irregular bodies of porphyritic gabbro and melagabbro (units 11 and 12) are common in Threehouse mafic wackes (unit 8) north of Chisel Lake and east of the Photo Lake mine site. These intrusions include pyroxenite, melagabbro and gabbro (unit 11) and plagioclase- and plagioclase-pyroxene phyric gabbro (unit 12). The textural and compositional variation in these intrusions is comparable to those in the overlying Threehouse pillowed basalt and basaltic andesite flows (unit 9). Shallow emplacement of the gabbro intrusions is suggested by scattered (<<1%) 1-3 mm quartz amygdales and by local prominent zones of quartz amygdales. A synvolcanic emplacement of the gabbro intrusions is conclusively demonstrated by the local presence of pepperites. Threehouse formation plagioclase and plagioclase-pyroxene phyric gabbro intrusions at Photo Lake are different in size and shape within the Photo Lake rhyolite and quartz-feldspar porphyry than they are in the adjacent Threehouse mafic wacke. In the competent Photo Lake rhyolite and quartz-feldspar porphyry they are present as 10-30 m wide dykes that cut 'stratigraphy' at a high angle, whereas in the Threehouse mafic wacke they form irregular sill-like bodies up to 100 m thick and 1.5 km long. The presence of the syn-Threehouse gabbro intrusions at the base of the Threehouse sequence at Photo Lake and related feeder dykes in the underlying Photo Lake rhyolite indicates that these sequences are structurally intact. A further implication is that the angular truncation of the Photo Lake stratigraphy and the quartz-feldspar porphyry intrusion at the base of the Threehouse mafic wackes may be due to an unconformity (Bailes and Simms, 1994).

Synkinematic intrusive rocks

Fine- to medium-grained gabbro (unit 13): Large dykes of massive, equigranular fine- to medium-grained gabbro (unit 13) cut across the Threehouse mafic volcaniclastic rocks (unit 8) and across the Chisel Lake massive Zn-Cu sulphide deposit (south of the Photo Lake map area). These intrusions are up to 200 m wide and several kilometres long. They are folded along with their host volcanic rocks. The folds and gabbro (unit 13) are cut by the Chisel Lake pluton (unit 14).

Chisel Lake pluton (unit 14): The Chisel Lake pluton is a 1.8 by 9.8 km, north-trending, canoe-shaped, internally zoned ultramafic-mafic body. Geological contacts for the Chisel Lake pluton are from Young (unpublished); the intrusion was not mapped during this project. Marginal phases of the Chisel Lake pluton are chilled against supracrustal rocks and truncate isoclinal F1-F2 folds that deform the main ore lens of the Chisel Lake massive sulphide deposit. Young (pers. comm., 1992) interprets the intrusion to be late- to post-metamorphic because rocks in the pluton display lower temperature metamorphic assemblages than the peak metamorphic assemblages in the host strata. F1 folds formed ca. 1.84 Ga (David et al., 1996) and regional metamorphism in the Snow Lake area occurred c.a. 1.81 Ga (David et al., 1996) indicating that the intrusion post dates the c.a. 1.89 Ga volcanism by at least 50 and possibly 80 Ma.

STRUCTURE

Folds

Recent structural studies in well bedded sedimentary rocks and derived paragneisses (e.g., Kraus and Williams, 1995) suggest that the following folding episodes have affected rocks of the Snow Lake area between 1840-1800 Ma: F_1 tight isoclinal folds with an associated muscovite cleavage, F_2 folds with a cleavage that is syn- to post-regional metamorphism, F_3 open folds (NNE trending) with an axial planar crenulation cleavage, and rare F_4 folds that are restricted to an area north of Snow Lake. The presence or absence of these folds (particularly F_1 or F_2 isoclinal folds) is not immediately obvious as the massive rhyolites at Photo Lake do not generally display internal layering or obvious facing directions. However, we suggest that significant F_{1-2} folds have not affected rocks in the immediate vicinity of the Photo Lake mine because synvolcanic Threehouse gabbro dykes in the Photo Lake rhyolite sequence are relatively undeformed.

Despite the apparent absence of large scale early isoclinal F_1-F_2 folds in the immediate vicinity of the Photo Lake mine, the host volcanic rocks are strongly deformed. This deformation is recorded by well developed schistosities and prominent stretching lineations. Two prominent cleavages are recognized: an earlier cleavage (S_1-S_2) that generally strikes west-northwest and dips moderately to shallowly to the north-northeast and a younger cleavage (S_3) that strikes north-northeast and dips steeply. The earlier cleavage is locally deformed by open F_3 folds whereas the younger cleavage is axial planar to the F_3 folds. In well bedded Threehouse mafic wackes of the 'Chisel basin' the early cleavage is locally axial planar to northwest moderate plunging isoclinal (F_{1-2}?) folds. The prominent, ubiquitous stretching lineation in Photo Lake rocks, which is probably a product of combined F_{1-2} and F_3 deformation, plunges moderately to shallowly to the north-northeast.

Faults

Faults locally offset the stratigraphy in the Photo Lake area, but because they have little or no expression in outcrop and occur in monotonous sequences, their along-strike definition is poorly constrained. Although most of the faults have only minor offset, the north-trending fault in the centre of the map area separates two very different successions. To the west of this fault there is a south- to southwest-facing mixed-lithology package, whereas to the east there is an east- to northeast-facing rhyolite-dominated package. Recognition of this fault is important as it truncates and offsets the ore-hosting Photo Lake rhyolites.

MASSIVE SULPHIDE DEPOSITS

Chisel North Zn-Cu VMS deposit

Chisel North is one of four Zn-Cu VMS deposits that occur along the contact between the 'older' and 'younger' volcanic sequences in the Chisel Lake area. The other deposits (Chisel, Lost and Ghost) all occur south of the map area. The sulphide deposits either directly overlie altered feldspar phyric Powderhouse dacite or a quartz phyric rhyolite, the latter locally termed the Chisel rhyolite. The Chisel and Chisel North deposits are 300 m apart and are connected by a 1-2 m thick sulphide-chert-wacke unit that contains anomalously high values of Zn and Ag (Galley et al., 1993). Fine grained, well bedded mafic volcaniclastic rocks (unit 8a) of the Threehouse formation form the immediate hanging wall to the Chisel and to the southern two thirds of the Chisel North deposits.

The Chisel North deposit plunges 10°-20° at an azimuth of 020° and is located 600 m below surface (Galley et al., 1993). The ore consists of up to 20 m of silicate-dolomite-rich semi-massive spalerite-rich ore with thinner layers of massive sulphide. The underlying Powderhouse dacite consists of recrystallized, hydrothermally altered rocks now composed of sericite and chlorite with abundant porphyroblasts of kyanite, biotite, staurolite and garnet. The Chisel North 'ore horizon' and the underlying altered Powderhouse continue to dip shallowly to the north whereas hanging wall rocks appear to reverse in dip, suggesting that there may be a structural discontinuity in the hanging wall to the deposit, possibly a fault.

Photo Lake Cu-Zn-Au VMS deposit

The Photo Lake Cu-Zn-Au VMS deposit is hosted within the largest rhyolite domain in the Snow Lake area, the Photo Lake rhyolite (unit 6). Until the discovery of the Photo Lake deposit, this domain of rhyolite was generally considered to have low VMS potential. Although Photo Lake is a small deposit, it contains high Cu and Au values and it indicates that the Photo Lake rhyolite is much more prospective for economic VMS deposits than was previously considered.

Mapping in the Photo Lake area has identified the probable location of the Photo Lake VMS 'mine horizon' as the western contact of the heterolithologic mafic breccia (unit 2) to the north northwest of the mine site. Several areas of intensely altered rocks below this 'horizon' at the north margin of the map indicate that this area may have potential for further VMS mineralization. Although the Photo Lake deposit has been multiply folded (HBED 1997, pers. com.) we suggest that the section hosting the Photo Lake deposit is only broadly F_3 folded and monoclinal, facing to the east and northeast.

The relationship between the Photo Lake and Chisel North VMS deposits is not known. However, the two deposits are so dissimilar in their stratigraphic setting and in their metal content (Cu-Au vs. Zn-Ag) that they are unlikely to be directly related.

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