INTRODUCTION

The majority of volcanogenic massive sulphide (VMS) deposits at the east end of the Paleoproterozoic Flin Flon greenstone belt occur in the 1.89 Ga Snow Lake arc (SLA) assemblage (Syme and Bailes, 1993). The SLA hosts seven producing and past-producing base metal mines, and accounts for production and reserves of 20.7 million tonnes.

VMS deposits in the isotopically juvenile Snow Lake oceanic arc sequence are hosted within a 6 km thick monoclinal section that records in its stratigraphy and geochemistry a temporal evolution in arc development from primitive, through mature to arc rift (Bailes and Galley, 1996). VMS deposits occur in both the primitive and mature arc sequences and are interpreted to be products of arc extension and accompanying anomolously high heat flow, fracturing, and fluid circulation (Bailes and Galley, 1999).

Boninites, low-Ti tholeiites, and isotopically juvenile rhyolite flows, a rock association that has been attributed in both modern and Phanerozoic arcs to high temperature hydrous melting of refractory mantle sources in an extensional and/or proto arc environment (Beccaluva and Serri, 1988; Crawford et al., 1981; Swinden, 1996; Lapierre et al., 1985), forms the primitive arc. Voluminous volcaniclastic detritus (?from fault scarps), prominent synvolcanic dykes, isotopically juvenile rhyolite flows, and the fact that it is stratigraphically overlain by arc rift basalts with MORB-like geochemistry indicate that the mature arc also underwent extension.

Interpretation of VMS deposits at Snow Lake as products of an extensional geodynamic setting suggests that the traditional Flin Flon Belt exploration model, invoking ‘pluton-generated’ convective seawater, be augmented by the search for evidence of rifting. Economically significant rock associations at Snow Lake include geochemically primitive refractory mafic magmas (e.g., boninites), isotopically juvenile felsic magmas, bimodal basalt-rhyolite sequences, and arc rift basalts.

This CD-ROM contains the preliminary release of a geochemical data set for the SLA from which the interpretations on the setting of the Snow Lake VMS deposits published in previous papers were based (e.g., Bailes and Galley, 1996, 1999). The preliminary release of this data set was undertaken at the request of mining companies to facilitate exploration activities in the Snow Lake and adjacent areas. A more comprehensive report and discussion of the geochemistry of the volcanic and intrusive rocks of the SLA will follow in 2002.

The CD-ROM contains the initial release of 274 geochemical analyses of the SLA volcanic and intrusive rocks. Of the 274 analyses, 56 are of hydrothermally altered rocks, while the remainder were collected to avoid significant alteration or contamination by amygdales, veins or fractures. The CD-ROM also includes previously released journal papers that describe the main geological and geochemical attributes of rocks in the SLA. Bailes and Galley (1996) provide a discussion of the geological setting of the VMS deposits. Bailes and Galley (1999) interpret the paleotectonic setting of the rocks hosting the VMS deposits. Journal papers on the Snow Lake area stemming from CAMIRO Project 94e07—a study on the use of regional scale alteration zones and subvolcanic intrusions in the exploration for VMS deposits—describe the nature of the VMS-associated alteration zones in the SLA, present data and interpretation of the isotopic signatures of hydrothermal alteration zones, and discuss the role of subvolcanic intrusions in generating VMS deposits and will be released in a special edition of *Mineralium Deposita*.

Regional Geology

The Flin Flon Belt belongs to the juvenile (internal) zone of the Trans-Hudson Orogen, a collision zone formed during the 2.0-1.8 Ga amalgamation of several Archean microcontinents into a supercontinent, Laurentia (Hoffman, 1988). It is a collage of 1.92-1.88 Ga tectonostratigraphic assemblages juxtaposed during 1.88-1.87 Ga intra-oceanic accretion and subsequent 1.84-1.78 Ga terminal collision of the bounding Archean cratons (Lucas et al., 1996, Fig. 1). Based on their trace element contents, volcanic rocks in the Flin Flon Belt are known to include juvenile arc (~68%), juvenile ocean floor (~20%), minor (~12%) oceanic plateau, ocean island basalt, 'evolved' plutonic arc and undivided rocks (Syme and Bailes, 1993; Stern et al., 1995a, 1995b; Syme et al., 1996). Oceanic arc assemblages include tholeiite, calc alkaline and rare shoshonite and boninite suites (Stern et al., 1995a) almost identical to those forming in modern intra-oceanic arcs (e.g., Gill 1981). Most VMS deposits in the Flin Flon Belt occur in two ≥1.88 Ga juvenile arc segments, one near the town of Flin Flon and one at Snow Lake (Snow Lake arc assemblage). They are separated by an extensive, northeast-trending collage of 1.90 Ga (Stern et al., 1995a) MORB-like back arc-ocean floor basalt flows, associated gabbro and ultramafic rocks, that contains no known economic VMS deposits (Fig. 1).

The Snow Lake part of the Flin Flon Belt is dominated by 1.84-1.81 Ga fold-thrust style tectonics (Connors, 1996) that is atypical of central and western portions of the belt. This difference in tectonic style may reflect the fact that the entire Snow Lake portion of the Flin Flon Belt is a south-verging, allochthonous, northeast-dipping imbricate that was thrust between 1.84 and 1.81 Ga (Syme et al., 1995; Lucas et al., 1996) over the previously amalgamated collage of oceanic and arc rocks ("Amisk collage") to the west (Fig. 2, 3). The individual allochthons of volcanic rocks in the Snow Lake area, besides being bounded by thrust faults, are also generally separated by intervening imbricates of younger, approximately 1.84 Ga sedimentary rocks (Connors, 1996; David et al., 1996). The base of the thrust stack is interpreted to be the Morton Lake Fault Zone (Fig. 1, 2, 3). This thrust package has been subsequently modified by intrusion of 1.84-1.83 Ga granitic plutons, by northeast trending and plunging open folding (Kraus and Williams, 1999) and by 1.82-1.81 Ga (David et al., 1996) regional metamorphism to lower to middle almandine amphibolite facies (Froese and Moore, 1980).

Geology and Main Subdivisions of the SLA

The 15 km wide Snow Lake arc assemblage (allochthon) is noteworthy as one of the most completely exposed VMS-hosting domains in the Flin Flon Belt. The 7 producing and past-producing VMS mines, as well as all significant sulphide occurrences, are located within a 6 km thick, north-facing section of the allochthon, where they are spatially associated with two large, subvolcanic, multicomponent, tonalite-trondhjemite intrusive complexes (Fig. 4, 5, 6). The volcanic rocks, subvolcanic intrusive complexes and associated VMS deposits in this north-facing sequence are described in detail by Bailes and Galley (1996).

Volcanic strata and associated intrusions in the 6 km thick VMS-hosting section are divided into three distinct subdivisions (Fig. 4, 6): 1) a lower 2.5 km thick primitive arc subdivision that consists of mafic and minor felsic flows with negligible volcaniclastic rocks; 2) a middle 3 km thick mature arc section that comprises a lithologically diverse volcanic domain with rapid lateral facies variations and abundant volcaniclastic rocks; and 3) an upper 0.5 km thick arc rift section that consists of pillowed basalts with no intercalated felsic rocks or volcaniclastic detritus.

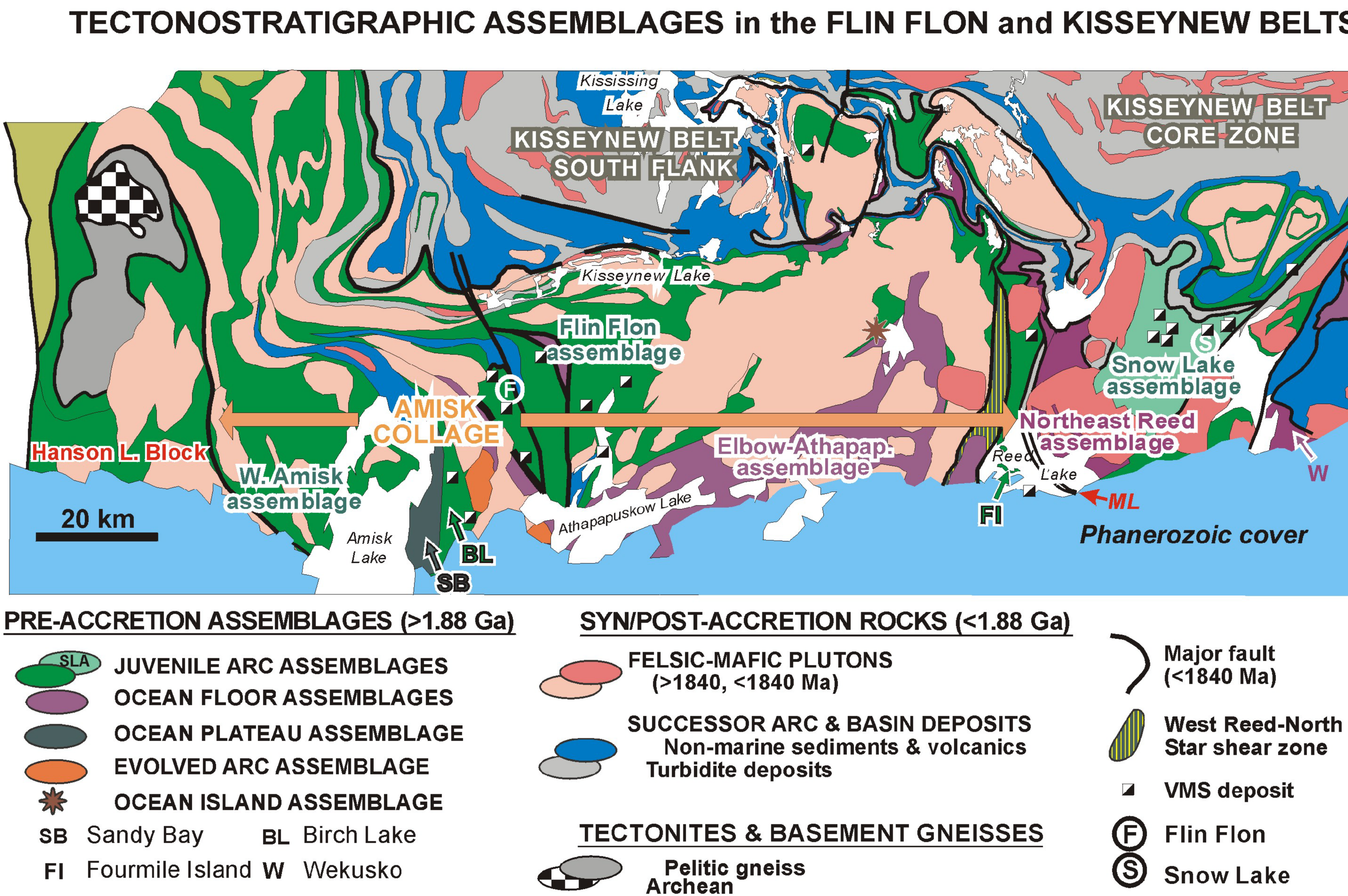

Figure 1: Simplified geology of the central and eastern portion of the Flin Flon Belt showing major tectonostratigraphic assemblages and plutons, and locations of mined VMS depostis. F: Flin Flon, S: Snow Lake, ML: Morton Lake fault zone.

Generalized geology of the Reed Lake - Snow Lake area

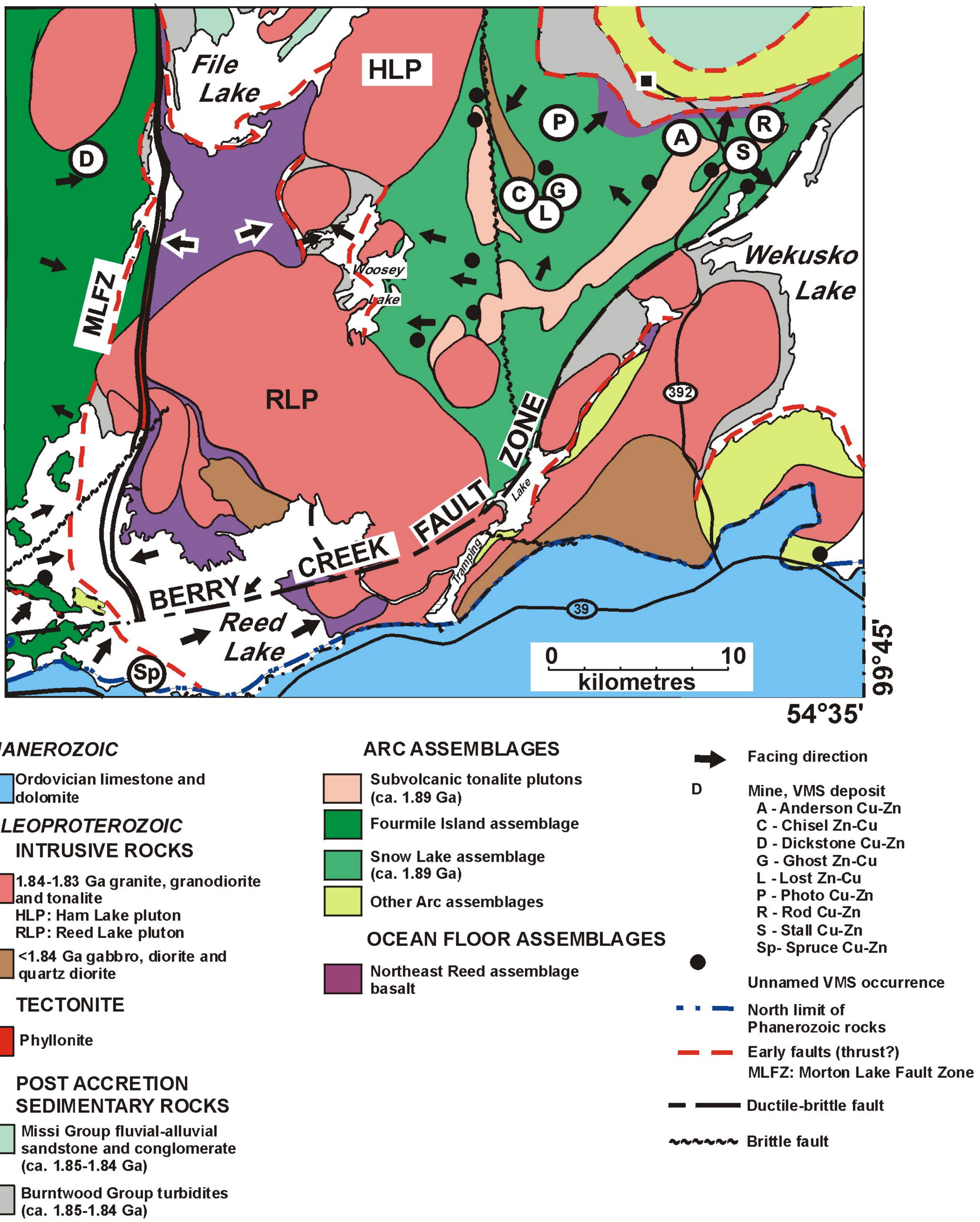

Figure 2: Generalized geology of the Reed LakeSnow Lake area modified from Syme et al. (1995) and Bailes et al. (1994). The Morton Lake fault zone (MLFZ) is interpreted to represent the basal thrust (Syme et al., 1995; Lucas et al., 1996) that separates the Snow Lake area from the central Flin Flon Belt (i.e., Amisk collage). The Snow Lake area is characterized by a structural style and by lithologies that are more comparable to the Kisseynew domain than those observed in the central Flin Flon Belt. The Snow Lake area consists of a series of Kisseynew-type allochthons of volcanic and sedimentary rocks.

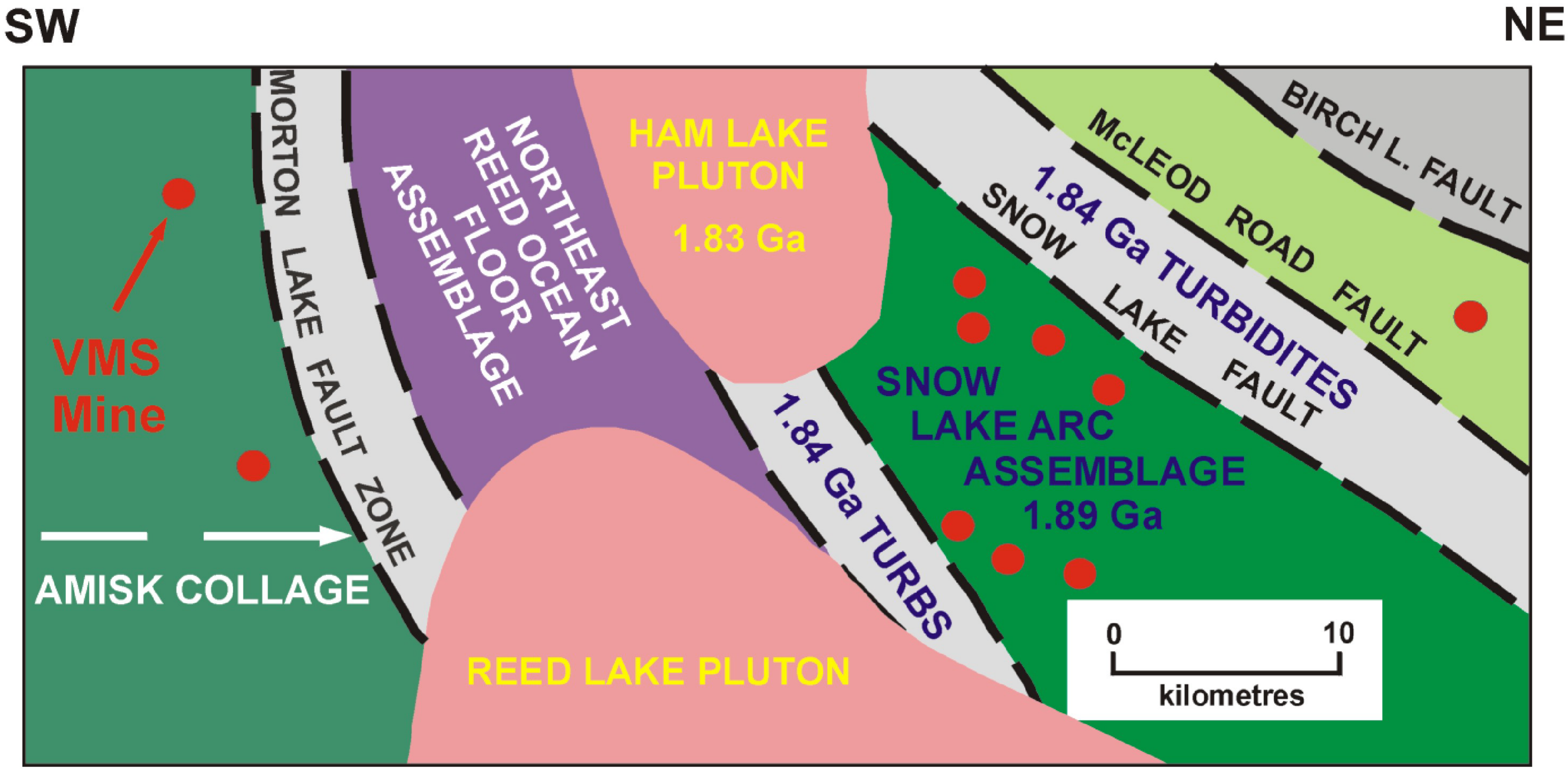

Figure 3: Schematic cross-section showing a series of allocthons in the Reed LakeSnow Lake area. 1.89 Ga panels of volcanic rocks are separated by thrust faults and panels of 1.84 Ga Burntwood Group sedimentary rocks. The allocthons of volcanic and younger sedimentary rocks are cut by late successor arc 1.84-1.83 Ga granite plutons. VMS mines are restricted to arc assemblages, with 7 of the 10 mines in the Snow Lake area located in an allocthon composed of Snow Lake arc assemblage rocks.

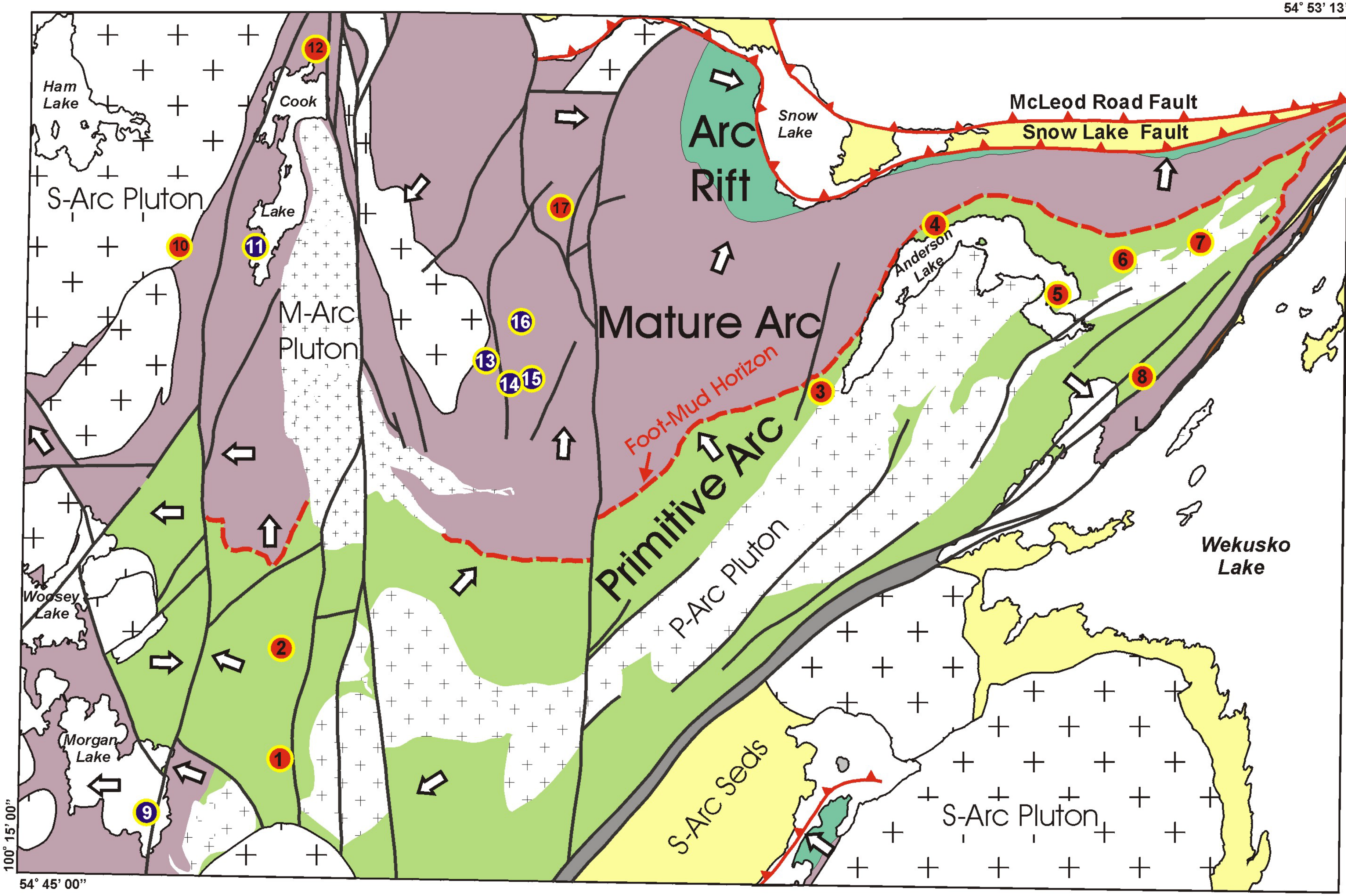

Figure 4: Plan view of the 1.89 Ga primitive arc, mature arc and arc rift components of the Snow Lake arc assemblage. Arrows show facing direction of supracrustal rocks. Also shown are ca. 1.84-1.83 Ga successor arc sedimentary and intrusive rocks, ca. 1.84 Ga thrust faults (teeth) and ca. 1.78 Ga normal faults (solid lines). Red (Cu-Zn) and blue (Zn-Cu) dots show distribution of VMS deposits in primitive arc (1-Pot Lake, 2-Raindrop, 3-Joanie zone, 4-Anderson Lake, 5-Ram zone, 6-Stall Lake, 7-Rod , 8-Linda) and mature arc (9-Morgan Lake, 10-Penn zone, 11-Bomber, 12-Cook Lake, 13-Chisel Lake, 14-Lost Lake, 15-Ghost Lake, 16-Chisel North, 17-Photo Lake) volcanic rocks. The Foot-Mud horizon is a sulphidic fine-grained volcaniclastic unit located at the contact between the primitive and mature arc sequences.

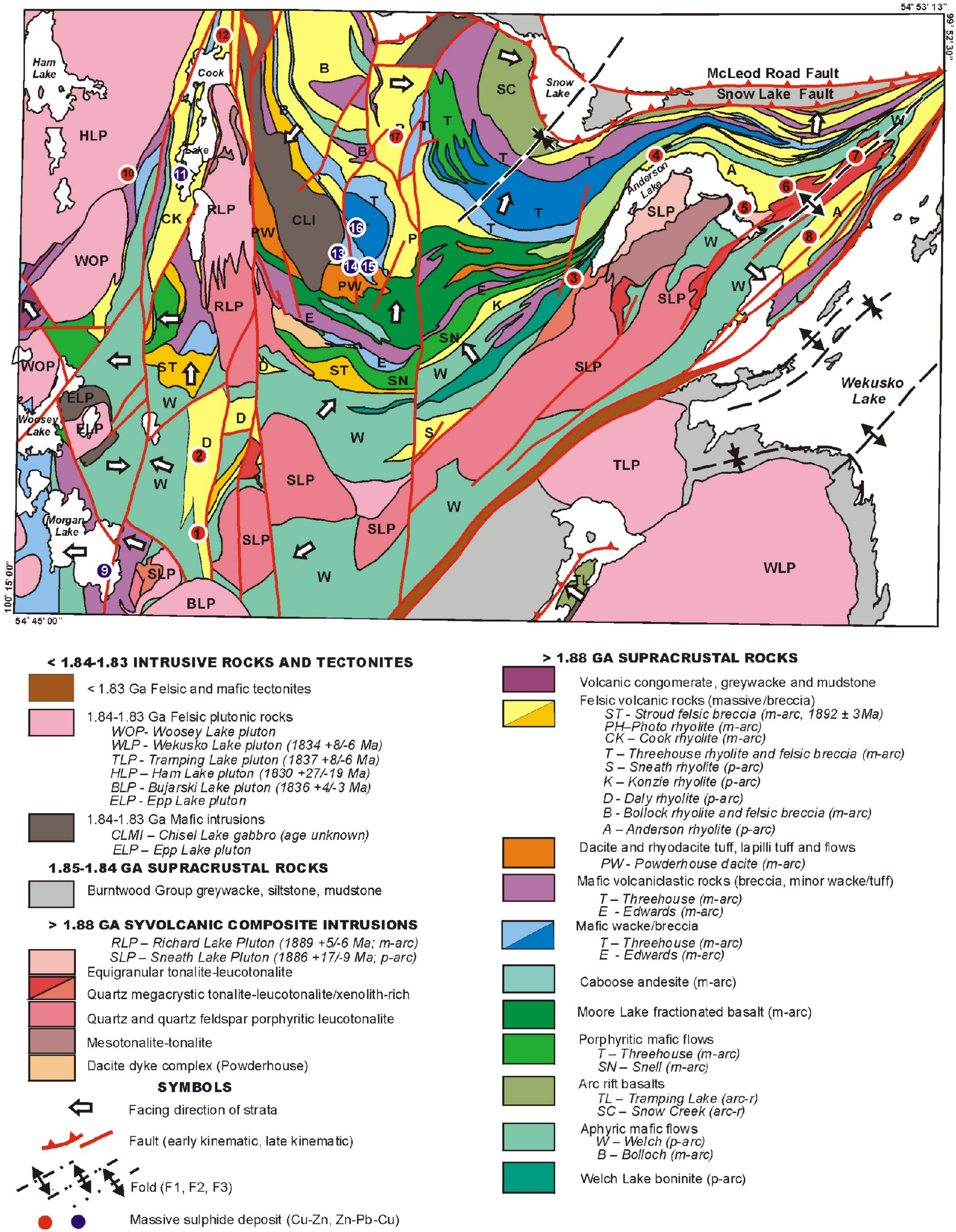

Figure 5: Simplified geological map of the Snow Lake area. VMS deposit names are given in the caption for Figure 4.

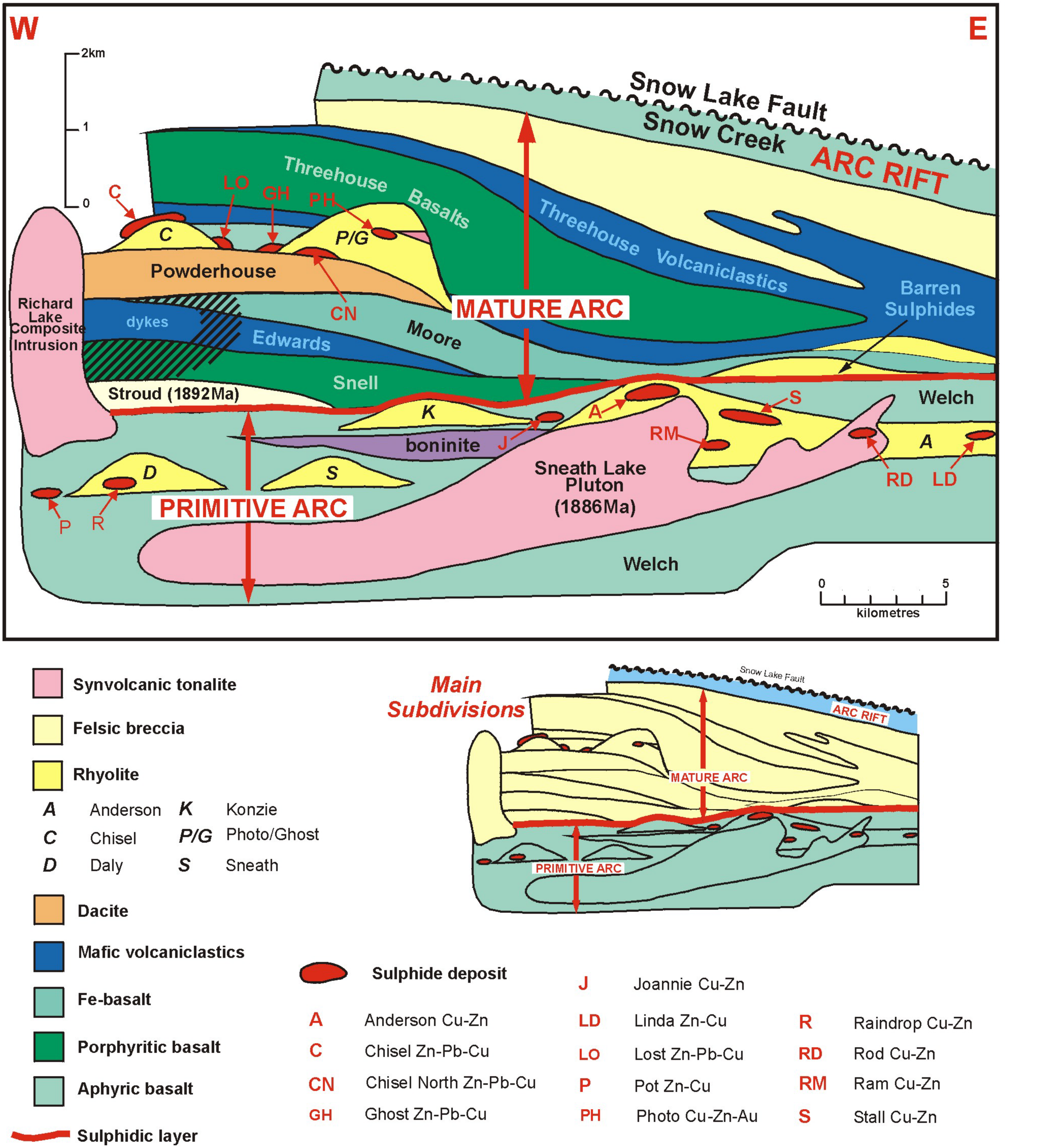

Figure 6: Schematic stratigraphic section showing setting of base-metal rich sulphide deposits in the Snow Lake arc assemblage. Note the spatial association of sulphide deposits with rhyolite complexes (names of rhyolite complexes indicated by letters). The Sneath Lake and Richard Lake plutons are intrusive complexes that include several phases, with younger phases (not shown separately in this diagram) intruding VMS-hosting rhyolites and alteration zones. For example, a late phase of the Sneath Lake intrusive complex has intruded and enveloped the Rod VMS deposit (RD) in the Anderson rhyolite and a late phase of the Richard Lake intrusive complex cuts across volcanic rocks already altered by an earlier phase of the intrusion. The U-Pb zircon age for the Sneath Lake pluton is poorly constrained (1886 +17/-9 Ma; David et al. 1996) and only indicates the subvolcanic nature of the pluton and not an actual age relative to the younger Stroud Lake felsic breccia (1892 3 Ma; David et al., 1996) and subvolcanic Richard Lake pluton (1889 +8/-6 Ma; Bailes et al., 1991).

Tectonic Setting of VMS Deposits in the SLA

The Snow Lake arc assemblage consists of over 60% mafic flows; the VMS deposits are associated with rhyolite flows in the sequence. This suggests that the VMS deposits are of the bimodal-mafic type documented by Barrie and Hannington (1997). The stratigraphic setting of these VMS deposits is described and documented in Bailes and Galley (1996 and references therein). In summary, economically significant VMS deposits in the Snow Lake arc assemblage occur in three stratigraphic settings: 1) Cu-rich deposits (e.g., Anderson, Stall) associated with rhyolite flows in the primitive arc, 2) Zn-rich deposits (e.g., Chisel, Ghost) associated with rhyolite flows in a volcaniclastic-dominated portion of the mature arc sequence, and 3) a Cu-Zn-Au deposit (Photo) associated with a large unit of rhyolite flows also in the mature arc section (Fig. 4, 5, 6). VMS deposits in both the primitive and mature arc sequences are spatially associated with large subvolcanic tonalite intrusive complexes (e.g., Sneath, Richard), located within rhyolite flow complexes and associated with regionally extensive semiconcordant zones of altered supracrustal rocks. Altered rocks are interpreted to be products of pluton-generated, seawater-dominated geothermal activity (Walford and Franklin, 1982; Bailes and Galley, 1996; Skirrow and Franklin, 1994). Discordant, planar zones of highly altered rocks in the footwall to VMS deposits are interpreted to be the trace of hydrothermally modified synvolcanic faults (Walford and Franklin, 1982; Bailes and Galley, 1996).

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