STRATIGRAPHY OF THE TATOGGA LAKE AREA NORTHWESTERN BRITISH COLUMBIA (104H/12&13, 104G/9&16)

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INTRODUCTION

This report summarizes preliminary results from the third year of field mapping as part of the Tatogga Lake project. This is a geologic and metallogenic mapping program initiated in 1994 to investigate the geology and associated mineral deposits of the Stikine Terrane along the northern margin of the Bowser Basin in northwestern British Columbia (Figure 1; Ash *et al.*, 1995, 1996a). The project area is located 80 kilometres south of Dease Lake and is transected by the Stewart-Cassiar Highway (Highway 37; Figure 2)

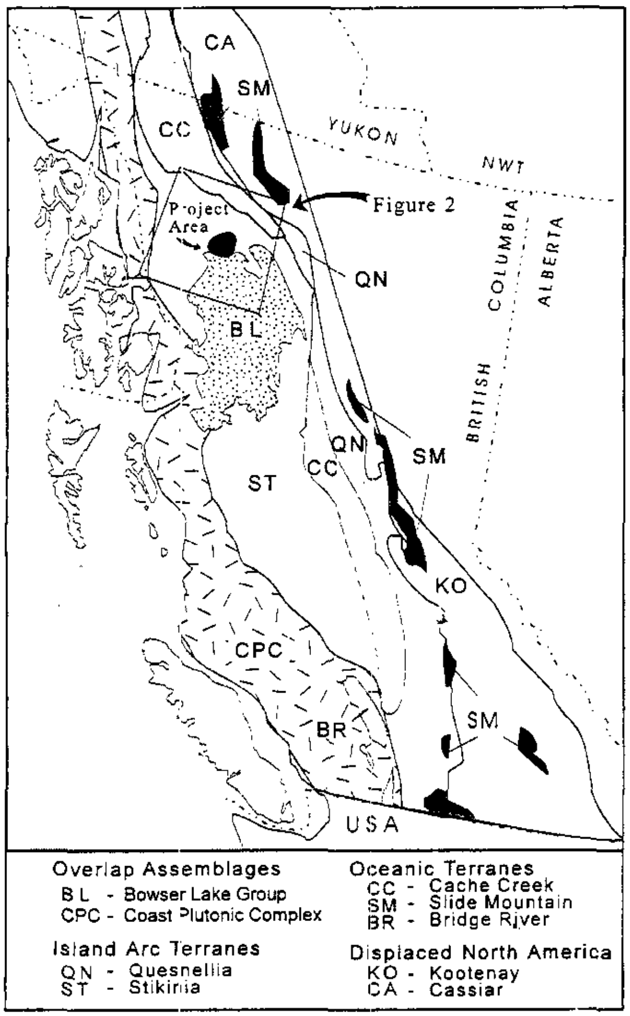

Figure 1. Regional geological setting of the Tatogga Lake project area.

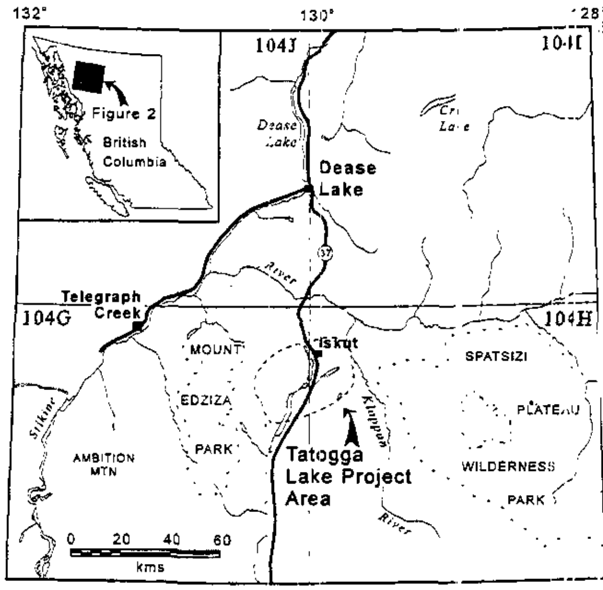

Figure 2. Geographic location of the Tatogga Lake project showing area covered in this report.

During 1996, fieldwork was conducted from July 6th to September 12th and focused on completing 1:20 000 scale mapping of the project area and evaluating selected mineral occurrences. Results of mapping for the Tatogga Lake area will be available in Open File format at a 1:50 000 scale (Ash *et al.*, in preparation).

Based on this years mapping, combined with newly obtained geochronological and geochemical data, an updated stratigraphic framework is presented. General descriptions of the various rock units throughout the map area have been given previously (Ash *et al.*, 1995, 1996a and references therein). For discussions of previous work, physiography and regional setting of the project area, refer to Ash *et al.* (1995).

GEOLOGIC SETTING

Mesozoic volcanic rocks underlie most of the study area and also host all known mineral occurrences (Figure 3). These rocks are divisible into three distinctive stratigraphic successions (Figure 4). The oldest of these is represented by the Middle(?) to Upper Triassic Stuhini Group which is dominated by marine clastic sediments with lesser mafic volcanics that are most prevalent in the southern half of the map area. The overlying Hazelton Group comprises two Lower Jurassic stratigraphic sequences. The oldest, Hettangian to Sinemurian, volcanic succession is dominated by thick, massive sections of intermediate volcaniclastic rocks which unconformably overlie the Triassic stratigraphy. A related suite of monzonitic subvolcanic stocks and sills (*ca.* 205 to 198 Ma) intrude the underlying Triassic rocks. Larger monzonitic stocks host porphyry Cu-Au mineralization, such as the Red Chris deposit.

The younger Pliensbachian to Toarcian succession comprises interstratifed bimodal basalt-rhyolite along with clastic sediments. This upper succession disconformably overlies the older Jurassic volcaniclastic rocks in the northwest and unconformably overlies Late Triassic rocks in the southwest and central parts of the map area. Subvolcanic dikes of alkali granite and felsite intrude and alter the volcaniclastic rocks in the northwest and central portions of the map area. These intrusions are commonly associated with impressive pyritiferous gossans containing elevated abundances of copper and gold.

Mesozoic volcanics are faulted against, and in part overlie metasedimentary and metavolcanic rocks of the Paleozoic Stikine Assemblage in the northeastern part of the Tatogga Lake map area. Along their southern margin the Mesozoic arc-volcanics are overlain by, and faulted against, Middle Jurassic, Bowser Lake Group sediments (Figure 3). A number of isolated, recent basaltic volcanic centers overlie the Lower Jurassic stratigraphy in the northwestern region of the map area.

PALEOZOIC STRATIGRAPHY

Foliated and deformed metasedimentary and metavolcanic rocks form a northwest-trending belt in the northeast corner of the Tatogga Lake map area (Ash *et al.*, 1995). Rock types include phylitic mafic and felsic metavolcanics, argillites as well as massive limestone and banded marbles. This deformed stratigraphic succession was previously designated as Permian or older (?) by Gabrielse and Tipper (1984) and Read (1984). More recently Read and Psutka (1990) and Evenchick and Thorkelson (1993) suggested a Carboniferous or possibly older age. A tonalitic intrusion, north from the confluence of Summit Creek clearly cuts the foliated host stratigraphy. The pluton is medium grained, equigranular to moderately foliated and varies from leucocratic to melanocratic with mafic minerals typically altered to chlorite. U-Pb zircon dating of the tonalite reveals an age of at least 365 Ma (Friedman, 1995), confirming that its deformed host rocks are older than Upper Devonian.

Direct constraints on the age of this Paleozoic succession are being evaluated by both biostratigraphic and isotopic methods. A sample of the massive limestone collected in 1994 contained poorly preserved conodonts that were tentatively interpreted to be of possible Middle Ordovician age (Mike Orchard, personal communication, 1995). In 1996, a number of different areas of the massive limestone were sampled for more diagnostic fossils; results are pending. Felsic metavolcanic rocks identified within the deformed Paleozoic section were collected for U-Pb dating. Initial processing indicates that sufficient zircon is present to provide an isotopic age.

MIDDLE (?) - LATE TRIASSIC STUHINI ARC SUCCESSION

Triassic strata are dominated by clastic sedimentary rocks, with lesser, though locally extensive mafic volcanics and their related epiclastics. Sediments include laminated to well bedded siltstone, mudstone, fine volcanic sandstone with lesser siliceous siltstone and chert, as well as extensive intervals of massive fine to medium grained feldspathic wacke/volcanic sandstone and rare limestone.

Mafic volcanic rocks comprise dark-green and maroon, monolithic augite phyric basalt with or without olivine and plagioclase phenocrysts. These occur mostly as flow and pillow breccia with lesser massive and pillowed flows. Near the top of the volcanic succession, augite phyric basalts are interbedded with, and overlain by, bedded maroon mudstone and coarse immature crystal-lithic wackes. Mafic volcanics occur most extensively along the southern margin of exposed Triassic rocks, elsewhere they form narrow discontinuous intervals within the sedimentary sequence. Throughout the western half of the map area the sedimentary rocks display a prominent east-trending bedding orientation. There is also a consistent southerly dip in the southwest part of the map area which contrasts with a consistent northerly dip in the northwest, suggesting a broad anticline.

Direct constraints on the age of the Triassic succession are based on a variety of fossil data. Radiolarian fauna recovered from cherts and siliceous

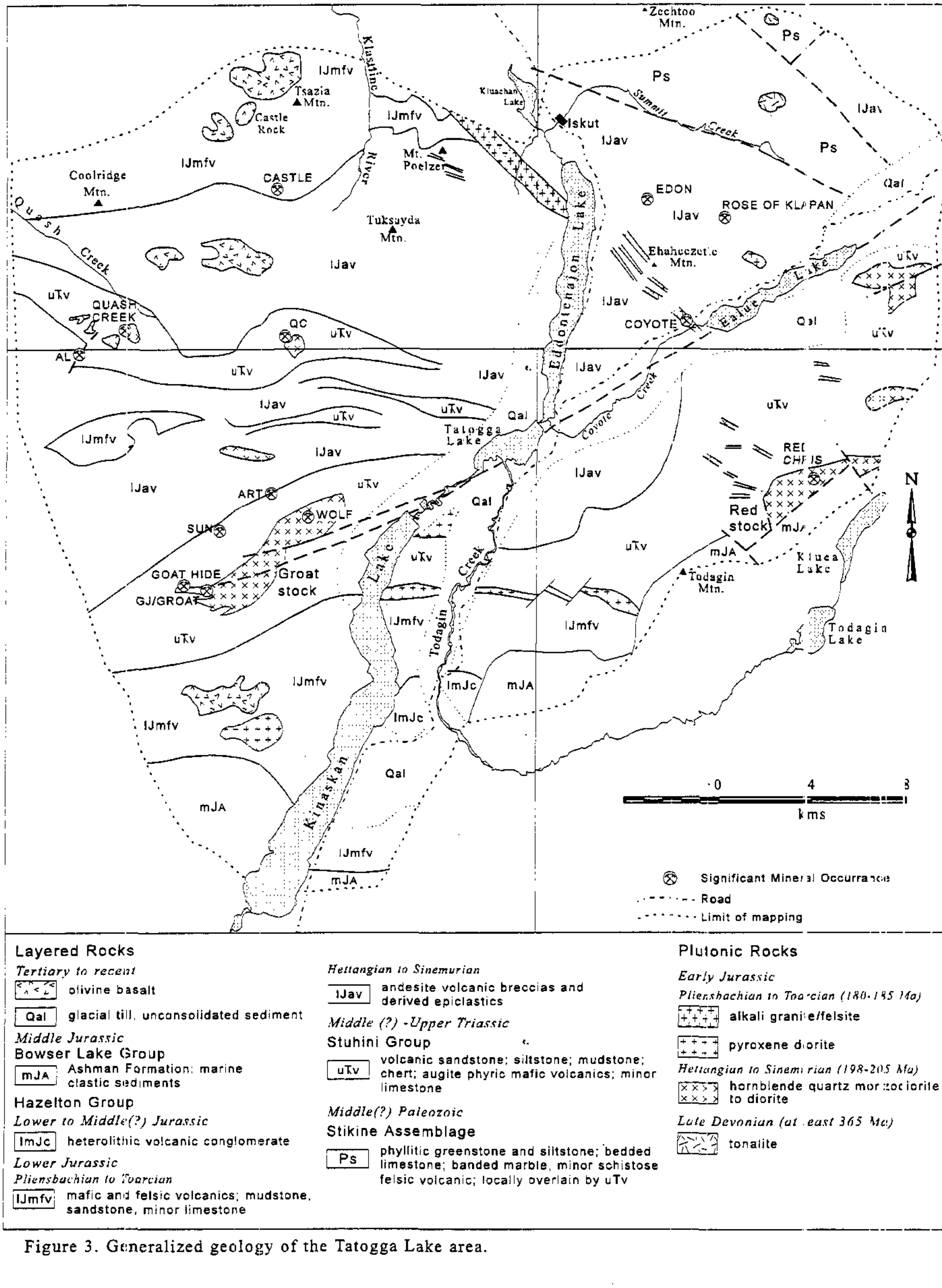

Figure 3. Generalized geology of the Tatogga Lake area.

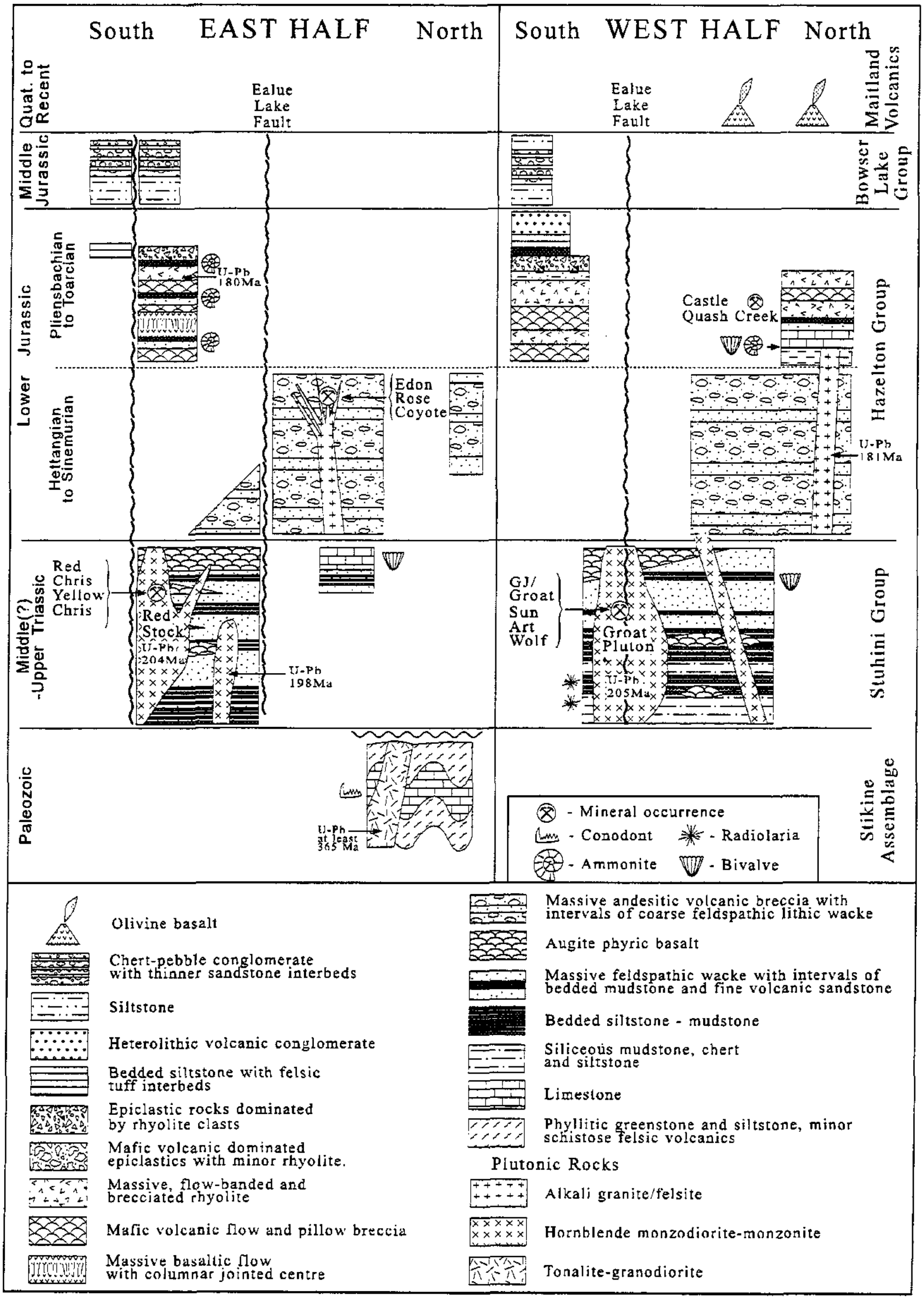

Figure 4. Schematic stratigraphic sections for the Tatogga Lake map area

mudstones near the southwestern end of the Groat pluton (Figure 3) are Middle(?) to Late Triassic (Ladinian(?)-Norian) in age (Ash *et al.*, 1996a). Souther (1972) reports Upper Norian bivalves from several localities on the Klastline Plateau near the headwaters of Quash Creek. An upper age limit is provided by an Early Jurassic hornblende monzodiorite-monzonite suite which intrudes the Triassic strata and returned dates of 205-198 Ma (Ash *et al.*, 1996b; Friedman 1995; Friedman and Ash, this volume).

A number of samples of black mudstone from inferred Late Triassic bedded sedimentary sequences are being evaluated for possible radiolarians. In addition, a sample of interpillow micrite from the augite phyric basaltic unit is being processed for possible conodonts.

LOWER JURASSIC STRATIGRAPHY

Two distinctive volcanic-plutonic suites are identified within the Lower Jurassic Hazelton Group in the Tatogga Lake map area. The older of the two is of predominantly intermediate composition and of Hettangian to Sinemurian age. The younger is a bimodal, basalt-rhyolite suite of Pliensbachian to Toarcian age.

HETTANGIAN TO SINEMURIAN VOLCANIC-PLUTONIC SUITE

Volcanic rocks of lowermost Early Jurassic age dominate the map area. These are mainly green and maroon, massive trachyandesitic volcanic breccias with occasional intervals of massive crystal-lithic tuffs/wackes and rare related epiclastic conglomerates and mudstones. Breccias vary from matrix to clast supported with subrounded to subangular clasts that comprise from 15 to 45% of the unit. Clasts vary from 1 to 20 centimetres but average 3 to 8 centimetres in size. They are usually plagioclase-hornblende phyric, with 15 to 35% subhedral to euhedral phenocrysts. Typically plagioclase is the dominant phenocrysts phase. Medium to coarse-grained immature, poorly sorted, feldspar-rich crystal lithic wacke/tuff dominates the matrix. Locally, fine to medium-grained, massive, maroon mudstone or fine-grained wacke comprises the matrix.

A sample of quartz-phyric alkali trachyte clasts from the volcanic breccia unit, returned a U-Pb zircon date of 202.1±4.2 Ma (Friedman, 1995). This sample was collected from an Ealue Lake roadside exposure that is intruded and chlorite-calcite-epidote altered by a swarm of felsite dikes, 2 to 4 metres wide.

Subvolcanic intrusive rocks interpreted to be cogenetic with the trachyandesitic volcanic unit occur throughout the map area. These intrusions form elongate stocks and dikes that cut Upper Triassic Stuhini Group clastic sediments and mafic volcanics. They are typically leucocratic, medium-grained, hornblende quartz monzodiorites to monzonites. Smaller dike-like bodies are usually hornblende-plagioclase porphyritic and may be rarely quartz porphyritic. Larger bodies, such as the Red stock and Groat pluton, contain both porphyritic and equigranular phases.

Five individual intrusive bodies from this suite, yield U-Pb zircon dates that range from 198 to 205 Ma (Friedman and Ash, this volume) and are coeval with the trachyandesitic volcanic breccia unit. Mineralogical and geochemical similarities between both the volcanic and intrusive rocks also supports a co-genetic relationship (Ash, unpublished data).

A previously assigned Late Triassic age (Souther, 1972; Cooper, 1978; Ash *et al.*, 1996), was based on interfingering of the volcanic breccia unit at its base with fossiliferous Upper Triassic sedimentary rocks. The new isotopic age data is consistent, within the limits of error, with the 208±7.5 Ma Triassic-Jurassic boundary assignment of Harland et al. (1990).

PLIENSBACHIAN TO TOARCIAN VOLCANIC-PLUTONIC SUITE

Bimodal mafic-felsic volcanic rocks and derived sediments of uppermost Early Jurassic age alternate over intervals of metres to several tens of metres in well exposed sections along the southwestern and northwestern margins of the map area (Figure 3). Basalt occurs most commonly as flow and pillow breccias with occasional massive and pillowed flows. The flows are dark grey-green to black, typically aphyric, fine-grained to aphanitic and commonly contain calcite filled amygdules. Felsic volcanics vary from pink to buff-white to lime-green and are locally gossanous. Rock types include ash and dust tuff, lapilli tuff-breccia, autobreccia and aphyric to quartz porphyritic massive and banded flows. Sedimentary rocks include interbedded or homogeneous intervals of mudstone, siltstone, sandstone and limestone.

Lithologic and stratigraphic differences are evident between southwestern and northwestern bimodal volcanic belts. In the southwest, these units form a relatively homoclinal, moderately inclined, southwest-facing succession that unconformably overlies Upper Triassic rocks. In contrast, the northwest belt has moderate to shallow dips, faces northeast and disconformably overlies Lower Jurassic intermediate volcaniclastic rocks. The southwestern section is much thicker, containing more extensive intervals of fine-grained clastic sediments that are only a minor component in the northwest. As well, mafic volcanic rocks are more voluminous in the south. A relatively continuous limestone interval, containing the diagnostic bivalve *Weyla,* occurs at the base of the section in the northern belt and has only been identified in one isolated locality in the southern belt.

The disconformable contact of the northwestern bimodal volcanic belt with the underlying intermediate volcaniclastic unit is exposed in a continuous west-facing cliff section, due east from Castle Rock (Figures 3 and 4). Maroon, andesitic lapilli-tuff breccias comprise the bottom 200 metres of the section. These are overlain by several metres of thin bedded maroon mudstone which are succeeded upwards by well-bedded limestone. The base of the limestone is extremely fossiliferous, with abundant bivalves over the first 20 to 30 centimetres. The limestone is overlain by interbedded siltstone and felsic lapilli-tuff breccia that is capped by several metres of autobrecciated rhyolite.

Northwest-trending alkali-granite to felsite dikes from several metres to over a kilometre wide, are interpreted to be coeval with the felsic volcanic rocks. They intrude and alter intermediate volcaniclastic rocks within the north-central region of the map area. Narrower dikes are aphanitic and vary from aphyric to locally quartz-alkali feldspar porphyritic. The widest dikes, located west of the north end of Eddonatenajon Lake, display the most textural variability. The core zone consists of medium-grained, equigranular alkali granite which grades to a medial zone of quartz ± alkali feldspar porphyry, then outward to a marginal phase of aphanitic, aphyric to locally quartz porphyritic massive and flow banded felsite.

Age control for the bimodal mafic-felsic volcanic succession is provided by both biostratigraphic and isotopic data. Ammonites of interpreted Pliensbachian age (Tipper, 1995; J. Palfy, personal communication, 1996) are common in mudstone intervals throughout the southern volcanic belt. Rare ammonites are also found with abundant bivalves in bedded limestone at the base of the bimodal succession in the northwestern corner of the project area. Radiolarian fauna (F. Cordey, personal communication, 1996) have been identified in a well bedded siliceous mudstone unit which occurs near the top of the southern bimodal volcanic succession. The bedded mudstone contains felsic tuff layers that appear to be immediately associated with, and most likely represent distal equivalents of the felsic volcanism. Radiolarian fauna from this unit are currently being evaluated and results are pending.

Preliminary U-Pb isotopic ages are 181.0 +5.9/-0.4 Ma, obtained from a massive fine-grained quartz porphyritic alkali rhyolite (CAS95-404c) from the south central portion of the map area, and a 180.0 +10.1/-1.0 Ma age from an alkali granite dike (CAS95-829) in the northwestern volcanic belt.

There is a notable discrepancy between the ~180 Ma calculated age of the felsic volcanic rocks compared to the interpreted Pliensbachian age (~ 190Ma) of ammonites found intercalated with the volcanic succession. The maximum isotopic dates for both of these rocks, however, closely approximates the fossil ages of the host sediments. The current calculated age for sample CAS95-404c is based on data from only 3 zircon fractions. Further fractions will be extracted from another sample collected in 1996.

During the 1996 field season the bimodal volcanic succession on the southwestern end of the Todagin Plateau (Ash *et al.*, 1996) was examined by József Pálfy as part of his Ph.D. thesis research at the University of British Columbia. This work combines biostratigraphic and isotopic age dating of suitable stratigraphic sections to refine calibration of the Jurassic time scale. New ammonite fossil localities were identified and an additional sample of the felsic volcanic unit was collected for an isotopic age determination. These data will be summarized elsewhere (Pálfy, in preparation).

BOWSER LAKE GROUP: ASHMAN FORMATION

Middle Jurassic (Bathonian to early Oxfordian) marine clastic sedimentary rocks (Gabrielse and Tipper, 1984; Poulton *et al.*, 1991) of the Bowser Lake Group are exposed along the southern margin of the map area. These are assigned to the basal Ashman Formation and comprise siltstone, chert-pebble conglomerate and sandstone (Evenchick and Thorkelson, 1993). The Bowser Lake rocks become progressively younger to the south as deposition was sourced in the north and deposited onto the tectonically active northern margin of the Bowser Basin (Ricketts, 1990; Ricketts and Evenchick, 1991; Green, 1991).

ECONOMIC GEOLOGY

Two distinct styles of intrusion-related, porphyry copper-gold mineralization are recognized in the Tatogga Lake map area. The first is characterized by intense quartz-ankerite-sericite alteration in zones of quartz stockwork associated with an Early Jurassic (*ca.* 205 to 198 Ma) suite of hornblende quartz diorite to monzonite subvolcanic intrusions. These intrude Late Triassic rocks and produce broad peripheral ankerite alteration halos. The Red Chris is the most significant deposit of this type and has been described previously (Ash *et al.*, 1995; Newell and Peatfield, 1995). A number of comparable, though smaller showings are associated with the Groat pluton (Figure 3). These include the GJ/Groat (MINFILE 104G-034), Sun (MINFILE 104G-087), Wolf (MINFILE 104G-045) and Goat Hide (MINFILE 104G-086).

The second type of mineralization is associated with a suite of (*ca.* 180 Ma) alkali granite/felsite dikes. It is characterized by finely disseminated pyrite±chalcopyrite in zones of silicification within the dikes and their immediate hostrocks. It forms prominent, rusty brown, iron oxide stain zones. The felsic rocks generally intrude andesitic breccias that are characterized by localized concentrations of epidote±potassic alteration surrounded by broad chlorite alteration halos with zones of pyritiferous gossan. Ankerite alteration or veining has not been identified in this type. Examples include the Edon (MINFILE 104H-004), Coyote (MINFILE 104H-012), Al (MINFILE 104G-044), Castle (MINFILE 104G-076), and possibly much of the Rose of Klappan group of showings.

CONCLUSIONS

- Mesozoic volcanic rocks in the Tatogga Lake map area comprise three distinct stratigraphic intervals; (1) Upper Triassic Stuhini Group clastic sediments and augite phyric mafic volcanics, (2) an older Lower Jurassic, Hettangian to Sinemurian intermediate volcaniclastic and coeval subvolcanic monzonitic intrusive suite, and (3) a younger Lower Jurassic, Pliensbachian to Toarcian bimodal basalt-rhyolite suite with cogenetic alkali granite/felsite subvolcanic intrusions.
- On the basis of mineralization, age of related intrusions, alteration type and lithological association, two distinct styles of porphyry copper-gold mineralization are recognized in the area. One is associated with a *ca.* 205 to 198 Ma suite of hornblende quartz diorite to monzonite intrusions which contain quartz stockwork zones hosting chalcopyrite±bornite mineralization associated with potassic to quartz-ankerite-sericite alteration. Another is characterized by pervasive pyritization and silicification associated with a *ca.* 180 Ma alkali granite/felsite dikes and stocks that intrude and epidote and chlorite alter intermediate volcaniclastic hostrocks.

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