

U-Pb AGE OF INTRUSIONS RELATED TO PORPHYRY Cu-Au MINERALIZATION IN THE TATOGGA LAKE AREA, NORTHWESTERN BRITISH COLUMBIA (104H/12NW, 104G/9NE)

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INTRODUCTION

U-Pb isotopic data and interpreted ages are presented for two intrusions that host porphyry Cu-Au mineralization within the Stikine Terrane in the Tatogga Lake map area, northwestern British Columbia (Ash *et al.*

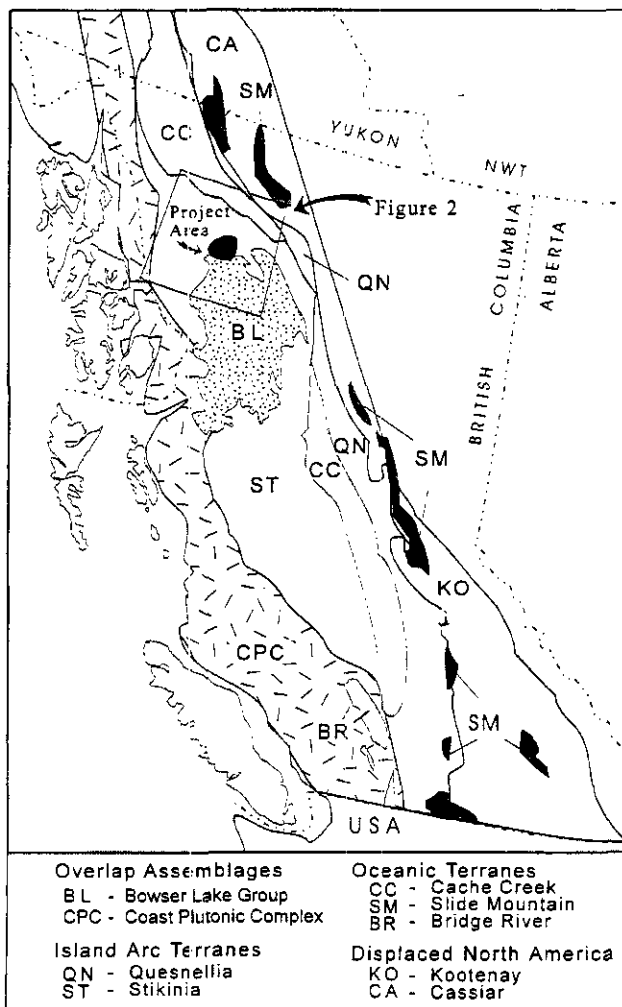


Figure 1. Regional geological setting of the Tatogga Lake project area.

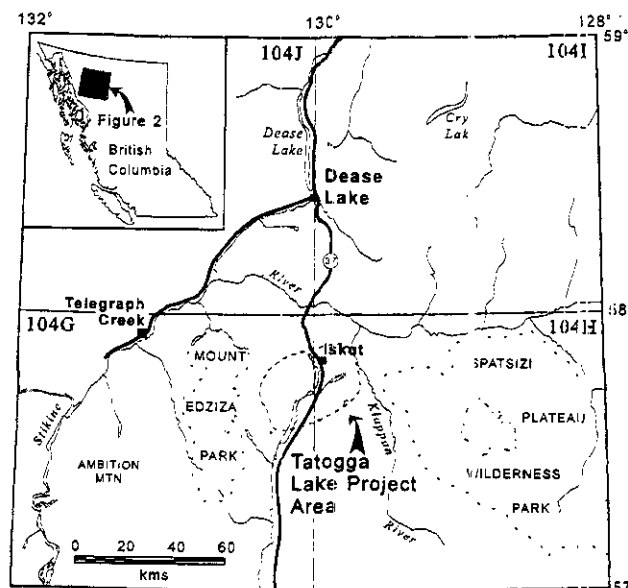


Figure 2. Geographic location of the Tatogga Lake project showing area covered in this report.

et al., this volume; Figures 1 and 2). The Red stock, located northwest of Kluea Lake hosts the Red-Chris deposit, and the Groat stock, located west of the north end of Kiniskan Lake is associated with a number of smaller, similar mineral occurrences. These intrusions belong to, and comprise the largest members of, a 205 Ma to 198 Ma magmatic suite which intrudes Middle(?) to Late Triassic Stuhini Group sediments and volcanics. Both of these intrusions have been the focus of interest since their potential for hosting economic Cu-Au mineralization was recognized in the early 1970's (Newell and Peatfield, 1995; Ash *et al.*, 1995, 1996a).

This work comprises a component of a U-Pb geochronology study which is part of a regional mapping and mineral deposits study of the Tatogga Lake map area (Ash *et al.*, 1995, 1996a, b, this volume). U-Pb dating was carried out at the Geochronology Laboratory of the Department of Earth and Ocean Sciences at the University of British Columbia.

GEOLOGICAL SETTING

The Tatogga Lake map area lies within the central part of the Stikine Terrane, along the northern margin of

the Bowser Basin in northwestern British Columbia (Figure 1). This terrane is underlain by a regionally extensive, northwest-trending belt of mainly Lower Mesozoic and lesser Paleozoic, island-arc volcanic rocks that were accreted to the North American continental margin during Middle Jurassic time (Brown *et al.*, 1986). The Tatogga Lake map area is dominated by Lower Mesozoic arc volcanic rocks (Figure 3). These strata are faulted against, and in part unconformably overlie Paleozoic Stikine assemblage metavolcanic and metasedimentary rocks in the northeast part of the map area and are overlain by, or are in fault contact with Middle Jurassic Bowser Lake Group clastic sedimentary rocks to the south. Isolated, recent mafic volcanic deposits unconformably overlie Mesozoic volcanic rocks in the northwest.

Lower Mesozoic strata are divisible into three distinctive volcanic sequences (Ash *et al.*, this volume). The lowest and oldest of these comprise Middle(?) to Upper Triassic Stuhini Group strata, which in the study area are represented by marine clastic and pelagic sediments, and by lesser mafic volcanic rocks. A suite of variably hydrothermally altered and Cu-Au mineralized subvolcanic monzonitic porphyry stocks and sills intrude these strata. This intrusive suite is thought to represent hypabyssal stocks and feeders to an earliest Lower Jurassic (Hettangian to Sinemurian) succession of compositionally intermediate volcanoclastic and related epiclastic rocks which rest unconformably on Triassic strata, and have been assigned to the Hazelton Group. An upper volcanic sequence in the map area, also assigned to the Hazelton Group, is Lower Jurassic in age (Pliensbachian to Toarcian). This sequence is composed of a bimodal basalt-rhyolite suite which unconformably overlies Stuhini Group rocks in the southwest and disconformably overlies, and locally intrudes, earliest Lower Jurassic volcanoclastic rocks within the northwestern portion of the map area.

QUARTZ MONZODIORITE TO MONZONITE SUITE

A suite of elongate, high-level, hornblende quartz monzodiorite to monzonite stocks and dikes intrude Middle (?)–Late Triassic Stuhini Group rocks within the Tatogga Lake area. The largest intrusions of this suite include the Red and Groat stocks, situated in the southern half of the area. These intrusions are southwest-trending, compositionally variable, hornblende-plagioclase porphyritic to equigranular bodies. Intrusive contacts of both stocks are characterized by wide zones of densely packed sheeted dikes or sills with intervening screens of country rock. Both stocks display similar styles of hydrothermal alteration and associated Cu-Au mineralization, however there is a marked contrast

between the intensely altered and well-mineralized Red Stock and the relatively fresh, less mineralized Groat stock.

These intrusions are characteristically medium grained, porphyritic to equigranular and weather a buff-white to light grey. Porphyritic varieties have medium to coarse-grained hornblende and plagioclase phenocrysts randomly oriented, to rarely trachytic in texture, in an aphanitic grey groundmass. Plagioclase is the dominant phenocryst phase (25 to 60 modal %), occurring as 2 to 5 millimetre subhedral tabular grains. Hornblende phenocrysts (3 to 20 modal %) generally occur as 2 to 5 millimetres grains, but locally form distinctive, coarse tabular phenocrysts up to 1 centimetre in length. The groundmass mineralogy comprises microcrystalline, anhedral, granular quartz and feldspar.

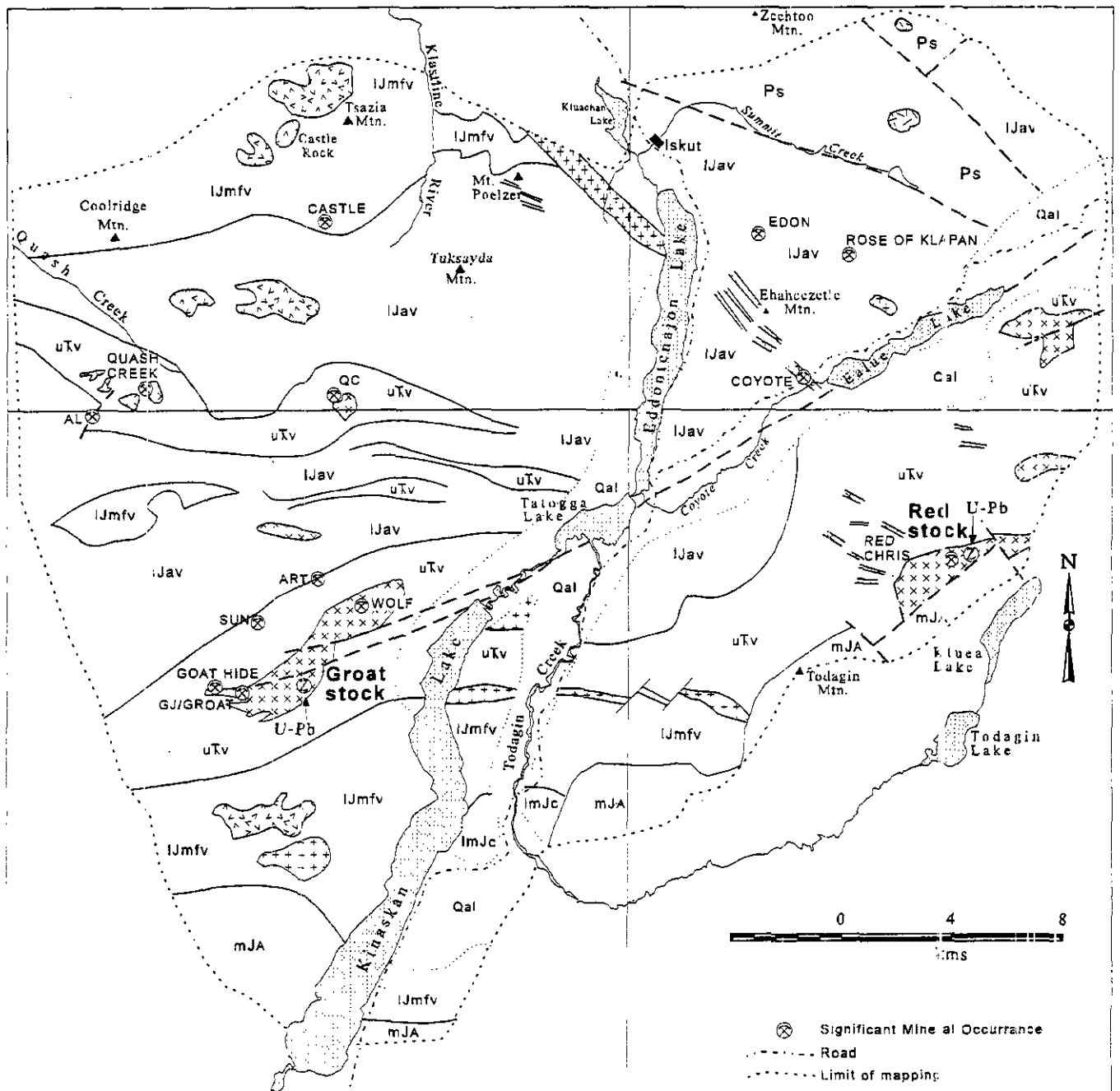
RED STOCK

The Red stock (Schink, 1977; Newell and Peatfield, 1995; Ash *et al.*, 1995, 1996a, b) is an elongate, east-northeasterly trending, subvolcanic, hornblende monzonite to quartz monzodiorite porphyry intrusion which is pervasively altered and faulted and hosts Cu-Au mineralization at the Red-Chris deposit. Mineralization within this porphyry Cu-Au deposit is characterized by chalcopyrite and localized concentrations of bornite within and marginal to quartz stockwork zones, which in turn lie within intensely carbonate-sericite altered Red stock host rock. Mineralized quartz stockwork zones dip steeply to the north and parallel the long axis of the stock. Deposit reserves are currently estimated at 494 million tonnes, grading 0.323% copper and 0.254 g/t gold (The Norther Miner, Vol. 82, No. 16, 1996).

The Red stock intrudes and alters Late Triassic massive volcanic wackes, siltstone and augite-porphyritic basalt in the southwestern area of the Todagin Plateau (Figure 3). The southern margin of the stock is faulted against Middle Jurassic sedimentary rocks of the Bowser Lake Group (Figure 3). Augite phyric basalts, locally termed the "Dynamite Hill volcanics" on the Red-Chris property, underlie the area directly north of the Red stock. They consist chiefly of monolithic flow and pillow breccias. Sedimentary rocks comprise thick sections of medium-grained, massive feldspathic volcanic wacke with occasional thinner intervals of bedded mudstone and fine volcanic sandstone. Both wackes and mafic volcanic rocks are pervasively carbonate altered, with mafic minerals in both typically replaced by ankerite or iron-magnesite.

GROAT STOCK

The Groat stock is a faulted, northeast trending, coarse grained porphyritic to fine grained equigranular



Layered Rocks		Hettangian to Sinemurian		Plutonic Rocks	
<i>Tertiary to recent</i>		<i>Hettangian to Sinemurian</i>		<i>Early Jurassic</i>	
[X<] olivine basalt		[IJav] andesite volcanic breccias and derived epiclastics		[Pliensbachian to Toarcian (180-195 Ma)]	
[Qal] glacial till, unconsolidated sediment		<i>Middle (?) - Upper Triassic</i>		[+++] alkali gran teffelsite	
<i>Middle Jurassic</i>		<i>Stuhini Group</i>		[+++] pyroxene clinorite	
Bowser Lake Group		[uTv] volcanic sandstone; siltstone; mudstone; chert; augite phyric mafic volcanics; minor limestone		<i>Hettangian to Sinemurian (198-205 Ma)</i>	
[mJA] Ashman Formation: marine clastic sediments		<i>Middle (?) Paleozoic</i>		[xxx] hornblende quartz monzodiorite to diorite	
Hazelton Group		<i>Stikine Assemblage</i>		<i>Late Devonian (at least 365 Ma)</i>	
<i>Lower to Middle (?) Jurassic</i>		[Ps] phyllitic greenstone and siltstone; bedded limestone; banded marble, minor schistose felsic volcanic; locally overlain by uTv		[x] tonalite	
[ImJc] heterolithic volcanic conglomerate					
<i>Lower Jurassic</i>					
<i>Pliensbachian to Toarcian</i>					
[IJmfv] mafic and felsic volcanics; mudstone, sandstone, minor limestone					

Figure 3. Generalized geology of the Tatogga Lake area.

intrusion with granodiorite to quartz monzonite modal compositions (Schmitt, 1977; Ash *et al.*, 1996a). This body intrudes Middle(?) to Upper Triassic, fine-grained clastic and pelagic sedimentary rocks several kilometres west of the northern end of Kiniskan Lake. Overall, the Groat stock is fresh relative to the intensely altered Red stock, however the intrusion and its immediate host rocks have locally been altered, silicified, brecciated and Cu-Au mineralized. The main minerals present in the relatively fresh portions of the intrusion are plagioclase, quartz, hornblende and orthoclase, with augite and biotite occurring as minor constituents of the more mafic phases of the body. Primary accessory minerals include titanite, apatite, magnetite and zircon (Schmitt, 1977).

GEOCHRONOLOGY

In the following section we report new U-Pb zircon and titanite data and interpreted crystallization ages for the Red and Groat stocks. Zircons grains were selected for analysis on the basis of their magnetic susceptibility, clarity, colour, grain size and morphology. In general only high quality (i.e., crack- and inclusion-free) grains were chosen. All fractions are then air abraded (Krogh, 1982), to remove about 10-20 volume % of the outer part of each grain. Complete U-Pb analytical procedures employed at the UBC Geochronology Laboratory are reported in Mortensen *et al.* (1995).

Below, brief descriptions of the rock samples are followed by discussions of the U-Pb geochronology, including zircon descriptions and data interpretation. U-Pb data are plotted on concordia diagrams in Figures 4 and 5 and presented in Table 1.

RED STOCK

A sample of Red stock weighing approximately 25 kilograms was collected from diamond drill core, DDH95-224 (at about 105 metres depth) (Figure 3; diamond drill hole 95-224; also see Ash *et al.*, 1996b). An attempt was made to obtain material which has not undergone intense alteration. The sample is of monzonitic composition, with variably albitized plagioclase and chloritized hornblende phenocrysts in a ground mass consisting of microcrystalline alkali feldspar and quartz. Accessory minerals include pyrite, apatite and zircon.

Abundant, high quality, clear, pale pink, zircons of euhedral to subhedral, prismatic morphology were recovered from this sample. In general, aspect ratios of crystals varied from approximately 2 to 5. Four zircon fractions were analysed, two of which are concordant (fractions C and D) and provide the best estimate for the crystallization age of the Red stock: 203.8 ± 1.3 Ma. The precision is based on the total overlap of concordant fractions C and D with the concordia curve (Figure 4).

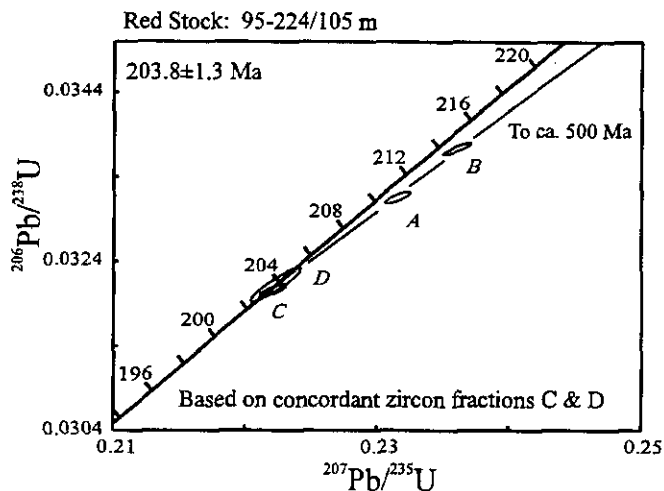


Figure 4. Concordia diagram for sample DDH95-224/105 m of the Red stock. Ellipses are plotted at the 2σ level of precision. See text for discussion.

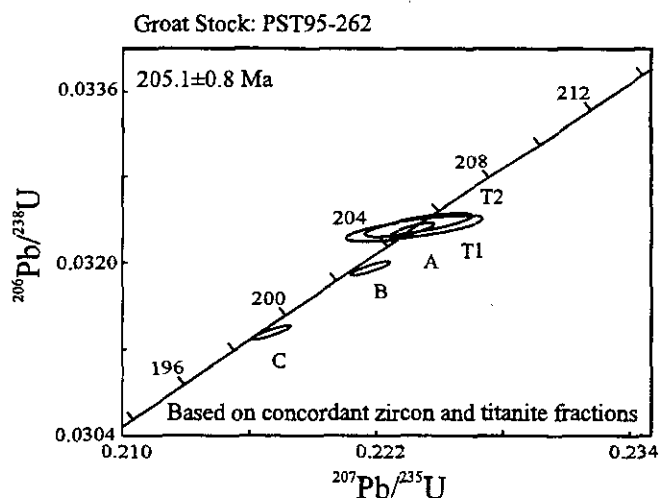


Figure 5. Concordia diagram for sample PST95-262 of the Groat stock. Ellipses are plotted at the 2σ level of precision. See text for discussion.

Relatively coarse fractions A and B are discordant, with somewhat older Pb/U and Pb/Pb ages, indicating the presence of a minor inherited zircon component (Figure 4, Table 1). A chord through all four ellipses gives an upper intercept of approximately 500 ± 100 Ma, which provides an indication of the average age of this inherited zircon component in fractions A and B.

An Early Jurassic crystallization age of 203.8 ± 1.3 Ma for the Red stock provides a firm maximum age for mineralization at the Red-Chris deposit. This age is considerably younger than a previously determined K-Ar whole rock date for the Red stock, (215 ± 14 Ma; Schink, 1977), although the error envelopes of the U-Pb and K-Ar ages do overlap. An imprecise K-Ar biotite date of 200 ± 16 Ma, for a post-mineral dyke at Red-Chris still provides the best minimum age estimate for mineralization. A post-mineral, late hydrothermal dike

TABLE 1. U-Pb ANALYTICAL DATA FOR THE RED AND GROAT STOCKS

Fraction	Wt mg	U ² ppm	Pb ³ ppm	²⁰⁶ Pb ⁴ pg	Pb ⁵ pg	²⁰⁸ Pb %	Isotopic ratios (1σ,%) ⁷			Apparent ages (1σ, Ma) ⁷	
							²⁰⁶ Pb/ ²³⁸ U	²⁰⁷ Pb/ ²³⁵ U	²⁰⁷ Pb/ ²⁰⁶ Pb	²⁰⁶ Pb/ ²³⁸ U	²⁰⁷ Pb/ ²⁰⁶ Pb
Red stock: 95-224/105 m											
A cc,N2,p	0.069	192	6	4342	6	7.9	0.03315(0.11)	0.2315(0.21)	0.05064(0.13)	210.2(0.4)	224.6(6.1)
B c,N2,p	0.074	209	7	2114	16	9.3	0.03373(0.10)	0.2361(0.23)	0.05075(0.14)	213.9(0.4)	225.7(6.7)
C m,N2,f	0.068	257	8	3592	10	9.3	0.03205(0.12)	0.2221(0.23)	0.05024(0.15)	203.4(0.5)	206.3(6.9)
D f,N2,p	0.071	236	8	2059	17	9.6	0.03212(0.32)	0.2223(0.43)	0.05019(0.18)	203.8(1.3)	203.6(8.2)
Groat Stock: PST95-262											
A m,N20,p	0.058	290	10	2840	12	12.0	0.03230(0.10)	0.2237(0.24)	0.05023(0.16)	204.9(0.4)	205.5(7.5)
B m,N20,p	0.067	445	15	3808	16	13.7	0.03195(0.11)	0.2217(0.21)	0.05034(0.12)	202.7(0.4)	210.5(5.8)
C f,N20,p,e	0.178	383	13	4332	30	14.1	0.03135(0.10)	0.2170(0.21)	0.05021(0.12)	199.0(0.4)	204.6(5.7)
T1 c,N20,b	0.730	70	3	292	382	22.3	0.03231(0.18)	0.2238(0.73)	0.05023(0.60)	205.0(0.7)	205.6(28.1)
T2 c,N20,b	0.700	76	3	405	282	23.7	0.03235(0.17)	0.2240(0.57)	0.05022(0.45)	205.2(0.7)	205.3(20.9)

Notes: Analytical techniques are listed in Mortensen *et al.* (1995).

¹ Upper case letter = fraction identifier; T1, T2 = titanite fractions; All zircon fractions air abraded; Grain size, intermediate dimension: cc = >180µm, c = <180µm and >134µm, m = <134µm and >104µm, f = <104µm; Magnetic codes: Franz magnetic separator sideslope at which grains are nonmagnetic (N) or Magnetic (M); e.g., N1 = nonmagnetic at 1°; Field strength for all fractions = 1.8A; Front slope for all fractions = 20°; Grain character codes: b = broken fragments, e = elongate, eq = equal, p = prismatic, s = stubby, t = tabular, ti = tips.

² U blank correction of 1-3pg ± 20%; U fractionation corrections were measured for each run with a double ²³³U-²³⁵U spike (about 0.005/amu).

³ Radiogenic Pb

⁴ Measured ratio corrected for spike and Pb fractionation of 0.0043/amu ± 20% (Daly collector) and 0.0012/amu ± 7% and laboratory blank Pb of 10pg ± 20%. Laboratory blank Pb concentrations and isotopic compositions based on total procedural blanks analysed throughout the duration of this study.

⁵ Total common Pb in analysis based on blank isotopic composition

⁶ Radiogenic Pb

⁷ Corrected for blank Pb, U and common Pb. Common Pb corrections based on Stacey Kramers model (Stacey and Kramer, 1975) at the age of the rock or the ²⁰⁷Pb/²⁰⁶Pb age of the fraction.

sampled for U-Pb geochronology should provide a more precise minimum age estimate for mineralization at the Red-Chris deposit (T. Baker, personal communication, 1996).

GROAT STOCK

Approximately 25 kilograms of equigranular hornblende quartz monzonite was collected from the southeastern part of the Groat stock for U-Pb geochronology. This sample is massive, medium to coarse grained and contains euhedral andesine laths which are poikilitically enclosed within larger hornblende and orthoclase grains.

Abundant, high quality zircon and titanite were recovered from this sample. The zircon is clear, colourless to pale amber and varies from prismatic to acicular in morphology, with aspect ratios of about 2 to 8. Only clear inclusions were observed (apatite and/or fluid inclusions) and no cores or zoning were visible in grains selected for analysis. The titanite is clear, pale yellow to nearly colourless, and occurs mainly as broken pieces of euhedral grains.

Three zircon and two titanite fractions were analysed from this sample. Both titanite analyses and zircon fraction A are concordant at approximately 205 Ma. The average ²⁰⁶Pb/²³⁸U age for these fractions provides the best estimate for the crystallization age of this rock, 205.1±0.8 Ma. The reported precision represents the total overlap of error envelopes for the three concordant analyses with the concordia curve (Figure 5). Zircon fractions B and C appear to have undergone minor Pb loss and B may also contain a minor component of inherited zircon.

The U-Pb age of this sample, 205.1±0.8 Ma, is interpreted as the crystallization age of the Groat stock, and it therefore provides a maximum age for ankerite alteration and mineralization hosted within this intrusion. A previously reported K-Ar hornblende cooling age of 200±16 Ma for the Groat pluton (Schmitt, 1977) is within error of the new U-Pb age.

DISCUSSION

The Red and Groat stocks belong to a suite of sills, dikes and subvolcanic intrusions recognized within the

Tatogga map area, which have been dated at 205 to 198 Ma (Ash *et al.*, 1996b). This suite is interpreted to represent the intrusive equivalents of an earliest Jurassic volcano-stratigraphic succession recognized within the map area, and is assigned to the lower Hazelton Group.

U-Pb crystallization ages for the Red and Groat stocks determined in this study, 203.8±1.3 Ma and 205.1±0.8 Ma, respectively, also represent maximum ages for alteration and Cu-Au mineralization hosted within these intrusions. Although these ages do not directly determine the timing of mineralization, the high level nature of these intrusions strongly suggest that they underwent rapid cooling. Furthermore, the style of mineralization and alteration suggests formation from magmatic-hydrothermal processes which likely followed primary igneous crystallization.

The Red and Groat stocks are broadly the same age as a suite of ca. 200-210 Ma mineralized porphyry Cu-Au intrusions which are widely distributed throughout Stikinia and Quesnellia (Mortensen, *et al.*, 1995). Regionally these deposits are considered to represent either the latest phase of magmatism associated with Triassic Stuhini/Takla/Nicola arcs or reflect a magmatic episode which post-dates these arcs. Field and temporal relationships within the the Tatogga map area indicate that these mineralized porphyry intrusions are related to earliest Jurassic magmatism associated with the lower Hazelton Group.

CONCLUSIONS

- The Red and Groat stocks belong to a suite of variably hydrothermally altered Early Jurassic 205 to 198 Ma quartz diorite to monzonite plutons in the Tatogga Lake area .
- Early Jurassic crystallization ages of 203.8±1.3 Ma for the Red stock and 205.1±0.8 Ma for the Groat stocks provides a firm maximum ages for mineralization hosted within these intrusions.
- Field and temporal relationships within the Tatogga map area indicate that these mineralized porphyry intrusions are related to earliest Jurassic magmatism associated with the lower Hazelton Group.

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