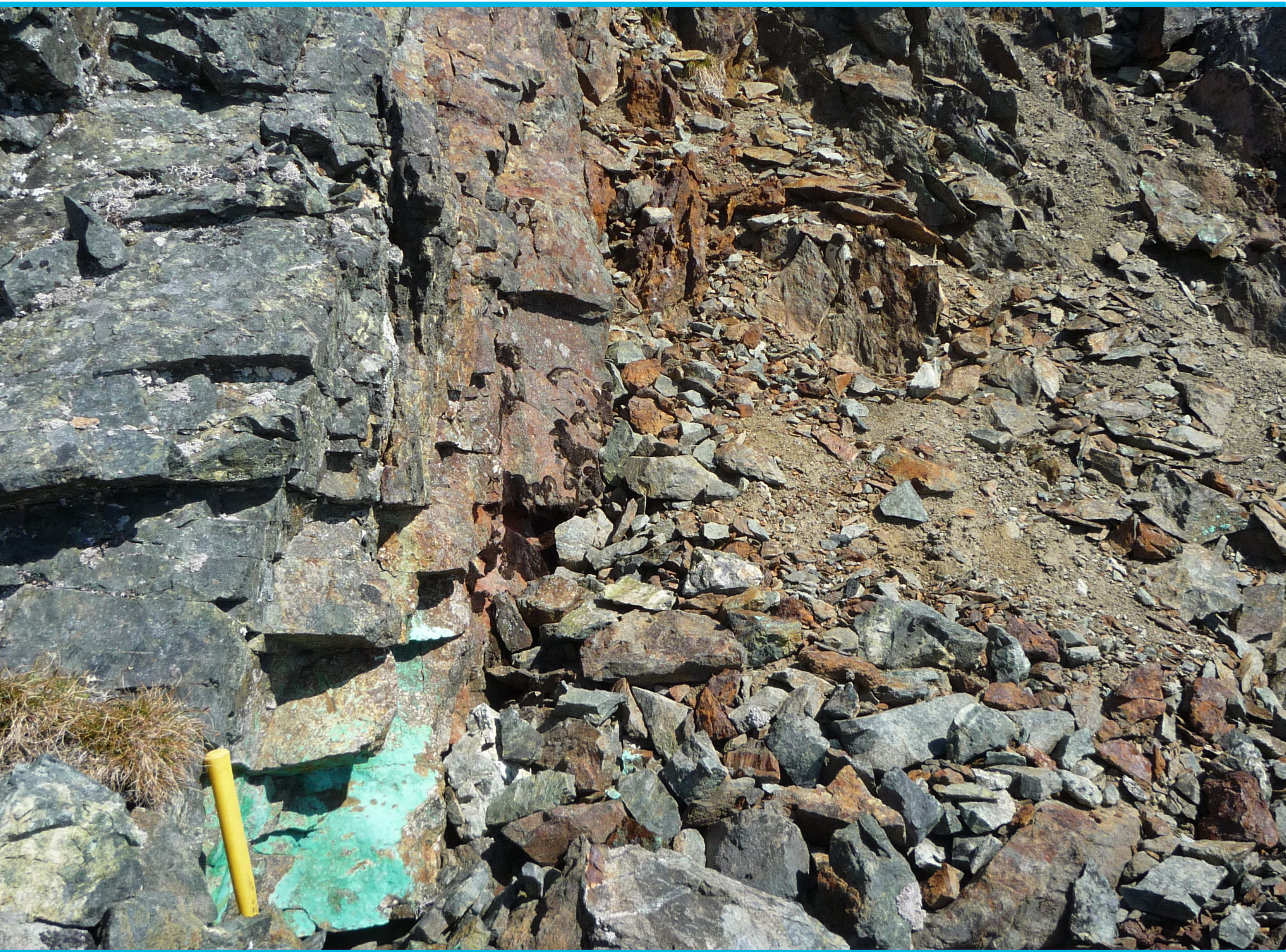

Laser ablation ICP-MS geochronologic data from Granduc and Rock and Roll deposits, northwest British Columbia

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Front cover: Copper staining in mineralized zone on the surface above the Granduc deposit workings.

Appendices for this paper can be downloaded from
https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/british-columbia-geological-survey/publications/geofiles#GF2019-01

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Abstract

U-Pb geochronological results reported by Mihalynuk et al. (2019) for host rocks of the Rock and Roll and Granduc volcanogenic massive sulphide (VMS) deposits in the Iskut area of northwestern British Columbia are consistent with the Late Triassic age suggested by previous workers. Although a direct age determination is still lacking, they constrained mineralization to between ~222 Ma and <~208 Ma for Granduc and 292 Ma to 186 Ma for Rock and Roll. The Late Triassic age may mark an important VMS mineralizing event within the submarine Stuhini arc, with implications for regional mineral exploration. Data from their study also provide constraints on two phases of superimposed deformation to between 210 Ma and 183 Ma. This GeoFile contains the full data set for detrital zircon samples summarized by Mihalynuk et al. (2019).

Keywords: volcanogenic massive sulphide, VMS, Besshi, Rock and Roll, Iskut, Granduc, geochronology, detrital zircon, Stuhini Group, Late Triassic, British Columbia Geological Survey

1. Introduction

Geofile 2019-1 presents the full detrital zircon dataset for two samples presented in Mihalynuk et al. (2019). The following text provides context for the accompanying data tables. Most of the text was extracted from Mihalynuk et al. (2019) with little modification and readers are encouraged to refer to that report for a more complete treatment of the geological setting.

Most prominent Late Triassic-Early Jurassic mineral deposits in northwestern British Columbia are calc-alkaline and alkaline Cu-Au-Mo porphyries and porphyry-related gold veins (e.g., Logan and Mihalynuk, 2014). Paleozoic and Early Mesozoic volcanogenic massive sulphide (VMS) deposits are much less common but are economically significant. They include past-producing mines such as Tulsequah Chief (Late Mississippian; Childe, 1997), Eskay Creek (Middle Jurassic, Aalenian; Childe, 1996) and Granduc (Late Triassic; Childe, 1997). VMS deposits form as accumulations of base metals in hydrothermal fields near active submarine magmatic centers. VMS prospective environments, such as ocean ridges, and volcanic arc and back arc rifts and calderas, tend to produce clusters or belts of economic deposits (e.g., Galley et al., 2007), making identification of prospective time periods a key criterion in VMS exploration. Unfortunately, the lack of a detailed stratigraphic and geochronological framework for much of northwestern British Columbia hinders exploration away from known occurrences. To address this problem, Mihalynuk et al. (2019) presented new geochronological data from host rocks at the Granduc mine and the Rock and Roll VMS deposit (Figs. 1, 2); herein we provide supplementary information.

Granduc is a Besshi-type massive sulphide Cu-Au-Ag deposit (Höy, 1991) located 40 km north-northwest of Stewart (Fig. 1). Between 1971 and 1984 Granduc produced 190,143.7 tonnes Cu, 124 million g Ag and 2 million g Au (Johnson, 2012; MINFILE 104B021). At the Main Zone, Measured, Indicated and Inferred resources are 5.16, 6.16 and 30.52 million tonnes with grades of 1.58, 1.39, and 1.40% Cu, 0.17 g/t Au, and 13.7, 11.4 and 13.3 g/t Ag (Morrison et al., 2013). Including the North Zone, total Inferred resources are 44.6 million tonnes grading 1.43% Cu, 0.19 g/t Au, and 10.7 g.t Ag; all at a 0.8% Cu-equivalent cut-off grade (Morrison et al., 2013).

Granduc was considered to be Late Triassic based on U-Pb dating of multi-grain zircon fractions separated from crosscutting mafi c dikes and intensely sheared mafic igneous rocks within the 'Mine Series' (Childe, 1997). However, the dikes are restricted to the footwall of the deposit and may not be coeval with mineralization. In addition, the relationship of the 'Mine Series' sample to mineralization is uncertain due to intense deformation.

Lead isotopic ages are not quantitative, however, they can be used as a guide to the relative age of mineralization. Lead

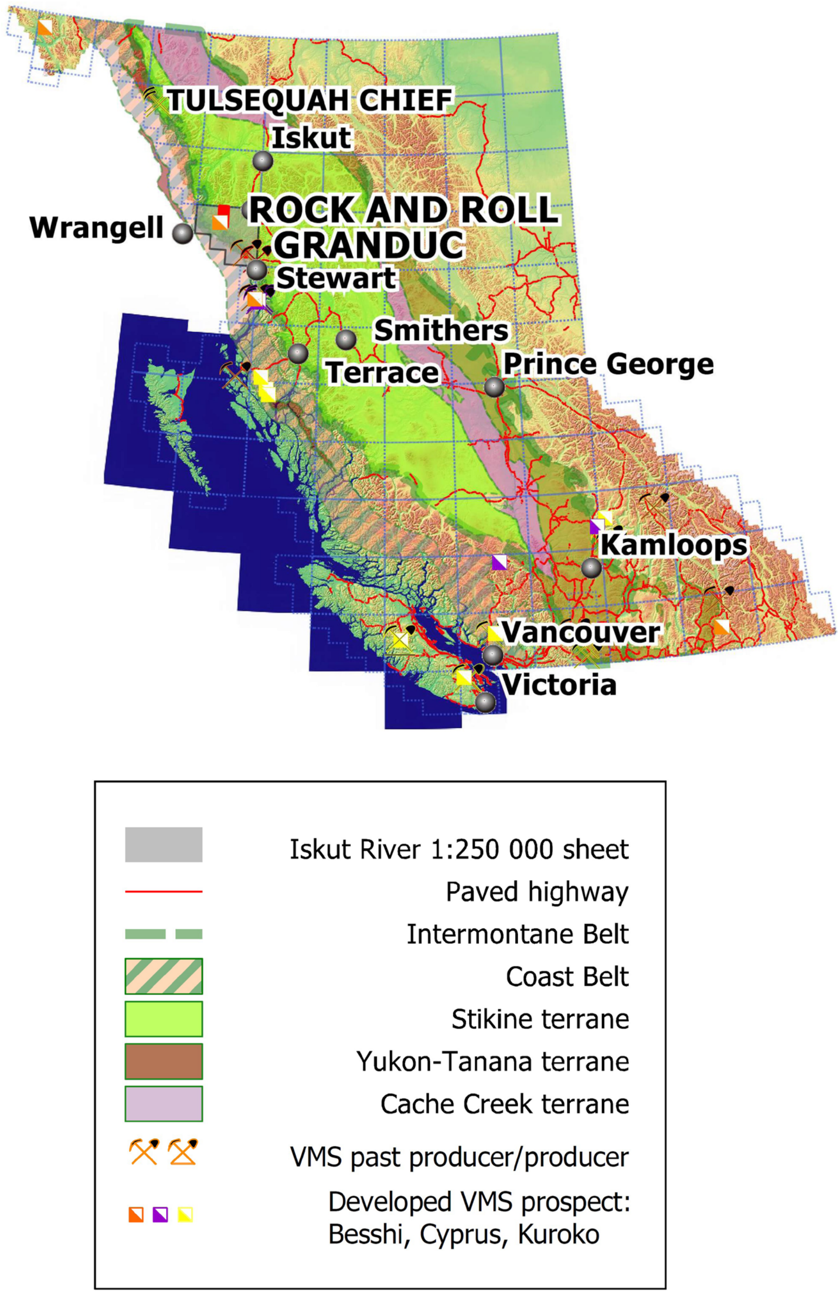
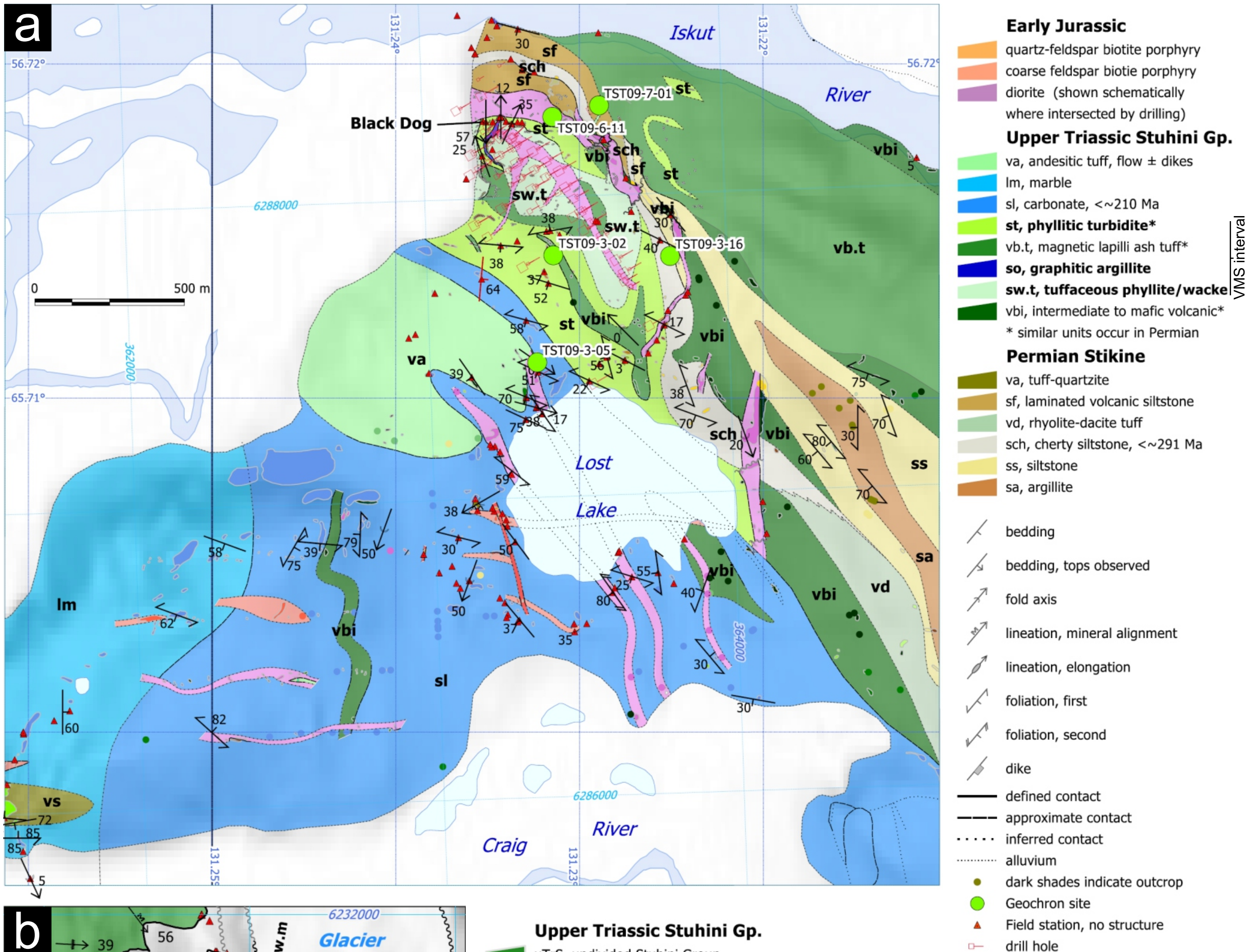


Fig. 1. Location of Rock and Roll and Granduc VMS deposits in northwest British Columbia. Terrane map modifi ed after Wheeler et al. (1991).

isotope signatures from Granduc sulphide mineralization (Childe, 1997) overlap of the $^{208}Pb/^{204}Pb$ cluster for the ~327 Ma Tulsequah VMS camp, but the $^{207}Pb/^{204}Pb$ cluster also overlaps data from the Schaft Creek porphyry copper deposit (Logan et al., 2000), which is well constrained as Late Triassic by U-Pb dating of its host intrusive body (Scott et al., 2008). Thus, ambiguity remains as to whether Granduc lies within the Stikine assemblage (Upper Paleozoic) or the Stuhini Group (Upper Triassic).

Rock and Roll is a precious metal-rich polymetallic massive sulphide deposit (Montgomery et al., 1991) along the south side of the lower Iskut River valley (Fig. 2a), approximately 115 km northwest of Stewart. It contains an estimated Indicated resource of 2.155 million tonnes grading 0.68 g/t Au, 82.7 g/t Ag, 0.22% Cu, 0.22% Pb, and 0.94% Zn at an Au-equivalent cut-off grade of 0.5 g/t (Jones, 2011). Geological mapping northeast of the Iskut River showed that layered rocks considered at the time to be part of the Stikine assemblage were lithologically more similar to rocks enclosing mineralization at the Rock and Roll deposit than they were to rocks of the Stuhini Group (Mihalynuk et al., 2010). However, geochronological and paleontological data to test this correlation, or to provide a direct age constraint on Rock and Roll mineralization, were lacking.

To address uncertainties regarding the age of the Granduc and Rock and Roll deposits, we collected samples of quartz-



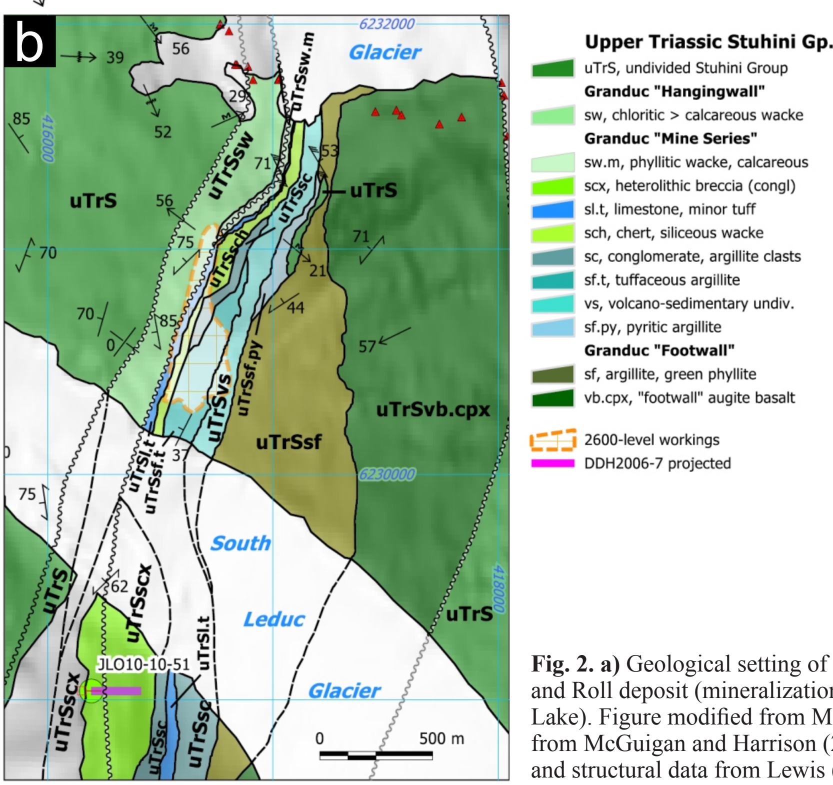


Fig. 2. a) Geological setting of samples collected for geochronology near the Rock and Roll deposit (mineralization outlined by concentration of drill holes north of Lost Lake). Figure modified from Mihalynuk et al. (2010). **b)** Map information compiled from McGuigan and Harrison (2010, unpublished report cited in Morrison et al., 2013) and structural data from Lewis (2013).

bearing clastic strata to establish maximum depositional ages using detrital zircon geochronology. In addition, we collected volcanic layers in the host stratigraphy and quartz diorite (that intrudes and shows irregular contacts with massive sulphide at Rock and Roll) for conventional CA-TIMS age determinations (Table 1 in Mihalynuk et al., 2019). We also collected sulphide samples to determine suitability for Re-Os dating, but found these sulphides to be Re impoverished and unsuitable for dating.

Samples were collected during fieldwork as part of a one-week reconnaissance in the lower Iskut River area, and follow-up in 2010, which included one fly camp at the Granduc deposit. Iskut River mapping and sampling was conducted near the Rock and Roll deposit in October 2009, as the initial phase of a partnership between the University of Victoria; the BC Ministry of Energy, Mines and Petroleum Resources; and Pacific North West Capital Corp (Mihalynuk et al., 2010). At the time, the geochronological component of work at the Rock and Roll deposit was to be incorporated in a thesis project, but that project did not advance significantly. Although location data for part of the data set were lost, they were recently recovered, and most geo-located data were released in Mihalynuk et al. (2019). To supplement information in Mihalynuk et al. (2019), the present release contains the results, methods, and quality control data from geochronological analyses of samples collected for detrital zircon age determination. Method descriptions and the works cited therein are included in the Excel workbook files.

2. U-Pb Laser Ablation-Inductively-Coupled Plasma Mass Spectroscopy (LA-ICP-MS) methods

LA-ICP-MS instrumentation included a New Wave UP-213 laser ablation system and a ThermoFinnigan Element2 single collector, double-focusing, magnetic sector ICP-MS. We used the data acquisition and reduction protocols detailed by Tafti et al. (2009), as summarized below. Zircons hand-picked from the heavy mineral concentrate were mounted in an epoxy puck along with grains of the Plešovice zircon standard (Sláma et al., 2008) and an in-house, 197 Ma standard zircon, and brought to a very high polish. High quality portions of each grain (free of alteration, inclusions, or possible inherited cores) were selected for analysis. The surface of the mount was washed for 10 minutes with dilute nitric acid and rinsed in ultraclean water before analysis. Line scans rather than spot analyses were employed to minimize elemental fractionation during the analyses. Backgrounds were measured with the laser shutter closed for ten seconds, followed by data collection with the laser firing for approximately 29 seconds. The time-integrated signals were analysed using GLITTER software (Van Actherbergh, 2001; Griffin et al., 2008), which automatically subtracts background measurements, propagates all analytical errors, and calculates isotopic ratios and ages. Corrections for mass and elemental fractionation were made by bracketing analyses of unknown grains with replicate analyses of the Plešovice zircon standard. A typical analytical session consisted of four analyses of the standard zircon, followed by four analyses of unknown zircons, two standard analyses, four unknown analyses, etc., and finally four standard analyses. The 197 Ma in-house zircon standard was analysed as an unknown to monitor the reproducibility of the age determinations on a run-to-run basis. Final interpretation and plotting of the analytical results used ISOPLOT software (Ludwig, 2003). Interpreted ages are based on a weighted average of the individual calculated $^{206}Pb/^{238}U$ ages. Although zircons typically contain negligible amounts of initial common Pb, it is important to monitor the amount of ^{204}Pb to evaluate the amount of initial common Pb, and/or blank Pb, in the zircons being analyzed. The argon that is used in an ICP-MS plasma commonly contains at least a small amount of Hg, and approximately 7% of natural Hg has a mass of 204. Measured count rates on mass 204 include ^{204}Hg as well as any ^{204}Pb that might be present, and direct measurement of 204Pb in a laser ablation analysis is therefore not possible. Instead, mass 202 is monitored; this corresponds exclusively to ^{202}Hg. The expected count rate for ^{204}Hg present in the analysis can then be calculated from the known isotopic composition of natural Hg, and any remaining counts at mass 204 can be attributed to ^{204}Pb. Using this method, it is possible to conclude that there was no measurable ^{204}Pb present in any of the analyses in this study.

3. U-Pb LA-ICP-MS results

3.1. Sample # JLO10-10-51

Heterolithic volcanic conglomerate at Granduc; ~208 Ma
Lat/Long: 56.1990° N, -130.3505° E (mean for Conus)

Clasts in heterolithic breccia of the Mine Series north and south of Leduc Glacier are primarily feldspar and lesser hornblende-feldspar porphyry. These strata have been included in the upper Mine Series and described as "green lapilli tuff, chert pebble conglomerate with a black calcareous matrix; minor dark green foliated volcanics" (Morrison et al., 2013, p. 68). Owing to the angularity of competent clasts in the sample analyzed, we refer to it as a breccia. The sample is a green volcanic clast-rich rock with a fine ash-rich matrix and includes minor black argillite and light coloured, rusty-weathering pyrite and pyrrhotite-veined clasts; strained incompetent altered clasts are aligned along the fabric and appear rounded.

Sample 10JLO-10-51 was collected from a 0.6 m interval (6.3m to 6.9m) from fresh, cut core of diamond drill hole 2006-7 (azimuth 90 degrees, inclined -58, end of hole 389.9m; McGuigan and Harrison, 2010, unpublished report cited in Morrison et al., 2013) that intersected mine series heterolithic breccia south of the Leduc Glacier (Fig. 2b). Historic drilling within this unit in the south zone intersected massive sulphide layers with true thicknesses of ~4 – 7m and grading between 3 and 4 % Cu (Morrison et al., 2013).

Abundant clear, doubly terminated zircons and fragments were separated from the sample. Analysis of the zircons produced a spectrum of dates with a main peak at ~ 208 Ma, and a secondary peak at ~ 304 Ma. Several zircons yielded ages between ~ 325 and 348 Ma. The juvenile, mainly volcanic provenance of the units suggests that the ~ 208 Ma age broadly represents the depositional age of the sediment. In addition, we interpret mineralized clasts in the heterolithic breccia unit as either indicating deposition that is coeval with mineralization or representing eroded or collapsed parts of an anoxic, subaqueous mineralized or mineralizing volcano-hydrothermal system. Thus, the heterolithic breccia age should broadly date VMS mineralization. The biotite and chlorite alteration displayed by the sample may be related to the same hydrothermal system or may be unrelated and due to later igneous intrusion and thermal metamorphism.

3.2. Sample # TST09-3-05
Rhyolite tuff and pyritic rhyolite in limestone near Rock and Roll, 209.7 ±0.9 Ma
Lat/Long: 56.7143° N, -131.2314° E (mean for Conus

Strongly foliated and folded limestone west and northwest of Lost Lake (Fig. 2a) was previously considered to be Permian (Kerr, 1948). It contains layers packed with green lapilli and ash-sized clasts and local resistant silty layers. The tuffaceous layers are typically less than 10 cm thick, although the sampled tuff layer is about 50 cm thick and pyritic, grading into pyritic carbonate. Pyrite grains within this layer display horizontal elongation in a southeast-northwest direction. Where sampled, the thick tuff layer is white and rust weathering, possibly more felsic than other tuff layers.

Of the zircons separated from the sample, twenty grains were selected for LA-ICP-MS analysis. Fourteen of these grains define a mean $^{206}Pb/^{238}U$ age of 209.7 ±0.9 Ma (95% confidence). This age is considered to represent the crystallization age of the tuff, coeval with the surrounding limestone. This age is consistent at the stage level with late Carnian to early Norian conodont ages (Golding et al., 2017) from limestone along strike, north of the Iskut River. At the substage level, the ~210 Ma age is younger than the conodont-bearing strata, because the early-middle Norian boundary is age calibrated at 224 Ma in British Columbia (Diakow et al., 2012) and globally (Kent et al., 2017 and citations therein). This suggests that limestone at Lost Lake was deposited over a protracted (>10 m.y.) period.

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