LA-ICP-MS and TIMS U-Pb data files from the Iskut project (Dease Lake to Kitsault)

JoAnne Nelson
Richard Friedman
Bram van Straaten

BRITISH COLUMBIA
Ministry of Energy, Mines and Low Carbon Innovation

GeoFile 2021-10

Ministry of Energy, Mines and Low Carbon Innovation
Mines, Competitiveness, and Authorizations Division
British Columbia Geological Survey

Recommendation citation: Nelson, J.L., Friedman, R., and van Straaten, B., 2021. LA-ICP-MS and TIMS U-Pb data files from the Iskut project (Dease Lake to Kitsault). British Columbia Ministry of Energy, Mines and Low Carbon Innovation, British Columbia Geological Survey Geofile 2021-10, 13 p.

Front cover: Betty Creek Formation tuff and volcanic breccia exposed on summit ridge above near-horizontal ledges of orange-weathering conglomerate and arkose of Snippaker unit (basal Hazelton Group) on Snippaker Ridge, lower Iskut River area.

Back cover. Above, characteristic zircons derived from main Jurassic and older sediment sources in Stikinia. Below, typical Jack Formation conglomerate near Bruce Glacier, with rounded intrusive clasts and carbonaceous mudstone intraclasts.

LA-ICP-MS and TIMS U-Pb data files from the Iskut project (Dease Lake to Kitsault)

JoAnne Nelson
Richard Friedman
Bram van Straaten

Ministry of Energy, Mines and Low Carbon Innovation
British Columbia Geological Survey
GeoFile 2021-10

LA-ICP-MS and TIMS U-Pb data files from the Iskut project (Dease Lake to Kitsault)

JoAnne Nelson[1, a], Richard Friedman,[2] and Bram van Straaten[1]

[1] British Columbia Geological Survey, Ministry of Energy, Mines and Low Carbon Innovation, Victoria, BC, V8W 9N3
[2] Pacific Centre for Geochemical and Isotopic Research, University of British Columbia, Vancouver, BC V6T 1Z4
[a]corresponding author: JoAnne.Nelson@gov.bc.ca

Recommendation citation: Nelson, J.L., Friedman, R., and van Straaten, B., 2021. LA-ICP-MS and TIMS U-Pb data files from the Iskut project (Dease Lake to Kitsault). British Columbia Ministry of Energy, Mines and Low Carbon Innovation, British Columbia Geological Survey GeoFile 2021-10, 13p.

Keywords: Stikinia, Iskut, Golden Triangle, U-Pb zircon crystallization ages, Hazelton Group, Triassic, Jurassic

1. Introduction

Between 2013 and 2016, stratigraphic and structural studies in northwestern Stikinia between Dease Lake and Kitsault (Fig. 1) focussed on uppermost Triassic to Middle Jurassic volcanic and sedimentary rocks of the Hazelton Group (Fig. 2). In the course of this work, 14 samples of siliciclastic rock were collected for LA-ICP-MS U-Pb analysis of detrital zircons, and 4 igneous samples were collected for U-Pb TIMS analysis. Herein we present complete data and calculations for the entire sample set (BCGS_GF2021-10.zip). This dataset provides constraints on the absolute age of intrusive and stratified protoliths, age and affinity of sedimentary sources, and timing of fault-related shearing. These data support previously published (Nelson et al., 2018; Nelson and van Straaten, 2021) and forthcoming studies.

The lower part of the Hazelton Group (Rhaetian-Pliensbachian) is related to island arc construction, along with coeval and cogenetic intrusions of the Tatogga and Texas Creek suites (Nelson et al., 2018). The upper part of the Hazelton Group (Pliensbachian-Bajocian) accumulated in a variety of post-arc, syn-collisional settings, including bimodal volcanic and sedimentary strata of the Iskut River Formation in the Eskay rift, widespread mainly sedimentary strata, and collision-proximal volcanic buildups of the Horn Mountain Formation near Dease Lake (Figs. 1, 2; van Straaten and Nelson, 2016; Nelson et al., 2018). Most of the mineral deposits in this very prolific region, popularly known as the Golden Triangle, are associated with the Hazelton Group and its cogenetic intrusions. Red Chris and the KSM trend are porphyry deposits related to the Tatogga and Texas Creek suites respectively. The Brucejack (Valley of the Kings) epithermal gold vein system formed at ca. 183 Ma, during a late stage of Hazelton arc activity (Tombe et al., 2018).

Detrital zircon samples were collected along a northerly transect extending for 270 km between Dease Lake and Kitsault (Fig. 1). This sampling was aimed at constraining the ages of siliciclastic units in the Hazelton Group and the ages of contributing sediment sources. The main focus of this project was in the central part of the Iskut-Stewart volcanic field, near the McTagg anticlinorium (areas 1, 2 and 3, Fig. 1) and on Snippaker Ridge in the Snip-Bronson corridor (area 4, Fig. 1). Basal Hazelton conglomerates were also sampled near Red Chris (area 5, Fig. 1) and near Gnat Pass (area 6, Fig. 1). Two samples of a conglomerate unit in the Iskut River Formation, on Mt. Clashmore near Kitsault (area 7, Fig. 1), represent sedimentation at the southern end of the Eskay rift.

2. McTagg anticlinorium

In this region, the basal unit of the Hazelton Group is an unusually mature siliciclastic sequence, the Jack Formation (Hettangian-Sinemurian), which contains conglomerates with rounded, primarily granitoid, clasts (Figs. 2, 3; Nelson and Kyba, 2014; Nelson et al., 2018). Detrital zircon samples 13JN01-05, 13JN11-06 and 13JN17-07 are from different stratigraphic levels in the Jack Formation (Fig. 2). All display main peaks ca. 225 Ma (Table 1), consistent with derivation from Late Triassic plutonic sources in the Stikine suite (Nelson and van Straaten, 2021). The youngest population in tuffaceous arkose sample 13JN17-07, collected at the top of the Jack Formation in the Brucejack area, is ca. 197 Ma. CA-TIMS analysis on zircons from a large plagioclase-phyric leucodiorite clast in the overlying basal Betty Creek conglomerate (13JN20-04) returned an igneous crystallization age of ca. 196 Ma (Table 2), which we consider to define the onset of Hazelton Group magmatism east of the McTagg anticlinorium (Fig. 2; Nelson et al., 2018).

Two samples from the upper part of the Hazelton Group, 13JN10-07 from the Spatsizi Formation and 13JN02-16 from the Bruce Glacier unit (Fig. 2), contain both penecontemporaneous grain populations and older grains recycled from the Jack Formation (Table 1).

A thick (>500 m) unit of coarse conglomerate with two 10 m interbeds of maroon pebbly mudstone occurs in a faulted panel west of the Tennyson porphyry prospect, south of the

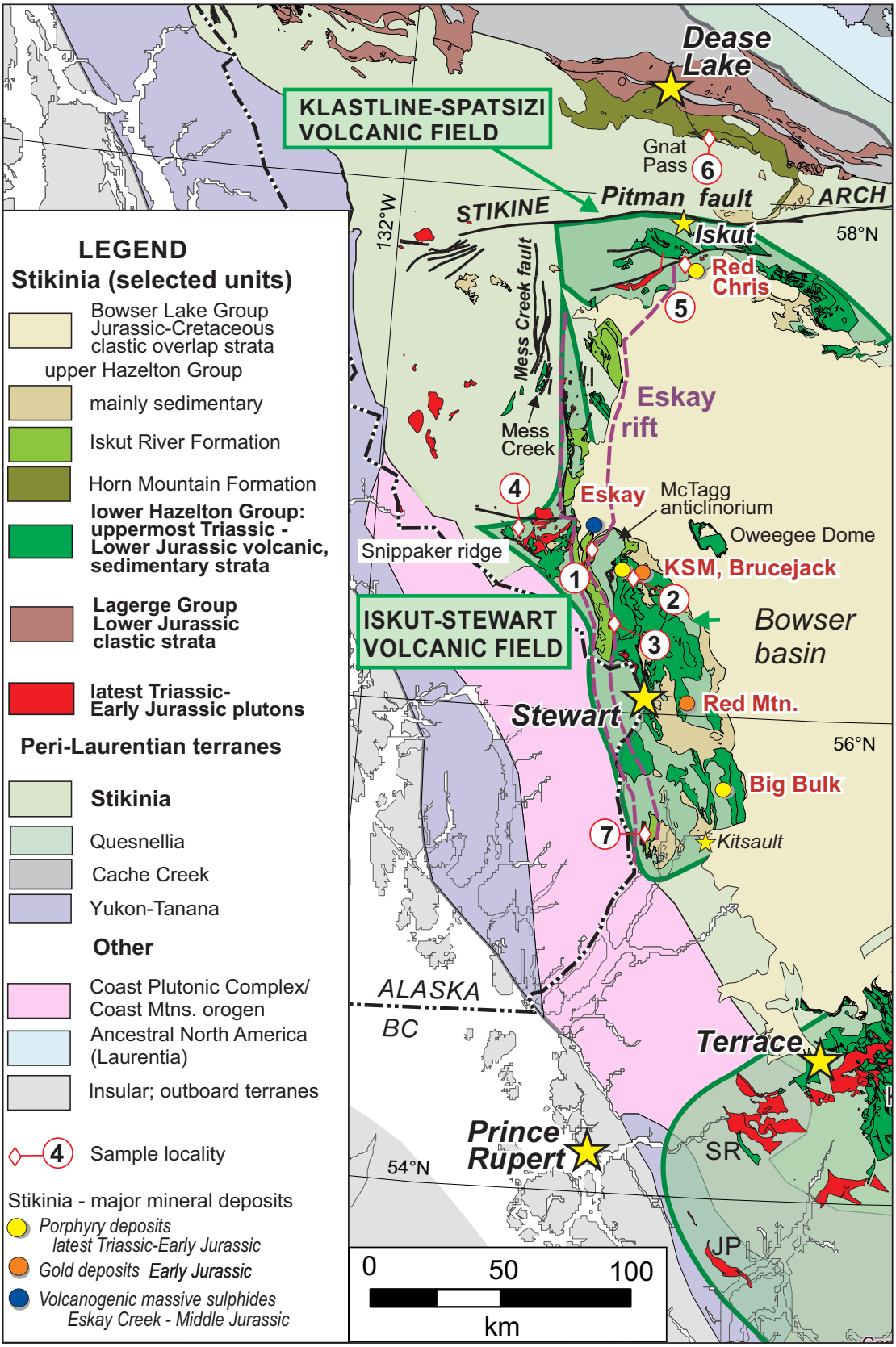


Fig. 1. Geology of northwestern Stikinia, including the Iskut-Stewart, Klastline-Spatsizi (lower Hazelton Group) and Eskay and Horn Mountain (upper Hazelton Group) volcanic belts, with detrital and igneous zircon sample areas. For stratigraphic context of sample areas 1-7, see Figure 2. For details of sample areas 1 and 2, see Figure 3. For details of sample area 4, see Figure 4. For details of sample area 7, see Figure 5.

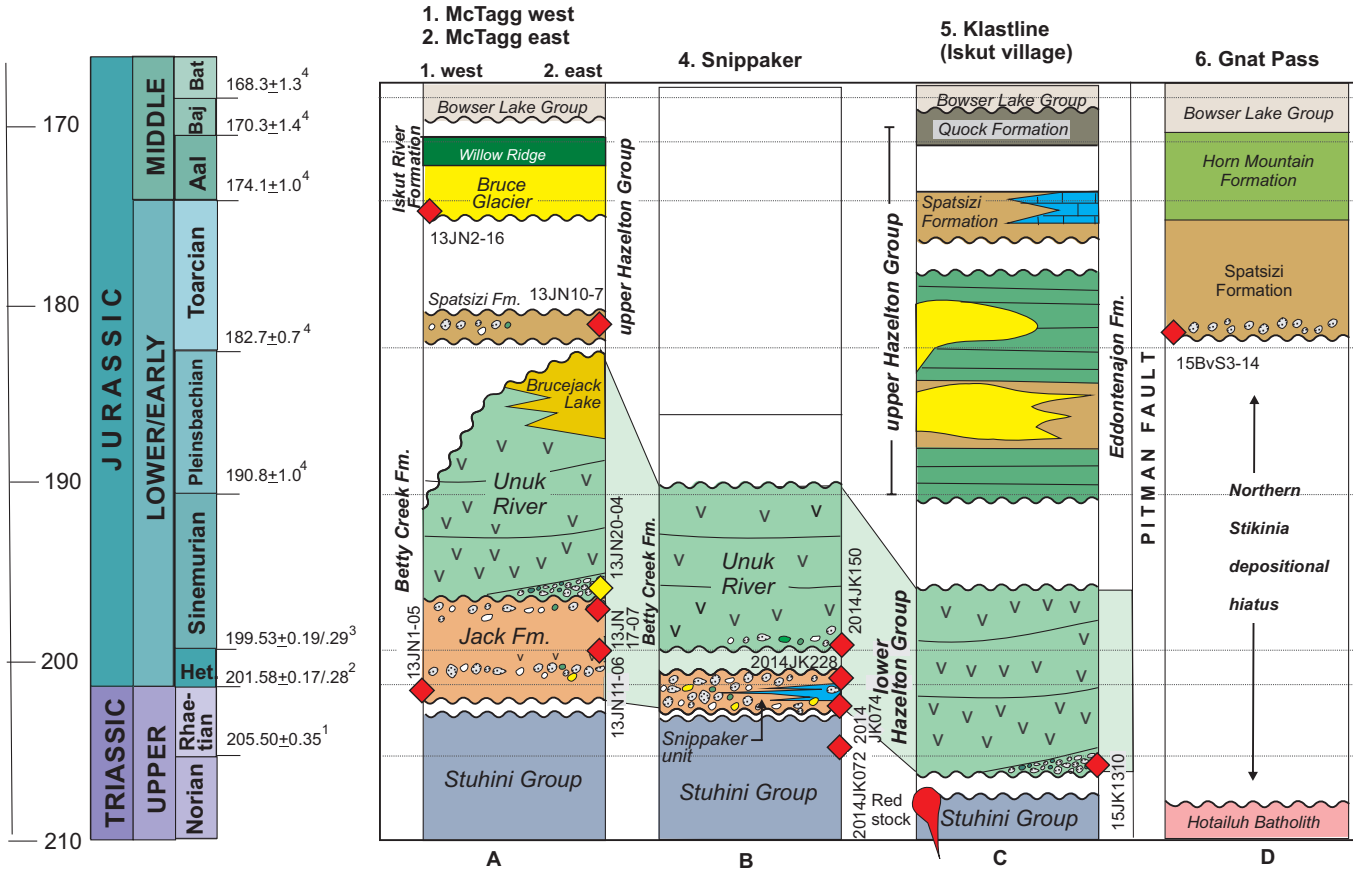


Fig. 2. Stratigraphic columns for sample areas 1-6 (see Fig. 1). Red symbols, LA-ICP-MS detrital zircon samples; yellow symbol, CA-TIMS igneous sample of boulder at the base of the Betty Creek Formation. Timescale age references: **1.** Norian-Rhaetian boundary (Wotzlaw et al. 2014); **2.** Rhaetian-Hettangian boundary (Schaltegger et al. 2008); **3.** Hettangian-Sinemurian boundary (Schaltegger et al., 2008); **4.** Cohen et al., (2013).

McTagg anticlinorium (area 3, Fig. 1). It contains clasts of andesite, basalt, black siliceous argillite, diorite, chert, quartz, limestone and silicified, cherty limestone, from sources in the Hazelton and Stuhini groups and possibly the Stikine assemblage (Nelson and Kyba, 2014). Sample 13JN26-06 is of this conglomerate. Main peaks are Early Jurassic (Table 1), compatible with deposition during Betty Creek volcanism. Alternatively, this could be a coarse clastic facies of the Iskut River Formation (Kinaskan unit, Nelson et al., 2018) deposited at the base of a fault scarp along the margin of the Eskay rift, that did not incorporate zircons from Iskut River Formation (ca. 175-170 Ma).

3. Snippaker Ridge and vicinity

The lower part of the Hazelton Group is well-exposed at Snippaker Ridge, south of the lower Iskut River (Figs. 1, 4). The basal part of the Snippaker unit consists of siliciclastic rocks with granitoid-rich conglomerates that strongly resemble those of the Jack Formation. However, the Snippaker rocks contain Upper Triassic (Rhaetian) macrofauna (Nelson et al., 2018). The Snippaker unit unconformably overlies arc-related volcaniclastic strata of the Stuhini Group (Fig. 2; Kyba and Nelson, 2015). In turn, the Snippaker unit is unconformably overlain by volcanic strata of the Betty Creek Formation, also in the lower part of the Hazelton Group (Fig. 2). Four detrital zircon samples were collected to document evolving sediment sources. Sample 2014JK072 is a Stuhini Group volcaniclastic greywacke from below the basal Hazelton unconformity. Youngest peaks at ca. 205 and 211 Ma (Table 1) likely represent the end stages of Stuhini volcanism in this region. Two Snippaker unit samples, 2014JK074 and 2014JK228, show ca. 220 Ma peaks (Table 1) that probably reflect Stikine Suite plutonic sources. Sample 2014JK150, from the basal Betty Creek conglomerate (Kyba and Nelson, 2015), has a youngest peak ca 199 Ma (MDA, Table 1), along with ca 204 and 216 Ma peaks from Stuhini sources. A sample of plagioclase-phyric diorite (2014JK227) that cuts the Betty Creek Formation on Snippaker Ridge is ca. 192 Ma (Table 2), providing a minimum age for the volcanic sequence.

The Snip-Bronson mineralized corridor is bounded to the south by the Sky fault system (Fig. 4), a long-lived, repeatedly reactivated fault array (Kyba and Nelson, 2015; Nelson and van Straaten, 2021). Syn-kinematic dikes from the Sky fault zone yielded U-Pb TIMS ages of ca. 194 Ma (sample 14JN18-03) and 191 Ma (sample 2014JK308; Table 2). These ages demonstrate faulting in the Early Jurassic, during Betty Creek volcanism, intrusion of Texas Creek Suite plutons, and associated porphyry-style and intrusion-related gold vein mineralization (Nelson and van Straaten, 2021).

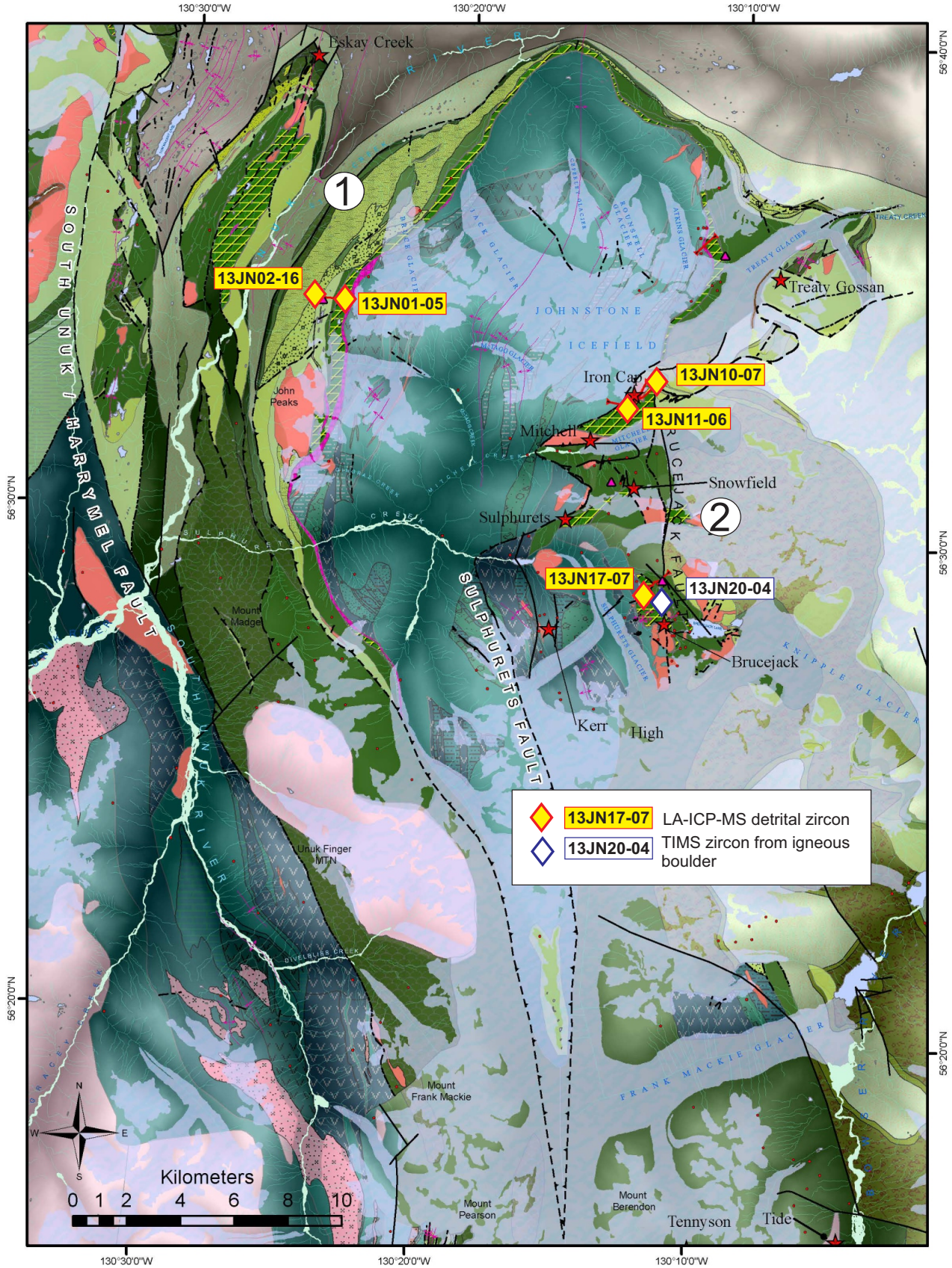


Fig. 3. Geology of the McTagg anticlinorium region with geochronologic sample sites. Geology of sample area 1 (Bruce Glacier) from Lewis (2013); see details in Nelson and Kyba (2014). Geology of sample area 2 (Mitchell-Iron Cap–Brucejack) from Nelson and Kyba (2014).

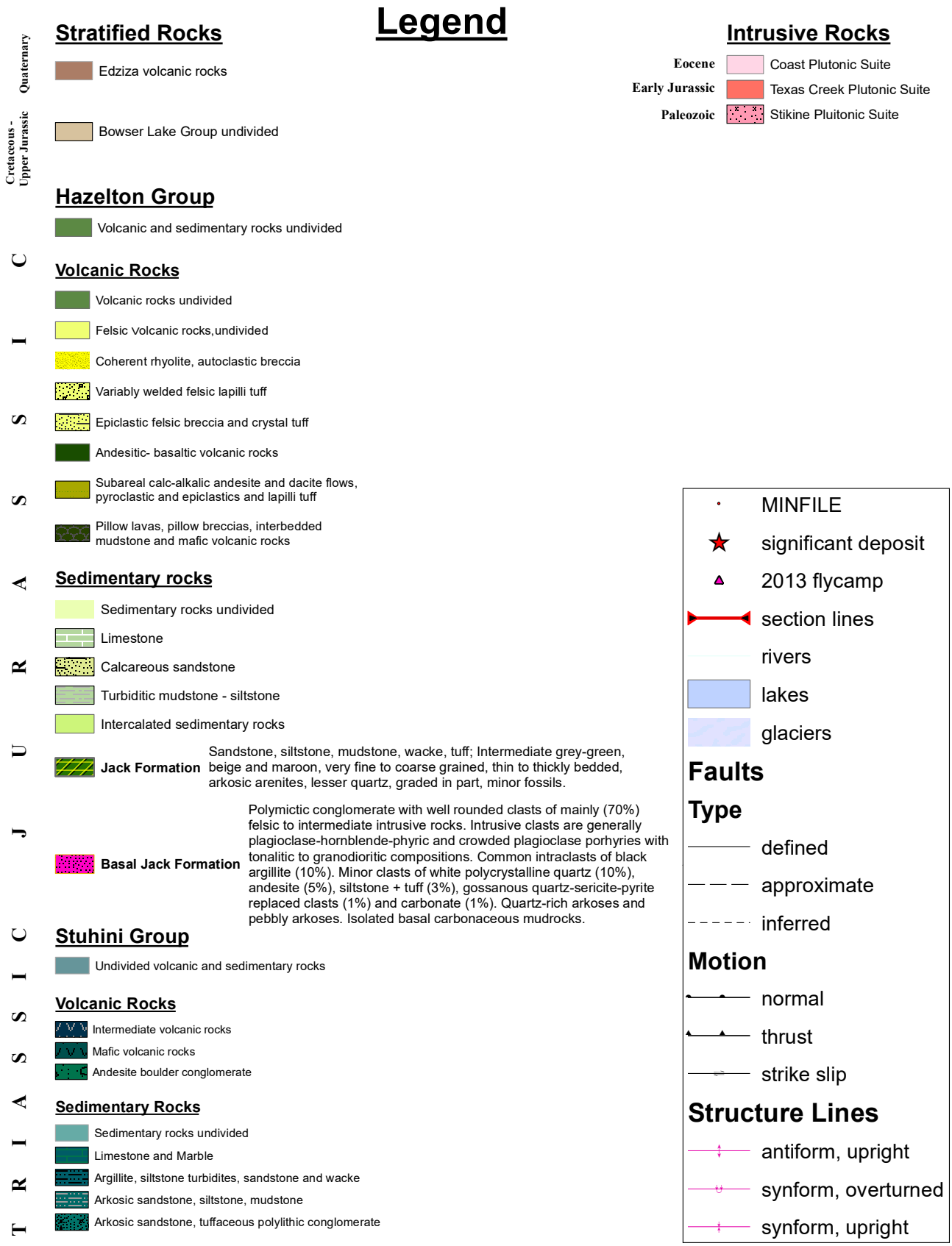


Fig. 3. continued

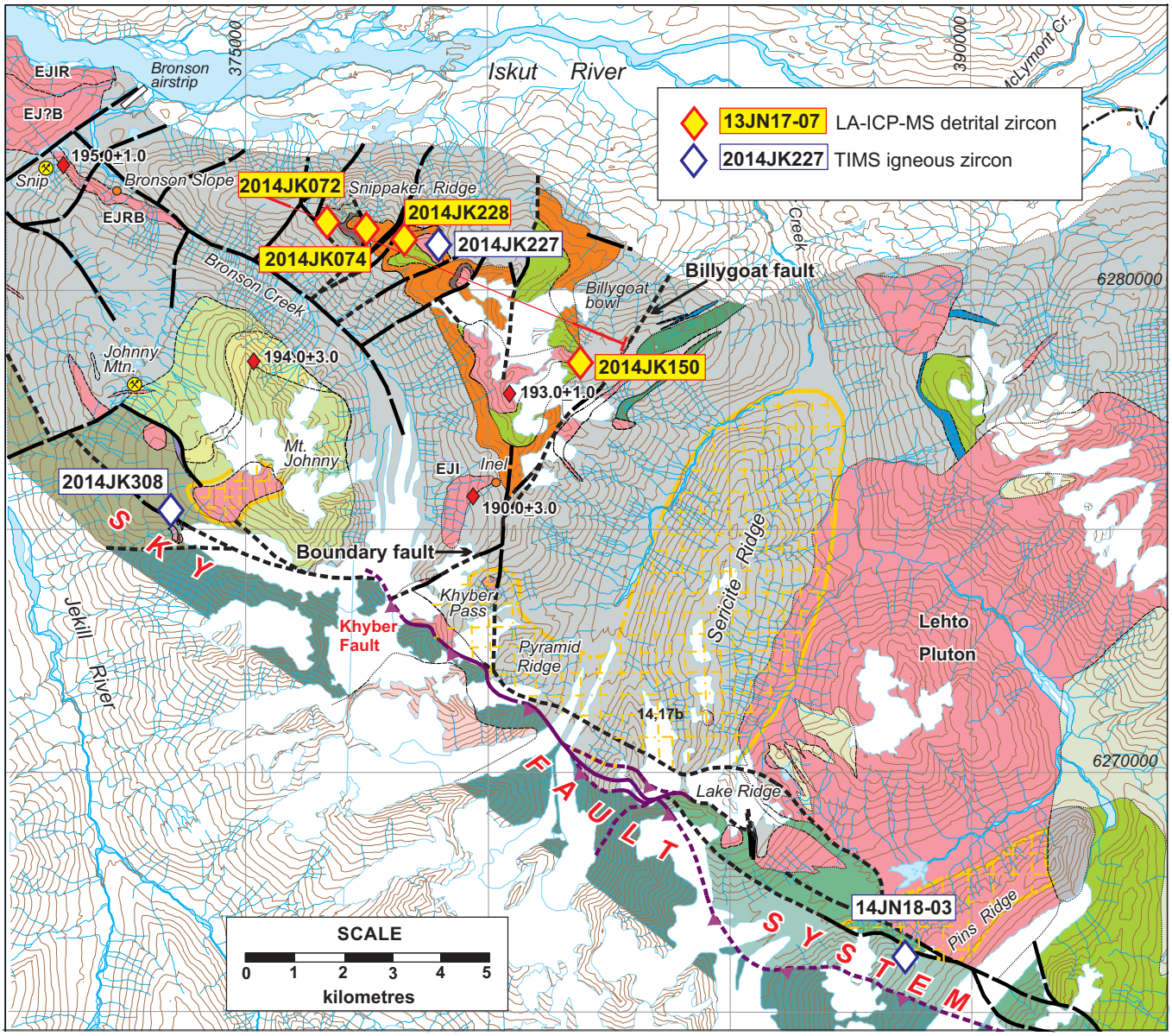


Fig. 4. Geology of the Snip-Bronson mineralized corridor and Snippaker Ridge with geochronologic sample sites (sample area 4, Fig. 1). For details and locality descriptions see Kyba and Nelson (2015).

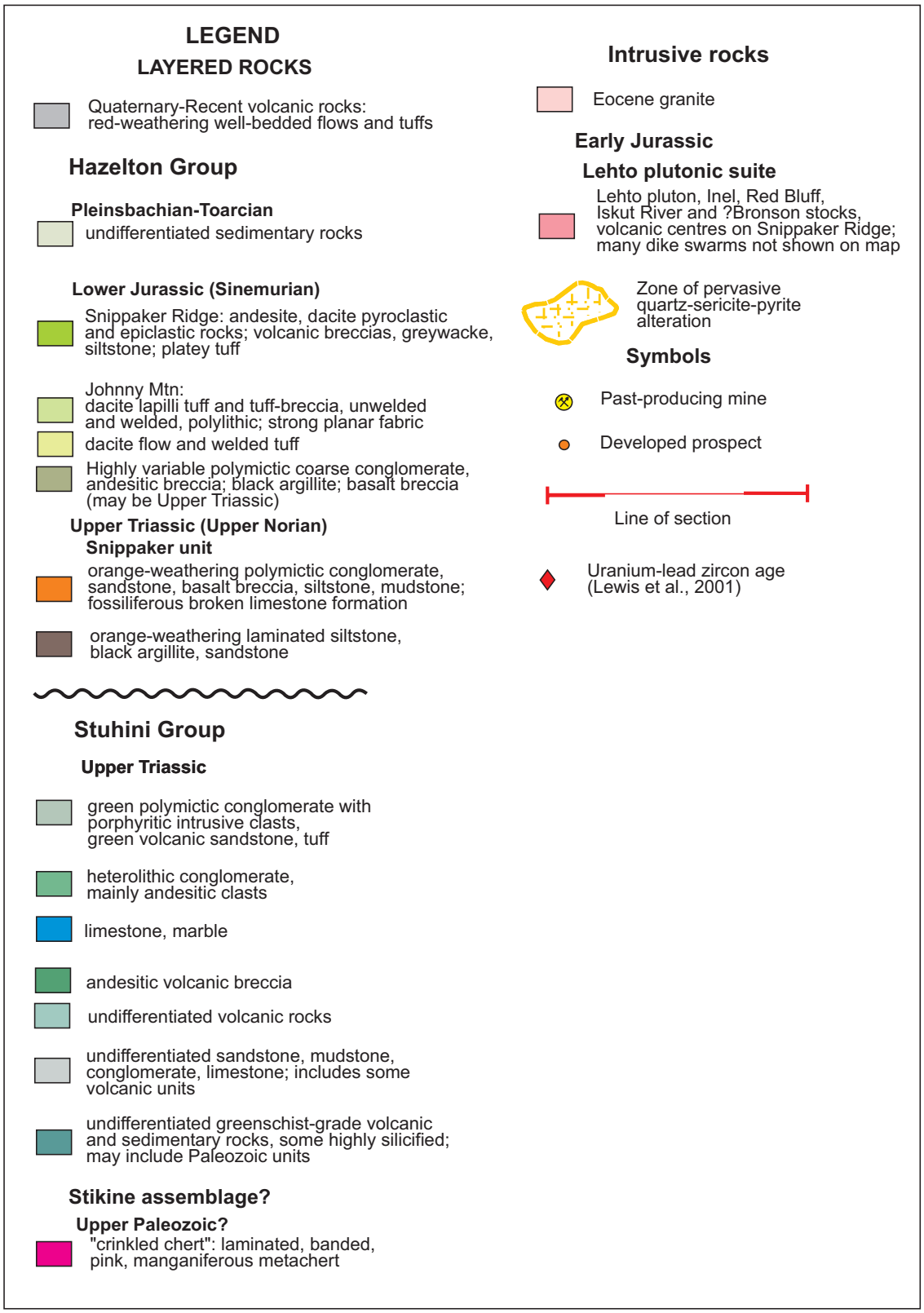


Fig. 4. continued.

Table 1. Summary, Hazelton Group detrital zircon geochronology and age population determinations. Tuffzirc and Unmix calculations from methods of Ludwig (2008).

Sample	UTM East	UTM North	Description	N <10 %	Probability plot peaks	Breaks in distribution (Scatterplot and TRUE/FALSE overlap at 1σ, 2σ)	Tuffzirc	Unmix	Wtd averages	Geological constraints
13JN01-05	413861	6270721	Arenite; arkose grit and pebbles; base of Jack Fm., Bruce Glacier (DZ)	52	223.66 Ma single peak (52 grains <10% discordant).	No breaks in TRUE for 1σ or 2σ. Scatter plot shows small breaks at 220, 225 Ma.	**223.65 +1.35 -1.75 Ma** all <10% discordant. <220: 217.50+1.85/-2.15 Ma. 220-224.9: 222.00+/-1.00. >=225: 227.00+/-2.00, 2 older grains (cores)?	Does not recognize multiple populations	All <10% discordant **223.0+/-1.5 Ma**, MSWD 1.14, prob. .22; <220 **217.0+/-2.6 Ma** MSWD .16, prob.999; 220-224.9 **222.2+/-1.9 Ma** MSWD .083, prob. 1.00; >=225 **228.1+/-12.3** Ma MSWD .79 Prob .73 (reasonable range of Stikine suite ages).	Jack Fm. regionally contains Hettangian-Sinemurian fossil collections (Lewis, 2013). Detrital zircons are much older than depositional age.
13JN02-16	412848	6270707	Base of Bruce Glacier unit; rhyodacite lapilli tuff, ignimbrite	64	172.96 Ma main peak, 188.96 Ma secondary peak; a few Late Triassic grains, one Mississippian grain.	Three breaks (1σ) 177.8-184.1; 197.2-220.6, 232.9-343 Ma.	All grains **175.40+0.90-1.90 Ma** coherent group of 56. 41 youngest grains (n=41) **173.50+1.60-1.10 Ma** (age of tuff); For 19 grains 184-1-197.2 Ma: 188.80+2.10-1.20 Ma.	Two populations **173.65+/-.41 Ma (1σ)**; **189+/-.89 Ma** (1σ).	Young population **173.64+-.80,** MSWD=.79, Prob .82 (MDA).; Texas Creek **189.0+/-1.8 Ma**, MSWD=1.6, Prob .041; could be mix of ages.	SHRIMP, TIMS ages of Bruce Glacier unit 178-173 Ma (Lewis 2013; Cutts et al.; 2015).
13JN10-07	425139	6268056	Spatsizi Fm. grit, north of Iron Cap alteration zone	63	186.16 Ma; small peak ca. 224 Ma.	Break between ca. 190 and ca. 220. One ca. 197.7 Ma grain shows as outlier at 1σ level. Could be older Texas Creek.	**186.40+/-.80 Ma** (all grains, n=63); oldest 7 grains **223.90+5.10-3.00 Ma**.	**186.39+/-.71 Ma; 223.9+/-3 Ma**	1) **186.23+/-.70 Ma,** MSWD 0.77, prob 0.89 (56 grains; MDA) 2) **223.4+/-3.1 Ma** MSWD 0.39 prob 0.86 (6 grains)	Overlain by tuffaceous siltstone with Middle Jurassic fauna (Lewis, 2013).
13JN11-06	424637	6267358	Jack Fm: altered grit, enclave in Iron Cap intrusion	42	Main peak 224.04 Ma. Single 200.2 Ma grain not maximum depositional (probably from intrusion).	No breaks in series except between single 200.2 Ma grain and the rest. Scatter plot shows break at ca. 230 Ma.	**224.10+1.60 -2.00 Ma** (all 42 grains). Oldest 8 grains 227-235 Ma **231.60+3.60 - 1.70 Ma**	**222.76+/-1.4 Ma** (.85); **230.1+/-6.1 Ma** (.15) validates idea of secondary older Late Triassic population (early Stikine suite)	34 grains <229 Ma: **222.4+/-1.3 Ma**, MSWD 0.93, prob .58. Oldest 7 grains (229-235 Ma) **232.3+/-3.3 Ma**, MSWD 0.25, prob 0.96. More support for idea of small older Stikine suite peak.	Jack Fm. regionally contains Hettangian-Sinemurian fossils (Lewis, 2013). Sample is from small screen in Iron Cap intrusion, which is not dated but considered equivalent to the nearby Mitchell porphyry (ca. 196 Ma; Febbo et al., 2019).
13JN17-07	425511	6260571	Jack Fm grit, near Katir Mine (Brucejack); olistrostromal block	55	Main peak 220.96 Ma; smaller peak 196.12 Ma	Break in 1σ series between 201.8 and 209 Ma. Breaks in scatter plot at 200, 209, 213, 228 Ma	**222.20+1.50 -1.30 Ma**, main peak (n= 50) >209 Ma.	populations: **197.3+/-2.3, 210.8+/-3.8, 221.97+/-1.4 and 233.8+/-3.9 Ma**. (agrees with scatterplot, wtd. ave.).	Youngest 5 grains **197.3+/-4.5 Ma,** MSWD 0.42, prob 0.79. (MDA) Wtd ave. 209-213 (4 grains): **210.5+/-5.6 Ma**, MSWD 0.12, prob 0.95; 216-228 (37 grains): **221.7+/-2.3 Ma**, MSDW 0.17, prob 1.00; >230 (9 grains): **233.8+/-5.8 Ma**, MSWD 0.14, prob. 0.998.	Geologically reasonable in that top of Jack is overlain by volcanic breccia at base of Unuk River andesite unit, with boulder dated at 196.26+/-0.12 Ma by TIMS U-Pb zircon (see 13JN20-04).

Table 1. continued

Sample	UTM East	UTM North	Description	N <10 %	Probability plot peaks	Breaks in distribution (Scatterplot and TRUE/FALSE overlap at 1σ, 2σ)	Tuffzirc	Unmix	Wtd averages	Geological constraints
13JN26-06	427304	6236284	Fanglomerate, Tennyson West	63	One broad peak 189.05 Ma	No breaks in either 2σ or 1σ series. One very young (ca. 174 Ma) grain (probably Pb loss).	Main peak tuffzirc **192.50 +2.50 -3.50**, (Sinemurian). Oldest 8 grains tuffzirc 210.5 Ma +5.50 -3.50, probably Stuhini Group source.	Grains 179-205 Ma (left out outliers). Isoplot calculates 2 populations **189.4+/-3.7** (**M**DA) and 194.6+/-5.4 Ma. Geologically reasonable (reflects the age range of Sulphurets intrusions).	Main peak tuffzirc **192.50 +2.50 -3.50**, (Sinemurian). Oldest 8 grains tuffsirc **210.5 +5.50 -3.50**, probably Stuhini Group source.	Fault-bounded panel. Adjacent panel to the east consists of Betty Creek Fm. andesite breccias intruded by ca. 200 Ma Tennyson porphyry.
2014JK 072	376707	6281397	Top of Stuhini Group volcaniclastic grit-greywacke	65	One broad peak 211.73 Ma	Youngest 4 grains (<201 Ma) show steep fall-off, (probable Pb loss). Breaks on scatter plot at 201, 209, 215, with oldest grains scattered (inherited cores? detrital?)	All grains: **211.75+1.75 -1.35 Ma**. Youngest 9 grains **203.40+0.70 -5.50 Ma**. 12 grains 203.4-208.4: **206.10+1.10 -2.00 Ma**. 37 grains 209-215: **211.80 +1.70 -0.80 Ma**.	Unmix on all grains >=203.4 Ma gives only 2 peaks at **210.5+/-1.2, 216.4+/-3 Ma**. Will not recognize ca. 205 Ma younger peak.	Wtd av.. 9 youngest: **201.5+/-2.2 Ma** MSWD 0.82 prob .59 (too young geologically); 12 grains 203.4-208.4**: 205.8+/-3.9 Ma** MSWD .066, prob 1.00 (MDA); 209-215: **211.9+/-2.3 Ma** MSWD .069, prob 1.00; 11 grains 216-225: **218.7+/-4.4 Ma**.	Unconformably overlain by Snippaker unit, which contains latest Triassic ammonite fauna (Lewis, 2013).
2014JK 074	376945	6281313	Base of Snippaker conglomerate; polymictic conglomerate with granitoid and, chert clasts in quartz-rich arkosic matrix.	33	Main peak 220.25 Ma, slightly skewed to older values. Small peaks at 318, 440 (latter is 2 grains only). Based on 33 grains; with discordance <10%. Rejected 18 grains with discordance >10%.	Breaks in series separate Triassic grains, 2 Carboniferous grains (315, 330), and 2 Silurian grains (434, 456). Scatter plot shows breaks at 215, 230 Ma. Oldest Triassic grains spread out (cores?).	Youngest 10 grains 209-217: **212.55+4.45 -1.55 Ma** (good match with main peak in underlying uppermost Stuhini). 10 grains 218-228: **221.30+5.70 -2.30 Ma**. 9 grains 239-261: **245.00+7.00 -5.00 Ma**. Wide age spread may indicate that cores are likely.	For grains <230 Ma, unmix only recognizes single peak at 218 Ma. After rejecting grains with >10% discordance there are only 33 grains left.	Wtd av.. 10 grains <218 : **213.9+/-4.9 Ma** MSWD 0.106, prob 1.000; 10 grains 218-228: **221.8+/-4.3 Ma** MSWD 0.20, prob 0.994; 9 grains 230-261: **244.6+/-6.7 Ma** MSWD 0.38, prob 0.93 (Paleozoic cores suspected).	Directly overlies uppermost Stuhini greywacke (sample 14JK072. Fossiliferous limestone with latest Triassic (Rhaetian) fauna (Lewis, 2013; Nelson et al., 2018) is higher in Snippaker unit.
2014JK 150	381980	6278429	Hazelton conglomerate directly above sub-Betty Creek Fm. unconformity	65	Main peak 203.78, smaller peak 216.75. One or two-grain peaks at 230, 276, 296, 318 Ma.	Breaks in series (1σ) between 222 and 228, 234 and 276 Ma, single grains 276, 296, 318 Ma. Breaks in scatter plot between youngest grain (195.5) and 200 Ma; 207.6 to 211.8; 218.4 to 220.7 Ma. Grains >228 Ma all outliers.	Main tuffzirc peak (all 65 grains) at **204.80 +1.00 -1.10 Ma**. Youngest 9 grains **198.50 +2.30 - 0.20 Ma (MDA**; Betty Creek Fm.). 31 grains 201.1-207.6: **204.40+0.60 - 0.20 Ma** (main peak). 20 grains 211.8-222.3: **216.15+2.15 -1.25 Ma** (second peak).	Three populations: **198.9+/-2 ; 204.35+/-0.9; 217.08+/-1.1 Ma**	Wtd. av.. 9 youngest grains **198.8+/-2.7 Ma**, MSWD 0.16, pro .996. (MDA) 31 grains 201.1-207.6: **204.4+/-1.4 Ma** (main peak). 20 grains 211.8-207.6: **217.0+/-2.1 Ma**, MSWD 0.37, prob 0.994	Thin local (channel fill?) conglomerate passes upwards into Unuk River andesite unit of Betty Creek Fm., regionally dated at 198-192 Ma (Lewis, 2013).

Table 1. continued

Sample	UTM East	UTM North	Description	N <10 %	Probability plot peaks	Breaks in distribution (Scatterplot and TRUE/FALSE overlap at 1σ, 2σ)	Tuffzirc	Unmix	Wtd averages	Geological constraints
2014JK 228	378139	6281098	Polymictic, granitoid clast-rich conglomerate near top of Snippaker unit	64	Main peak 220.85 Ma; suggestion of younger peak at 212; one grain 201.6 Ma.	Only break on test at 1σ sets off youngest grain at 201.6 Ma. Possibly significant because this is a conglomerate, not a volcanogenic deposit. On scatter plot, breaks at 215, 226. Oldest grains highly variable (possible cores?).	Main peak **220.90+1.00 -1.80 Ma** for all 64 grains. Youngest 16 grains (<215 Ma) **212.20 + 1.80 - 3.20 Ma**. Oldest 14 grains (224-236 Ma): **226.25 + 5.25 - 1.45 Ma**.	Three peaks at **209.92+/-1.5, 220.7+/-0.89, 229.2+/-2.9 Ma**. Agree with peaks in tuffzirc, wtd av.. "old" Stikine suite, "main" Stikine suite, Galore suite ages.	Wtd av.. 13 grains 207-215 Ma: **211.2+/-1.3 Ma**, MSWD 1.00 prob .45; 42 grains 215-226: **220.88+/-0.75 Ma**, MSWD 1.08, prob .34; 7 grains 227-236: **230.1+/-2.1 Ma**, MSWD 1.01, prob 0.42	Latest Triassic (Rhaetian) macrofauna locality 100 m stratigraphically below this site; unconformably overlain by ca 198.5 Ma conglomerate of sample 14JK150.
2015JK 1310	447873	6395938	Basal Hazelton conglomerate at Red Chris	61	Main peaks 221, 229 Ma. Paleozoic; 1 grain 298 Ma, small peaks at 313, 335 Ma.	Scatterplot breaks between 3 youngest grains (<216 Ma); between 222 and 225 Ma. Two oldest Triassic grains (241, 247) are outliers (cores?). Only series break is between Triassic and Paleozoic (298-353 Ma).	**227.10 + 3.40 -1.60** from 44 of 61 grains**; 219.75+1.25 -0.75 Ma** (12 grains 217-222 Ma); **230.50+4.20 -2.90 Ma** (27 grains 225-237 Ma). Unusual predominance of "oldest Stikine suite". Paleozoic grains (16) **334.45+9.55 -12.15 Ma** indicate multiple sources.	Two peaks for grains 217-237 Ma. **221.1+/-2.5 Ma**; **231.45+/-1.9 Ma**.	Youngest 3 grains **213.7+/-6.6 Ma,** MSWD 0.118, prob 0.89. (MDA). 12 grains 217-22: **219.7+/-3.7** Ma, MSWD 0.033, prob 1.000. 27 grains 225-237: **230.9+/-2.7 Ma**, MSWD 0.32, prob. 1.000. Also "oldest Stikine suite".	Overlying Hazelton Group contains latest Triassic (Rhaetian) fauna (Nelson et al., 2018). Red Chris porphyry intrusion, which is considered coeval and cogenetic with Hazelton volcanic sequence, is 211 - 206 Ma by TIMS methods on zircon (Rees et al., 2015).
15BVS-03-14	461607	6455278	Basal Spatsizi conglomerate on Cake Hill pluton, Hotailuh batholith, Gnat Pass.	64	Single peak at 214 Ma (64 grains)	Scatterplot shows homogeneous population except the oldest grains (224, 228, 231 Ma), which are outliers. Probably xenocrystic cores from older plutonic phases of Stikine Suite within the Hotailuh batholith	All grains **215.50+1.50 -1.50 Ma.** Single source (Cake Hill pluton, Hotailuh Batholith).	not applicable, as all data form single peak.	All grains **215.2+/-1.5 Ma**, MSWD .69, prob .97.	Unconformably overlies Hotailuh batholith (Cake Hill pluton; ca 220 Ma, van Straaten and Nelson 2016). Fossil locality higher in section yielded Early Toarcian fauna (Henderson and Perry, 1981).
16JN09-06	442380	6147465	Heterolithic conglomerate, Iskut River Fm. Mt. Clashmore; 70% felsic clasts, 25% dark grey mudstone, 1% grey chert. Same locality as EP-96-319-14 (Evenchick and McNicoll, 2002).	51	Main peak 171 Ma. Smaller peaks in 140s. Minor peaks at 180, 196, 203.	Scatterplot shows youngest population with ages 145-165. Coherent population 167-175.5 Ma. Older grains small clusters ca. 180, 196, 203 Ma (2-3 grains). Series shows 3 breaks at individual grains (1σ) 147.6 to 154.6. Picks out 3 grain cluster 179.2-181.1, 2 grain clusters at 196, 202.5-204. These are detrital grains from Texas Creek sources.	Tuffzirc all grains (51) **170.90 +1.00 -1.60 Ma** on coherent pop. of 40. **Max Dep.** Believable as Iskut River Fm. age, most clasts in conglomerate are intraformational rhyolites. Youngest grains (142-165 Ma) give 165.00 +2.70 - 2.30 with grains <160 Ma decreasing in age.	Unmix on 43 grains <=175.5 Ma: 146.04+/-.61 Ma (.2); 170.18+/-0.44 (.8). Looks very nice but I don't believe it!	9 youngest grains (<160 Ma) mean 146.0+/-2.5 Ma, MSWD 12, prob 0.000. Even main population 31 grains 167-176 Ma is 170.64+/-0.83, MSWD 3.1, prob 0.000. Probable lead loss.	Within mainly bimodal volcanic sequence of Iskut River Fm. which is dated regionally by fossil and U-Pb TIMS ages as Middle Jurassic (Aalenian-Bajocian; 176-170 Ma).

Table 1. continued

Sample	UTM East	UTM North	Description	N <10 %	Probability plot peaks	Breaks in distribution (Scatterplot and TRUE/FALSE overlap at 1σ, 2σ)	Tuffzirc	Unmix	Wtd averages	Geological constraints
16JN09-08	442283	6148076	Clast-rich polymictic conglomerate, Iskut River Fm. Mt. Clashmore, grey chert clasts, pebbly sandstone. On strike with Evenchick and McNicoll (2002) sample.	40	Main peak 216 Ma; secondary (double) peaks at 168, 174 Ma (IRF). 1 grain peak at 158. Small Texas Creek peaks at 190, 200. "Old" peak at 245 Ma.	Scatterplot shows breaks between youngest grain (158.2 Ma) and rest; 191-198, 210-214, 222-231 Ma. Steep decline in ages from 210 to 167; partly multiple sources, partly Pb loss from IRF grains?	For all grains, tuffzirc finds coherent group of 18 at 215.45+4.55 - 1.55 Ma (Stikine Suite detrital grains). 10 grains between 166.7 and 174.7 give 168.75+5.05 -1.75 Ma peak, representing IRF (**max dep**). 8 grains 176.6-191.5 give 182.90 +8.10 -4.90 Ma peak, reflecting multiple Texas Creek sources.	Unmix specified 4 populations. It suggests **172.13+/- 0.97 Ma** (.38) - **Max Dep.**, 193.3+/-2.3 Ma (.15), 215.19+/-1.8 Ma (.37) and 240.7+/-3.9 Ma (.10).	Weighted averages poorly as 16JN9-6. 10 grains 166.7-174.7: 170.7+/-2.3 Ma, MSWD 3.7, prob 0.000. 8 grains 176.9-191.5: 182.2+/-5.0, MSWD 7.0, prob 0.000. 14 grains 208.2-222.3: 215.4+/-2.1, MSWD 1.2, prob. .26 - best population, Stikine suite derived.	Within mainly bimodal volcanic sequence of Iskut River Fm. which is dated regionally by fossil and U-Pb TIMS ages as Middle Jurassic (Aalenian-Bajocian; 176-170 Ma). Same unit as 16JN9-6, 600 m along strike.

Table 2. Summary, Hazelton Group-allied plutonic rock CA-TIMS geochronological results.

Sample #	Easting	Northing	Description	TIMS age
	Zone 9			
14-JN-18-3	388213	6265776	Plagioclase-phyric dike with sheared margins cutting into and across S-C fabric on Pins ridge. C = 305/56 NE; S = 324/23 NE.	194.28±0.18 Ma
2014JK308	373530	6274904	Plagioclase-phyric dike with sheared margins and foliated chlorite cutting Sky fault system south side of Johnny Mountain. Internal flattening fabric 327/65 parallels bounding faults and fabrics in host conglomerates.	190.70±0.17 Ma
2014JK227	378594	6280926	Plagioclase-phyric diorite, top of Snippaker Mountain	191.55±0.20 Ma
13JN20-04	425715	6260099	Boulder, base of maroon volcaniclastic conglomerate facies of Betty Creek Fm. atop Jack Fm, near Katir mine. Crowded plagioclase porphyry (High level intrusive source?)	196.26 ±0.12 Ma

4. Red Chris

The Red Chris porphyry deposit (area 5, Fig. 1) is hosted by the ca. 206 Ma Red stock, part of the Tatogga suite (latest Triassic; Nelson et al., 2018). On the slope west of the mine, a thin basal Hazelton Group conglomerate unconformably overlies Stuhini Group basalt and thin-bedded sedimentary strata (Rees et al., 2015). Sample 2014JK1310 is of this conglomerate. It yielded multiple peaks between 214 and 230 Ma (Table 1), which span the entire known age range of the Stikine plutonic suite. It also contains a significant population of late Paleozoic grains, presumably derived from a nearby uplift of the Stikine assemblage and associated intrusive bodies.

5. Gnat Pass

In the Gnat Pass area, near the northern edge of Stikinia (area 6, Fig.1), the oldest Hazelton Group strata are Spatsizi Formation sandstone, siltstone, and tuff (Toarcian) that rest nonconformably on the Cake Hill pluton (ca. 215 Ma; van Straaten and Nelson, 2016). The sedimentary sequence passes gradationally upwards into Middle Jurassic, mainly volcanic rocks of the Horn Mountain Formation. Sample 15BVS03-14, of the basal Spatsizi conglomerate, was collected immediately above the unconformity. It shows a single age peak ca 215 Ma (Table 1), consistent with local derivation from the underlying pluton.

6. Mt. Clashmore

Mt. Clashmore is on the western flank of the southernmost Eskay rift, west of the Anyox Cu-rich VMS deposit (sample area 7, Fig.1; Fig. 5; Nelson, 2017). It is underlain by pillow basalt, pillow breccia, high-level mafic intrusions, mafic and felsic tuffs, siliciclastic strata, and minor rhyolite, all assigned to the Iskut River Formation (Middle Jurassic; Nelson, 2017). In a previous study, a conglomerate sample from Mt. Clashmore (EP-96-319-14, Evenchick and McNicoll, 2002) seven of 11 zircons of yielded Precambrian-Cambrian ages (SHRIMP; 1058, 1023, 987, 918, 612, 560, and 517 Ma). In the present study however, a sample from the same locality (16JN09-06), and another from the same conglomerate unit

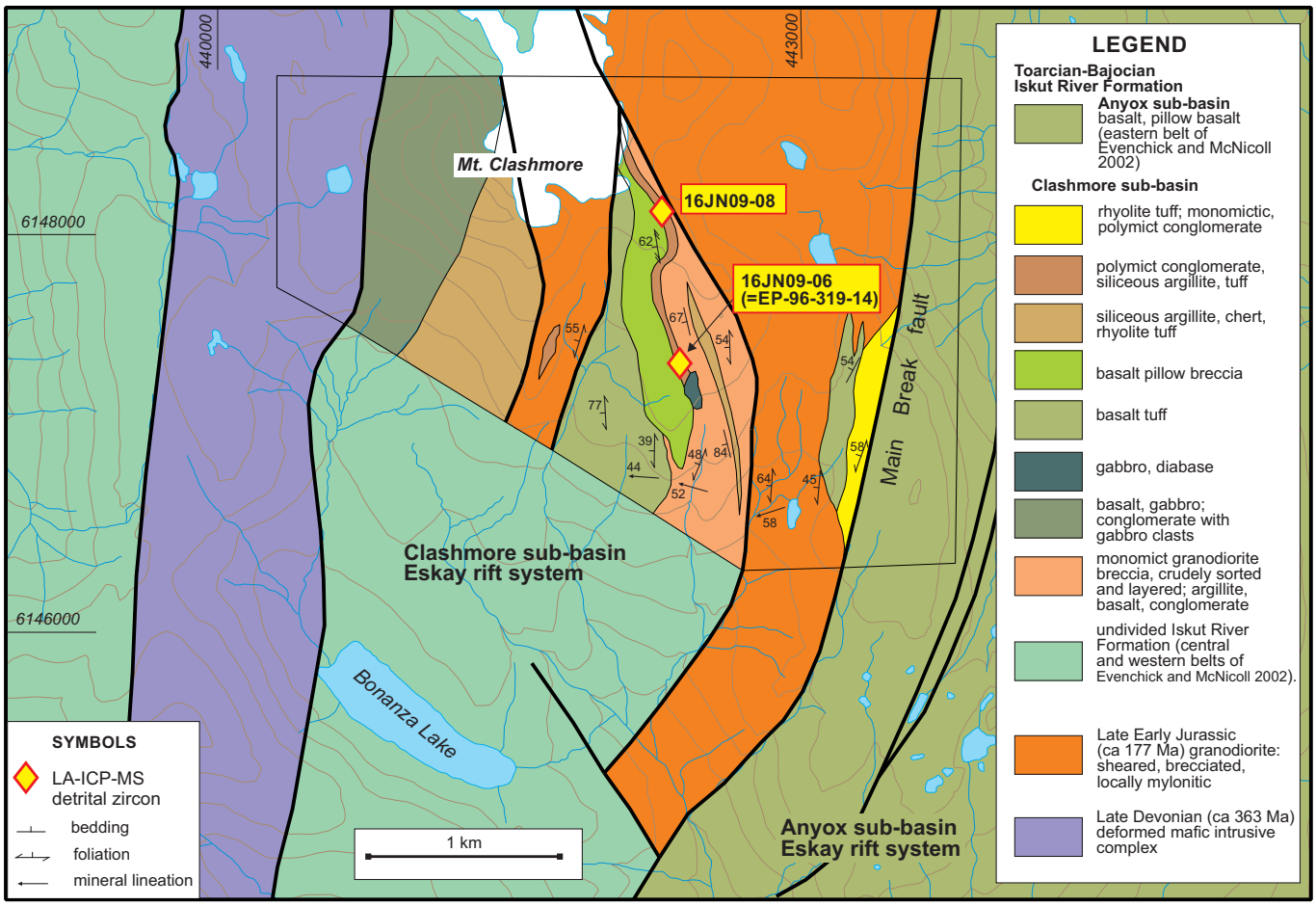


Fig. 5. Mt. Clashmore geology. For geological details and locality descriptions, see Nelson (2017). Previously reported sample EP-96-319-14 from Evenchick and McNicoll (2002).

800 m along strike (16JN09-08) yielded only Mesozoic zircons (Table 1). Both samples show youngest reliable peaks ca. 170 Ma, which is a reasonable age for the Iskut River Formation. Older peaks likely reflect recycling from the Stikine suite and Stuhini Group (ca. 215 Ma) and from the Texas Creek suite and lower Hazelton Group (ca. 180-193). Grains less than 160 Ma were probably affected by lead loss.

References cited

Cohen, K.M., Finney, S. and Gibbard, P.L., 2013 (updated). The ICS International Chronostratigraphic Chart (v2020/03). Episodes 36, 199-204. <https://stratigraphy.org/chart>

Cutts, J.A., McNicoll, V.J., Zagorevski, A., Anderson, R.G. and Martin, K. 2015. U-Pb geochronology of the Hazelton Group in the McTagg anticlinorium, Iskut River area, northwestern British Columbia. In: Geological Fieldwork 2014, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2015-1, pp. 87-102.

Evenchick, C.A., and McNicoll, V.J., 2002. Stratigraphy, structure, and geochronology of the Anyox pendant, northwest British Columbia, and implications for mineral exploration. Canadian Journal of Earth Sciences, 39, 1313-1332.

Febbo, G.E., Kennedy, L.A., Nelson, J.L., Savell, M.J. Campbell, M.E., Creaser, R.A. Friedman, R.M., van Straaten, B.I., and Stein, H.J., 2019. The evolution and structural modification of the supergiant Mitchell Au-Cu porphyry, northwestern British Columbia. Economic Geology, 114, 303-324.

Henderson, C.M. and Perry, D.G., 1981. A Lower Jurassic heteroporid bryozoan and associated biota, Turnagain Lake, British Columbia. Canadian Journal of Earth Sciences, 18, 457-468.

Kyba, J. and Nelson, J., 2015. Stratigraphic and tectonic framework of the Khyber-Sericite-Pins mineralized trend, lower Iskut River, northwest British Columbia. In: Geological Fieldwork 2014, British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Paper 2015-1, pp. 41-58.

Lewis, P.D., 2013. Iskut River area geology, northwest British Columbia (104B/08, 09, 10 & part of 104B/01, 07, 11): Geoscience BC Report 2013-05; 3 1:50,000-scale. <http://www.geosciencebc.com/projects/2009-003/>

Lewis, P.D., Mortensen, J.K., Childe, F., Friedman, R.M., Gabites, J.M., Ghosh, D., and Bevier, M.L., 2001. Geochronology data set. In: Lewis, P.D., Toma, A., Tosdal, R.M. (Eds.).

Metallogenesis of the Iskut River Area, Northwestern British Columbia. Mineral Deposit Research Unit, Special Publication Number 1, pp.89-96.

Ludwig, K., 2008. User's manual for Isoplot 3.70 – a geochronological toolkit for Microsoft Excel: Berkeley Geochronology Center Special Publication 4, 76 p. < http://www.bgc.org/isoplot_etc/isoplot.html >

Nelson, J.L., 2017. Composite pericratonic basement of west-central Stikinia and its influence on Jurassic magma conduits: Examples from the Terrace-Ecstall and Anyox areas. In: Geological Fieldwork 2016, British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Paper 2017-1, pp. 61-82.

Nelson, J.L. and Kyba, J., 2014. Structural and stratigraphic control of porphyry and related mineralization in the Treaty Glacier – KSM – Brucejack – Stewart trend of northwestern Stikinia. In: Geological Fieldwork 2013, British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Paper 2014-1, pp. 111-140.

Nelson, J.L. and van Straaten, B., 2021. Recurrent syn- to post-subduction mineralization along deep crustal corridors in the Iskut-Stewart-Kitsault region of western Stikinia, northwestern British Columbia. In: Sharman, E. R., Lang, J. R., and Chapman, J. B., (Eds.), Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update. Canadian Institute of Mining and Metallurgy Special Volume 57, pp. 194-211.

Nelson, J., Waldron, J., van Straaten, B., Zagorevski, A., and Rees, C., 2018. Revised stratigraphy of the Hazelton Group in the Iskut River region, northwestern British Columbia. In: Geological Fieldwork 2017, British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Paper 2018-1, pp. 15-38.

Rees, C., Riedell, K. B., Proffett, J. M., Macpherson, J., and Robertson, S., 2015. The Red Chris porphyry copper-gold deposit, northern British Columbia, Canada: Igneous phases, alteration, and controls of mineralization. Economic Geology, 110, 857–888.

Schaltegger, U., Guex, J., Bartolini, A., Schoene, B. and Ovtcharova, M. 2008. Precise U-Pb age constraints for end-Triassic mass extinction, its correlation to volcanism and Hettangian post-extinction recovery. Earth Planetary Science Letters, 267, 266-275.

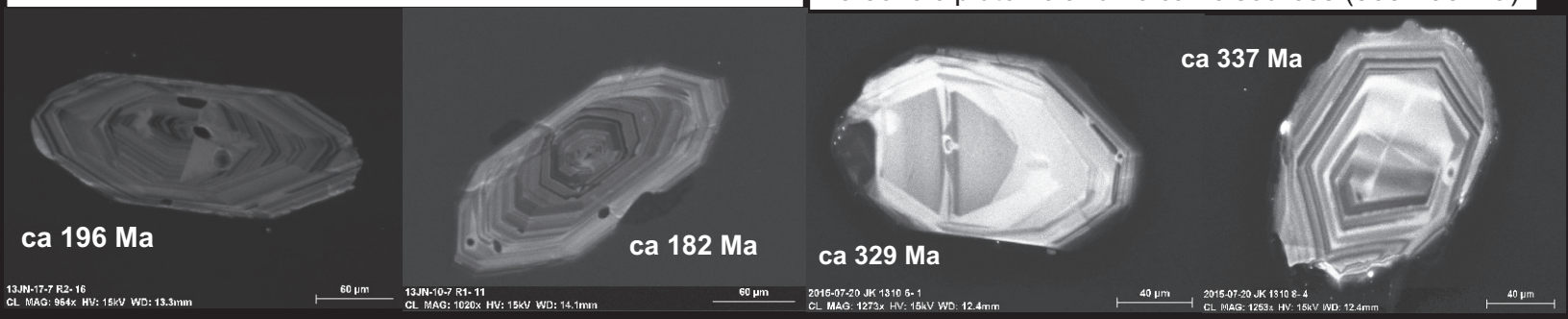
Tombe, S.P., Richards, J.P., Greig, C.J., Board, W.S., Creaser, R.A., Muehlenbachs, K.A., Larson, P.B., DuFrane, S.A., and Spell, T. 2018. Origin of the high-grade Early Jurassic Brucejack epithermal Au-Ag deposits, Sulphurets Mining Camp, northwestern British Columbia. Ore Geology Reviews, 95, 480-517.

van Straaten, B. and Nelson, J., 2016. Syn-collisional late Early to early Late Jurassic volcanism, plutonism and porphyry-style zoned alteration on the northern margin of Stikinia. In: Geological Fieldwork 2014, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2016-1, pp. 113-144.

Wotzlaw, J-F, Goex, J., Bartolini, A., Galley, Y., Krystyn, L., McRoberts, C.A., Taylor, D., Schoene, B. and Schaltegger, U., 2014. Towards accurate numerical calibration of the Late Triassic: High-precision U-Pb geochronology constraints on the duration of the Rhaetian. Geology, 42, 571-574. <doi: 10.1130/G35612.1>

Texas Creek suite - lower Hazelton Gp. (205-178 Ma)

Paleozoic plutonic and volcanic sources (360-290 Ma)



BRITISH COLUMBIA

Ministry of Energy, Mines and Low Carbon Innovation

BRITISH COLUMBIA GEOLOGICAL SURVEY est. 1895