Geology of the Tatogga property: Geologic framework for the Saddle North porphyry Cu-Au deposit and the Saddle South epithermal Au-Ag vein system, Iskut district, northwestern British Columbia

C.J. Greig[1, 2, a], N.P. Dudek[1], T.J. ver Hoeve[1], T.D.M. Quinn[1], G. Newton[1, 2], S.A. Makin[1], and R.E. Greig[1]

[1] C.J. Greig & Associates Ltd., 729 Okanagan Ave. E., Penticton, BC, V2A 3K7
[2] GT Gold Corp., Suite 610, 1100 Melville Street, Vancouver, BC, V6E 4A6
[a] corresponding author: cjgreig1@telus.net

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Abstract

Recent geologic mapping, new U-Pb zircon and Re-Os molybdenum geochronology, and an intensive drilling program provide the framework for two significant recent exploration discoveries on the Tatogga property, in the Iskut district of northwestern British Columbia. These data help to establish the Late Triassic to early Middle Jurassic evolution of host rocks, mineralization, syn- to post-mineral intrusions, and structures. Although mineralization at both the Saddle North porphyry copper-gold deposit and the Saddle South epithermal precious metals vein system is spatially related to latest Triassic to earliest Jurassic monzonitic intrusive rocks (including the Saddle North intrusive complex of the Tatogga suite), the property is underlain mainly by Upper Triassic and Lower Jurassic volcanosedimentary rocks of the Stuhini and Hazelton groups. Marine arc volcanic and related sedimentary rocks of the Stuhini Group were deposited in the Late Triassic, starting by at least ca. 224 Ma and continuing until after ca. 206 Ma, possibly from a magmatic centre near the Saddle North area. Although an abundance of hornblende- feldspar-phyric volcanic rocks is typically known as a hallmark of the Hazelton Group, our work indicates that common trachyandesitic or latitic rocks with abundant very fine-grained feldspar and subordinate hornblende are part of the Stuhini Group. Between ca. 206 and 202 Ma Stuhini Group rocks were intruded by partly coeval Tatogga suite plutonic rocks. Epithermal vein mineralization at Saddle South is considered to predate emplacement of these monzonitic intrusions and thus is thought to be older than the porphyry copper-gold mineralization that is genetically related to later phases of the monzonitic Saddle North intrusive complex. As indicated by clast compositions of Hazelton Group conglomerates and a structural discordance between the Stuhini Group on the southern part of the property and the Hazelton Group to the north, the Stuhini-Hazelton transition was marked by contractional deformation, uplift, and erosional stripping (all possibly related to early movement along the Poelzer fault), as has been documented elsewhere in northern Stikinia. Following renewed arc activity and shallow-marine to subaerial deposition of Hazelton Group volcanosedimentary strata, the later stages of Hazelton Group magmatism included intrusion of Early Jurassic felsic dikes (ca. 187 to 182 Ma) in west-northwest trending swarms that cut across folds in Stuhini Group rocks. Further contractional deformation affected both the Hazelton and Stuhini group rocks in the Cretaceous, during formation of the Skeena fold-thrust belt, and may locally have reactivated earlier structures. In the Late Cenozoic, mafic dikes fed volcanic flows and tuffaceous rocks exposed in the upper Klastline River valley.

Keywords: Stuhini, Hazelton, Iskut, Tatogga, Saddle North, Saddle South, Klastline River, porphyry Cu-Au, epithermal Au-Ag vein, sub-Hazelton Group unconformity, Poelzer fault, Golden Triangle, GT Gold Corp.

1. Introduction

Stikine terrane (Stikinia) is an oceanic island arc tectonostratigraphic unit consisting of mid-Paleozoic to Middle Jurassic rocks that underlie much of western British Columbia. Stikinia is the largest of numerous allochthonous to parautochthonous terranes that were accreted to the western margin of North America by the late Middle Jurassic to form the Intermontane Belt of the Canadian Cordillera (Coney et al., 1980; Monger et al., 1982, Nelson and Colpron, 2007). Most workers accept that Stikinia was subsequently consolidated with outboard terranes of the Insular Belt to the west (Wrangell and Alexander terranes), in the latest Jurassic to mid-Cretaceous (e.g., Gehrels et al., 1996).

In the Iskut district of northwestern British Columbia, and part of a loosely defined precious metals-rich area commonly referred to as the 'Golden Triangle', the Tatogga property (GT Gold Corp.) is underlain by Stikine terrane rocks (Figs. 1, 2). Exploration by GT Gold Corp. from 2016 to 2018 culminated in the drill discovery of significant new mineralized zones, the Saddle North porphyry copper-gold deposit and the Saddle South epithermal precious metals vein system (Greig et al., 2020). Although mineralization at both deposits is spatially

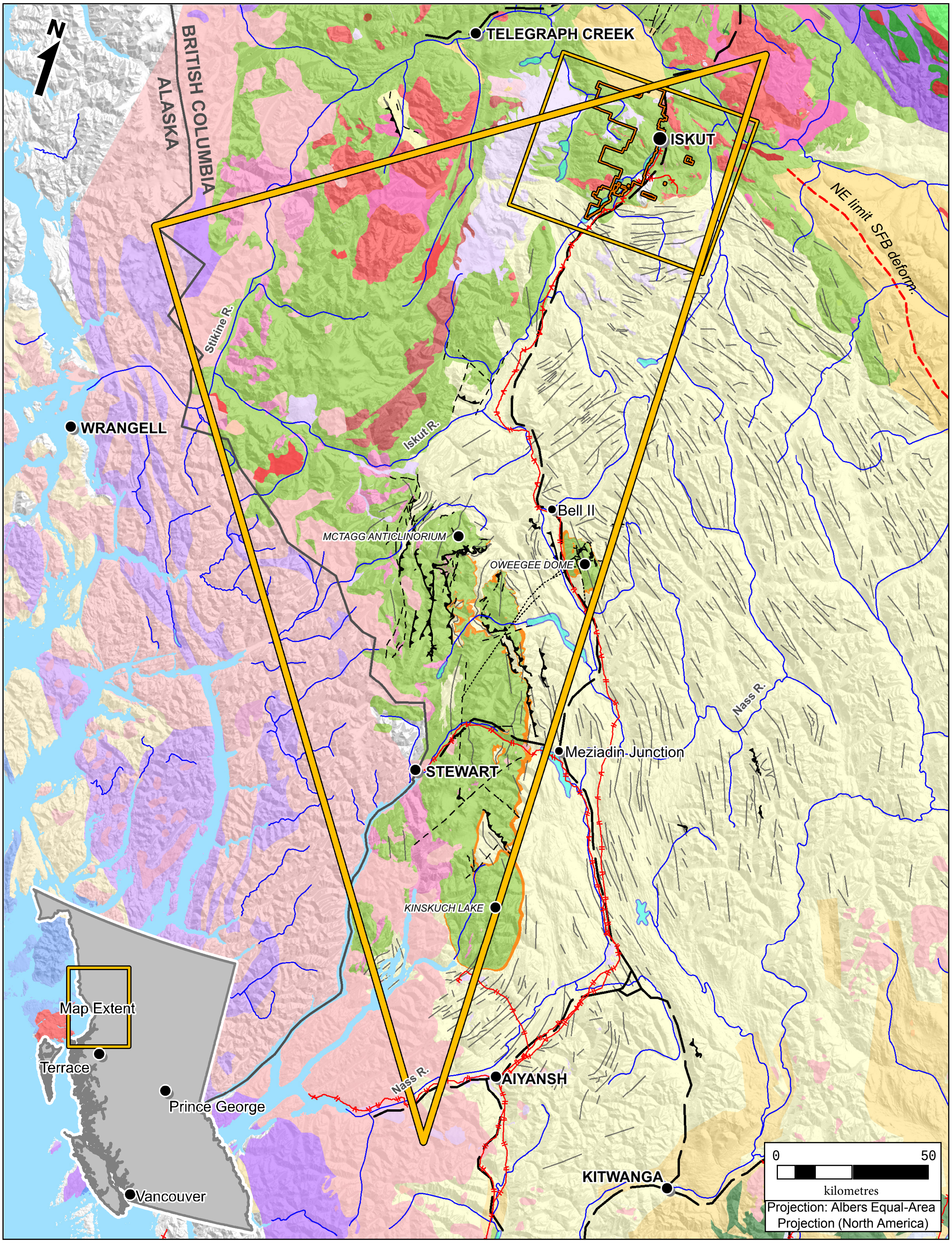

Fig. 1. Regional geology of northern Stikinia (see Figure 2 for legend).

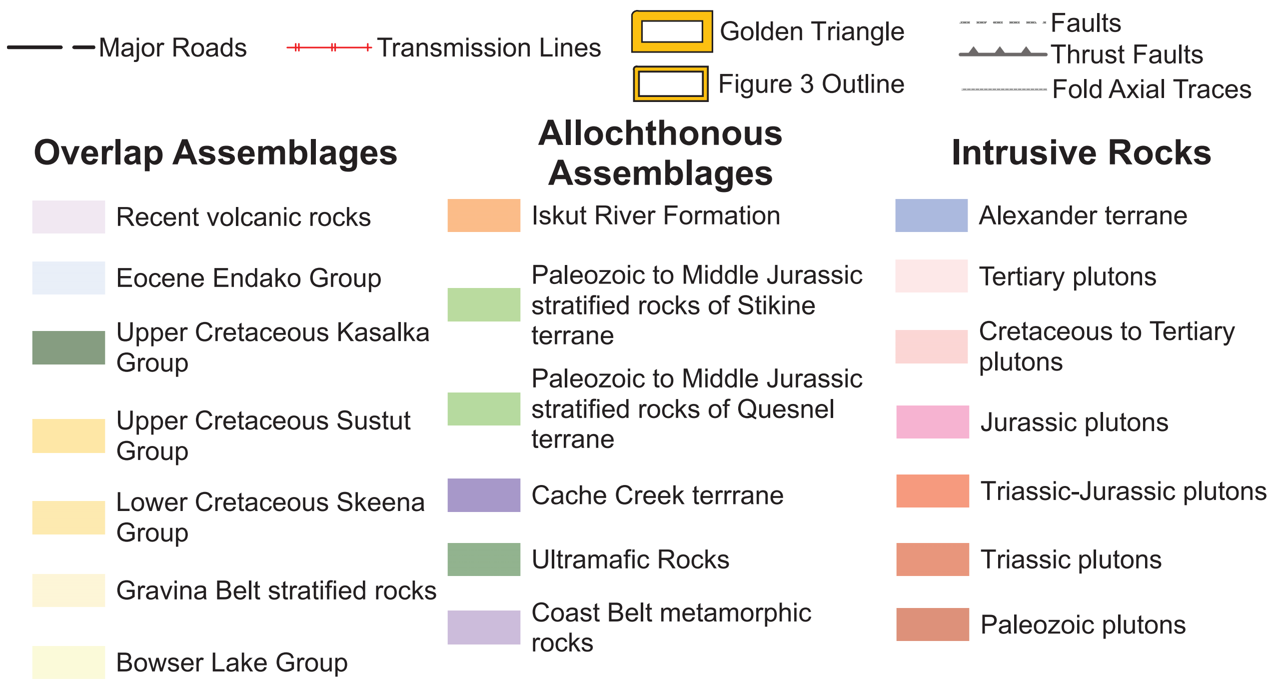

Fig. 2. Legend for Figure 1.

related to latest Triassic to earliest Jurassic monzonitic intrusive rocks (Tatogga suite), the property is underlain mainly by Upper Triassic and Lower Jurassic volcanosedimentary rocks of the Stuhini and Hazelton groups. The intrusive bodies and both of these supracrustal units are a focus of exploration, and the property provides an excellent locale to establish stratigraphic, structural, and temporal relationships of these rocks and their connections to mineralization. These relationships may mirror those across a key transitional interval in the tectonic and metallogenic history of northern Stikinia. Herein we report the results of mapping, drilling, and preliminary geochronologic studies of Triassic and Jurassic volcanosedimentary and allied intrusive rocks that host the mineral systems at the Tatogga property.

2. Geologic setting

Previous regional mapping in northern Stikinia, including in the northern Klastline Plateau where the Tatogga property lies (Figs. 3, 4) emphasized that Stuhini Group rocks are characterized by abundant pyroxene-bearing volcanic rocks (e.g., Souther, 1972; Ash et al., 1997a, b; Nelson et al., 2018). In the absence of age control, this characteristic, together with the presence of abundant marine sedimentary rocks, has helped to distinguish rocks assigned to the Stuhini Group (Upper Triassic) from those assigned to another island arc assemblage, the Hazelton Group, in which hornblende- feldspar-phyric volcanic rocks are considered characteristic. On this basis, most more recent previous work (e.g., Ash et al., 1997a; Miller and Smyth, 2015; Nelson et al., 2018) has shown much of the Klastline plateau and the southern part of the Tatogga property as being underlain by rocks in the lower part of the Hazelton Group, which Nelson et al. (2018) referred as the Klastline formation. However, regional pre-Hazelton Group contractional deformation (e.g., Greig, 2014) recognized in other parts of Stikinia, for example to the west near Telegraph Creek (e.g., Brown and Greig, 1990; Brown et al., 1996), to the south in the Sulphurets camp (Henderson et al., 1992), to the south and east at Oweegee dome (Greig, 1992; Greig and Evenchick, 1993) and in the Kinskuch Lake area south of Stewart (Greig, 1992; Miller et al., 2020) is also expressed in the Tatogga area, helping us distinguish between rocks of the Stuhini and Hazelton groups.

Upper Triassic and older rocks in the Iskut district are cut by latest Triassic to earliest Jurassic monzonitic intrusive rocks of the regionally developed Tatogga suite. On the Tatogga property they are part of a more extensive east-west trending mineralized magmatic belt that are referred to locally as the Saddle intrusions, with the porphyry copper-gold mineralization at Saddle North largely hosted by intrusive phases collectively known as the Saddle North intrusive complex. The belt of Saddle intrusions include intrusive rocks immediately to the west in the footwall of the Saddle South zone, farther westward at the adjacent Castle property, and possibly to the east at the North Rok property and the Red Chris mine, where intrusive rocks and mineralizing systems that are broadly coeval with those at Saddle are found (e.g., Rees et al., 2015; Zhu et al., 2018; Greig et al., 2021; Figs. 3, 4). Other nearby intrusive rocks in the Iskut district, including in the Edon and Todagin

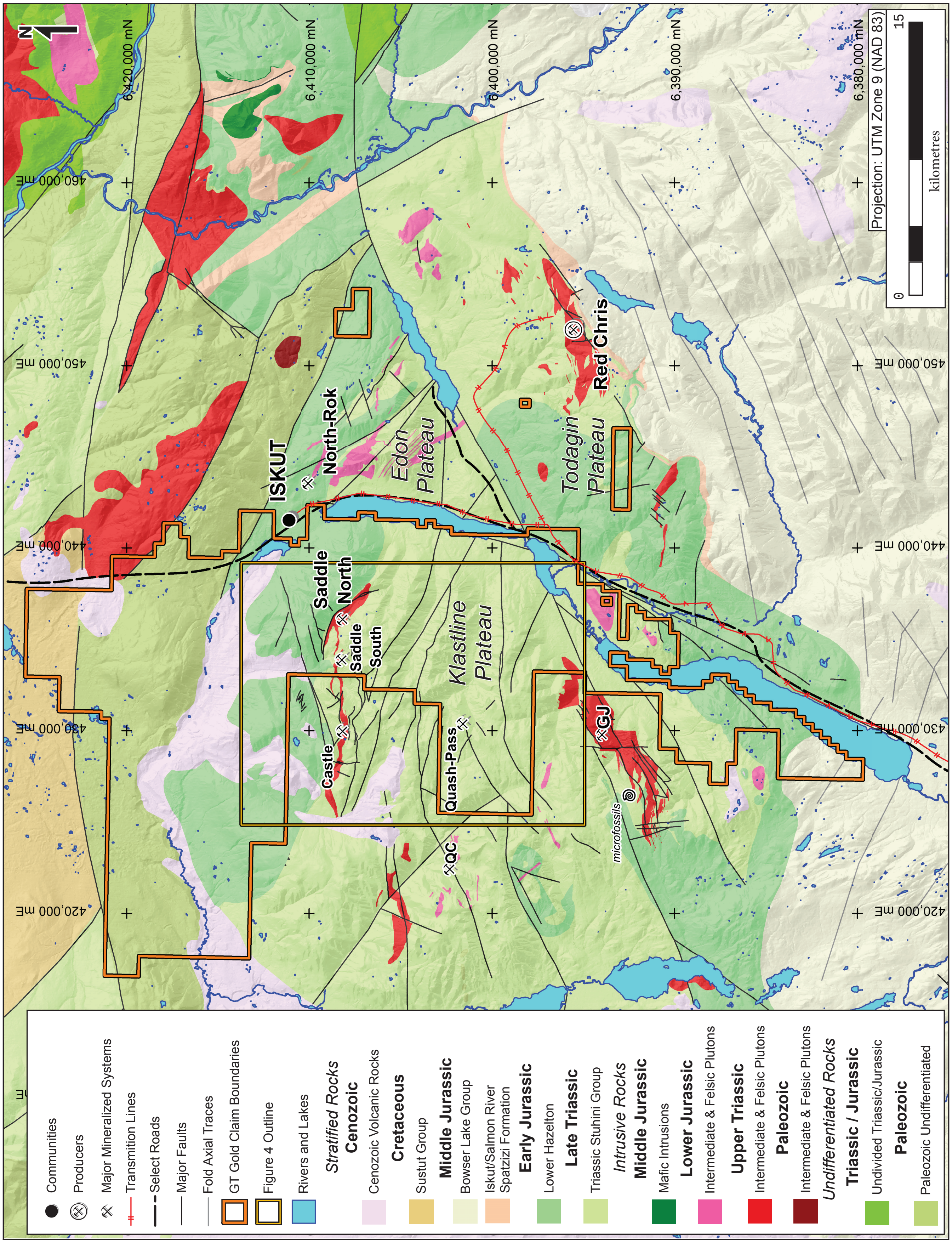

Fig. 3. Geology of the Klastline, Edon, and Todagin plateaus and Red-Chris mining camp, Iskut district.

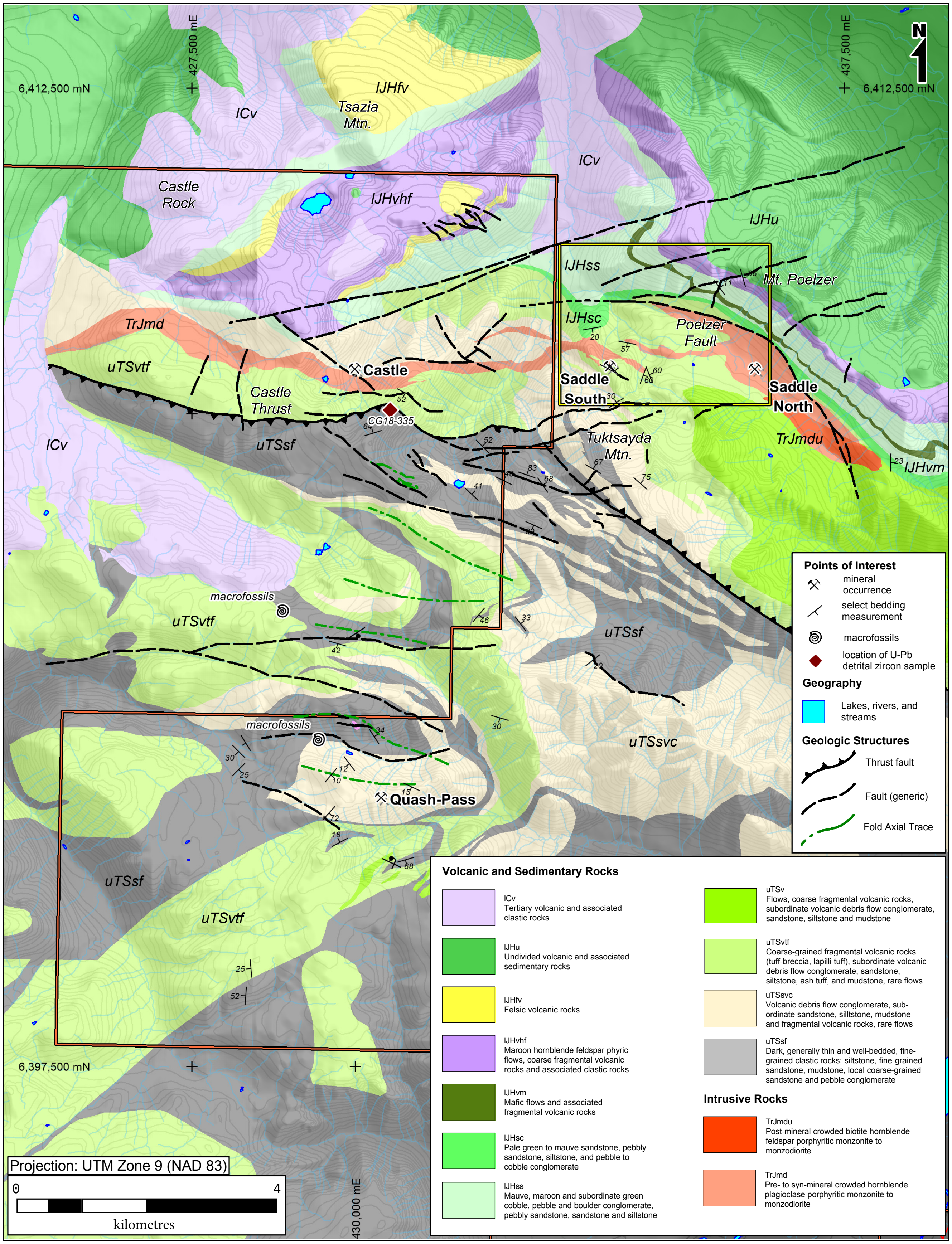

Fig. 4. Geology of the Tatogga property (geology west of northern Tatogga property after Oliver 2018).

plateaus to the north and east of the Klastline plateau, have been informally referred to as the Red suite, with individual bodies given local names, such as the Red stock (Rees et al., 2015), the Groat stock (e.g., Friedman and Ash, 1997), and the Castle stock (Bradford and Barresi, 2013). Although we favour the name Saddle intrusions, we also recognize the rationale behind, and the need for, a unifying and more regional name, such as Tatogga suite, as proposed by Nelson et al. (2018).

In the Iskut district, rocks in the upper part of the Hazelton Group commonly overlie the intrusions and their host rocks (e.g., Rees et al., 2015; Figs. 3-5). The upper Hazelton Group rocks are also commonly overlain by still younger rocks of the Bowser Lake Group (Middle Jurassic to mid-Cretaceous), or by Late Cenozoic volcanic rocks. In contrast to areas to the south, the structural grain in the region follows a more or less east-west trend (Figs. 3-5), aligned with the Skeena fold-thrust belt (mid-Cretaceous; Evenchick, 1991) and well displayed in Bowser Lake Group strata (Figs. 1-5).

3. Stratified rocks

3.1. Stuhini Group (Upper Triassic)

Much of the Klastline Plateau south of the Saddle zones is underlain by stratified Upper Triassic to (possibly) lowermost Jurassic rocks that we assign to the Stuhini Group (Fig. 4). New geochronological data from the area suggest that these rocks range from at least ca. 224 Ma (crystallization age) to ca. 206 Ma (maximum detrital zircon age; see section 5 below; Greig et al., 2021). Assignment to the Stuhini Group is supported by Upper Triassic (Ladinian?-Norian) marine macro- and micro-fossils found locally in rocks at the southern part of the property (Unit uTSsf below; Souther, 1972; Ash et al., 1996).

Based on predominant rock types, we divided Stuhini Group rocks into four units, which may be considered as facies assemblages (Figs. 4, 5): 1) unit uTSv, with poorly-stratified coarse-grained fragmental volcanic deposits and interbedded flows; 2) unit uTSvtf, with variably well-stratified pyroclastic rocks; 3) unit uTSsvc, with well-stratified pyroclastic rocks that are interbedded with epiclastic strata; and 4) unit uTSsf, with mainly epiclastic strata. We emphasize that lithotypes interfinger, repeating in time and space, and that each of these units contains strata that are indistinguishable from the main lithotypes of the other units.

3.1.1. Map units uTSv and uTSvtf

Units uTSv and uTSvtf are most common immediately south and southeast of the Saddle North deposit (Figs. 4-6). Unit uTSv includes volcanic flows (Figs. 7, 8), coarse fragmental volcanic rocks (Fig. 9) and subordinate volcanic conglomerate, sandstone, siltstone, and mudstone. Unit uTSvtf contains thickly stratified coarse-grained fragmental volcanic rocks including tuff-breccia and lapilli tuff (Figs. 9-11), subordinate volcanic conglomerate, sandstone, siltstone, ash tuff, and mudstone, and rare flows. As is common for the Stuhini Group throughout the property, both flows and fragments in tuffaceous and conglomeratic rocks are predominantly crowded hornblende- plagioclase feldspar-phyric trachyandesite or latite with abundant fine-grained plagioclase feldspar and rarely, potassium feldspar phenocrysts (Figs. 7, 11). Also present are local pyroxene and plagioclase- pyroxene-phyric flows (Fig. 8) and spatially associated pyroxene-bearing coarse fragmental rocks (Fig. 12). Rarely, pyroxene may occur with hornblende. Modal abundance estimates of sodium cobaltnitrate-stained hand samples (Figs. 7, 11, 12) confirm that the bulk of the rocks are trachyandesitic or latitic in composition.

Map unit uTSvtf consists mainly of poorly stratified coarse fragmental volcanic rocks such as tuff-breccia and ‘coarse’ (average fragment >10 cm) lapilli tuff (Fig. 7). Also abundant are ‘medium’ (average fragment >3 <10 cm) lapilli tuff (Fig. 10), and weakly stratified, poorly sorted boulder-cobble conglomerate. Less common are ‘fine’ (average fragment <3 cm) lapilli tuff (Fig. 12), ash tuff, pebble conglomerate, sandstone, siltstone and mudstone; flows are also present locally. As with map unit uTSv, fragments in the tuffaceous rocks, clasts in the conglomerate, and the local flows consist predominantly of crowded hornblende- feldspar-phyric trachyandesite containing fine-grained plagioclase feldspar phenocrysts, and fine- to medium-grained hornblende phenocrysts. Also present are rare pyroxene-phyric flows and pyroxene-phyric coarse-grained fragmental rocks. These rock types may also be found locally as clasts in the tuffaceous and conglomeratic rocks.

3.1.2. Map units uTSsvc and uTSsf

Map units uTSsvc and uTSsf have a greater proportion of epiclastic rocks and are typically better stratified than units uTSv and uTSvtf (Fig. 13). Unit uTSsvc consists of conglomerate (Figs. 14, 15), subordinate sandstone (Fig. 15), siltstone, mudstone (Fig. 16), trachyandesitic or latitic fragmental volcanic rocks, and rare trachyandesite or latite flows. Unit uTSsf consists mainly of generally dark, interstratified siliciclastic rocks, including fine-grained sandstone, siltstone, mudstone (Figs. 16-19), with local ash tuff, fine lapilli tuff, coarse-grained sandstone and pebble conglomerate. Pebble conglomerates and sandstones generally lack internal stratification but are arranged in repeated sharp-based fining-upward sequences (Fig. 15). Metre-scale dark grey, locally fossiliferous micritic limestone lenses are relatively common throughout. Clasts in units uTSsvc and uTSsf are similar in composition to the fragments in units uTSv and uTSvtf, consisting almost exclusively of hornblende-feldspar-phyric trachyandesite or latite with crowded fine-grained plagioclase and subordinate fine- to medium-grained hornblende phenocrysts (e.g., Fig. 14).

3.1.3. Distribution and geometry

The rocks of units uTSv and uTSvtf are most abundant in the northern part of the Tatogga property where they are commonly propylitically (chlorite-epidote)- and (or) iron carbonate-altered. Together they form a northwest-trending belt hosting the mineralized zones at Saddle North and Saddle South. They also appear to be common northeast of the Quash-Pass area

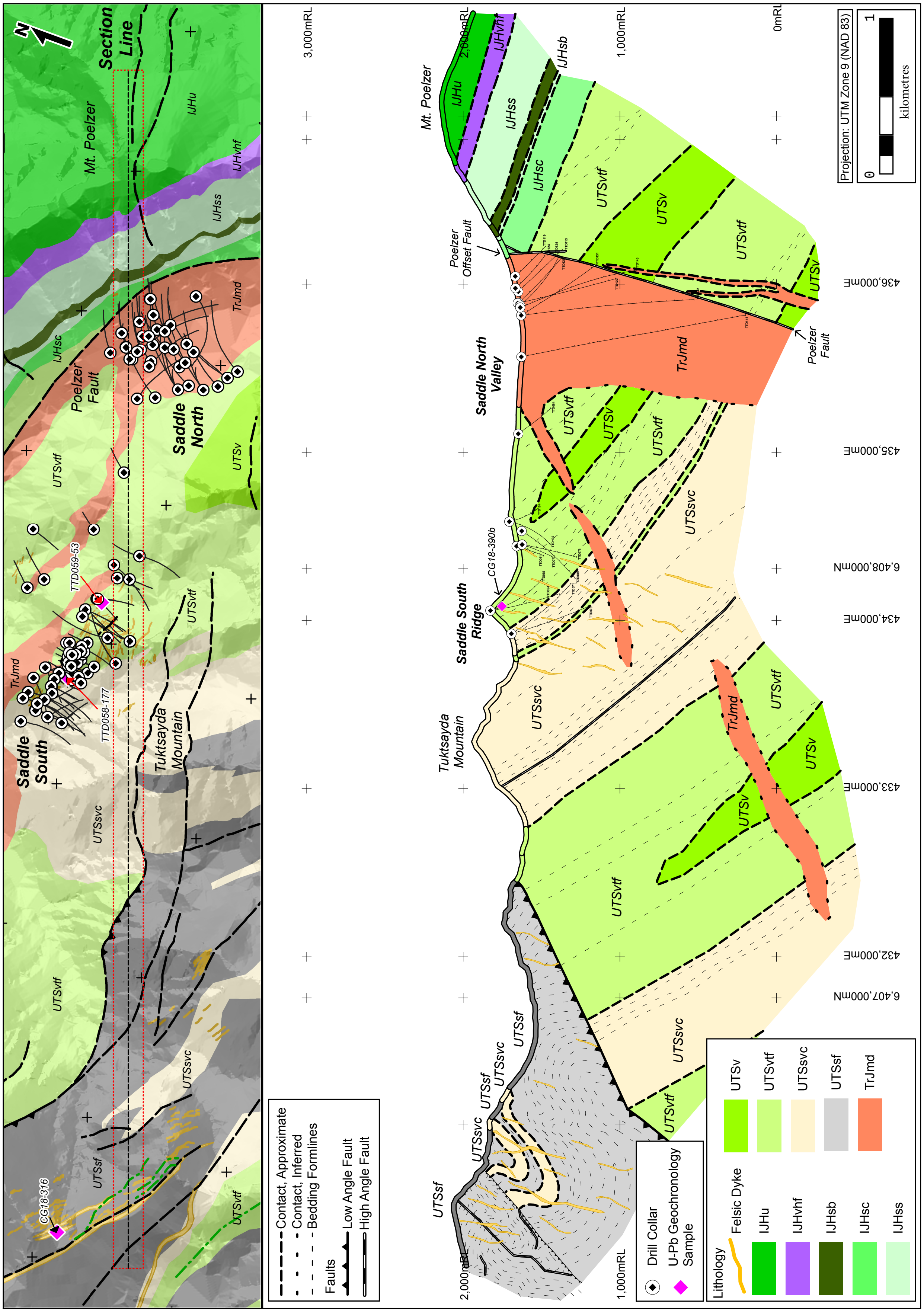

Fig. 5. Schematic cross section across the Saddle North and South mineralized zones and northern part of the Tatogga property.

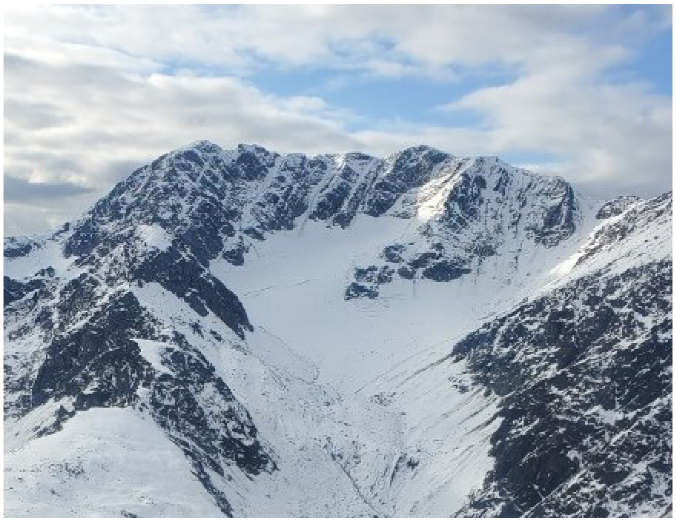

Fig. 6. View south-southeast along and up Saddle South ridge (left) toward Tuktsayda Mountain, showing northeast-dipping thickly stratified Stuhini Group fragmental volcanic rocks (unit uTSvtf).

Fig. 7. Stuhini Group, map unit UTSv. Crowded hornblende-feldspar-phyric trachyandesite flow, ~1.7 km southeast of Saddle North. Top stained with sodium cobaltnitrate for potassium feldspar.

Fig. 8. Stuhini Group map unit uTSv. Pyroxene- and feldspar-phyric basaltic trachyandesite or trachybasalt flow, ~700 m south of Saddle North.

Fig. 9. Stuhini Group, map unit uTSv. Medium- to coarse-trachyandesite lapilli tuff (upper) and block tuff (lower), Saddle South area.

(Fig. 4). Although not well stratified and lacking obvious tops indicators, on the central and the eastern part of the property the thick bedded and crudely stratified rocks of units uTSv and uTSvtf appear to define a moderately to steeply northeast dipping homocline that youngs to the northeast (Figs. 4, 5). To the southwest the coarse tuffaceous rocks are concordant with well-bedded uTSsvc and uTSsf rocks. Farther west, the rocks of units uTSsvc and uTSsf are commonly well folded and faulted (see section 6 below).

3.1.4. Environmental interpretation

As is typical of many volcanosedimentary sequences, Stuhini Group rocks in the Saddle area record the interplay of volcanism, erosion, and sedimentation repeated in time and space. Some of the coarser deposits of unit uTSv may represent a vent-proximal facies, whereas sandstones and pebble conglomerates are interpreted to represent turbiditic beds. The fossils in unit uTSsf (Souther, 1972; Ash et al., 1996; Figs. 3, 4) indicate marine sedimentation in part, and the near-ubiquitous dark colours of epiclastic facies may imply relatively deep (anoxic) waters. However, rare fragmental volcanic and coarse siliciclastic rocks with red clasts and matrix, such as at immediately southwest of Mt. Tuktsayda, might suggest sedimentation in an oxidizing environment and that shallow-marine conditions prevailed locally.

3.2. Hazelton Group (Lower Jurassic)

A distinctive well-layered volcanosedimentary sequence is exposed north of the Saddle area between Mount Poelzer and Tsazia Mountain (Figs. 4, 5 and 20); it also outcrops on the northern end of Saddle South ridge. Following Ash et al. (1997a, b) we assign these rocks to the Hazelton Group. With

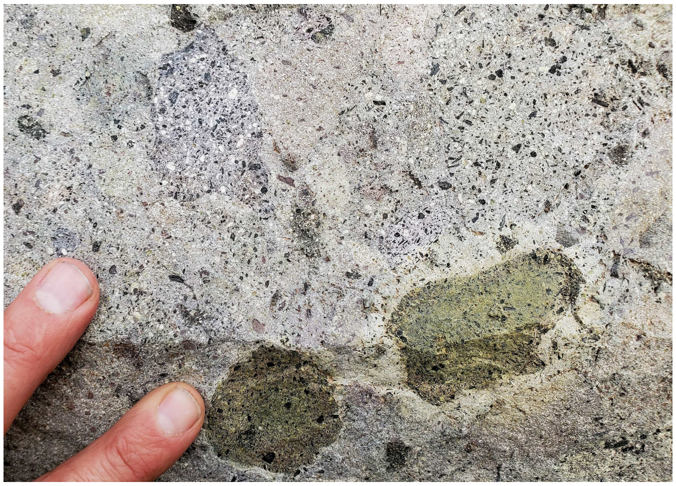

Fig. 10. Stuhini Group, map unit uTSvtf. Medium lapilli tuff with hornblende-feldspar-phyric fragments and pyroxene-phyric fragments (green) in pale weathering groundmass, ~900 m west-southwest of Saddle North and 450 m east-southeast of Saddle South.

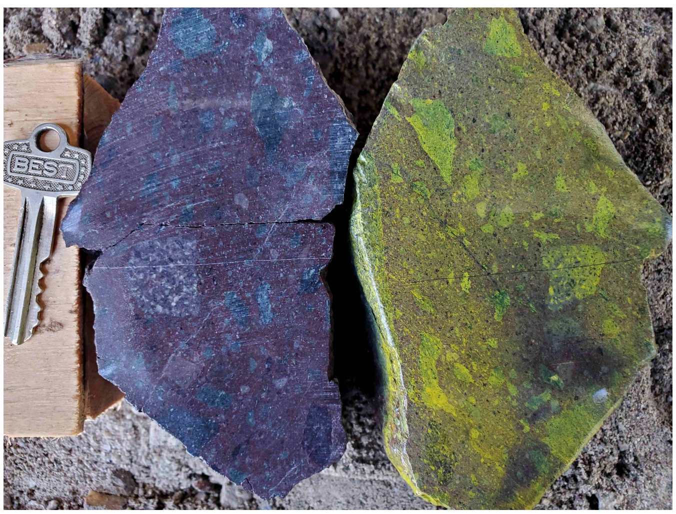

Fig. 11. Stuhini Group, map unit uTSvtf. Maroon and green trachyandesitic lapilli tuff (right stained with sodium cobaltnitrate for potassium feldspar); note relatively potassium feldspar-rich fragments, and possible monzonitic intrusive rock fragment (slightly coarser-grained), ~175 m north of Saddle South zone.

maroon to mauve and pale green colours, the rocks in this gently north-dipping sequence contrast sharply with the darker moderately to steeply south-dipping Stuhini Group rocks to the south suggesting an angular discordance between the two (see Fig. 5 and section 6 below). The contact is not observed at surface because it is faulted (note “Poelzer offset” fault, Fig. 5) and largely drift-covered, but the presence of an angular discordance is supported by the presence of common Stuhini Group cobbles and boulders, by pebbles and cobbles of altered rock and quartz (Fig. 21), plus an abundance of Late Triassic detrital zircon grains in basal sandstones (George et al., 2021).

Although we did not map in detail, and although the contact itself was not observed, we traversed through this section along gullies extending from the Saddle area toward the northwest-trending ridge that underlies Mount Poelzer (Figs. 5, 6). There the general character and a number of common rock types from the lower part of the sequence appear to have reasonable

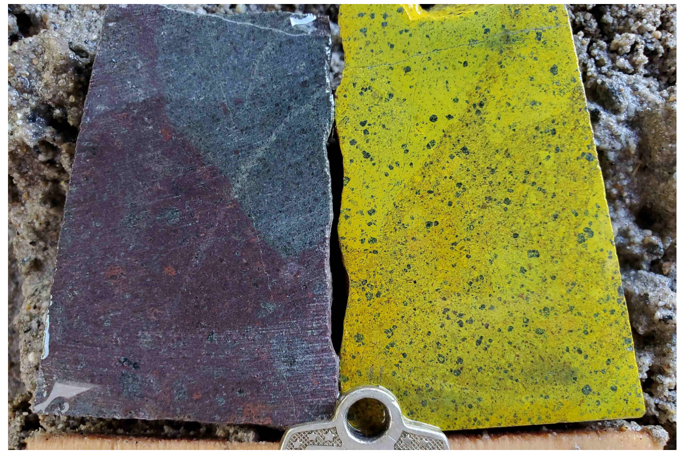

Fig. 12. Stuhini Group, map unit uTSv. Maroon and green pyroxene- and feldspar-phyric basaltic trachyandesite lapilli tuff (right stained with sodium cobaltnitrate for potassium feldspar; note slight difference in potassium feldspar content between fragments and matrix), ~2 km south of Saddle North deposit.

Fig. 13. View to the south-southeast, looking approximately down dip at gently southeasterly dipping moderately well-stratified Stuhini Group rocks of map units uTSsvc and uTSsf, on south side of valley, Quash-Pass area (see Figure 4 for location).

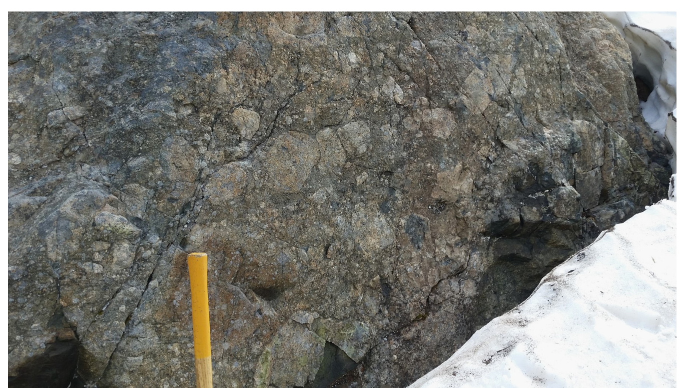

Fig. 14. Stuhini Group, map unit uTSsvc. Clast-supported boulder conglomerate or pyroclastic breccia with angular fragments of moderately crowded hornblende- and feldspar phyric trachyandesite, with carbonate cement.

Fig. 15. Stuhini Group, map unit uTSsvc. View south-southeast of moderately northeast-dipping dark grey, slightly rusty-weathering medium- to thick-bedded well-stratified and moderately well-sorted pebble conglomerate, above interbedded sandstone, siltstone and mudstone arranged in sharp-based Bouma-like fining upward sequences, ~1.5 km southwest of Saddle South.

Fig. 16. Stuhini Group; on right, well-bedded black mudstone (map unit uTSsf) possibly faulted against lapilli tuff on left; view to the northeast, immediately west of Tatogga property boundary, southwest of Saddle area.

Fig. 17. Stuhini Group, map unit uTSsf. View to the east of fine-grained sandstones and mudstones arranged in sharp-based Bouma-like fining upward sequences and containing a steeply south-southwest dipping spaced cleavage. About 1.6 km southwest of Saddle South, immediately west of Tatogga property boundary.

along-strike continuity, given the generally well-stratified nature of the package at all scales (Fig. 21) and evident in their aeromagnetic signature and grain, which parallels their strike (Miller and Smythe, 2015). Typically maroon pebble, cobble, and rare boulder conglomerates with local well-rounded clasts (Figs. 21, 22) are particularly abundant at the base of the section on the southwest side of the creek that drains the area of the Saddle North deposit near the lower, northern end of Saddle South ridge (unit lJHsc, Fig. 4). Significantly, the conglomerates bear very common clasts that appear to have been derived from subjacent and distinctive Stuhini Group, including finely feldspar- and hornblende-phyric rocks, and less common clasts displaying a pervasive internal alteration similar to that found in Stuhini Group rocks hosting the Saddle area mineralized zones.

The overlying unit (lJHss) appears to be largely sedimentary and includes conglomerate, pale grey-green sandstone, siltstone, and mauve to maroon, commonly pebbly, mudstone. A sample of sandstone from this part of the section yielded a maximum depositional age of slightly younger than 190 Ma (George et al., 2021), supporting the Hazelton Group assignment. Farther upsection, on the southwest-facing slopes of Mount Poelzer, a rare layer of concretion-bearing pale green lapilli tuff is interbedded with the sedimentary rocks. Still farther upsection is a 5-10 m thick interval with limey pods and limestone layers

Fig. 18. Stuhini Group, map unit uTSsf. Sandstone, siltstone and silty mudstone, top stained with sodium cobaltnitrate for potassium feldspar; note that even fine-grained siliciclastic rocks are rich in potassium feldspar. Possible bioturbation structures on right side of specimen. Quash Pass area, southern Tatogga property.

Fig. 19. Stuhini Group, map unit uTSsf. Thinly bedded and fine-grained ash tuff and tuffaceous siltstone and sandstone. Bottom stained with sodium cobaltnitrate for potassium feldspar; many ash layers have abundant potassium feldspar. Quash Pass area, southern Tatogga property.

interbedded with laminated black siliceous mudstone and rusty weathering sandstone (Fig. 23). Also within the Hazelton Group in this area is a resistant, strongly magnetic unit of what appears to be a mafic lithology (unit lJHvm; Figs. 4, 5). It may be a finely feldspar-phyric mafic flow or, alternatively, a sill that has hornfelsed its siliciclastic wallrocks.

Overlying this largely sedimentary sequence is a section of dark purple hornblende- feldspar-rich volcanic rocks (unit lJHvhf). Most abundant are coarse fragmental volcanic rocks, tuff-breccia, and coarse lapilli tuff that interfinger with local massive flows of similar andesitic or trachyandesitic composition. Phenocrysts in these rocks include hornblende (and pyroxene?) along with distinctive medium-grained

Fig. 20. Hazelton Group. View west from western slopes of Mount Poelzer of gently northwesterly dipping Hazelton Group rocks underlying ridge immediately west of Tsazia Mtn. (see Figure 4), along northern parts of Tatogga and neighbouring Castle property.

Fig. 21. Hazelton Group, unit lJHsc. Maroon pebble conglomerate with quartz pebbles (e.g., near tip of scriber) and variably rounded and poorly sorted clasts, near Mount Poelzer, north of Saddle North deposit.

Fig. 22. Hazelton Group, unit lJHsc. Polymictic pebble conglomerate with abundant red mudstone clasts, stained with sodium cobaltnitrate for potassium feldspar, northern end of Saddle South ridge.

Fig. 23. Hazelton Group. Local limestone beds on slopes of Mount Poelzer, showing interlayering of relatively resistant cherty (orange) and recessive limestone (grey) components, north of Saddle North deposit.

tabular-blocky feldspars that locally display glomeroporphyritic textures. The volcanic rocks are overlain by maroon fine-grained mudstone to siltstone. Still farther upsection, near the top of the ridge that underlies Mount Poelzer, a variety of rock types are exposed, including maroon mudstone, quartz-eye feldspar porphyry felsic dikes and dark mafic volcanic rocks, but neither previous workers (e.g., Miller and Smyth, 2015; Ash et al., 1997a) nor the present authors have mapped these rocks in enough detail.

3.3. Late Cenozoic volcanic rocks

Late Cenozoic volcanic rocks (unit lCv) locally overlie both Stuhini and Hazelton groups. These rocks likely correlate with those of the Mt. Edziza volcanic complex to the west, which range in age from about 11 Ma to several hundred thousand years B.P. (Souther, 1992). In the immediate vicinity of the Tatogga property, they occur either at elevation, such as to the west at the Castle property (Fig. 4), or in valley bottoms, such as along the upper parts of the Klastline River valley, immediately north of and downstream from the Saddle area.

Although these Late Cenozoic volcanic rocks were not the focus of our mapping, local outcrops were noted from the air in the valley of the Klastline River valley near where Ash et al. (1997a) documented several small outcrops. The Cenozoic units were also mapped in abundance farther down the Klastline River valley by Souther (1972). In addition, a strong magnetic signature with a distinctive flow-like texture is apparent on regional and property-scale aeromagnetic maps, particularly of the upper Klastline River valley. The magnetic signatures and their valley-parallel grain suggest valley filling mafic flows. The magnetic signature may indicate a volcanic vent not far downstream from the northern end of Saddle South ridge. The occurrence of the Late Cenozoic volcanic rocks both low in the valley bottoms and at much higher elevations such as along ridgetops on the Castle property suggests eruption onto a paleotopographic surface not unlike the present one.

4. Intrusive rocks

Numerous suites of intrusive rocks, most of which roughly follow east-west trends, cut stratified rocks at the Tatogga property. These include latest Triassic to earliest Jurassic monzonitic to monzodioritic rocks of the Tatogga suite, referred to herein as the Saddle intrusions and the Saddle North intrusive complex (units TrJmd and TrJmdu). At Saddle North, these rocks are closely associated, spatially and genetically, with porphyry copper-gold mineralization. Similarly, at Quash-Pass 6-7 km to the south, local monzonitic to dioritic rocks are associated spatially with alteration and local base- and precious metal-bearing veins. However, at Saddle South these rocks post-date precious metals mineralization. There, the monzonitic rocks occur in the immediate footwall of the steeply south-dipping mineralized zone and although they intrude the host Stuhini Group tuffaceous rocks, they do not host Saddle South-style gold- and silver-mineralized quartz-carbonate-pyrite veins, nor are they overlain by appreciable gold-in-soil geochemical anomalies which characterize the Saddle South zone at surface immediately to the south, and the westward projection of the Saddle North trend which lies not far to the north. Younger east-west trending dikes of felsic, intermediate, and mafic composition crosscut mineralization and the monzonitic rocks. These dikes are relatively abundant at Saddle South where crosscutting relationships indicate a generalized order of intrusion from felsic to intermediate to mafic. Several felsic dikes and one intermediate dike yield U-Pb zircon ages ranging from 187 to 182 Ma (Early Jurassic; see section 5 below; Greig et al., 2021), although some of the mafic dikes could be significantly younger given the regional abundance of Late Cenozoic volcanic rocks.

4.1. Late Triassic to Early Jurassic intrusive rocks (map units TrJmd and TrJmdu, Saddle intrusions, Tatogga intrusive suite)

In the Saddle area, stratified Upper Triassic rocks have been intruded by latest Triassic or earliest Jurassic porphyritic monzonitic and/or monzodioritic rocks with U-Pb zircon ages ranging from ca. 206 to 202 Ma (see section 5 below). These rocks are typified by the crowded fine-grained hornblende and plagioclase feldspar phenocrysts surrounded by a groundmass with potassium feldspar and minimal free quartz (Figs. 24-27). Particularly where altered, distinguishing these hypabyssal intrusive bodies from some Stuhini Group flows can be difficult. A notable feature of the intrusive rocks is the variation in the habit of amphibole, which forms either medium- to fine-grained blades or anhedral crystals that are intergrown with potassium feldspar in the groundmass of rocks crowded with fine-grained

Fig. 24. Saddle intrusion (Tatogga suite, unit TrJmd). Late Triassic to Early Jurassic hornblende monzodiorite porphyry bearing a few percent cognate mafic inclusions, including rectangular inclusion above finger, toward northern end of Saddle South ridge.

Fig. 25. Saddle intrusion CAP porphyry' (Tatogga suite, unit TrJmd). Well-foliated moderately quartz-sericite-pyrite altered, east side of Saddle South ridge.

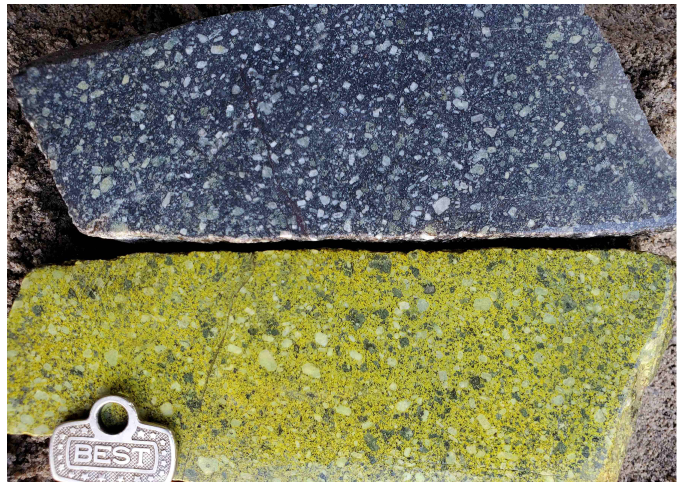

Fig. 26. Saddle intrusion (Tatogga suite, unit TrJmd). Fine-grained moderately altered monzonite porphyry. Hornblende (commonly epidote altered), potassium feldspar (largely in groundmass), and variably sericitized plagioclase, which is commonly pale yellow. On bottom, slab stained with sodium cobaltnitrate for potassium feldspar). From near the northern plutonic contact of monzonitic rocks that forms the northern boundary of the Saddle South mineralized zone.

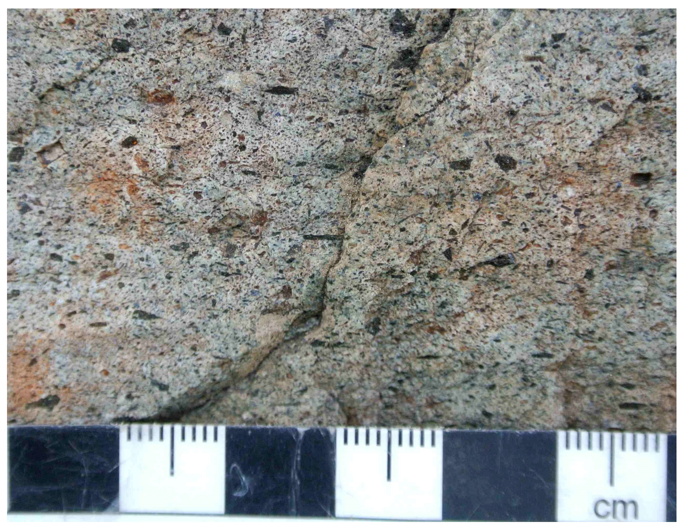

Fig. 27. Saddle intrusion (Tatogga suite, unit TrJmd). Crowded hornblende-pyroxene-plagioclase monzonite or monzodiorite porphyry with medium-grained epidote(?)- and leucoxene- altered mafic minerals and variably sericite altered plagioclase feldspar in a groundmass of very fine-grained potassium feldspar. Bottom slab stained with sodium cobaltnitrate for potassium feldspar). North of Saddle South mineralized zone.

euhedral plagioclase feldspar phenocrysts. Magnetite is a common accessory mineral in monzonitic and monzodioritc rocks, both in relatively unaltered variants and in more altered equivalents, such as in the core of the Saddle North mineralized system, where it occurs in veins, as replacements of amphibole and, presumably, as partly sulphide-replaced primary grains.

The most common lithology of this unit in the Saddle area is crowded fine-grained hornblende monzonite porphyry. The rocks are typically dark, although relatively fresh surfaces may be medium to dark grey; they at least locally host up to a few percent or more of cognate somewhat more mafic-rich inclusions (Fig. 24). Systematic sodium cobaltnitrate staining of samples reveals that the three main component rock-forming minerals (potassium feldspar, plagioclase, and hornblende) vary significantly in relative abundance and grain size (Figs. 25, 26). Variably overprinting styles of alteration may increase the variation in appearance and may emphasize the presence of mafic phenocrysts (Fig. 27). In more altered rocks, plagioclase feldspar is commonly sericite-altered and in stained slabs plagioclase feldspar generally takes on a pale yellow colour, likely reflecting the presence of the sericite (Fig. 26). Well-foliated varieties of the porphyritic rocks, such as the "CAP" porphyry common to the immediate footwall to north of the mineralized zone at Saddle South, and so-named in the field because of its conspicuous medium- and rarely coarse-grained amphibole, is typically quartz-sericite-pyrite altered (Fig. 27, part of map unit TrJmdu). A short distance farther north and downslope from the CAP porphyry, the Saddle intrusions exposed in the cliffs immediately north of the Saddle

South zone are generally dark and fine grained. The dark tone largely appears to represent very fine-grained mafic minerals (principally amphibole), and probably magnetite, intergrown with potassium feldspar in the groundmass to the abundant fine-grained plagioclase feldspar phenocrysts. Fine-grained potassium feldspar phenocrysts may be locally abundant; rarely, potassium feldspar forms megacrysts.

At Saddle North, the exact limits of the monzonitic intrusive rocks at surface remain to be fully defined. This is largely due to the limited exposure beneath a thick cover of colluvium and till, which typically ranges from a few m to at least 25 m thick. However, the intrusion is locally well exposed, such as in the cliffs immediately north of the Saddle South mineralized zone and in the creek draining west-northwest from the Saddle North deposit area (Figs. 4, 5). Along with abundant drill intersections at Saddle North and with local drill intersections between there and Saddle South, it is clear that the monzonitic rocks coincide with an easterly linear airborne magnetic high. This suggests that they are all part of an overall east-west trending intrusive system that continues into the well-exposed intrusive trend on the Castle property to the west (Fig. 4).

4.2. Early Jurassic and younger dikes

Multiple generations of m-scale, mafic to felsic dikes cut Stuhini Group stratified rocks. Most conspicuous are pale-weathering felsic dikes that occur at Saddle South and to the south and southwest and are readily visible cutting Stuhini Group rocks in cliff outcrops (Fig. 28). U-Pb zircon ages from four of these dikes range from ca. 186 to 182 Ma (see section 5 below). Although the dikes commonly take dog-leg bends, with abrupt changes in width from as much as 10 m to as little as 0.5 m within a few m, the dikes clearly follow general west-northwest trends (Fig. 5). Dike-wall parallel flow foliation is common, particularly along contacts with country rocks. Lithophysae are commonly aligned with flow-layering and flow-folding is locally well displayed. Systematic staining and a general lack of abundant quartz phenocrysts suggests the dikes are trachydacites or high-K rhyodacites. They range from aphyric, to potassium feldspar-phyric to sparsely hornblende- plagioclase feldspar-phyric. Locally the dikes are cut by abundant veins of different compositions, including quartz, calcite and iron carbonate, but systematic geochemical sampling of the dikes at Saddle South reveals that they do not host precious metals. Although the altered and mineralized country rocks may bear a well-developed foliation, the dikes themselves typically only display a spaced or fracture cleavage.

Several suites of darker intermediate to mafic dikes commonly cut the felsic dikes. In contrast to their felsic counterparts the mafic and intermediate dikes typically have more planar contacts and may be more continuous. Only one intermediate dike, of trachyandesitic composition, has been dated and it returned a 185 Ma U-Pb zircon age that is essentially coeval with those of the felsic dikes (see section 5 below). However, contact relationships observed in drill core suggest that in general the felsic dikes are the oldest and that most of the obviously mafic dikes (very dark green, as opposed to more obviously feldspar-rich varieties of intermediate composition) are the youngest.

The intermediate dikes may contain abundant and typically aligned feldspar microlites, in a felted or trachytic texture.

Fig. 28. View southeast showing steeply dipping light-toned Early Jurassic felsic dikes (~185 Ma) cutting generally more gently dipping, but folded, dark-toned well-stratified Upper Triassic fine-grained sedimentary rocks of the Stuhini Group (unit uTSsf). Immediately west of northern Tatogga property; helicopter upper left for scale.

The most notable of these, the informally named “DMcg” (Dike, Mafic, coarse-grained) suite at Saddle South, somewhat resembles the older Saddle intrusions. They are generally strongly magnetic and are coarse grained only relative to other intermediate to mafic dikes on the property, which are commonly aphyric to very fine grained. The most recognizable phenocrysts in the DMcg dikes are fine- to medium-grained plagioclase feldspar laths that are commonly aligned to form a trachytic fabric, much like their finer grained counterparts. Other characteristics that help distinguish the DMcg suite in the field are the very common presence of chlorite-quartz(?)-epidote veins and a propylitic alteration assemblage (minor pyrite, very common chlorite and epidote after mafic minerals). In contrast, similar veins and alteration are generally lacking in adjacent mafic dikes.

Contact relationships suggest that most of the obviously mafic dikes (very dark green, as opposed to more obviously feldspar-rich varieties of intermediate composition) are the youngest. Like the felsic dikes, both the mafic and intermediate dikes may host numerous veinlets (most commonly calcite), but few host veins containing base or precious metals. Given the abundance of nearby Late Cenozoic volcanic rocks, including the edifice at Mt. Edziza and a probable vent approximately 2 km north of Saddle South, some of the mafic dikes are conceivably Late Cenozoic.

5. Geochronology

The primary goal of our geochronology program was to establish the timing of mineralization at the Tatogga property. Our approach was both direct, by using Re-Os molybdenum geochronology on mineralized veins (three samples) and indirect, using U-Pb zircon geochronology to determine crystallization ages of interpreted mineralizing intrusions, and crystallization and maximum depositional ages of mineralized and non-mineralized wallrocks and country rocks (18 samples). The Re-Os ages were determined under contract with ALS-Global laboratories, via the University of Alberta geochronology laboratory. Molybdenite separates were analyzed by isotope dilution mass spectrometry using Carius-tube, solvent extraction, anion chromatography and negative thermal ionization mass spectrometry techniques (Selby and Creaser, 2004). The U-Pb zircon geochronology was undertaken at the Arizona Laserchron Center, Department of Geosciences, University of Arizona using laser ablation multicollector inductively coupled mass spectrometry (LA-ICPMS; Gehrels et al., 2008). Below we only summarize this work; full details are presented in Greig et al. (2021).

5.1. Stuhini Group

Three samples of stratified rocks from the Stuhini Group were dated. Two were collected from host hornblende-feldspar-phyric volcanic rocks intersected in drill core at the Saddle South mineralized zone (Fig. 5), and one was a detrital zircon sample collected from sandstone from unit uTSsf, approximately three kilometres west of the property boundary, on the adjacent Castle property (Fig. 4). All three samples yielded Late Triassic ages.

Sample TTD058-177m, with a crystallization age of 224.01 ±1.1 Ma, 2σ (Fig. 29), was collected from a section of coherent grey to maroon hornblende- feldspar-phyric coherent rocks

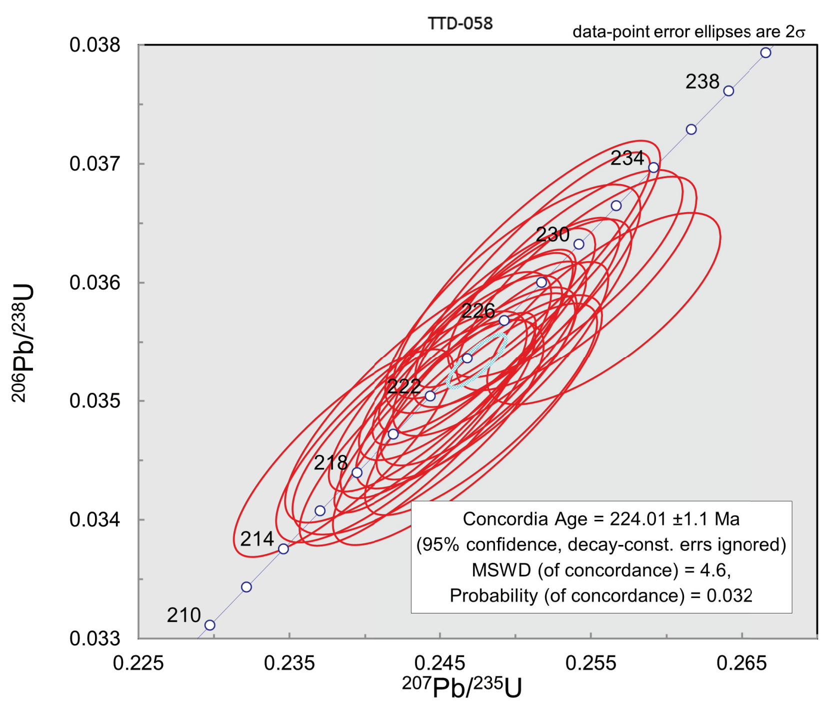

Fig. 29. Concordia diagram for sample TTD058-177m, Stuhini Group, unit uTSvtf, hornblende-feldspar-phyric flow, Saddle South mineralized zone.

within map unit uTSvtf. It is interpreted to be a flow, and is interlayered with tuff containing monomictic fragments that are lithologically indistinguishable from the flow. Sample TTD059-53m yielded an age of 220.3 ±2.0 Ma and was collected from a single decimetre-scale block in a hornblende- feldspar-phyric trachyandesite block tuff to the east of and upsection from TTD058-177m. The detrital zircon sample, CG18-335, was collected from a fine- to medium-grained sandstone turbiditic bed well to the west of the Saddle South mineralized zone, not far west of the western boundary of the Tatogga property (Fig. 4). The interpreted maximum depositional age of 205.9 ±2.1 Ma (Fig. 30) is based on a total of 315 analyses using 20 micron diameter laser spots.

These Late Triassic ages agree with macrofossil (Souther, 1972; Fig. 4) and microfossil (Ash et al., 1996; Fig. 3) ages reported for the Stuhini Group from elsewhere on the Tatogga property. In addition, George et al. (2021) reported Late Triassic maximum depositional ages of 206 Ma and 205 Ma for samples of sandstone collected from two locations to the southeast of the Saddle area.

5.2. Saddle intrusions and Saddle North intrusive complex (Tatogga intrusive suite)

We analyzed six samples from various phases of the Saddle North intrusive complex, three samples from rocks in the footwall of the Saddle South mineralized zone, and one sample from an intrusion intersected in a diamond-drill hole approximately midway between the Saddle North deposit and the mineralized zone at Saddle South. All of the samples were altered and/or mineralized to varying degrees by porphyry-style alteration and/or vein assemblages. U-Pb zircon ages for the Saddle intrusions range from 206.2 ±1.8 Ma for the interpreted oldest phase at the Saddle North deposit, to as young as 202.0 ±1.5 Ma for the sample collected from the drill hole midway between Saddle North and the Saddle South zone.

5.3. Early Jurassic and younger dikes

We obtained a U-Pb zircon age of 185 ±1.6 Ma from a fine-grained intermediate composition trachyandesite dike intruding monzodiorite of the Saddle intrusions. This dike contains abundant very fine-grained lath-like plagioclase feldspar with a notable trachytic fabric and was collected from near the base of the cliffs immediately north of the Saddle South mineralized zone. We also obtained ages from four felsic dikes ranging from 186.53 ±0.78 Ma, 2σ (sample CG18-316; Fig. 31) to 182.35 ±1.6 Ma. Similar ages are reported by George et al. (2021) for felsic dikes that intrude rocks in the upper part of the Hazelton Group west-northwest of Mount Poelzer. In contrast to the typical pale- or tan-weathering aphyric to feldspar phyric felsic dikes dated in the present study, the dikes dated by George et al. (2021) weather to shades of pink and commonly contain medium- to coarse-grained quartz eyes, which are notably absent in the dikes we dated.

5.4. Direct Re-Os molybdenite dating of mineralization

Three samples were collected from veins at the Saddle North deposit for Re-Os dating of molybdenite. Two of the samples yielded ages closely approximating the age of the host Saddle intrusions at 204.2 ±0.9 Ma and 204.6 ±0.9 Ma, while the other returned a significantly older age of 207.8 ±0.9 Ma. All

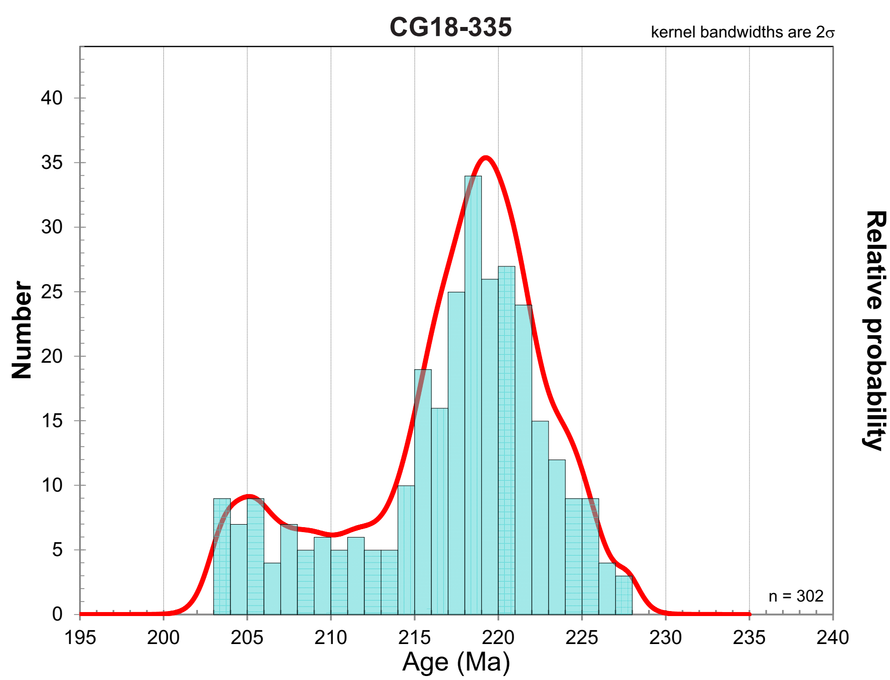

Fig. 30. Probability density plot for detrital zircon sample CG18-335, Stuhini Group, unit uTSsf, sandstone, approximately 3 km west-southwest of the Saddle South mineralized zone.

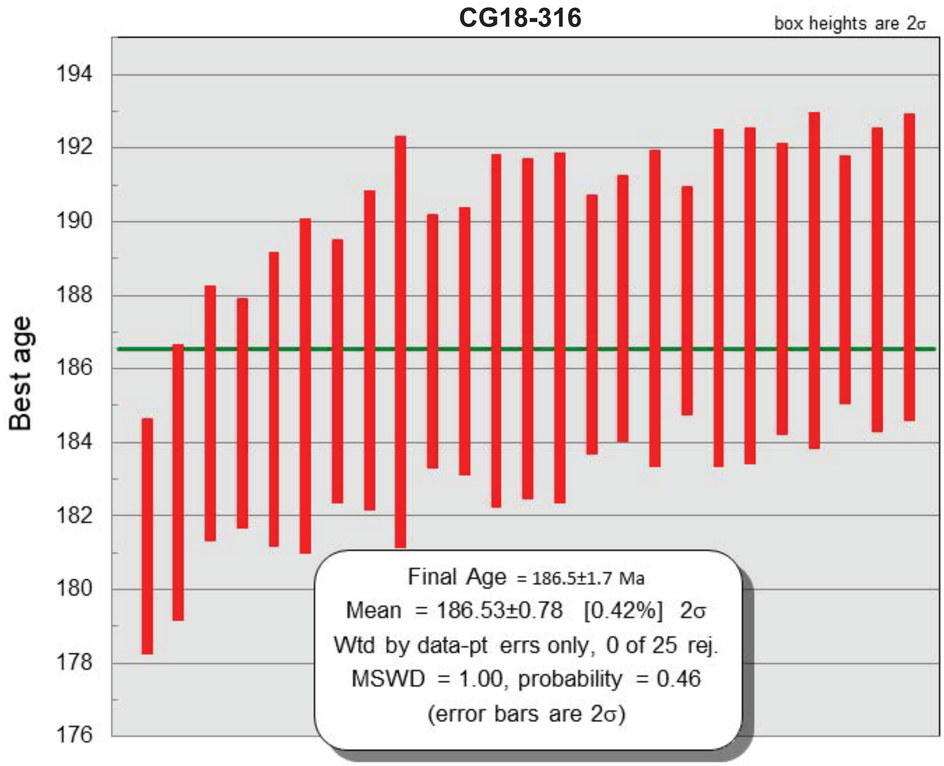

Fig. 31. Weighted mean diagram for age of felsic dike sample CG18-316; sample locality is from one of the light-toned felsic dikes shown in Figures 5 and 32; age calculated using the routines in Isoplot (Ludwig, 2008).

three samples were collected from calcite-quartz-chalcopyrite-pyrite veins containing sparse molybdenite hosted by well-mineralized potassically-altered phases of the Saddle North intrusive complex in the core of the deposit. Molybdenite is rarely recognized in the deposit and in the two youngest samples it occurs on slickenside surfaces that transect the veins; otherwise, all three sampled veins appear to be part of the main stage of mineralization.

6. Structural geology

Stratified Triassic and Jurassic rocks on the Tatogga property and adjacent areas to the west occupy two structural domains. One domain lies to the north of the Saddle area where rocks of the Hazelton Group dip gently northerly (Fig. 20), and the other lies to the south of the Saddle area where Stuhini Group rocks commonly dip moderately to steeply, either southerly or northerly, and locally display map-scale northerly vergent folds and thrusts that were developed before Early Jurassic felsic dikes were emplaced (Figs. 4-5, 32). The two structural domains correspond with the distribution of Stuhini Group rocks (southern domain) and Hazelton Group rocks (northern domain). In the immediate Saddle area, Stuhini Group host rocks dip moderately to steeply to the northeast. We consider that the structural discordance between the northern and southern domains records pre-Hazelton Group contractional deformation, in accord with Stuhini Group-Hazelton Group structural relationships and the sub-Hazelton Group unconformity recognized elsewhere in Stikinia (e.g., Brown and Greig, 1990; Henderson et al., 1992; Greig, 2014; Miller et al., 2020).

Several of the major faults in the Tatogga area appear to have complex histories. Two of the better-understood examples serve as illustrations. The Poelzer fault, which defines the northern limit of strong porphyry mineralization at Saddle North, trends west-northwest and dips steeply south-southwest. It is not generally exposed, in large part because it has been faulted off by a younger subvertical fault (the Poelzer Offset fault, Fig. 5) but within metres of its trace in drill core, it is marked by a pervasive foliation in host rocks that incorporates mineralized veins. The foliation and veins are locally folded, and foliated rocks locally occur as rotated fragments along with pieces of mineralized veins within pyrite- and clay-rich gouge along the trace of the fault, suggesting that early ductile or semi-ductile strain was followed by brittle reactivation. The fault commonly juxtaposes well-mineralized rocks in the hanging wall with those that are intensely altered but little-mineralized in the footwall. The early more ductile to later brittle deformation may reflect only part of the fault's history. This is because the rocks in the footwall of the fault host alteration (copper-poor quartz-sericite-pyrite assemblages) and mineralization (local high-grade epithermal vein-style gold) which presumably formed at shallower depths than much of the porphyry-style potassic alteration and copper-gold mineralization common to the hanging wall, which reaches the surface in hangingwall

Fig. 32. View west-southwest of light-toned Early Jurassic felsic dikes cutting northerly vergent folds and thrusts in dark-toned well-stratified Upper Triassic Stuhini Group mudstone, siltstone and fine-grained sandstone (unit uTSsf), west of northern Tatogga property.

rocks. This relationship suggests significant reverse-sense offset in post-mineralization but pre-Hazelton time (i.e., before the earliest Early Jurassic).

Approximately 2-3 km to the southwest of the Saddle area are two prominent west-northwest trending reverse faults that juxtapose massive Stuhini Group rocks to the north against generally better stratified rocks to the south (Fig. 4). The fault to the west is well exposed and clearly dips to the south, with folded Late Triassic or earliest Early Jurassic rocks that we have assigned to the Stuhini Group, and that have yielded a U-Pb detrital zircon maximum depositional age of ca. 205 Ma (see section 5), in its hangingwall (Fig. 5; see also Bradford and Barresi, 2013). The fault to the east is poorly constrained, and is interpreted to juxtapose relatively thickly bedded and weakly-stratified north-northeast dipping Late Triassic rocks in the Saddle South area with rocks to the south that also dip to the north-northeast but which yield younger, Late Triassic or earliest Early Jurassic U-Pb detrital zircon maximum depositional ages (George et al., 2021).

In spite of the local complexities, structural fabrics are remarkably consistent throughout the property and in a variety of settings and rock-types, generally dipping steeply to the southwest or south-southwest (Fig. 33). In less competent rock types, a pervasive foliation is commonly developed, such as in Hazelton Group sandstones immediately northeast of and up slope from the Saddle North deposit (Fig. 34), or in sericite-rich altered volcanic or intrusive rocks marginal to the Saddle North deposit (Fig. 35) or immediately adjacent to veins of the Saddle South mineralized vein field (Fig. 33). In more competent rocks, the fabric may be expressed as a similarly oriented south-southwest dipping fracture set. Based on reconnaissance work farther south on the property, such as near Quash-Pass, fabrics (Fig. 17) appear to be concordant with those to the north.

7. Discussion

7.1. Stuhini Group or Hazelton Group?

In contrast to other parts of Stikinia (e.g., Brown et al., 1996), Stuhini Group rocks in the Tatogga area include abundant crowded feldspar-phyric trachyandesitic to latitic volcanic rocks with abundant very fine-grained feldspar and common but subordinate hornblende phenocrysts that are set in a potassium feldspar-rich groundmass. Elsewhere, hornblende- feldspar-phyric volcanic rocks characterize the Hazelton Group and are uncommon in the Stuhini Group, which contains augite-phyric mafic volcanic rocks. On the Tatogga property and in the area of the Klastline plateau, the presence of these hornblende-feldspar-phyric examples ultimately led Ash et al. (1997a, b) to assign these rocks to the lower part of the Hazelton Group, although they had previously been assigned to the Stuhini Group (Souther, 1972; Ash et al., 1996). Furthermore, in our initial exploration in 2016 and 2017, the presence at Saddle South of common crowded hornblende- feldspar-phyric dark green to deep maroon volcanic rocks suggested to us that

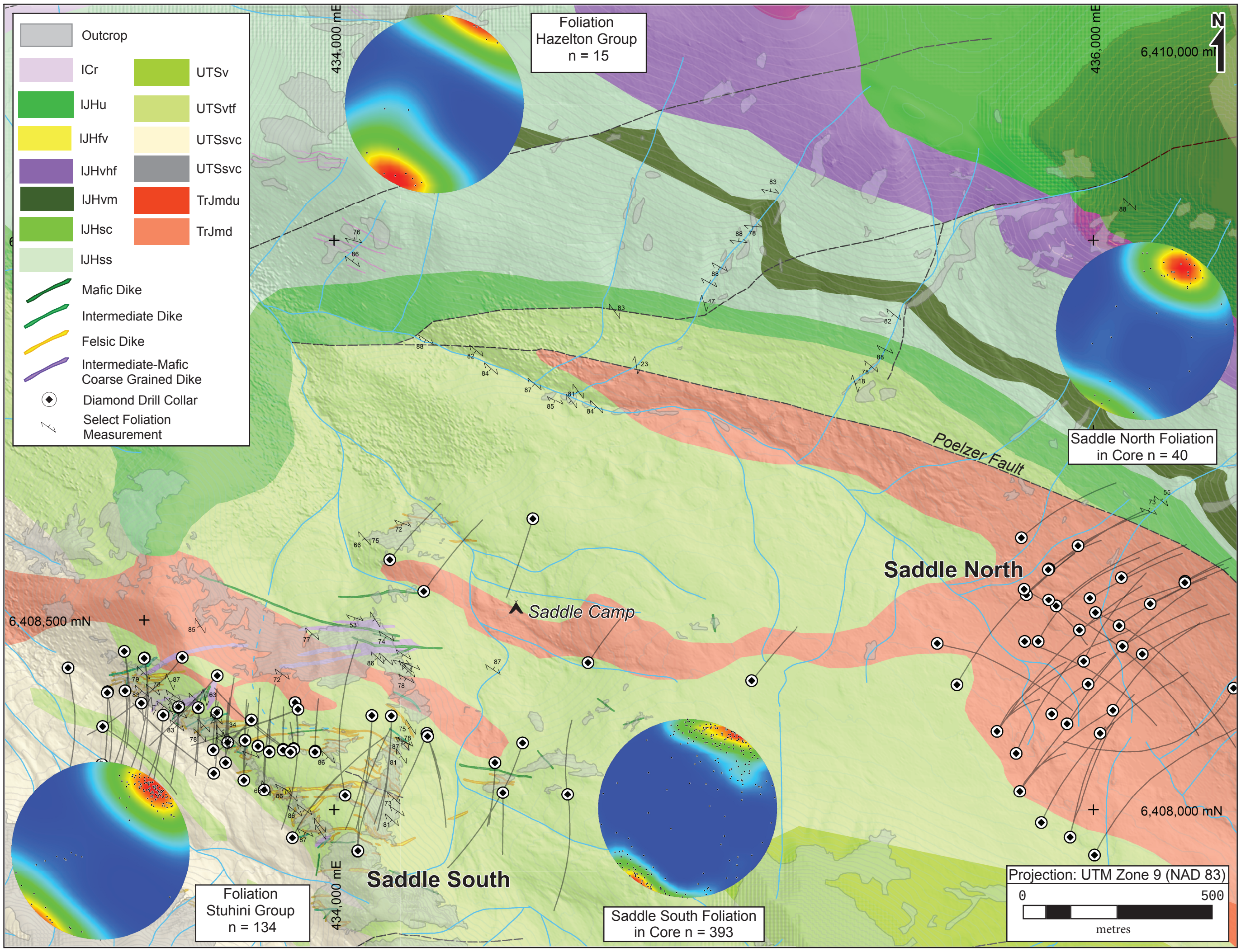

Fig. 33. Structural geology of the Saddle area, Tatogga property; stereoplots generated from equal area stereonet lower hemisphere projections with smoothed Kamb contouring.

the rocks hosting the mineralization indeed belonged to the Hazelton Group rather than to the Stuhini Group. However, the new Late Triassic U-Pb zircon data presented above for these hornblende- feldspar-phyric volcanic rocks in the Saddle South area indicate that they are considerably older than the lower part of the Hazelton Group of Nelson et al. (2018). We have therefore reverted to the assignments suggested by earlier mappers and consider them part of the Stuhini Group. Final resolution of the ages and assignments of rocks on other parts of the Klastline and nearby Edon and Todagin plateaus in the Iskut region awaits more detailed geochronological or paleontological work.

Clast compositions of conglomerates in the Hazelton Group and structural relationships also support assigning most of the rocks on the Klastline plateau to the Stuhini Group. Hazelton Group conglomerates contain clasts that appear to have been sourced from Stuhini Group hornblende- feldspar-phyric volcanic rocks, suggesting erosional stripping beneath the regionally developed sub-Hazelton Group unconformity. The structural discordance between Hazelton Group rocks in the northern part of the area, which dip gently and uniformly to the north, and rocks in the south, which are commonly folded and faulted, suggests that an episode of contractional deformation separates deposition of the two units. The U-Pb zircon ages from felsic dikes that cut folded rocks in the south indicates that this contraction took place before ca. 187 Ma.

7.2. Intrusive rocks and mineralization

Monzonite to monzodiorite intrusions (Saddle intrusions of the regionally developed Tatogga suite) are genetically related to mineralization at the Saddle North porphyry copper-gold deposit, as indicated by the close spatial association of porphyry-style stockwork veining, potassic alteration, and elevated grades of copper and gold, with contacts of later phases of the Saddle North complex intrusive (Flynn and Kelly, 2020). U-Pb zircon data indicate that this Late Triassic to earliest Jurassic magmatic centre was active between ca. 206 and 202 Ma. The youngest dated Saddle intrusion, intersected

Fig. 34. Well-developed steeply southwesterly dipping foliation developed in Hazelton Group sandstone, unit lJHss; view east toward valley of Saddle North deposit on lower slopes of the ridge underlying Mount Poelzer.

Fig. 35. Pervasively foliated and sericite- and iron carbonate-altered medium to coarse lapilli to block tuff of the Stuhini Group, between the Saddle South and Saddle North deposits; view to ESE, with steeply SSW dipping foliation.

in a drill hole midway between the Saddle North deposit and the Saddle South mineralized zone, hosts high-temperature vein and alteration assemblages (stockwork and sheeted pyrite-chalcopyrite-magnetite quartz veins in a potassically-alerted intrusive host), and two of the three Re-Os molybdenite ages from Saddle North are centred on 204 Ma, essentially coeval with the host intrusive host rocks. Intriguingly, the other Re-Os molybdenite date from Saddle North, which yielded an anomalously old age of 207.8 ±0.9 Ma, was collected from a vein in what we consider to be one of the younger intrusive phases of the Saddle North intrusive complex and deposit, with a significantly younger U-Pb zircon age (202.0 ±1.5 Ma; Greig et al., 2021). Does this suggest that the vein sampled is a xenolith, and that an earlier porphyry mineralizing event occurred in the Saddle camp?

At the Saddle South gold-silver mineralized vein zone, the lack of mineralization in footwall intrusive rocks that are coeval and appear to be continuous with intrusions at Saddle North (Greig et al., 2021) strongly suggests that Saddle South precious metals mineralization predates the emplacement of the intrusions, and therefore likely also the porphyry copper-gold mineralizing event at Saddle North. It is probable that mineralization at Saddle South was driven by a magmatic system that is not exposed because it is older than the Saddle North intrusions and is hosted by volcanic rocks that are older still (U-Pb crystallization ages of 224-220 Ma). The presence of an anomalous Re-Os age from Saddle North also corroborates the possibility of a separate, older hydrothermal-magmatic episode and that magmatism was long-lived.

7.3. Structural evolution: Deformation, uplift and erosion of Stikinia in latest Triassic to earliest Jurassic

Rocks of Stikinia were subjected to two major contractional episodes, one in the latest Triassic or earliest Jurassic (e.g., Greig, 2014), and the other in the mid-Cretaceous (Skeena fold and thrust belt; Evenchick, 1991). The older deformation took place very shortly after the mineralization at Saddle North on the Tatogga property, and before emplacement of Early Jurassic felsic dikes (ca. 187 to 182 Ma), which post-date the mineralizing events at both Saddle North and Saddle South. This earlier shortening is manifested in folding and faulting of the well-bedded Upper Triassic rocks to the west of the Tatogga property, which also occurred prior to the intrusion of Early Jurassic dikes (Fig. 32). In the Saddle area, as well as elsewhere in the region, and in the Stikine terrane in general, the Upper Triassic and older rocks appear to be overlain along a regional unconformity by rocks of the Hazelton Group. The full extent and cause of this tectonic event, and the unconformity related to it, remain incompletely understood and documented, but its significance to the Saddle North deposit, and to nearby porphyry Cu-Au deposits and prospects here in northern Stikinia is clear: the rocks and mineralized zones of the Saddle area were probably uplifted and partially unroofed. This made the mineralized zones easier to explore for and may also make them easier to exploit.

Mid-Cretaceous deformation and development of the Skeena fold and thrust belt (Evenchick, 1991, 2001) apparently coincided with the arrival of outboard terranes and their collision and/or consolidation with the present-day western margin of Stikinia (Monger et al., 1982; Monger, 2014). Near the Tatogga property, the belt is best displayed to the southeast and south where it is manifested as east-west trending folds involving strata of the Middle Jurassic and younger Bowser Lake Group (Figs. 1, 3). Bowser Lake Group rocks comprise an overlap assemblage deposited during and following the accretion of Stikinia to the North American margin, and they overlie the older and more varied arc-related rocks that play host to most mineralization at both the Tatogga property and throughout northern Stikinia.

Given that Bowser basin strata largely post-dated the major metallogenic episodes in this part of Stikinia, the formation of Skeena fold belt clearly did as well, and consequently the mid-Cretaceous structural overprint on the older underlying rocks and their contained mineralized zones needs to be acknowledged and potentially accounted for. Shortening across much of the fold belt is estimated at 40-50% (e.g., Evenchick 1991, 2001; Greig and Evenchick, 1993), and therefore that shortening must also have affected the older rocks, including those on the Tatogga property. Shortening also affected deposits and their host rocks to the south in the Eskay, Sulphurets and Stewart mining camps, where this mid-Cretaceous structural overprint has been well documented (e.g., Alldrick, 1993; Bridge, 1993; Lewis, 2001; Febbo et al., 2019). In these areas, the mid-Cretaceous deformation is manifested as faults and folds and in a commonly well-developed foliation, which is best expressed in less competent rock types.

In the northwest part of Bowser basin and in the Iskut region, Skeena belt structural trends are largely east-west, which differs from the northwest-southeast trends common across much of Bowser basin (Fig. 1). All structures in rocks of the northern Tatogga property align with the east-west trends of the Skeena belt. Although structural trends to the south, such as near Quash-Pass, are perhaps less well-developed and defined, they are also more or less concordant with these regional trends, as are the faults and folds mapped on and just beyond the limits of the property. This concordance suggests that the fabrics, and possibly faults such as the Poelzer fault, which parallels the orientation of foliation across the property, likely developed in the mid-Cretaceous. However, as is the case elsewhere in this part of the northern Cordillera (e.g., the Sulphurets camp, Nelson and Kyba, 2014; Febbo et al., 2019), such structures most likely had an earlier history. Conceivably, the Poelzer fault may have had a similar earlier history, perhaps rooted in basement to Stikinia.

8. Conclusion

Our recent mapping and geochronologic work helps to document the geologic setting of two new discoveries in northern Stikinia, the Saddle North porphyry copper-gold deposit, and the Saddle South epithermal precious metals vein system. The mineralized systems are closely associated spatially with east-west trending latest Triassic to earliest Jurassic crowded hornblende monzonite porphyry of the Saddle intrusions (Tatogga intrusive suite), which are similar in age and association to previously discovered mineralized systems at the nearby Red Chris mine, and at the GJ and North Rok properties. New geochronological data, along with stratigraphic and structural considerations, suggest that the rocks that host the Tatogga intrusions and which underlie much the Klastline plateau are part of the Stuhini Group (Upper Triassic), rather than Hazelton Group. The latter outcrop in the northernmost part of the Tatogga property and appear to unconformably overlie more deformed Stuhini Group rocks. In the Tatogga area, hornblende-phyric volcanic rocks are common in both the Stuhini and Hazelton groups. However, Stuhini Group rocks contain abundant very fine-grained plagioclase feldspar and are darker than the Hazelton Group, which appears to have been deposited in an oxidizing environment.

Further mapping and geochronologic studies are needed to confirm the results of our work and test our interpretations. The areas recommended for more work include the upper Hazelton Group section underlying Mount Poelzer and the northern end of Saddle South ridge, and the area south of the Saddle area, toward Quash-Pass, where further lithologic characterization and age control is necessary.

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