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Stikinia Bedrock Report of Activities, British Columbia and Yukon: GEM2 Cordillera

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Stikinia Bedrock Report of Activities, British Columbia and Yukon
GEM2 Cordillera

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Foreword

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for sustainable economic development in the North. The Program provides modern public geoscience that will set the stage for long-term decision making related to responsible land-use and resource development. Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and enables northern communities to make informed decisions about their land, economy and society. Building upon the success of its first five-years, GEM has been renewed until 2020 to continue producing new, publically available, regional-scale geoscience knowledge in Canada's North.

During the 2017 field season, research scientists from the GEM program successfully carried out 27 research activities, 26 of which will produce an activity report and 12 of which included fieldwork. Each activity included geological, geochemical and geophysical surveying. These activities have been undertaken in collaboration with provincial and territorial governments, Northerners and their institutions, academia and the private sector. GEM will continue to work with these key partners as the program advances.

Introduction

The northern Cordillera comprises a collage of terranes that were accreted to the North American continental margin during the Mesozoic (Fig. 1a). Each terrane has its own stratigraphy, tectonic history and mineral deposits, and bounded by faults (Coney et al. 1980). In many cases the presently defined terrane boundaries are either multiply reactivated or late, steep, post-accretionary faults. For example, the Teslin Fault (Fig. 2a), that separates Cache Creek, Stikinia and Quesnellia in Yukon has significant Cretaceous offset (ca. 125 km; Gabrielse et al. 2006). Identification of primary syn-accretionary terrane boundaries is hampered by inadequate knowledge of the internal composition of terranes stemming from improper assignment of late faults as terrane boundaries, rather than syn-accretionary faults.

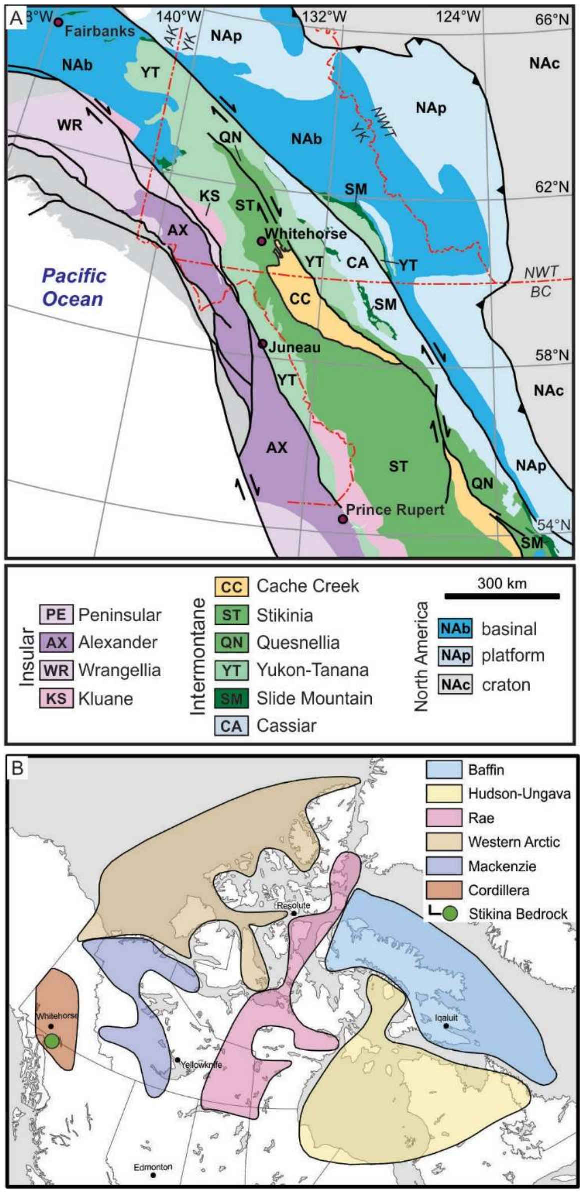

Figure 1 A. Terranes of the Northern Cordillera (from Colpron and Nelson 2011). B. GEM2: Cordillera project and Stikinia Bedrock activity footprints.

The Stikinia bedrock (*a.k.a. Whence Stikinia*) activity is primarily focused on resolving the terrane boundary between Stikinia and Cache Creek in southern Yukon and north-western British Columbia (Figs. 1b and 2). In particular the activity is looking at answering where Stikinia ends and Cache Creek begins (Fig. 2). Previous workers recognized three major tectonic boundaries in this area: the Llewellyn, King Salmon and Nahlin faults (Aitken 1959; Monger 1975; Mihalynuk et al. 1999; Mihalynuk et al. 2003; Mihalynuk et al. 2017). The Llewellyn Fault in part separates low grade Stikinia on its eastern side from high grade Yukon-Tanana terrane to the west (Fig. 1a; Mihalynuk et al. 1999). The juxtaposition of high and low grade rocks along a steep fault suggests significant transcurrent motion or displacement of an older shear zone. The King Salmon Fault (Fig. 2) marks the western edge of the Inklin Formation of the Laberge Group, which is a deep marine sedimentary sequence deposited between the Stikine and Cache Creek terranes. The King Salmon Fault forms part of a fold and thrust belt, but uniquely carries the distinctive Sinwa Formation limestone in its hanging wall (Mihalynuk et al. 2017). The Nahlin fault (Fig. 2) has previously been interpreted as the western edge of the Cache Creek in northern British Columbia. Our recent mapping suggests that what is presently mapped as the Nahlin Fault is actually several distinct structures (Zagorevski et al. 2016). Near its type locality, the Nahlin fault emplaces Cache Creek ophiolitic rocks over the Laberge Group sedimentary rocks (Fig. 2; e.g., Mihalynuk et al. 2003). In this area, the Nahlin fault likely forms part of the same fold and thrust belt as the King Salmon fault and does not represent a primary terrane boundary, especially since correlatives of ophiolitic rocks occur to the southwest of the fault (Childe and Thompson 1997; Gabrielse 1998; English et al. 2010; Schiarizza 2011). To the northwest of the type locality, the boundary between the Cache Creek ophiolitic rocks and the Laberge Group is marked by the probably Cretaceous, transcurrent Silver Salmon fault (Fig. 2;

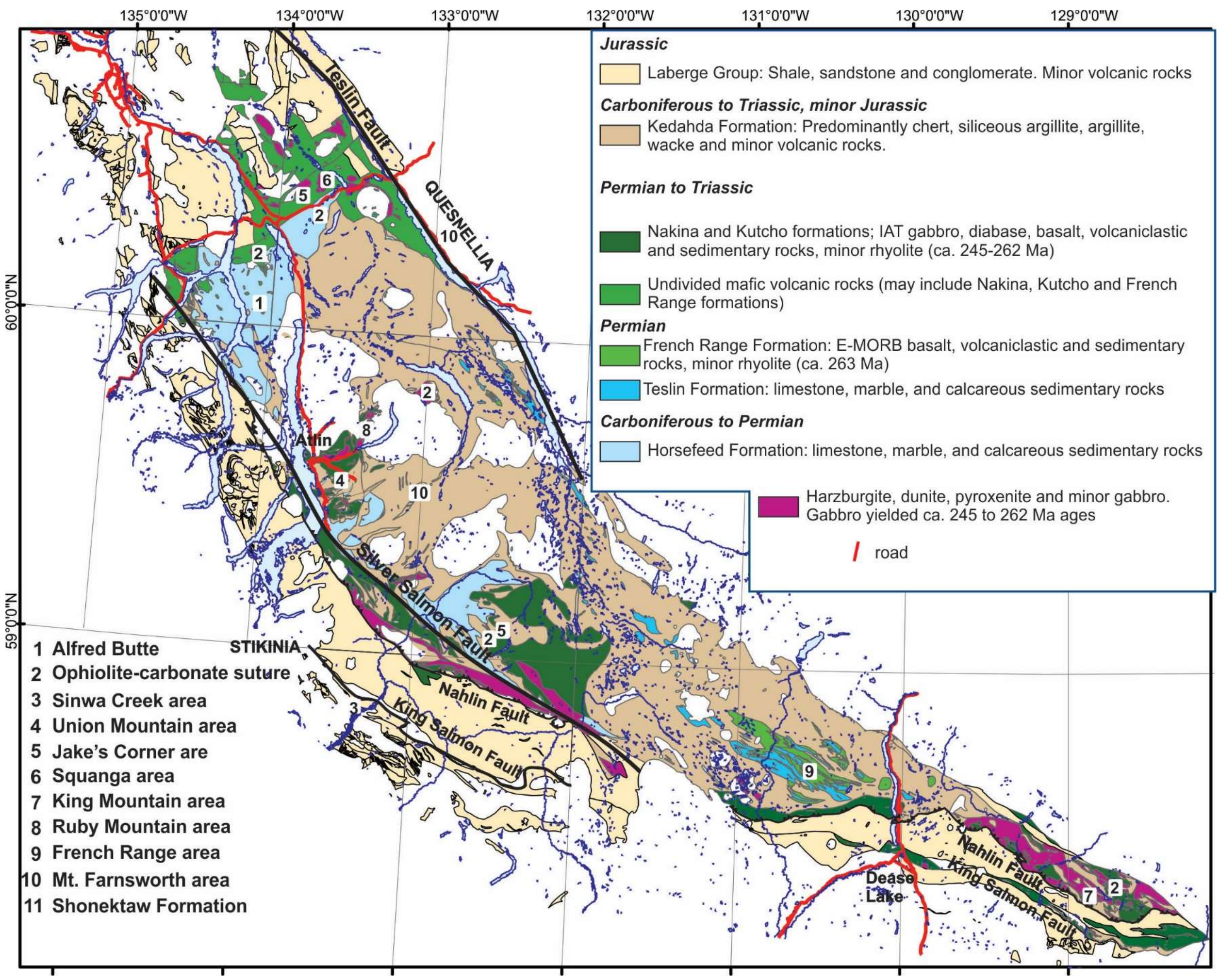

Figure 2 Simplified geology of the northern Cache Creek terrane showing the distribution of various tectono-stratigraphic units (simplified from Massey et al. 2005 and Colpron 2015)

Zagorevski et al. 2016). Work on the Silver Salmon fault and adjacent rocks is ongoing, and will be facilitated by a new aeromagnetic survey of NTS sheets 104M and 105D (Boulanger and Kiss 2017a, b, c).

As indicated above, the Llewellyn, King Salmon, and Nahlin faults do not correspond with primary, syn-accretionary terrane boundaries, but rather displace them. Identifying the syn-accretionary terrane boundaries and testing linkages and differences in the terranes as presently defined could potentially lead to a greatly improved tectonic framework for the northern Cordillera. As such, terrane assignments in the study area need to be reassessed. Summer 2017 fieldwork was predominantly focussed on three thematic problems that will allow reassessment of the terranes: (i) the nature of the basement beneath and volcanism within the Tethyan carbonate platform of the Cache Creek terrane; (ii) the nature and tectonic significance of Late Permian to early Triassic tholeiitic rocks and ophiolites in the Stikinia and Cache Creek terranes; and (iii) the Late Triassic overlap assemblage in Stikinia, Cache Creek and Quesnellia.

Volcanism in the Tethyan carbonate platform

Carboniferous to Permian limestone is a major constituent of the Cache Creek terrane (Fig. 2), commonly occurring as 900-1500 m thick limestone bodies that have been interpreted as atoll build-ups on ocean islands (Monger 1975). These limestones were deposited in warm shallow water and locally contain abundant fusilinids and algal structures. In northern British Columbia, these limestones are assigned to the Horsefeed and Teslin formations and are intercalated with OIB and E-MORB affinity volcanic rocks. The presence of abundant Permian fusilinid fauna that is similar to Tethyan faunal realm has led to the interpretation that these rocks are exotic (Monger and Ross 1971; Monger 1977; Sano et al. 2003). Coeval rocks in adjacent Stikinia lack the Tethyan fusilinid fauna, however this could be because they were deposited in a different environment (Monger and Ross 1971).

The accepted model that the Tethyan carbonate platform limestones were deposited on top of ocean islands needs to be re-evaluated in light of the recognition that the volcanic rocks are intercalated within the limestone. This suggests that volcanism was episodically active throughout the deposition of the carbonate platform from the Carboniferous to the Permian (e.g., Monger 1977). Normally atolls form once volcanism wanes and then stops altogether, leading to thermal subsidence of the volcanic edifice, with carbonate deposition keeping pace with the subsidence. Furthermore, the Tethyan carbonate platform, in comparison to modern systems, is anomalously large for atolls and carbonate banks (Purdy and Winterer 2001). For instance, the Horsefeed Formation north of 59°N has a surface exposure greater than 4000 km^2 without consideration for the potential shortening due to folding and imbrication, continuation of carbonates below younger sedimentary sequences (Fig. 2) and to the south (e.g., Sano et al. 2001). The area north of 59°N alone would place the Horsefeed Formation in the top 2% of modern atolls (Purdy and Winterer 2001), excluding shallow carbonate shelves such as the Great Barrier Reef. This requires either an extensive oceanic plateau that produced anomalous atolls over an extended period of time, or these carbonates are underlain by continental or arc basement. The nature of the basement to the Horsefeed Formation, which is critical to assessing how exotic this platform is to adjacent terranes, has yet to be ascertained. Although the adjacent Stikinia does not contain Tethyan fauna, it is locally characterised by within-plate volcanism during the Paleozoic (Gunning et al. 2006). Similarly, magmatism along the Laurentian margin during departure of the Yukon-Tanana terrane is also in part characterized by OIB magmatism in the Paleozoic (Piercey et al. 2004). Lack of data on the volcanic rocks from the Tethyan carbonate platform in the study area however precludes meaningful comparisons.

In order to address these issues, reconnaissance mapping and sampling was conducted at Alfred Butte, east of Tagish Lake (#1 in Fig. 2). This area is characterized by excellent exposures of intercalated Middle Pennsylvanian to Lower Permian Horsefeed Formation limestone and volcanic rocks (Monger 1975). Volcanic rocks occurs as metre to decimetre thick sequences of variably haematized green mafic flows, volcaniclastic and epiclastic sedimentary rocks. Volcanic rocks are conformable with the surrounding limestone, exhibiting scouring and mixing with the limestone. Minor andesitic to felsic tuff and mafic hypabyssal intrusions are locally present. Volcanic rocks were sampled for geochemical and isotopic analyses. Limestone samples were collected above and below each volcanic layer to constrain the deposition age using conodonts and to allow comparison to fusilinid faunas (Monger 1975). Volcaniclastic flows and felsic tuffs were sampled for U-Pb zircon geochronology to determine the age of volcanism and, if inheritance can be identified, the provenance of the basement.

Late Permian to early Triassic tholeiitic rocks and ophiolites

An intriguing characteristic of the Cache Creek and Stikine terranes is the presence of Late Permian to Middle Triassic tholeiitic rocks and ophiolites along their boundary (Fig. 2). Early models placed these rocks into the Cache Creek and interpreted them as ocean floor (Monger 1975). Although this terrane assignment became entrenched in Cordilleran models, subsequent studies showed that these rocks were younger than the Tethyan carbonate platform and formed in arc-backarc environment (e.g., Childe and Thompson 1997; Gordey et al. 1998; English et al. 2010; Schiarizza 2011; Bickerton 2013; McGoldrick et al. 2017). Recent reconnaissance mapping observed the poorly exposed suture between the Tethyan carbonate platform and ophiolites (#2 in Fig. 2) indicating that the Cache Creek terrane, as presently defined, is a composite terrane that comprises at least two distinct blocks (Zagorevski et al. 2016).

Apart from a clear lack of affinity to the Tethyan carbonate platform, the origin and tectonic significance of these ophiolites is unclear at present as they are largely separated from the adjacent Stikinia by the Laberge Group sedimentary basin (Fig. 2). English et al. (2010) suggested that these ophiolitic rocks formed part of the forearc to the Stuhini arc, which is the Late Triassic arc phase of Stikinia. This proposed tectonic affinity to Stikinia is consistent with the Middle Triassic Joe Mountain Formation in Yukon, which has been interpreted as the stratigraphic basement to Late Triassic Stikinia (Hart 1997), however this interpretation is being re-investigated (Bordet 2017). Middle Triassic zircons that are typical of Cache Creek terrane ages occur in sandstone in the Sinwa Creek area (#3 in Fig. 2; Mihalynuk et al. 2017), which is consistent with a Middle to Late Triassic link between Stikinia and Cache Creek. To further understand the significance of the Late Permian to Early Triassic island arc magmatism along the Stikinia-Cache Creek boundary studies of ophiolitic rocks through field mapping and geochemistry are on-going.

Geochemical investigations of crust and mantle

Geochemistry of volcanic rocks has been critical in recognizing that ophiolites in orogenic belts do not represent normal ocean floor, but rather form parts of arc-back systems that were accreted to continental margins (e.g., Pearce 2014). Geochemical studies in Stikinia and Cache Creek have generally been limited and sporadic precluding determination of clear regional patterns of magmatism (Ash 1994; Jobin-Bevans 1995; Childe and Thompson 1997; English et al. 2010; Schiarizza 2011; Bickerton 2013; Bickerton et al. 2013). Over the last several years we have been collecting regional data on volcanic, plutonic and mantle rocks to characterize the distribution of arc and within-plate magmas, and the aerially extensive, but poorly studied mantle (Zagorevski 2016; McGoldrick et al. 2017).

Regional scale geochemical investigation of ophiolitic crustal rocks indicate that they are characterized by similar magma production over an extended period of time (ca. 261 to 245 Ma: Gordey et al. 1998; Mihalynuk et al. 2003). The main exception to this is in the King Mountain area (Fig. 2), where ophiolitic rocks comprise boninite and minor tholeiite. We are continuing to collect and analyze palaeontological samples that are intimately associated with basalt to further constrain the evolution of magmas over time. On a local scale, crustal rocks from the Union Mountain area, Atlin, are quite diverse, ranging from the depleted arc tholeiites to calc-alkaline basalts. It appears that the calc-alkaline lavas dominate the eastern edge of the mountain and appear to disconformably overlie the tholeiites and mantle rocks. This contrasts with the pattern observed immediately to the west of Union Mountain, where tholeiitic dykes cut calc-alkaline microgabbro. This implies that there are at least two calc-alkaline events in this area.

Geochemical investigation of mantle peridotites suggest that they form deca-kilometer-scale blocks or domains with distinct geochemical signature ranging from fertile to refractory. For example, there appears to be a difference between mantle rocks in the town of Atlin from those on the adjacent Monarch and Union mountains (Fig. 2), suggesting there is some kind of major boundary between them. Peridotites from the Ruby Mountain area (Fig. 2) have diverse geochemical signatures indicating a mixture of ultramafic cumulates and mantle, however the thermal and metasomatic overprint of the adjacent Fourth of July and Surprise Lake batholiths makes these rocks a poor target for detailed mapping. Mantle samples near Jake’s Corner indicate fertile mantle, whereas peridotites immediately to the east near Squanga Lake are highly variable. The most refractory mantle samples that we have identified in the northern Cache Creek terrane occur in the King Mountain area, where they are associated with voluminous boninite magmas. The variability between the peridotite domains may represent transitional characteristics in a highly heterogeneous mantle or tectonic juxtaposition of mantle domains, in essence defining various ophiolitic terranes. Further work is needed to properly constrain the origin of these transitions and whether they represent original mantle heterogeneity or tectonic juxtaposition.

Two localities that display exceptional preservation of primary mineralogy at Little Squanga in Yukon and Union Mountain in B.C. were targeted this summer for additional sampling (Fig. 2). Preliminary investigations of these sites identified coarse orthopyroxene porphyroclasts that are fractured and veined by lherzolite, probably recording late stage melt mobility. Electron probe data show that the late minerals are more refractory than the porphyroclasts, recording progressive depletion as a result of partial melting synchronous with deformation. Near Jake’s Corner, spinel-rich symplectites were discovered that could potentially represent garnet pseudomorphs, suggesting rapid exhumation of mantle. Rapid exhumation of the mantle is consistent with the crustal structure of the ophiolitic rocks that suggests an ocean core complex.

Crustal structure of ophiolitic rocks

Late Permian to Middle Triassic ophiolitic rocks along the Stikinia – Cache Creek boundary are characterized by mantle sections juxtaposed with upper crustal sections. The absence of middle and lower crust along with the mantle – upper crust relationship indicates an intraoceanic detachment in an ocean core complex (Zagorevski et al. 2015; Zagorevski et al. 2016). A detailed study in the Atlin and Jake's Corner areas has been initiated to test this assertion.

Union Mountain in Atlin (Fig. 2) exposes the contact between mantle harzburgite and crustal basalt/gabbro. Mantle-crust contacts are tectonic, characterized by 15 to 20m of brecciated serpentinites, listwanites and/or ophicalcites. The brecciated serpentinites contain centimetre to meter scale clasts of compact serpentinite and gabbro/basalt in a finer, sheared serpentinite matrix. Larger clasts of gabbro (up to 10 m wide) float in serpentinized peridotite. Detailed investigation of these contacts revealed that there is a moderately dipping thrust fault juxtaposing peridotite and basalt. A similar contact at the top of Union Mountain does not appear to be a thrust zone, with shearing in the peridotites is oriented oblique to typical Cordilleran structures. Follow-up work (including petrographic and Raman spectroscopy) could potentially clarify temperatures of crystallisation and insight on fluid temperatures along the possible detachment.

The mantle-crust contact is also exposed in several localities between Jake's Corner and Squanga Lake (Fig. 2). In this area, mantle lherzolite is juxtaposed with gabbro and basalt. The main contact zone is a shallowly to moderately dipping normal fault, offset by steeply dipping normal faults. One deformed varitextured gabbro sample from the contact zone yielded a ca. 245 Ma age (Zagorevski et al. 2016). During the 2017 field campaign, a new peridotite-basalt contact zone was discovered 3 km SW of the previously known location. The contact seems to be exposed by a steeply dipping normal fault. The contact between serpentinized peridotites and basalt was also observed on a hill between Little Squanga and Squanga lakes. Detailed petrography in this shear zone and comparison with other known detachment zones should clarify the nature of the mantle-crust contact.

Late Triassic overlap assemblages in Stikinia, Cache Creek and Quesnellia

The closure of the Cache Creek Ocean and complete assembly of the Intermontane terranes is generally accepted to have occurred by the Middle Jurassic, based on the occurrence of blueschist facies rocks in the French Range area (Fig. 2; Mihalynuk et al. 2004). However, the Laberge Group overlap sedimentation between Cache Creek and Stikinia had started significantly earlier (as early as Sinemurian; e.g., English 2004), putting the sedimentary record at potential odds with the age of blueschist metamorphism. Specifically, if the overlap assemblage does indeed overlap these terranes, then the basin had already closed prior to the Middle Jurassic. Our mapping of the sedimentary rocks in the Cache Creek terrane indicate an additional complexity. In northern British Columbia, Late Triassic (Rhaetian: F. Cordey, unpublished data) chert sequences, previously assumed to be Paleozoic (Monger 1975), are stratigraphically interbedded with conglomerate that is derived from sources that have zircon provenances indicative of both Cache Creek and Stikinia-like sources

(Zagorevski et al. 2016). Similarly, interbedded sandstone and limestone of Norian age that unconformably overlie Paleozoic Cache Creek rocks have a distinctly Stikinia-like zircon provenance (N. Joyce, unpublished). Correlative Yukon rocks (Cordey et al. 1991; Jackson 1992; Gordey and Stevens 1994) yield a similar zircon provenance (N. Joyce, unpublished) indicating that this late Triassic assemblage is derived from Stikinia and does indeed overlap much of the presently defined Cache Creek terrane. In order to understand the tectonic significance of the apparent overlap we have initiated several thematic studies on the Late Triassic sedimentary rocks in Stikinia (Sinwa Formation), Cache Creek ("Kedahda" Formation) and time equivalent rocks in Quesnellia (Shonektaw Formation). The purpose of these studies is to further characterize these sequence, clarify contacts with their basement, understand their relationship to the current terrane concept, and eventually understand the reasons for distinct sedimentation patterns in adjacent sequences (limestone vs chert dominated).

Late Triassic cover to Stikinia

Stikinia is characterized by volcanism throughout the Late Triassic. This volcanism abruptly slowed down or was terminated for a short period of time close to the Norian – Rhaetian boundary leading to widespread deposition of limestone (Sinwa Formation in British Columbia and Hancock member of the Aksala Formation in Yukon). Fieldwork was carried out on Mount Sinwa (#3 in Fig. 2) during the summer of 2017, as a continuation of reconnaissance work started during the previous field season. The latest work consisted of an integrated lithostratigraphic, chemostratigraphic, and biostratigraphic study of the Norian-Rhaetian (Late Triassic) Sinwa Formation at its type locality. Samples will be processed for conodonts and analysis of δ13C, both of which will enable the recognition of the Norian-Rhaetian boundary in the Sinwa Formation. They will also facilitate correlation between the Sinwa Formation in B.C. and the Aksala Formation in Yukon, and evaluate the degree of diachroneity of this limestone unit. This detailed study is the first step towards recognising members within the Sinwa Formation, which is generally a uniform carbonate unit. Horizons rich in chert or bioclastic material could potentially prove to be useful in the subdivision and correlation of this formation. Finally, this study will allow characterization of Late Triassic climate and the depositional environment of the Sinwa Formation, which will aid in determining the tectonic setting of the Stikine terrane and provide insight into environmental changes in the lead up to the mass extinction at the end of the Triassic.

Late Triassic cover to Cache Creek terrane

Prior to the application of radiolaria biostratigraphy the northern Cache Creek chert sequences were presumed to be Paleozoic and either underlie or be interbedded with Tethyan carbonates (e.g., Aitken 1959; Monger 1975). Advancements in radiolaria separation techniques and biostratigraphy has enabled dating of these voluminous chert sequences (e.g., Bloodgood et al. 1990; Cordey et al. 1991; Mihalynuk et al. 2003; Golding et al. 2016) and shown that a significant volume of the chert is actually Middle to Late Triassic. Some of the chert is interbedded with volcaniclastic sandstone containing pristine crystals of hornblende and feldspar (Monger 1975). Reconnaissance studies at Mt.

Farnsworth (#10 in Fig. 2) indicated that the volcaniclastic sandstone is stratigraphically interbedded with Rhaetian chert (F. Cordey, unpublished data), and contains a detrital zircon provenance characteristic of Stikinia. This suggests that the chert-volcaniclastic package may form part of the regional overlap assemblage that stitches Stikinia and Paleozoic Cache Creek.

Mapping near Mt. Farnsworth indicates a discernible stratigraphy. The base of the section comprises thinly bedded chert. This chert could be either Paleozoic or a thrust-repeated slice of the Middle or Late Triassic chert. This chert is either structurally or stratigraphically overlain by a several hundred meter thick limestone which yielded Permian fusilinids (Aitken 1959; Monger 1975). Permian limestone is overlain by Rhaetian (F. Cordey, unpublished data) chert interbedded with hornblende and biotite-bearing siliciclastic, and volcaniclastic rocks below Mt. Farnsworth peak. The contact between Permian and Rhaetiac rocks is a poorly exposed zone with significant alteration, probably due to strong chemical contrast between chert and limestone. To the south, the Upper Triassic rocks appear to be underlain by more chert, and the Permian limestone is missing. These cherts may represent either Middle Triassic (Bloodgood et al. 1989) or Paleozoic chert packages. The change in lithologies below the Late Triassic sequence suggests that the contact may be either a shallow-dipping fault or an angular unconformity. Samples were collected for paleontological and detrital zircon provenance studies to better constrain the chronostratigraphy of Mt. Farnsworth.

Late Triassic cover to Quesnellia

The Teslin fault separates Quesnellia from the Cache Creek terrane in Yukon. Previous mapping in the Teslin Lake area correlated the rocks to the east of the lake with the Shonektaw Formation of Quesnellia (#11 in Fig. 2). In Yukon, these rocks comprise predominantly Norian, imbricated siliciclastic and volcaniclastic sedimentary rocks, chert, and limestone (Gordey and Stevens 1994). The main characteristic of these rocks that separates them from the adjacent Cache Creek terrane is the presence of augite and biotite-bearing sandstone and pale weathering volcaniclastic sandstone (Gordey and Stevens 1994; Gabrielse 1998). Thus, the assignment of these rocks to Quesnellia rests on the presence of volcaniclastic rocks and their occurrence to the east of the Teslin Fault that is predominantly Cretaceous in this area (Gabrielse et al. 2006). Hence, the Shonektaw formation presents a conundrum in the current terrane concept for the following reasons:

- Its terrane boundary is a late transcurrent fault with minimal vertical displacement (White et al. 2012).
- Coeval, lithologically similar rocks occur in the immediately adjacent Cache Creek terrane (e.g., Monger 1975; Jackson 1992; Gordey and Stevens 1994; see following).
- Shonektaw Formation in Yukon contains gabbro and peridotite (Gordey and Stevens 1994) that could represent slivers of ophiolite similar to the adjacent Cache Creek terrane.

Additional investigations northeast of Teslin Lake is on-going to resolve the provenance of the Shonektaw Formation, compare it to the adjacent Cache Creek and understand its relationship to the mafic-ultramafic bodies.

Mapping of the contact between gabbro-peridotite and the Shonektaw Formation suggests that the mafic-ultramafic rocks did not impart any thermal overprint on the sedimentary rocks. Similarly, the gabbroic and ultramafic bodies lack any apparent chilled margins. Together these features suggest that the contact in question is most likely tectonic, an interpretation supported by the nearby exposure of proto-mylonites. The association of gabbro and peridotite is consistent with an ophiolitic origin for these bodies, similar to the ophiolitic rocks immediately to the west of the Teslin Fault. This needs to be tested as Jurassic mafic-ultramafic intrusive complexes are well documented to the southeast in the Turnagain area.

The Shonektaw Formation in Yukon does seem to have a striking resemblance to the Late Triassic Cache Creek terrane at Mt. Farnsworth. Particularly the volcaniclastic members of Shonektaw and Mt. Farnsworth formations are petrographically very similar, including presence of fresh detrital biotite. We collected samples to characterize the U-Pb provenance of the Shonektaw Formation sedimentary rocks, geochemistry of the mafic-ultramafic complexes to identify their origin and tectonic affinity, and chert to compare these to the known radiolaria assemblages from the Cache Creek terrane.

Summary

Whence Stikinia aims to improve understanding of northern Cordilleran terrane interactions by looking past the previously assumed terrane boundaries and reassessing the underlying assumptions in the terrane assignments. Mapping and sample collections were predominantly focussed on the nature of the basement beneath and volcanism within the Paleozoic carbonate platform in the Cache Creek terrane, tectonic significance of Late Permian to early Triassic tholeiitic rocks and ophiolites and the Late Triassic overlap assemblage in Stikinia, Cache Creek and Quesnellia. The interim results from this study as outlined herein indicate that the previously interpreted terranes require significant reassessments.

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References

Aitken, J.D. 1959. Atlin map-area, British Columbia. Memoir - Geological Survey of Canada.
Ash, C.H. 1994. Origin and tectonics setting of ophiolitic ultramafic and related rocks in the Atlin area, British Columbia (NTS 104N). Bulletin - Ministry of Energy, Mines and Petroleum Resources **94**: 54.
Bickerton, L. 2013. The northern Cache Creek terrane: record of Middle Triassic arc activity and Jurassic-Cretaceous terrane imbrication. Simon Fraser University. p. 89.
Bickerton, L., Colpron, M., and Gibson, D. 2013. Cache Creek terrane, Stikinia, and overlap assemblages of eastern Whitehorse (NTS 105D) and western Teslin (NTS 105C) map areas. In: Yukon Exploration and Geology 2012, K.E. MacFarlane, M.G. Nordling, and P.J. Sack (eds.), Yukon Geological Survey, p. 1-17.
Bloodgood, M.A., Bellefontaine, K.A., Maddison, L., and Gertz, I.C. 1990. Geology of the Dixie Lake and Teresa Island map

area; NTS 104N/5, 6. Open File - British Columbia. Geological Survey Branch.
Bloodgood, M.A., Rees, C.J., and Lefebure, D.V. 1989. Geology of the Atlin area; NTS 104N/11W, 12E. Open File - British Columbia. Geological Survey Branch.
Bordet, E. 2017. Updates on the Middle Triassic-Middle Jurassic stratigraphy and structure of the Teslin Mountain and east Lake Laberge areas, south-central Yukon. . In: Yukon Exploration and Geology 2016, K.E. MacFarlane and L.H. Weston (eds.), Yukon Geological Survey: 1-24.
Boulanger, O., and Kiss, F. 2017a. Residual total magnetic field, aeromagnetic survey of the Llewellyn area, NTS 104-M/8 and parts of 104-M/1,2,6,7, British Columbia. Geological Survey of Canada, Open File 8287, 2017, 1 sheet, https://doi.org/10.4095/305322.
Boulanger, O., and Kiss, F. 2017b. Residual total magnetic field, aeromagnetic survey of the Llewellyn area, NTS 104-M/9, 10, 15, 16 and parts of 104-M/11, 14, British Columbia. Geological Survey of Canada, Open File 8288, 2017, 1 sheet, https://doi.org/10.4095/305323.
Boulanger, O., and Kiss, F. 2017c. Residual total magnetic field, aeromagnetic survey of the Llewellyn area, NTS 105-D/1, 2, 3 and parts of 105-D/6, 7, 8, Yukon. Geological Survey of Canada, Open File 8289, 2017, 1 sheet, https://doi.org/10.4095/305324.
Childe, F.C., and Thompson, J.F.H. 1997. Geological setting, U-Pb geochronology, and radiogenic isotopic characteristics of the Permo-Triassic Kutcho Assemblage, north-central British Columbia. Canadian Journal of Earth Sciences **34**(10): 1310-1324.
Colpron, M. 2015. Update of the Yukon Bedrock Geology Map. 1:1000000 http://data.geology.gov.yk.ca/Compilation/DownloadProduct/91.
Colpron, M., and Nelson, J.L. 2011. A Digital Atlas of Terranes for the Northern Cordillera. BC GeoFile 2011-11.
Coney, P.J., Jones, D.L., and Monger, J.W.H. 1980. Cordilleran suspect terranes. Nature [London] **288**(5789): 329-333.
Cordey, F., Gordey, S.P., and Orchard, M.J. 1991. New biostratigraphic data for the northern Cache Creek Terrane, Teslin map area, southern Yukon. Paper - Geological Survey of Canada, 67-76.
English, J.M. 2004. Convergent margin tectonics in the North American Cordillera; implications for continental growth and orogeny. *In* School of Earth and Ocean Sciences. University of Victoria, Victoria. p. 193.
English, J.M., Mihalynuk, M.G., and Johnston, S.T. 2010. Geochemistry of the northern Cache Creek Terrane and implications for accretionary processes in the Canadian Cordillera. Canadian Journal of Earth Sciences **47**(1): 13-34.
Gabrielse, H. 1998. Geology of the Cry Lake and Dease Lake map areas, north-central British Columbia. Bulletin - Geological Survey of Canada.
Gabrielse, H., Haggart, J.W., Murphy, D.C., Mortensen, J.K., Enkin, R.J., and Monger, J.W.H. 2006. Cretaceous and Cenozoic dextral orogen-parallel displacements, magmatism, and paleogeography, north-central Canadian Cordillera. Special Paper - Geological Association of Canada **46**: 255-276.
Golding, M.L., Orchard, M.J., and Zagorevski, A. 2016. Microfossils from the Cache Creek Complex in northern British Columbia and southern Yukon. Geological Survey of Canada, Open File 8033: 25. doi: 10.4095/298696.
Gordey, S.P., McNicoll, V.J., and Mortensen, J.K. 1998. New U-Pb ages from the Teslin area, southern Yukon, and their bearing on terrane evolution in the northern Cordillera. Current Research - Geological Survey of Canada, 129-148.
Gordey, S.P., and Stevens, R.A. 1994. Preliminary interpretation of bedrock geology of the Teslin area (105C), southern Yukon. Open-File Report - Geological Survey of Canada. doi: 10.4095/205239.
Gunning, M.H., Colpron, M., Hodder, R.W., Nelson, J.L., and Nelson, J.L. 2006. Contrasting volcanic styles and their tectonic implications for the Paleozoic Stikine Assemblage, western Stikine

Terrane, northwestern British Columbia. Special Paper - Geological Association of Canada **45**: 201-227.
Hart, C.J.R. 1997. A transect across Northern Stikinia: Geology of the Northern Whitehorse map area, Southern Yukon Territory (105D/13-16). Bulletin - Exploration and Geological Services Division, Yukon region **8**: 113.
Jackson, J.L. 1992. Tectonic analysis of the Nisling, northern Stikine and northern Cache Creek terranes, Yukon and British Columbia.
Jobin-Bevans, L.S. 1995. Petrology, geochemistry and origin of ultramafic bodies within the Cache Creek terrane, southern Yukon. University of Manitoba. p. 227.
Massey, N.W.D., MacIntyre, D.G., Desjardins, P.J., and Cooney, R.T. 2005. Digital Map of British Columbia: Whole Province, B.C. Ministry of Energy and Mines, GeoFile 2005-1.
McGoldrick, S., Zagorevski, A., and Canil, D. 2017. Geochemistry of volcanic and plutonic rocks from the Nahlin ophiolite with implications for a Permo-Triassic arc in the Cache Creek terrane, northwestern British Columbia. Canadian Journal of Earth Sciences. doi: 10.1139/cjes-2017-0069.
Mihalynuk, M.G., Erdmer, P., Ghent, E.D., Cordey, F., Archibald, D.A., Friedman, R.M., and Johannson, G.G. 2004. Coherent French Range blueschist; subduction to exhumation in <2.5 m.y.? GSA Bulletin **116**(7/8): 910-922.
Mihalynuk, M.G., Johnston, S.T., English, J.M., Cordey, F., Villeneuve, M.E., Rui, L., and Orchard, M.J. 2003. Atlin TGI; Part II, Regional geology and mineralization of the Nakina area (NTS 104N/2W and 3). Geological Fieldwork, 9-37.
Mihalynuk, M.G., Mountjoy, K.J., Smith, M.T., Currie, L.D., Gabites, J.E., Tipper, H.W., Orchard, M.J., Poulton, T.P., and Cordey, F. 1999. Geology and mineral resources of the Tagish Lake area (NTS 104M/8,9,10E, 15 and 104N/12W), northwestern British Columbia. Bulletin - British Columbia Ministry of Energy and Mines, Energy and Minerals Division, Geological Survey Branch.
Mihalynuk, M.G., Zagorevski, A., English, J.M., Orchard, M.J., Bidgood, A.K., Joyce, N., Friedman, R.M., and 2017. Geology of the Sinwa Creek area, northwest BC (104K/14). In: Geological Fieldwork 2016, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2017-1: 153-178.
Monger, J. 1975. Upper Paleozoic rocks of the Atlin Terrane, northwestern British Columbia and south-central Yukon. Paper - Geological Survey of Canada, 74-47.
Monger, J.W.H. 1977. Upper Paleozoic rocks of the western Canadian Cordillera and their bearing on Cordilleran evolution. Canadian Journal of Earth Sciences **14**(8): 1832-1859.
Monger, J.W.H., and Ross, C.A. 1971. Distribution of fusulinaceans in the western Canadian Cordillera. Canadian Journal of Earth Sciences **8**: 259-278.
Pearce, J.A. 2014. Immobile element fingerprinting of ophiolites. Elements **10**(2): 101-108. doi: 10.2113/gselements.10.2.101.
Piercey, S.J., Murphy, D.C., Mortensen, J.K., and Creaser, R.A. 2004. Mid-Paleozoic initiation of the northern Cordilleran marginal backarc basin; geologic, geochemical, and neodymium isotope evidence from the oldest mafic magmatic rocks in the Yukon-Tanana Terrane, Finlayson Lake District, southeast Yukon, C. Geological Society of America Bulletin **116**(9-10): 1087-1106. doi: 10.1130/b25162.1.
Purdy, E.G., and Winterer, E.L. 2001. Origin of atoll lagoons. Geological Society of America Bulletin **113**(7): 837-854.
Sano, H., Igawa, T., and Onoue, T. 2003. Atlin TGI; Part V, Carbonate and siliceous rocks of the Cache Creek Terrane, southern Sentinel Mountain, NTS 104N/5E and 6W. Geological Fieldwork, 57-64.
Sano, H., Struik, L.C., Rui, L., and MacIntyre, D.G. 2001. Facies interpretation of Middle Carboniferous to Lower Permian Pope succession limestone of Cache Creek Group, Fort St. James, central British Columbia. Canadian Journal of Earth Sciences **38**: 535-550.

Schiarizza, P. 2011. Geology of the Kutcho Assemblage between Kehlechoa and Tucho Rivers, northern British Columbia (NTS 104I/01, 02). Geological Fieldwork, Ministry of Energy, Mines and Petroleum Resources, Paper 2012-1: 99-118.

White, D., Colpron, M., and Buffett, G. 2012. Seismic and geological constraints on the structure and hydrocarbon potential of the northern Whitehorse Trough, Yukon, Canada. Bulletin of Canadian Petroleum Geology **60**(4): 239-255. doi: 10.2113/gscpgbull.60.4.239.

Zagorevski, A. 2016. Geochemical data of the northern Cache Creek and Stikine terranes and their overlap assemblages, British Columbia and Yukon. Geological Survey of Canada, Open File 8039: 1 .zip file.

Zagorevski, A., Corriveau, A.-S., McGoldrick, S., Bedard, J.H., Canil, D., Golding, M., Joyce, N., and Mihalynuk, M. 2015. Geological framework of ancient oceanic crust in northwestern British Columbia and southwestern Yukon, GEM 2 Cordillera. Geological Survey of Canada, Open File 7957, 12 p.

Zagorevski, A., Mihalynuk, M.G., McGoldrick, S., Bedard, J.H., Golding, M., Joyce, N.L., Lawley, C., Canil, D., Corriveau, A.S., Bogatu, A., and Tremblay, A. 2016. Geological framework of ancient oceanic crust in northwestern British Columbia and southwestern Yukon, GEM 2 Cordillera. Open-File Report - Geological Survey of Canada. doi: 10.4095/299196.