Cordilleran Tectonics Workshop

March 2-4, 2018
Whitehorse, Yukon

Lake Laberge from Mount Laurier, E.Bordet, 2016

2018 Cordilleran Tectonics Workshop

High Country Inn, Whitehorse, Yukon

Friday, March 2, 2018

Ballroom A

6:00 PM	***Ice breaker + Registration + Poster setup***		
8:30 PM	***(cash bar)***		

Saturday, March 3, 2018

Ballrooms A+B

Time		*Speaker*	*Abstract*
8:00 AM	***Registration*** ***coffee + muffins***		
8:30 AM	Neoproterozoic and Cambrian sandstones and intrusive rocks in central Idaho	*Paul Link*	***p. 5***
8:50 AM	Evidence for two phases of Rodinian rift-related magmatism in Cambrian rocks of western Laurentia	*Lauren Madronich*	***p. 6***
9:10 AM	Early Paleozoic post-breakup magmatism along the Cordilleran margin of western North America: new geochronological and geochemical results from the Kechika group, Yukon, Canada	*Roddy Campbell*	***p. 7***
9:30 AM	Geologic history of the Tay River area, central Yukon; a story of long lived crustal structures	*Rosie Cobbett*	***p. 8***
9:50 AM	***discussion + coffee + posters***		
11:10 AM	Detrital zircon U-Pb geochronological and Hf isotopic constraints on the geological evolution of North Yukon	*Maurice Colpron*	***p. 9***
11:30 AM	**KEYNOTE 1 –** Hf Isotopic Signature of Northern Cordilleran Terranes: Implications for Tectonic History and DZ Methodology	*George Gehrels*	***p. 10***
12:15 PM	***lunch*** ***posters + discussion***		
1:30 PM	Some thoughts on Late Paleozoic to Early Mesozoic geologic evolution of Wrangellia	*Steve Israel*	***p. 13***
1:50 PM	Revised stratigraphy of the Hazelton Group in the Iskut River region, northwestern British Columbia	*JoAnne Nelson*	***p. 14***
2:10 PM	Jurassic stratigraphy and tectonic evolution of the Whitehorse trough, central Yukon: New insights from laser ablation split stream (LASS) detrital zircon U-Pb geochronology and Hf isotope geochemistry	*Leigh van Drecht*	***p. 15***
2:30 PM	Cretaceous magmatism in the Teslin Mountain & Lake Laberge area, Yukon	*Esther Bordet*	***p. 16***
2:50 PM	***Discussion***		
3:00 PM	***Posters***		
3:30 PM	***(cash bar + munchies)***		

7:00 PM	***dinner @ Antoinette's*** ***(*** *4121 - 4th Avenue* ***)***		

Sunday, March 4, 2018

Ballrooms A+B

Time		*Speaker*	*Abstract*
8:00 AM	***coffee + muffins + posters***		
9:00 AM	Margin-Parallel translation of the Cretaceous-Paleocene Yakutat terrane, Alaska	*John Garver*	***p. 17***
9:20 AM	Cenozoic deformation and rock exhumation at the Yakutat-North American collision zone	*Eva Enklemann*	***p. 18***
9:40 AM	Fault Rock Evolution, Preliminary Geochronology, and the Record of Ductile to Brittle, Late Eocene-Late Miocene Strain Partitioning Along the Denali Fault Zone in Southwestern Yukon, Canada	*Jonathan Caine*	***p. 19***
10:00 AM	Oroclinal bending in the Cascadia subduction zone forearc and its relation to concave plate margin geometry	*Theron Finley*	***p. 20***
10:20 AM	***discussion + coffee + posters***		
11:00 AM	Canadian Cordilleran deformation supports the concept of a “continental bulldozer”	*Jim Monger*	***p. 21***
11:30 AM	**KEYNOTE 2 –** New Perspectives on the Coast Mountains Batholith	*George Gehrels*	***p. 22***

12:15 PM	***lunch***		
	posters + discussion		
1:00 PM	Lithostratigraphic Control on Structural Style and the Impact on Hydrocarbon Distribution in the Foothills of British Columbia	*Mark Cooper*	***p. 25***
1:20 PM	Relationship between magmatism, tectonics and porphyry copper systems in the Yukon-Tanana upland, eastern Alaska	*Doug Kreiner*	***p. 27***
1:40 PM	Structural controls on gold in progressively deformed host rocks: examples from Phanerozoic orogenic gold districts of the Canadian Cordillera	*Murray Allan*	***p. 28***
2:00 PM	***Discussion***		
2:30 PM	***Where to next year ??***		
3:00 PM	***posters + discussion***		
4:30 PM			

Posters		***Presenter***	***Abstract***
1	Yukon Bedrock geology map (YGS instand)	*Maurice Colpron*	***map***
2	BC geology (vertical)	*JoAnne Nelson*	***map***
3	Alaska geology	*Jamey Jones*	***map***
4	Bedrock geology of the Teslin Mountain, east Lake Laberge, and east Lower Laberge areas, south central Yukon	*Esther Bordet*	***map***
5	Geology Map Update of Tay River and NE Glenlyon Areas	*Rosie Cobbett*	***map***
6	Geophysical reassessment of the role of ancient crustal structures on the development of the western Laurentian margin, Yukon and NWT, Canada	*M. Colpron (for N. Hayward)*	***p. 39***
7	From Cantung to the Inconnu thrust: bedrock geology compilation of parts of the Frances Lake (105H) and Flat River (95E) areas, southeast Yukon	*David Moynihan*	***map***
8	Upper mantle and lower crustal xenoliths from the upper Hyland River region, SE Yukon	*Colin Padget*	***p. 43***
9	Bedrock geology of the eastern Rackla belt, Yukon	*David Moynihan*	***map***
10	Characterization and provenance of the Neoproterozoic “upper” Group in the Coal Creek Inlier, Ogilvie Mountains	*James Busch*	***p. 33***
11	New contributions to the bedrock geology of the Mount Freegold district, Dawson Range, Yukon (NTS 115I/2, 6 and 7)	*Melissa Friend*	***p. 38***
12	Strike-slip fault controlled magmatism and mineralization of the Mount Freegold district, Yukon Territory (NTS 115/I2, 115/I6, 115/I7)	*Murray Allan & Melissa Friend*	***p. 31***
13	Late Triassic to Middle Jurassic magmatism, sedimentation and tectonics in the Intermontane terranes of Yukon	*Maurice Colpron*	***p. 34***
14	Post-accretionary deformation of the Intermontane region, southern Yukon and northern British Columbia, Canadian Cordillera	*Dawn Kellett*	***p. 40***
15	Characterization of Paleocene to Eocene magmatism and tectonics in southwest Yukon and their role in regional metallogeny	*Steve Israel*	***map***
16	Late Triassic mafic volcanism along the Insular-Intermontane terrane suture: insight from the Bear Creek assemblage, southwest Yukon	*Joel Cubley*	***p. 35***
17	The Porcupine Shear Zone of northern Yukon and Alaska - evaluating large-scale terrane displacement in the Arctic	*Karol Faehnrich*	***p. 36***
18	The latest Cretaceous-early Eocene Pacific-Arctic?-Atlantic connection: co-evolution of strike-slip fault systems, oroclines and transverse thrust-and-fold belts in the northwestern North American Cordillera	*Don Murphy*	***p. 41***
19	Investigations of the structural and thermal interface between the Purcell Anticlinorium and the Kootenay Arc	*Nicole Rioseco*	***p. 44***
20	The Murray dyke swarm of southern British Columbia and its role in Eocene extensional tectonics	*Anastasia Ogloff*	***p. 42***
21	Structural heterogeneity, thermal spring distribution, and geothermal energy potential along the Southern Rocky Mountain Trench	*Theron Finley*	***p. 37***
22	Controls on the rheological properties of peridotite at a palaeosubduction interface: a transect across the base of the Oman-UAE ophiolite	*Tyler Ambrose*	***p. 32***

Neoproterozoic and Cambrian Sandstones and Intrusive Rocks in Central Idaho

Brennan, Daniel T., Link, Paul K., and Pearson, D.P.,*
*Department of Geosciences, Idaho State University (*Presentor)*

In central Idaho north of the Snake River Plain, syn- and early post-rift sedimentary rocks associated with Neoproterozoic to Cambrian Rodinian rifting are absent or dramatically thinner than the well-documented sections along much of the western Laurentian margin. However, our recent geologic mapping in the Bayhorse and Clayton areas of central Idaho suggests that a >2.5 km thick, relatively intact Neoproterozoic to Cambrian section is present, similar to the Stibnite area to the northwest, and to SE Idaho. These strata are largely obscured by the Idaho batholith to the south and west. Components of this central Idaho stratigraphy include:

1. A 664±6 Ma tuff encountered in a borehole at Daugherty Gulch that may correlate with an upper tuff in the Scout Mountain Member of the Pocatello Formation,

2. Abundant ~650 Ma detrital zircons in the uppermost Ramshorn Slate and lower Clayton Mine Quartzite interpreted to have a provenance in intrusive rocks of the 650 Ma Big Creek belt,

3. A lower fine grained succession (Garden Creek Phyllite and Ramshorn Slate) that may correlate with the upper Pocatello Formation and Papoose Creek formations. The lower Ramshorn Slate contains Kinneyia trace fossils, that would have been destroyed by burrowing in Cambrian time. The trace fossils are thus consistent with the Ediacaran correlation.

4. The thick Ediacaran and Cambrian Clayton Mine quartzite, which in addition to a mix of locally sourced 650-665 Ma Big Creek pluton grains, contains Grenville-aged and Paleoproterozoic detrital zircons. The Grenville-age grains are not present in the uppermost part of the Clayton Mine, suggesting the rise of the Transcontinental arch about 530 Ma cut off the Grenville source. The Clayton Mine unit may correlate with much of the Brigham Group of SE Idaho and contains a strong 1780-1790 Ma detrital zircon age peak. The source rocks for these grains are not known.

5. Upper Cambrian feldspathic sandstones that were deposited across southeast Idaho, Montana and Wyoming during the Sauk II-III regressive boundary contain distinctive 490-500 Ma detrital zircon grains, derived from Late Cambrian Beaverhead belt plutons in the Lemhi Arch of east-central Idaho. Correlative upper Cambrian rocks, as well as a thick section of Cambrian carbonates, are not found.

6. The overlying Middle Ordovician Swan Peak-Kinnikinic quartzites from Idaho south to Nevada contain yet a different detrital zircon age population with almost all grains > 1800 Ma and a peak at 1860 Ma thought to be derived from the Peace River Arch.

These new results from central Idaho suggest the presence of a relatively thick section of Neoproterozoic to Cambrian sedimentary rocks deposited southwest of the Lemhi Arch, which was a relatively unextended crustal block known to have undergone late Cambrian exhumation. The Lemhi Arch is coincident with the northwest-trending Mesoproterozoic Lemhi subbasin of the Belt Supergroup and ~1.37 Ga mafic magmatism. The similarities between the Bayhorse and southeast Idaho section suggest that initial rifting in central Idaho was broadly coincident with southeast Idaho.

Evidence for two phases of Rodinian rift-related magmatism in Cambrian rocks of western Laurentia

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Matthews, William, University of Calgary

An understanding of the breakup of Rodinia along the western margin of Laurentia is hindered by a limited record of rift-related magmatic rocks. Previous work identified two main periods of magmatism associated with periods of crustal thinning: (1) Cryogenian magmatism synchronous with deposition of the Windermere Supergroup and (2) late Ediacaran and Cambrian magmatism associated with initiation of the Laurentian passive margin. Detrital zircons from 23 samples of basal Sauk sequence sandstones and a tuff along the Laurentian margin from central British Columbia, Canada to New Mexico, USA provide an additional record of rift-related magmatism.

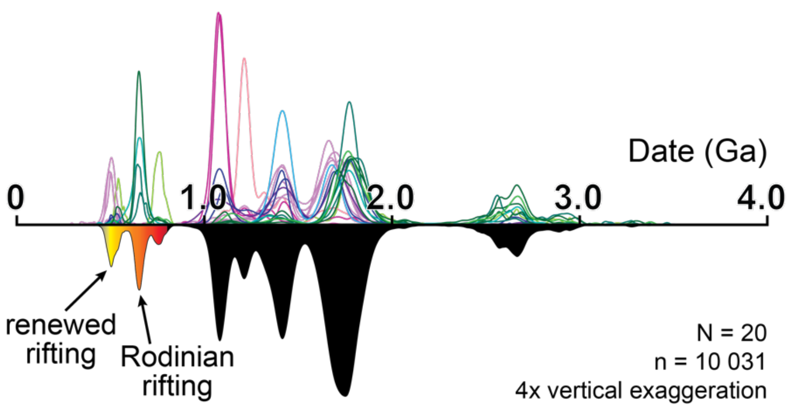

Figure 1. Overlain normalized probability density plots (PDP) of U-Pb zircons for samples of Cambrian rocks yielding grains less than 800 Ma. The PDP for all is reflected below, showing two dominant peaks of 506 and 656 Ma. Curves for northern samples from British Columbia and Alberta are green; Utah and Colorado are blue; southwestern US are pink and purple.

Over 600 zircon grains from each sample of basal Sauk sequence sandstones were measured to identify Neoproterozoic and Cambrian grains. These grains were re-ablated to reduce the uncertainty of the dates and to measure trace-element compositions. Samples from strata in Canada contain grains yielding dates of 780 Ma through 525 Ma (Figure 1; green curves). Trace-element compositions of the 780 to 600 Ma populations are consistent with mafic source rocks while the 580 to 525 Ma populations derive from sources with mixed compositions. In samples from the southwestern USA, Cryogenian age populations are much less prevalent and have compositions indicative of mafic to intermediate source rocks. Late Ediacaran to Cambrian grains are much more abundant in the south end of the study area and have mixed trace element chemistries (Figure 1; pink and purple curves).

The new U-Pb detrital zircon age and trace element data show spatial and temporal trends that enrich our understanding of the timing and mode of magmatism along the margin. A lull in magmatism between 640 and 580 Ma clearly separates Windermere events from those associated with the formation of the Paleozoic passive margin. Magmatism is dominantly mafic during the initial phase of crustal thinning during Cryogenian time. The second phase of magmatism, associated with latest Neoproterozoic to Cambrian initiation of the passive margin, is synchronous throughout the study area and exhibits mixed chemistry.

Early Paleozoic post-breakup magmatism along the Cordilleran margin of western North America: new geochronological and geochemical results from the Kechika group, Yukon, Canada

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The tectonic significance of post-breakup volcanic rocks within the lower Paleozoic passive margin successions from NW Canada to SW United States remains an outstanding problem in Cordilleran geology. Episodes of mafic to felsic volcanism and related rift tectonism occurred up to 40 m.y. after early Cambrian breakup and the onset of seafloor spreading along western Laurentia. Published pure- and simple-shear rift models for the Cordilleran margin, however, infer a short-lived period of rifting mostly based on Ediacaran-Cambrian platformal successions with limited magmatism (e.g., Hamill group, SE British Columbia) and do not fully predict the driving forces behind Cambrian-Ordovician post-breakup magmatism in more outboard regions (e.g., Cassiar terrane, Kootenay terrane, Kechika trough). In this talk, we report new results from Cambrian-Ordovician volcanic and intrusive rocks of the Kechika group, Cassiar terrane, central Yukon, to propose a magma-poor rift or North Atlantic-type model for western North America and investigate the post-breakup stratigraphy of the Cordilleran margin.

The primary lithofacies of the Kechika group include pillow lava, sediment-matrix breccia, and monomictic basalt breccia, which are indicative of submarine volcanic centres and comagmatic sill-sediment complexes. New zircon CA-TIMS U-Pb age dates indicate that these lithofacies were deposited during the late Cambrian (ca. 488-483 Ma) and Early Ordovician (473 Ma). Basaltic flows and sills yield whole-rock trace element and Nd-Hf isotopic values that are consistent with the low degree partial melting of an enriched mantle source. Comagmatic intrusive rocks have trace element and Nd-Hf isotopic values that are consistent with variable levels of crustal assimilation.

Based on these data the timing and geochemical signatures of Kechika group volcanism confirm previous constraints for Cambrian Series 2 to Ordovician alkalic magmatism throughout western North America. Linkages between local extensional faulting and coeval volcanic strata throughout the early Paleozoic outboard basins of Yukon and British Columbia suggest that the outer continental margin underwent post-breakup extensional tectonism. After lithospheric breakup, outboard basins of the Newfoundland-Iberia rift system continued to experience volcanism, thinning of the underlying lithospheric mantle, extensional faulting and were influenced by complex bounding strike-slip structures. We propose that potential modern analogues for the Kechika group include off-axis, post-breakup strata emplaced along the Newfoundland-Iberia rifted margin. This work is consistent with the application of a magma-poor rift model to the Cordilleran margin and may help explain the contrast between relatively magma-poor Ediacaran-Cambrian platformal successions, and widespread syn- to post-breakup volcanic rocks in outboard Cambrian and Ordovician successions.

Geologic history of the Tay River area, central Yukon; a story of long lived crustal structures

Cobbett, Rosie, Yukon Geological Survey, Rosie.Cobbett@gov.yk.ca

Detailed mapping in the Tay River area in central Yukon has provided enough geologic information to construct a reasonably detailed geologic history of the area starting in the lower Cambrian and ending with the intrusion of middle Cretaceous plutons. The history is not different from the generally accepted story of the development of the western edge of Laurentia but does provide some new insights into the role crustal structures play on the distribution of rocks through time. In the Tay River area we see evidence for the existence of crustal structures that have been reactivated throughout the Paleozoic including the Twopete fault, a structure that was active in the Devonian and maybe earlier.

The oldest strata in the Tay River area, the lower Cambrian Mount Mye formation, represents deposition of fine-clastic rocks into the Selwyn Basin, a carbonate-platform bounded basin situated along the western edge of Laurentia. Within the Mount Mye formation, metavolcanic rocks are a result of short-lived rift-driven extension that created margin parallel crustal breaks along the Laurentian margin. Sedimentation resumed in the Selwyn Basin with the deposition of the Cambrian to Ordovician Vangorda formation. In the Ordovician to Silurian another period of extension along the edge of Laurentia facilitated the eruption and deposition of volcanic rocks of the Menzie Creek Formation in the same area as the lower Cambrian volcanics. Instead of new crustal breaks, relic structures were reactivated and controlled volcanism.

In the Silurian to Middle Devonian, basinal sedimentation resumed in the Selwyn basin with deposition of fine-clastic rocks and chert of the Road River and lower Earn Groups. In the Late Devonian, rifting of the Yukon Tanana terrane (fragment of the Laurentian margin) created major extension along the western edge of Laurentia, which again reactivated margin parallel structures. In response to this extension, quartz-rich clastic rocks and minor volcanic rocks of the upper Earn Group were deposited across Selwyn basin and mark the end of basinal sedimentation. Both the distribution of the upper Earn Group and the volcanic rocks within it are locally concentrated near the Twopete fault, a structure we argue is a reactivated crustal scale growth fault.

In the Carboniferous to Triassic, the edge of North America returned to a continental slope environment with the deposition of clastic and carbonate rocks and chert. This ended in the Jurassic when the accretion of arc and continental fragments caused wide spread deformation along the western edge of North America. Lastly, subduction related plutonism intruded the deformed continental margin with granitic material. These plutons form a linear belt that parallels the Twopete fault and occur near the Paleozoic volcanic rocks in the Tay River area. We suggest the Cretaceous intrusions preferentially intrude along the same relic crustal breaks that control the distribution of the volcanic rocks and the upper Earn Group.

Detrital zircon U-Pb geochronological and Hf isotopic constraints on the geological evolution of North Yukon

Maurice Colpron, Yukon Geological Survey
W.C. McClelland, University of Iowa
Justin Strauss, Dartmouth College

North Yukon lies at the juncture of two major tectonic domains that define the western and northern edges of the North American continent – the northern Cordilleran mountain belt and the Arctic Ocean. Both tectonic provinces share a long and complicated history dating back to the Neoproterozoic breakup of Rodinia and subsequent development of the western (Cordilleran) and northern (Franklinian) continental margins of Laurentia. In the middle Paleozoic, passive margin deposition was interrupted along the Franklinian margin by compressional and strike-slip tectonism, culminating in the Late Devonian-Early Mississippian Ellesmerian orogeny, while western Laurentia witnessed onset of subduction and development of a convergent margin. These tectonic events are inferred to relate geodynamically with large-scale terrane displacements from the Arctic realm into northeast Panthalassa in the Paleozoic. The subsequent Mesozoic construction of the Cordilleran accretionary orogen is closely linked with Cretaceous opening of the Canada Basin; and the Tertiary onset of the Aleutian trench and development of the modern transform margin of northwestern North America coincide with opening of the North Atlantic and Eurasian basins.

To help refine understanding of the geological evolution of the region, we present detrital zircon U-Pb and Hf isotopic data for 19 sandstone and conglomerate samples from Neoproterozoic to Tertiary strata collected across North Yukon, between ~69°15’N and 67°10’N. Neoproterozoic-Cambrian strata exhibit distinct Precambrian sources, with dominance of Paleoproterozoic zircons (peak at 1.8-1.7 Ga) in northern samples and abundant Mesoproterozoic grains (1.5-1.0 Ga) in the south; signals that compare well with coeval strata along the Franklinian margin.

Precambrian zircons from Carboniferous and younger strata reflect mostly recycling of local older strata. Carboniferous conglomerates all show Late Devonian peaks (378-365 Ma) consistent with erosion of nearby granites. Triassic to Paleocene samples yielded a range of Neoproterozoic-Paleozoic zircons recycled from nearby Devonian flysch. Most significantly, these samples also yielded juvenile zircons that are close to depositional age, but for which arc sources are only known in southern Yukon and Alaska, more than 700 km away.

Hf Isotopic Signature of Northern Cordilleran Terranes: Implications for Tectonic History and DZ Methodology

Gehrels, George (University of Arizona, ggehrels@email.arizona.edu)
McClelland, William (University of Iowa)

Hf isotope data sets have recently become available for a variety of terranes in the northern Cordillera and Arctic regions, including the Mystic (Malkowski and Hampton, 2014), Alexander (Beranek *et al*., 2013; Tochilin *et al*., 2014; White *et al*., 2016), Yukon-Tanana (Pecha *et al*., 2016), Taku (Giesler *et al*., 2016), Wrangellia (Gehrels and McClelland, 2011), Doonerak (Strauss *et al*., 2017), and Pearya (Malone *et al*., 2018) terranes as well as the Franklinian and Sverdrup basins (Rohr *et al.,* 2010; Anfinson *et al*., 2012; Midwinter *et al*., 2016). Epsilon Hf values that have been measured from detrital zircons in Paleozoic-lower Mesozoic strata from these terranes record significant variations in the involvement of juvenile versus evolved crust during magmatism. Although connections among the various terranes are uncertain, and there are differing models for primary ties to Laurentia, all record a consistent set of "pull-downs" in epsilon Hf which coincide with well-known phases of orogenic activity/crustal thickening along Laurentia's northeastern and northwestern margins. The pull-downs and their apparently associated orogenic phases occurred at ~475 Ma (Taconic), ~420 Ma (Caledonian), ~360 Ma (Ellesmerian-Antler), and ~270 Ma (Klondike-Sonoma).

Similarities in Hf isotope patterns with tectonic events along the Arctic and Cordilleran margins support current models in which all of these terranes formed in a complex but coherent orogenic system along the Arctic and then northern Cordilleran margins, and also demonstrate that Hf isotopes of detrital zircons provide a powerful tool for analyzing terrane connections and correlations, sedimentary provenance, and source terrane characteristics. Hf isotope signatures from these assemblages may also provide insights into tectonic processes, as the magnitude of evolved/juvenile variations is similar to excursions observed during supercontinent assembly/breakup, and the time scale resembles currently popular models for orogenic cyclicity.

To facilitate use of Hf isotope information, we offer several new types of diagrams that portray both U-Pb and Lu-Hf data in the time domain. For provenance, U-Pb Crystallization Age is plotted against Source Terrane Age, which is the average age of source materials from which the zircons crystallized (T_{DM}). For source terrane characterization, Crystallization Age is plotted against Crustal Residence Time (T_{DM} – $T_{crystalization}$). And for tectonic classification, Crustal Residence Time (T_{DM} – $T_{crystalization}$) is plotted against Lag Time ($T_{crystalization}$ - $T_{deposition}$). The latter provides a powerful tool for coordinated analysis of surficial processes (e.g., erosion, transport, deposition, recycling), and deep-crustal processes (e.g., crustal thickening, crustal melting, magmatism).

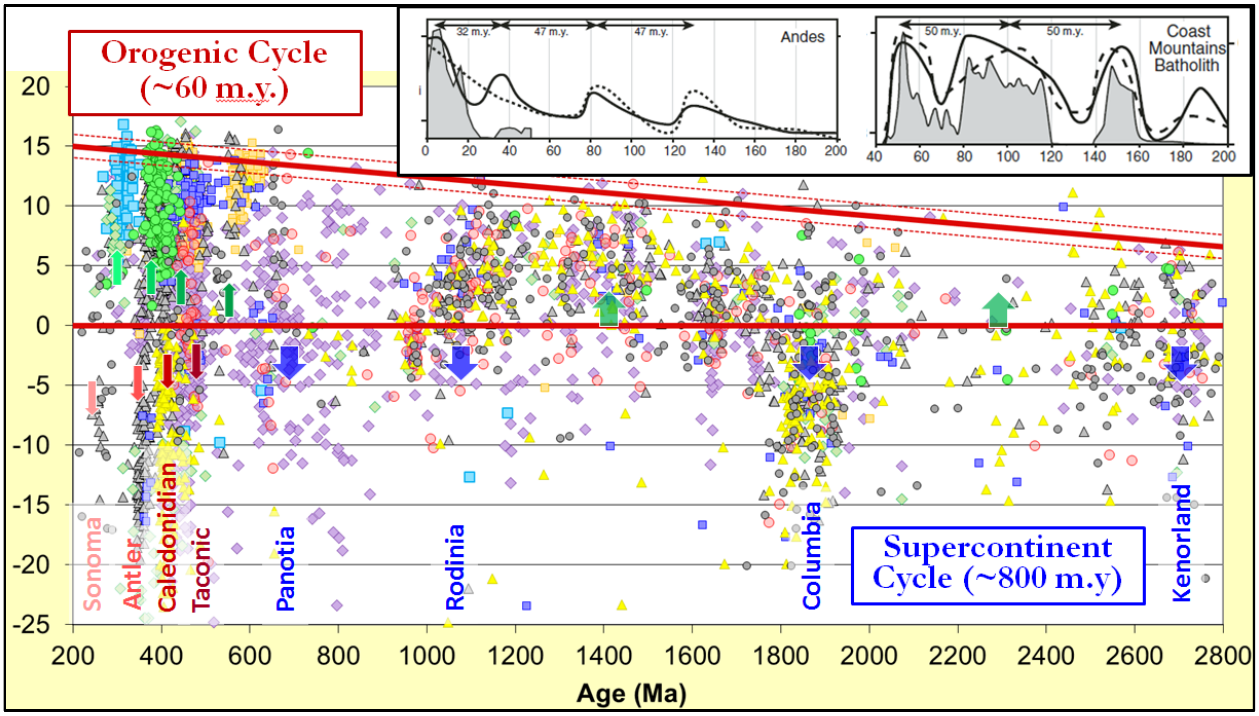

Figure 1. Plot of available U-Pb/Hf data for northern Cordilleran and circum-Arctic assemblages. "Pull-ups" and "pull-downs" in epsilon Hf are interpreted to record cyclic processes of crustal thinning/thickening that control the proportions of juvenile/evolved crust involved in magmatism.

Some thoughts on Late Paleozoic to Early Mesozoic geologic evolution of Wrangellia

Steve Israel (YGS), Luke Beranek (MUN), Bill McClelland (U of Iowa) and Rosie Cobbett (YGS)

Wrangellia has long been considered one of the largest and most exotic terranes in the North American Cordillera and although a tremendous amount of new information has been produced from these rocks, there are still many questions as to how the terrane fits into the larger tectonic framework. Complicating factors in trying to understand Wrangellia stem from the fact that it has a long geologic history, from Devonian to Late Triassic, and that rocks of the terrane are found from Alaska all the way to the lower forty-eight states. We present new geochronology, geochemistry and stratigraphic relationships that aim to answer some of these questions, but also opens doors to new questions.

In Yukon and Alaska, Paleozoic Wrangellia is characterized by Mississippian to Permian volcanic and sedimentary rocks of the Skolai Group. The oldest rocks (ca. 352 Ma) are non-arc basalt intercalated with chert and intermediate to felsic crystal tuff of the lower Station Creek Formation. These are overlain by Pennsylvanian, intermediate to mafic volcanic and volcaniclastic rocks of the upper Station Creek Formation that pass gradationally into marine mudstone, sandstone, conglomerate and carbonate of the Permian Hasen Creek Formation. The Skolai Group rocks have been deformed and unconformably overlain by Middle and Late Triassic sedimentary and volcanic rocks. The age of this deformation is not known, but must pre-date deposition of Middle Triassic sediments and volcanics. Late Permian mica cooling ages from the Alexander terrane (thought to be at least in part the basement to Wrangellia), may reflect this deformation event.

Six detrital zircon samples of Permian Wrangellia from Yukon and one from Vancouver Island indicate that much of the Permian strata is sourced from the underlying volcanic sequences, and possibly older basement. Detrital zircon peaks from Wrangellia are remarkably similar to the Mystic subterrane of the Farewell terrane located in Alaska and may suggest that Permian strata from Wrangellia are part of a much larger regional overlap assemblage found across several terranes.

Newly recognized Late Triassic (ca. 220-216 Ma) volcanic and magmatic rocks overlie and intrude Paleozoic and older Triassic stratigraphy. These rocks are intermediate to felsic in composition and have calc-alkaline, arc-like signatures. It is possible that these rocks represent the initiation of the Talkeetna-Bonanza arc system that formed across Wrangellia, mainly in the Early Jurassic.

Revised stratigraphy of the Hazelton Group in the Iskut River region, northwestern British Columbia

JoAnne Nelson[1a], John Waldron[2], Bram van Straaten[1], Alex Zagorevski[3], and Chris Rees[4]

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The Iskut River region hosts many significant porphyry, precious-metal vein and volcanogenic massive sulphide deposits. Most of these deposits are related to the Hazelton Group (latest Triassic to Middle Jurassic) and affiliated intrusions. Current knowledge of the Hazelton Group is the outcome of piecemeal, local mapping contributions over many years by different workers at different scales, resulting in inconsistencies and errors in stratigraphic nomenclature. Given that exploration interest in the region remains high, and that considerable work has recently been done in the region, a reappraisal of this nomenclature, applying provisions in the North American Stratigraphic Code is required. In our new stratigraphic framework, newly recognized units are given local geographic names; others are correlated with previously established units. Two newly defined lowermost Hazelton units, the Klastline formation and the Snippaker unit, are latest Triassic, showing that earliest Hazelton volcanism and sedimentation were coeval with formation of the Red Chris porphyry deposit. These, along with siliciclastic rocks of the Jack Formation (Lower Jurassic) and mainly andesite successions such as the Betty Creek Formation, comprise the lower Hazelton Group. The upper Hazelton Group includes the Iskut River Formation (mainly Aalenian-Bajocian) comprising the bimodal volcanic-sedimentary succession within the Eskay rift that hosts the Eskay volcanogenic massive sulphide deposit; mainly sedimentary units such as the Spatsizi Formation and Quock Formation that occur throughout central Stikinia; the Mount Dilworth Formation, a stratified Middle Jurassic felsic volcanic unit that occurs outside but near the Eskay rift; and the Edontenajon formation (new informal name), an unusual Pleinsbachian-Toarcian bimodal volcanic-sedimentary sequence that outcrops near the hamlet of Iskut.

Jurassic stratigraphy and tectonic evolution of the Whitehorse trough, central Yukon: New insights from laser ablation split stream (LASS) detrital zircon U-Pb geochronology and Hf isotope geochemistry

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The sedimentary rocks of the Laberge Group in central Yukon record the Late Triassic to Middle Jurassic exhumation and erosion of the Intermontane terranes (Stikinia, Quesnellia, Yukon-Tanana, Cache Creek) and tectonic evolution of the Whitehorse trough. Marginal-marine and deep-marine rocks of the Laberge Group unconformably overlie shallow-water, arc marginal rocks of the upper Lewes River Group (Mesozoic Stikinia) and represent a rapid change in depositional environments. New field observations document the lateral variation of depositional environments from north to south and the unconformable relationships between basal Laberge Group strata and underlying rocks of Stikinia. Detrital zircon U-Pb and Hf isotope studies have been conducted with the novel laser ablation split steam (LASS) technique to yield further constraints on maximum depositional ages, provenance, and tectonic significance of the Laberge Group strata.

The Tanglefoot formation, which is comprised of marginal-marine to tidal strata with intervening mass-flow conglomerate, is restricted to the northern apex of the trough. The Richthofen formation, which is comprised of turbiditic strata and mass-flow conglomerate, characterizes the central region of the trough. This indicates a southward deepening of Laberge Group strata. Basal Laberge Group strata overlie various units of the Lewes River Group, including Norian to Rhaetian limestone, limestone conglomerate, and the Carnian Povoas formation, which suggests there was variable topography in the Whitehorse trough during the Early Jurassic. Detrital zircon samples from the Tanglefoot and Richthofen formations yield maximum depositional ages that range from Late Triassic to Early Jurassic. Maximum depositional ages of basal strata from this study support a westerly transgression of strata from the axis of the trough as well as a potential easterly transgression after the initial uplift of the trough shoulders. Dominant Late Triassic (Carnian) and Late Triassic to Early Jurassic age peaks are consistent with Laberge Group strata being sourced from Mesozoic arc successions of Stikinia and 216-178 Ma plutons that intrude the Intermontane terranes. Minor late Paleozoic age peaks similarly indicate provenance from arc successions of Stikinia, Quesnellia and Yukon-Tanana (e.g., Takhini, Klinkit assemblages). Late Paleozoic age peaks are absent in basal strata located in western regions of the trough, which indicate multiple paleodrainage pathways and source regions for basal Laberge Group strata. Detrital zircon Hf isotopic compositions range from juvenile to evolved and thus indicate a progressive change from Late Triassic mantle-derived to Early Jurassic crustally-contaminated magmatism.

Cretaceous magmatism in the Teslin Mountain & Lake Laberge area, Yukon

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Cretaceous magmatic activity in the Cordillera occurred during continuous eastward subduction of the Kula, Farallon and Resurrection plates under North America following Middle to Late Jurassic accretion of volcanic arcs to the margin. This resulted in crustal shortening and thickening of the Cordilleran orogen. In addition, large scale transpressional to transtensional settings produced pathways for post-accretionary arc activity and mineralization.

Recent bedrock mapping in the Lake Laberge area, south-central Yukon, identified Cretaceous magmatic bodies and dikes intruding Middle Triassic to Middle Jurassic stratigraphy. Three large plutons are exposed southwest of Joe Mountain (Cap Creek pluton), southwest of Teslin Mountain (Laurier Creek pluton), and at Teslin Mountain (Teslin Mountain pluton); the extrusive equivalent Open Creek volcanic complex is exposed north of Teslin Mountain. In addition, a discrete but pervasive intrusive igneous system is composed of hundreds of dikes. Plutons and dikes are dominated by calc-alkaline, I-type granite and granodiorite composed of plagioclase, quartz ± biotite and/or hornblende crystals. Mafic to intermediate dikes (gabbro to diorite) are reported along the regional Goddard dextral strike-slip fault. Preliminary geochronology identified five distinct age trends within the magmatic rocks, ranging from Early to Late Cretaceous. Most ages are related to known plutonic suites, such as the Teslin, Whitehorse (middle Cretaceous), and Rancheria suites (Late Cretaceous). The Open Creek volcanic complex (Late Cretaceous) is spatially and temporally related to the Teslin Mountain pluton. Two of the four dikes dated returned ages between 138-136 Ma, a previously unrecognized magmatic suite in the Yukon and informally named the Goddard suite.

Cretaceous dikes and plutons are spatially associated with mineral occurrences, including Cu-Mo porphyry, Cu or Mo skarn, and vein-associated Au. Therefore, the study of these Cretaceous magmatic systems not only provides better understanding of the timing and mechanisms of orogen formation, but is also important for further mineral exploration.

Margin-Parallel translation of the Cretaceous-Paleocene Yakutat terrane, Alaska

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The Yakutat terrane is a composite terrane comprised of a Paleocene oceanic basaltic unit (unnamed) and Upper Cretaceous-Paleocene flysch and mélange of the Yakutat Group. Detrital zircons in the Yakutat Group flysch and Yakutat Group mélange are essentially identical which appears to out rule previous correlations to comparable units in the Chugach terrane. Detrital zircon facies have a maximum depositional age (MDA) range of ~60 to 72 Ma and primary grain-age populations occur at 73-74 Ma, 90-91 Ma, 1370-1380 Ma, and 1705-1710 Ma. Distinctive Precambrian zircons have Cretaceous metamorphic rims that grew between 67 and 90 Ma and they were derived from a metamorphic source terrane that was exhumed rapidly at ~85 Ma. Correlation of geologic units and comparison of distinctive detrital zircon facies allow for comparisons to units in the Pacific Northwest and California. The Yakutat Group mélange is a sedimentary mélange dominated by sandstones, most of which are arkosic with white mica, and they also contains slices and phacoids of marble/greenstone, metaigneous blocks, and chert. The age of the inclusions, and the distinctive ages and isotopic signature of the arkosic facies is identical to age-correlative units of the Nanaimo Group and the Western Mélange Belt in the Pacific Northwest. We suggest that these three distinctive units were originally together at the southern end of the Baja BC block (southern Vancouver Island) in the Paleocene, but were excised and translated northward after initial collision of older units of the Siletz terrane. This scenario implies that the location of the Kula-Farallon ridge was initially south of the North Cascades-San Juan thrust system, but then jumped rapidly northward in the Eocene, perhaps due to subduction of north-stepping transform segments. Eocene to Miocene translation of the Yakutat terrane was accommodated by strike slip faulting along the western margin of the Canadian Cordillera, and a primary result was the truncation of units along that margin. The original depositional setting of the Yakutat Group in the Maastrichtian may have been along the Southern California arc because it has a similar provenance to the correlative Orocopia Schist.

Cenozoic deformation and rock exhumation at the Yakutat-North American collision zone

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The high mountainous topography of southeast Alaska and southwest Yukon is the result of the ongoing oblique subduction and collision of the Yakutat microplate with the North American Plate. Of particular interest is the region of the St. Elias syntaxis that formed at the eastern corner of the indenting Yakutat microplate. In this region, the strike-slip motion along the dextral Fairweather Fault changes to convergence in a structurally complex pattern that is largely unknown due to remoteness and heavy glaciation. Numerical modeling studies suggest strain concentration accompanied by high vertical uplift focused in the syntaxis region, and partitioning of strain that is partially transferred farther inboard in the North American Plate into Yukon.

Surface uplift combined with erosion results in the exhumation of rocks from deeper crustal levels, which can be quantified by thermochronology methods such as fission track and U-Th/He dating. In particular, detrital thermochronology of sediments derived from glaciers has been successful for investigating the spatial and temporal pattern of exhumation in the St. Elias Mountains underneath the ice. This paper presents detrital apatite and zircon fission-track data derived from sediment of glaciers draining the St. Elias Mountains towards the coast (SE Alaska) and the northeast (SW Yukon), as well as bedrock thermochronology data from the ice-free mountain ridges. Integrating the new data from the Canadian side with the Alaskan data and other geologic and geophysical observations reveal the deformation and thermal history of the different terranes that have been accreted to the North American margin since the late Mesozoic. The efficient interaction between tectonic uplift and glacial erosion resulted in rapid exhumation (>1 km/Myr) on the wet coastal side and much lower rates (<0.5 km/Myr) on the dry northern side. At the syntaxis region extreme rates of more than 4 km/Myr occur in a localized region that shifted from north to south over the past 10 Myr. This exhumation pattern is accommodated by an evolving positive, two-sided flower structure that resulted temporarily in localized deep-seated rock exhumation. The new data from the Yukon side reveal that rock exhumation due to Yakutat collision is spatially very limited to <30 km northeast of the plate boundary, and the majority of rocks composing the Kluane Range record Mesozoic cooling.

Fault Rock Evolution, Preliminary Geochronology, and the Record of Ductile to Brittle, Late Eocene-Late Miocene Strain Partitioning Along the Denali Fault Zone in Southwestern Yukon, Canada

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Subsidiary brittle damage can be kinematically linked to the Denali master fault in bedrock exposures at three localities in the Kluane Ranges. The damage includes synkinematic hematite coated calcite, hematite coated chlorite, and carbonaceous material coated slip surfaces along major and minor subsidiary faults. At the southwest end of Kluane Lake where the principal slip zone is not exposed, exposures of Wrangellian metavolcaniclastic rocks and greenstones host reverse-slip kinematic indicators that are consistently overprinted by strike-slip indicators. Linking these data with the concealed main trace of the Denali fault is established from co-linear primarily reverse fault mean orientations ($\bar{x}$=324/82, n=87) and ~co-planar with strike-slip faults ($\bar{x}$=337/83, n=60) that are also, on average, co-oriented with each other. Computed best-fit kinematic shortening directions also are co-axial ($P_{dip\ slip}$=02/229 and $P_{strike\ slip}$=05/223).

Full bedrock exposures of the Denali fault zone are found 30-40 km south of Kluane Lake at Telluride and Kimberley Creeks. Greenschist facies, carbonaceous metapelites of the Mississippian to Permian Hansen Creek formation to the SW are juxtaposed against Late Triassic altered, ultramafic and greenschist metavolcanic rocks of the Bear Creek assemblage to the NE at Telluride (Israel et al., 2014). At Kimberley, Late Triassic greenstones to the SW are juxtaposed against Bear Creek siliciclastic and metavolcanic mélange to the NW. At each locality, a complex, central principal slip zone (PSZ) is ~10 to 35 m wide and is composed of intercalated qtz±kao±mus±illite±carbonaceous-material±alb±kspar±cal±py mylonites and overprinting cataclasites. Bear Creek ultramafic rocks in the NE PSZ have undergone fault-related carbonate and Cr-rich mica (CRM) alteration. CRMs are present as foliated stringers in mylonites, veins, and disseminations in the NE PSZ, but also as disseminations in isoclinally folded qtz±cal stringers in metapelite of the SW PSZ. Synkinematic calcite, quartz, carbonaceous clay, and hematite coated slip surfaces are found in the PSZ and damage zones.

At Telluride, dip-slip faults are primarily reverse ($\bar{x}$=312/84, n =17) and ~co-planar with strike-slip faults ($\bar{x}$=143/86, n=28) with ~co-axial best-fit shortening directions (P_{ds}=00/021 and P_{ss}=00/004). At Kimberley, best-fit reverse ($\bar{x}$=298/81, n=4), normal ($\bar{x}$=121/85, n=12) and strike-slip ($\bar{x}$=333/83, n=37) faults show P_{rev}=08/033, T_{nor}=13/015, P_{ss}=06/190 where strike-slip overprints normal slip, and carbonaceous fault rocks with complex flattening strains are overlain by a brittley deformed Oligocene Amphitheater-like conglomerate.

Telluride CRM samples from both sides of the PSZ yielded four $^{40}Ar/^{39}Ar$ plateau ages of 33.4 ± 0.3 to 40.3 ± 1.4 Ma. Fault-related authigenic and “detrital” illite polytypes are found in the Kimberley PZS. Encapsulated $^{39}Ar/^{40}Ar$ geochronology results in authigenic total gas ages spanning ca. 9.2 to 17.6 Ma and “detrital” illites of ca. 22.9 Ma. CRM and illite ages from fault-related rocks provide evidence that the fault zone from Telluride though Kimberley was active from the Late Eocene through Late Miocene, consistent with regionally extensive strain localization (cf. Roeske et al., 2012) and local sedimentation patterns. Folded mylonites overprinted by cataclasites, brittle reverse- and normal-slip faults consistently overprinted by strike-slip faults provide a complex, bedrock record of strain compatibility, reactivation, transpressional and transtensional deformation in the ductile and brittle regimes.

Oroclinal bending in the Cascadia subduction zone forearc and its relation to concave plate margin geometry

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Many convergent margins worldwide are concave in map pattern towards the overriding plate, but some (e.g., Cascadia, Bolivia) exhibit concavity towards the lower plate. In Cascadia, this geometry persists throughout the forearc, and backarc-foreland, and likely results from a persistent tectonic process affecting the long-term evolution of the margin. We examine the concave-outboard Cascadia margin and find that several datasets are consistent with continuous oroclinal bending of the forearc. Paleomagnetic declinations, structural measurements, and volcanic arc migration rates indicate that oroclinal bending began in the forearc in the Eocene to Miocene. Crustal rotations derived from both paleomagnetic declinations and GNSS (Global Navigation Satellite System) measurements share a NE-SW axial trace across the Olympic Peninsula, suggesting that oroclinal bending continues in the present day. Crustal fault kinematics and stress inversions from crustal earthquakes are consistent with tectonic models of oroclinal bending, where compression in the core of the orocline and extension on the periphery result in opposing strike-slip kinematics in each limb. Compression in the core of the orocline may also have a physiographic manifestation in the form of the Olympic Mountains, a prominent topographic feature in the forearc. Both the shape of the locked portion of the plate interface and the obliquity of convergence may have causative roles in orocline formation. The coincidence of the widest part of the locked-zone with the maximum interseismic forearc velocity and the axial trace of the orocline leads us to suggest that some inelastic strain in the Cascadia forearc occurs in direct response to locking on the subduction megathrust; thus the shape of the subduction megathrust has long-term effects on the shape of the upper plate. Alternatively, orocline formation may be a product of margin parallel translation of the upper plate arc and forearc, and the shape of the subduction zone a response to, rather than a cause of, oroclinal bending.

Canadian Cordilleran deformation supports the concept of a "continental bulldozer"

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Latitude changes of the North American craton during Mesozoic-Cenozoic time (Kent and Irving, 2010) combined with longitudinal craton movement based on Atlantic spreading and the proposal (Torsvik *et al*., 2008) that Africa has been the least mobile continent since the late Paleozoic, outline a probable trajectory for the North American craton since the early Mesozoic. A summary review of style and timing of deformation in the Canadian Cordillera, when correlated with times of trajectory changes, supports many previous suggestions that absolute motion of the craton is the primary driver of Cordilleran mountain-building.

During the past ~240 million years, the western margin of the Laurasia-North America Plate has been the site of arc magmatism where weak arc/back arc lithosphere, sandwiched between strong ocean and craton lithospheres intermittently coupled across convergent or transform plate boundaries, focused strain that is recorded by Cordilleran structures. The distribution and style of structures formed within the "soft plate margin", which was oriented ~meridionally, mirror changes in the North American craton trajectory. Structures formed when the craton moved due westward record dominant orogen-normal compression: between ~180-160 Ma, all arc terranes were accreted and orogeny was initiated in the eastern Cordillera; between 120-60 Ma, the entire Cordillera emerged. Before and between these intervals, when the craton moved northwestward, structures record southward (sinistral) movement relative to the craton in the collage of accreted terranes. After ~60 Ma, southwestward craton movement coincided with northward (dextral, relative) displacements that disrupted the newly-established orogen. The coincidence between times of orogeny when the craton moved due westward and orogen-parallel displacements when craton motion had a northward or southward component is evidence that the craton acted as a "continental bulldozer" whose engine, according to Bokelmann (2002), was asthenospheric flow acting on the ±300 km deep lithospheric "keel" of the North American craton.

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New Perspectives on the Coast Mountains Batholith

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The Coast Mountains Batholith (CMB) is similar to other Cordilleran batholiths in consisting of plutonic/metamorphic rocks and ductile shear zones of Late Jurassic to Eocene age. To first order, magmatism youngs eastward, with Late Jurassic (160-140 Ma) and Early Cretaceous (120-100 Ma) magmatism along the west flank of the orogen, Late Cretaceous-Paleocene (100-60 Ma) magmatism in the central core, and Eocene (60-50 Ma) magmatism along the eastern flank.

Available U-Pb geochronologic data (~500 U-Pb ages) demonstrate that the detailed age pattern is much more complex. In the central portion of the batholith (Portland Canal to Cape Caution), U-Pb ages record a history of (1) eastward-migrating Late Jurassic-Early Cretaceous magmatism along the west flank, (2) non-migrating Late Jurassic-Early Cretaceous magmatism along the east flank, and (3) Late Cretaceous-Eocene magmatism that welded the two segments together and migrated eastward (Gehrels *et al*., 2009). This duplication of Late Jurassic-Early Cretaceous magmatic belts was ascribed to ~800 km of motion along a sinistral fault that brought the western belt outboard of the eastern belt (following Monger *et al*., 1994). In the southern portion of the batholith, the lack of eastward-younging ages, as described by Friedman and Armstrong (1995) and Cecil *et al*. (2016), and supported by paleomagnetic data (Rusmore *et al*., 2013), suggest that Late Jurassic-Early Cretaceous plutons in the southern portion of the batholith belong entirely to the non-migrating/eastern belt.

Geochemical information acquired from the central portion of the batholith provides an interesting record of magma petrogenesis and crustal evolution. For the western/migrating belt, rates of magmatic addition can be reconstructed from the geochronologic record adjusted for the areal distribution of each magmatic component (Fig. 1). The resulting record of high rates of magmatic addition at 160-140 Ma, 120-80 Ma, and 60-50 Ma is similar to other portions of the Cordilleran margin. Available Sr, Nd, and Hf isotopic and La/Yb elemental data suggest that high-flux magmatism involved thicker/older crust, whereas magmatic lulls involved thinner/more juvenile crust (Cecil *et al*., 2011; Girardi *et al*., 2012). Variations in U/Th record a dramatic influx of metamorphic fluids at 105-80 Ma and 60-50 Ma. All of these patterns show a moderate correlation with rates of convergence of the Farallon and Kula plates (Fig. 1).

A tectonically conservative interpretation is that all batholith components formed near their present position along a west-facing convergent margin system built along the western margin of North America (e.g., Armstrong, 1988; van der Heyden, 1992), perhaps with ~800-1200 km of sinistral-then-dextral motion along the coast (Gehrels *et al*., 2009). More mobilistic interpretations posit that (1) the eastern and western segments of the batholith are separated by a fault (the Coast Shear Zone) that has 2000-1500 km of 85-60 Ma dextral displacement (e.g., Hollister and Andronicos, 1997), (2) the batholith formed on a ribbon continent that was located farther south and outboard of the Cordilleran margin during Late Cretaceous-early Tertiary time (Johnston, 2001), and (3) Late Jurassic magmatism formed in two different subduction systems that faced each other until ~140 Ma, followed by west-facing magmatism after ~140 Ma (Sigloch and Mihalynuk, 2013, 2017). No single model is consistent with all available geologic, geochronologic, faunal, detrital zircon, and paleomagnetic data.

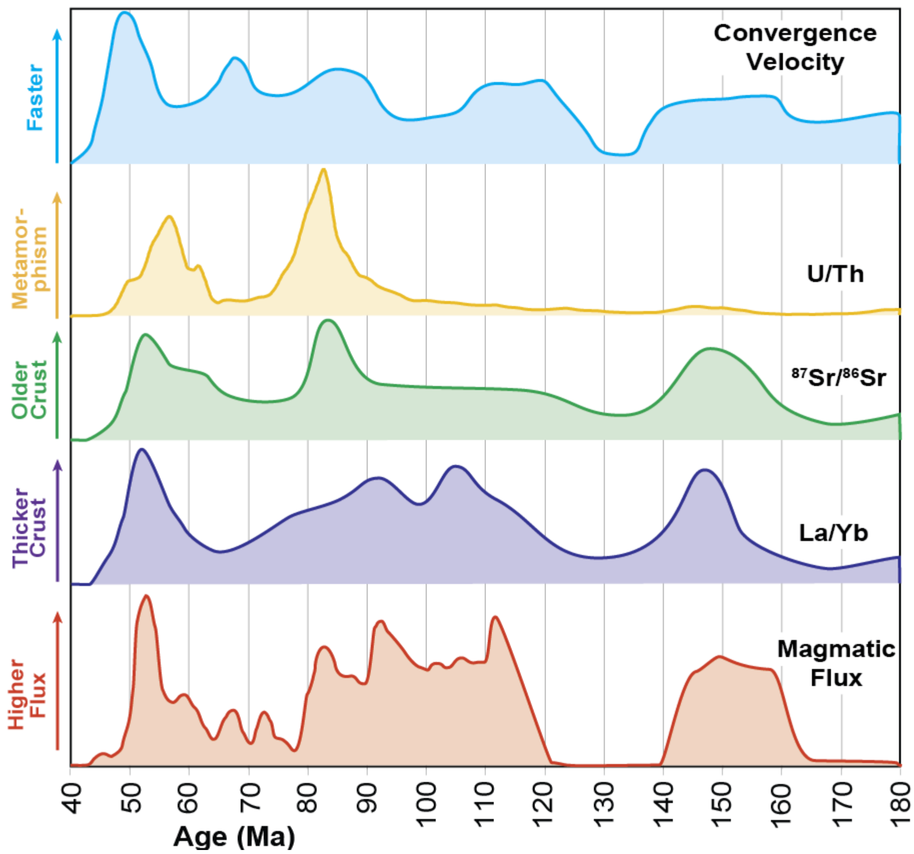

Figure 1. Summary of information available for the central Coast Mountains batholith: magmatic flux and U/Th curves from Gehrels et al. (2009), $^{87}Sr/^{86}Sr$ and La/Yb data from Girardi et al. (2012), and convergence velocities for the Farallon and Kula plates (from Muller et al., 2016, calculated for the latitude of Prince Rupert using Gplates).

Lithostratigraphic Control on Structural Style and the Impact on Hydrocarbon Distribution in the Foothills of British Columbia

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The foothills of the Canadian Rockies in British Columbia have some significant differences from the Alberta foothills located along strike to the south. Large displacement thrusts in the foothills of British Columbia are rare and the deformation style is dominated by folding above thrusts with relatively small displacements. Within the foothills of Alberta and British Columbia there are also systematic variations in structural style from south to north that can be related to facies changes in the Paleozoic and Mesozoic stratigraphy (Fig. 1). These facies changes influence detachment levels, fold geometry and displacements on individual thrusts that are superimposed on cumulative changes in basement structure that occur across the Peace River Arch, the Fort St John Graben and the Hay River Fault zone. These features converge as they intersect the foothills belt near Williston Lake which is located at a major change in surface geology; Triassic strata dominate at outcrop to the north of Williston Lake, whereas mostly younger Mesozoic strata are exposed south of the lake. South of Williston Lake the foothills are dominated by thin-skinned deformation that creates a series of detachment and fault propagation folds, some of which host significant gas fields. To the north of Williston Lake there is extensive evidence of the reactivation of basement structures. Some of these basement structures show clear evidence of earlier extension controlling growth sequences; others appear to be inherited from strike slip fault systems.

The changes in structural style and the hydrocarbon field distribution for a series of key conventional and unconventional plays are illustrated in a series of maps and regional cross-sections. Alternative visualisations of the regional cross sections have been constructed to show the variations in lithofacies rather than stratigraphic units (Fig 2). This helps to highlight the changes in mechanical stratigraphy from north to south which together with the influence of pre-existing basement structures are considered to be a significant influences on regional structural style, trap geometries and field distribution in the foothills (Fig 3).

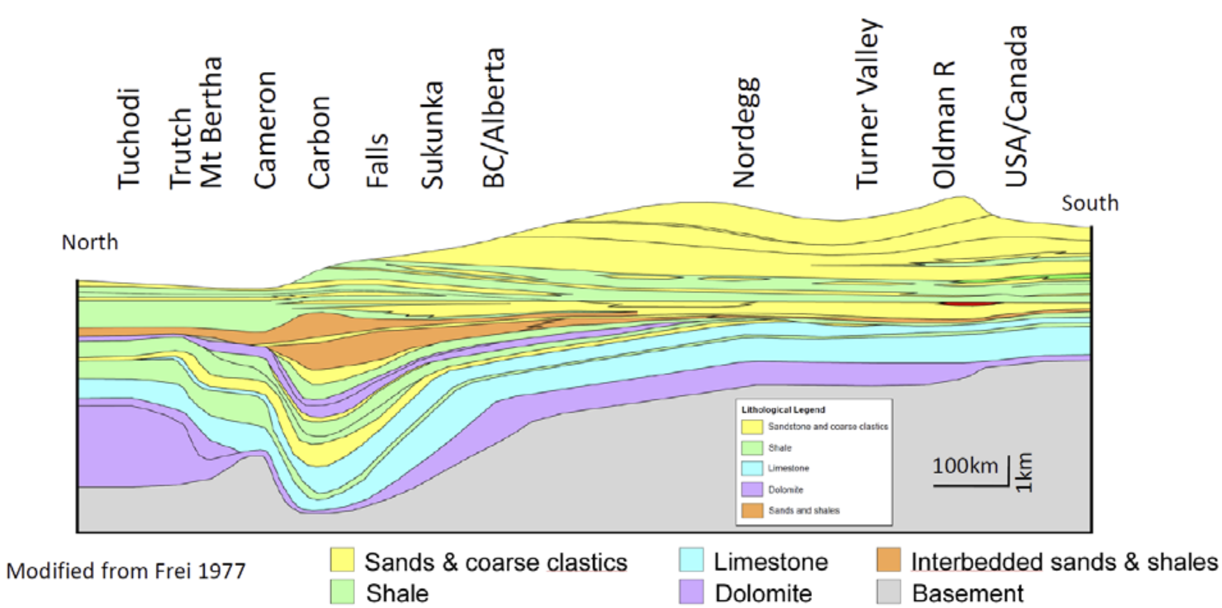

Figure 1. Lithological unit thickness variations in the foothills

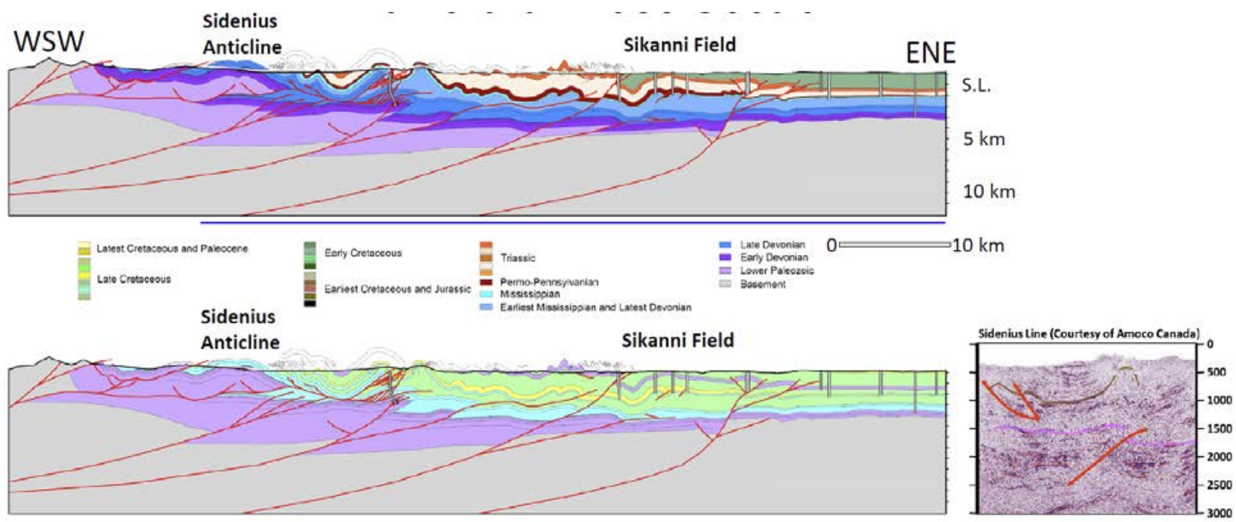

Figure 2. Mt Bertha structural cross section showing conventional colouring of units by formation in the upper section and the same section coloured by dominant lithology in the lower section. The legend for the lithologies is shown in Fig 1.

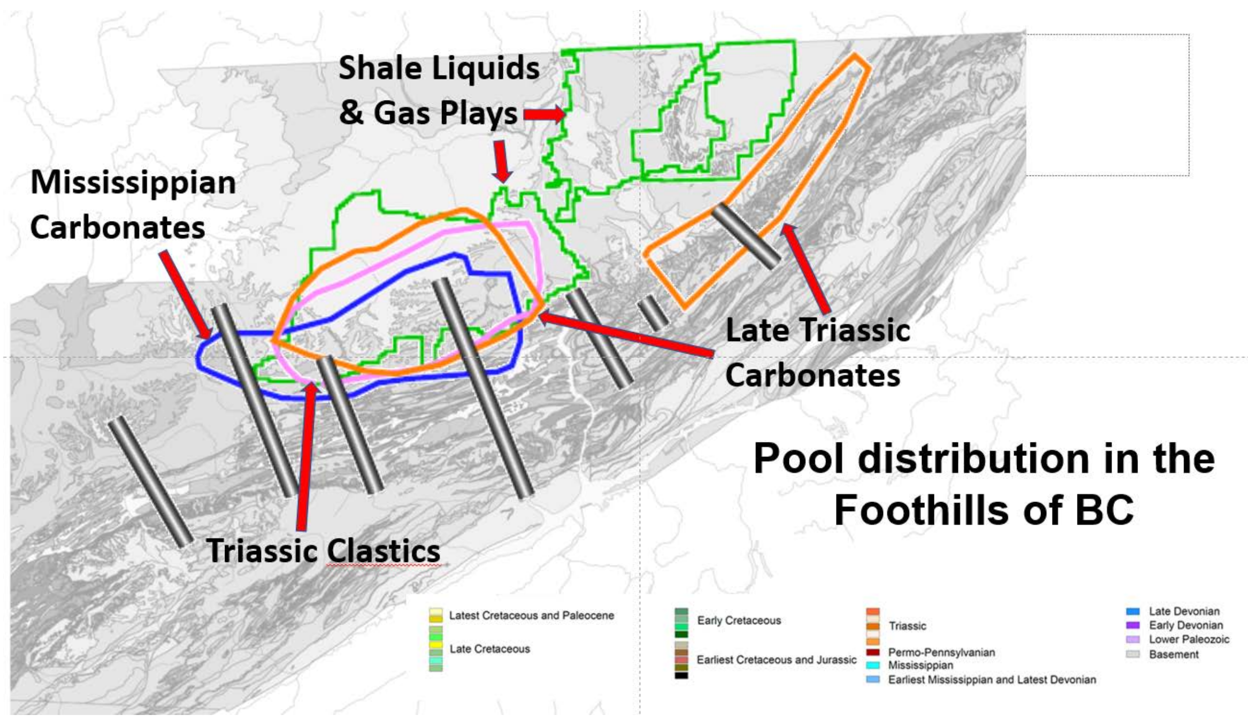

Figure 3. Selected foothills hydrocarbon plays located on a greyed out surface geology map showing the influence of structural style on play fairway distribution.

Relationship between magmatism, tectonics and porphyry copper systems in the Yukon-Tanana upland, eastern Alaska

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Presumed Cretaceous porphyry Cu(±Mo±Au) occurrences are scattered throughout the Yukon-Tanana upland in eastern Alaska and western Yukon. Known occurrences in eastern Alaska are poorly characterized despite a recent discovery and overall resurgence in exploration. New field mapping, drill core observations, petrography, geochemistry, and age dates allow for better characterization of the geologic and geochemical parameters of the porphyry systems and identify key linkages to regional tectonic and igneous events.

The Yukon-Tanana upland is largely underlain by structurally complex metamorphic rocks. They represent a variety of tectonic environments and are crosscut by Late Devonian to early Tertiary igneous suites. Porphyry systems and related mineralization are mostly associated with Jurassic and younger suites. At the LWM prospect, perhaps one of the oldest, hydrothermally altered dikes associated with carbonate-replacement mineralization yielded both UPb zircon and a sericite incremental heating ages of ca. 188-203 Ma. Mid-Cretaceous (ca. 115-90 Ma) magmatism was widespread and volumetrically significant and exhibits Ce- and Eu-isotopic evidence indicating crustal contributions. These felsic plutons seemingly lack mineralization in eastern Alaska, unlike in western Yukon. Instead, most known porphyry occurrences are associated with Late Cretaceous to earliest Tertiary suites of calc-alkaline granite-granodioritic plutons ranging from ca. 73 to 65 Ma. These systems contain classic porphyry-style mineralization characterized by quartz-sulfide veining with sericite, K-feldspar, and biotite envelopes and associated carbonate-replacement and skarn assemblages. Mineralization is vein controlled and disseminated throughout host rocks. Molybdenite is present in many systems (e.g. Taurus, Mosquito, Little Enchilada, Road Metal, LWM) and gold is reported in a few (e.g. Taurus, Road Metal). Pyrrhotite-pyrite-bearing assemblages are present in a few Late Cretaceous systems, whereas others are pyrite-chalcopyrite with distal specularite±magnetite. Tourmaline-rich alteration is abundant in some Late Cretaceous systems but absent in others.

Despite the extensive mid Cretaceous magmatism in eastern Alaska, there is little to no known mineralization extending 300 km along strike from the Pogo gold system in eastern Alaska through the western Yukon. In contrast, in eastern Alaska, the Late Cretaceous is characterized by volumetrically small stocks, dikes and plugs of intermediate to felsic calc-alkaline, more-oxidized arc plutons. Porphyry systems associated with these plutons exhibit diverse characteristics which are a function of the igneous composition, host rocks, and other geological factors.

Structural controls on gold in progressively deformed host rocks: examples from Phanerozoic orogenic gold districts of the Canadian Cordillera

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Orogenic gold systems typically form where progressive deformation of lithologically heterogeneous host rocks is responsible for dynamic changes in permeability structure and fluid flow. Although mineralization is typically introduced late in the deformational sequence, many orogenic gold systems contain earlier (and potentially cryptic) hydrothermal features that have been structurally overprinted. As a consequence, the structural and hydrothermal histories of orogenic gold systems are genetically and temporally inseparable. These relationships are examined using Mesozoic gold camps of British Columbia (Cariboo, Cassiar, Sheep Creek) and Yukon (Klondike, Sixtymile) as examples. In all districts, fold and thrust geometries, ductile strain fabrics, and vein orientations and kinematics are broadly consistent with orogen-normal shortening and orogen-parallel extension that is tectonically related to Jurassic to Cretaceous collision of Intermontane terranes with the ancient North American margin. Ductile overprinting of veins and altered wall rock is especially common in micaceous lithologies. New $^{40}Ar/^{39}Ar$ and U-Pb data constrain the timing of vein formation to 160 – 134 Ma in the Cariboo district, 143 – 129 Ma in the Cassiar district, and ~133 Ma in the Sheep Creek camp. A wide range of Middle to Late Jurassic cooling ages in the Klondike district suggest unresolved complexities in the structural and thermal history, and also hint at protracted hydrothermal activity. Collectively, geochronological data and structural field observations indicate that veins and mineralization formed diachronously in response to long-lived collisional strain. The earliest veins formed during incipient brittle failure of the progressively deforming rock mass, and are typically barren with respect to gold. Gold typically precipitated in low-strain, brittle environments during the terminal, retrograde stages of orogen-normal shortening, when the interconnectivity of fault-fracture networks and fluid flux were likely at their maximum.

POSTER ABSTRACTS

Alphabetically

Strike-slip fault controlled magmatism and mineralization of the Mount Freegold district, Yukon Territory (NTS 115/I2, 115/I6, 115/I7)

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New 1:25,000 scale mapping of Yukon's Mount Freegold district reveals the structural and magmatic framework for porphyry, skarn, and epithermal mineralization in the area, which includes over 2 Moz of gold in the Revenue and Nucleus deposits. The district coincides with a major extensional relay zone in the Big Creek fault – a regionally significant dextral strike-slip structure in which local zones of extension facilitated emplacement of mid- to Late Cretaceous plutons, hypabyssal stocks, dikes, and intrusive porphyry-breccia complexes. New mapping delineates a previously unmapped granite pluton at Mount Freegold that potentially represents the magma chamber feeding ca. 105 Ma dikes and associated gold-magnetite skarn mineralization of the Margarete and Augusta occurrences. In addition, the ca. 77 Ma Stoddart pluton is delineated, which locally hosts porphyry-style mineralization of the Stoddart Cu-Mo occurrence, and represents the magmatic roots of hypabyssal intrusive rocks at the Revenue Cu-Mo-Au-Ag deposit and Nucleus Au-Ag-Cu deposit. The relay zone in the Big Creek fault system is partly plugged by quartz syenite of the ca. 70 Ma Seymour Creek stock, which hosts copper mineralization in veins and also as magmatic copper sulphide in a mafic border phase. The Seymour Creek stock is cut by a southern strand of the Big Creek fault system, revealing episodic fault movement over a minimum 35 m.y. time interval, during which at least three separate epochs of magmatic-hydrothermal mineralization took place.

Controls on the rheological properties of peridotite at a palaeosubduction interface: a transect across the base of the Oman-UAE ophiolite

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Studies of experimentally deformed rocks and small-scale natural shear zones have demonstrated that volumetrically minor phases can control strain localisation by limiting grain growth and promoting grain-size sensitive deformation mechanisms. Such studies are often used to infer a critical role for minor phases in the development of plate boundaries. However, the role of of minor phases in strain localisation at plate boundaries remains to be tested by direct observation. To test the hypothesis that minor phases control strain localisation at plate boundaries, we conducted microstructural analyses of peridotite samples collected across the base of the Oman-UAE ophiolite. The base of the ophiolite is marked by the Semail thrust, which represents the now exhumed contact between subducted oceanic crust and the overlying mantle wedge. As such, the base of the ophiolite provides the opportunity to directly examine a former plate boundary.

Our results demonstrate that the mean olivine grain size is inversely proportional to the abundance of minor phases (primarily pyroxene), consistent with suppression of grain growth by grain-boundary pinning. Our results also reveal that mean olivine grain size is proportional to CPO strength, suggesting that the fraction of strain accommodated by different deformation mechanisms varied spatially. Experimentally-derived flow laws indicate that under the inferred deformation conditions the viscosity of olivine was grain-size sensitive. As such, grain size, and thereby the abundance of minor phases, influenced viscosity during subduction-related deformation along the base of the mantle wedge.

We calculate that viscosity and strain rate respectively decrease and increase by approximately an order of magnitude towards the base of the ophiolite. Our data indicate that this rheological weakening was primarily the result of more abundant secondary phases near the base of the ophiolite. Our interpretations are consistent with those of previous studies on experimentally deformed rocks and smaller-scale natural shear zones that indicate minor phases can strongly influence strain localisation. However, our study demonstrates for the first time that minor phases can control strain localisation at the scale of a major plate boundary.

Characterization and provenance of the Neoproterozoic “upper” Group in the Coal Creek Inlier, Ogilvie Mountains

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Neoproterozoic and lower Paleozoic rocks in Yukon generally record a protracted phase of extensional tectonism followed by passive margin sedimentation along the ancestral northwestern margin of Laurentia. The exact timing of the rift-drift transition is poorly understood and a lack of extensive exposure along the western margin of the Yukon block, a paleogeographic element of northwestern Laurentia, has made paleoenvironmental reconstructions difficult in the context of defining sediment source regions and correlating regional sequence stratigraphic boundaries. The Ediacaran “upper” Group of the Coal Creek inlier (Ogilvie Mountains) represents a key succession for comparison with correlative units elsewhere on the western margin of Laurentia to establish general provenance, paleogeographic setting, relative sea level fluctuations, and constraints on the timing of active tectonism during the Neoproterozoic-Cambrian; however, relatively few studies have examined the “upper” Group within the Coal Creek inlier and attempted to link provenance, geochemical, and stratigraphic data with other locations in northwestern Laurentia. During the Summer of 2017, our team established one fly camp in the Coal Creek inlier from which we measured twelve stratigraphic sections and collected a suite of samples for detrital zircon U/Pb geochronology, Lu/Hf isotopes, sandstone petrography, micropaleontology, carbonate carbon and oxygen isotopes, and Re-Os geochronology. These data will build upon previous work on the stratigraphy of the Coal Creek inlier and incorporate unpublished detrital zircon datasets from the region to establish a key provenance dataset for identifying potential source regions during Neoproterozoic-early Paleozoic tectonism along the northwestern margin of Laurentia.

Late Triassic to Middle Jurassic magmatism, sedimentation and tectonics in the Intermontane terranes of Yukon

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A series of Late Triassic to Early Jurassic granitoid plutons intrude the Intermontane terranes (Stikinia, Quesnellia, Yukon-Tanana) in southern Yukon. These are the northern continuation of two paired magmatic belts intruding Stikinia and Quesnellia in BC that converge in southern Yukon and peter out into eastern-central Alaska. In BC, these plutons are host to prolific Cu-Au porphyry deposits. The hairpin geometry of the Late Triassic-Early Jurassic magmatic belts form part of the argument that led to proposal of the oroclinal enclosure of the Cache Creek terrane.

In Yukon, the Late Triassic-Early Jurassic plutons define three magmatic suites: Stikine (216-214 Ma), Minto (204-194 Ma), and Long Lake (188-182 Ma) suites. Plutons of the Stikine suite are generally more mafic monzodiorite to quartz diorite, form small plutons and are restricted to Stikinia. They are inferred to represent upper crustal (<4 kbar), subvolcanic intrusions to basaltic andesite of the Lewes River arc (Stikinia). The Minto suite straddles the northern apex of Stikinia/Quesnellia in central Yukon. It comprises variably deformed granodiorite that were emplaced at lower crustal depths (5-7 kbar) and host high-grade Cu-Au mineralization (Minto, Carmacks). These plutons were emplaced during accretion of the Intermontane terranes to western North America and onset of orogenesis in the northern Cordillera. The slightly younger Long Lake suite comprises granodiorite and granite that were emplaced at shallower crustal level (3-6 kbar) during development of the syncollisional Whitehorse trough, following regional exhumation. Trace element and isotopic data for the Minto and Long Lake suites show decreasing subduction influence consistent with syncollisional emplacement and crustal thickening.

Concurrent with intrusion of the Minto and Long Lake suite, and exhumation of the Yukon-Tanana infrastructure, the Laberge Group records subsidence and marine sedimentation in the Whitehorse trough from Sinemurian to Bajocian. The Whitehorse trough was an axial trough flanked by highlands and characterized by near-shore facies in the north and deeper water deposits to the south, that were probably continuous with forearc deposits in the Cache Creek terrane. Detrital zircon in the Laberge Group were primarily locally sourced in the Late Triassic – Early Jurassic igneous rocks flanking Whitehorse trough, with minor contributions of Paleozoic zircons matching sources in Yukon-Tanana terrane (and inheritance in Jurassic plutons). The Whitehorse trough was deposited over Stikinia, Quesnellia and the Cache Creek terrane during initial convergence of the Intermontane terranes.

Middle Jurassic plutons of the Bryde suite (172-168 Ma) are post-collisional granitoids that intruded the amalgamated terranes and Whitehorse trough at shallow crustal levels. These plutons have alkalic tendencies and range from monzonite to syenite to granite compositions. They locally host porphyry Cu mineralization (Mars). They are isotopically juvenile and are reasonably interpreted as product of slab break off. The end of marine sedimentation and uplift of the nascent northern Cordilleran mountains are recorded by fluvial-lacustrine conglomerate and sandstone of the Upper Jurassic-Lower Cretaceous Tantalus Formation. Late Jurassic detrital zircons in the Tantalus Formation may be in part locally derived from the 163-161 Ma McGregor pluton, the youngest known Jurassic intrusion in the Intermontane terranes of Yukon, but younger zircons (159-148 Ma) are most likely exotic contributions from the Late Jurassic arc in the Insular terranes to the west.

Late Triassic mafic volcanism along the Insular-Intermontane terrane suture: insight from the Bear Creek assemblage, southwest Yukon

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The Bear Creek assemblage (BCA) in southwest Yukon is a package of deformed Late Triassic to Middle Jurassic metavolcanic, volcaniclastic, and clastic units originally mapped as part of the Nikolai Formation of Wrangellia. Stratigraphic interpretations from recent mapping and emerging geochronological and geochemical constraints challenge this correlation and open the door to new interpretations about the origin and tectonic importance of the assemblage. Whole rock geochemical data suggest mafic metavolcanics within the BCA were originally tholeiitic basalts. Trace element analyses record volcanism that transitions upwards from enriched mid-ocean ridge basalt (E-MORB) or ocean-island basalt (OIB) to MORB affinities within the stratigraphy. No geochemical evidence exists for arc volcanism or the close proximity of a volcanic arc. Building a better understanding of the tectonic setting of the BCA and its relationship to nearby terranes is key as extensive Triassic metallogenic belts exist in the region (e.g. magmatic Ni-Cu-PGE deposits of Wrangellia and VMS deposits of the Alexander terrane).

Evidence for an extensive ocean basin between the Insular and Intermontane terranes in Late Triassic to Middle Jurassic time has not been previously documented in southern Yukon or southeastern Alaska. Its presence has been speculated, however, based on geophysical and geodynamic modelling results. We present competing models for the documented volcanism in back-arc and mid-ocean rift settings. Geochemical comparisons with data from Late Triassic to Middle Jurassic basalts from surrounding terranes (Alexander, Wrangellia, Taku) and basins (Gravina belt) in SW Yukon/SE Alaska suggest similarities between the lower BCA and western Taku terrane, though the MORB signatures recorded in the BCA are not documented in the small number of Taku analyses. Correlation is supported by stratigraphic similarities. A BCA-Taku correlation would extend evidence for a Late Triassic ocean basin along the Insular-Intermontane suture from southwest Yukon to the southern-most extent of SE Alaska.

The Porcupine Shear Zone of northern Yukon and Alaska - evaluating large-scale terrane displacement in the Arctic

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The enigmatic Porcupine shear zone of northern Yukon and Alaska separates the North Slope subterrane of Arctic Alaska from the autochthonous northwestern margin of Laurentia. Although previous researchers have postulated large-scale Paleozoic and Mesozoic strike-slip displacement along this structure, others have argued for models of minimal-displacement based on the proposed similarity of Neoproterozoic-early Paleozoic strata across the fault zone. During the summer of 2017, we conducted field work along the Porcupine River in northwestern Yukon to: 1) assess the stratigraphy and provenance of Neoproterozoic–early Paleozoic(?) strata along the Porcupine Shear Zone, and 2) examine the displacement history of this major structure. Mesoproterozoic(?) to Neoproterozoic siliciclastic and carbonate rocks along the Porcupine River form semi-coherent to incoherent fault-bounded blocks with evidence for polyphase folding, faulting, and pervasive brecciation. Mafic dikes of presumed Neoproterozoic (ca. 720 Ma?) age cut the aforementioned strata and are locally highly deformed. Ongoing field- and lab-based research aims to address stratigraphic correlations (or lack thereof) between these strata within the Porcupine Shear Zone and coeval units on the opposite sides of the structure through a combination of carbon and strontium isotope chemostratigraphy, Nd isotope geochemistry, and U-Pb/Hf detrital zircon geochronology. Resolving the timing and nature of magmatism in this region will also provide further means of correlation across the northern margin of Laurentia. This summer (2018) we will conduct detailed structural mapping across the border into eastern Alaska. This will be accompanied by sampling of early to late Paleozoic strata to provide a more thorough comparison to early Paleozoic strata in the North Slope of Arctic Alaska. Our preliminary results confirm that the Porcupine Shear Zone is a profound margin-bounding strike-slip fault that must be accounted for in tectonic models for both Paleozoic terrane transfer and the Mesozoic opening of the Canada Basin.

Structural heterogeneity, thermal spring distribution, and geothermal energy potential along the Southern Rocky Mountain Trench

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A number of thermal springs occur along the Southern Rocky Mountain Trench (SRMT), indicating the possibility of a fault-hosted geothermal system at depth. No specific heat source has been identified for these springs and flow system geometries have not been determined. Because fault zones act both as conduits and barriers to groundwater flow, understanding the fault zone architecture is critical in evaluating geothermal potential. Here, we compile available structural and geophysical data from the vicinity of the SRMT to provide a synthesis of the interpreted subsurface. Critical cross-sections are re-drafted to aid in stratigraphic correlation along the SRMT. Locations and estimated circulation depths of thermal spring systems along the SRMT are compared against mapped geological structures, and simple hydrogeological models are proposed for each spring. It has been shown that thermal springs can locally depress geothermal gradients, meaning that while thermal springs may be useful exploration tools, they may be poor drilling targets. Our structural synthesis allows us to better constrain the location of potential hot water reservoirs that are unperturbed by spring outflow. We evaluate the broad relations between fault kinematics and spring occurrence, and consider possible causes for the notable lack of thermal springs between the latitudes of 51°N and 52.5°N. We find that fault kinematics play a role in controlling the distribution of thermal springs in the SRMT. However, there is much uncertainty regarding the kinematic history and subsurface geometry of several key faults, and further targeted structural mapping is required.

New contributions to the bedrock geology of the Mount Freegold district, Dawson Range, Yukon (NTS 115I/2, 6 and 7)

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The Dawson Range of west-central Yukon contains economically significant porphyry, skarn, epithermal and related styles of mineralization in a regionally extensive belt that stretches approximately 150km from the Casino porphyry Cu-Mo-Au deposit to the town of Carmacks. Three main magmatic episodes that span mid to Late Cretaceous time each generated magmatic hydrothermal mineralization that contributes to this northwest trending polymetallic belt, suggesting several pulses of fertile magma generation. The Mount Freegold district in the eastern Dawson Range is an ideal natural laboratory to test the relationships between the structural framework, magmatism and hydrothermal mineralization in the region. The district is located within a major extensional relay zone in the Big Creek fault system – a regionally significant dextral strike-slip structure in which localized extension facilitated emplacement of mid to Late Cretaceous plutons, hypabyssal stocks, dikes and intrusive porphyry-breccia complexes. Recent studies have improved geochronological constraints on Cretaceous magmatism in the Mount Freegold district (e.g., Bineli Betsi and Bennett, 2010; Allan *et al*., 2013), but the petrogenetic and geochemical attributes of the causative intrusions have not been established on a systematic basis. Consequently, there is a need to systematically examine these magmatic suites in terms of their compositional, geochronological, and lithogeochemical characteristics to assess the fertility, tectonic drivers, and structural control on mineralization.

New bedrock mapping in the Mount Freegold district provides an improved interpretation of the nature, timing and distribution of key mineralizing magmatic rocks: the mid-Cretaceous Whitehorse suite, Late Cretaceous Casino suite, and Late Cretaceous Prospector Mountain Suite. Field descriptions of geologic units of the Mount Freegold district are based primarily on observations made during the 2017 field season, with unit assignments facilitated by previously published and yet unpublished U-Pb geochronological data obtained as part of this study. New mapping defines a previously unrecognized granite pluton at Mount Freegold, as well as the ca. 77 Ma Stoddart pluton, which represents the magmatic roots of hypabyssal intrusive rocks at the Revenue Cu-Mo-Au-Ag deposit and Nucleus Au-Ag-Cu deposit. The relay zone in the Big Creek fault system is partly plugged by the ca. 70 Ma Seymour Creek stock, which is cut by a southern strand of the fault system. Episodic fault movement took place over a minimum 35 m.y. interval during which at least three distinct episodes of magmatic-hydrothermal mineralization occurred. Ongoing petrological, geochemical and geochronological studies will provide additional insights into the character and fertility of magmatic rocks in the Mount Freegold district, augmenting the field-based observations and interpretations presented herein.

Geophysical reassessment of the role of ancient crustal structures on the development of the western Laurentian margin, Yukon and NWT, Canada

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The structure of the western margin of the North American craton (Laurentia) in the northern Canadian Cordillera is reassessed through 3D inversion of new compilations of Bouguer gravity and aeromagnetic data. The region's tectonic history is obscured by partial burial beneath Selwyn Basin, and a tectonic overprint that includes terrane accretion, regional plutonism, and strike-slip faults.

Despite the implied complexity, preliminary interpretations of the structure of the Laurentian margin have been adopted with few refinements in over two decades. Regionally continuous, NE-trending, crustal lineaments, including the Fort Norman line and Leith Ridge fault, were interpreted as having had long-standing influence on the craton development, its western margin, and overlapping sedimentary basin.

New results reveal limited evidence for the regional continuity of the NE-trending lineaments. Instead, models suggest that the structure of the Laurentian margin is characterised by segmentation on numerous structures of varied strike. The western margin of the craton and its structures are bound by a NW-trending structure that connects with the Richardson Trough to the north and may have been active during Misty Creek embayment rifting. This boundary also marks the easternmost limit of both granitic intrusions in Selwyn Basin, which gravity models suggest are of greater extent than reflected on geological maps, and SEDEX occurrences. An ENE-trending structure beneath northern Selwyn Basin is interpreted as marking the southern edge of a previously unidentified cratonic promontory, akin to the Liard line that marks a transfer fault that bounds the promontory of the Macdonald Platform, south of Selwyn Basin.

Post-accretionary deformation of the Intermontane region, southern Yukon and northern British Columbia, Canadian Cordillera

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Jurassic and later post-accretionary structures in the northern Canadian Cordillera generally lack absolute timing constraints and their kinematics are only broadly understood. This is largely due to the challenges in directly dating motion on brittle faults, as well as the recessive nature of brittle faults which often form linear topographic lows in the landscape. Low temperature multi-thermochronology can provide constraints on timing and kinematics of brittle faults. Apatite and zircon U-Th/He and fission track dating methods are used to develop footwall and hanging wall temperature-time models for Jurassic to Paleogene faults in the Intermontane region of southern Yukon and northern British Columbia.

Preliminary results, which also incorporate complementary detrital zircon U-Pb and detrital muscovite Ar/Ar age data, illustrate the potential of these methods for reconstructing the post-accretionary structural history of the Intermontane region. For example, multi-geo- and thermochronological results across the King Salmon fault in northern British Columbia demonstrate contrasting burial/heating and cooling histories for footwall and hanging wall Laberge Group units of the Whitehorse trough. Detrital zircon U-Pb data constrain comparable Pliensbachian to Toarcian depositional ages for Laberge Group samples from both structural positions and zircon double dating results (U-Pb and U-Th/He ages from individual crystals) confirm their volcanic source. Muscovite in footwall Laberge Group rocks preserve undisturbed Early Jurassic detrital ages, while zircon U-Th/He yields reset Early Cretaceous ages. Thus footwall Laberge Group and older basement rocks were buried and heated to between 400-180 °C during Late Jurassic (Oxfordian) to Early Cretaceous (Albian) while hanging wall Laberge Group rocks remained above ~180 °C. Both footwall and hanging wall Laberge Group rocks exhibit cooling through ~40 °C at ca. 40 Ma suggesting a common late exhumation history. These temperature-time models will be compared where possible against age constraints obtained by direct dating of fault materials: K-Ar dating of fault gouge illite and U-Pb dating of calcite slickenfibres.

The latest Cretaceous-early Eocene Pacific-Arctic?-Atlantic connection: co-evolution of strike-slip fault systems, oroclines and transverse thrust-and-fold belts in the northwestern North American Cordillera

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Comprehensive understanding of the pre-Paleogene kinematic evolution of the North American Cordillera in the context of evolving global plate interactions must begin with an understanding of the complex Late Cretaceous-early Eocene structural geometry and evolution of the northwestern Cordillera of Alaska, USA and Yukon, Canada. I present a kinematic model of the region that shows how regional strike-slip fault systems, including plate boundary transform faults, interacted with each other, and with north-striking oroclinal folds and thrust-and-fold belts which formed progressively during coeval shortening between Eurasia and North America. These Late Cretaceous-early Eocene interactions are manifestations of plate re-organizations in the Pacific and Atlantic-Arctic regions which took place at that time, and led to rifting and seafloor spreading within the globe-encircling Eurasian-North American plate as well as to the formation of transform-dominant North American-Pacific (*sensu lato*) and possibly North American-Arctic plate boundaries.

In addition to presenting a kinematic model, this poster explores some of the implications of a restoration of the Cordillera to a Late Cretaceous time frame, a restoration made possible by the fuller understanding of the kinematic evolution of the Cordillera afforded by the model.

The Murray dyke swarm of southern British Columbia and its role in Eocene extensional tectonics

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A set of subparallel dykes of the Eocene Challis-Kamloops belt, here named the Murray dyke swarm, crop out near the confluence of Murray Creek and the Thompson River near the town of Spences Bridge in southern British Columbia. The swarm is ~2 km wide and has a sheeted morphology. The swarm strikes north-northeast, dips steeply to the east and outlying dykes crop out for at least 23 km along strike. Dyke abundances range from 95% dykes in the core of the swarm to ~10% percent on the margins. Taken together, the swarm represents ~70% crustal extension over a width of ~2 km. Inter-dyke margins are generally subparallel and wavy, and locally grade into a convoluted texture that may have been caused by magma mingling. Relationships among dykes suggests multiple injections of similar magma into existing dykes prior to solidification. The morphology of the dykes indicates magmatism may have been short-lived and was coeval with extension.

The dykes are predominantly andesite with minor basaltic andesite to dacite, and are subalkaline. A preliminary U-Pb TIMS zircon date yielded an Eocene age of ~ 48 Ma. The dykes are fine-grained, porphyritic to aphanitic, with hornblende and plagioclase phenocrysts and locally abundant grains of pyrite. Rarely, small dykelets of pink aplite cut the dykes, representing the latest stage of magmatic activity. Amygdules of epidote, calcite and quartz are common. Patches of secondary epidote occur in the dykes and immediate country rock, consistent with low grade metamorphism. A steeply dipping, north-striking strike-slip fault truncates the swarm. Dykes near the fault commonly host slickensides consistent with sinistral displacement. Volcanic equivalents of the swarm are not preserved in the immediate vicinity but are present regionally as the Princeton and Kamloops groups. The swarm is hosted by the mid-Cretaceous Spences Bridge Group and related dykes. A new U-Pb LA-ICPMS zircon date of 104 ± 3 Ma was obtained on one of the Spences Bridge Group dykes.

Upper mantle and lower crustal xenoliths from the upper Hyland River region, SE Yukon

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Approximately 50 upper mantle and lower crustal xenoliths were collected from basanite dykes that intrude Neoproterozoic-Palaeozoic metasedimentary rocks in the upper Hyland River region of southeast Yukon Territory. The dykes are 1-5 metres in diameter, and commonly exhibit columnar jointing along their margins. The most abundant ultramafic xenoliths are spinel-bearing lherzolites, with lesser olivine websterites. The suite also includes one plagioclase-bearing, and one amphibole-bearing sample. Crustal xenoliths are dominantly granulite facies paragneisses, with subordinate orthogneiss samples. The xenoliths occur as discrete subrounded to subangular fragments up to 8 cm in maximum dimension. The lherzolite samples consist of olivine (~Fo90), orthopyroxene (Mg# of 0.90), clinopyroxene (Mg# of 0.88-0.90), brown spinel (Mg# of 0.76; Cr# of 0.1), and Fe-Ni sulphide, and exhibit a protogranular texture. Orthopyroxene locally contain fine exsolution lamellae of clinopyroxene. Pressure conditions are constrained through the calculation of isochemical P-T phase diagrams in the Na_2O-CaO-FeO-MgO-Al_2O_3-SiO_2-Cr_2O_3 system for spinel lherzolite samples. Estimated pressures range from 10-15 kbar (33-50 Km). Temperature estimates from 3 samples and 27 mineral pairs using two-pyroxene geothermometry give equilibrium temperature estimates between 930 – 1100˚C at 12.5 kbar, with a pressure dependency of less than 5˚C/kbar. Granulite facies paragneiss samples contain plagioclase, K-feldspar, orthopyroxene, garnet, sillimanite, quartz, graphite, monazite, and zircon. Numerous samples contain 1-8 mm rounded domains of patchy, symplectic intergrowths of plagioclase, spinel, and orthopyroxene. These domains are interpreted as pseudomorphs after garnet and consist of three distinct textural and compositional zones, which may record various stages of post-peak metamorphic decompression. Preliminary estimates of pressure and temperature for these samples were obtained through a combination of conventional thermobarometry and modeling in the Na_2O-CaO-K_2O-FeO-MgO-Al_2O_3-SiO_2 system. Pressure and temperature is estimated at approximately 11.5 kbar and 950˚C, respectively. Preliminary U-Pb zircon analyses by LA-ICP-MS on mineral separates from crushed xenolith samples give ages as young as 29.5 ± 0.5 Ma, constraining the age of the intrusion of these dykes to the Oligocene or younger.

Investigations of the structural and thermal interface between the Purcell Anticlinorium and the Kootenay Arc

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The aim of this project is to elucidate the nature of the tectonothermal interface between three structural domains which are bounded by the towns of Kimberley, Creston, and Crawford Bay in southeastern British Columbia. They include 1) the Purcell Anticlinorium, 2) the Kootenay Arc, and 3) the Priest River Complex. The Purcell Anticlinorium (PA), in the east of the area, is a Mesozoic (Cordilleran) regional structure composed of Mesoproterozoic Belt-Purcell Supergroup, Neoproterozoic Windermere Supergroup, and lower Paleozoic strata that are of ancestral North American affinity. These rocks have been metamorphosed at low grades within the biotite and chlorite zones. Mica cooling ages are as old as Mesoproterozoic in this domain. The Kootenay Arc (KA), in the northwest of the area, is an arcuate salient involving highly deformed marginal rocks of North American affinity, as well as arc related rocks accreted during Cordilleran orogenesis, and reaches sillimanite grade. Mica cooling ages are in the range 100-50 Ma in the KA. Between the Purcell Anticlinorium and Kootenay Arc is transitional structural, metamorphic and thermochronological interface. In the southwestern portion of the field area, the Eocene Purcell Trench Fault (PTF), an east side down extensional normal fault, juxtaposes the Belt-Purcell rocks of low metamorphic grade (part of the PA) against the northern-most exposures of the Priest River Complex, a metamorphic core complex comprising amphibolite facies metamorphic rocks and 50-70 Ma cooling ages.

Argillaceous rocks within the Belt-Purcell Supergroup in the PA preserve bedding (S_0) and a penetrative slatey cleavage (S_{1PA}) whose dips fall within a range of 15-30 ° from that of S_0. The absence of S_{1PA} within overlying Windermere rocks indicates that the development of this cleavage occurred prior to the Neoproterozoic. Biotite and chlorite porphyroblasts in this domain postdate cleavage development. Within the Kootenay Arc, the dominant rock fabrics (S_1 and S_2) are associated with two Cordilleran deformation events: Middle Jurassic (D_1), and early Cretaceous (D_2). The D_1 deformation is characterised by a penetrative S_1 schistosity (S_{1KA}) in rocks of low metamorphic grade. These were overprinted by D_2, which is characterised by an S2 (S_{2KA}) schistosity that is axial planar to F_2 folds. D_2 deformation was accompanied by Barrovian regional metamorphism, whose low margin (chlorite/biotite zone) extends eastward into the PA.

A westward transect in the northern portion of the field area crosses the transition between the PA, in which S_0 and S_{1PA} (Mesoproterozoic) are the dominant structures, and the K_A, in which S_{1KA} is deformed by S_{2KA} (both Mesozoic). The first indication of Mesozoic structural modification of the Mesoproterozoic PA structures is a crenulation of S_{1PA} that occurs in the westernmost exposures of the basal unit of the Belt-Purcell Supergroup, the Aldridge formation. The crenulations increase in intensity westward, resulting in a crenulation cleavage that evolves further into a full-blown schistosity (S_{2KA}) that is characteristic of the KA. This structural transition serves as evidence for the impingement of Mesozoic deformation signatures on the western margin of the Purcell Anticlinorium. Large scale folding of the Purcell Anticlinorium appears to be related to D_2. When plotted on a stereonet, fold axes defined by S_0 and S_{1PA} are roughly coincident with the cluster of lineations that are attributed to the crenulation of S_{1PA}, and which are contained within S_{2KA} in the KA. In the southern portion of the Purcell Anticlinorium, where it is juxtaposed against the Priest River complex, there is no discernable evidence of a westward change in metamorphic grade, or structural style, approaching the Purcell Trench Fault. Future work will focus on the contrast, and nature of the transition, in cooling history between the PA and KA, as revealed by Ar/Ar thermochronology in hornblende and micas.

Majestic Loki, by Ryan Burke (2014)