Cordilleran Tectonics Workshop

2012

Harbour Towers Hotel, Victoria, BC

Program and abstracts

Pacific Section - Geological Association of Canada

Cordilleran Tectonics Workshop – The Early Years

This workshop that you are attending is an intellectual gathering like no other. It has no official sanction, no governing body; it is part of no organization, and yet every year in February it convenes in a different part of Canada, hosted by a university or government geological survey, each time with a different tone and flavour depending on who comes and where current research is focused. It belongs to all of us in the Cordilleran geological research community, especially the students. This is its 38th meeting. For many of us, it may seem as if CTW always existed. It is time that we wrote its origins down, so that these are remembered.

It all began in 1975 with a suggestion from John Reesor, then Chief of the Crustal Geology Division of the Geological Survey of Canada to Ray Price at Queen's University, that students doing field work in the southeastern Cordillera with GSC support would meet together to report their findings – sing for their suppers – and also engage as a group in informal discussions. Ray invited not just his own students, but Dick Brown's contingent from Carleton, Philip Simony's from University of Calgary, and Eric Mountjoy's from McGill. In his invitation, Ray instructed the students to make their presentations as informal as possible, using field compilation maps and sketches as well as blackboard sketches. Ten students presented that first year. One of that year's attendees, Philip Simony, will be at the 2012 workshop here in Victoria.

The 1976 meeting was still small (17 presentations), still at Queen's, and still entirely focused on structure and stratigraphy of the Omineca belt. Titles were full of odd geographic names that soon became part of the common vocabulary: Akolkolex, Clachnacudainn, Frenchman Cap, Horsethief Creek, Miette. One new student that year was Price's Ph.D. student, Jim Sears, who then was working in the Selkirk Mountains, and who moved on to teach at the University of Montana. We will hear from Jim at this session on Siberia-Laurentia connections, a topic he first addressed at CTW in 1978. By 1977, the third year, news had spread and participation had risen to over 40. This caused Ray to register a concern that "the size of these gatherings obviously is rising to a critical threshold that will preclude easy informal communication." However, Paul Schiarizza (BCGS) attended in 1977, and he remembers that the discussion often involved different people's observations of the same outcrop. It was still a workshop in the truest sense of the word.

By 1978 the CTW at Queen's had expanded to a two-day event. The first inklings of "beyond the Ominecas" came in that year, with an overview of plate tectonics in the Canadian Cordillera by

Jim Monger. Jim had spent the winter of ’77-‘78 at GSC in Ottawa, toiling one day a week in the paleomag lab at Blackburn Hamlets with Ted Irving on Asitka, Takla and Hazelton cores from eastern Stikinia. They had mounted the Cordilleran part of the Geological Map of Canada on a small sheet of ¼” plywood, used the jig-saw in the lab to cut around terrane boundaries, and then carried the puzzle down to the workshop at Queens for Ted to present the mobilist implications of the new paleomagnetic data. Jim will lead off this 2012 workshop with a retrospective on the influence of “big picture” ideas in the development of our understanding of the Cordilleran orogen over the last 40 years.

From 1978 into the early 1980’s, the workshop grew and sent fingers into different areas of the Cordillera, different interests and disciplines: Peter Read on the Stikine Canyon, Bob Anderson on the Hotailuh batholith, Dave Klepacki on the Slide Mountain terrane, Jim Mortensen on the Yukon-Tanana terrane – building the foundations of our current knowledge of the orogen. In 1982, Ray Price moved from Queen’s to a directorship at the Geological Survey of Canada and the CTW began its nomadic phase. In 1983 it was at UBC, and one of the posters was John Wheeler’s draft of his considerably refined and updated version of the Tectonic Assemblage Map of the Canadian Cordillera. The first version of this map, published in 1981, was a project carried out under the leadership of Howard Tipper, who organized a group of “winter works” (= seasonally unemployed) geologists to compile the map from the mostly completed series ~1:250,000 scale Cordilleran geological maps. The current Tectonic Assemblage Map was published in 1991. It is proudly displayed in this room in all its wonderful combination of accurate detail and overarching thematic structure. Note, however, that 20 years of research advances, many reported at CTW meetings, have not yet been incorporated in a revised tectonic map of the Cordillera: this remains to be done. The task continues.

Ray Price, founder of the CTW, cannot be with us this year. He sends his regrets and also his meticulously kept programs and correspondence relating to the early meetings, on which some of this note is based. But the CTW, his creation, lives on and will live on as long as researchers retain their fascination with the Cordillera and their commitment to somehow, some way, somewhere, meet each year to talk about it.

JoAnne Nelson

Based in part on correspondence and schedules from Ray Price, 1975-1983, and conversations with Jim Monger and Paul Schiarizza, February 2012.

2012 Cordilleran Tectonics Workshop
Schedule

SATURDAY FEBRUARY 25, 2012

8:00-8:45	***Arrive, register if not done so on Friday, view posters, informal discussion***	
8:45	***Please find your seat***	
8:50-9:20	*Jim Monger and Mitch Mihalynuk*	**Canadian Cordilleran geosynclines, tectonic assemblages, terranes and mineral deposits**
9:20-9:40	*Francesca Furlanetto*	**The Racklan orogeny and its new role in the reconstruction of the supercontinent Columbia**
9:40-10:00	*Kirstii Medig, D.J. Thorkelson, E.C. Turner, W.J. Davis, H.D. Gibson, R.H. Rainbird and D.D. Marshall*	**Stratigraphy and geochronology of the Pinguicula Group: local and exotic sediment provenance**
10:00-10:15	***Discussion***	
10:15-10:30	***Coffee***	
10:30-10:50	*Justin V. Strauss, Francis A. MacDonald, John E. Repetski, John F. Taylor and William C. McClelland*	**New sedimentological and geochemical constraints on the early Paleozoic history of the North Slope subterrane of Arctic Alaska**
10:50-11:10	*Leo Millonig, Axel Gerdes and Lee A. Groat*	**U-Th-Pb geochronology of meta-carbonatites and meta-alkaline rocks in the southern Canadian Cordillera: A geodynamic perspective**
11:10-11:30	*Alexei Rukhlov and Dinu Pana*	**Tectonic and metallogenic significance of mafic magmatism of the Belt-Purcell basin in the Lewis thrust sheet of southwestern Alberta**
11:30-11:50	*Meghan Hewton, D. Marshall, L. Ootes, L. Loughrey and R. Creaser*	**Emerald mineralization in the Mackenzie Mountains: A relationship to a major Paleozoic fluid-flow event and back-arc basin development**

11:50-12:10	***Discussion***	
12:10-1:20	***Lunch and posters***	
1:20-1:40	*Cees van Staal, Monica Escayola,, William McClelland, Meredith Petrie, Jane Gilotti* [3] *and Jim Ryan*	**Some comments on the Paleozoic tectonic history of the Yukon Tanana-Slide mountain terranes**
1:40-2:00	*Steven Scott , Sharon Carr, Don Murphy and Eric de Kemp*	**Lithology of the western margin of the Yukon-Tanana terrane near Tincup Lake, Yukon Territory, and structural evolution during Late Mesozoic to Paleogene orogenesis**
2:00-2:20	*Cynthia Dusel-Bacon, John N. Aleinokoff, Paul B. O'Sullivan, Warren C. Day, John F. Slack and Chris r. Siron*	**Implications of U-Pb zircon and apatite fission track ages for the setting and origin of carbonate replacement mineralization in the western Fortymile mining district, east-central Alaska**
2:20-2:40	*Gerald Griesel, R.J. Newberry, L.K. Freeman, B.A. Elliott, D.J. Szumigala, T.A. Lough and Melanie Werdon*	**Moran area, Ruby and Tozitna terranes, central-interior Alaska: a mystery wrapped in an enigma**
2:40-3:00	***Discussion***	
3:00-3:15	***Coffee***	
3:15-3:35	*Reid Staples, Dan Gibson, Maurice Colpron, Jim Ryan, Rob Berman and Don Murphy*	**Diachronous metamorphism, deformation and exhumation within amphibolite-facies rocks of Yukon-Tanana terrane**
3:35-3:55	*Edward Ghent*	**Very nearly UHP metamorphism - lawsonite and epidote eclogites from western Canada**
3:55-4:15	*Jim Sears*	**A model for moving the Siberian craton from SW North America to the Urals along coast-parallel transform faults: Paleomagnetic and geologic evidence**
4:15-4:35	***Discussion***	
4:35-5:00	***Posters, informal discussion***	

SUNDAY FEBRUARY 26 2012

8:30 - 9:00	***Posters, informal discussion***	
9:00-9:20	*Paul Schiarizza*	**Geology of the Kutcho assemblage, northern British Columbia: an intra-oceanic arc within Cache Creek terrane**
9:20-9:40	*Mitch Mihalynuk*	**Sitlika-Kutcho arc, Pangea-B and Cabo Slab constraints on Cordilleran paleogeography**
9:40-10:00	*Larry Diakow, M.J. Orchard and R. Friedman*	**Absolute ages for the Norian Stage: a contribution from southern British Columbia, Canada**
10:00-10:15	***Discussion***	
10:15-10:30	***Coffee***	
10:30-10:50	*Alex Zagorevski*	**Geochemical variability and evolution of northwestern Stikinia**
10:50-11:10	*J.W.F. Waldron, J.-F. Gagnon, T. Barresi, J.L. Nelson, T.P. Poulton and F. Cordey*	**The Upper Hazelton Group and its significance for the Jurassic evolution of the Stikine terrane, British Columbia**
11:10-11:30	*Angen, Joel, Cees van Staal, Shoufa Lin and JoAnne Nelson*	**New structural observations and geochronology from the southern Alexander terrane near Porcher Island: further evidence for mid-Cretaceous tectonic escape**
11-30-11:50	*Elizabeth R. Schermer, Julia E. Labadie, Gerry Griesel and Aaron Fitts*	**New constraints on Jurassic-Tertiary deformation and metamorphism in the North Cascades crystalline core**
11:50-12:10	***Discussion***	
12:10-1:20	***Lunch and posters***	

1:20-1:40	*Witold Ciolkiewicz, Jim Mortensen, Jim Ryan and Craig Hart*	**Space-time-composition patterns of the Late Cretaceous magmatism in west-central Yukon and east-central Alaska: Insights into the tectonic evolution of the northern Cordillera**
1:40-2:00	*Esther Bordet and Craig J.R. Hart*	**Eocene Volcanic and Structural Framework of Central British Columbia: Insights for the Tectonic Evolution of the Canadian Cordillera**
2:00-2:20	*Dinu Pana, Tim O'Brien and Ben van der Plum*	**An early Eocene deformation phase in the Alberta portion of the Canadian Rocky Mountain fold-and-thrust belt: new evidence from $^{40}Ar/^{39}Ar$ dating of clay-rich fault gouge**
2:20-2:40	*Sharlene Hartman and John W. F. Waldron*	**LiDAR assisted mapping and deformation history of Crowsnest Pass, Alberta**
2:40-3:00	***Discussion***	
3:00-3:15	***Coffee***	
3:15-3:35	*John I. Garver and C. Davidson*	**Terrane translation in the north Pacific prior to establishment of the Aleutian-Kamchatka arc: history of the Olutorsky (Kamchatka) and Chugach-Prince William terranes (Alaska)**
3:35-3:55	*Brendan R. Smithyman and Ron M. Clowes*	**Waveform tomography in 2.5-D to account for 3-D geometry: Application to reflection data in central British Columbia**
3:55-4:15	*Roy Hyndman*	**Why is the Cordillera a mobile belt? Why is it high? Why is there lower crust detachment? Why is there current Barrovian crustal metamorphic conditions?**
4:15-4:30	***Discussion***	
4:30-4:45	***Whence the Workshop 2013?***	

2012 Cordilleran Tectonics Workshop
List of poster presentations

To all poster presenters: check at registration for location of your assigned space.

Space number	Author(s)	Title	Assigned interviewers
1	*Charles M. Henderson and Josh Ouellet*	**Chronostratigraphy and tectonostratigraphy of the Late Paleozoic cratonic succession in east-central British Columbia and implications for Slide Mountain Ocean/pericratonic terrane geology**	
2	*Meredith Petrie, J.A. Gilotti, W.C. McClelland, and C. van Staal*	**New field relationships and a preliminary U/Pb SHRIMP age for eclogite in the St. Cyr area, Yukon-Tanana terrane**	Ghent, Ed; Henderson, Charles
3	*Thomas Moore and Paul O'Sullivan*	**New Detrital Zircon U-Pb Results from the Yukon-Tanana Terrane in the Fairbanks Mining District, Alaska**	
4	*Luke Bickerton, Maurice Colpron, Dan Gibson and James L. Crowley*	**Proposed mapping, geochronology, and petrography of rocks at the northern termination of the Cache Creek terrane, Marsh Lake area, southern Yukon**	Mihalynuk, Mitch; Monger, Jim
5	*Maurice Colpron*	**Preliminary observations on the geology of the Rackla belt, Mount Ferrell map-area (NTS 106C/3), central Yukon**	
6	*Jim Ryan, Alex Zagorevski, Charlie Roots, Ellie Knight, Nathan Hayward, John Chapman and Witold Ciolkiewicz*	**Geological insights from new mapping in the Dawson Range – White Gold district, Yukon**	
7	*Rohanna Gibson, Stephen Johnston and Steve Israel*	**Bedrock mapping and structural analysis of Killermun Lake region, southwest Yukon - mineral potential and tectonic significance**	Henry, Amber; Joliffe, Jennifer

8	*Steve Israel and Liz Westerberg*	**Geology and mineral potential of the northwestern Aishihik Lake map area, parts of NTS 115H/12 and 13**	
9	*Alexander Nielsen, Derek Thorkelson, Dan Marshall, and Dan Gibson*	**The Wernecke igneous clasts in Yukon Canada: evidence for a Paleoproterozoic volcanic arc terrane at 1.7 Ga and its obduction onto ancestral North America**	Sears, Jim; Gilotti, Jane
10	*Sharon D. Carr and Philip S. Simony*	**Cretaceous to Eocene evolution of the southeastern Canadian Cordillera: Continuity of Rocky Mountain thrust systems with zones of "in-sequence" mid-crustal flow**	
11	*Mrs. Leonard Luli and Fatmir Staka*	**Evolution of the Thrust Belt in Southern Albania**	Sears, Jim; van Staal, Cees
12	*Vincent Twomey and Dan Gibson*	**The geology of the Okanagan Valley shear zone from Penticton to Kelowna, British Columbia**	Pattison, Dave; Britton, Jim
13	*Deanne van Rooyen and S.D. Carr*	**Links between ^{40}Ar/^{39}Ar cooling dates and deformation history on the southern flank of the Thor-Odin dome BC: overlapping compressional and extensional regimes in the Eocene**	Gibson, Dan; Pana, Dinu
14	*Darrel G. F. Long and Jordan Mathieu*	**Testing paleohydrological estimates of drainage basin size in the Cretaceous and Tertiary of the Bonnet Plume Basin using petrology**	
15	*Ewan R. Webster and David R.M. Pattison*	**Jurassic and Cretaceous metamorphism and deformation between the southern Kootenay Arc and Purcell Anticlinorium, southeastern British Columbia**	Carr, Sharon; Ferri, Fil

16	*Suzanne Paradis*	**New geoscience contributions to SEDEX-MVT base metal exploration in Selwyn and Purcell basins - Targeted Geoscience Initiative-4**	
17	*David P. Moynihan and David R.M. Pattison*	**Calculation of P-T paths incorporating chemical fractionation and diffusion in garnet: a case study from the Kootenay Arc, British Columbia, Canada**	Gibson, Dan; Simony, Phil
18	*Olivia Iverson J.B. Mahoney, and J. Logan*	**Reassessment of Triassic and Jurassic volcanic strata in the Dease Lake region, northern British Columbia**	Zagorevsky, Alex; Waldron, John
19	*Bram van Straaten, Jim Logan and Larry Diakow*	**Mesozoic magmatic and metallogenetic history of the Hotailuh batholith (northwestern BC)**	
20	*Graham Nixon, J. S. Scoates and D. E. Ames*	**Orogenic Ni-Cu-PGE: the Turnagain Alaskan-type intrusion, northern BC**	
21	*Ivanka Mitrovic and Dan Gibson*	**Examining the interplay of the arc magmatism, deformation and metamorphism within the southern coast-cascade orogen, Harrison Lake, British Columbia**	Carr, Sharon; Garver, John
22	*Ginny Casey and John MacRae*	**Petrogenesis of basalt and limestone in a highly metamorphosed region at Open Bay, Quadra Island**	Nixon, Graham; Ray, Gerry
23	*Eric Hoffnagle and Liz Shermer*	**New U-Pb zircon ages from the Yellow Aster Complex, northwestern Washington State**	Mahoney, Brian; Colpron, Maurice
24	*Brian Mahoney, JoAnne Nelson, G. Gehrels, S. Karl, L. Diakow, J. Angen, and C. van Staal*	**Paleozoic evolution of the southern Alexander terrane, northwestern British Columbia**	

New structural observations and geochronology from the southern Alexander terrane near Porcher Island: further evidence for mid-Cretaceous tectonic escape

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Abstract

Structural observations have led to the identification of northwest-striking sinistral shear zones as well as one north-striking dextral shear zone near Porcher Island in northwest BC. Their geometry suggests formation as a ductile conjugate set. This hypothesis is supported by new U-Pb zircon geochronology of synkinematic dykes indicating that sinistral and dextral shear zones were at least in part coeval during the mid-Cretaceous. Outcrop scale conjugate shear bands reflect the geometry of the map scale shear zones. The maximum shortening direction required to form a conjugate set with this geometry would be WSW-ENE, or approximately orogen normal.

Modern tectonic escape of the Tibetan Plateau is occurring as a result of orogen normal compression as India collides with Asia (Zhang et al., 2004). Tectonic escape of the Intermontane block during the mid-Cretaceous as proposed by Colpron et al., (2011) and Nelson et al., (2011) may similarly be the result of significant orogen normal compression. The question remains: what is the source of that compression?

References

Colpron, M., Murphy, D., Nelson, J., 2011, Crustal structures in Yukon and implications for gold mineralization in the northern Cordillera: Abstract, Cordilleran Tectonics Workshop 2011, p. 6-7.

Nelson, J.L., Colpron, M., Murphy, D., Israel, S., Angen, J., 2011a, Mid-Cretaceous dextral and sinistral fault systems in the northern Cordillera, northward escape of the Intermontane block, and the search for a plate tectonic moose-gooser: Abstract, Cordilleran Tectonics Workshop 2011, p. 20-23.

Zhang P., Shen Z., Wang M., Gan W., Burgmann R., Molnar P., Wang, Q., Niu, Z., Sun, J., Wu, J., Hanrong, S., Xinzhao, Y., 2004. Continuous deformation of the Tibetan Plateau from global positioning system data: Geology, v. 32, p. 809– 812.

Proposed mapping, geochronology, and petrography of rocks at the northern termination of the Cache Creek terrane, Marsh Lake area, southern Yukon

Luke Bickerton[1], Maurice Colpron[2], Dan Gibson[1] and James L. Crowley[3]
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In the Canadian Cordillera, Stikinia and Quesnellia represent early Mesozoic terranes of peri-Laurentian affinity that developed as allochthonous, low-latitude island arcs partially built upon the mid- to late Paleozoic Yukon-Tanana terrane (and correlatives). These arc terranes bound pelagic sedimentary rocks, oceanic seamount and ophiolite assemblages of the exotic Cache Creek terrane, which locally contains distinctive Early Permian Tethyan fusulinid fauna. This contrasts with the less exotic McCloud fauna found in Quesnellia and Stikinia. In south-central Yukon the exposure of Cache Creek terrane terminates where it is enveloped by Stikina and Quesnellia; a geometry which led, in part, to the model of oroclinal entrapment of the exotic Cache Creek terrane (Mihalynuk et al., 1994). In the northern Canadian Cordillera, these terranes are overlapped and imbricated with syn-orogenic Lower to Middle Jurassic basinal sedimentary rocks of the Whitehorse trough (Laberge Group). According to Mihalynuk et al. (1994, 2004), these rocks represent a forearc basin that formed during the subduction of Cache Creek oceanic lithosphere beneath a continuous Stikinia/Quesnellia arc.

This project proposes to examine the relationships between the Whitehorse trough and the Intermontane terranes of Stikinia and Cache Creek near its northern termination in southern Yukon. This will involve detailed, 1:20 000-scale geological mapping of the Marsh Lake-Mount Michie area (105D/8-9), petrographic and geochemical analyses, and igneous and detrital zircon U-Pb geochronology. The project will also aim to improve the understanding of prospective syngenetic base metal, intrusion-related and orogenic gold mineralization in the region.

Recent reconnaissance work in the Marsh Lake-Mount Michie area has revealed a number of observations that are not currently captured on existing geological maps:

1. The Cache Creek terrane is apparently dominated by fine-grained intrusive rocks (gabbro, pyroxenite) and lesser pelagic sedimentary rocks (chert, argillite). However, the relationships between these lithologies (structural or stratigraphic) are uncertain.
2. An extensive sequence of previously unrecognized felsic volcanic rocks appears on the main ridges in the study area. Preliminary geochronology suggests that these rocks are probably early Cenozoic and occur 70-80 km east of the main belt of Cenozoic volcanic rocks in southern Yukon. This study will characterize and date this volcanic sequence.
3. Mount Michie is underlain by a succession of volcanic-lithic sandstone-mudstone couplets and minor conglomerate that are assigned on current maps to the Laberge Group. Detrital zircons from this unit form a uniform population of sharply-faceted grains that yielded an age of 244.54 ± 0.13 Ma; a pattern that differs from the multiple populations of detrital zircon typically found in Laberge Group sandstone, which are dominated by Early Jurassic zircons derived from nearby intrusions (M. Colpron, unpublished data). The Early Triassic detrital zircons were probably derived from a volcanic terrane similar to the Kutcho assemblage of the Cache Creek complex in northern British Columbia. This study will further characterize this sedimentary succession and elucidate stratigraphic correlations.

References:

Mihalynuk, M.G., Nelson, J.-A., and Diakow, L.J. 1994. Cache Creek terrane entrapment: Oroclinal paradox within the Canadian Cordillera. Tectonics, **13:** 575-595.

Mihalynuk, M.G., Erdmer, P., Ghent, E.D., Cordey, F., Archibald, D.A., Friedman, R.M. and Johansson, G.G. 2004. Coherent French Range Blueschist: Subduction to Exhumation in 2.5 m.y.? Geological Society of America Bulletin, **116:** 910–922.

Eocene Volcanic and Structural Framework of Central British Columbia: Insights for the Tectonic Evolution of the Canadian Cordillera

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Eocene volcanic rocks constitute key elements in the evolution of the North American Cordillera. They are the youngest exposed lithologies in many regions and so provide the most recent geological record of spatiotemporal evolution and interactions between volcanism, plutonism, strike-slip and extensional faulting, and mineralization in Eocene time. Major changes of plate configurations and motions along the margin of North America around 56 Ma are responsible for extensive Eocene magmatism, the possible opening of slab-windows, and the transition from compressional regime to one of crustal extension and strike-slip tectonics (Ewing 1980; Engebretson *et al.* 1985; Thorkelson & Taylor 1989; Struik 1993). These tectonic changes are reflected by a number of magmatic and structural features including: voluminous alkaline to calc-alkaline volcanic sequences and intrusions, some associated with caldera systems; orogen-scale strike-slip faults; extensional grabens; and the exhumation of metamorphic core complexes (e.g. Ewing 1980; Armstrong 1982; Souther 1991; Struik 1993).

Thick, discontinuous sequences of volcanic rocks of the Nechako region of central British Columbia are dominated by dacites, rhyodacites and rhyolites that display calc-alkaline affinities characteristic of continental volcanic arcs. However, the distribution of these rocks 400-600 km inboard from the subduction trench suggests that mechanisms and geometries such as slab-windows or slab delamination may be contributing and resulting in an arc-style magmatic environment.

Isotopic ages for Eocene volcanic rocks in the Nechako region are between 53 and 44 Ma for Eocene andesitic, dacitic and rhyolitic flows and ignimbrites (Rouse & Mathews 1988; Grainger *et al.* 2001; Mihalynuk *et al.* 2008). Recent isotopic dating on volcaniclastic rocks, andesitic and rhyolitic lava flows from two oil and gas wells returned Early Eocene ages ranging from 60 to 48 Ma (Riddell 2010). The wide distribution and important lateral and temporal variations of Eocene volcanism suggest that multiple volcanic events are taking place at several discrete volcanic centres.

The structural setting of the Nechako region is located between two orogen-scale dextral strike-slip fault systems: the Fraser fault to the east and the Yalakom fault to the west. Field evidence of extensional deformation is rare because of limited exposure, however geochronological data coupled with interpretations of seismic and gravity data suggest that great thicknesses of Eocene rocks were deposited in northwest-trending pull-apart basins formed prior and during the Middle to Late Eocene (Hayward & Calvert 2011; Riddell 2010).

Data from the Nechako region suggest that the spatial extent, emplacement and deposition of Eocene volcanic rocks may be coeval and partly controlled by active fault systems and structural depressions, as seen in other parts of the Canadian Cordillera. However, the deposition of large volumes of volcanic rocks could also result from primary volcanic processes and caldera formation. A three-dimensional Eocene thickness model for the Nechako region will integrate results from mapping, wells, geophysical surveys and structural interpretations. This model will constitute a structural framework for Eocene volcanic rocks of the Nechako region, and will support interpretation of the processes that formed and deformed these rocks.

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Cretaceous to Eocene evolution of the southeastern Canadian Cordillera: Continuity of Rocky Mountain thrust systems with zones of "in-sequence" mid-crustal flow

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The Cretaceous to Eocene tectonic setting of the southeastern Canadian Cordillera was one of oblique plate convergence. We document the internal geometrical development of the ~400 km wide, east-verging, retrowedge side of the orogen during this time. In the External zone, the Rocky Mountains and Foothills are characterized by three major east-verging, Late Cretaceous to Eocene, thin-skinned, piggyback thrust and fold systems (Bourgeau – Lewis, McConnell, Foothills). They root westward into a basal décollement and accommodated ~180 km of shortening. The Western Internal zone is characterized by tracts of metamorphic rocks and metamorphic core complexes (e.g. Kettle, Okanagan, Priest River and Valhalla), some of which are basement-cored domes (e.g. Frenchman Cap, Thor-Odin, and Spokane). They have a downward-younging progression of Late Cretaceous to Eocene metamorphism and deformation in infrastructural flow zones characterized by transposition foliation, migmatites, flow folds and 1-7 km thick shear zones (e.g. Gwillim Creek shear zone, Monashee décollement, Eocene basal décollement). In the Eastern Internal zone, a relict ~100-200 km wide Early Cretaceous orogen, that predated emplacement of ca. 100 Ma plutons, is nested between the External and Western Internal zones. The geology and architecture of the Internal and External zones can be explained by progressive development of major Late Cretaceous to Eocene shear zone systems in the Internal zone that can be directly linked with coeval thrust and fold systems in the External zone. The linkage was via Late Cretaceous activation and Late Cretaceous to Early Eocene reactivation of the 150-200 km-wide central portion of the Rocky Mountain basal décollement that lies beneath and translated the intervening Early Cretaceous orogen. During the latest stages of shortening, in the Early Eocene, extensional shear zone systems in the Internal zone, localized on tectonothermal culminations, were concomitant with shortening in the External zone. Motion of deep-seated Early Eocene décollements beneath some of these culminations may have contributed to their doming. Crustal shortening ended at ca.52 Ma due to a change in tectonic setting to that of a transtensional tectonic regime, coinciding with the end of thrusting in the External thrust belt and with crustal-scale extension in the Western Internal zone. (*See also Simony & Carr, 2011. Journal of Structural Geology 33: 1417-1434).*

PETROGENESIS OF BASALT AND LIMESTONE IN A HIGHLY METAMORPHOSED REGION AT OPEN BAY, QUADRA ISLAND.

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At Open Bay on Quadra Island, BC, an intriguing geologic boundary between the Karmutsen basalt and the Quatsino formation limestone is exposed along the shoreline, providing an excellent view of metamorphism of a wide variety of rock types. A site at Open Bay was used for a research project in a third year course at Vancouver Island University which has been continued into 2012. Pockets of altered volcanic rock with boudin morphology lie parallel to adjacent limestone bedding, and appear to some degree to be lithologically similar to the adjacent Karmutsen formation basalt, but further analysis has revealed some differences in mineralogy and geochemistry. This study will include:

1) An investigation of the regional metamorphism, and;
2) Geochemical and mineralogical observations, which will determine if the basalts are portions of the Karmutsen basalts that have been altered during tectonic activity, or if they are injections of basalt from a different source that intruded at some time during formation of this area.

Other questions include the role that the limestone has played in altering the geochemical composition, and the degree to which the basalts have been altered. From the geochemical analyses conducted thus far we can infer that although the boudins have similar chemistry in both major and trace elements, such as TiO_2, SiO_2, and P_2O_5, to the basalt, but they do not appear to share a common petrogenesis method based on the lithology and mineralogical analyses. Further investigation into the petrogenesis observations is continuing to provide a clearer understanding of this site.

Space-time-composition patterns of the Late Cretaceous magmatism in west-central Yukon and east-central Alaska: Insights into the tectonic evolution of the northern Cordillera

Witold Ciolkiewicz, Jim Mortensen, Jim Ryan, Craig Hart

Late Cretaceous volcanic and plutonic complexes that occur in west-central Yukon and east-central Alaska form a ~600 km long, northwest striking, metallogenic province. The magmatism is part of a Late Cretaceous belt that spans the entire length of the northern Cordillera, along the western continental margin. Despite its significance for the tectonic evolution of the northern Cordillera and its known metallogenic potential, the nature of the Late Cretaceous magmatism is poorly constrained and its tectonic provenance remains unresolved.

In west-central Yukon and east-central Alaska, the Late Cretaceous magmatic occurrences are confined to the Intermontane terranes. Magmatism comprises small, high-level, calc-alkaline felsic plutons that are regionally coeval and may be comagmatic with voluminous, widespread sub-aerial mafic volcanics (Woodsworth et al., 1991). Enigmatically, the volcanics display calc-alkaline trace element signatures, but their high K_2O contents were interpreted as evidence of a mantle source (Francis and Minarik, 2008; Johnston et al., 1996). A few tectonic settings were suggested to account for these characteristics, including mantle plumes (Johnston et al., 1996), a break-off of a west-dipping subducting slab (Hildebrand, 2009), and magmatism associated with oblique east-dipping subduction (Souther, 1991), but several lines of evidence make those models incomplete, and the nature and source of the volcanism remain controversial.

Plutonic and hypabyssal volcanic magmatism is volumetrically minor, but appears spatially and temporally associated with 18 known mineralized complexes that include the giant ~8 Moz Au Casino deposit and the ~1 Moz Au Nucleus/Mount Freegold deposit. Due to its rich endowment in base and precious metals, the Late Cretaceous intrusive and hypabyssal volcanic magmatism remains a target of intense exploration effort. The region is characterised by rugged and remote terrain and by vast underexplored areas, which combined with the lack of a regional-scale integrated metallogenic model and the small footprint of the known Late Cretaceous mineral deposits, makes efficient and targeted exploration challenging.

We present preliminary findings of the first integrated regional-scale study of Late Cretaceous intrusive and volcanic magmatism in west-central Yukon and east-central Alaska. The principal goals of this Ph.D. thesis are to: (1) provide an internally consistent spatial, geological, geochemical and temporal characterisation of the regional volcanic and plutonic magmatism; (2) develop a better understanding of the Late Cretaceous metallogeny in west-central Yukon and east-central Alaska; (3) develop a regional tectonic model for the Late Cretaceous magmatism in west-central Yukon and east-central Alaska.

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Preliminary observations on the geology of the Rackla belt, Mount Ferrell map-area (NTS 106C/3), central Yukon

Maurice Colpron, Yukon Geological Survey

The Mount Ferrell area straddles the Paleozoic platform-basin transition at the northern edge of Selwyn basin and the structural corridor of the Dawson thrust, a geological and metallogenic belt informally referred to as the Rackla belt. Main facies and structural domains are delimited by the Kathleen Lakes and Dawson faults. Paleozoic carbonate rocks of the Mackenzie platform occur north of the Kathleen Lakes fault; their coeval slope deposits (shale and carbonate debris flows) are bound by the Kathleen Lakes and Dawson thrust. Strata of Selwyn basin (Hyland Group) and overlying mid-Paleozoic Earn and Tsichu groups occur in the hangingwall of the Dawson thrust. Igneous rocks of probable Paleozoic age are restricted to the Dawson thrust zone; their localized occurrence is consistent with the hypothesis that the Dawson fault may have an earlier history related to development of the basin margin in Paleozoic time. The area is affected by northeast-verging folds and thrust faults. Folds are generally upright in the southern part of the area and become progressively tighter and overturned to the northeast closer to the Dawson thrust. Timing of fold-and-thrust deformation is unconstrained in the area, but presumed to be broadly Cretaceous in age. Kinematics and timing of the Kathleen Lakes fault remain enigmatic; it may be linked to Tertiary deformation in North Yukon (?). The Rackla belt is actively being explored for gold and silver occurrences, including possible Carlin-type gold mineralization, and has potential for base metal deposits.

Absolute ages for the Norian Stage: a contribution from southern British Columbia, Canada

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Direct absolute age calibration for the Upper Triassic is largely unavailable and age estimates have relied on magnetostratigraphic correlation between Tethyan marine successions and the Newark basin non-marine succession, and summations of cyclostratigraphic periodicities derived from the latter. On that basis a broad range of ages have been suggested; for example, the base of the Norian at ~216 Ma or ~227 Ma, and that of the Rhaetian at ~204 or ~210 Ma. Rare chronometric ages presently provide a base Carnian age at ~237 Ma, an age of ~231 Ma within the upper Carnian, and a top Rhaetian at ~201 Ma.

Upper Triassic strata of the Nicola Group in the Merritt area, 200 km east of Vancouver, form part of the southwestern margin of the Quesnel terrane, a subduction-generated magmatic arc that stretches north-northwesterly throughout the B.C. Cordillera. Several U-Pb TIMS dates, which include chemically abraded grains, supported by conodont biostratigraphy obtained from two separate sections of the Nicola Group provide constraints on the lower to middle parts of the Norian. The sections located at

Castillion Creek and 9 km farther northeast at Iron Mountain consist of broadly similar strata composed of bedded feldspar-rich siltstone-sandstone, lesser limestone and minor mudstone. Interlayered volcanic rocks with contrasting compositions include mafic lava flows and comparatively thin felsic lapilli-rich and rare ash tuff interbeds.

At Castillion Creek a 400 m-long by 12 m-high cut adjacent to the Coquihalla highway exposes massive mafic lava separating parallel-bedded intervals dominated by feldspathic sandstone, calcareous siltstone, siliceous exhalite and limestone. Numerous steeply inclined normal faults and a few south-verging contraction faults cause small offsets. A rare rhyolitic ash-tuff layer, up to 20 cm thick, locally rests on mafic lava and comprises the base for conformably overlying sedimentary strata. This rhyolite bed yields a U-Pb age of 224.47+0.29/-0.64 Ma based on the median of a coherent group of ten ^{206}Pb/^{238}U dates. Limestone that depositionally overlies the rhyolite tuff produced middle Norian conodonts consisting of *Epigondolella spiculata* and *E. tozeri*.

At Iron Mountain, a U-Pb age of 223.80+/-0.74 Ma, based on the weighted average of four ^{206}Pb/^{238}U dates, was determined from dacitic crystal-ash tuff that is depositionally overlain by an internally conformable 60 m-thick section composed of limestone, lesser dacitic fragmental volcanic and feldspathic sandstone beds. Successive carbonate beds yield the conodonts *Epigondolella quadrata* and *E. triangularis*, diagnostic for the early Norian. Waterlain rhyolitic ash forming prominent white bands in siltstone at the top of the measured section, with the potential to bracket the conodont fauna, unfortunately failed to produce zircons. However, the lower Norian ammonoid *Wangoceras* occurs in sandstone that is stratigraphically beneath this ash-bearing siltstone but overlying the highest conodont collection, the early Norian age of which is corroborated.

The association of the two similar U-Pb dates of ~224 Ma with conodonts interpreted as both lower and middle Norian in age is anomalous and demands additional work to be undertaken. The date from Castillion Creek places a maximum age on the *spiculata* conodont Zone (equivalent to the North American lower *Columbianus* ammonoid Zone) of the early part of the middle Norian. In this case, the possibility of a non-sequence needs to be addressed. The less precise but similar U-Pb age from Iron Mountain lies beneath conodont fauna of the early Norian *triangularis* conodont Zone and ammonoids of the middle part of the early Norian Dawsoni Zone, although it may also fall within those zones. Although neither location yet provide tightly bracketed fauna or zircons, these dates appear consistent with an older base-Norian (~227 Ma).

IMPLICATIONS OF NEW SHRIMP U-Pb ZIRCON AND APATITE FISSION TRACK AGES FOR THE SETTING AND ORIGIN OF CARBONATE REPLACEMENT MINERALIZATION IN THE WESTERN FORTYMILE MINING DISTRICT, EAST-CENTRAL ALASKA

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Epigenetic base- and precious-metal prospects in the Mount Veta area of the Fortymile district are the focus of recent industry exploration and a multi-disciplinary study by the USGS. The district is located in the eastern Yukon-Tanana Upland (YTU), which is bounded by the Tintina and Denali right-lateral fault systems. The YTU is cut by steep NE-trending faults that record both left-lateral and dip-slip movement. New SHRIMP U-Pb zircon ages (*n*=29) in the Mount Veta area document magmatic episodes at ca. 217–210, 188–184, 111–98, and 70 (±2) Ma. Intrusions of 210, 188, and 70 Ma occur within 3 km of the Little Whiteman (LWM) Zn-Pb-Ag-(Cu) carbonate replacement prospect. Sulfide bodies at LWM formed as NE-trending, steeply SE-dipping, chimney-shaped replacements of Paleozoic marble in the hanging wall of the NE-trending Kechumstuk fault and along contacts with steeply dipping feldspar porphyry dikes that intrude the marble. In some of these dikes, the intensity of quartz-sericite-pyrite alteration increases towards the sulfide lenses. Zircon from one dike yielded a 187.7±4.8 Ma U-Pb age. Secondary sericite from a different, highly altered porphyry dike yielded a ^{40}Ar/^{39}Ar age of 187.5±2.0 Ma for the most retentive 6 fractions (28% of ^{39}Ar released) with minor gas loss at ~65 Ma (P. Layer and J. Benowitz, written commun., 2011). These ages are consistent with sulfide replacement during 187 Ma magmatism. However, Pb isotopic compositions for sphalerite and galena from LWM drill core are more radiogenic than those for K-feldspar from nearby Jurassic intrusions and overlap with those from mid- to Late Cretaceous plutons. Pb isotope data allow an alternative interpretation in which the 187 Ma ^{40}Ar/^{39}Ar apparent sericite age records initial alteration of the porphyry dikes, whereas the disturbance at ~65 Ma age records mineralization by fluids at a temperature below the closure temperature of the Ar system in sericite.

Apatite fission track (AFT) ages from igneous rocks (*n*=27) in the Mount Veta area indicate multiple episodes of Paleogene (40 ± 10 Ma) cooling through the ~110°C AFT closure temperature. However, geologic relations around the 69-Ma Middle Fork caldera 20 km north of Mount Veta suggest that these rocks were near the surface in the Late Cretaceous, and therefore likely were reheated to >110°C sometime in the early Tertiary. The nature of the suggested post-69-Ma reheating is unknown. We interpret the Paleogene cooling implied by the AFT data to indicate uplift, exhumation, and cooling related to far-field movement on the Denali and Tintina faults. Two samples near faults have AFT ages of ca. 19 and 10 Ma, recording local re-heating by fluids in the Neogene. Cenozoic faults may have reactivated Mesozoic structures, such as those associated with the 187 Ma porphyry dikes that are parallel to the Kechumstuk fault.

THE RACKLAN OROGENY AND ITS NEW ROLE IN THE RECONSTRUCTION OF THE SUPERCONTINENT COLUMBIA

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New age determinations on rocks of the Wernecke Supergroup and of the Wernecke Breccia (Wernecke Mountains, Yukon) are provided to give a new picture of the geologic history of the northwestern margin of the North American craton during late Paleoproterozoic – early Mesoproterozoic.

The maximum age of the Wernecke Supergroup, given by the U-Pb age of the youngest detrital zircon (1610±30 Ma) suggests that the sedimentary succession is ca 70 my younger than previously hypothesized by Thorkelson et al 2001. Lu-Hf garnet ages on garnet bearing schists of the Fairchild Lake Group give ages around 1600 Ma and 1370 Ma: the first age is related to the Racklan Orogeny, and the younger event was probably related to a reheating episode (Hart River Sills emplacement). A 1598.8 ± 1.0 Ma U-Pb titanite age on one sample from the Wernecke Breccia supports the previous age determination by Thorkelson et al 2001.

Taken together, these data allow the revision of the geologic history of the Wernecke Supergroup, first with the Bonnet Plume River intrusions now interpreted as fragments of an exotic terrane obducted on top of the deformed Wernecke Supergroup during the Racklan Orogeny and then incorporated within the Wernecke Breccia, and second with a significant increase in the role that the Racklan-Forward orogenic system has in the reconstruction of the supercontinent Columbia. Previously interpreted as an isolated orogenic event in Yukon (and Northwest Territories), the Racklan Orogeny is now viewed as part of a continuous orogenic belt that encompasses most of the supercontinent Columbia: extending from southern and eastern Laurentia (with the Mazatzal and Labradorian orogenies) to Scandinavia (Gothian Orogeny) and Amazonia (Quatro-Cachoeiras Orogeny), this mountain chain very likely continued also through western Laurentia (the Laclede Augen Gneiss in Priest River Complex might be a remnant of it) and/or other continents (e.g. Australia), before reconnecting with the Racklan-Forward Orogeny up in the Yukon.

Terrane translation in the north Pacific prior to establishment of the Aleutian-Kamchatka arc: history of the Olutorsky (Kamchatka) and Chugach-Prince William terranes (Alaska)

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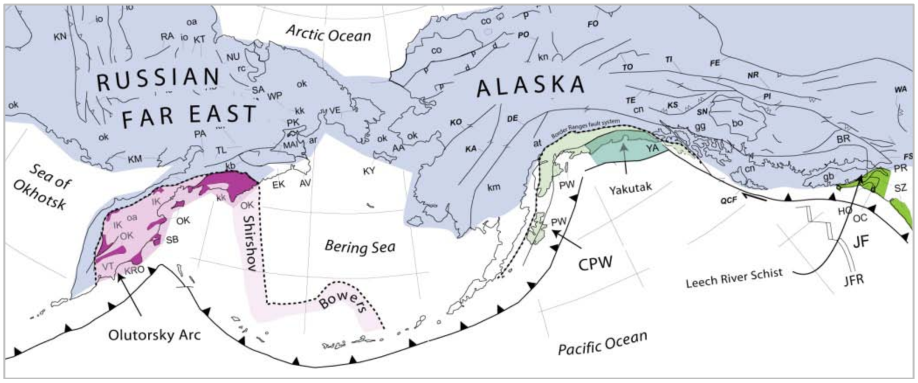
The North American Cordillera has been assembled through the formation, accretion, and translation of a number of tectonostratigraphic terranes, and much of this assembly has occurred since the Cretaceous. Terrane translation in this time interval has been almost exclusively northward due to the relative motion of Pacific plates with respect to North America, and as a result Alaska and Kamchatka have been on the receiving end of north-translated terranes. Despite nearly thirty years of investigations on terrane movement and translation, some basic questions remain. An important piece of the Cordilleran puzzle is establishing temporal connections across the Bering Sea. Here we examine two different outboard terranes in Alaska and Kamchatka formed in the Late Cretaceous to Paleocene and subsequently translated on or by fast northward moving oceanic plates to the northernmost North American Cordillera. In Kamchatka, the primary exposed outboard terrane is the Olutorsky terrane, which represents an accreted oceanic island arc. The Upper Cretaceous oceanic rocks of the Olutorsky terrane collided in the Eocene (50-45 Ma), at which time the margin was dominated by the Okhotsk-Chukotka continental arc and associated accretionary complex. The timing of accretion is well constrained by the Shamanka pluton (45 Ma) that crosscut the overthurst in central Kamchatka and by the age of exhumed metamorphic rocks in the southern part of the collision zone. Paleomagnetic data combined with geologic relations suggest formation of the Olutorsky arc about 2000 km to the south in an intraoceanic setting. It is possible that elements of the Olutorsky arc can be traced offshore to the Shirshov and Bowers ridges in the Bering Sea.



In Alaska, the Chugach-Prince William (CPW) composite terrane contains Upper Cretaceous-Paleocene flysch well-exposed for ~2200 km in southern Alaska that is inferred to be one of the thickest accretionary complexes in the world. Flysch of the CPW was accreted to the continental margin and then experienced a regionally extensive thermal metamorphism driven by near-trench plutonism of the diachronous Sanak-Baranof suite. A number of paleomagnetic studies have shown that paleopoles from volcanic rocks interbedded with the CPW require formation several thousand kilometers to the south and subsequent northward coast-parallel translation. One part of this movement history includes high-T metamorphism and plutonism of the schists of Baranof (SE Alaska) and of Leech River (Vancouver Island), which have since been separated by translation. Translation of the CPW is controversial, but several lines of evidence suggest the CPW must be more-or-less in place by ~40 Ma. Hence we have two major outboard terranes in the north Pacific that travelled rapidly northward on Pacific plates prior to the death of the Kula plate, and their accretion marks an important phase of margin growth immediately preceding establishment of the Aleutian-Kamchatka arc and subduction of Pacific lithosphere. Collision of the Yakutat terrane is ongoing and has occurred since the Miocene.

VERY NEARLY UHP METAMORPHISM-LAWSONITE AND EPIDOTE ECLOGITES FROM WESTERN CANADA

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UHP metamorphism is defined on the presence or former presence of coesite, suggesting metamorphic pressures greater than ~2.7 GPa. Some lawsonite and epidote-bearing eclogites from western Canada were metamorphosed at pressures slightly below the stability field of coesite, ~2.0-2.5 GPa. The question is, is this a fundamental discontinuity in the tectonic process of subduction? Most UHP metamorphic terranes were produced by subduction of cool continental crust to depths of ~100 km or more. Most of the lawsonite and epidote-bearing eclogite, involve subduction of oceanic lithosphere with little or no involvement of continental crust. In some cases some sedimentary rocks are included in the metamorphism. With further subduction could these rocks have produced UHP metamorphism? P-T paths of both types of subduction are similar until they diverge at higher P and T. The silica phase, if present, is quartz and the quartz inclusions in garnet do not show textures suggesting replacement of coesite. P-T pseudosections (isochemical phase diagram sections) using garnet isoclines and garnet-clinopyroxene-phengite and glaucophane-talc-clinopyroxene thermobarometry suggest P-T conditions were not in the stability field of coesite. Chemical zoning in garnet typically shows bell-shaped patterns for Mn suggesting prograde growth and no homogenization at higher temperatures. In some cases the rocks contain little or no silica phase, either in the matrix or as inclusions (also true for many Type C eclogites, e.g., Franciscan eclogites in California).The lack of primary quartz is surprising since reactions that eliminate plagioclase should produce SiO_2. This suggests SiO_2 may be removed by fluids during the reactions. Fluid involvement is also suggested because few of the bulk rock analyses are “good” basalts. The mineral assemblages lacking stable plagioclase and lacking evidence of coesite might be best termed very high pressure metamorphism, rather than simply high-pressure metamorphism.

Bedrock mapping and structural analysis of Killermun Lake region, southwest Yukon - mineral potential and tectonic significance

Rohanna Gibson, Stephen Johnston & Steve Israel

High-grade gold mineralization is found within quartz-carbonate veins located near the structural contact between metamorphic rocks of the Kluane Schist and igneous rocks of the Ruby Range batholith in the Killermun Lake area, southwest Yukon. To gain a better understanding of the nature of gold mineralization, small-scale (1:10,000-scale) bedrock mapping was conducted in the Killermun Lake area to determine the lithologic and structural character of the rocks hosting mineralization.

The Killermun Lake area is characterized by a northeast dipping structural stack, with ortho- and para-gneiss apparently overlying quartz-biotite schist. All rocks are deformed by a penetrative foliation that has a general northeast shallow dip. Foliation and later folding is thought to be the result of Late Cretaceous, southwest directed thrusting of the Yukon-Tanana terrane over the Kluane Schist. Structural data collected from the map area is used, to construct cross-sections and analyzed using stereonets, to determine the three-dimensional geometry of these rock units. Petrographic study of rock units and microstructures will help to develop our understanding of the regional geology and determine the controls on gold mineralization.

Gold is found in quartz-carbonate-arsenopyrite veins that crosscut the main foliation within the gneissic unit. An orogenic model has been proposed for the gold mineralization, and this model will be considered within the framework of structural and petrographic data. The timing and mechanism of this gold mineralization will be considered within the lithotectonic setting, to improve our understanding of the tectonics of the area and assist in future exploration.

MORAN AREA, RUBY AND TOZITNA TERRANES, CENTRAL-INTERIOR ALASKA: a mystery wrapped up in an enigma

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In 2011, the Alaska Division of Geological & Geophysical Surveys (DGGS) conducted 300 mi^2 of 1:63,360-scale geologic mapping in the Moran Dome area of Central-Interior Alaska. The Moran project map area is located 150 miles west of Fairbanks, in the eastern Kokrines Hills, immediately north of the Yukon River, which follows the Kaltag, regional-scale, right-lateral, strike-slip fault system. DGGS geologists have distinguished eight mappable units, two regional metamorphic events, at least four ductile deformation events, and a single intrusive event followed by brittle deformation.

The Proterozoic to Paleozoic Ruby Terrane (RT) underlies most of the Moran area. DGGS subdivides the RT into four meta-sedimentary units, which spatially correspond with interpretations of the DGGS Moran airborne geophysical data. From structurally lowest to highest they are calcareous-mica-albite-quartz schist, massive to foliated quartzite, pelitic schist, and interlayered graphitic quartz schist and quartzite. Shallow-dipping S_2 foliation is axial planar to recumbent F_2 isoclinal folds, and refolded by upright, open-to-close-profile NE- and SW-plunging F_3 folds and lesser upright, open-to-close-profile NW- and SE-plunging F_4 folds. Stretching lineations plunge shallowly to the NW and SE. A Kaltag-parallel, steep, E–W-trending, S_3 foliation cuts S_2 along the Yukon River. Intermixed within the meta-sedimentary units are outcrop- to map-scale pods of mafic amphibole-feldspar schist, with local relict magmatic augite. Trace-element geochemistry indicates diverse tectonic settings: (1) two distinct groups of volcanic arc basalts (VAB), (2) within-plate basalt (WPB), and (3) a low Ti, P, and Zr group of unknown affinity.

The allochthonous Jurassic Tozitna Terrane (TT) structurally overlies the RT, presumably in thrust contact. Meta-mafic rocks have a trace-element-indicated mid-ocean-ridge basalt setting, with several locations of anomalous VAB and WPB. Shallow NE- and SW-dipping foliation is folded about an upright NW-trending axis, which is parallel to shallow-plunging L_1 stretching lineations. Shear-sense indicators parallel to L_1 are mixed, with six samples showing top-to-the-NW, two samples showing top-to-the-SE, and two samples with mixed sense.

RT mafic schists record a high-pressure epidote-amphibolite±garnet M_1 event strongly overprinted by an M_2 greenschist-facies albite+chlorite+actinolite assemblage. Relict late-magmatic hornblende replacing augite in mafic cumulate indicates an even earlier hydrothermal metamorphism. In Pelitic rocks abundant chloritoid and paragonite suggests high-P M_1 conditions; mineral compositional geobarometry indicates P of 9-11 kb. M_1 syn-S_1 garnet porphyroblasts are wrapped by S_2 biotite and overprinted by an M_2 greenschist-facies event. Microprobe analyses of TT rocks confirmed pumpellyite and that blue amphiboles are riebeckite, crossite, and compositionally zoned ferro-glaucophane to ferro-hornblende. Late magmatic to early-post-magmatic hornblende in clinopyroxenite cumulate indicates pre-regional metamorphic P of 4-6 kb. TT rocks typically contain sub-to-euhedral augite porphyroclasts within a lower-greenschist-facies mylonitic foliation defined by chlorite+albite±riebekite±actinolite±pumpellyite.

The Early Cretaceous Melozitna pluton (MP) intrudes the RT. It is predominantly a very coarse-grained, porphyritic, K-feldspar-megacrystic, biotite monzogranite, with lesser medium-grained, equigranular, two-mica granite and granite porphyry dikes. Locally abrupt textural and compositional changes suggest multiple levels of the pluton are juxtaposed by late, brittle faulting. Rocks of the MP contain 67-76 wt.% SiO_2 (average ~74 wt.%), display slightly peraluminous composition (average Al Saturation Index ~1.2), and generally plot in the high-K calc-alkaline field (average K_2O wt.% = 4.93). Tectonomagmatic plots indicate a within-plate granite signature, with elevated Rb, Nb, and locally Y, suggesting extensional or transtensional emplacement processes.

The RT represents a composite metamorphic terrane of sedimentary and mafic protoliths with multiple tectonic affinities. In meta-sedimentary units, D_1 formed the S_1 foliation and high-grade M_1 event, followed by D_2 isoclinal F_2 folding and subsequent S_2 foliation. Foliation in the mafic schists is parallel to this S_2, therefore their juxtaposition is$\leq D_2$. D_3 records moderate NW-SE compression, which created the upright F_3 folds. Both the RT and TT exhibit NE-SW compressional D_4 features, shallow NW- and SE-plunging F_4 fold axes and stretching lineations, suggesting they were juxtaposed to each other by this time. Preliminary conclusions are: (1) RT mafic rocks and M_1 conditions suggests greater similarities to the Yukon_Tanana Terrane than rocks of the Seward Peninsula or Brooks Range, (2) Thrusting of the TT over the RT post-dates D_2. On-going work and forthcoming geochronologic data by DGGS will provide further insight into the tectonogenesis of the Ruby and Tozitna terranes.

LiDAR assisted mapping and deformation history of Crowsnest Pass, Alberta

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The Crowsnest Pass area, located in southern Alberta, is part of the foothills of the Cordillera Orogen. Detailed geological mapping revealed the location of map-scale structures in the Crowsnest Pass area. The use of LiDAR data increases the accuracy of geological mapping. Bare-earth-filtered digital elevation models (DEM) constructed from LiDAR data, and displayed in shaded relief images, show subtle topographic features. LiDAR-derived maps taken into the field helped to interpret inaccessible or hazardous areas. Using several “hill shade” maps, utilising different azimuths and sun angles, lineaments are manually traced. The lineaments, with field data, help with interpreting the location of geologic structures. The resulting geological map shows a number of folds that have close spatial relationships to faults. Some of these folds resemble standard fault-bend and fault-propagation folds. Many kinematic models have been proposed to describe these types of folds, each with different predicted distributions of strain and layer thickness. Several methods of strain analysis, including Fry plots and calcite strain gauge methods, have been used on the backlimbs, hinges and forelimbs to help to determine fold kinematics. In addition, the accurate geological map and cross sections reveal changes in thickness across folds. These methods are used to test the kinematic models for folds in the area. These results will be of relevance to thrust-fold relationships in other areas within the Cordillera.

Chronostratigraphy and tectonostratigraphy of the Late Paleozoic cratonic succession in east-central British Columbia and implications for Slide Mountain Ocean/pericratonic terrane geology

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The geologic history of the Slide Mountain Ocean and adjacent pericratonic terrane rocks is difficult to unravel, but a different approach investigating the near-by North American craton (NW Pangea) may yield new insights. The cratonic succession is punctuated by numerous unconformities that are interpreted to be largely a product of tectonic control as determined by angular relationships, conglomerate distribution and basin structural inversion. A series of tectonic events (C2-P6) have previously been established in north-central Nevada (Trexler *et al*., 2004; GSA Bull.) and, on the basis of conodont biostratigraphy, can be correlated with successions at least into NEBC. It is assumed that some answers for this punctuated tectonic control may be resolved by comparison of events in and around the Slide Mountain Ocean; here we mention some results in the Barkerville region of the Cariboo gold belt. Timing becomes the key!

Mid-Pennsylvanian (Moscovian/C4/314-309 Ma) rocks are represented by a warm-temperate carbonate ramp succession including the Ksituan and Belcourt formations. These units are similar to the Alex Allan Formation in the Cariboo Terrane in terms of lithology and conodont assemblages. Dolomitization of Ksituan Formation carbonate produces a gas reservoir in east-central BC – these dolomitizing fluids were possibly driven by a later P2 event.

A late Pennsylvanian (Kasimovian/C6/307 Ma) event reorganized the basins in east-central BC by uplifting some blocks and creating accommodation elsewhere. Locally these structural inversions may be related to extension or compression, but in Nevada the C6 event resulted in a major angular unconformity. In east-central BC, Asselian age (295-299 Ma) carbonate assemblages are mostly heterozoan, but one region is anomalous with a photozoan assemblage. A peninsular shaped high restricted cool upwelling waters from affecting a shallow interior sea (analogous with Baja Peninsula and Sea of Cortez) that contains warm-water photozoan assemblages including *Palaeoaplysina* reefs and fusulinids (*Pseudofusulina attenuata* and *P. acuta*) that have been described from the McCloud Lst of the Klamath Terrane as well as central-Nevada. This indicates that faunal similarity between cratonic rocks and terranes is affected by more than a simple distance function, but also by the occurrence of appropriate environments. The Sugar Limestone within the Barkerville Terrane is the same age and includes a conodont species previously recorded only in Nevada and Bolivia. The Sugar Lst represents the youngest stratified rocks of the Barkerville Terrane and is correlative to the youngest rocks of the Antler Formation at Sliding Mt near Barkerville (Struik and Orchard, 1985; Geology). The Antler was later imbricated by numerous thrust faults of uncertain age, but obviously younger than 295 Ma.

An Early Permian (Artinskian) P2 event (~290 Ma) also resulted in structural inversion of basins on the cratonic margin creating an isolated Peace River Basin in west-central Alberta and a broad high throughout much of east-central BC. Did this high result from lithospheric loading associated with compression and could the driver be closure within the nearby Slide Mountain Ocean and thrusting in the Antler Formation? The next significant event (P4) at ~275 Ma generates an angular unconformity in SEBC and basin reorganization across the cratonic margin. Intrusives in the Barkerville Terrane dated at 277-281 Ma (Ferri and O’Brien, 2002; BC Open Report) may be related to this event. Subsequently, the Fantasque and Ranger Canyon formations were deposited from about 272-262 Ma and form a thin unit that is persistent throughout the entire cratonic region. This implies a tectonically quiet interval that may coincide with the widest extent of the Slide Mountain Ocean, prior to closure associated with the Late Permian Sonoma Orogeny (P6) or later during the Triassic. Basin reorganization associated with the P6 event may have provided a western source for sedimentation affecting shale gas reservoir characteristics in the Montney Formation.

Previous work (Nelson *et al*., 2006; GAC Spec Paper 45) has suggested that the Slide Mountain Ocean was the locus of active back-arc seafloor spreading from mid-Carboniferous to Middle Permian followed by closure during the Sonoma Orogeny. The punctuated Late Paleozoic cratonic succession summarized above suggests that Slide Mountain Ocean evolution between the Antler and Sonoma orogenies was very complex and that ‘accordion-tectonics’ may have had several beats.

Emerald mineralization in the Mackenzie Mountains: A relationship to a major Paleozoic fluid-flow event and back-arc basin development

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Emeralds are most commonly formed by the introduction of Be-rich fluids to Cr (±V)-rich host rocks, and can be classified into three major categories: type 1 emerald deposits are associated with Be-bearing granites or pegmatites intruding mafic or ultramafic host rocks; type 2 deposits are the schist-hosted, or metamorphic emeralds formed by metasomatic fluids in upper greenschist to amphibolite facies metamorphic environments coincident with major crustal breaks (ie. shear zones and thrusts); and type 3 emerald deposits, recognized only in Colombia, formed via in-situ thermochemical sulphate reduction of hydrothermal sulphate brines that mobilized Be, V, and Cr by organic matter in host black shales.

Emerald mineralization at the Mountain River occurrence in the Mackenzie Mountains, Northwest Territories, is associated with extensional quartz-carbonate veins hosted in organic-poor deepwater sandstones and siltstones of the Neoproterozoic Windermere Supergroup. The section hosting the emerald veins is located within the hanging wall of a thrust fault that emplaced Neoproterozoic siliciclastics above Paleozoic carbonates. There exists no local evidence of felsic igneous activity or significant regional metamorphism (regional metamorphism is sub-greenschist facies). Hydrogen isotope compositions of water extracted from emerald range between -65‰ and -49‰ (V-SMOW). The $\delta^{18}O_{V\text{-}SMOW}$ values for emerald and quartz range between 16.2‰ and 17.2‰, and 17.9‰ and 18.9‰, respectively. One dolomite sample returned a $\delta^{18}O_{V\text{-}SMOW}$ value of 18.1‰. Temperature of mineralization was determined by mineral pair $\delta^{18}O_{V\text{-}SMOW}$ equilibration (quartz-emerald, quartz-dolomite, emerald-dolomite) to be in the range 379 to 415°C. Fluid inclusion analyses indicate saline (>22 wt% NaCl equivalent) CO_2-bearing brines and homogenization temperatures between 200 and 250°C. Combining fluid inclusion isochores with isotope equilibration temperatures indicates fluid pressures on the order of 2.0 to 4.5 kbar, which correspond to depths of 6 to 12 km. Euhedral pyrite intergrown with emerald yields a 5 point Re-Os model 1 isochron age of 345 ± 20 Ma and an elevated initial $^{187}Os/^{188}Os$ ratio of 3.2, indicating a crustal fluid source.

Isotopic, fluid inclusion, and geologic data indicate the Mountain River emeralds formed from non-magmatic fluids and are genetically most similar to the Colombian-type mineralization model, with some geological differences. We hypothesize that emerald formation resulted from the circulation of hydrothermal brines through basinal siliciclastic, carbonate, and evaporitic rocks, scavenging Be, V, and Cr during the late Paleozoic. The fluids involved and age of the occurrence are comparable to that of extensive base-metal mineralization throughout the northern Cordillera (carbonate-hosted lead-zinc, sedimentary exhalative and volcanogenic massive sulphide), and substantiates the argument for a large-scale hydrothermal brine movement event during the Late Devonian to Early Mississippian that resulted in base-metal mineralization and the Manetoe Facies dolomitization event. Nelson et al. (2006) relate this massive fluid flow event to incipient rifting and the development of a back-arc basin as the Yukon-Tanana basement rifted away from Laurentia, and the Slide Mountain Ocean and subsidiary basins began to open.

New U-Pb zircon ages from the Yellow Aster complex, northwest Washington State

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The Yellow Aster and Turtleback complexes in northwest Washington are accreted terranes that have been recently reinterpreted as the basement of the newly proposed Chilliwack composite terrane (Brown et al., 2010). The composite terrane now broadly links the Chilliwack, Yellow Aster, Turtleback, and East Sound terranes from the foothills of the North Cascades to the San Juan Islands. Findings of Brown et al. (2010) and Brown (unpublished data) suggested paragneisses of the Yellow Aster Complex have detrital zircons indicative of northwest Laurentia and an outboard source, likely the Alexander terrane. They also concluded that Late Silurian to Late Devonian (418-375 Ma) igneous ages correlate to other Mid-Paleozoic fringing arcs throughout the Cordillera (e.g. Yukon-Tanana). New U-Pb zircon LA-ICPMS ages from the Yellow Aster Complex are presented here. Analyses were performed at the Arizona Laserchron Center.

Six samples were analyzed for this study, including four quartzose calc-silicate paragneisses and two intrusives. A quartzose calc-silicate paragneiss (sample 39) from Yellow Aster Butte contains 41 percent Archean and Paleoproterozoic zircons, 44 percent Mesoproterozoic zircons (1600-1000 Ma), five percent Neoproterozoic and a youngest peak age of 434.4 ± 6 (10%). From Schriebers Meadow, quartzose calc-silicate paragneiss (YA-5) contains 14 percent Archean and Paleoproterozoic zircons, 40 percent Mesoproterozoic zircons, seven percent Neoproterozoic zircons, and a youngest peak age of 416.5 ± 5.8 (38%). Two other quartzose calc-silicate paragneisses (10b and 11) from Schriebers Meadow have single peak ages of 409 ± 5 and 405 ± 4.2 Ma, respectively. Sample 11 contains a variety of Proterozoic zircons, however, these older ages are only represented by one grain each. Sample 03 is a foliated intrusive from Schriebers Meadow with a peak age of 393.6 ± 5.7 Ma. The other intrusive (34) from Yellow Aster Butte, is undeformed and interpreted as post-tectonic, but contained zircons with single-grain ages ranging from ≈406 to ≈2800 Ma, interpreted as inherited from the country rock due to the lack of a peak population.

In samples 39 and YA-5, a significant proportion of detrital zircon ages fall within the North American magmatic gap (1490-1610 Ma) and early Paleozoic time (400-500 Ma) which suggests an exotic sedimentary source, likely the Alexander terrane. These ages are not indicative of western Laurentia, but are similar to ages known from the Karheen Formation of the Alexander terrane (Gehrels et al., 1996; Grove et al., 2008). This is in contrast to a paragneiss from the Yellow Aster Complex (YA-2 of Brown et al., 2010) that suggests a dominant northwestern Laurentian affinity, similar to peri-Laurentian terranes (e.g. Yukon-Tanana). This suggests the Yellow Aster Complex had different sedimentary sources at different times. The Late Devonian East Sound sample of Brown et al. (2010) also has a detrital zircon age pattern similar to the Karheen Formation.

Samples 10b and 11 are calc-silicate rocks interbedded with marble and quartzite. The single peak zircon ages of 10b and 11, as well as the age of orthogneiss sample 03, are within the range of other intrusives from the Yellow Aster and Turtleback complexes. The single peak zircon ages of samples 10b and 11 are interpreted to reflect deposition of tuff within a calc-silicate protolith. Also in samples 10b and 11, zircons with ages around 400 Ma have high U-Th ratios which might date a metamorphic event. Previously dated intrusions from the Yellow Aster and Turtleback complexes ranging from 418-375 Ma are undeformed and cross-cut meta-sedimentary rocks.

The basement of the Chilliwack composite terrane exhibits a complex geologic history yet to be fully understood. Sedimentary rocks as young as 414 Ma were deformed and metamorphosed. Pre-, syn- and post-tectonic intrusions range from 418-375 Ma, but the timing of dike emplacement with respect to metamorphism and deformation remains confusing due to the presence of younger (≈393 Ma) deformed and older (≈418 Ma) undeformed intrusions. Peak populations of detrital zircons indicate that magmatism in the source region spanned from >426 to <400 Ma.

Why is the Cordillera a mobile belt? Why is it high? Why is there lower crust detachment? Why is there current Barrovian crustal metamorphic conditions?

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The North American Cordillera and most mountain belts are uniformly hot backarcs. The high temperatures have a number of important consequences.

(1) The high elevation. Global mountain belts including the Cordillera are commonly concluded to result from crustal thickening associated with continental collision, with high elevations supported by crustal roots. However, accumulating seismic structure data indicate that only a few mountain belts have a crustal root. Most of the North American Cordillera has 30-35 km crust in contrast to 40-45 km for the lower elevation craton and other stable areas, a violation of Airy isostasy. It has been shown previously that most such mountain belts are in present or recent backarcs that are uniformly hot. From thermal constraints we predict a uniform ~1,600 m elevation support of the Cordillera by thermal expansion compared to stable areas. Over most of the Cordillera the actual elevation difference after correction for variable crustal thickness and density is in excellent agreement. When subduction and shallow backarc convection stop, the lithosphere may cool and the elevation of mountain belts subside over ~300 Ma.

Some of the other consequences of uniformly hot backarcs like the Cordillera are:

(2) They have hot, thin and weak lithospheres, i.e., they are “mobile belts” that are weak enough to deform readily under changing plate tectonic forces. Cold cratons are strong and require very special conditions to deform. The Cordillera at present and for the past ~300 Ma has been widely and variably extended and stretched, it has been shortened, and it has been shredded by transcurrent faulting, i.e., a “mobile belt”.

(3) There are regional horizontal detachments in the hot and therefore ductile lower crust across the whole Cordillera that rise in the basal detachments of the foreland belts. A present example is active thrusting in the northern Cordillera Mackenzie Mountains in response to the current Yakutat terrane collision on the coast,

(4) There are regional Barrovian metamorphism crustal gradients with current temperatures at the Moho of 800-900C. For ancient orogenic belts, such metamorphic gradients were produced in a subduction backarc prior to continental collision and then were exhumed by collision processes,

(5) Earthquakes only occur in the upper 10-15 km “brittle” part of the Cordillera crust. Temperatures are too high at greater depths.

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Geology and mineral potential of the northwestern Aishihik Lake map area, parts of NTS 115H/12 and 13

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Bedrock geological mapping in the northwestern Aishihik Lake map sheet in 2011 extended previous 1:50000 scale geology mapping carried out in southwest Yukon over the past several summers. This mapping is part of a project that has been focused on the geological and tectonic relationships of rocks found north of the Denali fault and south of the Nisling River.

Regionally, Paleozoic rocks of the Yukon-Tanana terrane are thrust southwestward over the Late Cretaceous Kluane Schist. Much of this faulted contact is overprinted by the partially syn-kinematic, Paleocene, Ruby Range batholith. At its base the batholith is strongly foliated to mylonitized and is intimately associated with a partially migmatitic paragneiss that is likely highly metamorphosed Kluane Schist. Away from the base, the batholith becomes massive and the upper level of the Ruby Range consists of myrolitic quartz diorite and granodiorite.

In the northwestern Aishihik Lake map sheet, coeval quartz-feldspar porphyry is found associated with the Ruby Range batholith as well as a Paleocene volcanic package assigned to the Rhyolite Creek complex. The volcanic rocks consist of rhyolitic flows and tuffs, dacitic to andesitic flows, breccias and tuffs and rare basalt flows. A series of north to northwest striking, high-angle faults are likely syn-volcanic and appear to control some of the deposition of the volcanic rocks.

The area is most prospective for copper-gold porphyry and epithermal gold mineralization. Anomalous values for sliver, arsenic, mercury, zinc, copper and gold are found in along late brittle faults and fractures. Recent regional exploration carried out by several companies has identified areas of very high gold in soils over several kilometres within the Yukon-Tanana terrane where it is spatially associated with the Paleocene volcanic rocks and high level miarolitic Ruby Range batholith.

Reassessment of Triassic and Jurassic volcanic strata in the Dease Lake region, northern British Columbia

O. Iverson, J.B. Mahoney, and J. Logan

Detailed stratigraphy and sedimentology, petrography, detrital zircon geochronology, and whole rock geochemistry of volcanic strata mapped as the Triassic Stuhini and Tsaybahe Groups in the Dease Lake area indicate that these rocks actually belong to the middle Jurassic Hazelton Group.

This project focuses on two well-exposed stratigraphic sections including a reference section north of the Cake Hill pluton first described by Anderson (1981, 1983), and a second section on the north flank of Thenatlodi Mountain. The reference section was originally interpreted to be the Late Triassic Stuhini Group in thrust contact with the Late Triassic Cake Hill pluton. Subsequent work suggested that these strata were correlative with the informal Middle Triassic Tsaybahe Group. The detrital zircon analysis of this section indicates that these strata are much younger than originally interpreted, and are correlative with the Early to Middle Jurassic Hazelton Group. This indicates that the Hotailuh thrust fault does not exist and that the entire section is an upright stratigraphic sequence of Middle Jurassic strata unconformably overlying the Cake Hill pluton. Stratigraphic similarities between these strata and those exposed on Thenatlodi Mountain suggests that the Hazelton Group is much more widespread than previously interpreted in this region.

Whole rock geochemical analysis, including major, trace and select REE analysis, is in progress on volcanogenic rocks from the measured sections and regional collections. The objective is to compare and contrast the geochemical character of rocks now recognized to be Early to Middle Jurassic in age with those mapped as the Stuhini and Tsaybahe groups.

Testing paleohydrological estimates of drainage basin size in the Cretaceous and Tertiary of the Bonnet Plume Basin using petrology

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One of the key questions in documenting the paleohydrologic evolution of clastic basins is the estimation of size of the catchment area. This can be done using a variety of physically constrained methods utilizing maximum and modal grain size, cross-bed thickness distribution, and estimates of channel dimensions. Estimates made using these methods can be directly tested using petrographic analysis of lithotypes if these have survived erosion and transport from the source area, especially where the basin is surrounded by a broad range of lithotypes. In this study clastic strata from the Bonnet Plume basin (NTS 106E) in northern Yukon were examined physically and petrographically to determine if these approaches produced comparable results. The Bonnet Plume basin is a structural and physiographic depression at the intersection of the Richardson Mountains and Mackenzie Mountain front. The basin was formed in a trans-tensional setting at the same time as mountain building in western Canada. The basin fill has been divided into a lower and upper member of Cretaceous and Tertiary age and contains significant hydrocarbon reserves.

Petrographic study of chert and other resistate siliceous lithic fragments allows direct matching of grains to specific formations in the northern Mackenzie Mountains. The clasts include 18 varieties of chert, 12 varieties of resistant mudrock, and 20 other distinct lithotypes. In order to accommodate potential source rocks the lower member would have had a minimum area of ~11,200 km^2, while the upper member requires a catchment of at least 21,000 km^2.

The average estimates of basin size using paleo-hydrological analysis indicates a catchment area of 25,237 km^2 for the lower member, and 40,247 km^2. Slope estimates for both the upper and lower member are similar at 0.0004 m/m. Although the absolute values are not identical, the relative increase in basin size indicated by both methods is identical, indicating that both methods are viable. A further test will be undertaken to see if zircon populations in both the upper and lower members show similar changes in catchment basin size.

Evolution of the Thrust Belt in Southern Albania

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The southern Albania thrust belt comprises Mesozoic-Eocene carbonate sequences incorporated into three major Tertiary thrust sheets verging towards the Apulia foreland in the southwest. The problem of the structural evolution has been previously approached through a hypothesis of orthogonal thin-skinned thrusting controlled by a differential areal extent of Permo-Triassic evaporites.

This research uses the interpretation of several seismic profiles to address questions such as those relating to the subsurface geometric patterns of the thrust sheets, the kinematic framework the evaporites operated in, the role of the pre-existing faults and the timing of the evolution.

The interpretation demonstrates that significant along-strike changes characterize the subsurface geometry of the thrust sheets. The Permo-Triassic evaporites facilitated their buttressing against a buffer zone in the Apulian foreland primarily within an orthogonal compressional regime. Regional clockwise rotation about a pivot point to the north may have provided a transpressional component along the thrusts. Pre-existing normal faults played a significant role in thrusting and accommodation of the strain partitioning. The main structural events included thin-skinned thrusting during Oligocene-Aquitanian, formation of a buffer zone in the foreland during the Burdigalian and subsequent thrust - buttressing during the Miocene. Post-Pliocene deformation occurs in the foredeep basin.

PALEOZOIC EVOLUTION OF THE SOUTHERN ALEXANDER TERRANE, NORTHWEST BRITISH COLUMBIA

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Bedrock mapping and geochronology, in coastal NW British Columbia constrain the Paleozoic evolution of the southern Alexander Terrane (AT). The lowest stratigraphic unit is the Late Cambrian to Middle Ordovician Descon Formation (ca. 460-520 Ma), which consists of andesitic breccia, tuff, felsic volcanic rocks, volcanogenic sediments and associated hypabyssal rocks produced by island arc magmatism. It is overlain by two stratigraphically distinct Devonian clastic successions. The Karheen Formation contains lithic feldspathic arenite and plutonic cobble conglomerate with shallow water sedimentary structures and pillow basalt. The Mathieson Channel Formation contains lithic feldspathic sandstone, matrix-supported polymict conglomerate, abundant carbonate and basalt. Detrital zircon populations (ca 400-460 Ma), with a peak at 423 Ma, between the two formations overlap. The two sequences are interpreted to have been deposited in different parts of a basin unconformably overlying the Descon Formation. Descon-age zircons within the sequence are minor, and the primary source seems to have been late Ordovician-Silurian plutonic rocks that are not recognized in the region.

The Banks Island assemblage, west of the AT, contains rhythmically interbedded thin bedded quartzite and carbonate with a detrital zircon signature of ca. 410-420 Ma and subordinate Precambrian peaks. It may correlate with thin bedded successions in the Mathieson Channel unit. Enigmatic quartzite cobble conglomerate occurs in one locality along the western edge of the AT, and displays a broad, enigmatic Proterozoic detrital spectra (ca 900-2000 Ma). The detrital zircon spectra of thin bedded strata adjacent to the Jorkins Point conglomerate contains a Descon-age peak that suggests a potential linkage to the AT.

Metamorphic complexes on Porcher Island occur along the western edge of typical Alexander stratified rocks, east of the Banks Island outcrop belt. Evidence for Devonian tectonism is shown by deep burial and metamorphism of both Descon-age strata (protolith age ca. 490 Ma) and plutonic bodies as young as ca 413 Ma, cut by post-deformational plutonism (ca. 410 Ma). This may represent a mid-Paleozoic accretionary boundary between the AT and a pericratonic fragment, while the Karheen, Mathieson Channel and Banks Island strata may represent the associated clastic overlap.

Stratigraphy and geochronology of the Pinguicula Group: local and exotic sediment provenance

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The late Meso- or early Neoproterozoic Pinguicula Group, Wernecke Mountains, Yukon, is a siliciclastic and carbonate succession deposited on an angular unconformity developed on the Wernecke Supergroup. The group consists of three units. Unit A consists of a fining-upward conglomerate and sandstone unit, deposited on an underlying regolith on the Wernecke Supergroup, overlain by a monotonous siltstone succession. Unit B is a dolostone and limestone succession in which shallower-water facies, deposited above storm wave-base, grade upsection into slope facies with intraclast rudstones and turbidites. Unit C is a deep-water dolostone and limestone succession that has been pervasively altered by carbonate veins, zebra dolomite, and coarsely crystalline dolostone. Detailed stratigraphic observations indicate that the Pinguicula Group was deposited during overall deepening of the basin: fining-upward siliciclastic facies of unit A are overlain by mid-slope carbonate facies of unit B, which grade to lower slope and possibly basinal carbonate facies of unit C.

Detrital zircon geochronology from the Pinguicula Group provides information on provenance and age of the sediment deposited in the Pinguicula basin. Neoarchean and Paleoproterozoic populations are abundant and may be derived from the underlying Wernecke Supergroup or the Laurentian craton. A distinctive population from the Mesoproterozoic, between 1610 and 1490 Ma (North American Magmatic Gap), suggests that sediment may have been derived from Australia. In addition, detrital zircon $^{207}Pb/^{206}Pb$ ages from the Wernecke inlier are as young as 1144±25 Ma (one grain), which raises the possibility that the Pinguicula Group is younger than ~1150 Ma. The reliability of this finding will be addressed by additional geochronology. If additional grains of this age are found, and the depositional age of <1150 Ma is confirmed, then correlations between the Pinguicula Group and other successions in northern Canada will need to be revisited.

Sitlika-Kutcho arc, Pangaea-B and Cabo Slab constraints on Cordilleran paleogeography

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Oceanic sediments deposited near eastern and western Pangaea contain fossil fauna displaying a high degree of endemism arising from isolation of warm-water marine realms as the Pangaean supercontinent extended into both polar regions. Such faunas have historically provided one of the principal longitudinal controls for paleogeographic reconstructions of arc terranes of the North American Cordillera. Seismic structure of the Earth's mantle offers a complimentary and potentially more precise tool for paleographic location of subducted slabs and the path of arcs that are generated as the slabs sink. Mapping of slab relicts within the mantle by seismic tomography (*cf*. van der Meer, et al., *Nature Geoscience*, 2010) is based upon the assumptions: (a) positive perturbations in mantle velocities on the order of +0.4% are due principally to negative thermal anomalies arising from subducted slabs of cold ocean crust, (b) within a few hundred kilometres of passing the trench the slab sinks vertically, (c) sinking velocities are on the order of 1-2 cm/a, and (d) thermal (seismic) contrast in slabs older than ~300 m.y. is presently insufficient to permit accurate mapping, limiting the technique to arcs of Late Carboniferous or younger age. Positive velocity anomalies that can be mapped to modern subducting slabs provide unambiguous examples of the efficacy of this technique, but complexities of the mantle, such as mineral phase boundaries and convection, make extrapolation of the technique to the deep mantle a challenge. Thus, an isolated high velocity domain near the core-mantle boundary, like the one resident beneath the west-central Pacific Ocean (with its western limit under southern Baja peninsula), is of more speculative origin. Herein called the "Cabo slab", it resides at depths permissive of subduction between ~270 and 240 Ma (e.g. van der Meer et al., 2010; Fig.1).
Location and size of the Cabo slab is consistent with an origin beneath the Kutcho-Sitlika arc (K-S arc), relicts of which span an age range of ~265 – 238 Ma. Cabo slab occupies a northwest-elongated area of about 33° x 25° (~2150 x 1600 km) at a mean depth of 2650 km. Additional constraints on the location of Kutcho-Sitlika arc nucleation are provided by:

- Early Mississippian maximum age of offscraped strata within the associated Cache Creek accretionary complex.
- application of a simple Atlantic-style model for Rodinia supercontinent inversion, including:
  - ♦ rift-to-drift transition of ~570 - 600 Ma for formation of Panthalassa along western Laurentia,
  - ♦ initiation of subduction along northwest Laurentia around 390 Ma,
  - ♦ a reassembled Pangaea plus Paleotethys-Chimerian realm that spanned half of the equatorial globe at ~280 Ma (e.g. Torsvik et al., *Reviews of Geophysics*, 2008),
  - ♦ and plate growth / consumption rates (~60 mm/a) that fall well within those displayed by modern Earth (e.g. Müller et al., G^3, 2008).
- Extents of seismic anomalies can be interpreted to indicate a Kutcho arc length (2150 km) and ~25 Ma duration, roughly consistent with fossilized extents of the arc.
- Predominant isotopic ages from samples of oceanic crust associated with the Kutcho arc are coeval with the oldest interpreted volcanic ages, as is typical of initial oceanic arc / forearc crust age relationships in ophiolitic belts worldwide.

Initiation of the K-S arc is coeval with Pangaea B to Pangaea A reconfiguration and may be genetically linked to the proposed ~3500km of dextral motion of Laurentia with respect to a counter-clockwise rotating Gondwana (*cf.* Irving, *AGU Monograph 145*, 2004). A northeast-dipping plate is imaged by tomography, and interpreted to have formed as K-S subduction initiated east of the Panthalassa spreading ridge and stalled as the trench began to overtake buoyant young ocean crust near the ridge (explaining the relatively short duration of the K-S arc). Other slab relicts beneath present day northwest Pacific and Central America can be interpreted as residua from Permian and early Mesozoic subduction beneath the Stikine, Quesnel, Wrangellia and Klondike arc. Paleogeographers have opportunities to fine tune younger Cordilleran arc volcanism with even greater confidence as such arcs should be explained by the passage of Farallon and younger slabs beneath North America. Such slabs will be increasingly well-imaged thanks to on-going data acquisition from USArray and complementary seismic networks, together with innovative processing techniques.

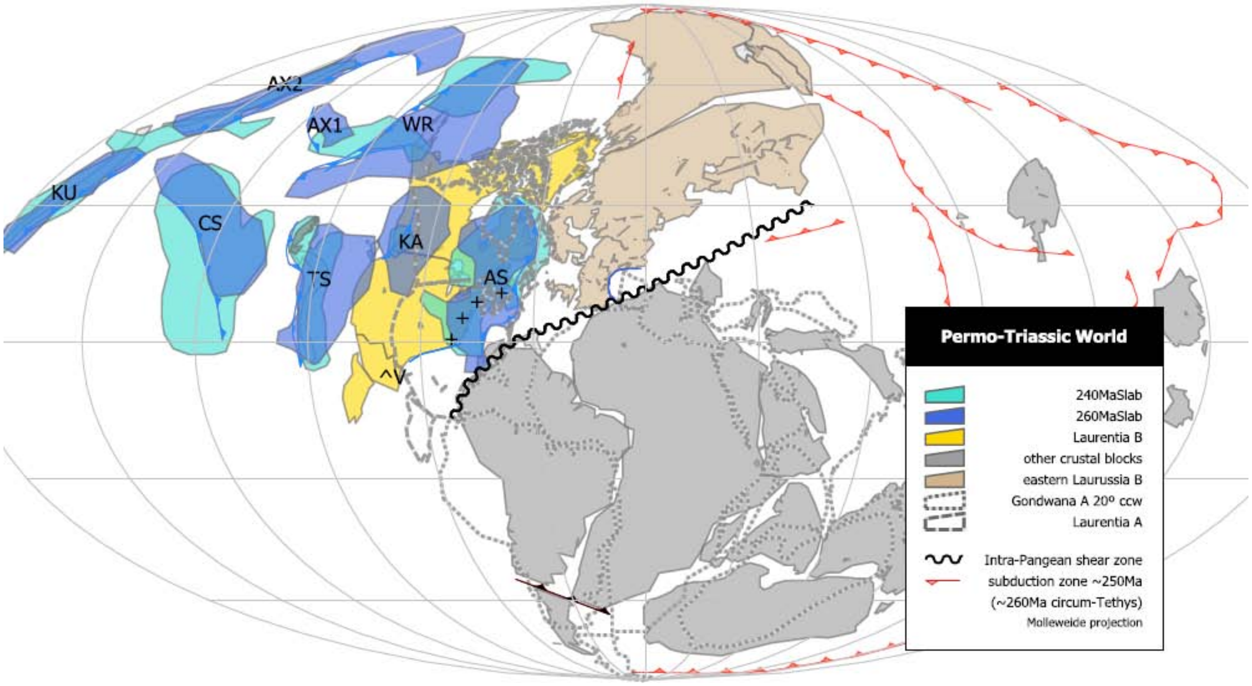

Figure 1. Paleogeographic reconstruction of Pangaea B *circa* 280 Ma (Laurentia B in yellow; *cf.* Irving, 2004 and his earlier work) with details of intra-Pangaean and Chimerian crustal blocks from van der Meer et al. (2010). By 265 Ma, ~3500 km of dextral compressional offset was accommodated, mainly along high-angle shear zones and final assembly of Pangaea (Laurentia into Laurussia) was complete (resulting in Wegenerian Pangaea A). Extents of mantle high velocity zones interpreted as slabs from the data of van der Meer et al. (2010) are shown at ~260 Ma (dark blue) and ~240 Ma (light blue). For clarity, only slabs that bear directly on evolution of the North American Cordillera are shown. These include: Cabo slab (CS), Atlantis slab (AS, first recognized by van der Meer et al. (2010) who estimated maximum/minimum ages of 285 +/-5 to 220 +/-10 Ma), Trans-Americas slab (TS, with maximum/minimum ages of 219 +/-11 to 178 +/-15 Ma, *ibid*); and unnamed slabs in the northwest Pacific which are herein interpreted as relicts of subduction beneath Wrangellia (WR) and Alexander (AX1, AX2) terranes, the Klondike arc (KA), and perhaps the Kurosegawa Terrane of Japan (KU). Atlantis slab is of about the same size and interpreted age as the Cabo slab, consistent with Permian* plate consumption and formation of the late Paleozoic Appalachian magmatic belt, the origin of which has been of long-standing debate. (*possibly to Early Triassic, but with sinking retarded due to strength and buoyancy of transitional lithosphere; Late Permian plutons preserved in Laurentia at are schematically shown at +).

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U-Th-Pb geochronology of meta-carbonatites and meta-alkaline rocks in the southern Canadian Cordillera: A geodynamic perspective

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U-Pb and Th-Pb ages of zircons from eight meta-carbonatite and four meta-alkaline rock samples provide evidence for three distinct episodes of carbonatite and alkaline magmatism in the southern Canadian Cordillera spanning a period of ~460 Ma. The earliest, Neoproterozoic event occurred at ~800 - 700 Ma and coincides with the postulated initial break-up of Rodinia. The second, previously undocumented, event of carbonatitic magmatism is constraint to the Latest Cambrian to Early Ordovician at ~500 - 490 Ma and corresponds to a period of extensional tectonics that affected the western continental margin of North America from the Canadian Cordillera to the southerwestern United States. The youngest and most prevalent period of alkaline igneous activity occurred in Late Devonian to Early Carboniferous times at ~360 - 340 Ma and resulted from extensional tectonics, presumably caused by slab rollback. In addition, different episodes of amphibolite-facies metamorphism subsequently affected the igneous rocks between ~170 – 50 Ma. This dataset puts new constraints on the timing of carbonatite and alkaline igneous activity and the evolution of (ancestral) North America’s western continental margin from Neoproterozoic to Carboniferous times.

Examining the interplay of the arc magmatism, deformation and metamorphism within the southern coast-cascade orogen, Harrison Lake, British Columbia

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The Harrison Lake region offers an excellent natural laboratory to study fundamental geological processes such as the interaction between terrane accretion, arc magmatism, and the attendant deformation and metamorphism. The focus of this study is the Breakenridge plutonic complex which is found along the northeastern side of Harrison Lake in southwestern British Columbia. This elongate metaplutonic body is a sheeted intrusion characterized by intercalated screens of country rock and plutonic sills, folded into an upright doubly plunging antiform that parallels the orogen of the southern Coast Belt. The metamorphosed volcano-sedimentary units within the country rock are characterized by polyphase metamorphism and deformational events, as well as a sharp rise of metamorphic grade over a distance of 15-20 km from zeolite facies in the south to upper amphibolite facies, kyanite-melt bearing rocks to the north, but the structural evidence for faults and shear zones that may have facilitated the metamorphic break are lacking. As such, previous workers have proposed a variety of the tectonic models for this region. The two principal models include: magma loading (*Brown and Walker, 1993; Brown and McClelland, 2000*) versus a collisional model involving terrane accretion (*Journeay and Friedman, 1993*). The goal of the current research is to characterize the timing and geological relationships between the emplacement of the Breakenridge plutonic complex and the attendant deformation and metamorphism. It will also advance our knowledge of pluton emplacement mechanisms. In turn, this will allow us to examine, test and refine, if necessary, the proposed models for the region. These relationships will be assessed by detailed mapping, structural, petrologic, thermobarometric and geochronological analyses.

Field work carried out in the summer of 2011 consisted of mapping bedrock, structures and metamorphic assemblages at a 1:20,000 scale. Samples of the various phases of the Breakenridge pluton and the surrounding country rocks were collected for subsequent petrologic, geochemical, geochronological and structural analyses, which are currently underway. Electron Microprobe (EMP) analysis will provide insight into pressure-temperature conditions through conventional thermobarometry and XRF-derived bulk rock composition will be used for calculating isochemical sections. The igneous and metamorphic rock samples will be dated via monazite and zircon U-Pb analyses using LA-ICPMS and ID-TIMS. Data collection is in its incipient stages and preliminary results of the ongoing research will be presented at the workshop.

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Some Canadian Cordilleran geohistory: geosynclines, tectonic assemblages, mineral deposits, terranes and? LIPs

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A consequence of mid-19th century discovery and exploitation of economic deposits in British Columbia – mainly gold and coal – was recognition of the need for a geological survey. Systematic studies started in 1871 when BC entered Confederation. By 1900 the main geological elements and evolution of the Cordillera had been outlined. An eastern geosyncline of mainly Paleozoic sedimentary strata, and western Paleozoic and early Mesozoic geosynclines containing volcanic and sedimentary rocks were recognized as having been deformed, intruded, metamorphosed and elevated during Mesozoic-Cenozoic orogeny. By the 1960s, several new mines were in development, and mapping at a scale of ~1:250,000 was mostly complete. Geological information was synthesized at a benchmark meeting on the Tectonic History and Mineral Deposits of the Western Cordillera held in Vancouver in 1964. At the meeting geosynclinal terminology was retained, but that was shortly to change.

The idea that continents drifted became well-known about 100 years ago but was strongly opposed by many Northern Hemisphere geologists until the 1960s, when new knowledge of the ~65% of Earth's surface covered by deep oceans led to formulation of the plate tectonic hypothesis. This proposed that outer solid Earth is armoured with rigid lithospheric plates that are continually in motion with respect to one another. In 1970, the application of plate tectonic concepts to Cordilleran geology was presented in Vancouver at the first meeting of what became the Cordilleran Section of the GAC.

Distinctive associations of rock types form at plate boundaries and within plates where continents and oceans adjoin. These can be identified in the rock record and their distribution is shown on 1981 and 1991 Tectonic Assemblage maps of the Canadian Cordillera. The eastern geosyncline was re-interpreted in "actualistic" terms as analogous with the present Atlantic continental margin, and the western geosynclines as remnants of volcanic arcs, ocean floors and back-arc basins formed in settings akin to those of the southwestern Pacific Ocean and Indonesia. Such interpretations were quickly adopted by economic geologists, because analogies can be readily drawn with modern settings within which deposits form, such as "black smokers" on the Juan de Fuca Ridge, or porphyry deposits in an arc environment such as Lepanto, Philippines. The presently jumbled fragments of arcs and ocean floor in the western Cordillera form a collage of "terranes", a term first used in 1972 in southeastern Alaska and in the Klamath Mountains. By 1980 the terrane concept was applied to the entire Cordillera, and was subsequently exported world-wide to other orogenic systems. Paleomagnetic, paleontological, and detrital zircon fingerprints ideally indicate original terrane homelands and the "terrane tracks" travelled to their present locations. By the Middle Jurassic (174 Ma) most terranes had at least begun accretion to some part of the old Laurentian margin, and by mid-Cretaceous time (100 Ma) all but marginal parts of the Cordillera were above sea level, carried continental arcs, and the region resembled the present Andes in many ways.

Some rocks in the Cordillera, such as the Triassic Karmutsen-Nikolai basalt with associated Cu-Ni-PGE mineralization, and possibly the Miocene Columbia River basalt, do not fit neatly into plate tectonic models. The process of top-down cooling of rigid oceanic plates controlling patterns of upper mantle convection has for ~40 years been viewed by most as independent of other global heat-loss phenomena such as Large Igneous Provinces and mantle plumes. In the last two decades, studies spearheaded by seismic tomographic imaging of the entire mantle seem to be integrating the present dichotomy into models of whole-mantle circulation.

New Detrital Zircon U-Pb Results from the Yukon-Tanana Terrane in the Fairbanks Mining District, Alaska

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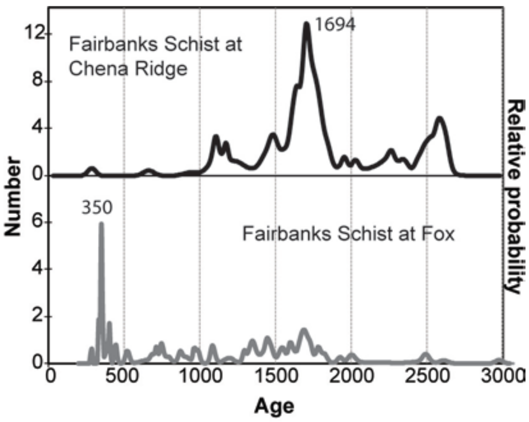
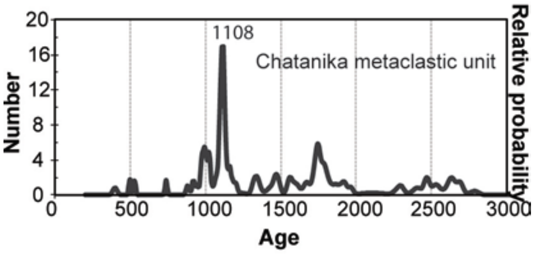
The Yukon-Tannana terrane (YTT) encompasses a broad region of polydeformed and polymetamorphic rocks between the Tintina and Denali faults in the eastern part of interior Alaska. In the Fairbanks area, Newberry and others (1996) divided the YTT into four units: (1) the metasedimentary and metabasites of the Fairbanks Schist; (2) the Ordovician(?) to Upper Devonian Birch Hill sequence; (3) the Devonian metavolcanic and metasedimentary Muskox sequence; and (4) klippen of eclogitic metabasite and metasedimentary rocks assigned to the Chatanika "terrane".

To better understand the origin of these metamorphic rocks, we analyzed the U-Pb ages of zircons in samples of metaclastic rocks from the Fairbanks Schist at Chena Ridge, metaclastic rocks and an associated metabasite at Fox, a calcschist from the Birch Hill sequence in Fairbanks, and a paragonitic metasandstone from the Chatanika terrane. Dominant zircon populations in the sample of Fairbanks Schist at Chena Ridge reveal a dominant peak at 1.6-1.8 Ga and smaller peaks at 2.6-2.7 Ga and 1.1-1.2 Ga. The same unit at Fox, in contrast, has a dominant age population at about 350 Ma with lesser numbers of zircon distributed between 400 Ma and 1.8 Ga. A nearby sample of metabasite contained zircon grains dated at 347±14 and 351±12 Ma and a felsic segregation within the metabasite yielded ages of 355±16 and 365±13 Ma. The dominant zircon age population in a paragonitic schist from the Chatanika terrane is 1.1 Ga with subordinate peaks at 1.0 Ga, 1.7-1.8 Ga, and broad distributions between 1.3-1.9 Ga and 2.3-2.7 Ga. The Birch Hill sequence yielded only seven datable zircons, of which five are Paleozoic and two are ~1.2 Ga.

The results from the sample of Fairbanks Schist at Chena Ridge are similar to those reported from other parts of YTT in Alaska. Both the metaclastic rocks and metabasite in the Fairbanks Schist at Fox, however, are dominated by Carboniferous zircons, which has not been previously reported. Likewise, the Chatanika terrane sample is dominated by Grenvillian (~1.0-1.2 Ga) zircons, a result also not previously recognized in YTT. A North American provenance for these samples seems probable, but other scenarios should be considered.





Calculation of P-T paths incorporating chemical fractionation and diffusion in garnet: a case study from the Kootenay Arc, British Columbia, Canada

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The significance of garnet zoning in metapelitic rocks from the southeastern Canadian Cordillera is investigated through comparison with the results of forward models incorporating chemical fractionation and intracrystalline diffusion. Garnet crystals in graphitic metapelite from the staurolite/kyanite zones of a Barrovian sequence display textural sector zoning in their central regions and are characterised by a three-part chemical zoning pattern. Zoning is concentric and generally continuous from core to rim. Garnet zoning records growth during the initial phases of prograde metamorphism; growth stopped before peak metamorphism, probably when staurolite started to crystallise. Detailed modelling was carried out on a representative sample (DM-06-128), and a best-fit P-T path calculated by iteratively matching garnet compositions with the results of THERIAK forward models incorporating chemical fractionation. Further modelling using THERIA_G suggests diffusion did not significantly modify chemical zoning profiles. The sector-zoned part of the garnet, comprising the first two chemical zones, records > 2 Kbar burial along a linear gradient of 40 bars/ ºC, followed by ~ 0.6 Kbar of exhumation. Renewed burial of > 0.4 Kbar prior to the end of garnet growth in recorded by distinctive low-Ca rim zones that do not display textural sector zoning. Although there was further heating of up to 50 ºC following cessation of garnet growth, equilibrium may not have been maintained throughout this interval.

The Wernecke igneous clasts in Yukon Canada: evidence for a Paleoproterozoic volcanic arc terrane at 1.7 Ga and its obduction onto ancestral North America

Alexander Nielsen, Derek Thorkelson, Dan Marshall, and Dan Gibson

The origin of the Wernecke igneous clasts is an enigma that bears on the Proterozoic evolution of the northwestern margin of Laurentia. Wernecke igneous clasts are found exclusively within the Wernecke Breccias of central and northern Yukon, which are developed within the Wernecke Supergroup. The field relations and ages of the observed Wernecke igneous clasts (1714-1706 Ma) relative to the Wernecke Supergroup (<1640 Ma), indicate that they did not intrude the Wernecke Supergroup. The Wernecke igneous clasts comprise clasts of igneous rock ranging in size from microclasts up to clasts 900 m x 200 m x 30 m in size. Clasts of mafic to intermediate subalkaline and alkaline plutonic and volcanic rocks are the most common, but fragments of volcaniclastic sediments have also been found. Geochemical characteristics of the Wernecke igneous clasts suggest that they were derived from a volcanic arc with a component of within-plate magmatism. Neodymium isotope analysis suggests that they magmatically assimilated older continental crust.

We suggest that the Wernecke igneous clasts were formed as part of a volcanic arc built on a continental fragment (possibly a rifted fragment of Laurentia) or the leading edge of another continent, which was obducted onto the northwestern margin of Laurentia. In response to this obduction and the related tectonic loading of the crust, the Wernecke Breccias may have been developed. The breccias fragmented the obducted arc and clasts of volcanic and plutonic rock from the terrane foundered into the Wernecke Breccias, some reaching the level of the Wernecke Supergroup. Subsequent erosion removed the arc terrane entirely before the deposition of the Pinguicula Group sediments.

Orogenic Ni-Cu-PGE: the Turnagain Alaskan-type intrusion, northern British Columbia

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Magmatic Ni-Cu-PGE sulphide deposits in supra-subduction zone (SSZ) settings are becoming an increasingly important economic resource worldwide yet remain poorly understood and underexplored. Projects initiated recently under the Targeted Geoscience Initiative No 4 in the Canadian Cordillera seek to address critical knowledge gaps in order to develop new mineral deposit models and robust exploration criteria. Our use of the term “orogenic” includes all SSZ ultramafic-mafic intrusions exclusive of ophiolite complexes and accreted LIPs (e.g. Wrangellia).

The Turnagain ultramafic intrusion is an Early Jurassic Alaskan-type body unusually enriched in Ni-Cu-PGE sulphides. Exploration by *Hard Creek Nickel Corporation (HNC)* has determined a resource of 223.2 Mt @ 0.22 wt % Ni and 0.014 wt % Co (measured); 524.5 Mt @ 0.21% Ni and 0.013% Co (indicated); and 537.5 Mt @ 0.20% Ni and 0.013% Co (inferred). The principal mineralization is hosted by wehrlite and dunite (Horsetrail zone), and the principal sulphide minerals are pyrrhotite, pentlandite and chalcopyrite. Work by Scheel (MSc., 2007) has established: 1) the age of the Turnagain intrusion (190 ± 1 Ma) based on U-Pb zircon and ^{40}Ar-^{39}Ar dating; 2) significant crustal contamination of the parental magmas based on Nd and Pb isotopic data; and 3) critical contributions of sulphur and graphite from carbonaceous phyllite wallrocks which led to reduction of parental magmas and subsequently triggered sulphide saturation as determined by S isotopes, petrography and field observations.

Erdmer et al. (2005) have proposed that the Turnagain intrusion is hosted by a Carboniferous (Mississippian) metasedimentary and metavolcanic assemblage that conformably overlies miogeoclinal rocks of Ancestral North America and is not part of an accreted terrane. However, a regional TEM airborne survey conducted by *HNC* shows the following important features: 1) graphitic phyllite and slate wallrocks to the Turnagain intrusion show a marked electromagnetic response (conductivity) not shared by ultramafic or meta-sedimentary/volcanic rocks to the west; 2) mapping traverses north and east of the Turnagain intrusion demonstrate that the sharp, curvilinear EM boundary to the east separates these highly conductive graphitic rocks from poorly conductive strata of Ancestral North America (Kechika Formation and Atan Group); 3) this EM boundary transects miogeoclinal stratigraphy as mapped by Gabrielse (1998) and passes through a 800m gap in outcrop separating Atan Group strata from graphitic phyllite, a gap that Erdmer et al. (2005) assumed to be underlain by the Kechika Formation. Based on these observations, we infer that this EM boundary represents a fault separating miogeoclinal rocks of Ancestral North America from Mississippian assemblages representing the basement to the accreted Quesnel Terrane (Yukon-Tanana Terrane), the latter hosting the Early Jurassic Turnagain intrusion. Intriguingly, the northern end of this fault bends sharply westwards towards the Kutcho Fault in a manner similar to the steeply dipping, reverse fault delineating the northern and eastern margins of the Turnagain intrusion. Thus, we infer that the terrane-bounding fault is a reverse fault marking tectonic emplacement of an accreted terrane (Yukon-Tanana - Quesnellia) onto the North American miogeocline. This interpretation appears consistent with the tight to slightly overturned, eastward-verging folds in the graphitic phyllites documented by Erdmer et al. (2005) and juxtaposed strata of the Ancestral North American miogeocline which occupy the southwesterly-dipping limb of a large homoclinal structure (Gabrielse, 1998).

AN EARLY EOCENE DEFORMATION PHASE IN THE ALBERTA PORTION OF THE CANADIAN ROCKY MOUNTAIN FOLD-AND-THRUST BELT; NEW EVIDENCE FROM ^{40}Ar/^{39}Ar DATING OF CLAY-RICH FAULT GOUGE

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The Rocky Mountain fold-and-thrust belt of western Canada consists of a series of eastward-propagating thrusts that transported ‘miogeoclinal’ and foreland basin sediments during Mesozoic and early Cenozoic deformation. In this study, we present new ages of clay-rich fault gouge collected from thrust faults located in the Rocky Mountains and Foothills of Alberta. The ages unravel a major Early Eocene phase of deformation and hint at older Jurassic and Cretaceous tectonic pulses that correlate well with the deposition of major clastic wedges within the adjacent foreland basin. Ages of faults were obtained by extrapolating results of four grain-size fractions with varying percentages of detrital (2M1) and authigenic (1Md) illite polytypes and their ^{40}Ar/^{39}Ar total gas ages.

In the eastern Front Ranges and western Foothills, gouge samples from four major thrust faults, including the McConnell, Nikanassin, Brule and Muskeg thrust faults, yielded similar ages of 54 Ma. These Early Eocene ages represent the last phase of compressional deformation within the Rocky Mountains fold-and-thrust belt of southern Canada. To the west, in the Front Ranges, the Greenock Thrust yielded an age of 103.3 ± 3.1 Ma. This late Early Cretaceous age coincides within analytical error with the initiation of the deposition of the Fort St. John-Dunvegan ‘clastic wedge’ with a depocentre in the Peace River region, and with both the emplacement of ‘mid-Cretaceous plutons’ in the Omineca Belt and deposition of the Crowsnest volcanics in the southern Canadian Rockies. Farther west, in the Main Ranges, a sample of gouge from the Pyramid Thrust (north east of Jasper) produced an age of 162.8 ± 4.9 Ma. This Middle to Late Jurassic age, the oldest faulting age preserved in the foreland, coincides within analytical error with the pre-Oxfordian unconformity recorded in the Fernie Formation and likely represents the age of initiation of thin-skinned deformation in the Rockies.

These new results, combined with recent results from the southern Alberta Rocky Mountains (e.g., ~72 Ma ages obtained from the Rundle thrust system), support the interpretation that the Rocky Mountain fold-and-thrust belt in southern Canada formed through a series of forward-propagating deformation pulses, ranging in age from the late Middle Jurassic to the Early Eocene.

New geoscience contributions to SEDEX-MVT base metal exploration in Selwyn and Purcell basins - Targeted Geoscience Initiative-4

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SEDEX deposits are an important resource for Zn and Pb. In 2004, SEDEX deposits accounted for 38.4% and 65.1% of the western world's Zn reserves and resources, respectively. They also furnish more than 36% of the world's (2009) zinc production.

The current genetic model for SEDEX deposits was formulated 30 years ago, and few new physicochemical data (e.g., source of fluids, source of ore-transporting ligands, source of metals, physical and geochemical properties of the hydrothermal fluids, plumbing system or pathways, and physical and chemical traps for metals) have been obtained since. Additionally the role of post-rift carbonaceous sediments (host to most SEDEX) in ore formation remains poorly understood and there are few well-established exploration indicators of ore potential in these rocks. It is therefore impossible to distinguish between rift basins that are likely to contain SEDEX deposits from those that are not, and to determine the stratigraphic level at which SEDEX are most likely to occur. A genetic and spatial relationship has been suggested between SEDEX and MVT deposits of the northern Cordillera; this relationship needs to be verified.

To close these knowledge gaps, the following objectives will be addressed:

- Identification of new mineralogical, geochemical, and isotopic tools to vector to basins, stratigraphic successions, and SEDEX ore system;
- Characterization of the hydrothermal fluid geochemistry related to SEDEX ore system; and comparison with the chemistry of fluids related to MVT systems;
- Understanding of the processes that control surficial geochemical dispersion around SEDEX and MVT deposits; and
- Develop new methods for 3D structural-stratigraphic modelling supporting mineral discovery in the Purcell Basin, southern BC.

Several SEDEX-MVT activities are targeted to achieve the objectives.

Selwyn Basin, Yukon, NWT

- Hydrothermal event recognition and SEDEX deposit vectoring method development in the Selwyn Basin using field-portable instrumentation – Jan Peter and Suzanne Paradis (GSC)
- Recognition of sedimentary exhalative mineralizing event horizons in shales of the Howards Pass and MacMillan Pass regions, Yukon and N.W.T. – Dan Layton-Matthews and Mike Gadd (PhD student, Queen's university)
- Nature of the vent fluids in the Mac Pass SEDEX deposits, Selwyn Basin – Sarah Gleeson and Joseph Magnall (PhD student, University of Alberta)
- Geochemical and Mineralogical Controls on Metal Dispersal Downstream of Mineralization in the Mackenzie Mountains – Heather Jamieson, Kristina Skeries (MSc student, Queen's university) and Steve Day (GSC)
- Mineral potential of Late Proterozoic to Early Paleozoic black shales and carbonate rocks in the Mackenzie Mountains, NWT – Elizabeth Turner and Sean O'Hare (MSc student, Laurentian University)
- A thermodynamic equilibrium approach to surficial geochemical vectoring: a case study of SEDEX and MVT deposits in the Canadian cordillera - Paul Gammon (GSC)
- Lithogeochemical, mineralogical and isotopic alteration vectors for vein and strata bound carbonate-hosted deposits: A case study of the Prairie Creek deposit, Prairie Creek Embayment, NWT - Andrew Conly (Laurentian U), Suzanne Paradis and Bruce Taylor (GSC)

Purcell Basin, BC

- 3D Structural-stratigraphic modelling supporting mineral discovery in the Purcell Basin, southern BC - Eric de Kemp, Ernst Schetselaar, John Lydon, Jamel Joseph (GSC)
- Modelling aeromagnetic data, Purcell Basin, southern BC - Mike Thomas, Eric de Kemp, Ernst Schetselaar, John Lydon (GSC)
- Diagenetic indicators for SEDEX ore environments - John Lydon (GSC)

New field relationships and a preliminary U/Pb SHRIMP age for eclogite in the St. Cyr area, Yukon-Tanana terrane

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Eclogite in the St. Cyr area of the Yukon-Tanana terrane preserve evidence of subduction-related high-pressure (HP) metamorphism. Previous studies (e.g. Erdmer et al., 1998; Fallas et al., 1999) have addressed the tectonic implications of eclogite in the St. Cyr area. These studies concluded that the eclogite in the St. Cyr area are part of an oceanic mélange associated with the Slide Mountain Ocean (SMO) terrane. However, high pressures and penetrative fabrics shared by the St. Cyr area metabasites and their quartzofeldspathic host contrast with the low-grade, variably deformed SMO assemblage. Moreover, the metamorphic conditions and fabrics exhibited by the St. Cyr rocks are characteristic of the Yukon-Tanana arc basement, the Snowcap assemblage. To address these discrepancies, new field mapping at a scale of 1:20,000 was undertaken during the summers of 2010 and 2011, with the goal of matching the style of deformation in the St. Cyr area to either the SMO or the Snowcap assemblage.

New field mapping shows that a large slice of quartz-rich tectonites host garnet-amphibolite bodies several kilometers in length and tens of meters in width. Eclogite is preserved as structurally conformable layers within the cores of the amphibolite bodies. Eclogite and garnet amphibolites share the penetrative deformation of the surrounding quartz-rich tectonites. Meter- to several tens of meter-sized serpentinized dunite bodies occur within the field area, and are structurally associated with a region of non-garnet-bearing amphibolites that presumably did not reach HP conditions. These results are in contrast to mapping by Fallas et al. (1998), which depicted ultramafics, eclogites and garnet-bearing amphibolites as small, variably deformed enclaves within the metaigneous Anvil allochthon (now considered the SMO terrane).

In addition to mapping, in *situ* U/Pb SHRIMP zircon dating was undertaken to petrographically and geochemically link zircon ages with eclogite facies metamorphism. A preliminary U/Pb SHRIMP zircon age was obtained from eclogite sample MP10-143. Zircon grains are small (100 μm or less in diameter), rounded and display sector zoning characteristic of growth under HP conditions (Corfu et al., 2003). Trace element data from the dated zircons show no Eu anomaly, suggesting that they grew in the absence of feldspar, consistent with eclogite facies metamorphism (Rubatto, 2002). The U/Pb SHRIMP zircon age of 271 ± 4 Ma indicates that eclogite facies metamorphism in the St. Cyr area is late Permian in age, and is compatible with ages from other eclogite localities in the Yukon-Tanana terrane, such as Ross River and Last Peak (Creaser et al., 1997; Erdmer et al., 1998).

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Tectonic and metallogenic significance of mafic magmatism of the Belt-Purcell basin in the Lewis thrust sheet of southwestern Alberta

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We present new mineralogical, geochemical, Sr-Pb-Nd isotopic and zircon SHRIMP U-Pb data from Mesoproterozoic igneous rocks in the Lewis thrust sheet of Clark Range in southwestern Alberta. These rocks comprise pillowed and massive flows of Purcell Lava and mafic sills and dikes within shallow-water to subaerial successions of the Belt-Purcell Supergroup deposited on the edge of the Mesoproterozoic (1.47–1.40 Ga) intracontinental rift basin. Voluminous syn-rift "Moyie sills" intrude stratigraphically lower, thick turbidite fill in the centre of the main rift branch to the west but magmatic rocks are absent within their lateral equivalents in Alberta. Mesoproterozoic igneous rocks of Clark Range include silica-oversaturated and olivine-tholeiitic to alkali-olivine basalts. Ti-rich ferritschermakite and magnesiohastingsite, Ti-annite, ilmenite, ulvöspinel and Fe-rich olivine (Fo_{43}) reflect their hydrous, high-Fe and high-Ti nature. Primary magma composition (mg# = 67) is reconstructed by addition of 7% olivine (Fo_{85}) to the most primitive tholeiitic basalt. Based on olivine- and cpx-liquid equilibration models, we infer these magmas might have been in equilibrium with mantle spinel lherzolite at 1.1–1.4 GPa (37–48 km depth), with mantle potential temperature 98°C higher than MORB mantle. Two-oxide, amphibole, two-feldspar and plagioclase-liquid models estimate H_2O content in these magmas between 0.9–7.7 wt %, with fO_2 between -2.6– 1.3 log units relative to NNO buffer and temperature between 730–1050°C. Normalized incompatible-element and REE patterns are similar to modern OIB, with >100 times chondritic Ce concentrations and average La_N/Yb_N of 9.3. All of the analyzed intrusions have radiogenic initial $^{87}Sr/^{86}Sr_{1450}$ (11–98 epsilon units relative to bulk Earth) and radiogenic $^{143}Nd/^{144}Nd_{1450}$ (0.9–6.3 epsilon units relative to CHUR), except a potassic trachybasalt sill at Yarrow Creek that has unradiogenic εNd = -3.0. Initial $^{143}Nd/^{144}Nd$ correlates negatively with model depleted-mantle Nd extraction dates (1.42–2.20 Ga) and positively with Ti/Yb suggesting crustal contamination; this is consistent with positive correlation between initial $^{87}Sr/^{86}Sr$ and SiO_2 and low Ce/Pb and Nb/U ratios in these rocks. Lack of correlation between initial $^{87}Sr/^{86}Sr$ and Ba/Yb, coupled with enriched Ba/Nb and La/Nb also indicates enriched mantle. Initial $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$ linear arrays have similar slope as modern OIB-MORB regression. SHRIMP U-Pb dates on zircons separated from basaltic intrusions of Clark Range indicate events at 3566 Ma, 3112 Ma, 3058–3025 Ma, 2926–2867 Ma, 2834–2761 Ma, 2722–2634 Ma, 2606–2552 Ma, 2426 Ma(?), 2052–2002 Ma, 1733–1715 Ma, 1615 Ma, 1341 Ma, 1151 Ma, 571 Ma and 398 Ma. The 3566–1615 Ma dates are from inherited zircons that record tectonomagmatic evolution of the Archean Medicine Hat crystalline basement that underlies the Belt-Purcell basin. The younger dates post-date the Belt-Purcell magmatism. They may reflect postulated "East Kootenay Orogeny" (1341 Ma), Grenville assembly of Rhodinia (1151 Ma), continental break-up (571 Ma) and subsequent rifting along the proto-Pacific continental margin (398 Ma). The new results provide insights into petrogenesis and metallogeny of the Purcell intracontinental magmatism and tectonic evolution of western Laurentia. The geochemical and isotopic signatures of the mafic magmatism, coupled with the mantle potential temperature in excess of MORB and volume of initial magma upflow (>50,000 km^3) along the rift axis during the short interval of 2–5 Ma, are similar to continental flood-basalt and rift provinces elsewhere. The new evidence is consistent with a mantle plume as a trigger for Belt-Purcell rifting and basaltic magmatism. Mafic dike swarm aligned with the rift axis on the adjacent Wyoming craton represents the initial pulse of magmatism at ca. 1.5 Ga. Basaltic magmatism, syn-depositional faulting and associated syngenetic to diagenetic Pb-Zn and Cu-Ag mineralization of Clark Range record middle to late Purcell activity that shifted towards the northeastern margin of the rift basin. The high-precision SHRIMP U-Pb data provide important geochronological constraints on the geological history of southwestern Alberta.

Geological insights from new mapping in the Dawson Range – White Gold district, Yukon

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The Dawson Range is underlain by the basement rocks of the Yukon-Tanana terrane (YTT), intruded and overlain by locally voluminous late Triassic to Tertiary plutonic and volcanic rocks. The YTT comprises a thoroughly deformed and metamorphosed pre-Devonian to Permian basement complex. Pre-Devonian quartzite, psammite and marble (Snowcap assemblage; SCA), and Devono-Mississippian carbonaceous quartzite to psammite (Nasina assemblage) form the oldest rocks. These are overlain and intruded by Devonian to Permian volcano-sedimentary sequences and related plutonic suites respectively. The latter include predominantly arc-related Devonian to Mississippian Finlayson assemblage, the Mississippian Simpson Range plutonic suite, and Permian Sulphur Creek plutonic suite (Klondike assemblage). The Devono-Mississippian arc rocks are constrained to the east side of the map area.

Two distinct and prominent Permian belts of the metavolcanic and metaplutonic rocks of the Klondike assemblage transect the region. The eastern belt trends from the Klondike district southeastward into McQuesten map area. The western belt trends southeastward along the north side of the Dawson Range batholith from the western Stewart River map area to Sonora Gulch. Our mapping indicates sparse but important occurrences of ultramafic rocks, which either uniquely characterize these belts or apparently demarcate their boundaries. Hence, we interpret some of the ultramafic occurrences as defining a crustal-scale break which may have played an important role in localization of young magmas, subseqeuntly reactivated as younger structures.

The eastern part of the area is primarily underlain by augite-phyric volcanic rocks typical of the Late Triassic Quesnel Arc, in part built on the YTT basement. These rocks are intruded by granodiorite to monzogranite of the Early Jurassic Aishihik plutonic suite that hosts the high-grade Minto Cu-Au mine.

The central Dawson Range is dominated by the aerially extensive mid-Cretaceous Whitehorse plutonic suite, locally overlain by Carmacks Group volcanics, and intruded by volumetrically minor late Cretaceous shallow intrusions (Casino and Prospector Mountain suites). The majority of mid to late Cretaceous mineral occurrences (epithermal, porphyry, skarn etc.) appear to have close association to these igneous suites, however, there also appears to be a strong co-spatial relationship with the Permian Klondike Assemblage. Other mineral occurrences are structurally hosted, and may be associated with late regional faults that are identifiable in the new aeromagnetic dataset. While some of these mid to late Cretaceous structures have long strike length, they do not necessarily have significant offset (e.g., Big Creek Fault). Unconformities of mid to late Cretaceous volcanic and sedimentary sequences across the region help constrain crustal depth through time, thus providing a guide to the expected deposits types at the exposed crustal level.

New constraints on Jurassic-Tertiary deformation and metamorphism in the North Cascades crystalline core

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New structural and geochronologic results from the North Cascades provide a detailed history of metamorphism and deformation affecting Triassic island arc and ocean-floor rocks, and plutonic rocks emplaced during Cretaceous arc magmatism. In the Cascade River region, deformation of the Chelan Mountains terrane (Napeequa ocean-floor rocks, Marblemount meta-quartz diorite (MMQD), Cascade River unit, CRU) occurred at different crustal levels, in at least four phases spanning ~100 m.y. D1 formed large-scale recumbent isoclinal folds of stratigraphy and S1 foliation. Metasedimentary units (CRU) and a sill injection complex (Magic Mt. gneiss) show large-magnitude shortening while MMQD plutonic rocks experienced lower strain, and partitioning into areas of NW-SE shortening and NW-striking dextral transpressive shear. Vergence of D1 recumbent folds may be NW or SW. U-Pb zircon dates bracket D1 deformation and metamorphism to between ~155 Ma and ~138 Ma. These dates are older than previous estimates of early deformation in the Cascades, inferred as mid to Late Cretaceous. Correlation with similar rocks in southern British Columbia suggests that D1 is related to terrane accretion.

D2 –D4 caused fold interference patterns and localized shear zones throughout the study area. D2 deformation and metamorphism appears to be higher grade in the Mt. Formidable region (S2 fabric, SW-vergent gently reclined folds) and lower grade to the NW near Razorback Mt., where the principal structure is the SW-vergent Razorback thrust. Cooling below ~500°C by 83Ma is dated by Ar/Ar on hornblende, and the 81 Ma (U-Pb) Cyclone lakes pluton contains a weak thrust-related fabric. At 76 Ma, the magmatic epidote-bearing Marble Creek pluton was emplaced into the Chelan Mountains terrane and deformed. The 73 Ma Hidden Lake Peak pluton cross-cuts fabric in the CRU, and the 73-74 Ma Jordan Lakes pluton cross-cuts the Razorback thrust fabric. Later events are poorly dated, but Ar/Ar on biotite suggests cooling to ~300°C by ~58-60 Ma. Early Tertiary deformation in the study area was at much lower grade than areas of the Cascade crystalline core to the east, and included NW-SE shortening in open folds and top-NW shear along narrow low-grade mylonite zones.

Late Jurassic or Early Cretaceous deformation, metamorphism and magmatism suggests potential links with SE Wrangellia in the Harrison lake region, or with Quesnellia terrane. Further work is needed to document the nature and timing of early magmatic and tectonic events in the Cascades core. The spatial and temporal relationships of NW-SE and NE-SW shortening indicate protracted transpression in the Cretaceous arc following terrane accretion.

Geology of the Kutcho assemblage, northern British Columbia: an intra-oceanic arc within Cache Creek terrane

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The area around upper Kutcho Creek, 100 km east of Dease Lake, was mapped by the BC Geological Survey Branch, with support from Kutcho Copper Corporation and the Geological Survey of Canada (Edges Program), during the 2010 and 2011 field seasons. The project goals are to gain a better understanding of, and provide more detailed geological maps for, the Permo-Triassic Kutcho assemblage, which hosts the Kutcho Creek volcanogenic massive sulphide deposit.

The map area covers the east end of the King Salmon allochthon, which forms part of the boundary between Cache Creek and Stikine terranes. The allochthon includes the the Kutcho assemblage, and unconformably overlying Triassic-Jurassic metasedimentary rocks of the Whitehorse trough, as well as a basal fault panel comprising metabasalt, chert, limestone and serpentinite melange of the Cache Creek complex, also unconformably overlain by Whitehorse trough metasedimentary rocks. All rocks are penetratively deformed and characterized by a cleavage or schistosity defined by greenschist facies mineral assembalges. South-verging folds and north-dipping thrust faults that deform the main map units are broadly contemporaneous with the metamorphism and probably formed in early Middle Jurassic time. The allochthon is bounded to the south by the north-dipping King Salmon thrust fault, and to the north by the Nahlin fault. Clastic sedimentary rocks of the Takwahoni Formation and Bowser Lake Group, deposited above arc rocks of Stikine terrane, occur in the footwall of the King Salmon fault, and oceanic rocks of the Cache Creek complex crop out on the north side of the Nahlin fault. The northwest-striking Kutcho fault truncates the King Salmon allochthon near the northeast edge of the map area, and juxtaposes it against undated plutonic rocks, mainly granodiorite and quartz diorite, which are part of the Quesnel arc terrane. The Kutcho fault is part of a dextral strike-slip system that offsets the King Salmon allochthon from correlative rocks of the Sitlika assemablage, which crop out 300 km to the south in the Takla Lake area of central British Columbia.

The map area encompasses the largest exposure belt of the Permo-Triassic Kutcho assemblage, which comprises a heterogeneous package of schists derived from felsic and mafic volcanic and volcaniclastic rocks and associated felsic and mafic intrusions. The assemblage is subdivided into 3 main divisions that, except for local fold repetitions, generally dip and face to the north. Sericite-chlorite schists at the base of the southern division contain feldspar, quartz and lithic fragments and were derived mainly from sandstones and granule to pebble conglomerates with a felsic volcanic source. These are overlain by epidote-chlorite-actinolite-plagioclase schists derived from mafic volcanic and volcaniclastic rocks, and local dioritic intrusions. The central division includes similar mafic schist, as thin units intercalated with felsic volcaniclastic schist and thin-bedded sandstone, phyllite and chert. However, the most characterisitc feature of the central division are thin to thick units of coherent quartz-phyric rhyolite which, together with abundant tonalite intrusions, indicate a proximal volcanic setting. The northern division of the Kutcho assemblage, which hosts the Kutcho Creek Cu-Zn massive sulphide deposit, comprises units of chlorite-sericite schist that contain variable proportions of quartz and feldspar crystals, and felsic volcanic and plutonic lithic fragments. These were derived largely from mass flow deposits and related epiclastic rocks, but include some rhyolite flows and tuffs. The uppermost unit within this division, above the massive sulphide lenses, comprises an upward-fining sequence of thin-bedded volcanic sandstone, siltstone and slate.

The Whitehorse trough includes a locally developed conglomerate unit containing clasts derived from the Kutcho assemblage, and overlying limestone, slate, siltstone and sandstone correlated with the regionally extensive Late Triassic Sinwa and Early to Middle Jurassic Inklin formations. These rocks overlie the northern division of the Kutcho assemblage in the northeastern part of the map area, but the basal contact cuts through the northern and central divisions to rest above the southern division in the southwestern part of the map area.

Lithology of the western margin of the Yukon-Tanana terrane near Tincup Lake, Yukon Territory, and structural evolution during Late Mesozoic to Paleogene orogenesis

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The study area between Tincup and Toshingermann lakes (NTS 115G11/14) comprises 12 map units of polyfolded upper greenschist to lower amphibolite facies metasedimentary and metavolcanic rocks. They are structurally overlain by Late Triassic and older upper greenschist facies gabbro, peridotite and pyroxenite of the Doghead assemblage. Correlations between packages of map units and regional assemblages within the Yukon Tanana terrane are made on the basis of lithologic similarity. The structurally lowest and oldest (?) package is > 1 km thick and consists of interlayered ±Grt-Chl-Bt-Ms psammitic schist, Cal marble and Hbl-Act amphibolite correlated with the Snowcap assemblage. An ~ 2 km thick package of quartzite, interbedded (?) quartzite and Cal marble, Cal marble with disseminated Qz grain (?) layers and Gr phyllite correlated the Finlayson assemblage. Overlying these rocks is a 4 km thick package of ±Grt-Mag-Act-Ab-Bt-Ms-Chl psammite, psammitic schist and schist, Cal marble with minor quartzite, and Grt-Ab-Bt-Ms-Chl psammite, psammitic schist and schist tentatively correlated with the Klinkit assemblage. The lower contact is angular with respect to underlying units and is interpreted as an unconformity. Well exposed Cal marble marker units constrain the orientation and geometry of map units in the area which underwent four phases of folding in the Late Permian (?) to Late Cretaceous. In the Nuntaea Creek area the map pattern is controlled by F2 long limbs that are moderately to steeply S dipping. In the Toshingermann Lakes area S dipping or gently NW dipping F3 limbs control the map pattern. Inclusion trails (S_i) in Grt are oriented at a high angle to the dominant foliation $S_{0=1}$. $S_{0=1}$ is concordant with compositional layering (S_0). It is a rough to moderately rough disjunctive foliation defined by the preferred orientation of metamorphic Cal±Bt±Ms±Chl. Microlithons show a strong to complete preferred orientation of Qz±Fsp in siliciclastic units and Cal in calcareous units. $S_{0=1}$ is axial planar to meso-scale rootless folds suggesting that $S_{0=1}$ is a transposition foliation. $S_{0=1}$ was folded by tight to isoclinal, gently to steeply inclined, gently to moderately W plunging F_2 folds. F_2 folds have an axial planar cleavage (S_2), spaced at 1 to 15 cm, defined by oriented Ms±Chl±Cal. F_3 folds are gentle to open, moderately inclined to the S and plunge gently to the W. S_3 axial planar foliation occurs in fold hinges of schist, is spaced between 1 and 5 cm and is defined by the preferred orientation of Chl+Ms. It is uncertain whether the Doghead assemblage was structurally emplaced and deformed during F_2; however, it must have been emplaced prior to or during F3 since it occurs in a 2 km wide F_3 synform. F_4 is characterized by open, upright, moderately S plunging folds. South-dipping, brittle normal faults crosscut folds and are in turn cut by a network of near-vertical, left normal and normal right faults striking 305˚-335˚ and with 500 - 2000m spacing. The steep faults are inferred to be related to the Denali fault and were coeval with regional strike slip faults that cut the Late Cretaceous to Early Paleocene Ruby Range Batholith to the south. Explicit 3D Gocad modeling of map scale folds and brittle structures in the study area provides an intuitive representation of geological and spatial relationships between the aforementioned rock types and structures and provides a test of modeling methodology.

A model for moving the Siberian craton from SW North America to the Urals along coast-parallel transform faults: Paleomagnetic and geologic evidence

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The original proposal that the Siberian craton rifted from SW North America to open the Cordilleran and Verkhoyansk miogeoclines was based on correlation of Paleoproterozoic tectonic trends, Mesoproterozoic intracratonic basins, and Paleozoic conjugate rift margins between the two cratons (Sears and Price, 1978; 2003). Published paleomagnetic evidence from Ordovician and younger rocks of the Siberian and North American cratons is closely consistent with a model in which the Siberian craton separated from North America in Late Neoproterozoic to Early Cambrian time and rotated clockwise along coast-parallel transform faults, colliding with Europe to form the Ural Mountains in Late Paleozoic time. The model suggests that there were two major transforms concentric to an Euler pole of rotation in Greenland. The inner one is proposed to have been an extensional transform that opened a seaway for the Cordilleran and Verkhoyansk conjugate shelves, and the outer one a compressional transform that sheared a long string of terranes off the southern edge of North America. These later became accreted to the Verkhoyansk and Cordilleran margins. The Kolyma terrane loop in NE Russia contains continental shelf slivers with Siberian and North American stratigraphic and faunal affinities, while some terranes in the northern Cordillera have Siberian faunal affinities.The model permits some Cordilleran terranes to have migrated out of the Appalachians along the Appalachian plate boundary and then to have slid along the outer transform into the Cordilleran realm. The transforms converted into convergent boundaries during the middle and late Paleozoic as the Siberian craton neared its final resting place. The outer transform converted into a trench, and migrated away from North America to open the Slide Mountain back arc basin and a correlative basin in Siberia. The terranes scattered along the outer transform were overprinted by middle and late Paleozoic arc magmatism, and during the Mesozoic were accreted to the Cordillera and the Kolyma terrane loop in NE Russia.

Waveform tomography in 2.5-D to account for 3-D geometry: Application to reflection data in central British Columbia

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In order to improve the tractability of waveform tomography when applied to seismic field data acquired along a crooked line, we implement 2.5-D forward modeling and inversion. Waveform tomography combines conventional velocity-model building (i.e. tomography) with full-waveform inversion to reconstruct an image of subsurface acoustic velocity. For reasons of computational efficiency, it is desirable to use 2-D full-waveform inversion when processing data acquired with 2-D seismic survey geometry. However, crooked-line acquisition results in a cross-line component of the source-receiver offset that cannot be accounted for by 2-D forward modeling. If the cross-line geometry components are significant, full-waveform inversion may be intractable with a normal 2-D approach.

Our data set consists of refracted arrivals from a vibroseis multichannel seismic survey along crooked roads in the Nechako Basin, south-central BC. We carry out traveltime tomography in 3-D followed by full-waveform inversion in 2.5-D to build a detailed velocity model for the upper 2–3 km of the crust. The initial traveltime tomography step is used to produce a best-fit 2-D model that represents the earth model along the profile (averaged in the cross-line direction). The data waveforms contain significant information that is not utilized by traveltime inversion. By applying full-waveform inversion in 2.5-D (i.e. extending the 2-D model in the cross-line direction), we invert these data to produce an updated model with significantly improved detail. Computing the model updates in 2.5-D accounts for 3-D geometric spreading and point sources. The 2.5-D result is generated by combining the series of 2-D wavefields through a Fourier transform. This represents a solution to the 3-D viscoacoustic wave equation, which avoids many of the limitations of a purely 2-D method. The increased computational cost is modest: the 2.5-D method requires ~40x the computation time used by our 2-D method. A case study using Nechako Basin data is presented 1) to contrast the 2.5-D method with an earlier approach that used a static correction for geometry followed by the more usual 2-D full-waveform inversion and 2) to illustrate geological interpretation based on the near-surface velocity model. The interpretation indicates possible sub-basins in the Nechako Basin and delineates the Eocene volcanic rocks of the study area. When 3-D geometry is present on the seismic acquisition line, this newly developed 2.5-D method yields improved results over 2-D full-waveform inversion. In addition, the 2.5-D method is substantially less expensive computationally than full 3-D full-waveform inversion applied to 2-D crooked-line acquisition.

Diachronous metamorphism, deformation and exhumation within amphibolite-facies rocks of Yukon-Tanana terrane

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Diachronous metamorphism, deformation and exhumation within lower amphibolite-facies rocks of Yukon-Tanana terrane (YTT) is revealed from in situ U-Th-Pb monazite SHRIMP geochronology and P-T modeling. Previous work by Berman et al. (2007) within amphibolite-facies rocks of YTT in the Stewart River map area in west-central Yukon revealed two high-pressure tectonometamorphic events prior to exhumation in the Jurassic (Hunt and Roddick, 1992; Villeneuve, 2002, and unpublished data). The Permian (c. 260-240 Ma) high pressure (~9 kbar and 600°C) metamorphic event was synchronous with regional transposition deformation (c. 260 -254Ma), and interpreted to reflect intra-arc thickening during west-dipping subduction of Slide Mountain. A second high-pressure (~7.8 kbar and 595°C) event was dated at c. 195-187 Ma, and interpreted to record the internal duplication of YTT during its collision with the North American craton, with deformation at this time distributed heterogeneously into high strain zones.

Restoration of the approximately 430 km of Tertiary dextral displacement along the Tintina fault juxtaposes amphibolite facies YTT rocks of the Finlayson map area, NE of the fault, to those of the eastern Stewart River map area, SW of the fault. In contrast to the western Stewart River, where YTT was deformed, metamorphosed and exhumed to upper crustal levels by late Early Jurassic, in situ U-Th-Pb SHRIMP and trace element chemical analysis of monazite, coupled with quantitative phase equilibra modelling, reveals that YTT rocks to the east in the western Finlayson and eastern Stewart River regions, experienced high-pressure (>8 kbar) amphibolite-facies metamorphism in the Middle Jurassic to Early Cretaceous. Elongated Th-rich cores and Th-poor rims of matrix monazite grains oriented parallel to the penetrative ductile foliation at Finlayson yield c. 163 to 154 Ma ages. Quantitative P-T data obtained from synkinematic garnet from the same Finlayson samples suggest these ages record a Middle to Late Jurassic tectonometamorphic event characterized by a clockwise prograde P-T path culminating at peak P-T conditions of > 8 kbar and at least 620°C. Younger ages at c. 146 Ma obtained from a monazite rim, and a grain oriented perpendicular to the main foliation, overlap with the oldest ages obtained from the northeastern portion of the Stewart River map area (Berman et al., 2007), which are interpreted to date c. 146-119 Ma high-pressure (~9 kbar and 670°C) post-kinematic metamorphism (Berman et al., 2007; and this study).

Mid-Cretaceous (c. 114 Ma) exhumation in the eastern Stewart River map area is recorded by Y-rich monazite that formed from the breakdown of garnet during the onset of decompression from 9 kbar. Similarly, mid-Cretaceous exhumation within the northwestern Finlayson map area is recorded by c. 123 Ma hornblende and 111 Ma biotite ^{40}Ar/^{39}Ar cooling ages (Murphy et al., 2001). Exhumation in these regions may be linked to mid-Cretaceous crustal extension and exhumation documented in east-central Alaska (Pavlis et al., 1993; Dusel-Bacon et al., 2002). Extensional exhumation may be kinematically linked to a series of en echelon, mid-Cretaceous strike-slip faults, which include the Teslin, d'Abbadie, Big Salmon and Tadru faults southwest of the Tintina fault, and the Hess-MacMillan system to the northeast. Alternatively, extension and exhumation may be driven by outboard subduction and/or gravitational instability of an over-thickened crust (Pavlis et al., 1993; Dusel-Bacon et al., 2002).

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New sedimentological and geochemical constraints on the early Paleozoic history of the North Slope subterrane of Arctic Alaska

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Alaska is an amalgamation of allochthonous and parautochthonous crustal fragments largely juxtaposed by Cretaceous–Neogene strike-slip faults or separated by Jurassic–Tertiary sedimentary basins. The origin, displacement history, and final consolidation of these terranes have been the subject of considerable controversy since their initial recognition in the 1970's. Arctic Alaska is a large composite terrane that underlies the North Slope of Alaska and makes up the majority of the E-W trending Brooks Range. On the basis of differing stratigraphic relationships and structural position within the Brookian orogen, this composite terrane has been divided from north to south into the North Slope, Endicott Mountains, De Long Mountains, Hammond, Coldfoot, and Slate Creek subterranes. The pre-Mesozoic geology of Arctic Alaska is still only known at a reconnaissance-level and the relationship amongst these distinct subterranes is poorly understood. Fieldwork conducted over the summers of 2010 and 2011 in the Shublik and Sadlerochit Mountains of the North Slope subterrane focused on characterizing Neoproterozoic–early Paleozoic sedimentary successions in order to provide new constraints on the evolution of the North Slope subterrane. A combined approach of structural mapping and logging of detailed stratigraphic sections integrated with chemostratigraphic, biostratigraphic, and geochronologic analyses has enabled new interpretations of the pre-Mesozoic geologic history of Arctic Alaska. Specifically, we have dispelled the existence of an angular unconformity between the Neoproterozoic Katakturuk Dolomite and Cambro–Ordovician Nanook Limestone, recognized and divided the Nanook Limestone into two new informal members based on sedimentological observations, and provided supportive evidence for a significant exposure event prior to deposition of the lower Devonian Mt. Copleston Limestone. Chemostratigraphic and biostratigraphic data provide new age constraints on the Nanook Limestone and future work will continue to unravel the complex Neoproterozoic–Early Paleozoic geologic history of Arctic Alaska and begun to shed light on the tectonic evolution of this displaced crustal fragment.

THE GEOLOGY OF THE OKANAGAN VALLEY SHEAR ZONE FROM PENTICTON TO KELOWNA, BRITISH COLUMBIA

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Along the east side of the Okanagan Valley between Penticton and Kelowna in southern British Columbia there is excellent exposure of a segment of the moderate to shallowly west dipping Okanagan Valley shear zone (OVSZ), a west-northwest-directed extensional structure that was instrumental in the Eocene orogenic collapse of the southern Canadian Cordillera. Along the east side of the valley, sheared Eocene plutons and leucosomes derived from anatectic melting and Eocene ^{40}Ar-^{39}Ar cooling ages are recorded within amphibolite facies rocks within the footwall domain of the OVSZ. By contrast to the west within the hanging wall, layered sedimentary and volcanic greenschist/sub greenschist facies rocks record Mesozoic cooling ages. In this region, most recent geological compilations for this region are at 1:250 000 scale (Tempelman-Kluit, 1989), with the OVSZ yet to be studied in detail, particularly in relation to its thermo-kinematic evolution. The objectives of this research are to incorporate detailed (1:10 000) structural and bedrock mapping within and adjacent to the shear zone, and collect a suite of samples for microstructural, thermochronometric and themobarometric analysis. The goal is to better constrain the evolution of the shear zone in terms of onset, duration and cessation, while placing it within a kinematic framework for the region by building on previous work to the south by Brown (2010) and to the north by Bardoux (1993).

Structural analysis will include documenting the progressive development of finite strain markers and examine shear sense indicators, including detailed microfabric analysis (u-stage, EBSD) on quartz-rich samples within the shear zone. These fabrics will be utilised to quantify shear sense, type of flow, strain variation and temperature of deformation within the shear zone. The rates and conditions under which the microstructures are formed in the shear zone will be further constrained using thermochronology and thermobarometry. *In situ* laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) of zircon and/or monazite within texturally meaningful structural and metamorphic domains will be used to constrain the timing of fabric evolution and metamorphic recrystallisation within the shear zone**.** Geochemical analyses (major, trace and REE) will be used to estimate the evolution of pressure temperature (P-T) conditions within the shear zone by linking conventional themobarometry and isochemical phase diagrams with the microstructural and thermochronological analysis. Further, ^{40}Ar/^{39}Ar anlaysis of biotite, muscovite and hornblende may also be used to constrain the lower temperature evolution of the shear zone. Integration of these data will be used to construct P-T-D-t paths that will better constrain timing, depth, rate of exhumation, and tectonic significance of the OVSZ.

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Links between ^{40}Ar/^{39}Ar cooling dates and deformation history on the southern flank of the Thor-Odin dome BC: overlapping compressional and extensional regimes in the Eocene

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The southern flank of the Thor-Odin dome comprises an ~12 km thick S-dipping panel of amphibolite to granulite facies rocks, the lower half of which is migmatitic. Throughout the structural section the rocks have a pervasive composite transposition foliation, with rootless folds, folded by syn- and refolded by post-metamorphic NE verging folds. Metamorphism and the youngest stages of ductile deformation are Late Cretaceous to Eocene and young progressively down section. On the basis of cross cutting granitoids dated by U-Pb studies, transposition and folding had ceased by: (i) 73 Ma at the highest structural levels (e.g. in the southern part of the study area near Whatshan Lake and west of the dome at Joss Mountain); (ii) 64 – 62 Ma (in the central section west of Arrow Park lake); (iii) ~58 Ma on the upper margin of the dome at Cariboo Alp; and, (iv) ~56 – 54 Ma within the dome. Cooling from the thermal peak of metamorphism to ~300^{o}C occurred between 62 and 52 Ma on the basis of ^{40}Ar/^{39}Ar cooling dates. Thor-Odin dome and its southern flank lie in the footwall of the ~55 Ma and younger, E-dipping Columbia River normal fault. Proposed models for the exhumation of the dome and overlying rocks on the southern flank include extension, extrusion or diapirism (with an erosional contribution).

^{40}Ar/^{39}Ar cooling dates on hornblende, muscovite and biotite from 80 samples at all structural levels were studied in order to place constraints on the timing of the exhumation over a temperature range of ~600 to 300^{o}C. Hornblende ^{40}Ar/^{39}Ar cooling dates (calculated closure temperatures from 500 - 600^{o}C) are ~62-58 Ma at the top of the panel, ~57-56 Ma in the middle, and ~55-53 Ma near the upper margin of the dome. Hornblende ^{40}Ar/^{39}Ar data from migmatites in the dome are disturbed and do not produce meaningful dates. Biotite cooling dates (280 - 350^{o}C) are ~52-51 Ma throughout the 12 km thick structural section, including the dome. Since rocks from all different structural levels cooled through ~300^{o}C at the same time the structural section was tilted prior to cooling or cooling rates were extraordinarily high. 51-50.5 ± 0.2 Ma muscovite dates from greenschist-facies muscovite intergrowths in extensional structures in the dome, grew below their closure temperature and date late stage extension.

The downward younging progression of deformation and the thermal history are consistent with that of a highly strained crystalline sheet that was deforming progressively as it overrode a basement ramp, the Monashee ramp imaged in Lithoprobe seismic reflection profiles 6, 7 and 8. Exhumation and cooling as a result of syn-convergent extension in the upper part of the structural section was ongoing during the last stages of transposition and folding in the dome in the Late Paleocene to Early Eocene. By ~51 Ma, extensional structures were active at all structural levels reflecting crustal scale extension and exhumation via normal faulting linked to continuing motion on the Columbia River and possibly the Okanagan Valley extensional fault systems.

Some comments on the Paleozoic tectonic history of the Yukon Tanana-Slide mountain terranes

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The Frasnian-Missisipian tectonic setting of the Yukon Tanana (YTT) and Slide mountain (SMT) terranes are generally regarded to have involved initiation of east-directed subduction, arc formation on the leading edge of ancestral Laurentia and back-arc rifting that culminated in opening of an oceanic marginal basin by Early Mississippian times. However, regional studies mainly carried out during the Ancient Pacific margin NATMAP (e.g. Colpron, Nelson, Murphy and co-workers, Berman, Ryan and Gordey) revealed that upper plate extension was interrupted by a short-lived phase of late Famenian- Mississippian contraction-related deformation and metamorphism (similar in age to Antler deformation in the western US) that immediately predated and/or slightly overlapped with the opening of the Slide Mountain ocean. Such an interruption of a slab-roll back induced extension either suggests arrival and underthrusting of a buoyant tectonic element at the west-facing trench or another tectonic setting such as was proposed for the Antler orogeny in the northern Sierras (e.g. Dickinson). Application of the latter model requires that Antler orogenesis in YTT was due to east-facing (west-dipping) Devonian subduction of a narrow oceanic seaway beneath YTT, followed by a subduction polarity reversal after Famennian accretion. The pros and cons of these two models will be discussed.

Another tectonic problem relates to the evolution of the SMT. Studies of SMT ophiolitic rocks consistently revealed assemblages characterised by abundant mantle rocks with thin crustal covers. Pillow basalts are rare and sheeted dikes are virtually absent. Lower crustal cumulates are also rare or absent. These characteristics suggest these assemblages represent Ligurian-type (ocean-continent transition zone) ophiolites formed during rifting, exhumation of lithospheric mantle and very slow-spreading. Our new U-Pb zircon ages, however, suggest that these rocks formed over a large time span: from Missisipian times (350-340 Ma in the White Mountains) to Pennsylvanian (ca. 309 Ma) in the St. Cyr klippe to Permian (ca. 282 Ma in the Eikland Mtn ophiolite and ca. 265 Ma in the Midnight dome and Clinton creek localities of the Dawson-Clinton Creek assemblages). Eclogite in the St. Cyr klippe yielded a U-Pb zircon age of ca. 271 Ma. These ages suggest that 1. SMT was unlikely one simple oceanic backarc basin and 2. deep subduction of SMT oceanic lithosphere overlapped with rifting and generation of Ligurian-style ophiolites elsewhere in the SMT.

Mesozoic magmatism and metallogeny of the Hotailuh batholith (northern British Columbia)

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The composite Late Triassic to Middle Jurassic Hotailuh batholith occupies 2275 km^2 at the centre of the Stikine arch, close to the northern margin of the Stikine terrane. We present the results of detailed mapping, geochonological and geochemical sampling aimed at refining the temporal magmatic and geochemical evolution of the batholith, and building a metallogenic framework that relates mineralization to magmatic events. The project is part of the Geoscience BC funded QUEST-Northwest program developed to stimulate mineral exploration in the northwestern part of the province.

Geological cross-cutting relationships and a total of ten new zircon U-Pb LA-ICP-MS and hornblende and biotite Ar-Ar age dates provide improved control on the temporal magmatic evolution of the Hotailuh batholith. The study confirms and refines the previously established three-fold subdivision of the Hotailuh batholith, including:

- The Late Triassic plutonic suite comprising the areally extensive calc-alkaline felsic to intermediate Cake Hill pluton and the subordinate, mainly alkaline, ultramafic to mafic Beggerlay Creek pluton and Gnat Lakes ultramafite.
- The Early Jurassic plutonic suite comprising the calc-alkaline felsic McBride River pluton.
- The Middle Jurassic Three Sisters plutonic suite comprising four calc-alkaline mafic, intermediate to felsic plutonic phases.

Recurring magmatism within the batholith throughout the Triassic and Jurassic periods has a strong volcanic arc trace element signature.

Mineralization occurs predominantly near the edge of the batholith and close to contacts between different plutons or plutonic phases. Occurrences hosted in Late Triassic rocks are situated close to the ductile to brittle Gnat Pass fault zone on the western edge of the batholith, and include the newly dated Late Triassic quartz-plagioclase porphyry that hosts the Gnat Pass copper deposit (est. 30 Mt @ 0.39% Cu). Several newly discovered vein-hosted copper mineral occurrences are found within the Middle Jurassic Three Sisters pluton, and are generally associated with larger gossanous pyrite-dominated zones.

This study confirms that the Hotailuh batholith is prospective for porphyry-style copper mineral deposits that formed during several mineralizing events – an older event at ca. 220 Ma and a younger event at ca. 170 Ma. The Late Triassic calc-alkaline metallogenic event produced the Gnat Pass porphyry Cu and several other Cu and Cu-Au occurrences on the edges of the Hotailuh batholith, and may be temporally related with Cu mineralization at Schaft Creek further to the southwest. Although latest Triassic alkaline intrusions with potential for porphyry Cu-Au (cf. Galore Creek, Red Chris, GJ to the south and southwest) have not been identified, future work will test for contemporary mineralization in the Hotailuh batholith. Abundant mineral showings east of the Early Jurassic McBride River pluton have yet to be examined in this study, however they appear to have a similar setting as the KSM deposits hosted in the Early Jurassic Texas Creek plutonic suite further to the southwest. Newly discovered mineral occurrences in Middle Jurassic plutonic rocks represent a relatively unrecognized metallogenic event that deserves more attention.

The Upper Hazelton Group and its significance for the Jurassic evolution of the Stikine terrane, British Columbia

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The Lower to Middle Jurassic Hazelton Group records the final stages of arc activity in the intra-oceanic Stikine terrane, followed by the earliest stages of its accretion within the Cordilleran terrane collage. The Upper Hazelton Group (UHG) is exposed on the periphery of the Bowser Basin. Around most of this area, mainly sedimentary strata lie above Lower Hazelton Group arc and back-arc strata, and below the clastic basin fill of the Bowser Lake Group. However, a 300 kilometre-long arc-rift system west of the Bowser basin, the Eskay rift extends from Anyox in the south to Kinaskan Lake in the north, and includes the Iskut River area; in this area a thick volcanic succession is preserved in the Upper Hazelton Group. Upper Hazelton Group stratigraphy has been confused because small areas have been mapped and subdivided by many previous workers using different lithostratigraphic schemes. Stratigraphic relationships can be clarified based on measurement and correlation of representative stratigraphic sections throughout the regional extent of the unit.

The most significant recommended changes are: 1) informal division of the Hazelton Group into upper and lower parts, and recognition of a diachronous unconformity at the base of the UHG; 2) Revision of units labelled Spatsizi and Quock in the north, and extension of the Quock Formation (elevation from previous member status) to include all stratigraphically equivalent units of blocky, thinly-bedded siliceous mudstone and tuff around the periphery of the Bowser basin and 3) introduction of a new stratigraphic unit, the Iskut River Formation, for the rift-related facies in the Iskut River area. These changes aid in regional correlation of units, which in turn increases understanding the Stikine terrane as it evolved from an independent arc to part of the active western Laurentian margin.

Jurassic and Cretaceous metamorphism and deformation between the southern Kootenay Arc and Purcell Anticlinorium, southeastern British Columbia

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The region between Nelson, Salmo and Creston lies in the southern part of the Kootenay Arc, a complex tectonic interface between accreted oceanic arc-related rocks of Quesnellia and distal marginal rocks of ancestral North American. The geological complexity of this region derives from several phases of deformation, metamorphism and voluminous granitoid intrusion, ranging in age from Jurassic to Eocene, all related to Cordilleran orogenesis.

There is a continuous narrow band of north-south trending amphibolite facies metamorphic rocks that extends from northern Idaho, to the northern end of Kootenay Lake. Two major episodes of regional metamorphism have contributed to this metamorphic high, the first during the mid-Jurassic and second in the late Cretaceous (Archibald et al., 1983. CJES, vol. 21). Most mid-Jurassic granitoid intrusions are post-kinematic but some were emplaced syn-kinematically with respect to the regional penetrative deformation (Evenchick et al., 2007. GSA special paper 443). The Mine and Wall stocks (~167-171Ma) belong to this suite of intrusions and are syn to post-kinematic plutons that intruded Neoproterozoic rocks of the Windermere and Belt Purcell Supergroups. The stocks have imprinted upon the country rocks a staurolite bearing contact aureole. Several occurrences of kyanite have been identified within the contact aureole and on-going petrological work is focusing on the origin, and timing of kyanite growth with respect to plutonism and regional metamorphism. Archibald et al., (1983) inferred a counter clockwise P-T-t path based on the presence of post-kinematic kyanite, indicating burial and Barrovian metamorphism of the intrusions to depth following their emplacement. The younger Porcupine Stock (~157Ma, K-Ar hornblende age) is situated 4kms to the northwest of the Wall Stock and has a low pressure cordierite and andalusite bearing contact aureole. This implies emplacement at higher levels in the crust than the Mine and Wall stocks, suggesting that the region around the Mine and Wall stocks was unlikely to have been buried to kyanite-forming P-T conditions following emplacement.

The post-kinematic kyanite found within the contact aureole therefore has two possible sources: post-intrusion regional Jurassic metamorphism, or development in association with the narrow band of north-south trending Cretaceous Barrovian regional metamorphism. The Cretaceous metamorphism extends west from the Purcell Trench Fault to the eastern edge of the Mine stock. Determining the age of kyanite growth therefore has significant implications for the burial-heating-intrusion history of the area. Field based observations and preliminary petrological work will be presented.

Geochemical variability and evolution of northwestern Stikinia

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The Late Triassic Stuhini-Lewes River-Semenoff arc was founded on a composite basement comprising the Paleozoic Stikine assemblage, Yukon-Tanana terrane and Boswell assemblage. The present configuration of these rocks, comprising arc terranes enclosing exotic Cache Creek terrane, has been largely attributed to an orocline. This study focuses on the along and across-arc geochemical characteristics of the Late Triassic Stikinia to test the polarity of the Stuhini-Lewes River Arc. The Late Triassic Stikinia characteristically comprises augite to feldspar porphyritic lavas and volcaniclastic rocks of shoshonitic to calc-alkaline affinities and lesser alkaline rocks. Basaltic to andesitic rocks are the dominant volcanic rocks; minor picritic and rhyodacitic rocks occur sporadically. The plutonic rocks range from granite to gabbro with minor clinopyroxenite and hornblendite. In general, Triassic rocks do not appear to show significant systematic major or trace element differences along and across strike of present-day Stikinia (i.e., roughly longitudinal and latitudinal sections). Element ratios that are known to vary across modern arcs (e.g., Nb/Ta. Nb/Zr) do not exhibit any systematic longitudinal and latitudinal changes. The lack of systematic geochemical variation may be in part attributed to poor geochronological constraints, such that different phases of magmatism related to migration of the arc front are indistinguishable with the present geochronological dataset. This is supported by a geochemical transect through a tilted Norian to Rhaetian section near Atlin which displays similarly non-systematic geochemical variation.