2005 Cordilleran Tectonics Workshop

February 18-20th
High Country Inn
Whitehorse, Yukon

Hosted by:

Yukon Geological Survey

Yukon Energy, Mines and Resources

The 2005 Cordilleran Tectonics Workshop was made possible by generous funding by the Yukon Geological Survey (Energy, Mines and Resources), surplus funding from the 2004 workshop in Calgary (organized by Larry Lane) and your contributions.

2005 Cordilleran Tectonics Workshop

High Country Inn, Whitehorse, Yukon

Friday, Feb. 18

7:30 PM	***Ice breaker + Registration***		
10:00 PM	***(cash bar + munchies)***		

Saturday, Feb. 19

			Abstract
8:30 AM	***Registration***		
9:00 AM	Preliminary field, petrological, and geochemical characterization of the Princeton Group, an Eocene volcanic field in Southern B.C	*R. Ickert and D.J. Thorkelson*	***p. 12***
9:30 AM	Volcanology of the Quaternary valley basalts of southern British Columbia	*C.L. Sluggett and D.J. Thorkelson*	***p. 19***
10:00 AM	Lithosphere-scale geophysical discontinuity near Fort Nelson, B.C: part of a Proterozoic strike-slip fault extending from the Arctic coast to southern BC	*D.J. Thorkelson*	***p. 19***
10:30 AM	***coffee + discussion + posters***		
11:15 AM	Detrital zircon geochronology and provenance of late Proterozoic and mid-Paleozoic successions outboard of the miogeocline, southeastern Canadian Cordillera	*Y. Lemieux, R.I. Thompson and P. Erdmer*	***p. 14***
11:45 AM	Proterozoic strain in the core of the Frenchman Cap dome, Monashee complex; tectonic implications of a strong basement	*F. Gervais, R.L. Brown and J.L. Crowley*	***p. 10***
12:15 PM	***lunch***		
	posters + discussion		
1:30 PM	Diachronous (?) emplacement of leucocratic dykes at the Thor-Odin dome, Monashee Complex	*A.C. Parmenter and P.F. Williams*	***p. 17***
2:00 PM	The Frigg dykes of the southern Thor–Odin culmination of the Monashee complex, southern British Columbia and evidence for diachronous tectonism	*P. McNeill and P. Williams*	***p. 15***
2:30 PM	Paleocene high-grade thermal peak, anatectic front and high strain in the Thor-Odin area, Monashee Complex: constraints for tectonic models of the southern Canadian Cordillera	*A.M. Hinchey and S.D. Carr*	***p. 11***
3:00 PM	Brittle faulting in the Thor–Odin culmination, Monashee complex, southern Canadian Cordillera: constraints on geometry and kinematics	*S. Kruse and P.F. Williams*	***p. 13***
3:30 PM	***coffee***		
	posters + discussion		
5:00 PM			

7:00 PM	***dinner @ Sanchez Cantina*** ***(*** *corner Hansen St. & 3rd Avenue* ***)***		

Sunday, Feb. 20

8:30 AM	Geology and Tectonics of the Nootka Island Region: A New Model for the Westcoast Crystalline Complex	*S. Close and D. Marshall*	***p. 7***
9:00 AM	Prolonged deformation within a long-lived magmatic arc at the boundary between the Insular and Intermontane superterranes, west-central British Columbia	*S. Israel*	***p. 13***
9:30 AM	3-D mapping of a Paleocene crustal-scale thrust ramp in the southern Omineca belt; some tectonic implications	*P.S. Simony and S.D. Carr*	***p. 18***
10:00 AM	Channel flow in the North American Cordillera?	*R.L. Brown*	***p. 6***
10:30 AM	***coffee + discussion***		
11:00 AM	Deformation of the upper Kaza Gp-lower Isaac Fm, (Neoproterozoic) Windermere Supergroup, east-central BC	*K. Wallace and J. Waldron*	***p. 21***
11:30 AM	Fault-propagation fold mechanisms of the Centre Peak anticline and temperatures of syn-tectonic veins, Livingstone Range of southern Alberta	*M.A. Cooley, R.A. Price, J.M. Dixon and T.K. Kyser*	***p. 8***
12:00 PM	***lunch***		
	posters + discussion		

Sunday, Feb. 20 (afternoon)

1:00 PM	Intra-arc rift basin development within a Mississippian continental arc system; an example from the Little Salmon Formation, northern Canadian Cordillera, Yukon	*R.-L. Simard, J. Dostal and M. Colpron*	***p. 18***
1:30 PM	The timing of high-pressure metamorphism, exhumation, and structural emplacement of the Klatsa metamorphic assemblage of Yukon-Tanana terrane, Finlayson Lake belt, southeastern Yukon	*F. Devine, D.C. Murphy, S.D. Carr, W.J. Davis, S. Smith and R.G. Berman*	***p. 9***
2:00 PM	The Northern Cordilleran mid-Cretaceous Plutonic Province: Redox and Tectonics	*C.J.R. Hart and J.L. Mair*	***p. 11***
2:30 PM	***Where to next year??***		
2:40 PM	***coffee***		
4:00 PM	***posters + discussion***		

Posters

1	Structural role in the emplacement of the Little Nahanni Pegmatite Group, Logan Mountains, Northwest Territories.	*E.M. Barnes and L.A. Groat*	***p. 5***
2	The upper Hazelton Group, northwest British Columbia: An example of the arc building to rifting transition	*T. Barresi, J. Nelson, D. Alldrick and J. Dostal*	***p. 5***
3	Tracking uplift and subsidence associated with the Yellowstone hotspot through the northern US Cordillera: Insights from detrital zircons in Miocene to Recent sediments of the Western Snake River Plain and Oregon-Idaho graben, Oregon and Idaho, USA	*L.P. Beranek, P.K. Link and C.M. Fanning*	***p. 6***
4	A new tectonic assemblage map for the pericratonic terranes of Yukon and northern B.C.	*M. Colpron*	***p. 7***
5	Fault-propagation fold mechanisms of the Centre Peak anticline and temperatures of syn-tectonic veins, Livingstone Range of southern Alberta	*M.A. Cooley, R.A. Price, J.M. Dixon and T.K. Kyser*	***p. 8***
6	Weakly deformed ~1.85 Ga granites in the Monashee complex, British Columbia: evidence for a rigid basement during Tertiary orogenesis in the hinterland of the Canadian Cordillera	*J.L. Crowley, R.L. Brown, H.D. Gibson, M. Tubrett*	***p. 8***
7	From push to pull: tectonomagmatic evolution of the Buck Creek Complex (central British Columbia)	*J. Dostal, J.V. Owen and B.N. Church*	***p. 10***
8	The southern termination of the Western Ranges and Main Ranges of the Southern Canadian Rocky Mountains: Tectonic and implications of new stratigraphic, structural, and geochronologic data.	*K.P. Larson, R.A. Price, and D.A. Archibald*	***p. 14***
9	Clasts from the past, Latest Jurassic-Earliest Cretaceous foreland basin conglomerates, northeast B.C. and NW Alberta	*M. McMechan, R. Anderson and R. Creaser*	***p. 15***
10	The petrography and geochemistry of the Quartet Mountain lamprophyre suite	*D. Milidragovic, D.J. Thorkelson and D.D. Marshall*	***p. 16***
11	The Simpson Lake Assemblage – Remnants of a Permian Forearc Basin in Southeastern Yukon	*J.K. Mortensen and P. Erdmer*	***p. 16***
12	Paleozoic magmatism and crustal recycling along the ancient Pacific margin of North America, northern Cordillera	*S.J. Piercey, J.L. Nelson and M. Colpron*	***p. 17***
13	Structural evolution of the Tally Ho shear zone (NTS 105D), southern Yukon	*A. Tizzard and S.T. Johnston*	***p. 20***
14	Preliminary age constraints of regional mid-Jurassic fluid movement in the Pelly Mountains, central Yukon – NTS 105F	*D. Turner, C. Hart and L. Groat*	***p. 20***

Participants:

Abbott, Grant	YGS	Grant.Abbott@gov.yk.ca
Barnes, Elspeth	UBC	ebarnes@eos.ubc.ca
Barresi, Tony	St. Mary's	tony.barresi@smu.ca
Beranek, Luke	Idaho State	beraluke@isu.edu
Bradshaw, Geoff	YGS	geoff.bradshaw@gov.yk.ca
Breitsprecher, Katrin	UBC	breitspr@telus.net
Brown, Richard L.	Carleton	rlbrown@rideau.net
Bruce, Olwyn	YGS	olwyn.bruce@gov.yk.ca
Carr, Sharon	Carleton	scarr@ccs.carleton.ca
Close, Scott	SFU	sclose@sfu.ca
Colpron, Maurice	YGS	Maurice.Colpron@gov.yk.ca
Cooley, Mike	Queen's	cooleym@students.geol.queensu.ca
Crowley, Jim*	MIT	jlcrowle@mit.edu
Devine, Fionnuala	Carleton	devinefd@yahoo.ca
Dostal, Jarda	St. Mary's	jdostal@smu.ca
Fonseca, Anna	Akhbar Geological	afonseca@klondiker.com
Gervais, Felix	Carleton	gervais_felix@yahoo.ca
Gibson, Dan	SFU	hdgibson@sfu.ca
Hart, Craig	YGS	Craig.Hart@gov.yk.ca
Hill, Rod	YGS	rhill@gov.yk.ca
Hinchey, Alana	Carleton	ahinchey@connect.carleton.ca
Hunt, Julie	YGS	julie.hunt@gov.yk.ca
Ickert, Ryan	SFU	ryani@sfu.ca
Israel, Steve	YGS	Steve.Israel@gov.yk.ca
Kruse, Stefan	UNB	q09ay@unb.ca
Larson, Kyle	Queen's	larson@students.geol.queensu.ca
Lemieux, Yvon	U of A	ylemieux@ualberta.ca
Lewis, Lara	YGS	lara.lewis@gov.yk.ca
Mann, Bill	Klondike Gold	kgcorp@northwestel.net
McMechan, Margot	GSC Calgary	mmcmecha@nrcan.gc.ca
McNeill, Paul	UNB	i4lcz@unb.ca
Milidragovic, Dejan	SFU	dmilidra@sfu.ca
Mortensen, Jim	UBC	jmortensen@eos.ubc.ca
Murphy, Don	YGS	dmurphy@northwestel.net
Nelson, JoAnne	BCGS	JoAnne.Nelson@gems1.gov.bc.ca
Parmenter, Andy	UNB	a228k@unb.ca
Piercey, Steve*	Laurentian	spiercey@nickel.laurentian.ca
Pigage, Lee	YGS	lee.pigage@gov.yk.ca
Roots, Charlie	GSC Whitehorse	Charlie.Roots@gov.yk.ca
Simard, Renée-Luce	Dalhousie	rsimard@dal.ca
Simony, Philip	U of C	pssimony@ucalgary.ca
Sluggett, Christa	SFU	christas@sfu.ca
Thorkelson, Derek	SFU	dthorkel@sfu.ca
Tizzard, Amy	UVic	Amy.Tizzard@gov.yk.ca
Turner, Dave	UBC	dturner@eos.ubc.ca
Waldron, John	U of A	John.Waldron@ualberta.ca
Wallace, Ken	U of A	shearzone68@yahoo.ca
Williams, Paul	UNB	pfw@unb.ca

** Not present – poster only.*

Structural role in the emplacement of the Little Nahanni Pegmatite Group, Logan Mountains, Northwest Territories

Elspeth M. Barnes and Lee A. Groat,
University of British Columbia

The purpose of the study is to determine the regional geological setting and P-T-x conditions during emplacement of the Cretaceous Little Nahanni Pegmatite Group (LNPG) of the Selwyn Basin area, Northwest Territories (Groat et al., 1994 and 2003; Mauthner et al., 1995; Mauthner, 1996). This rare element, lithium-cesium-tantalum (LCT)-type pegmatitic dike swarm of >200 dikes was emplaced into the Precambrian to Lower Cambrian offshelf facies of the Hyland Group (Gordey and Anderson, 1993).

Extensive vertical exposure of the dikes reveals mineralogic and textural changes with elevation that suggest that the pore fluid pressure of the dikes decreased during emplacement. Radiogenic and stable isotopic analysis, fluid inclusion studies, geochemistry and field studies will be used to investigate the timing, conditions and mechanisms of dike emplacement. Results from this research are expected to increase our understanding of the formation of pegmatites and dikes in general and their crystallization textures, and to add to our interpretation of the regional setting.

Previous studies (Gordey and Anderson, 1993) recorded a northwest trend to the folds and larger thrust faults in the area e.g. the Fork Anticline and the March Fault. The orientation of the LNPG dike swarm is sub-parallel to the March Fault and to the axial trace of the fold axis of the Fork Anticline suggesting that previously formed anisotropies were used during dike propagation. An aspect of this research will be to map the full extent of the dike swarm and undertake a structural study of the area to determine the validity of this connection.

The upper Hazelton Group in Northwest British Columbia: An example of the Arc Building to Rifting Transition

Barresi[1], T., Nelson[2], J.L., Alldrick[2], D.J., Dostal[1], J.
1- St. Mary's University
2- B.C. Geological Survey Branch

In island arcs, the latest stage of subduction related processes is commonly followed by an extensional tectonic régime. The Stikine Terrane of the Canadian Cordillera records one such transition in the rocks of the Early to Middle Jurassic upper Hazelton Group, in northwestern British Columbia. These rocks are host to the world-class Eskay Creek volcanogenic massive sulfide (VMS) deposit. Recent targeted studies of the upper Hazelton Group have documented a number of characteristics which confirm that the upper Hazelton Group represents a shift from arc building during the Early Jurassic to an extensional environment during the late Early to Middle Jurassic. These characteristics include 1) the presence of original rift bounding faults 2) unconformities that are associated with rift filling conglomerates, including one that grades into more distal facies argillite; 3) a shift in the geochemical signature of mainly intermediate Early Jurassic calc-alkaline volcanic rocks to Middle Jurassic bimodal rhyolites and tholeiitic basalts; and 4) evidence for a major transcurrent tectonic régime, which opened distinct rift segments that were separated by horsts of older Stikinian units. Although the upper Hazelton Group is composed of separate sub-basins, the lithologies, geochemistry and morphologies of far-separated segments correspond closely to one another. The Willow Ridge Complex (WRC), and the Pillow Basalt Ridge Complex (PBR), which are 100 km apart, each contain a succession of sedimentary and bimodal volcanic rocks between 1000 m thick sequences of mainly pillow basalt. These middle units, in both regions, are very similar to the strata that host the Eskay Creek deposit and may represent a repetition of the conditions that were favorable to mineralization at Eskay Creek.

New whole-rock major oxide and trace element geochemical analyses of 17 samples collected from the WRC agree with previous interpretations that they were deposited in a rift setting. The chemistry of these rocks is similar to those that host the Eskay Creek VMS deposit and other VMS hosting volcanic rocks world-wide. The WRC is composed of a bimodal suite of mainly basalts and rhyolites. Basalts from the WRC are characterized by: a) a negative correlation of TiO_2 with Mg number in compositionally-similar, TiO_2-rich tholeiitic MORB; b) a slight enrichment in light REE (La_n/Sm_n = 1.83) and flat heavy REE (Gd_n/Yb_n = 1.19); c) slight enrichment of strongly incompatible elements and a small negative Nb anomaly in mantle-normalized incompatible-element diagrams. Rhyolites from the WRC have broadly similar characteristics to basalts (La_n/Sm_n = 3.01, and Gd_n/Yb_n = 0.86) but they have strong negative Ti and weak positive Zr anomalies. The similarity in trace element abundances between rhyolites and basalts rules out derivation of rhyolite from basalt via fractional crystallization. All but the most primitive basalts are interpreted to be derived from sub-lithospheric mantle, and rhyolites are interpreted to be derived from partial melting of crustal rocks.

Tracking uplift and subsidence associated with the Yellowstone hotspot through the northern US Cordillera: Insights from detrital zircons in Miocene to Recent sediments of the Western Snake River Plain and Oregon-Idaho graben, Oregon and Idaho, USA

Luke P. Beranek[1], Paul Karl Link[1] and C. Mark Fanning[2]

1- Department of Geosciences, Idaho State University, Pocatello, Idaho, 83209, USA

2- PRISE, Research School of Earth Sciences, The Australian National University, Canberra, ACT, 0200, Australia

Detrital zircon sampling of the Snake River Plain supports the model of topographic development whereby Neogene to Recent drainage patterns surrounding the Snake River Plain formed in direct response to uplift and subsidence adjacent to the NE-migrating tumescent bulge of the Yellowstone hotspot through the northern US Cordillera. SW passage of the North American Plate over the fixed Yellowstone plume led to a 1 km-high, broad volcanic highland that disrupted existing drainages and delivered them radially away from the eruptive center. Thermal deflation, NW-trending extension, and mafic dike emplacement allowed for the present day Snake River Plain to subside in the wake of the hotspot. The Snake River Plain became the ultimate base level for streams draining south-central and southern Idaho, northern Nevada, and western Wyoming.

We report new U-Pb detrital zircon SHRIMP data from thirteen 30 to 60-grain random samples in Miocene to Recent sediments of the Oregon-Idaho graben (OIG) and Western Snake River Plain (WSRP), Oregon and Idaho. These new data supplement the existing database of nearly 1000 grains in the Snake River system that has determined the U-Pb signature of the Antler and Sevier thrust belts (Cordilleran miogeocline), Eocene Challis Magmatic Event associated with early Cenozoic back arc extension, and the Jura-Cretaceous Cordilleran magmatic belt of Idaho and Nevada.

Middle to late Miocene (16-10 Ma) sediments within the OIG and WSRP have age spectra representing the Eocene (52-42 Ma) Challis Volcanics, Cretaceous (100-70 Ma) Atlanta lobe of the Idaho batholith, and Permo-Triassic accreted terranes (ca. 250 Ma), indicating that basins were fed only by sources north of the Snake River Plain. Detrital zircons from northern Nevada are not present. Middle to late Miocene drainage in northern Nevada is proposed to have been to the south-south east, away from the 17-10 Ma hotspot volcanic fields.

By the late Miocene (ca. 7.5 Ma), drainage in southwestern Idaho had reversed, as detrital zircons from late Eocene (42-35 Ma) volcanics from northern Nevada were added to the WSRP.

From the Miocene to earliest Pliocene (16-5 Ma), OIG and WSRP sediments lack detrital zircons from the Cordilleran orogenic belt, indicating the continental divide was within the Cretaceous Idaho batholith and Eocene Challis Volcanics, and west of the central Idaho thrust belt, which drained to the east.

Previous detrital zircon work near Hagerman Fossil Beds National Monument (Link et al., 2002) indicates that Pliocene (ca. 5 Ma) sands contain grains of the Cordilleran miogeocline from the north, demonstrating that by that time the central Idaho thrust belt was captured into the Snake River system. By 3.3 Ma, late Eocene (42-35 Ma) and Jurassic (ca. 160 Ma) grains from northern Nevada were captured by the subsiding central Snake River Plain.

These data display the power and utility of detrital zircon studies in tracking drainage capture in Miocene to Recent fluvial systems.

Channel Flow in the North American Cordillera?

Richard L. Brown

Department of Earth Sciences, Carleton University

Channel flow models developed by Beaumont & Jamieson are being rigorously tested in the Himalayan orogen. At a recent Geological Society conference in the UK the possibility of applying such models to other orogens was widely discussed. A paper presented by Brown and Gibson at that meeting, and less formally at the Cordilleran Workshop last year, concluded that there is evidence to support channel flow in parts of the southern Omineca belt of the Canadian Cordillera. On the other hand Simony and Carr have described relationships in the Valhalla region that argue against channel flow in that part of the southern Omineca belt.

The concept of "infrastructure" and "suprastructure" has been understood since the early years of tectonics. But the nature of the infrastructure-suprastructure transition remains enigmatic. There is reason to believe that this boundary places an upper limit on low strength ductile flow of the middle crust. In other words the suprastructure is the "lid" of the ductile low strength middle crust. But what of the base of the ductile layer, does strength decrease with depth or increase to form an underlying "suprastructure"? During plate boundary convergence cold rocks are generally underplated beneath the thick and mobile middle crust, thus maintaining a relatively high strength lower crust, which would place a lower bound on the ductile middle crust. When these conditions are satisfied within an orogen the stage is set for channel flow. What is needed in addition is a gradient that is sufficient to generate flow within the channel.

To test for channel flow in the North American Cordillera the boundaries of the channel must be identified and vorticity of flow established. In the Omineca belt and in the Coast belt, maps reveal exhumed areas of middle crustal rocks and "infrastructure-suprastructure" boundaries have been identified. But we have only limited knowledge of the nature of these boundaries. The question that needs to be asked is: during flow of the infrastructure, was the suprastructure (the lid) ever left behind? It is necessary to establish that the ductile middle crust was advancing toward the foreland at a greater rate than the overlying suprastructure for some period during the growth of the orogen. This is a complex question since obvious fault boundaries with clear kinematics are not a necessary requirement, and establishing the relative roles of crustal thinning and crustal ductile shear strain is not trivial.

Was there a plateau region across the Intermontane belt in Cretaceous time? Rapid exhumation of middle crust occurred within the Omineca and Coast belts in the Late Cretaceous. Such exhumation in a time of plate boundary convergence and crustal thickening could have been driven by flow from beneath a plateau region above the Intermontane belt.

Geology and Tectonics of the Nootka Island Region: A New Model for the Westcoast Crystalline Complex

Scott Close and Dan Marshall
Simon Fraser University

Nootka Island, one of many islands along the western edge of Vancouver Island, exists as a subareal exposure of exotic terrain near the Cascadia subduction zone. Little research has been conducted on Nootka Island and its geology was mis-interpreted in the past, thus influencing the regional tectonic model. However, as a result of recent logging, exposition, and interest, closer examinations of Nootka Island continue to reveal the genesis of Wrangellia, one of North America's exotic accretionary terranes.

Preliminary mapping of island displays the Karmutsen and Bonanza Group volcanics, two of the three independent volcanic episodes forming Wrangellia. Geochemistry of the two massively bedded basalt-basaltic andesitic extrusive volcanics are tholeiitic and calk-alkaline, respectively. Minor, inter-bedded sedimentary layers are infrequent but provide carbon and oxygen isotope data for thermobarometery. Structural evidence includes S1, primary NW shearing concordant with the Westcoast Fault Zone, and S2, secondary NE faulting, aligned with the Nootka Fault and likely a result of post-accretionary northward translation. Field research also indicates that the previously proposed Westcoast Crystalline Complex requires redefinition. Amphibolite schists of the WCC are not evident, and the migmatites appear within metasomatic aureoles around the intrusions. These are amphibolite grade and exhibit second-stage hornblende, plagioclase, and epidote formation in the leucosomes. The An-Ab content of the plagioclase between the mesosome and leucosome, hornblende-plagioclase thermometer, Na/Al contents of the hornblendes, and Ar-Ar of the second-stage hornblendes constrain the duration, temperature, pressure, and chronology of metamorphism.

A new tectonic assemblage map for the pericratonic terranes of Yukon and northern British Columbia

Maurice Colpron
Yukon Geological Survey

Regional bedrock mapping of the pericratonic Yukon-Tanana and related terranes in Yukon and British Columbia was conducted under the auspices of the Ancient Pacific Margin NATMAP project (1999-2003). These new maps, published as Open Files by BCGS, YGS and GSC, together with extensive U-Pb geochronology, conodont biostratigraphy, and geochemistry provide the basis for defining a new tectonostratigraphic framework for the pericratonic terranes of the northern Cordillera; terranes which until now were amongst the most enigmatic of the Canadian Cordillera. The Yukon-Tanana terrane comprises four unconformity-bounded tectonic assemblages of regional extent: (1) ***Snowcap*** – a pre-late Devonian metasedimentary complex of probable continental margin affinity (North American?) which forms the "basement" to overlying (and intruding) Paleozoic arc (and locally back-arc) successions; (2) ***Finlayson*** – Late Devonian to Middle Mississippian bimodal metavolcanic and associated metasedimentary rocks of arc and back-arc character that locally host significant massive sulphide deposits; (3) ***Klinkit*** – Late Mississippian to Early Permian mafic to intermediate volcanic, volcaniclastic and carbonate rocks of island arc character that share stratigraphic affinities with Paleozoic Quesnellia of central and southern B.C. (Lay Range, Harper Ranch); and (4) ***Klondike*** – Middle to Late Permian calc-alkaline felsic metavolcanic rocks of arc character. Chert, basalt and serpentinite of the ***Slide Mountain assemblage*** are coeval and locally depositionally linked with arc/back-arc assemblages of Yukon-Tanana terrane and likely represent a marginal (back-arc) ocean that formed as the arc front of the Yukon-Tanana terrane rifted and retreated away from North America in mid- to late Paleozoic time. This poster presents a new compilation map for Yukon-Tanana and related terranes showing the distribution of the newly defined tectonic assemblages. This map will be released in 2005 as a YGS Open File and will be the basis for a major upgrade of the Yukon Digital Geology (Gordey and Makepeace, 1999).

Fault-propagation fold mechanisms of the Centre Peak anticline and temperatures of syn-tectonic veins, Livingstone Range of southern Alberta

Michael A. Cooley, Raymond A. Price, John M. Dixon, and T. Kurtis Kyser
Queen's University

The Livingstone Range anticlinorium is located above a large (~1000 m) frontal ramp along which the Livingstone thrust cuts abruptly up-section from a regionally extensive detachment in the Upper Devonian Palliser Formation to a regional detachment in the Jurassic Fernie Group. Minor deviations of the frontal ramp, where the thrust changed from bedding-parallel to across-bedding, have resulted in the formation of multiple folds in the hangwall. The anticlinorium consists of two or three parallel and closely-spaced fault-propagation fold anticlines with associated thrust faults that have splayed upward from the underlying Livingstone thrust and which die-out upward in the core of concentric flexural-slip folds. During flexural slip folding, as the fold limbs rotated toward steeper dips, interstratal slip was transferred to the thrust faults.

Retrodeformation of a plasticine geometric model of a cross section through the Centre Peak anticline elucidates the processes that occurred during formation of this fault-propagation fold: initiation of the fold structure occurred as the hanging-wall ramp was thrust up onto the footwall flat, the axial plane of the anticline remained fixed at the base of the moving hangingwall ramp as the fold tightened, the back limb remained planar and became longer with increased displacement as it passed through a synclinal hinge, propagation of a new thrust fault up through the core of the fold, and extension of the upper part of the forelimb during later stages of fold tightening.

New isotope geochemistry and fluid inclusion work on thrust-related veins in the Livingstone Range indicate relatively cool temperatures for vein formation. Homogenisation temperatures of primary petroleum fluid inclusions in quartz give an average minimum temperature estimate of 60 ºC. Quartz/calcite geothermometry of one sample gave a calculated equilibrium temperature of 120 ºC. These low temperatures are likely due to infiltration of cool meteoric waters during deformation. The presence of meteoric water is confirmed by consistent meteoric signatures in all thrust-fault-related veins.

Weakly deformed ~1.85 Ga granites in the Monashee complex, British Columbia: evidence for a rigid basement during Tertiary orogenesis in the hinterland of the Canadian Cordillera

Crowley, J.L.[1], Brown, R.L.[2], Gibson, H.D.[3], Tubrett, M.[4]

[1] MIT, Cambridge, MA
[2] Carleton University, Ottawa, ON
[3] Simon Fraser University, Burnaby, BC
[4] Memorial University, St. John's, NL

Granites are superb recorders of deformation and melting in high-grade rocks because they are ubiquitous and contain abundant accessory minerals that can be dated by U-(Th)-Pb methods. Obtaining accurate and precise igneous crystallization ages from granites is therefore crucial for tectonic models of orogenesis. A major uncertainty in models for the hinterland of the Canadian Cordillera is the structural state of the deepest exposed levels (basement rocks) in the Monashee complex during Tertiary orogenesis. A study in the Frenchman Cap dome (FCD) concluded that parts of the basement remained essentially rigid in the Tertiary as structurally higher rocks were transported eastward, whereas a study based in the adjacent Thor-Odin dome (TOD) concluded that extension-assisted diapiric ascent of partially molten basement rocks occurred during Tertiary orogenic collapse. Critical to each of model is the age and nature of granites in the basement; 1.85 Ga U-Pb dates from several weakly deformed to undeformed granites in the FCD were assumed to represent the timing of igneous crystallization, and Tertiary U-Pb dates from two migmatites from the TOD were inferred to indicate the timing of partial melting throughout the dome.

Previous U-Pb dating in the FCD was performed without knowledge of the internal zoning of the dated minerals, so it could not be ruled out that the 1.85 Ga grains were xenocrysts in Tertiary granites. We therefore undertook this study to determine if granites in the FCD crystallized at ~1.85 Ga or in the Tertiary. Five samples from a small region (1 km^2) at Bourne Glacier were studied, comprising weakly deformed to undeformed, non-migmatitic granite sheets and pegmatite dykes, and a folded leucosome layer, all containing zircon and monazite. The zoning and chemical composition of the grains were studied with an electron microprobe, and U-Pb dating was performed by LA-ICPMS and IDTIMS. These methods allowed us to chemically characterize the grains and acquire many dates (>40 per sample) that significantly refined our age interpretations.

We conclude that all samples crystallized from igneous melts at ~1.85 Ga because they passed four "tests" designed to assess whether zircon and monazite are xenocrystic. Test 1 (Age): Most zircon grains are entirely ~1.85 Ga, with the exception being 2.1-1.9 Ga cores in a few grains and minor rims that are too narrow to date. Likewise, most monazite grains are ~1.85 Ga, with the exception being narrow Tertiary rims and one sample that contains only Tertiary grains. The presence of mainly ~1.85 Ga dates is important because it would be unlikely for Tertiary melts to have inherited ~1.85 Ga xenocrysts from country rocks that are known to be 2.1-1.9 Ga. Test 2 (Chemistry): The ~1.85 Ga monazite has concentrations of Th, U, Ce, Y, Si, and Ca that are uniform within samples, slightly to moderately different between samples, and significantly different from Tertiary monazite that is chemically heterogeneous within samples. Test 3 (Internal zoning): The ~1.85 Ga zircon and monazite grains have oscillatory zoning patterns, typical of growth from granitic melts, that are similar within samples, but different between samples. Combining the zoning and chemical data strongly suggests that igneous crystallization occurred in distinct ~1.85 Ga melts, which would be unlikely if the grains were xenocrysts in Tertiary granites. Moreover, the heterogeneous chemistry and weak, irregular zoning in Tertiary monazite are suggestive of metamorphic growth. Test 4 (Cross-cutting relationships): Relative ages of the granites as indicated by field relationships are borne out by precise dating; a folded leucosome layer is 10 myr older than a granite sheet, which is 10 myr older than a cross-cutting dyke. It would be exceptionally fortuitous for Tertiary melts to have selectively inherited xenocrysts with this age pattern.

Our results show that partial melting in part of the FCD basement occurred before 1.85 Ga and only minor ductile deformation occurred since then. Based on similar field relationships found in other parts of the FCD, we suggest that a rigid basement was widespread in the Tertiary. If so, then a starkly different Tertiary structural setting apparently existed in the FCD compared with the TOD, which had partially molten basement. An extensive U-Pb dating and mapping program is required to delineate and explain differences between the domes. Only then can realistic tectonic models for the deepest structural levels in the Cordillera be proposed.

The timing of high-pressure metamorphism, exhumation, and structural emplacement of the Klatsa metamorphic assemblage of Yukon-Tanana terrane, Finlayson Lake belt, southeastern Yukon.

Devine, F.[1], Murphy, D.C.[2], Carr, S.D.[1], Davis, W.J.[3], Smith, S.[3] and Berman, R.G.[3]

[1] Carleton University, Ottawa, Ontario
[2] Yukon Geological Survey, Whitehorse, Yukon
[3] Geological Survey of Canada, Ottawa, Ontario

The newly defined Klatsa metamorphic assemblage occurs in the southern Campbell Range, near the southeastern margin of Yukon-Tanana terrane in the Finlayson Lake belt, southeastern Yukon. The tectonically mixed assemblage comprises polydeformed layered schists, serpentinized ultramafic rocks, leucogabbro, and exotic metasedimentary rocks. New geochronological evidence suggest that all these elements were metamorphosed, locally to eclogite facies, and deformed together in the Late Devonian -Early Mississippian. Field evidence and regional structural considerations suggest that the Klatsa metamorphic assemblage was juxtaposed with surrounding greenschist facies rocks by displacement on the regionally extensive Cleaver Lake thrust

The layered schists of the Klatsa metamorphic assemblage include quartz-muscovite schist with lenses of metabasite. Erdmer et al. (1998) suggest eclogite facies metamorphism and report evidence of Mississippian cooling of the unit. However, the timing and location of metamorphism and exhumation of the layered schists within the Paleozoic Yukon-Tanana arc, as well as their structural emplacement in the southern Campbell Range, was unclear.

Detailed SHRIMP geochronology on zircon and $^{40}Ar/^{39}Ar$ dating of muscovite provide constraints on protolith ages and timing of high-pressure metamorphism and exhumation. Zircons from the quartz-muscovite schist of the layered schists unit have inherited cores in zircon with Proterozoic to Ordovician ages ranging from 473 ± 13 Ma to 2825 ± 25 Ma. The quartz-muscovite schist and the metabasite of the layered schists yielded metamorphic zircon ages of 353.0 ± 3.7 Ma and 353.1 ± 2.4 Ma, respectively. Inclusions in metamorphic zircon indicate a high-pressure metamorphic facies petrogenesis. $^{40}Ar/^{39}Ar$ ages dating muscovite from the metabasite of the layered schists yields a preliminary age of 353.3 ± 0.79 Ma. Leucogabbro from the mafic-ultramafic member of the Klatsa metamorphic assemblage also yielded similar metamorphic recrystallization age of 351 ± 12 Ma, surrounding magmatic zircon with an age of 368.0 ± 9.9 Ma.

Geological mapping in the southern Campbell Range has established the structural setting of the layered schists and grouped the unit as part of the Klatsa metamorphic assemblage. The new geochronological data reveal a history of eclogite facies high-pressure metamorphism of the assemblage, followed by rapid exhumation in the Early Mississippian. We suggest arc to frontal-arc exhumation of the metamorphic assemblage followed by structural emplacement along the regionally recognized Cleaver Lake thrust fault (Murphy et al., 2005) during Early Permian shortening of YTT.

References:

Erdmer, P., Ghent, E.D., Archibald, D.A., Stout, M.Z. 1998. Paleozoic and Mesozoic high-pressure metamorphism at the margin of ancestral North America in central Yukon. Geological Society of America Bulletin **110**: 615-629.

Murphy, D.C., Mortensen, J. K., Piercey, S. J., Orchard, M.J., Gehrels, G.E. 2005 (accepted). Mid- to late Paleozoic tectonostratigraphic evolution of the northeasternmost part of Yukon-Tanana Terrane and adjacent parts of Slide Mountain Terrane, Finlayson Lake massive sulphide district, southeastern Yukon. *In:* Paleozoic tectonic and metallogenic evolution of pericratonic terranes at the ancient Pacific margin of North America, Canadian and Alaskan Cordillera, *Edited by* M. Colpron, J.L. Nelson and R.I. Thompson. Geological Association of Canada Special Paper, accepted, 2005.

From Push to Pull: Tectonomagmatic Evolution of the Buck Creek Complex (Central British Columbia)

J. Dostal[1], J.V. Owen[1] and B.N. Church[2]
1. Department of Geology, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada
2. 600 Parkridge St., Victoria, British Columbia V8Z 6N7, Canada

The Buck Creek volcanic complex of the Intermontane Superterrane of the Canadian Cordillera records a long history of volcanic activity from the Cretaceous through to the Eocene, when magmatic activity peaked, to the Miocene. Its basement includes primitive continental arc volcanic rocks of the Jurassic Hazelton Group (~200 Ma old; mainly basalt and andesites) emplaced prior to the accretion of Stikinia during the Mesozoic. In contrast, in the post-accretionary volcanic complex, the major pulse of volcanism started with the extrusion of continental margin calc-alkaline rocks (basaltic andesites to rhyolites) of the Cretaceous Tip Top Hill Formation (~85 Ma old). Their Nd-Sr isotopic compositions resemble those of the pre-accretionary Hazelton Group. However, this post-accretionary Cretaceous arc was more evolved and its crust significantly thicker than the Hazelton. Mafic rocks of both the Hazelton and Tip Top Hill suites were generated from a spinel-bearing mantle source.

The Eocene volcanics (~50 Ma old) evolved from typical high-K calc alkaline mafic/intermediate rocks that resemble intraplate tholeiitic basalts. Collectively, the Eocene rocks had a common (and comparatively deep) source, likely garnet-bearing subcontinental lithosphere. These compositional variations are probably related, in part, to an increase in the degree of partial melting. They record a gradual change from a compressional to an extensional tectonic environment, and overall represent an arc setting that matured and thickened over a *ca.* 35 Ma time frame, culminating in Eocene extension coincident with the cessation of compression in the foreland fold-and-thrust belt. Overlying intraplate alkali basaltic rocks of Miocene age appear to represent the final stage of this transition, as subduction-modified lithospheric mantle was replaced by a new asthenospheric mantle source. The association of Cretaceous, Eocene and Miocene volcanic rocks in the Buck Creek complex is widespread in the region, suggesting that this model of tectono-magmatic evolution can be applied elsewhere in central British Columbia.

Proterozoic strain in the core of the Frenchman Cap dome, Monashee complex; tectonic implications of a strong basement

Félix Gervais[1], Richard L. Brown[1], James L. Crowley[2]
[1]Department of Earth Sciences, Carleton University, Ottawa
[2]Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology

Numerous models have been proposed for the tectonic evolution of the Monashee complex in the southern Omineca Belt. These models are grouped into two broad categories according to the ductility of rocks in the core of the two gneiss domes of the complex, the Frenchman Cap (FCD) and Thor-Odin (TOD) domes. Models that require a highly ductile core include diapirism, channel flow and crustal extension (extensional metamorphic core complex). By contrast, other models necessitate a competent core, such as underthrusting, crustal-scale boudinage, cross folding and thrust-ramping. A downward strain gradient toward the core of the FCD was previously inferred from TIMS U-Pb dating of zircon, monazite, and titanite dating from several granitoid dykes. SHRIMP U-Pb zircon dating of migmatites from the TOD revealed a complex history of zircon growth ending with Eocene partial melting, which raised the question whether the TIMS dating in the FCD could have missed the discrete magmatic rims (i.e., the dykes are Eocene). The dykes in the FCD were thus recollected for in-situ LA-ICP-MS U-Pb dating to resolve this question.

This contribution compares the structural setting of tonalite dykes at two different structural levels in the basement of the FCD. The dykes (formerly termed the Bourne granite) are thought to be the same age throughout the FCD because they contain characteristic euhedral allanite. The first area is near Pettipiece Pass at the contact between basement and cover (metasedimentary) rocks, and the other at the toe of the Bourne Glacier located ~2 km structurally lower. The differences between the two localities are striking and include: 1) tonalite dykes emplaced immediately below the cover rocks were deformed by the same generation of folds as the cover rocks (N-verging, isoclinal F_2 overprinted by NE-verging, cascading F_3). By contrast, the deeper dykes are clearly discordant, intermingled with a coarse pegmatitic phase, and often present evidence that they were folded in the magmatic state (e.g. floating trains of euhedral feldspar/biotite/hornblende, delicate apophyses); 2) near Pettipiece Pass, the strain ellipsoid reconstructed from the orientation of tonalite dykes is oblate with a NE-SW direction of maximum stretch and a sub vertical direction of maximum shortening. Near Bourne Glacier the deformation is heterogeneous with evidence that the dykes were emplaced at the end of a NW-directed constrictional increment of strain; 3) a few tonalite dykes from both localities contain garnets and they have distinct XCa, XMg, XFe, XMn zoning profiles; 4) all the linear trends cluster in the SW quadrant in the Pettipiece Pass area, while they define a broad SE-NW girdle in the Bourne Glacier area; 5) the only place where tonalite dykes are clearly deformed at the deeper level is in a discrete (5m thick) top-to-the-east shear zone in a sillimanite schist. All these features demonstrate that the two structural levels experienced different deformation and metamorphic histories.

Thus, the structural analysis at the Bourne Glacier locality suggests that the tonalite dykes were emplaced at the end of an old tectonic event. The in-situ LA-ICP-MS dating of monazite and zircon shows that the dykes, the coarse pegmatitic phase intermingled with them, as well as another pegmatite dyke cross-cutting the other two were all emplaced at ~1850 Ma. Therefore, apart from discrete shear zones, the basement of the FCD in the studied locality remained strong during the Cordilleran orogeny and only the upper carapace was reworked. Since diapirism and crustal extension require involvement of a thick portion of the crust, and no major break is known between FCD and TOD, these models are not viable explanations for the tectonic evolution of the Monashee complex. Channel flow may have occurred in middle crustal rocks above FCD and may have included the upper level of TOD.

Paleocene-Eocene high-grade metamorphism, anatectic front and high strain in the Thor-Odin area, Monashee Complex: constraints for a tectonic model of the southern Canadian Cordillera

Alana M. Hinchey and Sharon D. Carr
Ottawa-Carleton Geoscience Center,
Department of Earth Sciences,
Carleton University, Ottawa, Ontario, K1S 5B6.

Thor-Odin dome of the Monashee Complex is located in the hinterland of the southern Canadian Rocky Mountain thrust belt. The dome comprises supracrustal and > 1.8 Ga North American basement rocks that experienced polydeformation, high-grade metamorphism and anatexis during the Mesozoic-Eocene Cordilleran orogen. Pervasive Paleocene - Eocene deformation transposed and overprinted Precambrian relationships and structures. The timing of onset of Cordilleran events in Thor-Odin is uncertain; however, deformation and prograde metamorphism were ongoing in the Late Cretaceous in the immediately overlying rocks and likely in Thor-Odin rocks as well. Peak P-T conditions of ~800°C and 8-10 kb constrain the depth of burial of the basement rocks to ~30 km. Ca. 56 Ma SHRIMP ages of syntectonic leucosome from basement gneiss indicate that anatexis occurred in the Paleocene. Melting may have localized strain and enhanced strain rates leading to transposition and the formation of large-scale folds. This is the youngest deformation and metamorphism in the hinterland, and was synchronous with the final stages of compression in the Foothills. Anatexis in Thor-Odin continued until ca. 52 Ma as the dome underwent isothermal decompression and exhumation during regional extension. Peraluminous leucogranites formed via partial melting of the basement gneiss, and localized extensional structures. Thor-Odin is the deepest exposed level of a panel of strained rocks that developed during progressive loading, thickening and heating of the crust. At structural levels above Thor-Odin, to the south, west and north of the dome, at Cariboo Alp, Joss Mountain and Three Valley Gap, respectively, the rocks preserve a record of deformation, high-grade metamorphism and anatexis that was older than 58 Ma, and 2. m.y. older than events in Thor-Odin. In the Paleocene, Thor-Odin was deeper and hotter than adjacent rocks of Frenchman Cap dome in the northern Monashee Complex indicating that there are two different structural panels within the complex that were juxtaposed late in the tectonic evolution.

The Northern Cordilleran mid-Cretaceous Plutonic Province: Redox and Tectonics

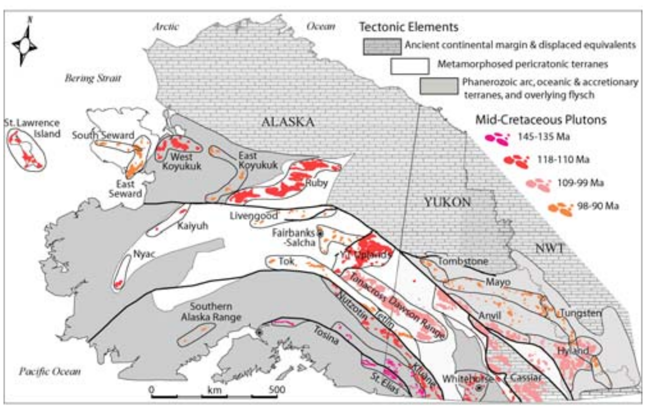
Craig J.R. Hart and John L. Mair
Yukon Geological Survey, Whitehorse, Yukon, Y1A 2C6,
and Centre for Global Metallogeny, University of Western Australia, Perth, WA

The northern North American Cordillera of Alaska and Yukon is well-endowed with approximately one thousand batholiths, plutons, stocks and dykes that were episodically emplaced into the growing continental margin during the Early and mid-Cretaceous (145-90 Ma) and span pre, syn and post accretionary times. The plutons span a breadth of 700 km from near Pacific tidewater to inboard elements of the continental margin. The plutons are divisible into 25 plutonic suites and belts that are 50 to 200 km wide, mostly parallel the region's structural fabric, and are characterized by lithological, geochemical, isotopic and age similarities. As well, aeromagnetic characteristics, magnetic susceptibility, and whole-rock ferric:ferrous ratios are used to ascertain the redox character to define magnetite- and ilmenite-series plutonic belts. Distribution of the plutonic suites with respect to their timing and redox character allows the reconstruction of the geological and tectonic events that led to their formation.

Widespread pre-115 Ma plutonism of magnetite-series plutons was subsequently followed by widespread ilmenite-series plutons, and terminated with a final minor episode of magnetite-series plutons. The oldest magnetite-series components (145-125 Ma) may have been pre-accretionary and coeval with Late Jurassic oceanic arc-building events prior to their accretion to form part of the Insular terranes on the outermost parts of the orogen. Subsequent magmatism (118-99 Ma) was also magnetite-series, with metaluminous, arc-type, calc-alkaline plutonism occurring further inboard, through the eastern Insular terranes to Stikinia in the Intermontane belt, and to the far northwest through the West Koyukuk belt and across St. Lawrence Island. Ilmenite-series granitoids were first emplaced at about 113 Ma, likely in response to crustal thickening in response to terrane accretion. These granitoids include the intrusion of the large Ruby-Kayuh-Nyac system, and then the belts of peraluminous granitoids that characterize the Yukon-Tanana Uplands. The later-stage suites (109-96 Ma; Cassiar, Hyland) are slightly more oxidized than those in the other ilmenite-series belts and are classed here as weakly magnetite-series. These were followed by the emplacement of reduced, ilmenite-series suites (98 to 92 Ma; Tungsten, Mayo, Fairbanks, Salcha). The last plutonic event is defined by the 92-90 Ma alkalic, variably magnetite-series Livengood and Tombstone suites that were intruded in the most-inboard tectonic position.

There is an overall inland younging trend in the ages of the plutonic belts regardless of their oxidation state. But magnetite-series plutonic belts were active 5-10 million years prior to the initiation of significant ilmenite series plutonism at ca. 109 Ma. Otherwise, magnetite and ilmenite series plutonism was contemporaneous during the period from 109 to about 95 Ma. However, ilmenite-series plutonism begins to dominate late in this episode (97-92 Ma), and to have been followed by the small, late, alkalic magnetite-series event.

Major problems still exist. There is a dearth of U-Pb ages for Alaskan granitoids and a lack of accuracy in existing K-Ar and Rb-Sr dates. Similarly granites in southwest Yukon have been ignored since that region and are almost completely devoid of data. The batholiths and plutons of southeast Yukon still remain enigmatic and suite-defining characteristics remain vague. Cassiar suite in south-central Yukon represents at least three different suites but suffers from lack of study, as do those in the Finlayson area.



Preliminary field, petrological, and geochemical characterization of the Princeton Group, an Eocene volcanic field in Southern B.C.

Ickert, R., and Thorkelson, D.J.
Department of Earth Sciences, Simon Fraser University

We present the preliminary results of an investigation into volcanic rocks of the Princeton Group (PG). The PG is a package of volcanic and terrestrial epiclastic rocks exposed in southern British Columbia from about 49°N to 50°20'N and 120°W to 121°10'W in the vicinity of Princeton and Merritt. Existing K-Ar ages indicate that most of the volcanism occurred in the early Eocene at ca. 49 Ma, although some eruptions may have begun as early as 52 Ma. The group is broadly coeval with a number of other volcanic fields in BC and the northern US and forms part of the Challis-Kamloops Volcanic Belt that stretches from central BC southward into Oregon and Wyoming.

The PG consists of thick dacite domes and/or cryptodomes, flows, pyroclastic fall deposits, and subvolcanic sills and dikes. Epiclastic rocks, including sandstones, conglomerates and coal are concentrated in fault bounded basins. Major deformation is limited to brittle faulting along major strike-slip and normal faults, although evidence of minor local tectonic activity, such as small-scale faulting, occurs throughout. Porphyritic dacite clasts and hornblende phenocrysts interpreted to be sourced form lavas in the PG appear in some tilted sandstones and conglomerates, consistent with previous interpretations that volcanic activity was at least partially syn-tectonic.

Lavas of the PG are predominantly andesites to dacites, although rare basaltic-andesites and rhyolites also occur. Phenocryst-rich (30-50 vol. %) plagioclase-hornblende dacites and andesites are common. Plagioclase phenocrysts in these porphyritic rocks are commonly zoned, have older cores, and are rounded, thereby preserving evidence for a protracted crustal history for the associated magmas. Other, more mafic andesites and basaltic-andesites are typically macroscopically aphyric but have a holocrystalline groundmass of plagioclase and one or two pyroxenes. Magnetite is ubiquitous.

Geochemical investigation indicates that volcanic activity was subalkalic and calc-alkaline. High large ion lithophile element/high field strength element ratios among the least evolved samples (e.g. Ba/Nb> 100) suggest a subduction-modified mantle source region for PG volcanic activity. There are many similarities to high-Mg# andesites described in the Japanese Setouchi volcanic belt, the Aleutian arc, and in the Cascade arc including a high Mg# (molar Mg/Mg+Fe^{2+}; >60) and fractionated heavy rare earth elements (HREE; Gd_n/Yb_n>2). These characteristics are consistent with previous interpretations that part of the Challis-Kamloops belt was generated by subduction, although fractionated HREE in primitive samples may indicate that magma genesis occurred above young subducted crust.

Prolonged deformation within a long-lived magmatic arc at the boundary between the Insular and Intermontane superterranes, west-central British Columbia

Steve Israel
Yukon Geological Survey, Whitehorse, Yukon

The Atnarko metamorphic complex (AMC) records at least 200 my of magmatic and structural activity within mid-to-upper crustal levels of the Coast Belt located at the boundary between the Insular and Intermontane superterranes. The AMC consists of upper greenschist to amphibolite grade gneisses, migmatites, metavolcanic and metasedimentary rocks intruded by variably aged and deformed plutonic rocks. To the west the AMC is juxtaposed next to relatively unmetamorphosed Early Cretaceous volcanic and sedimentary rocks of the Monarch assemblage and appears to be thrust over undeformed granitic rocks to the north. The southern AMC is cored by ~4 km of migmatitic gneisses that are flanked on each side by interlayered metavolcanic and metasedimentary rocks. Gneisses range in age from ~180 Ma in the south and central portions of the complex to 130 Ma and 114 Ma in the north. Age of the metavolcanic and metasedimentary rocks is unknown, however in the south are intruded by a ~180 Ma quartz diorite.

Intrusions are intimately linked to several structural and metamorphic events with syn-to-late kinematic tectonic bodies dated at 180 Ma, ~158 Ma, 148 Ma, 130 Ma, 114 Ma and 103 Ma. The structural character of the complex changes dramatically from south to north. Southwest directed contraction in the south is evident from southwest verging folds and northeast dipping shear zones with down dip mineral lineations. Contraction resulted in tight to isoclinal, refolded folds with northwest and southeast trending axes. Structural features noted in the field suggest that contraction was accompanied by dextral shearing. 157 Ma syn-tectonic quartz diorite and 158 Ma metamorphic zircons from metarhyolite likely record the onset of this event which appears to have been active to at least ~140 Ma. The northern portion of the AMC is dominated by northeast trending structural fabrics that are developed in ~130 to 114 Ma granodiorites that intrude gneisses, metavolcanic and metasedimentary rocks. These fabrics have been interpreted to be the result of mid-Cretaceous (?) north-northwest directed thrusting. Biotite cooling ages suggest uplift of the northern portion of the AMC occurred during the mid-Cretaceous followed by slightly younger hornblende and biotite ages from the south. Northeast trending folds overprint structures in the south and are believed to reflect this north directed contraction. Syn-tectonic intrusions in the south that exhibit both northeast trending structures and north verging folds suggest that contraction continued until ~80 Ma. All contractional features found in the north and south are overprinted by steeply dipping, northwest striking mylonite zones. Kinematics from several mylonites indicate both sinistral and dextral movement occurred. Age of the mylonites are not well constrained but a 73 Ma biotite age from near one of the larger zones may record time of deformation. All structures are intruded by post-kinematic Early Tertiary plutons.

The regional tectonic framework of the AMC is uncertain. The AMC in part resembles the Gamsby complex, a Late Jurassic metamorphic complex located 150 km northwest. However, differences in structural character and ages of deformation preclude definitive correlation. Late Proterozoic inheritance from AMC metavolcanic rocks may suggest a relationship with continental margin rocks of the Burke Channel assemblage found to the southwest of the AMC. The lack of Eocene cooling ages and no evidence for normal displacement does not allow for comparison with other extensional core complexes found along the Intermontane superterrane/Coast Belt boundary.

Brittle faulting in the Thor–Odin culmination, Monashee complex, southern Canadian Cordillera: constraints on geometry and kinematics.

Stefan Kruse and Paul F. Williams
University of New Brunswick

Eocene brittle faults and fractures within the Thor–Odin culmination of the Monashee complex of the southern Canadian Cordillera are divisible into three distinct sets. Initial N–S trending strike-slip faults were overprinted and reactivated by normal faults with a NNW–SSE trend. A third set of E–W trending faults with uncertain kinematics overprints the earlier fault sets. Regional faults weather recessively forming long topographic lineaments which transect the Monashee complex. The Victor Creek fault defines one such lineament. Detailed mapping within the northern Thor–Odin culmination, reveals a piercement point (fold hinge) on the east side of the fault which does not outcrop on the west side. The minimum displacement required on the Victor Creek Fault to down-drop the fold hinge below the level of exposure on the west side is 1350 m, assuming normal down-to-the west displacement. Displacement could be much greater than this conservative estimate, if the fault is strike-slip.

The southern termination of the Western Ranges and Main Ranges of the Southern Canadian Rocky Mountains: Tectonic implications of new stratigraphic, structural, and geochronologic data

K.P. Larson, R.A. Price and D.A. Archibald
Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, Ontario

The Wild Horse River map-area includes the southern termination of the Western Ranges subprovince of the Southern Canadian Rocky Mountains, which occurs at the Crowsnest Pass cross-strike discontinuity, a northeast-southwest trending tectonic feature marked by profound changes in stratigraphy and geologic structure. Cambrian and Ordovician strata in the Wild Horse River map-area record a southeastward basin-margin transition from the Cordilleran miogeocline to Montania, an adjacent cratonic platform. These strata are imbricated by the east-verging Ruault Lake thrust, which, along with the strata that it cuts, has been synformally back-folded in the west limb of the Porcupine Creek fan structure. The stark contrasts between the thin, attenuated lower Paleozoic succession of the Western Ranges and the thick miogeoclinal succession of the Western Main Ranges suggests that the Lussier River fault, which separates the two subprovinces, involves significant horizontal displacement.

Upper Cambrian and Ordovician strata within the Wild Horse River map-area contain local intercalations of diatreme-related volcanic rocks, the emplacement of which may have been controlled by the same crustal-scale structures that defined the the north-south trending margin of this part of the Cordilleran miogeocline.

The Boulder Creek fault, one of a series of transverse faults that coincides with the Crowsnest Pass Cross-Strike Discontinuity, records a complex history of reactivation: Cenozoic sinistral normal displacement has been superimposed upon Mesozoic dextral reverse displacement that involved reactivation and inversion of a Neoproterozoic basin-margin normal fault that is aligned with a Paleoproterozoic crustal suture.

Middle Cretaceous plutonic rocks that crop out in the Wild Horse River map-area are the only such rocks known east of the Southern Rocky Mountain trench. They have been dated using $^{40}Ar/^{39}Ar$ thermochronology on muscovite which has yielded robust cooling ages of ~108 Ma. These plutonic bodies, which predominantly comprise k-feldspar porphyritic monzonites, crosscut and thermally overprint all thrust and fold-related deformation in both the Western Ranges and Western Main Ranges, thereby constraining the formation of these structure to pre-108 Ma.

Detrital zircon geochronology and provenance of late Proterozoic and mid-Paleozoic successions outboard of the miogeocline, southeastern Canadian Cordillera

Yvon Lemieux[1], Robert I. Thompson[2] and Philippe Erdmer[1]
1-Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, T6G 2E7
2-Geological Survey of Canada, Pacific Geoscience Center, P.O. Box 6000, Sidney, British Columbia, V8L 4B2

The Kootenay Arc is a north-trending arcuate structural zone of metamorphosed and polydeformed rocks in southeastern British Columbia and northeastern Washington. It has been interpreted to be the locus of the transition between autochthonous continental margin strata to the east, and outboard and accreted Paleozoic to Mesozoic units of uncertain paleogeographic origin to the west. A U-Pb study of detrital zircons using laser ablation-inductively coupled plasma mass spectrometry (LA-ICP-MS) was undertaken in the upper succession of the Monashee Complex mantling gneiss as well as in mid-Paleozoic strata of the Chase Formation exposed in the northern Kootenay Arc areas and adjacent outboard strata. Our study shows that the analyzed units are dominated by >1.75 Ga zircons. Grenvillian-age (1.0-1.3 Ga) zircons also occur in both successions. Mid-Paleozoic, Eocambrian, 800-1300 Ma, and 1400-1750 Ma zircon populations also characterize the Chase Formation. We interpret the mid-Paleozoic and Eocambrian grains to have been shed from nearby magmatic sources. We speculate that local plutonic activities as well as orogenic events along the western Canadian Cordilleran margin might have provided the 0.8-1.3 Ga zircons. Moreover, we interpret the 1.4-1.75 Ga zircons to have been derived from recycled Mesoproterozoic Belt-Purcell Supergroup strata in southern British Columbia and northwestern United States. Thus, our study shows that the investigated Proterozoic and Paleozoic successions demonstrate sedimentologic and depositional relationships with respect to ancestral North America, and as such, are interpreted to represent outboard extensions of the Cordilleran miogeoclinal succession.

Clasts from the past, Latest Jurassic-Earliest Cretaceous foreland basin conglomerates, northeast British Columbia and northwest Alberta

Margot McMechan[1], Bob Anderson[2], Robert A. Creaser[3] and Fil Ferri[4]

[1] Geological Survey of Canada- Calgary, 3303 33rd St. NW, Calgary T2L 2A7

[2]Geological Survey of Canada- Pacific, 101-605 Robson St., Vancouver V6B 5J3;

[3] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, T6G 2E3

[4]BC Ministry of Energy and Mines, PO Box 9323, Stn. Prov. Govt., Victoria, B.C., V8W 9N3

Conglomerates containing volcanic, igneous or intensely deformed metamorphic clasts are extremely rare within the Upper Jurassic to Paleocene Alberta foreland basin. The latest Jurassic to earliest Cretaceous Monteith conglomerates, exposed in the Rocky Mountain Foothills between 53°55' and 54°35'N, are the oldest of four known occurrences. Monteith conglomerates occur in lenses up to 30 m thick, typically with erosional bases, asymmetric channel fill profiles and large epsilon crossbeds. They are interpreted as delta front distributary channel, channel mouth bar, and fluvial channel deposits in a northwesterly trending delta along the west side of the foreland basin.

Monteith conglomerates contain up to 12% volcanic clasts, 1-2% milky quartz, < 1% metamorphic clasts including foliated, quartzite with minor biotite and muscovite; feldspar metasandstone; muscovite, biotite, quartz schist; graphitic, quartz mylonite and argillite. Chert is the dominant clast type and increases in abundance northward (65 to 90%) as the amount of non-quartzite sedimentary clasts (siltstone, quartz sandstone, dolostone and limestone) decreases to near zero.

Thirteen volcanic clasts that included (augite-) (quartz) plagioclase-porphyry, siliceous volcaniclastic, and felsic aphanitic rocks were analysed. Their geochemical compositions reveal a mixture of affinities. The rhyolite and dacite compositions are subalkaline dominantly calc-alkaline, low potash, and peraluminous with some affinities equivalent to typical volcanic arc granite. But multi-element diagrams indicate large-ion lithophile, U, and Zr enrichments compared to MORB, and mixed Sr and Ti but an absence of Nb depletions typical of arc-related rocks.

Rare earth element (REE) patterns are flat with low overall REE abundances and a pronounced Eu* anomaly. Rb/Sr and Sm/Nd isotopes from 8 of these clasts all show continental, isotopically evolved character assuming a ~ Jurassic emplacement age for the primary igneous units, with initial Sr ratios showing a range from 0.708 – 0.725, and initial εNd values ranging from –0.3 to - 11.8. These data are also permissive of a considerably older emplacement age for the primary igneous units, possibly as old as Paleozoic.

The geochemical characteristics for the volcanic clasts are unique compared to published compositions for Paleozoic or Middle Jurassic volcanic or plutonic source areas east of the $Sr_i \geq 0.706$ line, as required by their isotopically evolved Sr and Nd character. Devonian-Mississippian rhyolitic rocks from the southern Omineca Mountains (F.Ferri, 1994 and unpub.) are the most closely similar in major and some trace element compositions.

Intensely deformed metasedimentary clasts were derived from Late Jurassic uplift of the Omineca Belt. Only a few areas were uplifted enough to expose biotite bearing rocks, and the clasts most likely came from what is now the Swannell Ranges, Hobson Lake area or possibly the western Selkirk Mountains or Southern Kootenay Arc.

The Frigg dykes of the southern Thor–Odin culmination of the Monashee complex, southern, British Columbia and evidence for diachronous tectonism

Paul McNeill and Paul F. Williams

The University of New Brunswick

Fredericton, NB, E3B 5A3

The Frigg dykes outcrop in superbly exposed areas near Mt. Odin. They are typically dark green, negatively weathered and south-easterly striking for distances up to 400m, though they tend to be less than three meters wide. Their dip varies but they are generally steep to moderate. The dykes are predominately composed of biotite and hornblende with lesser amounts of titanite, plagioclase, quartz, chlorite and clinopyroxene is present as porphyroclasts.

Macroscopically, the dykes clearly cross cut the transposition foliation predominate in the area but are folded into open, north-easterly verging folds, interpreted as D3 structures. Likewise, the dykes cross-cut granitic aplite and pegmatite dykes interpreted as migmatitic neosome. There are outcrops, however, where leucosome does cross-cut the Frigg dykes suggesting that the dykes do not postdate all migmatization. These relationships between the Frigg dykes and fabrics within the Thor–Odin culmination are truly unique to the area.

Microstrucurally, the dykes contain a well developed cleavage that is defined by biotite, hornblende and titanite. This cleavage is folded by open folds that kink the foliation in an orientation that is consistent with F3 folds found nearby and is overprinted by hornblende porphyroblasts. Quartz-hornblende symplectite coronas occur about clinopyroxene porphyroclsts.

Using mesoscopic and microscopic observations with geochemical data, a tentative correlation is drawn between the Frigg dykes and the suite of lamprophyre dykes common throughout the southern Omineca belt and the Monashee Complex. Neighbouring late-stage mafic dykes yield Eocene emplacement ages.

An Eocene age for the Frigg dykes, when considered with the geological relationships observed, requires that the timing of metamorphism and post-transposition-deformation is approximately Eocene and that the transposition foliation, and associated fabrics, is older. This is not the case for late-stage mafic dykes at higher structural levels, where dykes postdate most, if not all, deformation and metamorphism. This suggests that tectonism is diachronous between high and low structural levels within the Thor–Odin culmination – fabrics at deep structural levels are younger than fabrics at higher structural levels. The independent evidence presented here appear to support previously proposed models of downward younging tectonism in the southern Cordillera.

Petrography and geochemistry of the Quartet Mountain lamprophyres

Dejan Milidragovic, Derek J. Thorkelson, Daniel D. Marshall
Simon Fraser University

The late Neoproterozoic-early Cambrian Quartet Mountain lamprophyres are mafic, alkaline dykes that intrude the Wernecke and Mackenzie Mountains supergroups in the Wernecke Mountains of northern Yukon. The dykes are dark grey, aphanitic, phlogopite +/- diopside +/- olivine, ultramafic lamprophyres characterized by high volatile contents (4.7-24.8 wt.%), pervasive chlorite and clay replacement of the groundmass and complete replacement of olivine phenocrysts and xenocrysts by opaques, chlorite, and carbonate. The lamprophyres are silica undersaturated, enriched in alkali and alkaline earth elements, with strongly fractionated rare earth elements and high magnesium numbers (63-86). Trace element geochemistry is consistent with small degrees of partial melting of an underlying, enriched mantle source, traces of which were locally preserved as xenoliths. The late Neoproterozoic-early Paleozoic continental extension that took place along the northwestern margin of Laurentia likely led to the emplacement of the lamprophyres.

One of the lamprophyres contains abundant pseudomorphed olivine xenocrysts and xenoliths of inferred crustal and mantle affinities. Three general types of crustal xenoliths were identified: finely banded, garnet-sillimanite-quartz gneiss with trace amounts of zircon, garnet-quartz gneiss, and finely laminated feldspar-carbonate gneiss. The mantle xenoliths are largely serpentinized, rich in opaque minerals and contain relict orthopyroxene and trace amounts of clinopyroxene. The identification of crustal xenoliths represents the first opportunity to characterize the age and nature of the crystalline basement beneath Yukon. The zircons were identified using scanning electron miscroscopy, and show a complex pattern of zonation, which appears to reflect a protracted history of growth, dissolution and re-growth under igneous and possibly metamorphic conditions.

The Simpson Lake Assemblage – Remnants of a Permian Forearc Basin in Southeastern Yukon

Jim Mortensen[1] and Philippe Erdmer[2]
1- Earth & Ocean Sciences, UBC
2- Earth & Atmospheric Sciences, U of Alberta

An unusual assemblage of sedimentary rock units seen in scattered exposures in a north-south trending belt at least 125 km long from Watson Lake on the south to Simpson Lake on the north represents remnants of a Permian forearc basin. The main components of the assemblage are thin-bedded siltstone, sandstone and minor argillaceous limestone with interbeds of pebble to boulder conglomerate. The conglomerates include clasts of:

- massive greenstone with arc tholeiite compositions
- andesitic to dacitic porphyry with calc-alkaline arc compositions and mid-Permian crystallization ages
- blueschist and eclogite with MORB chemistry and mid-Permian to Early Triassic cooling ages
- ophiolitic detritus, including locally abundant serpentenite

A felsic volcanic unit that appears to be a flow rock is interlayered with the sediments in one locality and yields a calc-alkaline arc rhyolite composition and a Late Permian U-Pb zircon age. Small volumes of interlayered basalt and basaltic breccia with arc tholeiite chemistry also occur within the sediments in several localities along the belt. Conodonts recovered from a gritty limestone near the northern end of the belt yield mid-Permian ages. The data indicate that the assemblage accumulated within a mid-Permian depocentre immediately adjacent to an active arc. The basin received coarse, mafic to felsic detritus from the coeval arc, as well as material eroded from exposed portions of a Permian subduction complex. Collectively these observations can only be accommodated within a forearc basin setting. The package is cut by small intrusions of Early Jurassic age. It appears to be in fault contact with strata of the Selwyn Basin immediately to the east and Slide Mountain and Yukon-Tanana rocks to the west. Similar rock units, although with less abundant high P/low T metamorphic assemblages have been mapped farther to the north in the Frances Lake area.

Diachronous(?) emplacement of leucocratic dykes at the Thor-Odin dome, Monashee Complex

Andrew C. Parmenter and Paul F. Williams
Dept. of Geology
University of New Brunswick

Leucocratic dykes intrude the west-dipping western flank of the Thor-Odin dome in the vicinity of Cranberry Mountain. The dykes vary in character from fine-grained and generally aplitic, to coarse-grained (pegmatitic) and biotite- or chlorite-rich. Tourmaline is a local accessory in all phases. The dykes cross-cut all lithostratigraphic units, including basement and cover gneisses, except a younger suite of lamprophyre dykes. Similar leucocratic intrusions, well documented in other areas throughout the southern Omineca belt, are interpreted as being related to the intrusive Ladybird leucogranite suite, which was emplaced syn-kinematically into the middle crust in the footwall of a low-angle extensional fault zone during Eocene crustal extension. The timing of emplacement of the Ladybird suite and its relationship to the tectonic history of the region, however, is ambiguous and controversial.

The dykes at Cranberry Mountain can be separated into two main groups, based predominantly on their geometric relationship with the regional transposition foliation (S_T). The oldest dykes are open to isoclinally folded and generally preserved either sub-parallel to, or at an acute angle to, S_T. In some cases the dykes are boudinaged and strongly attenuated, while in others isoclinally folded dykes are tight to isoclinally refolded. They are dominantly pegmatitic, and locally may also exhibit a well-developed leucosome core and melanosome rim indicative of in situ partial melting. The latest of these dykes are shallowly dipping and inclined to S_T at ~45°. They show a progression from this orientation to parallel to S_T, rotating and folding and then boudinaging in the process. These observations, and the overall geometry of the dykes, suggest an intrusive history related to non-coaxial, top-to-the-northeast, deformation. This kinematic story is consistent with the D1-D3 interval of deformation observed regionally throughout the dome and its periphery.

The oldest dykes are transected by a swarm of moderately to shallowly, east-northeast-dipping, tabular, intrusions. These dykes are distinguished by the fact that they appear to post-date the bulk of the observed ductile deformation, that they are consistently preserved at a sub-perpendicular orientation to $S_{T,}$ and are generally aplitic. The dykes are offset by west-vergent, S_T-parallel slip, and by ductile west-side-down shear bands that cut obliquely across St. They are also offset by approximately north-trending, sub-vertical, brittle faults. A possible interpretation, consistent with field observations and previous interpretations, is that these dykes post-date the aforementioned non-coaxial shearing event and indicate the onset of coaxial crustal extension.

A statistical analysis of the distribution of the angle between S_T and dyke orientation, for the entire data set, yields two maxima. One peak occurs at an angular difference of less than 15° and another at greater than 75°. These results are consistent with the field observations, as described above, that indicate the possibility of two separate dyke populations. The former intruding during non-coaxial top-to-the northeast deformation and the latter during coaxial crustal extension. It is evident, therefore, that the boundary conditions for dyke emplacement were different for the two populations, however, it is unclear whether or not this change involved any significant hiatus in the deformation.

Paleozoic magmatism and crustal recycling along the ancient Pacific margin of North America, northern Cordillera

Stephen J. Piercey[1], JoAnne L. Nelson[2], Maurice Colpron[3]
1 - Department of Earth Sciences, Laurentian University,
2- British Columbia Geological Survey
3- Yukon Geological Survey

The Yukon-Tanana (YTT) and related terranes (Slide Mountain and Stikine) in the northern Cordillera record episodic magmatic activity along the ancient Pacific margin of North America in the Paleozoic. Devonian to Permian igneous rocks in the YTT record six cycles of arc, arc-rift, continental rift and back-arc basin magmatism, each cycle separated from the others by changes in the locus and/or character of igneous activity, as well as deformational episodes and unconformities. The first four cycles, from Middle Devonian to Late Mississippian, record largely bimodal arc magmatism above a west-facing (east-dipping) subduction zone in the western part of the terrane, with corresponding mid- to Late Devonian rifting of the continental margin and subsequent Early Mississippian back-arc basin magmatism to the east. The fifth cycle, of Pennsylvanian to Early Permian age, involved more primitive, mafic to intermediate volcanism in a west-facing arc with a corresponding marginal back-arc basin to the east (the Slide Mountain ocean). The final cycle reflects subduction reversal in mid- to Late Permian, to an east-facing (west-dipping) subduction zone consuming Slide Mountain lithosphere, and associated continental-arc magmatism to the west.

Mafic rocks in all cycles were derived from variably enriched sources, with contributions from depleted mantle wedge or back-arc asthenosphere, and enriched lithospheric mantle, with or without a subducted slab component. Felsic rocks in arc, arc-rift and back-arc geodynamic settings were derived predominantly from melting and recycling of upper continental crust ($La/Sm_{UCN} \approx 1$). Arc felsic rocks have calc-alkalic and tholeiitic signatures, whereas non-arc rocks are enriched in high field strength elements and rare-earth elements (A-type or peralkaline signatures). Notably, throughout the ~150 m.y. of mid- to late Paleozoic magmatism in the YTT, there are no systematic temporal variations in the composition of most mafic and felsic rocks. Igneous source regions and magmatic processes remained essentially unchanged throughout the Paleozoic. The magmatic evolution of the YTT is dominated over much of its history by recycling of upper crustal material with lesser juvenile contributions. The addition of juvenile material ($\varepsilon Nd_t > 0$) to the YTT crust is limited to two distinct episodes: one near the Devonian-Mississippian boundary (~360 Ma) and one in the Permian (~275 Ma), both of which closely follow the initiation of, or renewed spreading within, a back-arc basin environment.

An important geochemical trait of many mafic rocks in YTT intra-arc rifts and back-arc basins is their high Nb/Th_{mn} and $Nb/La_{mn} > 1$ (mn = primitive mantle normalized), implying excess Nb relative to Th and La compared to primitive mantle ratios. Excess Nb in these rocks suggests a recycled oceanic crust component in their genesis and is a common feature of plume-derived magmas and magmatic rocks from large igneous provinces (LIP). The recurrence of this recycled oceanic crust component over the entire magmatic history of the YTT, and its low volume of eruptions, argues against a direct plume or LIP origin. We suggest that this signature reflects recycling of a LIP component in the YTT lithospheric mantle that was acquired during lithospheric fertilization by LIP magmatism associated with the Neoproterozoic breakup of the supercontinent Rodinia.

Intra-arc rift basin development within a Mississippian continental arc system; example from the Little Salmon Formation, northern Canadian Cordillera, Yukon

Simard[1], R.-L., Dostal[2], J., and Colpron[3], M.

1- Dalhousie University
2- St. Mary's University
3- Yukon Geological Survey

In the northern Canadian Cordillera, the belt of pericratonic terranes is poorly known, although information on its geological evolution is essential for a Late Paleozoic paleogeographic reconstruction of the pre-accretion history of this part of the Cordillera. The pericratonic terranes, composed of several Devonian-Carboniferous arcs and basins mostly built atop continentally-derived metasedimentary sequences, were accreted to the Laurentian craton in Early Mesozoic time.

The remains of one of these arc systems, the Little Salmon arc, are well exposed in the Yukon-Tanana pericratonic terrane of central Yukon. The lower part of the magmatic sequence is formed by Mississippian quartz-feldspar phyric felsic rocks that host a massive sulfide occurrence. These calc-alkaline rocks which have elevated concentrations of incompatible trace elements such as Th, La and Zr accompanied by strong negative Nb and Ti anomalies on the mantle-normalized trace-element patterns, probably represent high-level intrusions, formed by crustal melting.

Conformably overlying these felsic rocks is a thick pile of alkali basalts with a strong LREE enrichment ($[La/Yb]_N \cong 13.7$) and highly positive ε_{Nd} values (+7.3), typical of an asthenospheric source. The volcanic facies of the alkali basalts show an important change along strike; the northern portion is dominated by proximal volcanic lithofacies such as massive and pillowed lava flows associated with abundant polymictic volcanic breccia and coarse crystal-tuff, as well as an exhalative Mn-chert horizon, whereas the southern portion is composed solely of distal volcanic lithofacies such as abundant clastic deposits with some fine grained alkali-basalt volcaniclastic deposits. This abrupt facies change is aligned with a fault affecting all the underlying units, which suggests the presence of a fault scarp.

The northern portion of the alkali basalt sequence records seamount formation atop an extensional synvolcanic fault associated with the development of rift basin(s) during the rifting Little Salmon arc system, whereas the southern portion represents sediments deposited onto the rift-floor sediment plains of one of these basins. Hydrothermal deposits found within the seamount stratigraphy are unequivocal signs of an active hydrothermal system within that basin.

The rifting of the Little Salmon arc system resembles that of the modern Izu-Bonin-Mariana arc and/or the proto-Japan island arc extension and thinning. The resulting rift basins are well-known environments in which important hydrothermal circulation has been observed, and well-accepted analogues to where most major Phanerozoic VMS deposits formed. This study demonstrates that these pericratonic sequences in the northern Canadian Cordillera have a potential for hosting world-class VMS deposits.

3-D Mapping of a Paleocene Crustal-Scale Thrust Ramp in the Southern Omineca Belt; Some Tectonic Implications

Simony, P. S.[1] and Carr, S. D.[2]

1- University of Calgary, Calgary, AB, T2N 1N4
2- Ottawa Carleton Geoscience Centre, Carleton University,
Ottawa, ON, K1S 5B6

A crustal-scale thrust ramp beneath the ductile Gwillim Creek shear zone was delineated by mapping the shear zone and its hanging wall strain gradient in the region of Valhalla complex, southeast British Columbia. The Gwillim Creek shear zone is a Late Cretaceous to Paleocene top-to-the-east shear zone that forms the base of a 30 km thick thrust sheet composed of Middle Jurassic, Early Cretaceous, mid-Cretaceous and Paleocene granitoid sheets emplaced into Paleozoic to Jurassic pericratonic and arc strata. It is exposed in the cores of three culminations, Valhalla, Passmore and China Creek, within the antiformal

Valhalla complex, and has also been located indirectly by exposures of its hanging wall strain zone in erosional "windows" at the base of plutons in deep valleys in Valhalla complex (e.g. Pass Creek and Bear Creek). The trace of the Gwillim Creek shear zone may outcrop on the southern and western flanks of Thor-Odin complex on the basis of field mapping and Lithoprobe seismic reflection data from the region between Thor-Odin and northern Valhalla complexes.

The Gwillim Creek shear zone rises eastward as well as southward relative to geological markers in its hanging wall and thus outlines the hanging wall portion of combined frontal and lateral ramps. The corresponding footwall ramp lies at depth to the west of Valhalla complex, but ductile shear may well have obliterated it. In northern Valhalla complex, in Valhalla and Passmore culminations, the Gwillim Creek shear zone lies beneath strata of pericratonic affinity metamorphosed to migmatitic sillimanite - K-feldspar zone, whereas, to the south in China Creek culmination the Gwillim Creek shear zone rose to lie near the base of overthrust Quesnel terrane rocks metamorphosed to sillimanite - muscovite zone with only minor leucosome in the shear zone. Petrology and U-Th-Pb monazite geochronology suggest that rocks that were metamorphosed between 75 and 65 Ma at the base of the ramp, moved up the ramp rapidly at about 60 Ma and were quenched by refrigeration from below. Pegmatite within the Gwillim Creek shear zone from near the top of the ramp in China Creek yields a U-Pb zircon age of ca. 90 Ma while monazites yield ages in the 87-77 Ma range. These data suggest that the Gwillim Creek shear zone may have been active from ca. 90 Ma to 60 Ma but that the ramp developed late in the tectonic history. A portion of the old, pre-ramp trajectory of the Gwillim Creek shear zone is to be expected in the hanging wall, mostly obliterated by recrystallisation and by post -65 Ma plutons, which form extensive sheets in northern Valhalla complex. Mapping and petrology suggest a ramp ~12 km high with a 10^o to 15^o degree ramp angle, and a width across strike of 40 - 50 km. It was perhaps localized by a lateral thermal gradient with cooler, stiffer rocks to the east. Movement up the ramp would have added 12 km locally to the orogenic wedge near the ramp. The 58-54 Ma extensional top-down-to-the-east Valkyr shear zone coincides with Valhalla complex and approximately with the zone of over thickened orogenic wedge. It may have formed, along with related faults, in response to the instability of the over thickened wedge and overlapped in time with thrusting at depth. This situation could have led to crustal thickening and heating followed by decompression and crustal melting to generate the 58-54 Ma Ladybird leucogranite.

Volcanology of the Quaternary valley basalts of southern British Columbia

Sluggett, C.L. and Thorkelson, D.J.
Department of Earth Sciences, Simon Fraser University

Gently dipping mafic flows are preserved as narrow terraces on valley walls in the southern interior of British Columbia. These "valley basalts" include the Lambly Creek Basalt in the Westbank region, and the Quilchena lavas in the Merritt area. In both regions, K-Ar whole rock ages indicate a Quaternary age of ca. 0.5 to 0.76 Ma. These lavas are lithologically similar to the Chilcotin Group plateau basalts of Pliocene and Miocene age, which cover much of the southwestern interior. The "valley basalts" and the Chilcotin Group were erupted in a back-arc environment behind the Pemberton (late Tertiary) and Garibaldi (Quaternary) volcanic chains in the Coast belt of southwestern BC.

Throughout the study area, the valley basalts crop out half-way up valley walls, in exposures that range between 10 to 50 m high. Generally, 5-8 flows are preserved at each locality, although ~20 flows were observed in one of the thickest sections, north of Missezula Lake between Merritt and Princeton. Primary volcanic features such as pipe vesicles, vesicle cylinders, and reddened, ropey flow tops are preserved in most of the flows. Some flows are locally brecciated and intermixed with unconsolidated silt. Taken together, these characteristics suggest that the lavas were pahoehoe flows that locally encountered shallow ponds, which brought about brecciation of the lava and mixing with pond silt. Flow indicators suggest the flows in the Merritt region moved northward, while the Lambly Creek basalt flowed southeast towards Kelowna.

The "valley basalts" range from basaltic trachy-andesites and trachy-basalts to basalts and basaltic andesites. The flows are generally aphyric, although rare phenocrysts of olivine and plagioclase are present in some flows. Geochemically, the valley basalts range from subalkaline to alkaline, are intermediate between calc-alkaline and tholeiitic, and are broadly similar to continental rift-related rocks.

Lithosphere-scale geophysical discontinuity near Fort Nelson, B.C: part of a Proterozoic strike-slip fault extending from the Arctic coast to southern BC

Derek J. Thorkelson
Department of Earth Sciences, Simon Fraser University, Burnaby BC, V5A 1S6

Existing geophysical data and first-order interpretations show a marked subsurface discontinuity 100 km west of Fort Nelson, BC. The discontinuity dips steeply to the east, involves the crust and upper mantle, and is herein interpreted as a lithospheric-scale Proterozoic fault. The discontinuity is evident from three types of data: seismic reflection and refraction, gravity, and aeromagnetics. To the west of the discontinuity, as shown on the LITHOPROBE seismic reflection profile, the crust is dominated by highly reflective panels. To the east, the crust is poorly reflective and the few distinct reflectors present are not contiguous with those to the west. Similarly, LITHOPROBE seismic refraction information shows a prominent contrast across the discontinuity, with the upper mantle and middle to upper crust having markedly higher seismic velocities to the west. The contrast in velocity is consistent with the outcome of Bouger gravity modeling which shows that the upper mantle and upper crust are significantly denser to the west. These changes in physical properties coincide with the abrupt western edge of the prominent Fort Nelson magnetic "high," and an anomalously shallow MOHO.

The geophysical discontinuity near Fort Nelson continues to the north, into the western NWT, as shown by patterns of gravity and magnetic susceptibility. In the NWT, the discontinuity separates the narrow, north-trending Fort Simpson magnetic anomaly (*sensu stricto)* to the east from large elliptical anomalies to the west. These elliptical anomalies have, by some authors, been regarded as an extension of the Fort Simpson feature, but that correlation is not supported by gravity variations and is rejected. Specifically, the Fort Simpson magnetic anomaly is coincident with a linear, positive Bouger gravity anomaly, but this anomaly veers north-northeast in the area south of Great Bear Lake, i.e., away from the western elliptical aeromagnetic anomalies. Farther north, the discontinuity appears to merge with the Cape Bathurst line, an aeromagnetically-defined feature which broadly corresponds with gravity variations and continues north-northwestward to the Arctic coast. To the south of the Fort Nelson region, the discontinuity trends southward and into the Steamboat-Fraser feature, a line of positive gravity and magnetic anomalies which continue into southern BC. Previous interpretations of the Steamboat-Fraser feature include a pre-Cordilleran-orogen fault and post-Cordilleran-orogen mega-dyke.

The geophysical discontinuity near Fort Nelson is a lithospheric-scale feature because it juxtaposes differing domains in both the crust and mantle. It is most favourably regarded as a Proterozoic fault because it separates upper crustal panels reasonably interpreted as Proterozoic strata, but does not affect overlying Paleozoic rocks. A Proterozoic age of motion is consistent with possible ages of its northern and southern continuations, the Cape Bathurst and Steamboat-Fraser lines. Taken together, this structure extends for over 2000 km and may be a transcurrent fault along which Proterozoic supracrustal strata and underlying lithosphere in western Laurentia were displaced relative to the main cratonal landmass. The amount and sense of displacement along this fault should be considered in reconstructions of Precambrian continents.

Structural evolution of the Tally Ho shear zone (NTS 105D), southern Yukon

Amy Tizzard and Stephen Johnston
University of Victoria

The Tally Ho shear zone is located along the western boundary of the Whitehorse Trough in southern Yukon, and separates the Stikine Terrane to the east and the Nisling assemblage to the west. Complex geologic structures, Jurassic and Cretaceous plutonism and abundant Tertiary volcanism obscure the nature of this boundary and its relation to adjacent terranes. Pyroxenite, gabbro, marble, and highly strained volcaniclastic rocks form a 3-km-wide belt that is in intrusive- and fault-contact with megacrystic granite and granodiorite, respectively. Structural relations in the field indicate that the ultramafic rocks in the Tally Ho shear zone are allochthonous, and have been thrust to their present position and subsequently folded in the Early Jurassic. Younger brittle and semi-brittle faulting occurred along the Llewellyn fault in the Late Cretaceous.

Preliminary age constraints of regional mid-Jurassic fluid movement in the Pelly Mountains, central Yukon – NTS 105F

Dave Turner[1], Craig Hart[2] and Lee Groat[1]
1- University of British Columbia
2- Yukon Geological Survey

The Pelly Mountains are dominated by Paleozoic Cassiar Platform sediments that largely comprise of miogeoclinal carbonates, shales and quartzites. Within these rocks are Devono-Mississippian felsic volcanic strata of the Pelly Mountain Volcanic Belt (PMVB) whose subvolcanic equivalents form a 30 km-long, NW-trending belt of syenitic plutons. Post-Late Triassic deformation resulted in a series of thrust faults (Seagull, Porcupine, Cloutier, St. Cyr, and McConnell) and panels which dominate the local structure and are roughly sub-parallel to the Tintina Trench. These regional structures were then locally affected by high-angle block faulting and thermal overprinting associated with the emplacement of mid-Cretaceous granitic plutons (e.g. the Ketza and Seagull Uplifts).

The "True Blue" beryl occurrence consists of numerous quartz-siderite veins and tension gashes that cut Mississippian volcanics and the largest of the Devono-Mississippian plutons (U-Pb age of 362.7 +- 3.6 Ma). Beryl mineralization is associated with fluorite and allanite precipitation and occurs in the tension gashes and quartz veins but is restricted to those that cut the syenite. A Sm-Nd isochron result of 172 +- 5 Ma (n=6) from vein fluorite suggests that mineralization may not be directly related to the intrusion of the host pluton. Instead, it indicates possible mid-Jurassic regional fluid flow that was likely generated in response to east-verging Jurassic thrusting. Supporting evidence for timing is cryptic, but previous K-Ar and Ar-Ar dates in the area that have not been affected by Cretaceous thermal overprinting also yield Early to Mid-Jurassic cooling ages.

Many mineral occurrences are present in the Pelly Mountains and particularly within the Ketza Seagull District. Previous studies suggested that much of the epigenetic mineralization in the Pelly Mountains is likely, but not conclusively, related to buried intrusions. A widespread mid-Jurassic fluid-flow event could provide an explanation for these mineral occurrences that do not conform to a Cretaceous intrusion-related model. Also noted in previous studies is a rough mineralogical zoning of mineralized showings that was largely controlled by host rock. The observation between mineralogy of an occurrence and its host rock fits well with mineralization at "True Blue" where Be-REE-Th-enriched vein minerals (i.e., beryl, fluorite and allanite) are hosted in an evolved rare element enriched syenite. Accordingly, this mid-Jurassic fluid has the potential to mobilize significant amounts of elements typically considered immobile. Iron-carbonate and fluorite, characteristic minerals of the veins at True Blue, are also present in several nearby mineral occurrences. Better constraints on the timing of fluid flow and hydrothermal mineralization not related to Cretaceous magmatism can provide constraints for the timing of deformation in the Pelly Mountains.

Deformation of the Upper Kaza Gp-Lower Isaac Fm, (Neoproterozoic) Windermere Supergroup, East-central BC

Wallace, Ken D. and Waldron, John W.F.
Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton AB, T6G 2E3

The Windermere Supergroup comprises of Neoproterozoic strata deposited on the former continental margin of North America. In the eastern Cariboo Mountains, the stratigraphic succession consists primarily of sand-rich basin-floor turbidites (Kaza Gp) to mud-rich slope facies (Isaac Fm). Since their deposition, these rocks have undergone four generations of folding, primarily during Cordilleran deformation. The rocks are folded at map scale, cleaved and display stretched pyrite crystals that locally define a strong lineation. Furthermore, cleavage planes are overprinted by at least two generations of kinks.

However, not all deformation structures of the area are believed to have a tectonic origin. Strata-bound units of thin-bedded silty-mudstone turbidites up to 50 m thick, which show evidence of movement (movement zones), are common in the lower Isaac Fm. The base of movement zones truncate underlying bedding with orientation consistent to local stratigraphy. Internally, strata are 5 to 15 degrees off strike with local stratigraphy. Planar slip planes that separate divergent strata lack fault gouge. Furthermore, folds in which mudstone layers maintain constant thickness and sandstone layers thicken from limb to hinge are common.

Massive silty-mudstone units up to 80 m thick, with abundant, dispersed, poorly sorted clasts of quartz, locally-sourced (massive and stratified) mudstone and sandstone, and shelf-derrived shallow-water carbonates, commonly overlie and incise into movement zones. Clasts within these units are preserved in various stages of deformation, ranging from rounded blocks, to boudinage and folded blocks, to sandstone blocks in partial disintegration. These units are interpreted as debris flow deposits.

The strong spatial association of movement zones with debris flow deposits suggests that deformation structures within the movement zones developed during sliding of a semi-consolidated slide mass on the continental slope, rather than the sole result of tectonic deformation.

Volcanostratigraphy and VMS Potential of Upper Hazelton Group in Southwestern Stikinia

S.M. Gordee[1], J.K. Mortensen[1], J.B. Mahoney[2], and R.L. Hooper
1- University of British Columbia
2- University of Wisconsin – Eau Clair

Little-deformed Middle Jurassic volcanogenic strata of the upper Hazelton Group are widespread in the NE Bella Coola and SE Whitesail Lake map areas in west-central British Columbia. The goal of our last two field seasons has been to assess the potential for Eskay Creek-type volcanogenic massive sulphide (ECT-VMS) deposits in this portion of southern Stikinia. Detailed geologic mapping and U-Pb dating indicate that Hazelton Group rocks in this area are similar to host-rocks of the Eskay Creek deposit in terms of both age and depositional environment. Specific results of our study that emphasize the high potential for this type of mineralization in the area include: (1) a linear arrangement of extrusive felsic domes, together with (2) indications of a synvolcanic extensional structure; (3) evidence for shallow water deposition; (4) the presence of known Middle Jurassic syngenetic (e.g., Nifty) and epigenetic mineral occurrences; (5) stratiform pyrite locally within tuffaceous mudstones; and (6) widespread epidosites that may reflect semi-conformable alteration above a buried subvolcanic intrusion. Ongoing petrographic, geochronologic and lithogeochemical investigations will better constrain the tectono-magmatic regime during deposition of upper Hazelton Group rocks in the area, and facilitate exploration for ECT-VMS deposits in southern Stikinia.