CORDILLERAN TECTONICS WORKSHOP 2007

PROGRAM AND ABSTRACTS

TELUS Centre, University of Alberta

Friday February 16

19:00 - 22:00	Ice breaker, munchies, registration, posters

Saturday February 17

Time	**Author(s)**	**Topic**
08:10 - 08:50	*Buffet light breakfast*	POSTERS
08:50 - 09:00	Philippe Erdmer	Welcome & announcements
09:00 - 09:20	**Bob Anderson**, Suzanne Paradis, Bob Thompson	Targeted Geoscience program Cordilleran Project - What's in it for you?
09:20 - 09:40	**Jean-François Gagnon**, John Waldron, Fabrice Cordey and Carol Evenchick	Early stratigraphic record and subsidence history of the Bowser Basin, northwest British Columbia
09:40 - 10:00	**Walter Loogman**, John Waldron, Carol Evenchick	Development of the northwest Skeena fold belt, northwest British Columbia
10:00 - 10:20	Discussion	
10:20 - 10:40	*Break*	POSTERS
10:40 - 11:00	Michael Cooley, **Ray Price**	Chevron-style, flexural slip, thrust-propagation folding, Livingstone Range anticlinorium, southern Alberta Foothills, Canada
11:00 - 11:20	**Jamie Kraft**, Bob Thompson, Philippe Erdmer	A stratigraphic link between Milford Group(?) strata and the Eagle Bay assemblage: new interpretations from Upper Arrow Lake, southeastern British Columbia

11:20 - 11:40	**Paul Glombick**, Tom Chacko, Philippe Erdmer, Bob Thompson	Thermotectonic evolution of the Shuswap metamorphic complex in the Vernon area
11:40 - 12:00	Discussion	
12:00 - 13:20	*Buffet lunch*	POSTERS
13:20 - 14:00	**Félix Gervais**, Dick Brown	Exhumation by sequential extrusive flow above a basement ramp documented from P-T-t-d paths, Monashee complex, SE Canadian Cordillera
14:00 - 14:20	**Andy Parmenter,** Paul Williams	A regionally developed transposition foliation in the Monashee complex and its tectonic significance
14:20 - 14:40	**Paul Williams**, Stefan Kruse	The Monashee reflection revisited
14:40 - 15:00	Discussion	
15:00 - 15:20	*Break*	POSTERS
15:20 - 15:40	**Erik Parker**, Philip Simony, Ed Ghent	Folds and thrust faults in metamorphic rocks of the east flank of the Selkirk fan; a reinterpretation of the Esplanade thrust
15:40 - 16:00	**David Moynihan,** David Pattison	Tectonic significance of the isograd pattern around Kootenay Lake, SE British Columbia
16:00 - 16:20	**Martyn Unsworth**, Ted Bertrand, Volkan Tuncer, Ersan Turkoglu, Wolfgang Soyer	Images of the lithospheric structure beneath the Canadian Cordillera : New results from long-period magnetotelluric studies
16:20 - 16:40	Discussion	
Until 21:00		POSTERS

Sunday February 18

08:20 - 09:00	*Buffet light breakfast*	
09:00 - 09:20	**Katrin Breitsprecher**, Dominique Weis, James Scoates, Bob Anderson	Isotope and trace element geochemistry of Mesozoic intrusions, Quesnel terrane, south-central British Columbia: preliminary results
09:20 - 09:40	**Graham Andrews**, Kelly Russell	The thickness and distribution of Neogene volcanic rocks in the Intermontane Belt: insights from volcanic facies studies
09:40 - 10:00	**Dejan Milidragovic**, Derek Thorkelson, Bill Davis, Dan Marshall, Dan Gibson	Grenvillian metamorphism and uncertain provenance: preliminary results of a geochronological study of crustal xenoliths, Wernecke Mountains, Yukon
10:00 - 10:20	Discussion	
10:20 - 10:40	*Break*	
10:40 - 11:00	**Kirsten Rasmussen**, Jim Mortensen, Hendrick Falck	Mid-Cretaceous granitoids in the southwestern Northwest Territories and southeastern Yukon: implications for magma source regions, tectonic setting, and metallogeny
11:00 - 11:20	Maurice Colpron	Tectonostratigraphic framework and Paleozoic evolution of pericratonic terranes in the northern Cordillera
11:20 - 11:40	**Ed Ghent**, Ben Edwards, Kelly Russell, Jim Mortensen	Granulite facies xenoliths from Prindle Volcano, Alaska: implications for the northern Cordilleran crustal lithosphere
11:40 - 12:00	Discussion, announcements	
12:00 END		

Posters
(Friday 19:00 to Sunday 12:00)

Bob Anderson, Suzanne Paradis, Bob Thompson	Targeted Geoscience program Cordilleran Project - What's in it for you?
Luke Beranek, Jim Mortensen	A Triassic link between Yukon-Tanana terrane and North America: insights from new provenance data
Sarah Brown, Dan Gibson, Derek Thorkelson	Constraining the timing of extension along the southern section of the Okanagan Valley fault, southern British Columbia
Michael Cooley, Ray Price	Chevron-style, flexural slip, thrust-propagation folding, Livingstone Range anticlinorium, southern Alberta Foothills, Canada
Charles Ferguson, Brad Johnson	Laramide folding of Jurassic plutonic rocks and structures related to Early Cretaceous back-arc basin formation in southeastern Arizona
David Gardner, Stephen Johnston	Sedimentology, correlation, and depositional environment of the Upper Purcell Supergroup, northern Purcell Basin, southeastern British Columbia, Canada
Chris Leslie, Jim Mortensen	Investigations of the crystalline basement beneath the Mackenzie Mountains of the northern Cordillera, NWT
Margot McMechan, Barry Richards	TGI-3 studies, Kananaskis area, southeastern British Columbia
Don Murphy	The three "Windy McKinley" terranes of Stevenson Ridge (115JK), western Yukon
Jim Mortensen	New geological mapping and structural studies in the Klondike gold district, Yukon
David Trippett, Dan Gibson	Tectonic setting and evolution of the Bigmouth fault, northern Selkirk Mountains, southeasternl British Columbia
Martyn Unsworth, Ted Bertrand, Volkan Tuncer, Ersan Turkoglu, Wolfgang Soyer	Images of the lithospheric structure beneath the Canadian Cordillera: New results from long-period magnetotelluric studies

Abstracts
(in alphabetical order by first author)

The thickness and distribution of Neogene volcanic rocks in the Intermontane Belt: insights from volcanic facies studies

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Cenozoic volcanic rocks cover > 50,000 km^2 of the Intermontane Belt, although their true distribution and thickness are very poorly constrained. Recent and on-going investigations of the Neogene Chilcotin Group basalts seek to better constrain their distribution and thickness, primarily to enhance the regional mineral exploration potential. Field-based volcanic facies studies have, for the first time, begun to shed light on the three-dimensional architecture of the Chilcotin Group. Preliminary findings suggest that rather than being a uniformly thick (~ 100 m) and laterally continuous sheet, as previously thought; the Chilcotin Group basalts are typically thin (<< 50 m thick). Thicknesses of basalt in excess of 50m are only observed in exhumed paleo-valleys. Such exposures comprise volcanic lithofacies components such as hyaloclastite deposits, pillow lavas, intercalated fluvial conglomerates, and peperites indicating the gradual infilling of paleo-drainage systems by basaltic volcanism. These findings will have a significant effect on the development and interpretation of geophysical models for mineral exploration, and provide new data to constrain the topographic evolution of the Intermontane Belt and the Fraser River drainage basin.

A Triassic link between Yukon-Tanana terrane and North America: Insights from new provenance data

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Triassic sedimentary rocks of Yukon are present within many regional tectonic elements in the northern Cordillera, including the Yukon-Tanana terrane (YTT), Slide Mountain terrane (SMT), Cassiar terrane (CT), and North American passive margin (NAM). Triassic rocks appear similar in character and unconformably overlie all older rock units; therefore, these rocks may

form a sedimentary overlap assemblage that represents the first linkage of allochthonous terranes to North America.

Our new provenance data demonstrate the presence of an overlap assemblage linking the YTT to the NAM by the Early to Middle Triassic. Conodont-constrained Triassic sedimentary rocks of the autochthonous NAM contain detrital zircon whose ages represent four main source areas: (1) 252-360 Ma rocks of the composite YTT Paleozoic magmatic complex (western-derived); (2) ca. 295-317 Ma rocks whose ages are rare in YTT and may be recycled from the Semenof block (Paleozoic Stikinia, western-derived); (3) ca. 400-530 Ma ages that may be ultimately derived from Arctic Canada (Pearya terrane or Caledonian - Innuitian orogens?); and (4) Proterozoic and Archean basement complexes of North America.

Middle to late Paleozoic magmatism is absent from the NAM but is a diagnostic feature of the YTT; therefore Late Devonian - Late Permian detrital zircons (252-360 Ma) within North American Triassic sediments requires YTT to be accreted to the Ancient Pacific Margin by the early Mesozoic, more than 40 m.y. before the presumed Early to Middle Jurassic docking event. The earliest influx of YTT-derived sediment to the NAM is constrained by the type section of the Early Triassic (Smithian) Jones Lake Formation along the Yukon-NWT border (NTS 105I/13). The Jones Lake Formation contains 343-348 Ma detrital zircons, which are ages unique to YTT but absent from the NAM.

We suggest the initial YTT-NAM collisional event occurred in latest Permian time (Sonoman orogeny equivalent?). Early to Middle Triassic rocks of Yukon represent sediments shed from the uplifted hinterland of YTT (upper plate) into a peripheral foreland basin on the NAM (lower plate); Middle to Late Triassic rocks of YTT, SMT, and NAM form a sedimentary overlap assemblage linking all tectonic elements by the early Mesozoic.

Isotope and trace element geochemistry of Mesozoic intrusions, Quesnel terrane, south-central British Columbia: preliminary results

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Mesozoic igneous rocks of the Quesnel terrane in southern British Columbia are associated with accretionary tectonism in the Canadian Cordillera. Compositions of specific temporal suites record variations in source or process through time as each arc system evolves, collides, and equilibrates as part of a new, thickened crust. Specifically, these changes in source or process are dependent on the state of the subducting slab throughout the life-cycle of a specific arc. The slab states are: 1) incipient subduction (no slab at asthenospheric depths, and simple compression to slab underplating at lithospheric depths); 2) steady-state subduction (continuous slab from trench to at least the 410 km discontinuity); and 3) boudinaging and foundering of slab following a collision event (slab removal at lithospheric depths, with delayed presence at asthenospheric depths). Mantle types associated with the three slab states are: 1) nonmetasomatized asthenospheric mantle overlain by lithospheric mantle with composition inherited from a pre-convergence tectonic state (e.g. harzburgitic at formerly divergent margins); 2) metasomatized asthenospheric mantle wedge with depleted (lherzolitic) lithospheric mantle; and 3) possible addition of sub-slab asthenospheric (fertile) mantle, facilitated by removal of the slab barrier. Crustal inputs include assimilation by mantle-derived magma ascent as the arc evolves, to crustal anatexis following collision. These variations in available sources with respect to both mantle reservoirs and crustal responses should be recognizable in the geochemistry and the Rb-Sr, Sm-Nd, Pb-Pb, and Lu-Hf isotopic compositions of the rocks.

One tectonic cycle is represented by Late Triassic to Middle Jurassic igneous rocks of the southern Quesnel terrane, which have been targeted for geochemical and Rb-Sr, Sm-Nd, Pb-Pb and Lu-Hf isotopic analysis. We present compositional fingerprinting for intrusions of this age range from the Similkameen region, British Columbia. These samples represent the southerly subset of 57 new geochemical samples collected in 2006, which include rocks of similar ages from the more northerly Thuya and Takomkane batholiths. The new isotopic compositions, and the Hf and Pb isotopes in particular, are used to re-evaluate whether pre-collision (>185 Ma) Quesnellian arc rocks were emplaced in the presence or absence of radiogenic (Precambrian) crust, which has implications for the relationship of the Quesnel terrane to ancestral North America.

It is anticipated that with further study, the geochemistry of the sampled suites, and especially the Rb-Sr, Sm-Nd, Pb-Pb and Lu-Hf isotopic systematics, may correlate with the predicted variations in slab dynamics at depth through one or more cycles of arc development, evolution and accretion. In turn, changes in magma source over the course of this tectonic cycle may partly account for observed trends in porphyry-mineralization style. With some exceptions, notably including the Late Triassic calc-alkaline Highland Valley Deposit, the broad mineralization trends which have been observed for the Quesnel terrane are: 1) alkalic Cu-Au ±Ag porphyry mineralization is typically hosted in latest Triassic intrusions; 2) calc-alkaline Cu±Au±Mo porphyry mineralization is commonly hosted in Early Jurassic intrusions; and 3) low-F Mo-type porphyry mineralization is hosted by Middle Jurassic and younger intrusions.

Constraining the timing and magnitude of extension along the southern section of the Okanagan Valley Fault, southern BC.

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Within the southern Okanagan Valley, medium- to high-grade metamorphic rocks are juxtaposed against nearly pristine volcanic and sedimentary rocks. Previous work has demonstrated that the nature of the boundary between these two disparate packages of rock is predominantly a <1 km-thick ductile shear zone, termed the Okanagan Valley fault (OVF). The shear zone grades abruptly from cataclasite to mylonite in amphibolite-grade gneiss, which, along with younger granitic intrusions, has undergone polyphase deformation and shows evidence of significant flattening. Linear fabric elements and kinematic criteria (e.g., rotated porphyroclasts, boudinaged pegmatite dykes, sheath folds, C/S fabrics) strongly indicate extensional motion through which the hanging-wall has moved to the west.

Farther to the north, within the central portion of the OVF, recent work has attributed minimal displacement to the OVF and brought into question previous estimates for the magnitude of extensional displacement as determined to the south (~45-90 km) and north (~32 km). The apparent disparity in the estimated magnitude of extension along the trace of the OVF may provide insight into the along-strike variation in displacement along a fault such this, and/or require a revised interpretation of the tectonic nature of this shear zone. To help address this problem, it is imperative to reexamine the southern portion of the OVF as little work has been done in the last 20 years. In order to better understand the nature of the OVF and constrain motion along the southern portion of the shear zone, we intend to conduct a comprehensive thermo-structural analysis. This work will comprise 1:50 000 scale mapping and strain analysis to constrain the dimensions and geometry of the shear zone. This study will be complemented by petrography, geothermobarometry, U-Pb geochronology (e.g., *in situ* dating of metamorphic and fabric-forming minerals) and thermochronology to constrain the P-T-t path and rate of exhumation related to extension. Lastly, geochemistry of the gneissic rocks within the footwall will be used in an attempt to identify their protolith.

Tectonostratigraphic framework and Paleozoic evolution of pericratonic terranes in the northern Cordillera

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The pericratonic terranes of the northern Cordillera (including Yukon-Tanana [YTT] and Slide Mountain [SM] terranes) consist of complexly deformed and metamorphosed mid- to late Paleozoic continental margin, arc and marginal basin assemblages. They underlie large portions of the northern Cordillera, but yet they remained some of its most poorly understood elements until recently. Recent regional mapping of YTT and related terranes in Yukon, northern B.C. and eastern Alaska provides the basis for a new tectonostratigraphic framework and Paleozoic evolution of the pericratonic realm.

YTT of Yukon and B.C. consists of four tectonic assemblages of regional extent. They comprise a basal siliciclastic assemblage of continental margin affinity (Snowcap assemblage) overlain by three unconformity-bounded, mid- to late Paleozoic volcano-sedimentary successions of continental arc and back-arc affinities (Finlayson, Klinkit and Klondike assemblages). Coeval oceanic rocks of the SM assemblage record contemporaneous development of a marginal ocean basin. Much of east-central Alaska that was formerly assigned to YTT is now re-interpreted as part of the parautochthonous continental margin.

The Paleozoic tectonic evolution of the northern pericratonic realm includes: 1) Middle to Late Devonian regional extension and rifting of part of the distal continental margin (Snowcap assemblage); 2) Late Devonian onset of arc and back-arc magmatism in both YTT and distal portions of the North American margin (NAM; eastern Alaska, Selwyn basin, Kootenay terrane of southern B.C.); 3) Early Mississippian opening of the SM marginal ocean between the YTT arc and NAM (including pericratonic rocks of eastern Alaska); 4) superimposed Carboniferous arc magmatism in YTT (Finlayson and Klinkit assemblages), punctuated by at least one episode of regional, intra-arc deformation; and 5) Middle to Late Permian arc magmatism and development of HP rocks along the eastern edge of YTT. The Middle Devonian to Early Permian evolution of YTT is interpreted to have occurred above an east-dipping subduction zone, with slab-rollback as driver of regional extension. The Middle Permian marked a change to westard subduction of SM lithosphere beneath YTT. Closure of the SM ocean and accretion of YTT to the NAM plate are indicated by occurrence of YTT detritus in Triassic clastic strata of the NAM.

Chevron-style, flexural slip, thrust-propagation folding, Livingstone Range anticlinorium, southern Alberta Foothills, Canada

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The Livingstone Range anticlinorium (LRA) is a long (>65 km) narrow (<5 km) structural culmination that coincides with a major hanging-wall ramp across which the Livingstone thrust cuts ~1000 m up-section eastward from a regional décollement in the upper part of Devonian Palliser Formation to another regional décollement within Jurassic Fernie Formation. This ramp includes minor ramps and flats that are controlled by locally important detachments within Carboniferous rocks in the lower part of the Banff Formation, in the Shunda Member and near the base of the Turner Valley Member of the Livingstone Formation. The anticlinorium consists mainly of chevron-style, flexural slip thrust-propagation folds that have conspicuous blind thrust faults along their hinge zones. This style of thrust propagation folding is particularly well illustrated by the Centre Peak anticline where it is exposed in natural cross sections in the canyons of Green and Morin creeks. The distinctive pattern of ramp-flat thrusting displayed along the hinge-zone thrust system of the asymmetric chevron-style Centre Peak anticline consists of a series of stacked detachment thrusts, each of which emerges from a different zone of inter-bed slip in the backlimb of the anticline and deflects the hinge zone. Each detachment thrust consists of two contrasting segments. The lower segment, which is parallel to bedding in the less steeply dipping backlimb of the fold, juxtaposes a hanging wall flat with a footwall ramp. The upper segment, which is sub-parallel with the steeply-dipping forelimb, juxtaposes a hanging wall ramp with what roughly approximates a footwall flat. Each successively lower detachment thrust dies out in the hinge zone at approximately the same stratigraphic level as the bedding detachment zone in the backlimb from which the overlying

detachment thrust fault emerges. Successively higher bedding detachment thrusts deflect the hinge zone eastward and therefore displacement along them is interpreted to have occurred after the displacement on the underlying thrust. The highest bedding detachment thrust, which formed last, terminates in the core of a concentric, parallel, flexural slip fold. It records the arrested evolution of the anticline. Displacements on the detachment thrusts were kinematically integrated with rotation of the fold limbs and with inter-bed slip within the fold limbs. The result is a distinctive chevron-style of flexural slip thrust-propagation folding. Mesoscale deformation in the anticline involved a form of cataclastic flow in which individual blocks of rock delimited by networks of small faults, joints and sheared bedding surfaces experienced little or no internal deformation while undergoing variable relative translation and rotation during thrust propagation and related folding. Pressure solution and vein formation were widespread but minor components of the deformation. Multiple sets of cross-cutting calcite and/or dolomite and/or hydrocarbon veins that are associated with the faults and fractures provide evidence of their intermittent reactivation and of infiltration first of fluids from underlying crystalline basement rocks, and later of meteoric fluids.

Laramide folding of Jurassic plutonic rocks and structures related to Early Cretaceous back-arc basin formation in southeastern Arizona

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Structural evolution of the Cordillera in southern Arizona over the past 200 million years was punctuated by three distinct magmatic arcs at ~170Ma, ~70Ma, and ~30Ma. Profound structural disturbances associated with each event are indicated by important regional unconformities.

The age(s) of contractional deformation involving Mesozoic rocks in southern Arizona has been an issue of debate for many years. A poorly understood middle Mesozoic contractional event that was reported to have involved sporadically preserved Jurassic strata throughout southeast Arizona has not been confirmed by subsequent mapping efforts. Instead it has become increasingly clear that the profound unconformity at the base of the widespread, Lower Cretaceous, mostly siliciclastic, lacustrine – marine Bisbee Group is related to extensional, possibly transtentional opening of a complex series of northwest-striking back-arc basins. The basin-bounding faults were locally reactivated during a complex Late Cretaceous folding event that resulted in poorly understood, map-scale fold interference patterns. An angular unconformity at the base of Late Cretaceous volcanics indicates that "Laramide" folding and faulting were over before ~70Ma in this part of the cordillera.

One of the last hold-outs of an area where Jurassic folding may have occurred is a fold-belt in the Mule Mountains near the Mexican border. Although the range includes the type area for the Lower Cretaceous Bisbee Group, the area in question includes only Paleozoic strata intruded by two suites of petrographically identical Jurassic and Late Cretaceous hypabyssal quartz-porphyry dikes, sills, and stocks. Detailed mapping shows that some of the intrusions are consistently oriented as if they were folded sills and dikes, whereas others cut across the folded strata with little regard to the fold structure. Furthermore, intrusions that appear to be folded show abundant evidence of internal brittle deformation whereas the others do not.

An angular unconformity at the base of the Lower Cretaceous Bisbee Group, although rare and sporadically preserved, is interpreted as evidence of fault block rotation during extensional faulting related to back-arc basin formation. Although some major faults related to formation of the back-arc basin were clearly reactivated during the Laramide, many others must have been folded, making their identification particularly difficult.

Early stratigraphic record and subsidence history of the Bowser Basin, northwest British Columbia

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The Bowser Basin, located in northwest British Columbia, was deposited over the Stikine Terrane of the Intermontane Belt during a period ranging from the Middle Jurassic to Late Early Cretaceous. It contains approximately 6 km of marine to non-marine clastic sediments mainly assigned to the Bowser Lake Group but also includes sediments of the upper Hazelton Group at the base of the succession. Recent thermal maturation investigations have shown the existence of effective petroleum systems in the Bowser Basin but stratigraphic relationships between prospective units remain poorly understood.

In order to investigate the subsidence history of the Bowser Basin, stratigraphic sections were measured in areas where the base of the succession is well exposed and constrained by paleontological data. Decompaction and backstripping analysis were then performed on those sections to explore different models for the tectonic evolution of the basin and understand how and when most of the accommodation space was generated.

Volcanogenic units of the lower Hazelton Group indicate that these rocks mostly accumulated in an oxidizing, subaerial environment. The transition from the volcanic arc assemblage of the lower Hazelton Group into a subsiding sedimentary basin can be traced above a regional unconformity surface. Above the unconformity, the deposition style of the upper Hazelton Group is variable on the basin scale. Depending on the paleotopography and the distance from active volcanic centres, the sediments incorporated more or less volcanic input and were deposited along with subaqueous and subaerial bimodal volcanic flows. Based on the observations made in measured stratigraphic sections, it appears that continuous sedimentation took place in a tectonically active, shallow marine basin on Stikinia from the Early Pliensbachian to Early Bajocian. Rapid lateral facies change and the variability of sediment thickness in the upper Hazelton Group are attributed to active normal faulting during an extensional back-arc stage that isolated multiple sub-basins. Following the end of rifting, thermal relaxation of the crust combined with eustatic sea-level rise generated new accommodation space in the basin where condensed sections of fine-grained deepwater sediments were deposited. The basin remained starved until the Bathonian when a new sediment source became available with the subaerial exposure of the Cache Creek Terrane and the Bowser Lake Group began to accumulate in the basin.

Sedimentology, correlation, and depositional environment of the Upper Purcell Supergroup, Northern Purcell Basin, Southeastern British Columbia, Canada

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The upper Purcell Supergroup was deposited in a marine to lagoonal setting ~1.4 Ga. Measured sections and mapping acquired during the summer 2006 in combination with existing maps permits a test of previous stratigraphic correlations. Replacement of Dutch Creek Formation to the west by the La France Creek Group reflects the westward thinning and increased sand-content of this unit. The Dutch Creek Formation is replaced to the south by the Gateway‹Roosville Formations. A micaceous north-tapering sandstone unit, the Phillips Formation separates the Gateway and Roosville Formations, and provides a record of syn-depositional change in the architecture of the Purcell basin. We speculate on potential reasons for Phillips Formation pinch out and attribute it to either continued basin subsidence to the south or to the presence of an unidentified large-scale fault.

Exhumation by sequential extrusive flow above a basement ramp documented from P-T-t-d paths, Monashee Complex, SE Canadian Cordillera

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The Monashee Complex (MC) of southeastern Canadian Cordillera consists of two domal culminations; the northern Frenchman Cap and the southern Thor-Odin domes. Gneisses of North-American basement that core Frenchman Cap dome have only been weakly affected by the Cordilleran Orogeny. An apparent coherently folded sequence of migmatitic metasediments and infolded basement slices crops out above the basement. The Sybley Creek Syncline (SCS), the structurally highest regional-scale fold of the MC, is located in the footwall of the Monashee décollement, which is a thrust-sense ductile shear zone forming the base of the Sil-Kfs-grade Selkirk Allochton panel.

Pseudosections were modelled with the thermodynamic software Perple_X'06 for different structural levels of Frenchman Cap dome and combined with existing and newly obtained geochronological data to derive detailed **P**ressure-**T**emperature-**t**ime-**d**eformation (P-T-t-d) paths. Four structural levels that are now juxtaposed were identified based on their contrasted P-T-t-d paths. At the upper level, Selkirk Allochton rocks experienced protracted flow in the middle crust throughout the Cretaceous and were exhumed to upper-crustal conditions between 70-60 Ma. By contrast, rocks from the upper limb of the SCS that are now located immediately below the Selkirk Allochton were at >35 km/800ºC at ca 59 Ma and were rapidly exhumed to <15 km/550ºC by 55 Ma. Similarly, the lower part of MC cover sequence and upper basement stayed within the Sil-Kfs field until ca 50 Ma before being rapidly exhumed. A novel model of sequential buoyancy-driven extrusion of partially molten crust above an underthrusted basement ramp is proposed. After their late-Cretaceous exhumation, rocks of the Selkirk Allochton acted as a passive upper lid to migmatites of MC that were sequentially extruded between them and a stiff basement. This extrusion was triggered in part by the density (and viscosity) drop predicted by Perple_X'06 to occur across the Ms-out isograd. High-grade rocks of SE-Canadian Cordillera thus record a complex and episodic exhumation history varying both in time and space. The exhumation process was controlled in part by density gradients internally created during metamorphism, but also by rheological contrasts between fertile partially molten rocks and refractory basement orthogneiss.

Granulite facies xenoliths from Prindle Volcano, Alaska: Implications for the northern Cordilleran crustal lithosphere

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Xenoliths collected from Prindle volcano, Alaska (Lat. 63.72 N; Long. 141.82 W) provide a unique opportunity to examine the lower crust of the northern Canadian Cordillera. The cone's pyroclastic deposits contain crustal and mantle-derived xenoliths. The crustal xenoliths include granulite facies metamorphic rocks and charnockites, comprising orthopyroxene (opx)-plagioclase (pl)-quartz (qtz) ± mesoperthite (msp) and clinopyroxene (cpx). Opx-cpx geothermometry yields equilibrium temperatures (T) from 770 to 1015 C at 10 kbar. Pl-cpx-qtz geobarometry yields pressures (P) of ~6.6-8.0 kbar. Integrated mesoperthite compositions suggest minimum temperatures of 1020-1140ºC at 10 kbar using solvus geothermometry. The absence of garnet in these rocks indicates a range of maximum pressure of 5 to 11.3 kbar, and calculated solidi constrain upper temperature limits. We conclude that the granulite facies assemblages represent relatively dry metamorphism at pressures indicative of crustal thicknesses similar to present day (~36 km). Zircon separates from a single crustal xenolith yield mainly Early Tertiary (48-63 Ma) U-Pb ages which are considerably younger than the cooling ages of the high-pressure amphibolites exposed at the surface. The distribution of zircon ages is interpreted as indicating zircon growth coincident with at least two different thermal events as expressed at surface: (i) the eruption of the Late Cretaceous Carmacks Group volcanic rocks in western Yukon and adjacent parts of Alaska, and (ii) emplacement of strongly bimodal high level intrusions across much of western Yukon and eastern Alaska in a possibly extensional tectonic regime. The distributions of zircon growth ages and the preservation of higher-than-present-day ($> 25 \pm 3$ C km^{-1}) geothermal gradients in the granulite facies rocks demonstrate the use of crustal xenoliths for recovering records of past, lithospheric-scale thermal-tectonic events.

Thermotectonic evolution of the Shuswap metamorphic complex in the Vernon area

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The metamorphic evolution of the Shuswap metamorphic complex in the Vernon area was studied using: (1) 1:20 000 scale geological mapping; (2) petrographic analysis (3) thermobarometry; (4) Gibbs method; (5) monazite-xenotime thermometry; and (6) *in-situ* U-Pb dating of monazite using laser ablation multiple collector-inductively coupled plasma mass spectrometry (LA-MC-ICP-MS).

Geological mapping reveals that the transition from superstructure to infrastructure occurs across a ~2 km metamorphic transition zone (MTZ). Map patterns indicate that the metamorphic transition zone has a sub-horizontal orientation at the regional scale and separates superstructure from underlying metamorphic infrastructure. The MTZ preserves a complete but attenuated metamorphic sequence, increasing in metamorphic grade with increasing structural depth from greenschist facies (chlorite zone) to upper amphibolite facies (K-feldspar-sillimanite zone). Abundant Paleocene to Early Eocene syn- to post-kinematic peraluminous granitic rocks of the Ladybird suite first appear at the sillimanite-in isograd. Near the western margin of the SMC, the MTZ is overprinted by the Okanagan Valley fault, a gently dipping shear zone with upper plate to the west shear-sense.

Garnet-bearing meta-pelitic rocks were used to constrain peak *P-T* conditions. Garnets within the garnet, staurolite, and sillimanite zones record growth zoning. Grossular-rich overgrowths are present in garnet within staurolite-bearing rocks. Garnets within the sillimanite to K-feldspar zone are homogeneous and yield P-T estimates of 8-10 kbar and 800-850°C.

Monazite MC-ICP-MS U-Pb ages reveal a complex metamorphic evolution that varies with metamorphic grade and structural level. Yttrium maps of zoned monazite grains were used to select age domains for analysis. Migmatitic pelitic schist exposed within the core of the Vernon antiform records monazite crystallization at 231, 168, 158, 145, 91, 63-60, and 51-49 Ma ($^{206}Pb/^{238}U$ weighted mean ages). This data agrees well with published U-Pb zircon ages from the core of the antiform. Upper amphibolite-facies migmatitic meta-pelitic rocks exposed within the southern Hunters Range area yielded $^{206}Pb/^{238}U$ weighted mean ages of 156, 135, 103, 90-86, 82, and 51-46 Ma. Farther east, in the Vidler Ridge/Pinnacles areas, meta-pelitic rocks within the staurolite and sillimanite zones yielded $^{206}Pb/^{238}U$ ages of 76-74 Ma and 49 Ma. Monazite growth events are tentatively linked with metamorphic reactions based on previous studies and monazite-xenotime thermometry. The new and previously published U-Pb zircon, monazite, and titanite ages from the Vernon area of the Shuswap metamorphic complex reveal an intricate and episodic history of metamorphism that is similar to other areas of the southeastern Canadian Cordillera where the transition from superstructure to infrastructure is exposed.

A stratigraphic link between Milford Group(?) strata and the Eagle Bay assemblage: new interpretations from Upper Arrow Lake, southeastern British Columbia

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Within the Kootenay Arc, an important regional unconformity separates the Mississippian Milford Group from the underlying lower Paleozoic Lardeau Group. However, strata correlative with the Devonian Chase and Silver Creek formations have recently been recognized beneath argillaceous rocks correlated with Milford Group (McHardy assemblage) along Upper Arrow Lake on the western margin of the northern Kootenay Arc. New mapping demonstrated that these argillaceous rocks, which were assigned to the Slide Mountain terrane (SMT), conformably overlie and interfinger with units we correlate with the Devonian Silver Creek and Chase formations. Combined with lithological similarities and time-stratigraphic consistency, this relationship implies that units of Slide Mountain terrane at Upper Arrow Lake may be, at least in part, correlative with the Devonian-Mississippian Eagle Bay assemblage, and do not represent a far-traveled terrane. If this unit ('McHardy assemblage') at Upper Arrow Lake is depositionally linked to Milford Group strata that overlie the Lardeau Group, this relationship would record stratigraphic continuity from the Upper Paleozoic Eagle Bay back-arc basin to the Cordilleran miogeocline.

Investigations of the crystalline basement beneath the Mackenzie Mountains of the Northern Cordillera, NWT

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The basement beneath a large portion of the northern Cordillera in northeastern BC, eastern Yukon and the southwestern Northwest Territories is referred to as the Nahanni domain. The age and composition of this basement is poorly known, as it is nowhere exposed. The aim of this study is to provide insight new into the tectonic, geochemical, and geochronological framework of the basement in part of the western Mackenzie Mountains. Initial fieldwork for the study was carried out in July and August 2006 in collaboration with the Sekwi Mountain Project funded by the Northwest Territories Geoscience Office.

The project comprises three separate research thrusts. First, representative samples were collected from seven mid-Cretaceous plutons in the study area that are thought to be crustally derived on the basis of mineralogy and geochemistry. Crystallization ages for the intrusions will be determined using in situ U-Pb zircon dating methods. Inherited zircon cores will also be dated and hafnium isotopic compositions of both cores and igneous rims will be determined using in situ methods. The age and hafnium isotopic composition of the inherited cores will provide critical information about the nature of the crustal material that was melted to produce the magmas (possibly including components of the underlying basement). Secondly, a comprehensive U-Pb detrital zircon study of 10 different clastic sedimentary units, which were stratigraphically sampled throughout the Sekwi Mountain Project map area, will be used to constrain the age and provenance of the individual sedimentary units. These units may include components from crystalline basement in the region and may also be present as inherited zircon cores in the Cretaceous intrusions. Finally, a small number of xenoliths, which are thought to be derived from underlying crystalline basement, were identified in a ~450 Ma ultramafic lamprophyre pipe termed the Mountain Diatreme. The Mountain Diatreme is one of nearly one hundred such diatremes in the central Mackenzie Mountains, many of which will be sampled for basement xenoliths in the 2007 field season. These will be dated and examined petrographically and geochemically to provide direct evidence for the nature of the Nahanni domain through which the diatremes intruded. Collectively all three studies will provide critical new information regarding the nature of the underlying basement in the Mackenzie Mountains and more broadly the Northern Cordillera.

Initial U-Pb results and preliminary interpretations from the detrital zircon study will be presented.

Development of the northwest Skeena Fold Belt, northwest British Columbia

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The Skeena Fold Belt is a widespread region of deformation with a distribution overlapping that of the Jurassic-Cretaceous Bowser Basin. The marine to non-marine clastic fill of the Bowser Basin is prospective for petroleum exploration; ongoing study of the fold belt serves to improve understanding of potential petroleum systems. The fold belt is structurally dominated by two regional fold sets. Folds trending northwest are most commonly located within the eastern two-thirds of the fold belt, whereas folds trending northeast are dominant in the western third of the fold belt. Normal, thrust, and strike-slip faults have been identified. Structural overprinting has been noted in all areas. Detailed structural mapping has been undertaken in order to resolve the timing relationships between these and other structures, and to develop a general history of shortening.

In the areas studied there are variable types of structural overprinting. The Iskut ridge area shows mappable deflection of north-trending folds by outcrop-scale southeast-trending folds. In the Cartmel Lake area multiple cleavage sets in outcrop and the lack of distortion of map-scale folds by intersecting faults interpreted to be unrelated to area folds suggests overprinting of these structures. The Sweeny Creek area reveals north-trending folds that increase in plunge northward, a result of overprinting by a kilometre-scale syncline. Structures in all three areas are consistent with early generally northwest-southeast shortening, followed by northeast-southwest shortening. Improved understanding of the deformation history of the Skeena Fold Belt has implications for interpreting structure and hypothesized strike-slip movement in adjacent areas of the Canadian Cordillera.

TGI-3 studies, Kananaskis area, southeastern British Columbia

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Kananaskis west half map area (50-51 N, 115–116 W) extends from the Purcell Anticlinorium in the southwest to the Rocky Mountain Front Ranges in the northeast. Major changes occur in the stratigraphic succession across the area: important east-west and north-south facies changes occur in the Cambrian, Ordovician and Upper Devonian sections. Within the Cambrian and Upper Devonian carbonate successions, Mississippi Valley Type Pb-Zn mineralization occurs in hydrothermal dolostone, carbonate breccias and associated shear zones near the facies change from eastern ramp and platform carbonates to western siliciclastic-dominant basin deposits. Over the next 4 years new detailed, multi-parameter, GIS maps at 1:50,000 scale will be produced for Kananaskis west half area, based on new mapping targeted on knowledge gaps and Cambrian and Upper Devonian metallotects, field observations by Dr. G.B. Leech and assistants, and published and unpublished maps.

Fieldwork in 2006 involved mapping in 82J/6, and 11 and preliminary examination of carbonate breccia pipes and related galena/sphalerite prospects in the Upper Devonian Palliser Formation. The pipes were emplaced in middle-ramp carbonates of the Palliser and comprise a core facies of calcite- and dolomite-cemented breccia surrounded by an extensive alteration halo of saddle dolomite. New mapping recognized that a significant thrust fault, locally folded to an east-west trend and placing basinal Middle Cambrian Chancellor Formation over more platformal Middle and Upper Cambrian deposits forms the southern limit of exposure of the Middle Cambrian platform and Eastern Main Ranges in the Canadian Rockies. The mapping led to the discovery of extensive hydrothermal dolostone containing minor sphalerite in the Palliser and a sill-like dioritic intrusion in the Middle Chancellor that contained conspicuous pyrite and pyrrhotite. The intrusion, exposed over an area of 1500 x 500 m, had a sill-like top and caused significant pyritization and contact metamorphism of adjacent Chancellor carbonates and siliciclastics.

Grenvillian Metamorphism and Uncertain Provenance: Preliminary Results of a Geochronological Study of Crustal Xenoliths, Wernecke Mountains, Yukon

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Sensitive High Resolution Ion Microprobe (SHRIMP) dating of very small, complexly zoned zircon crystals from five crustally-derived xenoliths has provided important new information about the tectonic evolution of the northern Yukon. The xenoliths were collected from a narrow ultramafic lamprophyre dyke that crosscuts the weakly metamorphosed carbonate of the Mackenzie Mountains Supergroup in the Wernecke Mountains, Yukon. Three of the xenoliths are kyanite or sillimanite-bearing, garnet-rich paragneisses, which have been partially retrograded. The other two xenoliths have been subjected to extensive retrograde metamorphism/metasomatism that has made the interpretation of their protoliths difficult.

Based on 62 analyses from 49 zircon grains we have made three important findings that shed new light on the crustal evolution of northwestern Laurentia. Three of the xenoliths contain zircon that is characterized by both growth of new zircon rims and recrystallization of older cores at ca. 1270 Ma. This event likely reflects the thermal disturbance at mid-crustal depth associated with the emplacement of ca. 1270 Bear River dykes. One of the highly altered xenoliths contains coarse relict orthopyroxene and zircon characterized by high Th/U ratios typical of igneous zircon. Accordingly, we tentatively interpret this xenolith to be a highly-altered equivalent of the Bear River dykes (part of the Mackenzie dyke swarm) that are scattered throughout much of the study area.

One xenolith contains abundant oscillatory-zoned zircon cores, interpreted to be of igneous origin, that give concordant U-Pb ages ranging from ca. 1500-1600 Ma. The xenolith is dominated by very fine-grained muscovite that defines a fine foliation, and by lenses of apatite commonly pseudomorphed by carbonate. Based on these observations we tentatively interpret this xenolith to be of metasedimentary origin. Zircon crystallized during this interval, informally referred to as North American magmatic gap, are typically regarded as good indicators of non-Laurentian provenance and, specifically, have been linked to Australian sources.

The other significant finding is the identification of a previously unrecognized, ca. 1150 Ma metamorphic event in the Wernecke Mountains that is recorded by three of the xenoliths. The timing of this event is broadly coeval with the Grenville orogeny, a series of mountain-building events worldwide that are thought to reflect the assembly of supercontinent Rodinia. Evidence for a major orogeny along the western margin of Laurentia is lacking, although hints of Grenville-age metamorphism and deformation have been found along much of the length of the Cordillera and along the Arctic margin.

New Geological Mapping and Structural Studies in the Klondike Gold District, Yukon

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Geological mapping and structural studies carried out during 2006 shed new light on the structural evolution of the Klondike Gold District and controls on orogenic gold-quartz veins in the area. The Klondike District was affected by five distinct deformation events. The D_1 and D_2 events produced the strong, sub-horizontal ductile recrystallization fabrics that are characteristic of both the Klondike Schist and structurally underlying Nasina Assemblage but are absent in ultramafic rocks and greenstones of structurally interleaved thrust slices of Slide Mountain Terrane. Intrusive relationships constrain the ages of D_1 and D_2 to Late Permian. A third phase of deformation (D_3) produced NW-trending, NE-verging folds with a strong axial planar spaced cleavage that deform the regional thrust faults. The D_4 event is only locally developed and comprises zones of NW-trending high angle reverse faults and associated kink folds. Finally D5 deformation is represented by high angle normal faults with much gouge development.

D_4 deformation zones are the most common structural setting for gold-bearing quartz veins in the Klondike. Gold-bearing veins are hosted by a wide range of host rocks, including quartz-muscovite schist, quartz augen schist, chloritic schist and quartz monzonitic gneiss. Wall rocks are mineralized only where the veins cut the chloritic schist, producing significant widths of carbonatized, pyritized and sericitized alteration that is locally gold-bearing. Gold-bearing veins occur only in the structurally highest panels of Klondike Schist; no significant amount of gold has yet been discovered in either the greenstones or ultramafic rocks of the Slide Mountain Terrane or in the underlying Nasina Assemblage.

Tectonic significance of the isograd pattern around Kootenay Lake, S.E. British Columbia

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Concentric isograds in the central Kootenay Arc (Omineca Belt, S.E. British Columbia) define a narrow, elongate regional metamorphic ‘high’. Metamorphic grade ranges from the chlorite/biotite zones on the flanks, to the sillimanite zone in the core. Work underway is aimed at understanding the formation of this isograd pattern and implications for the tectonic history of the area.

D1 (mid-Jurassic) resulted in the formation of a large isoclinal westward-closing recumbent fold, which was coaxially refolded around gently-plunging F2 axes (mid-Cretaceous). The dominant (S2) foliation dips gently to moderately-steeply west and is axial planar to overturned F2 folds, with L2 stretching lineations parallel to shallowly-plunging fold axes. The crest of a structural culmination, outlined by a reversal in the plunge of D2 folds and lineations, broadly coincides with the area of highest metamorphic grade.

D3 is manifested in west-side-down shear bands and associated crenulations/folds, mostly in pelitic lithologies. F3 crenulation/fold axes also show a reversal in plunge across the structural culmination, but in contrast to L2/F2 they plunge gently inwards towards the crestal region.

The western (upper) boundary of D3 fabrics coincides, at least in part, with a coeval west-dipping, brittle-ductile normal fault. This fault locally truncates the contact aureole of the Nelson Batholith and juxtaposes the low-pressure (andalusite-sillimanite) aureole against Barrovian (kyanite-sillimanite) rocks. There is a change in $^{40}Ar/^{39}Ar$ mica cooling ages across the fault, from ca.130 Ma in the hangingwall to 50-60 Ma in the amphibolite-facies footwall, suggesting D3 structures developed early in the Tertiary.

In contrast to the western margin, the eastern boundary of the amphibolite-facies belt appears to be gradational, with a steady decrease in metamorphic grade eastward towards the centre of the Purcell Anticlinorium. Similarly, biotite $^{40}Ar/^{39}Ar$ cooling ages increase gradually towards the centre of the Purcell Anticlinorium.

We suggest that early Tertiary (D3) normal faulting/shearing with along-strike variation in displacement is responsible for the concentric isograd pattern, reversal in plunge direction of D2 and D3 structures, and the distribution of cooling ages. Future structural, petrological, and geochronological work will test this hypothesis.

The three 'Windy McKinley' terranes of Stevenson Ridge (115JK), western Yukon

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Rocks assigned to the Windy McKinley Terrane occur in Stevenson Ridge and Kluane map areas of western Yukon. Based on new mapping in Stevenson Ridge area, rocks mapped as Windy McKinley Terrane have been divided into three fault-bound assemblages: 1) a structurally lowest assemblage of muscovite-quartz schist, calcsilicate schist, and minor marble, carbonaceous quartzite and schist, pebble meta-conglomerate and granitic meta-plutonic rocks; 2) an imbricated ophiolitic assemblage of meta-chert, probably intrusive greenstone, leucogabbro, variably serpentinized dunite and harzburgite, and mafic greywacke; and 3) an assemblage of fine-grained clastic and calcareous rocks intruded and variably hornfelsed by voluminous Early Triassic (Mortensen and Israel, 2006) gabbro. Assemblage 1 probably correlates with Yukon-Tanana Terrane. Assemblage 2 more strongly resembles the Chulitna Terrane of Alaska rather than either the Windy or McKinley terranes as originally defined.

Assemblage 3 resembles part of McKinley Terrane, as well as the Aurora Peak and Pingston terranes. These terrane re-assignments have implications for the area's mineral potential.

Folds and thrust faults in metamorphic rocks of the east flank of the Selkirk Fan; a re-interpretation of the Esplanade Thrust

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Northward from Rogers Pass, in the Selkirk Mountains of southeast British Columbia, the east flank of the Selkirk Fan consists of east-verging folds and thrust faults outlined by the Lower Cambrian Hamill Group and the underlying Neoproterozoic rocks equivalent to the Kaza Group and the Mica Creek Succession of the Cariboo Mountains. These were metamorphosed to garnet, staurolite and kyanite grades in the southern limit of the Selkirk – Monashee – Cariboo regional metamorphic complex. The Esplanade Syncline is part of a train of folds with axial planes, and related schistosity, dipping steeply southwest, in a zone immediately northeast of the Selkirk Fan Axis.

The core of the Syncline is occupied by a "grit" bearing unit. If that unit is correlated with grit at the base of the Mica Creek Succession then a thrust fault, the Esplanade Thrust, must lie under the grit and be folded into the Esplanade Syncline. Local shearing below the grit and truncation of marble layers reinforced that interpretation. Re-examination suggests that the "grit"-bearing unit may be younger and lie in normal succession above the marble, semipelite and pelite of the Mica Creek Succession that rims the Esplanade Syncline. The sharp, sheared contacts at the base of the grit, that locally truncate marble layers, may be local erosion surfaces, later sheared.

A thrust fault repeats the west-facing pelite – semipelite (with amphibolite) – marble sequence of the Mica Creek Succession on the slopes northeast of Rogers Pass. The fault continues northward to the west side of the Esplanade Syncline and truncates its west limb. The Syncline does not fold that thrust fault but lies in its footwall.

The staurolite and the garnet isograds cross the thrust fault so obliquely that a unique timing relationship is not revealed. Migmatitic semipelite to the west of the Syncline and of the thrust fault is consistent with the westward increase in metamorphic grade which could, but need not have, been accentuated by post-metamorphic thrust motion. Peak metamorphism overlapped with, and outlasted the time of evolution of schistosity. That schistosity and the peak metamorphic minerals are overprinted by a west-dipping crenulation cleavage.

The Esplanade Thrust, here redefined, carries a sheet in which the Kaza Group equivalents are thin (~1 km) and do not have much grit, over the Esplanade Syncline where grit is more abundant and the succession thicker.

A regionally developed transposition foliation in the Monashee Complex and its tectonic significance

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Transposition foliations at all scales are a common fabric element in gneissic terranes. Transposition develops by isoclinal refolding and dismemberment of earlier planar fabrics. Structures associated with transposition may include low-angle shear band cutoffs, rootless isoclinal folds with extreme attenuation in the limbs, and a prominent stretching lineation. Immature folds initiate with their fold hinge lines parallel to the vorticity vector and will rotate towards and into the stretching lineation orientation if deformation progresses. Continuation of this process may or may not produce sheath folds. The stretching lineation is parallel to the transport direction in monoclinic flow but not necessarily in triclinic flow.

The Monashee Complex comprises a spectacular example of transposition. It is characterized by a regionally persistent shallowly dipping pervasive fabric that formed during at three generations (F1/F2/F3) of isoclinal folding. Kinematic indicators are consistent with an overall top-to-the northeast non-coaxial ductile flow regime. There is an approximate parallelism between a NE-SW trending mineral stretching lineation and mature F1/F2 axes. Immature NE-verging F3 folds initiate with NW or SE plunging axes. Progressive re-alignment of the younger folds towards and into the shear direction is achieved by clockwise and counterclockwise rotation.

A similar kinematic and geometric relationship between early mature folds and the stretching lineation was observed further to the west at Joss Mountain (Johnston et al. 2000) and Mt.Tsuius (this study). These areas represent shallower crustal levels than the Monashee Complex, however the structural similarity between the different structural levels suggests that both areas underwent the same penetrative top-to-the northeast deformation within a coherent tectonic infrastructure (e.g. Johnston et al. 2000; Williams et al. 2006).

The complex-scale geometry is modified by later pervasive ductile and brittle E-W directed extension, as evidenced by the west-side-down Greenbush Lake shear zone (Johnston et al. 2000), brittle N-S oriented transcurrent faulting along the Victor Creek fault (Kruse and Williams 2005), and east-side-down movement along the Columbia River Fault. Together these events have modified and arched the complex into its present horst-like configuration.

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Mid-Cretaceous granitoids in the southwestern Northwest Territories and southeastern Yukon: implications for magma source regions, tectonic setting, and metallogeny

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A comprehensive study of mid-Cretaceous intrusions in the Mackenzie and Selwyn mountains of southwestern Northwest Territories and southeastern Yukon was undertaken to assess the regional metallogenic potential and to better define the source and tectonic setting of the magmatism. The study area comprises the easternmost extent of the Tintina Gold Province (TGP), an elongate band of Cretaceous intrusions characterized by metalliferous and non-metalliferous plutonic suites.

Four plutonic suites of the TGP have been identified within the study area: Tombstone (90-94 Ma), Tungsten (95-99 Ma), Tay River (96-100 Ma), and Hyland (100-106 Ma).

Tombstone suite intrusions are oxidized to reduced, alkaline to subalkaline, meta- to peraluminous (ASI = 0.8-1.16), medium- to coarse-grained, hornblende-biotite-(pyroxene) quartz monzonite, quartz monzodiorite, and granodiorite. Metallogenic associations for Tombstone intrusions in the study area include proximal Pb(Ag)-Zn, Cu, and Sb-Pb-As skarns, as well as proximal Au disseminated in wallrock, distal Pb(Ag)-Zn veins, rare gem (Be-elbaite), and possibly mafic-volcanic-hosted Cu-(Au). Tungsten suite intrusions are very small to small, fine-medium grained, weakly K-feldspar porphyritic (<0.5 cm), reduced, subalkaline, weakly peraluminous (ASI = 1.06-1.20), biotite +/- muscovite-(garnet/tourmaline) monzogranite. Metallogenically, Tungsten suite intrusions are associated with abundant W-Cu-(Zn-Bi-Au-Mo) skarns, as well as distal Pb(Ag)-Zn veins and one gem (Be-emerald) occurrence. A sub-suite, Tay River-Tungsten (96-100 Ma), shares features of both Tungsten and Tay River suites; although these intrusions do not have a significant metallogenic association, they may be associated with proximal Cu or W-Cu-(Zn-Bi-Au-Mo) skarns and distal Pb(Ag)-Zn veins. Tay River suite intrusions are typically very large, oxidized to reduced, sub-alkaline, weakly peraluminous (ASI = 0.98-1.14), medium- to coarse-grained, K-feldspar porphyritic (>1 cm), biotite-hornblende granodiorite. Metallogenic associations for Tay River suite intrusions include proximal Pb(Ag)-Zn or W-Cu-(Zn-Bi-Au-Mo) skarns, and rare distal Pb-(Ag)-Zn manto-style mineralization. Hyland suite intrusions are texturally similar to Tay River suite intrusions but are more strongly peraluminous (ASI = 0.98-1.30), biotite monzogranite and granodiorite.

Trace element discrimination diagrams are inconclusive with respect to granitic magma type (S-, A-, or I-type). Rare earth element primitive mantle normalized profiles* of all the intrusive suites are depleted in high field strength elements (Nb-Ta-P-Ti), and all suites display negative Eu anomalies of varying intensities when normalized to chrondritic values*. Tungsten suite intrusions may be distinguished geochemically from other muscovite-bearing intrusions (Hyland suite) by *Th/U > 1 (resulting in the crystallization of monazite), due to the higher degree of fractionation these intrusions have undergone. Based on the geochronological, geochemical (and isotopic) data combined with a broad spatial association, Tungsten suite intrusions are inferred to represent highly fractionated and crustally contaminated melts originally derived from coeval Tay River suite intrusions.

All four plutonic suites plot as a trend from relatively primitive lithospheric mantle isotopic compositions towards upper crustal isotopic compositions on the epsilon Nd vs. initial Sr ratio plot. There are several possible magma sources consistent with the more primitive isotopic data: (1) multiple partial melting events of immature arc-derived sediments, (2) high temperature partial melting of mafic lower crust (hornblende-bearing), and/or (3) influx of a mantle melt/fluid component. It is likely that a combination of these factors have operated to varying degrees along with AFC processes and local partial melting of middle to upper crust, resulting in the geochemical and isotopic signatures expressed by all four plutonic suites and the broad trend towards more primitive magmas with decreasing age.

*normalized to the primitive mantle (Sun and McDonough, 1989)

Tectonic Setting and Evolution of the Bigmouth Fault, Northern Selkirk Mountains,

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Within the northern Selkirk Mountains of southeastern British Columbia two distinctly different lithostratigraphic, metamorphosed and polydeformed packages of rock are juxtaposed across a boundary termed the Bigmouth fault. Although this boundary is particularly important with respect to interpreting the thermo-tectonic evolution of the region, its nature is poorly understood, and thus, is the focus of this study.

The Bigmouth fault has been interpreted as a normal fault that dips moderately to the southwest, striking roughly parallel the trend of the Selkirk Fan axis, which marks the eastward change from southwest-verging to northeast-verging structures in the southern Omineca belt. Along the trace of the fault the Upper Proterozoic, high-grade rocks (sillimanite plus melt) of the Windermere Supergroup are juxtaposed next to low- to medium-grade rocks of the Lower Paleozoic Lardeau Group and/or Badshot Formation. Locally, the contrast in metamorphic grade is complicated by the contact aureoles associated with the Bigmouth and Adamant plutons. Notwithstanding, geobarometric constraints across the fault have yielded a 2 kbar difference (i.e., ~5 kbar hanging wall, ~7 kbar footwall; Leatherbarrow, 1981). However, these constraints are considered equivocal because they are within error of each other and need to be reassessed using more modern techniques and thermodynamic databases. Even so, the 2 kbar difference appears to broadly agree with estimates of the fault-related throw (~5-7 km) based on the stratigraphic omission of the regionally extensive Hamill quartzite. More recently, work in the region has further exemplified the importance of understanding the nature of the Bigmouth fault. Geochronologic and structural data demonstrate that the fault also represents the boundary between rocks tectonized in the Middle Jurassic (hanging wall, west flank of the Selkirk fan) versus the Cretaceous (footwall, east flank of the fan).

Preliminary results are presented from detailed mapping at three locations along the Bigmouth fault, referred to as Camp 1 (headwaters of Birch Creek, near NW end of BMF), Camp 2 (Mount Medea area, ~20 km southeast of Camp 1), and Camp 3 (northern margin of Adamant pluton, ~15 km southeast of Camp 2). In summary, the mapping clearly shows a southwest-dipping high-strain shear zone separating the Windermere Supergroup from the Lardeau Group. In addition, the presence of voluminous leucogranitic melt appears to be a key characteristic associated with this boundary. At Camp 1, the transposition foliation (S_2) is generally moderately dipping to the southwest. Here, the shear zone is sub-parallel with the S_2 foliation, and was identified by the abundance of tops-to-the-southwest shear sense indicators (SSI; e.g., mantled porphyroclasts, rotated boudins and shear bands) in a melt-laden high-strain zone across the boundary between the Lardeau Group and Windermere Supergroup. . At Camp 2, the transposition foliation (S_2) is near vertical, and strikes to the northeast with subhorizontal stretching lineations, and abundant tops-to-the-northeast SSI's. In contrast, the shear zone related to the Bigmouth fault dips moderately to the southwest, with SSI's that demonstrate the shear zone developed during southwestward-directed shearing that post-dated the development of S_2. Along strike to the southeast, preliminary mapping at Camp 3 indicates that the trace of the Bigmouth fault intersects the northern margin of the Adamant pluton, as evidenced by a highly strained ductile zone that is locally proto-mylonitic to mylonitic. The exact nature of the interaction between the plutonic rocks and the shear zone is yet to be determined and will be the focus of next summer's fieldwork. Future work will also concentrate on refining the spatial, temporal and geologic constraints of this structure and how it fits into the overall tectonic framework of the southeastern Cordillera.

Images of the lithospheric structure beneath the Canadian Cordillera : New results from long-period magnetotelluric studies

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Magnetotelluric (MT) exploration is a geophysical method for remotely sensing subsurface electrical resistivity. This property is sensitive to the presence of fluids, such as partial melts and aqueous, saline fluids. Thus MT exploration gives information that is useful in understanding both the lithospheric composition and tectonics of orogenic belts.

MT data were collected at many locations in the Canadian Cordillera from 1970's to the Lithoprobe transects. These data revealed the presence of widespread fluids at mid-crustal depths in the Southern Cordillera. However, the instrumentation used was not capable of recording the low-frequency signals required for imaging the lower crust and mantle. Since 2003, a new phase of MT exploration in the Canadian Cordillera has been initiated by the University of Alberta. This has used low frequency (long-period) magnetotelluric data that has imaged the lower crust and upper mantle for the first time.

MT data has been collected on a profile extending from Vancouver Island to the Alberta basin. Zones of elevated electrical conductivity in the forearc region were interpreted as zones of fluid released from subducting Juan de Fuca plate. A low resistivity mantle wedge was also observed in the forearc and a free fluid phase is required to explain the electrical properties. Low resistivities were also observed in the upper mantle throughout the backarc and strongly support the hypothesis of a shallow, convecting asthenosphere. This enhanced upper mantle conductivity can be explained by either hydrogen ion diffusion in olivine minerals, or by a few percent partial melting (4%).

The Monashee reflection revisited

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The Lithoprobe seismic section S of the Thor-Odin (T-O) culmination of the Monashee complex (MC), reveals a curved, crosscutting reflection. The trace of the reflection plunges W at its western end where it extends to ~12s. To the E it passes through horizontal and then plunges E to ~2s, where it terminates at the end of the section. This reflection is referred to as the Monashee reflection and it has been interpreted as the subsurface expression of the Monashee décollement (MD) (e.g. Brown et al., 1992; Cook et al., 1992; Carr, 1995). The MD was described as a dome-shaped north-easterly vergent ductile thrust outcropping around the edge of the MC, and separating the MC below, from the Selkirk allochthon (SA) above (e.g. McNicoll and Brown, 1995). Detailed mapping of the MC and lower parts of the SA reveals that both (total thickness > 10 km) are characterised by a transposition fabric (S_T) resulting from northeasterly directed flow. Vergence in the MC is generally to the NE and in the SA changed through time from northeasterly to southwesterly. We have been unable to identify any discrete regional-scale structure with north-easterly vergence, distinct from the general transposition foliation (S_T), that could be considered the MD. There is however, a high-strain zone with a different kinematic history, which occupies a similar position to the interpreted MD. This zone, which we refer to as the Thor-Odin detachment (TOD), wraps around the MC parallel to the trace of S_T, and overprints all other ductile structures including S_T. It can be projected into the Monashee reflection, resulting in a periclinal surface consistent with the overall structure of T-O. At the surface the TOD is characterised by top-to-the-W kinematics on the W flank, top-to-the-E kinematics on the E flank, and horizontal E-W coaxial extension in the closure of the culmination. It is essentially two opposed normal shear zones linked by a zone of extension, and thus indicative of crustal-scale extension. The TOD is a late structure, overprinted only by brittle faults, so that its possible age is consistent with the regional interpretation of Eocene extension. Our efforts have been concentrated mainly on the W flank, since little of the E flank is imaged in the seismic section, and on the W flank, the difference in vergence makes the early S_T and late TOD fabrics most easily distinguished. In addition outcrop is generally better on the W flank.

On the seismic section the Monashee reflection is seen to cut S_T and has the appearance of a ductile shear band such as is seen at various scales throughout T-O. Deflections of S_T at the margins of the shear band are indicative of normal movement and the overall appearance is incompatible with a thrust origin. A second reflection visible in the seismic sections is cut by the Monashee reflection and present only in its hanging wall. This is consistent with normal movement but requires an ad hoc explanation if a thrust is proposed.

Field data collected on the W flank of T-O are consistent with that part of the TOD being a down-to-the-W, normal shear zone. Down-to-the-W shear bands are common, and at the margin of the zone, there is a rapid, but spasmodic, transition from a SW plunging kyanite lineation to a W plunging sillimanite lineation. Maximum pressures determined from rocks W of the TOD are consistently lower than pressures determined for the MC, and the age of peak metamorphism, which generally decreases gradually with depth in the SA and MC, suddenly jumps ~15 My across the TOD.

Preservation of the earlier S_T-related fabric in the TOD suggests that the accumulated TOD-related strain is not large. Pressure differences limit the displacement to between 6 and 15 km and based on the interpreted low strain and lithological similarities, we suspect that the actual displacement is closer to the lower limit.

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(45)