CORDILLERAN TECTONICS WORKSHOP

February 7-9, 2003

Carleton University
Ottawa, Ontario

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DAY 1 - SATURDAY

08:30-09:30 Presentation of posters - Foothills, Foreland belt, Bowser and Sustut basins, etc.

1) Architecture of a paleo-hydrocarbon reservoir; structural geology of the southern Livingstone range anticlinorium
M.A. Cooley, R.A. Price, J.M. Dixon, & T.K. Kyser

2) Geology of the Liard, Kotaneelee and Tlogotsho Ranges, SW Northwest Territories
G.F. Hynes, J.M. Dixon

3) Geology of the northern Foothills Region: Results of the Central Foreland NATMAP Project
L.S. Lane, K.M. Fallas, J.M. Bednarski, I.R. Smith, A.V. Okulitch

4) Structural geology of the Kakwa area, north-central Rocky Mountains and Foothills, British Columbia and Alberta.
M. McMechan

5) Geology and structure of the southern Jasper National Park, based on three recently compiled 1:50,000 scale maps and structure sections
E. Mountjoy, R. Price

6) Dynamics of fold-thrust structures in physical models deformed in a large geotechnical centrifuge
T.E. Noble, J.M. Dixon, S. Pfister

7) Indications for effective petroleum systems in Bowser and Sustut basins, north-central British Columbia
K.G. Osadetz, C.A. Evenchick, L.D. Stasiuk, N.S.F. Wilson

8) Fernie Area (82 G), Alberta and British Columbia
R. Price

9) Early Paleozoic evolution of the Canadian Cordilleran margin of Laurentia: Constraints from regional stratigraphic and biostratigraphic correlations
L.J. Pyle, C.R. Barnes

10) Subsurface investigation of the Muskwa assemblage of northeastern British Columbia and the Fort Simpson Basin of southwest Northwest Territories using a synthetic seismogram created from measured sections
S.M. Siegel

09:30-10:00 Coffee and posters

10:00-12:15 Oral presentations followed by general discussion

10:00-10:25 Architecture of a paleo-hydrocarbon reservoir; structural geology of the southern Livingstone range anticlinorium
M.A. Cooley, R.A. Price, J.M. Dixon, & T.K. Kyser

10:25-10:50 Geology of the Wild Horse area: The southern termination of the Western Ranges Sub-province of the Rocky Mountains, south-east British Columbia
K.P. Larson, R.A. Price

10:50-11:15 Assembly, break-up, and dispersal of the Proterozoic Laurentia-Siberia-Australia Troika
J.W. Sears, R.A. Price

11:15-12:15 General discussion

12:15-14:30 Lunch and poster session

14:30-14:45 Presentation of posters - Yukon

1) A new geological map for Glenlyon and northeast Carmacks areas, central Yukon
M. Colpron

2) Tectonic setting of high-pressure metamorphic rocks of Yukon-Tanana terrane in the Frances Lake area, Finlayson region, southeastern Yukon
F. Devine, S.D. Carr, D.C. Murphy

3) Geochemistry of tectonic significance of amphibolites from the Yukon-Tanana Terrane (YTT), Stewart River, Yukon: Preliminary results
S.J. Piercey, J.J. Ryan, S.P. Gordey, M.E. Villeneuve

4) Petrology and tectonic significance of K-feldspar augen granitoids in the Yukon-Tanana Terrane, Stewart River, Yukon
T.W. Ruks, S.J. Piercey, J.J. Ryan, S.P. Gordey

14:45-16:00 Oral presentations and general discussion

14:45-15:10 Geologic setting, nature, and structural evolution of intrusion hosted, Au bearing quartz veins at the Longline occurrence, Moosehorn Range area, west-central Yukon Territory
N. Joyce

15:10-15:35 Paleogeography of Late Paleozoic volcanic arcs on the western margin of the Ancestral North American craton: an example from the Klinkit Group, northern British Columbia and southern Yukon
R.-L. Simard, J. Dostal, C.F. Roots

15:35-16:00 General discussion

16:00-17:30 Coffee and poster session

DAY 2 - SUNDAY

09:00-09:30 Presentation of posters - southern Omineca and Intermontane belts

1) Stratigraphy and structure of the Mount Copeland area, Southern Omineca Belt, BC
L.T. Bjornson, R. Brown

2) Tectonic Evolution of the Selkirk Fan: A Composite Middle Jurassic - Cretaceous Structure, Northern Selkirk Mountains, Southern British Columbia
H.D. Gibson, R.L. Brown, S.D. Carr

3) Eocene melting of Precambrian lithospheric mantle: analcime-bearing volcanic rocks from the Challis-Kamloops belt of south central British Columbia
J. Dostal, K. Breitsprecher, B.N. Church, D. Thorkelson, T.S. Hamilton

4) Exploring the geochemical link between leucosome of migmatitic basement rocks and the Ladybird granite suite; Thor-Odin Dome, Monashee Complex, southeastern British Columbia
A. Hinchey, S. Carr

5) Significance of extensional structures in the north-east Thor-Odin culmination, Monashee Complex, BC
S. Kruse

6) Structural evolution of migmatites of the Thor-Odin area of the Monashee Complex, southern British Columbia
P.D. McNeill, P.F. Williams

7) The Thor-Odin Dome in the Shuswap Metamorphic Complex and the flow of orogenic crust
C. Teyssier, O. Vanderhaeghe, D.L. Whitney, B. Norlander, A. Fayon, A. Jeanningros, A. Mulch

09:30-10:00 Coffee and posters

10:00-13:00 Oral presentations followed by general discussion

10:00-10:25 Structural evolution of migmatites of the Thor-Odin area of the Monashee Complex, southern British Columbia
P.D. McNeill, P.F. Williams

10:25-10:50 Proterozoic migmatisation in a basement orthogneiss, and Late Cretaceous to Early Eocene monazite ages in cover rocks of Thor-

Odin dome of the Monashee Complex, southeastern British Columbia; a SHRIMP and ID-TIMS study.
Y.D. Kuiper, P.F. Williams

10:50-11:15 Thermotectonic evolution of the Selkirk fan: A composite Middle Jurassic – Cretaceous structure, northern Selkirk Mountains, southeastern Canadian Cordillera
H. D. Gibson, S.D. Carr, R.L. Brown

11:15-11:40 Relationship between multiple phases of Mesozoic deformation and metamorphism in the Cariboo Mountains, Omineca Belt, central British Columbia
L.F. Reid, L.M. Heaman, P.S. Simony, D.R.M. Pattison

11:40-12:30 Links between translation on the Foreland and metamorphism in the Core zone of the Fold and Thrust belt
P.S. Simony, L.F. Reid, S.D. Carr

12:30-13:00 General discussion

13:00-15:00 Lunch and poster session (followed by final discussion period)

Posters
(Listed alphabetically)

1)Stratigraphy and structure of the Mount Copeland area, Southern Omineca Belt, BC.
L.T. Bjornson, R. Brown

2)A new bedrock geology map for Glenlyon (105L) and northeast Carmacks (115I) map areas, central Yukon
M. Colpron

3)Architecture of a paleo-hydrocarbon reservoir; structural geology of the southern Livingstone range anticlinorium
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S.M. Siegel

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10)Links between translation on the Foreland and metamorphism in the Core zone of the Fold and Thrust belt
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Cordilleran Tectonics Workshop Participants

Name	Email Address
Bjornson, Leif	lbjornso@chat.carleton.ca
Carr, Sharon D.	scarr@ccs.carleton.ca
Colpron, Maurice	Maurice.Colpron@gov.yk.ca
Cooley, Mike	cooleym@geoladm.geol.queensu.ca
Demerling, Tina	cdemerling@engineer.com
Devine, Fionnuala	devinefd@yahoo.ca
Dostal, Jarda	dostal@stmarys.ca
Gibson, Dan	dhgibson@ccs.carleton.ca
Hinchey, Alana	arawling@ccs.carleton.ca
Hynes, Glenn	gfhynes@yahoo.ca
Joyce, Nancy	njoyce@nrcan.gc.ca
Kruse, Stefan	q09ay@unb.ca
Kuiper, Yvette	m083p@unb.ca
Lane, Larry	llane@nrcan.gc.ca
Larson, Kyle	larson@students.geol.queensu.ca
Markussen-Brown, Annetta	annettamb@hotmail.com
McCluskey, Lisa	lmcclusk@ucalgary.ca
McMechan, Margot	mmcmecha@nrcan.gc.ca
McNeil, Paul	i4lcz@unb.ca
McNicoll, Vicki	vmcnicoll@gsc.nrcan.gc.ca
Mountjoy, Eric	ericm@eps.mcgill.ca
Noble, Todd	noble@students.geol.queensu.ca, noble@geoladm.geol.queensu.ca
Osadetz, Kirk	kosadetz@nrcan.gc.ca
Piercy, Steve	spiercey@nickel.laurentian.ca
Price, Ray	price@geol.queensu.ca
Pyle, Leanne	lpyle@geol.queensu.ca
Reid, Leslie	lreid@geo.ucalgary.ca
Ruks, Tyler	ty.chris@sympatico.ca
Taylor, Chris	cnataylor@yahoo.com
Teyssier, Christian	teyssier@umn.edu
Thompson, Bob	bothomps@nrcan.gc.ca
Siegal, Samantha	smsiegel@ucalgary.ca
Simard, Renée-Luce	renee_luce@hotmail.com, rsimard@dal.ca
Simony, Philip	simony@geo.ucalgary.ca
Wallace, Ken	shearzone68@yahoo.ca
Williams, Paul	pfw@unb.ca

Stratigraphy and structure of the Mount Copeland area, Southern Omineca Belt, BC.

Leif T. Bjornson and Richard L. Brown
Ottawa-Carleton Geoscience Centre and Department of Earth Sciences, Carleton University

The Monashee complex of southeastern British Columbia is an exposure of high-grade metamorphic basement and cover rocks seen through a tectonic window in the Selkirk Allochthon. Paleoproterozoic paragneiss and orthogneiss comprise the lowest exposed level of the complex. These basement rocks are overlain by, and infolded with, a platformal metasedimentary sequence of clastic, carbonate, and volcanic rocks. The Monashee complex is bounded above by the Monashee décollement, a westerly rooted, northeasterly verging crustal scale zone of ductile shear. The study area is located on the southern flank of Frenchman Cap dome of the northern Monashee complex and has had a long and complex tectonic history. Various interpretations have been proposed for the development of the field area but recent mapping has shown a need for a reinterpretation of the stratigraphy and structure.

Detailed field mapping focussed on the sequence of lithologies and the relation of minor structures. The regional lithology, representing a transposed stratigraphy, in ascending order is migmatitic paragneiss and granitic orthogneiss of the crystalline basement, basal white quartzite, micaceous schist, a mixed unit of dominantly calc-silicate gneiss with minor quartzite and white marble, and micaceous schist. Repetition and inversion of the sequence is attributed to early-stage isoclinal folding (F_1/F_2). A major structural feature, the 'Bews Creek Fault', has been reinterpreted as a lithologic contact although it is adjacent to a zone of ductile strain. Attenuation of lithologic units has occurred but without significant omissions or repetitions. Late stage brittle faulting does not disrupt the sequence or structures. This new interpretation results in a simple lithological sequence and allows for correlation of units across the field area.

Five generations of deformation have been recognized in the Mount Copeland area. Interpretation of the phases of deformation were based on fold classification and preserved interference patterns. Two phases of pre- to syn-metamorphic intrafolial folds are found within the transposed stratigraphy (S_2). Phase one and two folds are represented by Type II and III interference patterns, respectively, from the superposition of later deformation. Phase one deformation has locally resulted in inverted sequences. Phase two deformation is associated with thrust nappes, sheath folds and the dominant transposition foliation (S_2) that occurred under upper-amphibolite facies conditions. Post-peak metamorphic deformation produced kilometre-scale, close to tight, northeasterly verging F_3's that fold the transposed stratigraphy. Late stage F_4's are rarely seen as north-south trending, large, open warps. The final stage of deformation are north-south trending brittle faults of minor displacement.

Vertical cross-sections based on the surface geology, relation of minor structures, and the refined lithologic sequence show an unrecognized three dimensional geometry. The results of this reinterpretation show the subsurface geology is more complex than previously proposed.

A new geological map of Glenlyon and eastern Carmacks areas, central Yukon

Colpron, M., Yukon Geology Program, P.O. Box 2703 (K-10), Whitehorse, YT, Y1A 2C6, maurice.colpron@gov.yk.ca.

Glenlyon and eastern Carmacks map areas extend from displaced North American miogeoclinal strata of Cassiar Terrane in the northeast to the accreted arc volcanic and clastic rocks of Stikine Terrane in the southwest. The core of the area is underlain by a northwest-trending belt of metasedimentary, metavolcanic and (meta)plutonic rocks of the Yukon-Tanana Terrane. Yukon-Tanana Terrane (YTT) southwest of Tintina Fault consists of an extensive basement complex (Snowcap complex) unconformably overlain by Late Devonian – Early Mississippian clastic rocks (Drury and Pelmac formations) and two successions of Carboniferous arc volcanic rocks and their associated plutonic suites (Little Kalzas and Little Salmon). The Snowcap complex consists predominantly of metaclastic rocks and minor marble and amphibolite that are typically metamorphosed to amphibolite grade. These rocks have experienced a more complex deformational and metamorphic history than overlying Late Devonian – Carboniferous strata.

The Snowcap complex is overlain by the Drury formation – a sequence of coarse-grained arkosic grit and quartzite that yielded Late Devonian detrital zircons exclusively. These detrital zircons and the composition of the grit indicate that it was likely derived from a nearby Late Devonian arc source. Quartzite of the Pelmac formation overlies both the Snowcap complex and the Drury formation. It is the most extensive siliciclastic unit in the area and locally contains Early Mississippian volcanic rocks which have alkalic to enriched-MORB geochemical signatures. In the north, the Pelmac quartzite is overlain by calc-alkaline volcanic rocks of the Little Kalzas formation (347-343 Ma). These rocks were deformed and metamorphosed before intrusion of the Tatlmain batholith at ca. 340 Ma. To the south, 340 Ma and younger volcanic rocks of the Little Salmon formation unconformably overlie the Pelmac formation. Conglomerate near the base of the Little Salmon formation contains deformed quartzite clasts and a K-feldspar-crystal grit yielded an Early Mississippian detrital zircon age similar to that of the Little Kalzas plutonic suite to the north. The Little Salmon formation consists of calc-alkaline andesite and volcaniclastic rocks that pass laterally along strike to alkali basalt of within-plate affinity. This is interpreted to indicate rifting of the Little Salmon arc. Zircons from dated samples of YTT ubiquitously have Proterozoic inheritance.

To the southwest, Yukon-Tanana Terrane is juxtaposed with the Semenof Block – a belt of mafic metavolcanic rocks of uncertain terrane affinity – along the Needlerock and Big Salmon faults. Along the southwest edge of the area, rock of the Semenof Block are juxtaposed with Mesozoic volcanic and clastic rocks of Stikine Terrane.

To the northeast, the Tummel fault zone delineates the contact between Yukon-Tanana and Cassiar terranes. The narrow belt of chert, argillite and greenstone which occurs within the Tummel fault zone probably correlates with the Slide Mountain Terrane.

The western part of the area is intruded by large Early Jurassic batholiths. The eastern part of the area is mostly intruded by small Cretaceous plutons. The area is dissected by a series of faults which are inferred to have compound deformational histories. Most faults appear to have an early component of southwest-verging thrusting (Early Jurassic?). They were later re-activated as dextral strike-slip faults (Cretaceous – Early Tertiary ?).

Download a copy of this map (*Open File 2002-9*) and of a preliminary report published in *Yukon Exploration and Geology 2002* from our website: www.geology.gov.yk.ca.

ARCHITECTURE OF A PALEO-HYDROCARBON RESERVOIR; STRUCTURAL GEOLOGY OF THE SOUTHERN LIVINGSTONE RANGE ANTICLINORIUM

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

Geological mapping of the southern Livingstone Range anticlinorium has outlined the array of fault-propagation folds that form the major structures of the area. The cores of the anticlines are occupied by thrust faults that splay from the underlying Livingstone Thrust and whose tip lines maintain the same stratigraphic level and trend parallel to the fold axes. The fault-propagation folds die out along strike where the plunge of the structures steepen, and where they meet lateral tear faults such as the Morin Creek tear fault. Tear faults are transfer faults which accommodate changes in thrust displacement along strike. Three tear faults at Pocket Creek acted as transfer zones for along-strike changes in thrust displacements and have small thrust faults terminating against them: marked changes in stratigraphic thickness occur across these tear faults. A tear fault at Daisy Creek is a steeply-dipping extension fault that developed within the Livingstone thrust sheet, showing evidence for north-south extension in the thrust sheet during thrusting. Two major back-thrusts were observed in the central part of the study area, both of which die out along strike and meet at a branch line with a fore-thrust. The branch lines coincide with the cores of anticlines where there is zero displacement for both faults.

Detailed structural mapping of the Centre Peak Anticline has outlined the system of detachment horizons in the back-limb, duplexes in the fold hinge, abundant small-displacement back-thrusts in the fore-limb, extension faults in the fore-limb, and cross faults in both limbs. Cross faults have a regular spacing of approximately 150 metres and are interpreted to have accommodated along-strike changes in fault displacements for the thrust faults and extension faults within the fold limbs. The cross faults were probably the most significant conduit of the paleo-hydrocarbon reservoir as indicated by the presence of a black hydrocarbon residue in fault surfaces and in the adjacent fractured zone.

Isotope Geochemistry of vein calcite found in the cross faults and in thrust faults indicate that the reservoir was a closed system. Meteoric isotopic signatures of calcite veins in all thrust faults indicates that meteoric waters were migrating up the thrusts. The formation-fluid isotopic signature of calcite veins from cross faults indicate that once fluids flowed into these cross faults they stayed there. The different isotopic signatures of the cross fault veins and the thrust fault veins indicates that the meteoric fluids migrating along the thrusts were not flushing through the cross faults, which would also have flushed out hydrocarbons or formation fluids.

Tectonic setting of high-pressure metamorphic rocks of Yukon-Tanana terrane in the Frances Lake area, Finlayson region, southeastern Yukon

Fionnuala Devine[1], Sharon D. Carr[1], Donald C. Murphy[2]
[1]Ottawa-Carleton Geoscience Centre, Department of Earth Sciences, 1125 Colonel By Drive, Carleton University, Ottawa, Ontario
[2]Yukon Geology Program, Yukon Government, Box 2703 (K-10), Whitehorse, Yukon

High-pressure metamorphic rocks and their host rocks that occur along the eastern margin of Yukon-Tanana terrane (YTT) are exposed in the Frances Lake area of the Finlayson region, and form the focus for M.Sc. thesis research. The study area comprises polydeformed and variably metamorphosed Paleozoic arc rocks and sedimentary packages of YTT that were thrust over the North American continental margin in the late Paleozoic.

In the Frances Lake area, a coarse-grained schist may represent a retrograded eclogite, and is structurally imbricated with greenschist-facies metasedimentary and metavolcanic rocks. The geological setting of this unit within the project area is similar to that of other eclogite occurrences in the Yukon. Mapping at 1:20 000 scale will determine the structural setting of this unit and establish the characteristics of the lithotectonic package that hosts it.

Blueschists and eclogites along the YTT-North American boundary have both Early Permian (U-Pb zircon and ^{40}Ar-^{39}Ar white mica) and Mississippian (^{40}Ar-^{39}Ar white mica) ages. The timing of high-pressure metamorphism in the Frances Lake rocks will be determined using U-Pb geochronology techniques, and ^{40}Ar-^{39}Ar methods on white mica will be used to determine the timing of denudation and cooling. The protolith of these rocks will be investigated by comparing lithogeochemical data with published data for other Finlayson region rock types. Petrographic studies and P-T investigations of suitable samples will provide insight into the metamorphic history of these rocks. Detrital zircon studies will constrain the provenance of metasedimentary rocks in the area.

Research is designed to elucidate the protolith ages, structural setting, and the metamorphic and thermal history of the area; this will help constrain the tectonic history of the YTT, and its accretion to North America.

Eocene Melting of Precambrian Lithospheric Mantle: Analcime-bearing Volcanic Rocks from the Challis-Kamloops Belt of south central British Columbia

J. Dostal, Department of Geology, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, jdostal@smu.ca; K. Breitsprecher, Department of Earth and Ocean Sciences, University of British Columbia, British Columbia V6T 1Z4; B.N. Church, Geological Services Consultant, 600 Parkridge Street, Victoria, British Columbia V8Z 6N7; D. Thorkelson, Department of Earth Sciences, Simon Fraser University, Barnaby, British Columbia V5A 1S6; T. S. Hamilton, Department of Chemistry and Geoscience, Camosun College, Victoria, British Columbia V9E 2C1

Potassic silica-undersaturated mafic volcanic rocks form a minor portion of the predominantly calc-alkaline Eocene Challis-Kamloops volcanic belt, which extends from the northwestern United States across British Columbia (Canada) to the southern Yukon. A major occurrence is in the Penticton Group in south-central British Columbia where they underlie a cumulative area of about 600 km^2 and reach a thickness of up to 500 m. These analcime-bearing rocks (~53-52 Ma old) are typically rhomb porphyries of ternary feldspar (An_{28} Ab_{52} Or_{20}). Additional phenocryst phases include clinopyroxene, analcime, phlogopite and rare olivine. The rocks with SiO_2 mostly in the range of 50 to 55 wt.%, are characterized by high total alkalis (>9 wt.%), particularly K_2O (>4.5 wt.%). Their mantle-normalized trace element patterns are distinctly enriched in large-ion-lithophile elements including Ba (3,500-6,000 ppm) and Th (40-60 ppm), and in light REE relative to heavy REE and high-field strength-elements, accompanied by negative anomalies for Nb and Ti. Their initial $^{87}Sr/^{86}Sr$ ratios (~ 0.7065) are elevated but relatively uniform whereas ε_{Nd} (~ -7.6 to - 4.3) is nonradiogenic and closer to EMII mantle component than other rocks of the Challis-Kamloops belt. The potassic silica-undersaturated rocks overlie Precambrian crust and lithosphere but their high content of incompatible trace elements is not due to crustal assimilation. It is proposed that the source of these mafic rocks was ancient metasomatized subcontinental mantle lithosphere, which was modified in a Precambrian subduction setting. These Early Tertiary magmas formed above the southern edge of the Kula plate adjacent to the Kule-Farallon slab window. Upwelling of the hotter asthenospheric mantle may have been the thermal trigger necessary to induce melting of fertile and metasomatized lithospheric mantle.

Thermotectonic evolution of the Selkirk fan: A composite Middle Jurassic – Cretaceous structure, northern Selkirk Mountains, southeastern Canadian Cordillera

H. Daniel Gibson, Sharon D. Carr, and Richard L. Brown

Ottawa-Carleton Geoscience Centre and Department of Earth Sciences, Carleton University, 1125 Colonel By Drive, Ottawa, ON, K1S 5B6. Emails: dhgibson@ccs.carleton.ca; rlbrown@rideau.net; scarr@ccs.carleton.ca

In the southeastern Canadian Cordillera a zone of structural divergence marks the transition from the ductile deformation, metamorphism and plutonism of the Omineca belt to the "thin-skinned" deformation of the Foreland belt. Understanding the development of this zone is fundamental to elucidating the transition from hinterland to foreland tectonics in the Cordillera. In the northern Selkirk Mountains of southeastern British Columbia a divergent, km-scale structure termed the Selkirk fan strikes SE-NW for more than 120 km, consists of low- to high-grade metamorphic rocks, and comprises at least three generations of superposed structures. Southwest verging, second generation folds (F_2) with shallow dipping axial surfaces (S_2) dominate the west flank of the fan. To the east of the fan axis second (F_2) and third generation folds (F_3) are northeast verging, and become increasingly overturned eastward toward the Rocky Mountain Trench. The kinematic development of the Selkirk fan has been the focus of considerable debate, but most researchers concluded that fan formation occurred primarily during Middle Jurassic time. New U-Th-Pb geochronologic data obtained by Isotope Dilution Thermal Ionization Mass Spectrometry (IDTIMS) and Sensitive High Resolution Ion Microprobe (SHRIMP) analyses point to a more complex and protracted origin for the fan, requiring significant revision of previous models. The data demonstrate that the thermo-structural development and exhumation of the west flank of the fan occurred principally in the Middle Jurassic (ca. 172-167 Ma). In contrast, east of the fan axis significant Cretaceous deformation (104-84 Ma) and Cretaceous to Paleocene metamorphism (144-56 Ma) were superimposed on an early transposition fabric. This was followed by or partly concomitant with Late Cretaceous to Early Tertiary exhumation. Thus, the Selkirk fan is a composite structure rather than a singular fan that developed during one progressive event. A tectonic model is proposed in which the Selkirk fan developed within a critically tapered orogenic wedge that evolved diachronously in response to changing boundary conditions associated with periods of terrane accretion on the western margin of North America.

During the Early to Middle Jurassic accretion of the Intermontane superterrane, a proto-F_{1-2} fan developed above a singularity where oceanic or marginal basin lithosphere was subducting eastward beneath continental lithosphere. Southwest verging structures developed within the prowedge immediately followed by development of northeast vergent structures in the retrowedge. Subsequently, the fan decoupled along a basal décollement system and was transferred northeastward, as rocks to the east were progressively incorporated into the orogenic wedge. The mid-Cretaceous (ca. 100 Ma) accretion of the Insular superterrane resulted in the rejuvenation of compressional forces acting upon the orogenic wedge. Out-of-sequence thrusting (e.g. Purcell thrust) and folding (F_{2-3}) served to thicken the tectonic pile, thus re-establishing critical taper and continued deformation in the foreland. This would explain the development of mid- to Late Cretaceous (ca. 104-81 Ma), northeast vergent F_3 folds found primarily in the east flank of the fan. At this time, the east flank of the fan was uplifted and exhumed relative to the western flank, bringing up deeper-seated rocks that were significantly tectonized in the mid-Cretaceous.

Exploring the geochemical link between leucosome of migmatitic basement rocks and the Ladybird granite suite; Thor-Odin Dome, Monashee Complex, southeastern British Columbia.

Alana Hinchey and Sharon Carr
Ottawa-Carleton Geoscience Center, Department of Earth Sciences, Carleton University, Ottawa, Ontario, K1S 5B6
arawling@ccs.carleton.ca

The Monashee Complex is part of the southern Omineca Belt and comprises three components; basement orthogneisses and paragneisses, and cover rocks. It contains two structural culminations, Frenchman cap in the north and Thor-Odin in the south. Thor-Odin of amphibolite-facies polydeformed, migmatitic, Paleoproterozoic, para- and orthogneiss. The rocks are the deepest exposed structural level in the Omineca belt and were exhumed by Eocene extensional faults. .

The tectonic activity in the area produced several distinct episodes of crustal anatexis, producing abundant migmatites. The rocks of Thor-Odin preserve four generations of structures that predate Eocene extension, and at least two generations of migmatites. Identifying, characterizing and dating these events is critical for understanding the Proterozoic and Mesozoic to Early Tertiary geological history of the area, and for testing tectonic models. It has been suggested that the melt leucosome in migmatites may have been the source of the late Paleocene to Early Eocene Ladybird granite suite.

Petrology of the aplitic veins of melt leucosome within the migmatites from the Saturday and Frigg glacier areas are similar. Compositions are typically plagioclase - quartz - potassium feldspar - biotite ± muscovite. Zircon forms accessory phases in some samples. Thin section textures of aplitic leucosome preserve both igneous and metamorphic textures. Granoblastic texture is common, while quartz surrounding tabular plagioclase is also observed. Quartz grains often display undulose extinction.

The major element chemistry of leucosome is characterized by ranges of SiO_2 from 70.1 to 75.0%, Al_2O_3 from 12.0 to 14.9% and K_2O from 1.2 to 7.2 %. The primitive mantle-normalized spider diagrams display some variations; all samples characteristically exhibit enrichments in LREE, Rb, and Sr, with marked depletions in Ti and negative Nb-Ta. Initial sampling of granites of the Ladybird suite display little variation in major element chemistry with ranges in SiO_2 from 72.5 to 72.7%, Al_2O_3 from 13.9 to 14.2% and K_2O from 4.8 to 5.3 %. The trace element chemistry also shows little variation. The primitive mantle-normalized spider diagrams exhibit enrichments in LREE, Rb, Ba, and Nd with marked depletions in Ti and a negative Nb-Ta anomaly. The trace element signature of the Ladybird granite suite indicates a strong correlation with that of the melt leucosome from Saturday and Frigg glacier. This supports the hypothesis that the migmatites from Thor Odin may be the source melt for the Ladybird granite suite.

Geology of the Liard, Kotaneelee, and Tlogotsho Ranges, SW Northwest Territories

G.F. Hynes* and J.M. Dixon
Department of Geological Sciences
Queen's University
hynes@students.geol.queensu.ca

The Liard, Kotaneelee and Tlogotsho Ranges lie within the southern Franklin Mountains of the southwestern Northwest Territories. In the study area, the ranges display a marked change in structural trend from northwest – southeast in the south to north northeast – south southwest in the north.

Geological mapping in the summer of 2002 documented several large-scale structures in the field area. In the southwest part of the map, the north – south trending Kotaneelee Anticline terminates as west-stepping en echelon box folds develop and trend north into the Etanda Dome. The western hinge-line of the westernmost fold swings northwest into the dome as the eastern hinge-line gently turns to the north – northeast and dies out in the central part of the map area. An asymmetric box fold is present in the northwest portion of the map area. The fold trends northeast-southwest with the southeastern limb dipping from 4 to 35° and the northwestern limb dipping 35°. A northwest-verging thrust fault in the Tlogotsho Range places the Prophet Formation on top of the Middle Mattson Formation. The estimated stratigraphic displacement is on the order of 650 – 750 m. An east-verging thrust fault was mapped in the Liard Range. The fault places Flett Formation limestone above Lower Mattson sandstone. The fault is interpreted to terminate southward in the hinge of an east-verging fold while the northern extent of the fault is difficult to determine due to lack of outcrop.

Physical analogue modeling, seismic interpretation and cross-section balancing will be used to investigate the possible causes of the change in structural trend of the Liard, Kotaneelee and Tlogotsho Ranges.

GEOLOGIC SETTING, NATURE, AND STRUCTURAL EVOLUTION OF INTRUSION-HOSTED AU-BEARING QUARTZ VEINS AT THE LONGLINE OCCURRENCE, MOOSEHORN RANGE AREA, WEST-CENTRAL YUKON TERRITORY

By Nancy Joyce

The Longline gold occurrence is located within the Tintina Gold Belt, in the Moosehorn Range area of west-central Yukon Territory. Gold occurs in sheeted, high-grade (~30 g/t), shallowly dipping mesothermal quartz veins hosted within mid-Cretaceous intrusions of the Dawson Range batholith.

Felsic to intermediate intrusions in the Moosehorn Range area are probably closely related; they were emplaced at ~96-100 Ma, and have similar geochemical and lead isotopic compositions. Geochemistry of the intrusive phases suggests the magmas were mantle-derived, subduction-related, and extensively contaminated by continental crust. The gold-bearing quartz veins post-date all of these intrusions and are cut by younger mafic dykes.

Metallic minerals inside the veins include galena, sphalerite, arsenopyrite, pyrite, boulangerite, tetrahedrite, native gold, and scheelite. The alteration assemblage includes muscovite, sericite, iron carbonate, pyrite, arsenopyrite, minor clay, quartz, and tourmaline. Vein minerals precipitated from moderately saline fluids, containing H_2O-CO_2-CH_4-NaCl ± N_2, at temperatures of ~260°-300°C, pressure of ~1.3 – 1.9 kbar, and depth of 5-7 km, assuming near-lithostatic fluid pressures. Lead isotopic studies indicate the Moosehorn Range area intrusions are not the source of the metals in the veins and the ultimate source remains uncertain.

The veins were emplaced between 92 and 93 Ma along NNW-striking, shallowly ENE-dipping brittle reverse fault structures during a WSW-verging contractional event. The veins are 1cm to 1m thick, sheeted, lens-shaped, banded, and locally connected by sub-horizontal dilational oreshoots, creating a ramp-flat geometry. The long axis of the oreshoots is NNW and slip along the reverse faults was up-dip towards the WSW.

Regional structural context for the formation of the veins is unclear. Prominent NNW-trending topographic and magnetic lineaments in the area may be dextral strike-slip faults along which there may be contractional and dilational jogs. Contraction at a jog in the vicinity of the Longline property may have generated the structures that host the veins. If so, dextral strike-slip faults and associated contractional and/or dilational jogs may be an important exploration guide to finding other shallowly dipping auriferous quartz vein systems in the region.

Significance of extensional structures in the north-east Thor-Odin culmination, Monashee Complex, BC.

Stefan Kruse
University of New Brunswick, Dept. of Geology,
PO Box 4400, E3B 5A3

Extensional structures in north-east Thor-Odin are evaluated to determine whether or not they are compatible crustal extension. Two sets of structures, early shear bands and late brittle faults are potential candidates to accomplish crustal extension due to late orogenic collapse.

Ductile shear bands exhibiting down-to-the-south (normal sense) movement are ubiquitous throughout the study area. These shear bands result in thinning and extension locally, but were probably not produced by overall crustal extension. Characteristics of the shear bands include i) common orientation with F_3 axial planes, ii) sillimanite zone metamorphism (consistent with metamorphism during D_3) and iii) shear bands are locally reoriented by top-to-the-northeast non-coaxial shear. This suggests that the shear bands may have developed during D_3 deformation as accommodation structures for the pure shear component of the general non-coaxial flow. Alternatively, if the shear plane was not parallel to the main foliation during deformation, shear bands of this nature would be expected to develop.

Three sets of brittle faults are common throughout the study area with the following characteristics i) strikes to the NNW, NE and ENE respectively ii) lower temperature (with respect to earlier structures) epidote, prehnite and chlorite mineralization, and iii) brittle behaviour in quartofeldspathic rocks and brittle-ductile behaviour in calc-silicates. The NE striking set exhibits oblique dextral-normal movement where the transcurrent component is greater than the normal component. The tectonic significance of the brittle faults is still under investigation. They may or may not be related to crustal extension and late orogenic collapse.

Proterozoic migmatisation in a basement orthogneiss, and Late Cretaceous to Early Eocene monazite ages in cover rocks of Thor-Odin dome of the Monashee Complex, southeastern British Columbia; a SHRIMP and ID-TIMS study.

Yvette D. Kuiper and Paul F. Williams
Department of Geology, University of New Brunswick, Fredericton, N.B., E3B 5A3 (kuiper@unb.ca)

Paleoproterozoic deformation and metamorphism in the Monashee Complex, has only been recognised previously in the northern dome (Frenchman Cap) of the Monashee Complex. Evidence is presented here for Paleoproterozoic migmatisation in basement rocks of the southern, Thor-Odin, dome. U-Pb ID-TIMS zircon and monazite, and SHRIMP zircon analyses were carried out on a basement migmatitic orthogneiss. It has a protolith age of ~2.1 Ga, based on an array of data from domains with concentric or sector zonation. The migmatisation age is ~1.8 Ga, the upper intercept age of a discordia chord through data of overgrowths, that are surrounding the zoned domains and that do not show internal structures. The lower intercept age of the discordia chord is 52 Ma, the same as the ID-TIMS age from reversely discordant monazite data. Dissolution rims between the ~1.8 Ga Ma overgrowths and the 52 Ma overgrowths provide evidence for dissolution of zircon sometime between ~1.8 Ga and 52 Ma.

Monazite from two pelitic schists have been dated by U-Pb ID-TIMS and SHRIMP methods in order to constrain the age of metamorphism in Thor-Odin. Monazite ages are between ~70 and 50 Ma. Additionally, upper intercept ages of discordia chords through ID-TIMS data indicate the presence of older, Paleoproterozoic (?), Pb, which may indicate the presence of older cores. However, these could not be found by electron microprobe or SHRIMP methods. Alternatively, an old (Paleoproterozoic?) monazite may have lost Pb, e.g. by recrystallisation, and some old radiogenic Pb may have remained in the monazite. The older Pb may either indicate an earlier, Paleoproterozoic (?), metamorphic event or the age of detrital monazites.

The ~70-50 Ma monazite and zircon ages are interpreted as being a result of fluid-assisted growth and recrystallisation, driven by crustal extension, based on a stable isotope study. Amphibolites with $^{40}Ar/^{39}Ar$ dates younger than ~75-70 Ma experienced the most ^{18}O- and D-depletion. These ages are interpreted as being a result of complete or partial Ar-loss in the presence of meteoric fluids. Non-igneous U-Pb accessory phases, younger than ~75-70 Ma, may then have grown during crustal extension in the presence of fluids. If correct, then Cordilleran metamorphism must have occurred before ~75-70 Ma, perhaps in the Middle Jurassic and/or mid-Cretaceous, as in structurally higher rocks that are presently surrounding the Monashee Complex. However, such ages, or any ages between the Paleoproterozoic and ~75-70 Ma, have not been reported in the Monashee Complex.

If, during deformation and metamorphism, partial or complete dissolution of existing U-Pb accessory phases occurred (as occurred in the migmatitic orthogneiss sometime between ~1.8 Ga and 52 Ma), it is possible that a deformation and/or metamorphic event is not recorded by minerals used for U-Pb dating. No evidence is preserved if no growth of U-Pb accessory phases occurred and if Pb loss in existing minerals was incomplete or absent. It is possible that rocks of the Monashee Complex were at deep structural levels during Middle Jurassic and/or mid-Cretaceous deformation and metamorphism, and that the rocks were too hot for U-Pb accessory phases to crystallise. Dissolution may have occurred instead. Crystallisation of minerals like zircon and monazite may not have occurred until the rocks cooled, e.g. during extension.

This study shows that even by using in situ dating methods, it may be impossible to date specific deformation and/or metamorphic events if no U-Pb accessory phases grew and if Pb loss in existing minerals was incomplete or absent.

Geology of the northern Foothills Region: Results of the Central Foreland NATMAP Project.

Lane, L. S., Fallas, K. M., Bednarski, J. M., Smith, I. R., and Okulitch, A. V.
Geological Survey of Canada
3303 - 33 St, NW, Calgary Alberta, T2L 2A7

In 2002, the Central Foreland NATMAP Project completed its final year of fieldwork. In the northern Liard Basin, 12 new bedrock geological maps at 1:50,000 scale are published or in production; of these 7 are substantially in the Yukon and 5 are in the NWT. New compilations of the Fort Liard (NTS 95B) and La Biche River (NTS 95C) 1:250,000 scale maps, and a project-wide compilation map at 1:500,000 scale will follow. The southern transect through Trutch (NTS 94G) produced 8 new detailed bedrock maps, and a new regional compilation. More formal publications including fully functional GIS products are also in the compilation and production stream. These products, available on CD-ROM, contain georeferenced interactive maps supported by a relational database containing lithological, structural and sample data from each outcrop, as well as generalized polygon data.

The effects of structural inheritance are apparent both within and between transects. In the northern transect, detailed mapping has clarified the geometry of apparently sinuous structural trends, as being the result of interference between northwest and northeast trends. These interference patterns probably result from the influence of early Paleozoic facies transitions. Whereas the reconnaissance maps inferred numerous thrust faults, our detailed mapping has shown that most of these structures consist of sharp-hinged box folds. Updated stratigraphy includes more detailed resolution of stratigraphic units throughout the Paleozoic, Triassic, Cretaceous and Tertiary. Within the southern transect, stratigraphic thickness and facies trends as well as abrupt changes in structural trends reflect the tectonic inheritance of Proterozoic and Late Paleozoic structures. The southern transect differs from the northern transect in the scale and orientation of structures, and in the thickness and preservation of stratigraphic units.

Surficial geological mapping in the southern transect has produced a 1:250,000 scale Open File map and a detailed drift geochemistry report on CD-ROM. These document the regional landslide history and the interaction between Laurentide, Cordilleran and local montane glaciers during the Late Wisconsinan. In the northern transect, compilation is also underway on an additional twenty 1:50,000 scale maps (Fort Liard 95B and La Biche River 95C). Eight 1:100,000 scale A-series maps of the two map areas will be published. In addition, a new hybrid geological map is available for some areas, which shows landslide areas on a bedrock geology base. These permit an immediate visual correlation between areas of high landslide activity and individual geological units, and the identification of regions prone to future failure.

This study also demonstrates a complete inundation of the landscape during the last glaciation. This represents a considerable increase in elevation (ice above 1800 m) and western extent (>80 km) of Laurentide ice than was previously recognized. Glacial flow histories will be utilized in interpreting regional drift geochemical surveys, the final samples for which have been submitted for analysis. Assessment of aggregate resources is also being undertaken, with the aim of facilitating future land use decisions in the area.

Geology of the Wild Horse Area: The southern termination of the Western Ranges Sub-Province of the Rocky Mountains, south-east British Columbia

Kyle P. Larson and Raymond A. Price
Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, Ontario, K7L 3N6

The Wild Horse River (WHR) area of southeastern British Columbia has the potential to provide critical new insights on the tectonic evolution of a complex segment of the Cordilleran miogeocline and of the Cordilleran foreland thrust and fold belt. The area is host to conspicuous and enigmatic contrasts in Cambrian stratigraphy between two structural panels with opposing vergence, anomalous mafic volcanics within Cambrian and Ordovician miogeoclinal strata, a puzzling steep transverse fault, and several small, post-kinematic(?), mid-Cretacous(?), granitic plutons that may lead to better dating of the local thrusting and folding.

The WHR area extends westward from the western part of the Porcupine Creek anticlinorium (Western Main Ranges sub-province of the southern Canadian Rockies), across a zone of west-verging back thrusting and folding, into east-verging structures of the Lussier River thrust sheet (Western Ranges sub-province of this part of the southern Canadian Rockies). The Western Main Ranges sub-province contains a thick succession of lower Cambrian to Ordovician, shaly, miogeoclinal strata, which include the anomalous mafic volcanic rocks. The Lussier River thrust sheet contains a condensed Cambrian to Ordovician miogeoclinal succession in which the thick mid-Upper Cambrian (to Lower Cambrian?) shaly miogeoclinal rocks are supplanted by a carbonate unit (Jubilee Dolomite). The southern boundary of the WHR area coincides with the Boulder Creek fault, a puzzling, steeply north-dipping, transverse fault with apparent normal slip. The Boulder Creek fault is a local component of the Crowsnest Pass Cross-Strike Discontinuity, a regional northeast-trending structural and tectono-stratigraphic feature that is marked by an abrupt change in the orientation of the entire foreland thrust and fold belt. The discontinuity also coincides with a 220-km right-hand shift in the locus of the boundary between the Cordilleran miogeocline and the cratonic platform southwestward from the southern Rocky Mountain of southeastern B. C. to the Selkirk Mountains of northeastern Washington.

Detailed mapping and structural and stratigraphic investigations in the WHR area will focus on: (1.) the nature and significance of the mafic volcanic rocks, (2.) the southern termination of the Paleozoic rocks in the Lussier River thrust sheet, (3.) the structural and stratigraphic relationships between the Lussier River thrust sheet and the Porcupine Creek anticlinorium, (4.) the age and regional tectonic implications of the granitic plutons, and (5.) the nature and regional tectonic significance of the Boulder Creek fault.

Structural geology of the Kakwa area, north-central Rocky Mountains and Foothills, British Columbia and Alberta. Margot McMechan, Geological Survey of Canada- Calgary; mmcmecha@nrcan.gc.ca

The structural geology of the Rocky Mountain fold and thrust belt between latitudes 53°45' N and 54°30' N and longitudes 119°W and 121° W is portrayed in a 1:125 000 scale compilation of twelve 1:50 000 NTS sheets, and on seven balanced cross sections constrained by surface geology, well data and, east of the Front Ranges, seismic interpretation. Fold and thrust belt deformation occurred in the Late Cretaceous to Early Eocene (approx. 89 - 55 Ma). Structural style was influenced by the competency of the deforming strata, and locally by pre-existing features formed during Neoproterozoic, Cambrian and Devonian extension. Uppermost Cretaceous and Tertiary clastic strata are exposed in the core of the Alberta Syncline. The northeastern limit of Cordilleran deformation that underlies its west limb changes in structural geometry from a folded west-vergent, upper detachment overlain by passively folded roof strata in the north to inner and outer tectonic wedges with emergent, west-vergent faults in the south. Jurassic and Cretaceous clastic strata form the dominate level of exposure in the Foothills. Box and chevron folds dominate the surface structural style with detachments at five different stratigraphic levels (Fernie, Gorman Creek, Shaftesbury, Kaskapau, Puskwaskau) locally separating folds of different wavelengths and amplitudes. A thrust belt of small to moderate (<10 km) displacement thrust faults carrying Middle Cambrian to Triassic strata underlies the exposed fold belt. Commonly some of the thrust displacement feeds into the Jurassic and Cretaceous detachments. This has resulted in local chevron folded thrust faults, and small stratigraphic separation and laterally discontinuous thrust fualts at surface. Only the Muskeg thrust with its late (out of sequence) displacement is laterally continuous.

Upper Paleozoic and Triassic strata form the dominant level of exposure in the Front Ranges. In most of the area these strata form a series of faulted folds enhanced by detachments in Upper Devonian (Perdrix) and Carboniferous (Banff) shales. These strata have been brought to surface by moderate displacement surfacing or nonsurfacing thrust faults that carry a thick lower Paleozoic section. The Rocky Mountains structural division consists of two large thrust sheets: the Mount St. George and the overlying Snake Indian thrust sheet. Both thrusts are folded by underlying thrust structures. Thick compentent lower Paleozoic strata form broad folds or thrust-parallel homoclines cut by subsidiary thrust faults and later normal faults. Underlying, cleaved Neoproterzoic strata are faulted and disharmonically folded with wavelength and amplitudes much smaller than folds in the overlying Lower Cambrian quartzite. Local east-west trending structures in the Mount St. George thrust sheet are interpreted to reflect Neoproterozoic and Cambrian extension structures (see McMechan, BCPG, v. 38A, p. 36-44) . A zone of closely spaced strike-slip and oblique-slip faults with an estimated 80 km displacement representing the southern extension of the Northern Rocky Mountain Trench fault zone crosses the western part of the Rocky Mountains. Strike slip faulting began after the initial movement on the Snake Indian thrust and occurred concurrently with fold and thrust belt deformation (see McMechan, CJES, v. 37, p. 1259-1273). The Snake Indian thrust is the major displacement thrust fault in this segment of the Rocky Mountain fold and thrust belt with a poorly constrained estimated displacement of 30 km. Balanced cross-sections indicate approximately 60 km of shortening occurred east of the Snake Indian thrust.

STRUCTURAL EVOLUTION OF MIGMATITES OF THE THOR-ODIN AREA OF THE MONASHEE COMPLEX, SOUTHERN BRITISH COLUMBIA.

MCNEILL, Paul D., and WILLIAMS, Paul F.,
Dept.of Geology, Univ of New Brunswick, PO Box 4400, Fredericton, E3B 5A3, Canada

The rocks of the Monashee Mountains of southern British Columbia record a complex geological evolution that began in the Palaeoproterozoic and ended in the Tertiary. At a minimum, the tectonic history of the area appears consistent with three basic events: The development of basement gneiss through an unknown tectonic event, a period of convergence presumably related to the early development of the Cordilleran orogen and a period of extension apparently related to the development of a dome. Recent studies have demonstrated at least six generations of structures which are regional in extent as well as associated classic migmatite structures.

A complete range of metatextite to diatextite can be demonstrated within the area of Thor-Odin and divided into a minimum of three structurally distinct migmatite generations. The first generation predates all recognizable generations of structures, both regional and local and is unrelated to Cordilleran orogenesis; it is recognized only within the basement gneiss. The second generation of migmatite postdates a Proterozoic to Paleozoic (?) regional unconformity and either predates or is synchronous with the early structural development of the orogen; it is recognized within both the basement and the cover gneiss. The third generation of migmatite is broadly coeval with the late structural development of the orogen (the formation of a dome); it is recognized in both the basement and cover gneiss.

These structural and migmatite relationships have implications for the tectonic evolution of the area. First, the fabric that is domed is a gneiss that is developed previous to the formation of the domal geometry. Second, the geometry of the Thor-Odin area can be explained in terms of large scale fold interference patterns resulting in a basement high. Third, anatectic structures are not limited to the late tectonic evolution of the area suggesting that the role of melting in the tectonic evolution may be passive.

Geology and structure of southern Jasper National Park, based on three recently compiled 1:50,000 scale maps and structure sections.

Eric Mountjoy, Department of Earth and Planetary Sciences, McGill University ericm@eps.mcgill.cal and Ray Price, Department of Geological Sciences, Queens University, Kingston ON price@geol.queensu.ca

The poster display comprises a set of three recent 1:50,000-scale geological maps and accompanying balanced cross-sections [George Creek GSC Map 1990A (2002), Southesk GSC Map 1924A (in press), and Athabasca Falls, GSC Map 2007A (in press)]. These portray the structure of the Foothills, Front Ranges, and eastern Main Ranges in an east-west strip across the southern Canadian Rockies between longitude 116° 30 and 118°00, and latitude 52°30 and 52°45).

Balanced structure sections 15, 16 and 17 show that the Bighorn/Nikanassin thrust sheet originated about 10 to 15 km west of the present surface trace of the Simpson Pass thrust, and that the minimum net displacement across the outer Foothills Belt is about 50 km. Sections 16 and 17 show that the total displacement across the Foothills and Front Ranges is about 100 to 120 km, and that almost half of this displacement occurred on the McConnell thrust. The cumulative displacement up to and including the Simpson Pass thrust (eastern Main Ranges) is between 175 and 210 km. This is comparable with, but slightly greater than, the 170 km estimated from the structure section about 60 km to the southeast drawn by Price and Mountjoy (1970).

The complex structure of the outer Foothills belt (George Creek map) involves duplex structures, tectonic wedging, and polyphase thrusting. The duplex structures, which are controlled by bedding detachment zones that occur in Jurassic marine shales in the Nikanassin Formation and in Upper Cretaceous marine shales in the Blackstone and Wapiabi Formations, are related to tectonic wedging and delamination of the Mesozoic strata in the "triangle structure" at the eastern edge of the thrust and fold belt. Locally, younger listric thrust faults that have propagated upward from detachment zones in underlying Paleozoic strata offset the duplex structures in the overlying Mesozoic strata.

A spectacular duplex structure involving Upper and Middle Cambrian strata occurs in the basal part of the McConnell Thrust sheet, south of Mt. Dalhousie near the head of Opabin Creek (SW corner of George Creek map).

The Bourgeau Thrust rapidly loses displacement to the northwest from the south end of Maligne Lake (south part of Southesk map), and disappears beneath the lake and Quaternary glacial and rockslide deposits around the north end of the lake (northeast part of Athabasca Falls map). A transfer zone appears to link the Bourgeau and the Pyramid thrusts. The Bourgeau thrust is the easternmost Front Range thrust to bring a thick section of Gog Group to the surface in the Sunwapta map area to the southeast. The Pyramid and related thrusts bring the Miette Group to the surface.

Listric normal faults are common in the eastern Main Ranges. The most prominent is the Tangle Ridge Fault, which is inferred to root in the underlying Pyramid thrust. It has a displacement of between 1200 and 2000 m near Mt. Kerkeslin.

Overall the structure and thrust displacements are similar to the structure further southeast near the North Saskatchewan River (Bow Athabasca regional section 11, Price and Mountjoy, 1970) and the regional cross section of Price and Fermor (1985) near Banff.

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Dynamics of Fold-Thrust Structures in Physical Models Deformed in a Large Geotechnical Centrifuge

Todd E. Noble*
Queen's University, Kingston, Ontario
<noble@geoladm.geol.queensu.ca>

John M. Dixon
Queen's University, Kingston, Ontario

Susan Pfister
C-CORE, St. John's, Newfoundland

ABSTRACT

We investigate the development of fold and thrust structures by scaled physical modelling, using the large geotechnical centrifuge with a radius of 5.5 m at C-CORE, Newfoundland. The experiments replicate models previously deformed in the smaller but higher-***g*** centrifuge at Queen's University. Multilayer models of foreland stratigraphic sequences are constructed of plasticine and silicone putty and shortened horizontally to simulate development of fold-thrust structures. The large models are ~950 mm long, 100 mm wide and 60-80 mm thick, and scaled at ~1×10^{-5} (10 mm = 1 km), 10x larger than the Queen's equivalents. The large centrifuge accommodates a servo-controlled mechanical drive system and load-monitoring devices to measure stress/strain/strain-rate relationships during shortening of a model.

In accord with scaling theory, the large models successfully reproduce the small-scale modelling results from the Queen's laboratory. Compression load cells in the test package measure changes in strength of a stratigraphic sequence, as fold and thrust structures nucleate during shortening of a model. The stress-strain curves derived from load-cell measurements indicate cyclical strain-hardening and strain-softening during progressive shortening of the models, and these strength variations may correlate with development of particular structures. The demonstration that load oscillations can be detected provides impetus for further investigation of the dynamics of folding and thrusting using the centrifuge technique. The large models will also be suitable for model seismic experiments aimed at refining techniques of seismic data processing and interpretation in areas of complex structure.

Indications for effective petroleum systems in Bowser and Sustut basins, north-central British Columbia

[1]K.G. Osadetz; [2]C. A. Evenchick, [3]F. Ferri, [1]L. D. Stasiuk and [1]N. S. F. Wilson

[1]Geological Survey of Canada: Calgary, 3303 33 St. NW, Calgary, AB, Canada, T2L 2A7;

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

[3]Resource Geology, New Ventures Branch, Ministry of Energy and Mines, PO Box 9323, 6th Floor, 1810 Blanshard St., Victoria, BC, Canada, V8W 9N3

Recent field work in the Bowser and Sustut basins has found 'live" oil in a breeched Skeena Fold Belt antiform in Jurassic Bowser Lake Group sedimentary rocks of the Intermontane Belt, British Columbia. This oil occurs as oil stains and petroleum fluid inclusions that are generally less than 45 degrees API. Condensate may also be present in some petroleum fluid inclusions. The intergranular porosity of the sample is filled by a pervasive cement that lacks petroleum fluid inclusions, and which probably post-dates the breeching of the structure. Elsewhere outcropping Bowser Lake Group sediments have preserved intergranular porosity and reservoir potential. Other, anecdotal, evidence suggests that natural gas may be seeping from sub-Bowser Lake Group rocks on the shore of Tatogga Lake, in the same general region. This provides direct evidence that there is at least one effective petroleum system in the Bowser and Sustut basins of the Intermontane Belt. The crude oils extracted from these samples have molecular compositions (terpane and sterane biomarkers) that indicate a source in ?Paleozoic marine carbonate rocks deposited in a meso-haline to hypersaline environment. The source of these oils likely lies in (Devonian to Permian) Stikine Assemblage Paleozoic carbonate strata that underlie Upper Triassic Stuhini Group and Lower to Middle Jurassic Hazelton Group successions on which the Middle to Upper Jurassic Bowser Lake and Upper Cretaceous Sustut successions were deposited. The observations are consistent with recent revisions of organic and thermal maturity levels in the Bowser and Sustut basins, based on new organic petrographic data. The new organic petrographic data are much more optimistic for oil and gas generation and preservation in these basins, although they illustrate large lateral and stratigraphic variations in thermal maturity that affect petroleum systems and potential reservoirs in ways neither well described or clearly understood. As a result of these new observations there is a pressing need to revise existing petroleum assessments to capture the impact of reduced risks in plays in both Bowser Lake and Sustut groups and to expand the set of plays to consider the newly recognized potential of underlying successions, especially the little known ?Toarcian clastic succession in the Hazelton Group. There is also a pressing need to act on this new and favourable evidence that an accessible, potential frontier petroleum province, the size of a European country lies effectively unexplored and undeveloped, except for the existing pipeline that traverses its southern portion.

Geochemistry of Tectonic Significance of Amphibolites from the Yukon-Tanana Terrane (YTT), Stewart River, Yukon: Preliminary Results.

Stephen J. Piercey, Mineral Exploration Research Centre and Department of Earth Sciences, Laurentian University, Ramsey Lake Road, Sudbury, ON, P3E 2C6, spiercey@laurentian.ca

James J. Ryan, Steven P. Gordey, Geological Survey of Canada, 101-605 Robson Street, Vancouver, B.C., V6B 5J3

Michael E. Villeneuve, Geological Survey of Canada, 601 Booth Street, Ottawa, ON, Canada K1A 0E8

Devonian-Mississippian mafic to intermediate amphibolite and associated gabbro and pyroxenite of the Yukon-Tanana Terrane (YTT) in the Stewart River area are stratigraphically and structurally interdigitated with a package of underlying quartz-rich metaclastic rocks (quartzite, pelite, quartz-mica schist, and marble). The amphibolitic rocks are variably deformed and metamorphosed, with most exhibiting strongly developed ductile foliation, often with porphyroblasts of hornblende and garnet. Some lower strain amphibolites exhibit abundant quartz-epidote patching and probable chert, features commonly seen in seafloor altered basaltic volcanic rocks. In addition, in places relict siliceous patches, common features seen in interpillow hyaloclastite and pillow rinds from subaqueous pillow lava eruptions. Preliminary trace element geochemical data for these mafic amphibolites indicate three suites: 1) island arc tholeiites (IAT;n=6); 2) light rare-earth element (LREE)-enriched IAT (L-IAT; n=3); and 3) normal mid-ocean ridge basalts (N-MORB; n=1). Island arc tholeiitic magmas are characterized by flat primitive mantle-normalized patterns (La/Sm_n = 1.0-1.4), with distinctive negative Nb anomalies relative to Th and La (Nb/Th = 1.8-5.2); the IAT are interpreted to have formed from a depleted mantle wedge with a subducted slab metasomatic signature. The L-IAT suite have similar primitive mantle normalized patterns to the IAT suite with a negative Nb anomaly (Nb/Th = 1.3-3.1), but the L-IAT suite tends towards higher La/Sm_n (1.6-1.9), Zr/Y (3.0-4.4), and Nb/Y (0.14-0.27) values, lower Nb/Th, and higher absolute Zr, Nb, Th, U, and LREE contents. The L-IAT sutie is interpreted to have formed from slightly more incompatible element-enriched portions of the mantle wedge and associated slab metasomatic flux. The sole N-MORB sample is LREE-depleted (La/Sm_n = 0.55), and has no negative Nb anomaly (Nb/Th = 18.5), suggesting no influence from subduced slab metasomatic flux during it's formation. The three suites of amphibolitic rocks represent the remnants of a regional Devonian-Mississippian arc and back-arc geodynamic system that developed along the ancient margin of the North American craton. The amphibolitic rocks of the Stewart River region record an arc magmatic system, represented by the IAT and L-IAT suites, that was subsequently rifted, represented by the N-MORB samples, during Devonian-Mississippian time. Their similar age, and position westward of the Finlayson Lake region upon restoration of Cretaceous-Tertiary movement along the Tintina Fault, suggests that the arc magmatism and subsequent rifting recorded by the Stewart River amphibolites represent the arc infrastructure to coeval Devonian back-arc magmatism recorded in the YTT of the Finlayson Lake VMS district.

Fernie Area (82 G), Alberta And British Columbia

Ray Price, Dept. of Geological Sciences and Engineering, Queen's University

Fernie Map-area (NTS 82G) straddles the southern Canadian Rockies adjacent to border with the United States, It extends from the autochthonous Paleocene strata of the Alberta syncline, across the Cordilleran foreland thrust and fold belt and the Rocky Mountain trench, into the allochthonous Mesoproterozoic Belt-Purcell Supergroup of the Omineca crystalline belt, in the eastern part of the Purcell anticlinorium. This new, up-to-date digital map compilation at a scale of 1:100,000, which will be used to prepare a set of balanced cross-section and a palinspastic reconstruction of this part of the thrust and fold belt, illustrates some important tectonic features of this part of the southeastern Canadian Cordillera.

The regional geology of Fernie map-area is dominated by the northeast-trending Crowsnest Pass cross strike discontinuity (CPCSD), which involves conspicuous along-strike changes in stratigraphy, structural style, physiography, the orientation of major thrust and fold structures, and the distribution of mid-Cretaceous igneous rocks. North of the CPCSD the major faults and folds are north-trending; south of the CPCSD they are northwest-trending. North of the CPCSD, the hinge zone between the Paleozoic Cordilleran miogeocline and cratonic platform coincides with the boundary between the Front Ranges and the Main Ranges of the Rockies and is north-trending; however, at the CPCSD, there is a 220-km right-hand deflection of the miogeoclinal hinge zone southwestward from the vicinity of Sparwood, B.C. in the Rocky Mountains to the vicinity of the Columbia River in northeastern Washington. The mid-Cretaceous granitic plutons that are characteristic of the Omineca belt extend into the Main Ranges of the Rockies along the CPCSD.

The CPCSD transects the Mesoproterozoic Belt-Purcell basin, and it is, in turn, transected by the listric, southwest-dipping normal faults of the southern Rocky Mountain trench. In the western Rocky Mountains, younger northeast-trending and north-trending thrust and fold structures are superimposed upon older, northwest-trending thrust and fold structures; but in the eastern Rocky Mountains and Foothills there is a smooth gradual transition from northwest-striking to north-striking thrust and fold structures.

The CPCSD can be attributed to intermittent tectonic reactivation of northeast-trending Paleoproterozoic Vulcan structure that extends into the Cordillera from the crystalline basement of southern Alberta. During Late Jurassic to Late Paleocene convergence with Cordilleran accreted terranes, supracrustal rocks were scraped off the under-riding North American basement and accreted to the over-riding Intermontane terrane. As the basal dècollement of the thrust and fold belt propagated up basin-margin ramps, sediments within the basins were detached and displaced on to the flat surface of the adjacent craton. This resulted in inversion of structural relief along the margins of the NW-trending Belt-Purcell basin and the N-trending and NE-trending Cordilleran miogeocline basin. Inverted basin-margin ramps became hanging-wall thrust ramps. Topographic relief produced by inversion of basin-margin ramps controlled the orientation of lateral propagation of the gravitationally spreading foreland thrust and fold belt critical-taper wedge.

Early Paleozoic Evolution of the Canadian Cordilleran Margin of Laurentia: Constraints from Regional Stratigraphic and Biostratigraphic Correlations

Leanne J. Pyle[1,2] and Christopher R. Barnes[1]

[1] School of Earth and Ocean Sciences, P. O. Box 3055, University of Victoria, Victoria, BC, V8W 3P6; crbarnes@uvic.ca
[2] Department of Geological Sciences, Queen's University, Kingston, ON K7L 3N6 (present address); lpyle@geol.queensu.ca

The western Laurentian margin rifted in the latest Neoproterozoic to early Cambrian, but appears not to have developed as a simple passive margin through a long, post-rift, drift phase. Over the last decade, our knowledge of the early Paleozoic tectonic history of the margin has been advanced through new stratigraphic and conodont biostratigraphic data from four platform-to-basin transects across the Canadian Cordilleran margin of Laurentia. In total, 26 stratigraphic sections were studied, from which over 25 km of strata were measured and described and over 1 200 conodont samples were collected (averaging 2.5-4 kg each) that yielded over 100 000 conodont elements. The conodont microfossils include key zonal species used for regional correlation of uppermost Cambrian to Middle Devonian strata along the Cordillera. Transect one lies in the southern Rocky Mountains of southwestern Alberta and southeastern British Columbia, from the Bow Platform to White River Trough. Transects two and three lie in the northern Rocky Mountains, northeastern British Columbia and span the MacDonald Platform to Kechika Trough and Ospika Embayment. Autochthonous strata of these transects is correlated to strata of the fourth transect across the parauthochthonous Cassiar Terrane. The stratigraphic framework records an evolutionary history of a margin that is more complex than a simple passive margin. The detailed conodont biostratigraphy temporally constrains at least two periods of renewed extension along the margin, in the latest Cambrian and late Early Ordovician. A well-defined ancient shelfbreak persisted from the late Early Ordovician to Devonian, possibly due to tectonic steepening, and the succession contains several intervals of slope debris breccia deposits, distal turbidite flows and associated alkalic volcanics. Siliciclastics in the succession were sourced by a reactivation of tectonic highs such as the Peace River Arch. Prominent hiatuses punctuate the succession, including unconformities of latest Ordovician-early Silurian, early-middle Silurian and sub-Devonian age. The Canadian Cordilleran margin during the early Paleozoic was not passive and was characterized more by repeated phases of extension with minor faulting, volcanism, basin foundering and platform flooding.

Relationship Between Multiple Phases of Mesozoic Deformation and Metamorphism in the Cariboo Mountains, Omineca Belt, central British Columbia

REID, L.F., Department of Geology and Geophysics, University of Calgary, Calgary, Alberta, Canada T2N 1N4, reid@geo.ucalgary.ca. HEAMAN, L.M., Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, T6G 2E3. SIMONY, P.S., University of Calgary, Calgary, Alberta, T2N 1N4. PATTISON, D.R.M., University of Calgary, Calgary, Alberta, T2N 1N4.

The Omineca Belt is the metamorphic and plutonic core of the southeastern Canadian Cordillera and contains the Selkirk-Monashee-Cariboo (SMC) complex. The SMC complex is the largest regional metamorphic complex in the Omineca Belt and contains domains that yield different ages for metamorphism and deformation. The nature of the boundaries between these domains is uncertain, and in several of the proposed models the boundaries are interpreted to be faults or cryptic shear zones. Such a boundary is exposed near Hobson Lake in the Cariboo Mountains where Middle Jurassic intrusions that post-date Jurassic metamorphism and deformation are overprinted by a younger deformation and metamorphism. U-Pb geochronology in conjunction with published data from the region indicates that the younger deformation and metamorphism in the Hobson Lake area is Early Cretaceous. Detailed geologic mapping together with microtextural and phase equilibrium analyses shows that there is a zone of transition in which Jurassic structures and metamorphic mineral assemblages, preserved at higher structural levels, are increasingly overprinted by Early Cretaceous metamorphism and deformation as depth increases. The Cretaceous deformation tightened the existing folds and reactivated foliations already present such that the overprinting did not form any significant fold interference patterns. This transition zone is gently dipping and undulating such as to preserve the Jurassic record at high structural levels in the SMC complex. A moderately northeast-dipping, oblique-slip fault (Goat Creek fault) places Late Jurassic—Early Cretaceous staurolite-kyanite grade rocks in the footwall against Early to Middle Jurassic biotite to garnet-biotite grade rocks in the hangingwall. The Goat Creek Fault has approximately 10 km of normal dip-slip displacement and a smaller but unknown dextral transition zone and clearly postdates the Early Cretaceous metamorphism, so it is not the boundary between the Jurassic and Early Cretaceous deformation and metamorphism.

Petrology and Tectonic Significance of K-feldspar Augen Granitoids in the Yukon-Tanana Terrane, Stewart River, Yukon

Ruks, T.W., Laurentian University, Department of Earth Sciences, Sudbury, Ontario, P3E 2C6
Piercey, S.J., Laurentian University, Department of Earth Sciences, Sudbury, Ontario, P3E 2C6
Ryan, J.J., Geological Survey of Canada, Vancouver, British Columbia, V6B 5J3
Gordey, S.P., Geological Survey of Canada, Vancouver, British Columbia, V6B 5J3

The Yukon Tanana Terrane (YTT) of the northern Cordillera extends over 1000 km from east-central Alaska to northern British Columbia, and is petrologically poorly understood. The Stewart River area (south of Dawson City) is underlain by one of the most widespread tracts of the YTT, but due to poor exposure and the remote nature of the area, its geology is also poorly understood. Potassic-feldspar augen granites of Devonian-Missippian age are found throughout the YTT, and are particularly relevant in the Stewart River area. The augen granites in the Stewart River area include a Permian suite that is undocumented in other parts of the YTT. The geochemistry of augen granites is used to characterize tectonic affinities for these intrusive rocks; however, at present there is insufficient geochronological data to confidently differentiate between the two suites. Preliminary geochemistry (containing a possible mix of both age suites) shows LREE enrichment, and relatively low HFSE contents, typical of melts generated in continental arcs. Similarities throughout the data set (in REE and trace elements) such as negative Nb, Eu, and Ti anomalies on primitive mantle-normalized plots, indicate arc affinities, and plagioclase and oxide fractionation, respectively. Upper continental crust-normalized REE plots have some samples exhibiting significant relative depletions and enrichments in LREE and HREE, respectively, while other samples appear to have been derived from, or strongly contaminated by a continental crust like material.

When compared to the similar aged VMS-deposit associated intrusive rocks in the Finlayson Lake District, the Stewart River area k-feldspar augen granites show similarities in the REE and trace elements patterns (exhibiting Nb, Eu and Ti anomalies). Tectonic discrimination plots show the Finlayson Lake augen granitoids have within-plate (A-type) signatures consistent with formation in a back arc environment, whereas the Stewart River augen granitoids have volcanic arc (I-type) signatures and likely developed in an arc-like setting. Preliminary results agree with previous ideas suggesting that the Stewart River region hosts the arc counterpart to the Devonian-Mississippian back arc environment observed in the Finlayson Lake region.

Assembly, Break-up, and Dispersal of the Proterozoic Laurentia- Siberia-Australia Troika:

J. W. Sears, Dept of Geology, University of Montana, Missoula, Montana and R. A. Price, Dept. of Geological sciences and Geological Engineering, Queen's University, Kingston, Ontario

New geochronologic, aeromagnetic, and paleomagnetic data tighten and reinforce the Paleoproterozoic to Early Cambrian connection between northern Siberia and western Laurentia. They also link northern Australian to Siberia and Laurentia as a mid-Paleoproterozoic to early Neoproterozoic troika.

The new paleomagnetic data from Laurentia (Elston et al., 2002), Siberia (Gallet et al., 2000), and Australia (Wingate et al., 2002) at ~1070 Ma impose important constraints on interpretations of late Mesoproterozoic (1050-1100 Ma) paleogeographic arrangements among the three cratons. The new data are inconsistent with the SWEAT (Moores, 1991), AUSWUS (Karlstrom et al., 2002), and similar hypotheses, which placed Australia or Antarctica against the western United States; however, they are consistent with the connection of the northern Siberian craton to southwestern Laurentia, and also with the connection of the northern Australian craton to the eastern Siberian craton outboard of southwestern Laurentia.

There is a tight connection between the northern margin of the Siberian craton and southwestern Laurentia, and it produces a detailed, seamless match in geological history spanning about 1.5 Ga from mid-Paleoproterozoic to Early Cambrian time. The connection between Siberia-Laurentia and northern Australia, although less thoroughly documented, produces a reasonable, but less detailed match in mid-Paleoproterozoic to early Neoproterozoic geology. Most of the Laurentia- Siberia-Australia troika formed between about 2.0 and 1.75 Ga by amalgamation of colliding fragments of Archean lithosphere and juvenile magmatic arcs, many of which straddle the future boundary between the two cratons. Mafic dykes and sills associated with the intracontinental rifting that produced Belt-Purcell basin (1.5-1.4 Ga) extend into Siberia where the Taimyr and Udzh troughs appear as the Siberian counterparts of the basin. The Late Mesoproterozoic Grenville orogen with it foreland margin can be tracked from southwestern Laurentia, through the northeastern Siberian craton, into central Australia. Mid-Neoproterozoic (~750 Ma) intra-continental rifting defined the intra-cratonic Windermere basin and the future boundary between the Laurentian and Siberian cratons but it did not evolve directly into sea-floor spreading at this time; however, complete separation and drift of the Australian craton from Siberia-Laurentia evidently did occur at about 750 Ma. Renewed rifting and magmatism along the Windermere rift in latest Neoproterozoic time culminated in the development of an Early Cambrian basin between the two cratons that was bordered on both sides by archeocyathan carbonate banks or reefs. During final separation and drift between the two cratons in the Atabanian or Botomian (~520 Ma), part of the archeocyathan reef that had formed on the Laurentian side of the basin was carried away with the Siberian craton.

Subsurface investigation of the Muskwa assemblage of north eastern British Columbia and the Fort Simpson Basin of south west Northwest Territories using a synthetic seismogram created from measured sections

Samantha Mary Siegel, Department of Geology and Geophysics,
University of Calgary

The > 6 Km Muskwa assemblage Proterozoic metasedimentary sequence is exposed in the Tuchodi anticlinorium of north eastern British Columbia adjacent to Line 2B of the 1999-2000 SNORCLE reflection survey.

Accordingly, application of standard techniques for calculation of the synthetic seismic response of the stratigraphic layering provides the best opportunity for correlation of the stratigraphic layers to regionally extensive seismic reflections.

In this project a synthetic seismic trace is calculated by first compiling measured sections of the Muskwa assemblage, then assigning appropriate velocities and densities to the different lithologies, and finally by convolving these results with an appropriate seismic wavelet for the recorded data set.

The resulting synthetic seismic trace is compared to the seismic data in order to trace the subsurface extent of the known Muskwa rocks along SNORCLE line 2b. Once this is accomplished the results can be compared with SNORCLE line 1 in an effort to help identify some of the strata within the Fort Simpson basin.

This procedure may prove be to a valuable technique for identifying and correlating surface outcrop to deep subsurface strata which have not been drilled and may not outcrop directly along seismic lines.

The age constraints on the Muskwa are between 1766 - 779 Ma (Ross et al, 2001). The lower part of the Muskwa are thought to belong to sequence A as defined by Young et al (1979), whereas the upper layers may include sequence B strata.

The Muskwa assemblage is thought to have been deposited in a rift basin, with sediments derived from the east (Ross, 2001). Because the Muskwa layers appear to correlate with the upper portions of seismic reflections that are mapped in the crust throughout much of the Northern Cordillera, they are fundamental to enhancing our understanding of the tectonics of western North America at the time of deposition as well as in helping to understand the regional geology of the northern Canadian Cordillera.

Comparison of the synthetic with SNORCLE line 2b shows that the Muskwa is represented in the subsurface and allows correlation of the individual formations to reflections.

Comparison of the results from line 2b to line 1 shows that strata of the Fort Simpson basin along line 1 have a strong seismic resemblance to the Muskwa assemblage, and suggests that the Muskwa assemblage or correlative strata are located in the subsurface within the Fort Simpson basin.

Results from this project suggest that this technique is valuable and may help with the problems of correlation of Proterozoic strata in the western Canadian Cordillera and elsewhere, and may therefore provide geoscientists with an additional tool for reconstruction of Proterozoic western North America.

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Paleogeography of Late Paleozoic volcanic arcs on the western margin of the Ancestral North American craton: an example from the Klinkit Group, northern British Columbia and southern Yukon.

Renée-Luce SIMARD, Department of Earth Sciences, Dalhousie University, Halifax, NS, B3H 3J5, rsimard@dal.ca, Jaroslav DOSTAL, Department of Geology, Saint Mary's University, Halifax, NS, B3H 3C3, jarda.dostal@stmarys.ca, Charlie F. ROOTS, Geological Survey of Canada, Yukon Geology Program, Box 2703 K-10, Whitehorse, Yukon, Y1A 2C6, charlie.roots@gov.yk.ca

The study of Late Paleozoic volcano-sedimentary sequences lying between Ancestral North America to the east and the accreted terranes to the west provides insights on the pre-accretion geographic elements of the western margin of the North American craton in Late Paleozoic time.

The detailed stratigraphic and geochemical study of the Mississippian to Permian volcano-sedimentary Klinkit Group of northern British Columbia and southern Yukon revealed that it is broadly coeval and compositionally similar to other volcano-sedimentary sequences that post-date the Devono-Mississippian Yukon-Tanana rock packages of the northern Canadian Cordillera.

The Klinkit Group is characterized in its lowermost part of carbonates of Mississippian to Early Pennsylvanian age, the English Creek and Screw Creek limestones, and by the upper Butsih and Mount McCleary formations, predominantly volcaniclastic rocks with minor clastic intervals. The Mount McCleary Formation also presents few metres of alkali-basalt. The volcaniclastic rocks are calc-alkaline and moderately fractionated. They indicate a volcanic-arc setting ($(La/Yb)_n$=2.77-4.73), with no involvement of the crust in their genesis (ε_{Nd}=+6.7 to +7.4). Alkali basalts in the Mount McCleary Formation ($(La/Yb)_n$=12.5-17.8) suggest an intra-arc rifting event.

The volcano-sedimentary Lay Range Assemblage of north-central British Columbia presents very similar stratigraphy and geochemistry to the Klinkit Group, suggesting a similar source region and tectonic history. It is interpreted as the basement of the Mesozoic Quesnel arc. However, the volcano-sedimentary Little Salmon formation of central Yukon also presents similar characteristics and is part of the pericratonic Yukon-Tanana terrane. This suggests that the pericratonic Yukon-Tanana terrane is possibly the northern equivalent to the basement of the Mesozoic arc of the Quesnel terrane, and therefore, that the Quesnel terrane overlies pericratonic pre-arc basement rocks.

The Klinkit and Lay Range volcano-sedimentary sequences are among the largest coherent pieces of a long-lived, Late Paleozoic arc system that was dismembered prior to its accretion onto Ancestral North America.

Links between translation in the Foreland and metamorphism in the Core zone of the Fold and Thrust belt

Simony, P.S.[(1)], Reid, L.F.[(1)], and Carr, S.D.[(2)]

[(1)] Geology and Geophysics Department, University of Calgary, Calgary, AB T2N 1N4
simony@geo.ucalgary.ca

[(2)] Ottawa-Carleton Geoscience Centre, Carleton University, Ottawa, ON K1S 5B6
scarr@ccs.carleton.ca

In attempting to model thrust belts we need the timing relationships between events in the thrust belt and in the core of the orogen. There are large data gaps and much difficult work remains to be done. Links between metamorphism and thrust motion are proposed here based on data obtained in recent years. Metamorphism and deformation with dates in the ~148-129 Ma interval overprint a pre-169 Ma metamorphic complex in the Cariboo and northern Monashee Mountains in a manner that is most easily explained if there had been little thrust motion between 170 Ma and 130 Ma. The clasts in the ~120 Ma Cadomin conglomerate in the Front Ranges suggests thrusting, uplift and erosion of tectonic elements now in the western Rockies and immediately to the west. Isograds of the 148-129 Ma metamorphism are deflected around the Malton basement complex in a way that suggests that a major lateral ramp in the thrust carrying the basement complex was inverted during post-metamorphic (post ~129 Ma) thrust motion that probably pre-dated 100-110 Ma, post-deformation muscovite argon ages in the western Rockies. The geochemistry of the mid-Cretaceous (~110-90 Ma) plutons of the southern Omineca belt is distinctly different from that of the Mid-Jurassic (~170-160 Ma) plutons despite a substantial geographic overlap. Thrust-repetition of the basement prior to, or during magma generation in the crust could explain many of the geochemical differences. The Late Cretaceous, ductile, compressional east-directed Gwillim Creek shear zone (CGSZ) lies at mid-crustal levels, exhumed in the Valhalla core complex from beneath the magmatic arc in the hinterland of the Fold and Thrust belt. Geochronology, in conjunction with metamorphic fabric data, shows that shear in GCSZ was associated with a ~78 Ma pegmatite swarm and ~76-67 Ma sillimanite-K-feldspar + melt metamorphism. A 63 Ma quartz-monzonite sheet in the hanging wall of the GCSZ was strained at its base while still hot. These ages correlate well with motion on the Lewis and related thrusts in the Rocky Mountain Front ranges. Decrease in motion northward on these structures is a major cause for northward decrease in shortening across the southern Rockies. This may correlate with the disappearance of ~70 Ma metamorphism northwest of the Monashee Mountains.

The Eocene ductile, extensional east-directed Valkyr shear zone (VSZ) forms the upper bounding surface of the Valhalla complex. Both the GCSZ and VSZ are warped across the Valhalla complex. Neither tectonic unloading nor diapiric upwelling adequately explain that geometry. Bending above a horse inserted during the final stages of thrusting in the Early Eocene may provide an explanation.

THE THOR-ODIN DOME IN THE SHUSWAP METAMORPHIC COMPLEX AND THE FLOW OF OROGENIC CRUST

Teyssier C.[1], Vanderhaeghe O.[2], Whitney D.L.[1], Norlander B.[1], Fayon, A.[1], Jeanningros A.[2], Mulch A.[3]; (1) University of Minnesota, Minneapolis, MN 55455 USA (e-mail: teyssier@umn.edu); (2) Université Henri Poincaré Nancy 1, UMR 7566 G2R, BP 239, 54506 Vandoeuvre-lès-Nancy, France; (3) University of Lausanne, IMG-BFSH-2, 1015 Lausanne, Switzerland;

One of the most important realizations in tectonics in the last 10 years is that active orogens are commonly underlain by a layer of partially molten crust. This layer can flow laterally (channel flow) and perhaps accommodate the growth of continental plateaux, or flow vertically to form gneiss and migmatite domes. We present results of a study aimed at understanding the lateral and vertical flow components of the partially molten crust that was exhumed in early Tertiary time in the Shuswap metamorphic core complex (MCC), British Columbia, beneath a low-angle detachment system.

1. Lateral flow: We have studied the flow of partially molten crust using the deformation of leucogranite sheets that were emplaced at ~60-55 Ma (Ladybird leucogranite). These leucogranite sill/laccolith sheets concentrate beneath the detachment; their deformation captures the flow kinematics of the upper 2-3 km of the partially-molten layer. This is a critical region to distinguish between channel flow (shear driven from below) and detachment-related flow (shear driven from above), because the predicted sense of shear is opposite for the two models. The anisotropy of magnetic susceptibility (AMS) of 91 leucogranite samples along a 70 km long traverse oriented E-W shows that magnetic foliation is dominantly flat-flying, and lineation is ~E-W, except in the region of Sugar Mountain (central part of the MCC), where lineation is steeply plunging. Analysis of shear-sense criteria on 60 samples cut parallel to the K_1-K_3 AMS plane indicate that the fabrics that developed under magmatic state, and high temperature to low-temperature solid state display top-to-W shear in the west and top-to-E shear in the east of the MCC. Sugar Mountain is the "kinematic hinge" of this system and shows more coaxial strain. These results are consistent with conjugate detachments and crustal boudinage and are inconsistent with channel flow for the period ~60-55 Ma.

2. Vertical flow: Upward flow is recorded in the near-isothermal decompression path of metamorphic rocks in the core of the Thor-Odin dome, accompanied by melt reactions, and indicating ΔP from >10 kbar to <5 kbar under T~750°C. This decompression is related to diapiric flow of the partially molten crust, driven by the positive feedback between decompression and melting. Activation of the detachments mentioned above, which led to upward motion of the deep footwall, decompression melting, and associated diapiric instabilities, may be at the origin of the migmatite domes, such as Thor-Odin, offset relative to the kinematic hinge of the core complex.

The structures and strain patterns around the dome indicate that lateral and vertical flow are not two separate events. Future work will attempt to understand the time scales and rates of lateral versus vertical flow. We will delineate the structure of the migmatite inside the Thor-Odin dome in order to better understand the space and time scales of gravitational instabilities, and their metamorphic and thermochronologic signatures. These studies will improve our knowledge of the flow of partially molten crust and of the first-order structures (flat-lying migmatite terrains, domes) that characterize many orogens.