

Cordilleran Tectonics Workshop

*February 22-24, 2008
UBC - Robson Square
Vancouver, British Columbia*

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**Organized by the UBC
Northern Cordilleran Research Group**

**Cordilleran Tectonics Workshop
Vancouver, British Columbia, February 22-24, 2008
University of British Columbia – Robson Square campus**

Maps and Directions – 1

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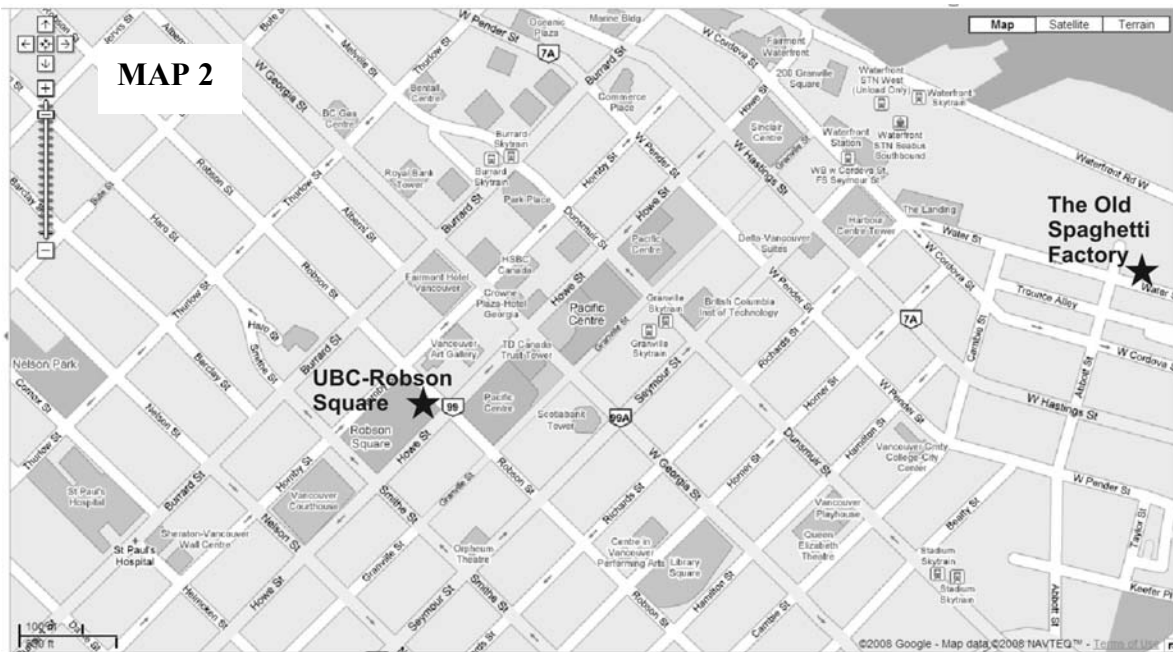
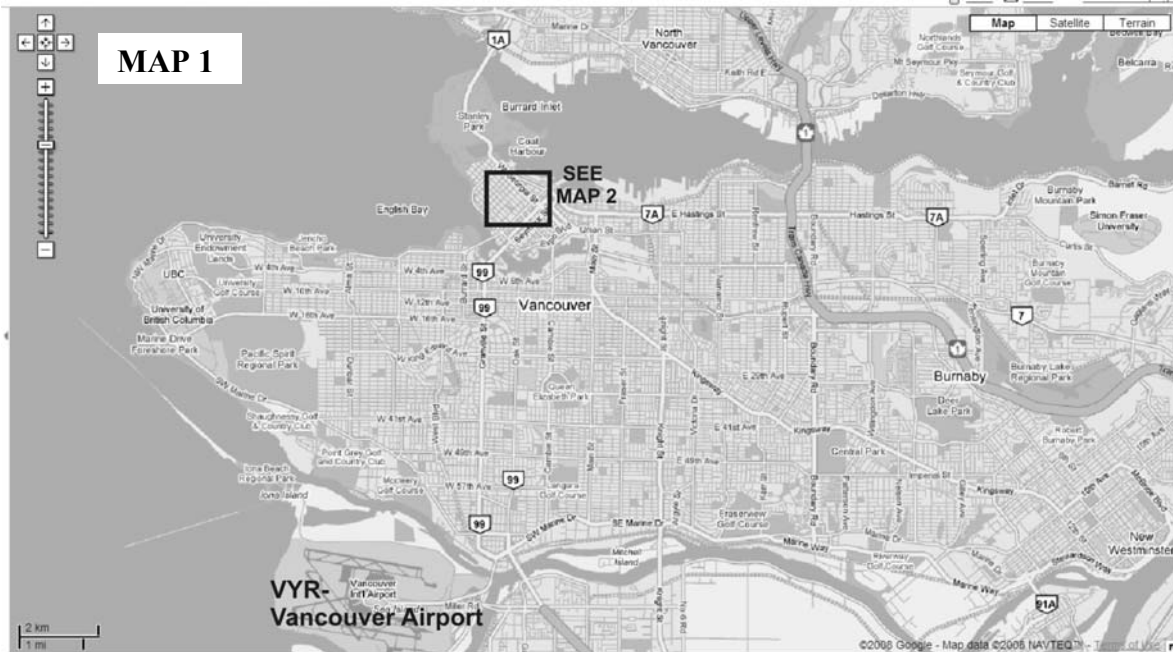
Technical Program – 3

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Participants – 9

Abstracts (in alphabetical order) – 10

The 2008 Cordilleran Tectonics Workshop is being held at UBC-Robson Square (800 Robson St; corner of Robson and Howe) in downtown Vancouver, ~14 km north of the Vancouver airport. The complex is largely underground; enter Robson Square by descending stairs on the southside of Robson Street. Registration, posters, and coffee will be on the ground floor (Plaza Level), talks are the Theatre on the lower level (Campus Level). Map 2 shows UBC-Robson Square in downtown and the group dinner location on Saturday night, The Old Spaghetti Factory (53 Water Street).



SCHEDULE OF EVENTS

Friday February 22

5pm – 8:00 pm at Robson Square, Plaza Level
Registration, Poster set-up

8:00 pm

Group bowling and billiards at Commodore Lanes, 1 block east of Robson Square, near the intersection of Granville & Robson streets. The dinner plan is to have pizza delivered.

Saturday February 23

7:30 am – 8:25 am

Registration, light breakfast, coffee, tea on the Plaza Level

8:25 am – 11:40 am (coffee break & posters from 10:00 – 10:20 am)

Morning oral presentations in the Theatre, Campus Level

11:40 am – 1:00 pm

Lunch break

1:00 – 3:00 pm (coffee break & posters from 2:00 – 2:20 pm)

Afternoon oral presentations in the Theatre, Campus Level

3:00 pm – 6:00 pm

Poster session on the Plaza Level

8:00 pm

Group dinner at The Old Spaghetti Factory, 53 Water Street. In Gastown neighbourhood, approximately 2 km northwest of Robson Square

Sunday February 24

8:00 am – 8:40 am

Light breakfast, coffee, tea on the Plaza Level

8:40 am – 11:40 am (coffee break & posters from 10:00 am – 10:30 am)

Morning oral presentations in the Theatre

11:40 am – 1:00 pm

Lunch break

1:00 pm – 3:00 pm

Afternoon oral presentations in the Theatre

~3:15 pm – CTW 2009 Planning; Coffee, posters, poster tear-down

TECHNICAL PROGRAM

Saturday February 23

- 8:25 AM Opening Remarks
- 8:30 AM **Nick Massey**
The Knob Hill Complex – a Paleozoic supra-subduction zone ophiolite in southeastern British Columbia? [p. 34]
- 8:50 AM **Donald C. Murphy**
Windy McKinley terrane, Stevenson Ridge area (NTS 115JK), western Yukon: composition and proposed correlations, with implications for the Triassic tectonic evolution of the western North American continental margin [p. 39]
- 9:10 AM **Bert C. Struik**
Could anomalous Cretaceous shortening of the southern Rocky Mountains locate the Cretaceous Kula-Farallon spreading ridge? [p. 52]
- 9:30 AM **Maurice Colpron** and JoAnne Nelson
The Northwest Passage: Incursion of Baltican and Siberian crustal fragments into eastern Panthalassa, and the mid-Paleozoic to early Mesozoic evolution of the Cordilleran margin of western North America [p. 14]
- 9:50 – 10:20 AM Discussion, coffee break, posters
- 10:20 AM **David Gardner**, Stephen T. Johnston, William J. Davis
Detrital zircon U-Pb provenance of the Upper Purcell Supergroup, southeastern British Columbia, Canada: Implications for Belt-Purcell basin models and paleogeographic reconstructions [p. 23]
- 10:40 AM **Edith Martel**, Charlie Roots, Steve Gordey, L. Ootes, B. Fischer, Christopher Leslie, J. Macdonald, M. Mercier
Sekwi Mountain Project: Overview of bedrock mapping and collaborative studies in central Mackenzie Mountains, NWT [p. 34]
- 11:00 AM **Christopher Leslie**, H.A. Sandeman, J.K. Mortensen
Diatremes and related volcanic rocks of the Lower Paleozoic Misty Creek Embayment, Mackenzie Mountains, NWT [p. 30]
- 11:20 AM **Darrell G.F. Long** and Elizabeth C. Turner
Direct evidence for active listric detachment faults and craton-normal transfer faults during evolution of the Neoproterozoic Mackenzie Mountains Supergroup, NWT, Canada [p. 32]
- 11:40 AM – 1:00 PM Discussion and Lunch break

- 1:00 PM **Elizabeth R. Schermer**
Polyphase deformation and metamorphism in the northwest North Cascades: hypothesis of large-scale shortening during transpression [p. 46]
- 1:20 PM **Gerry Griesel**, Elizabeth R. Schermer, Thomas Ullrich, James K. Mortensen
Kinematic analysis of a Cretaceous thrust zone, Cascade crystalline core, Washington [p. 26]
- 1:40 PM **Kristin O’Connell**, Sarah Roeske, Bernard Housen, Sean Gallen
Structural and paleomagnetic revisions of the Ghost Rocks Formation, Kodiak Islands, Alaska [p. 40]
- 2:00 – 2:20 PM Discussion, coffee break, posters
- 2:20 PM **Jamie L. Kraft**, Robert I. Thompson, and Phillipe Erdmer
Detrital zircon provenance of Paleozoic pericratonic assemblages of the Kootenay Arc near Revelstoke, British Columbia [p. 28]
- 2:40 PM **Luke P. Beranek**, Donald C. Murphy, Michael J. Orchard, James K. Mortensen
Late Triassic Tethyan conodonts in the peri-Laurentian realm: North American detrital zircons de-bug the Bug Island limestone [p. 10]
- 3:00 – 6:00 PM Poster Session – see page 6

Sunday February 24

- 8:40 AM **Micheal Moroskat** and Sarah A. Gleeson
The structurally controlled Zn-Pb-Ag Blende deposit: temporal constraints on regional deformation by sulphide precipitation [p. 37]
- 9:00 AM **Kathleen M. Durk**, Paul K. Link, C. Mark Fanning
SHRIMP U-Pb ages for 2650 Ma Archean orthogneiss, Mesoproterozoic paragneiss, 695 Ma Neoproterozoic orthogneiss, and 49 Ma Eocene Boulder Creek pluton, Pioneer Mountains, south-central Idaho [p. 16]
- 9:20 AM **Shawna E. White** and Phillipe Erdmer
Geology of the Nicola Group in the vicinity of the Iron Mask batholith, Kamloops, British Columbia [p. 54]
- 9:40 AM **Sarah Brown** and Dan Gibson
New investigations of the Okanagan Valley Fault: insights from mapping as a prelude to dating [p. 12]
- 10:00 – 10:30 AM Discussion, coffee break, posters

- 10:30 AM **Reid Staples**, Dan Marshall, H. Dan Gibson, Derek Thorkelson, Karin Fecova
P-T constraints and tectonic evolution of the Wolverine metamorphic complex [p. 50]
- 10:50 AM **Andy Parmenter** and Paul Williams
Deformation kinematics and intrusive history at Thor-Odin: A potential link between field scale observations and plate scale tectonics [p. 43]
- 11:10 AM **Philip S. Simony** and Sharon D. Carr
Linked thrust and infrastructural flow tectonics [p. 47]
- 11:30 AM **Félix Gervais** and Richard L. Brown
Testing the channel flow/ductile extrusion model in the southeastern Canadian Cordillera [p. 24]
- 11:50 AM – 1:30 PM Discussion, Lunch break
- 1:30 PM **Charles A. Ferguson**
Grand Teton to Grand Canyon, Pliocene course of the Green River and implications for Cenozoic uplift of the southern Rocky Mountains, USA [p. 20]
- 1:50 PM **Caleb N. Stroup**, Paul K. Link, Susanne U. Janecke, C. Mark Fanning, Luke P. Beranek
Provenance of Eocene to Oligocene sandstones of southwest Montana: Evidence from detrital zircons [p. 51]
- 2:10 PM **J.-F. Gagnon** and J.W.F. Waldron
Subsidence history and tectonic evolution of the Bowser basin, northwest British Columbia [p. 21]
- 2:30 PM **Walter Loogman** and J.W.F. Waldron
Structural history of the northwest Skeena Fold Belt, northwest British Columbia [p. 33]
- 2:50 PM **Aleksandar Mišković**, Urs Schaltegger, Jan Košler
Crustal evolution of the western Amazonian margin: zircon U-Pb geochronology and Lu-Hf isotopic constraints from the Peruvian Eastern Cordillera granitoids [p. 36]

POSTER PRESENTATIONS

Posters up Friday February 22 – Sunday February 24

Listed is suggested start time for authors to give oral presentation of their poster during Sat. session.

-1- Scott K. Blevings, Lori A. Kennedy, Ken A. Hickey

(3:10 PM)

Contrasting copper and gold mineralization styles along the contact between the Coast Plutonic Complex and the southeast Coast Belt, Taseko Lakes region (NTS-92O/04), southwestern British Columbia [p. 10]

-2- Katrin Breitsprecher, Dominique Weis, James S. Scoates, and Robert G. Anderson

(3:15 PM)

High-precision isotope (Hf, Pb, Nd, Sr) and trace-element geochemistry of Mesozoic intrusions, south-central British Columbia: assessing the role of subducted oceanic (Cache Creek basin) sediments in Quesnel arc magmagenesis [p. 11]

-3- Scott Close

(3:20 PM)

Geologic Map of Galore Creek, northwestern British Columbia [p. 13]

-4- Maurice Colpron

(3:25 PM)

Geology of the northern Whitehorse trough, Yukon [p. 13]

-5- Joel F. Cubley and David R. M. Pattison

(3:30 PM)

Metamorphism along the Kettle River fault, Christina Lake, British Columbia [p. 14]

-6- Deirdre Demerse, Lori Kennedy, Tom Ullrich

(3:35 PM)

Age, kinematics and significance of the Pootlass high strain zone, Bella Coola, BC [p. 15]

-7- Philippe Erdmer and Frederick A. Cook

(3:40 PM)

The evolving Cordilleran Lithosphere: erosion of the North American plate during orogenesis and terrane accretion [p. 17]

-8- Y. Eyal, K. Osadetz, S. Feinstein

(3:45 PM)

Brittle mesostructural kinematics in the Lake Okanagan Fault Zone: Implications for Eocene and younger deformation in the southern Canadian Cordillera [p. 18]

-9- R.-E. Farrell, G.D.M. Andrews, J.K. Russell, and R.G. Anderson

(3:50 PM)

Physical volcanology of the Chilcotin Group basalt: Preliminary insights on Cordilleran landscape evolution [p. 19]

- 10- Karin Fecova**, Dan Marshall, Reid Staples, G. Xue, Thomas Ullrich, Scott Close
(3:55 PM)
Layered intrusions and tectonic evolution of the Nootka Sound area (NTS 092E), Vancouver Island, British Columbia [p. 19]
- 11- Francesca Furlanetto**, D.J. Thorkelson, D. Marshall, H.D. Gibson, R.H. Rainbird
(4:00 PM)
Sedimentary provenance of the Paleoproterozoic Wernecke Supergroup, Yukon Territory: project outline and preliminary results [p. 21]
- 12- Sean F. Gallen**, Bernard A. Housen, Sarah M. Roeske, Kristin O'Connell
(4:05 PM)
The paleomagnetism of sedimentary rocks from the Ghost Rocks Formation, Kodiak Islands, Alaska [p. 22]
- 13- Steve Gordey**, Charlie Roots, Edith Martel, K. Fallas, E. Fisher, Christopher Leslie
(4:10 PM)
Bedrock transect across the Mackenzie Mountains at 64.5°N: A new look at crumpled old platform strata [p. 24]
- 14- Andrew Greene**, James S. Scoates, Dominique Weis, Graham T. Nixon
(4:15 PM)
Significance of picritic and tholeiitic lavas within Wrangellia flood basalts on Vancouver Island for the melting history and magmatic evolution of a major oceanic plateau [p. 25]
- 15- Erik C. Katvala** and Charles M. Henderson
(4:20 PM)
Revision of the Late Paleozoic history of the Alexander terrane [p. 27]
- 16- Julia E. Labadie** and Elizabeth R. Schermer
(4:25 PM)
The structural and tectonic history of the Mt. Formidable region, North Cascades, Washington [p. 28]
- 17- Larry Lane**
(4:30 PM)
Richardson Mountains: Overview of their Tectonic Evolution [p. 29]
- 18- Paul K. Link**, E.M. Kingsbury, S.M. Osterhout, C. M. Fanning, C.M. Dehler
(4:35 PM)
Sequence stratigraphy and detrital zircon populations in the Neoproterozoic (Cryogenian) Uinta Mountain Group, northern Utah [p. 31]
- 19- Catherine I. MacLaurin**, Peter S. Mustard, J. Brian Mahoney, James W. Haggart
(4:40 PM)
Stratigraphy, sedimentology, and hydrocarbon reservoir potential of the Lower Cretaceous Jackass Mountain Group, Chilko Lake area, British Columbia [p. 33]
- 20- J.W.H. Monger**
(4:45 PM)
Devolution of Canada's western mountains [p. 37]

- 21- James K. Mortensen**, Donald C. Murphy, and Luke P. Beranek
(4:50 PM)
Permo-Triassic orogeny in the northern Cordillera: Sonoma North? [p. 38]
- 22- David Moynihan** and David Pattison
(4:55 PM)
Barrovian and Buchan metamorphism in the central Kootenay Arc, southeastern British Columbia [p. 39]
- 23- Andrew V. Okulitch**
(5:00 PM)
Geology of the Okanagan Watershed, south-central British Columbia [p. 41]
- 24- Erik Parker**, Philip Simony, Ed Ghent
(5:05 PM)
Folding, faulting and metamorphism in rocks on the east flank of the Selkirk Fan; new evidence in support of the re-interpreted Esplanade Thrust Fault and thermochronometric constraints on metamorphism [p. 42]
- 25- Kirsten Rasmussen** and James K. Mortensen
(5:10 PM)
Cretaceous Magmatism in the Cordillera: a peek at what's to come! [p. 44]
- 26- Tyler W. Ruks** and James K. Mortensen
(5:15 PM)
Stratigraphic and paleotectonic studies of the middle Paleozoic Sicker Group and contained VMS occurrences, Vancouver Island, British Columbia [p. 45]
- 27- M. Iole Spalla, Davide Zanoni**, Paul F. Williams, Guido Gosso
(5:20 PM)
P-T evolutions along an E-W transect, in the Thor-Odin dome, from Blanket Mt. to the Thor-Odin detachment (Canadian Cordillera) [p. 48]
- 28- Graham Spray**, Ed Ghent, Philip Simony
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Metamorphism and tectonism in the Soards Creek area, Mica Creek, southeastern British Columbia [p. 49]
- 29- Reid Staples**, D. Marshall, K. Fecova, C.C. Downie, D. J. Thorkelson, L. Loughrey
(5:30 PM)
Structurally controlled iron oxide mineralization in the Iron Range and Mount Thompson region, B.C. [p. 51]
- 30- Elizabeth Westberg**, Maurice Colpron, H. Dan Gibson
(5:35 PM)
Constraining the conditions and timing of deformation and metamorphism of the Yukon-Tanana terrane in the Big Salmon Range of south-central Yukon [p. 53]

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Late Triassic Tethyan conodonts in the peri-Laurentian realm: North American detrital zircons de-bug the Bug Island limestone

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The Late Triassic Bug Island limestone of eastern Yukon contains *Paragondolella hallstattensis*, a conodont species typical of Tethyan strata in Eurasia. Tethyan conodonts are rare in the eastern Canadian Cordillera; the presence of *P. hallstattensis* in Yukon may suggest: (1) a far-traveled, non-North American (exotic) origin for the limestone or (2) Late Triassic environmental controls allowed the taxon to migrate from Tethys to the western Laurentian margin. Our detrital mineral (zircon, muscovite) and whole-rock geochemical (Nd isotope, trace element) provenance data from Permian-Jurassic sedimentary rocks of Yukon favor the latter explanation, and we interpret the limestone to be part of a Middle-Late Triassic overlap assemblage deposited on the North American autochthon following Permo-Triassic collision of Yukon-Tanana terrane and development of an Early to Middle Triassic peripheral foreland basin.

Detrital zircon ages ($n = 75$) from the Bug Island limestone compare favorably to age-populations known to Paleozoic-Triassic continental margin strata of the Canadian Cordillera. We argue these data support *P. hallstattensis* being deposited on the North American autochthon, far from Tethys; thus, *P. hallstattensis* has a wider distribution than previously known and its occurrence is not synonymous with large-scale translation. Further, provenance analyses of strata with ‘Tethyan fossils’ have high potential to aid geoscientists in reconstructing paleobiogeography and translation of Cordilleran terranes.

Contrasting copper and gold mineralization styles along the contact between the Coast Plutonic Complex and the southeast Coast Belt, Taseko Lakes region (NTS-92O/04), southwestern British Columbia

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Porphyry and epithermal deposits occur in orogenic belts and are generally subduction related. Many such deposits occur in the Canadian Cordillera, and generally linked to the subduction of the Pacific Plate beneath the western margin of North America. This subduction has also been interpreted to have caused the formation of the Coast Plutonic Complex – a string of plutonic rocks that occur all along the length of the western margin of British Columbia and into Alaska. The Southeast Coast Belt hosts several prospective and past-producing mineral deposits including the Bralorne (Minfile 092JNE001), Pioneer Mines (Minfile 092JNE004), and Prosperity deposits (Minfile 092O 041). Many porphyry and epithermal deposits occur along the margins of the Coast Plutonic Complex, but possible links between mineralization and the Coast Plutonic Complex remain unclear.

Several less developed mineral occurrences are present in the Taseko Lakes Region, some extremely proximal to the contact with the Coast Plutonic Complex. The majority of these occurrences appear to host porphyry and epithermal style mineralization, which include: The Hub (Minfile 092O 043), Northwest Copper (Minfile 092O 043), Pellaire (Minfile 092O 045),

Taseko-Empress (from here onwards referred to as Empress) (Minfile 092O 033), and Taylor-Windfall (Minfile 092O 028).

The purpose of this study has been to (1) characterize the alteration and mineralization of three separate mineral deposits in the Taseko Lakes Area (Pellaire, Taylor-Windfall and Empress), (2) identify approximate P-T conditions of formation for observed alteration and mineralization, (3) determine approximate geochronological ages for the observed mineralization in the region, (4) identify potential fluid sources for hydrothermal alteration, (5) provide accurate genetic classifications for the three deposits studied, and (6) assess any potential genetic relationships that may exist between the deposits, the Coast Plutonic Complex, and other deposits in the region.

High-precision isotope (Hf, Pb, Nd, Sr) and trace-element geochemistry of Mesozoic intrusions, south-central British Columbia: assessing the role of subducted oceanic (Cache Creek basin) sediments in Quesnel arc magmatogenesis

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Late Triassic to Early Jurassic (220-180 Ma) arc magmatism of the southern Quesnel terrane, British Columbia, is recorded in a north-trending belt of Nicola Group volcanic rocks and related intrusions, which occur as a series of regional centres representing the eroded roots of arc volcanoes. Preliminary isotopic results indicate a trend of increasingly radiogenic compositions with decreasing age of magmatism. The radiogenic component may be derived from assimilated older (Precambrian) crust, or subducted oceanic sediment incorporated into the magmas at depth. Distinguishing between the two radiogenic components has tectonic relevance, because identification of an assimilated crustal component, if present, would aid in addressing the question of the tectonic affinity of the southern Quesnel arc (North American vs. exotic).

The coupled ¹⁴³Nd/¹⁴⁴Nd and ¹⁷⁶Hf/¹⁷⁷Hf isotopic systems are the most useful tracers for distinguishing between the two potential radiogenic end-members, specifically crustal assimilation and subducted ocean sediment. We present new isotopic results comparing the time-transgressive variability in isotopic compositions (Rb-Sr, Sm-Nd, Pb-Pb, and Lu-Hf) of the Quesnel arc granitoids to those of the Cache Creek argillites. The Cache Creek sedimentary rocks represent the accretionary wedge of the Quesnel arc system, and thus provide a direct measure of ancient subducted sediment. We provide a preliminary assessment of the degree to which the subducted sediment component has affected the time-progressive compositional variations that are apparent in this arc system.

Additional aspects of the project will involve: 1) detailed isotopic study of zoned zircons from the Quesnel arc samples, including high-resolution, ion-microprobe (SHRIMP) U-Pb dating (to identify the potential crustal assimilated lithology), and Hf-zircon and O-zircon isotopic analyses, 2) geochemical and isotopic analyses of the appropriate crustal lithology following its identification by U-Pb SHRIMP dating, and 3) detailed geochemical modeling.

New investigations of the Okanagan Valley fault: insights from mapping as a prelude to dating

Sarah Brown and Dan Gibson

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In southern British Columbia the western margin of the Shuswap Metamorphic Complex (medium- to high-grade gneisses and granites) is juxtaposed against nearly pristine, non-metamorphosed volcanic and sedimentary rocks. This boundary is a predominantly 1-2 km-thick ductile shear zone, named the Okanagan Valley Fault (OVF), generally considered to be Eocene in age. The shear zone grades abruptly from cataclasite to mylonite in amphibolite-facies gneisses, which, along with younger granitic intrusions, have undergone polyphase deformation and show evidence of significant flattening. Structural information gives a dominantly NW-SE trending (291°) stretching lineation and a nearly horizontal planar transposition fabric. Fold hinges for folds interpreted to be generated during extension are generally parallel to the stretching lineation, suggesting progressive rotation into the extensional quadrant of strain approximately parallel to the transport direction.

In order to better understand the nature of the OVF and constrain motion along the southern portion of the shear zone, we are conducting a comprehensive structural, geochronological, and thermochronological analysis. The first stage of this research has been an extensive field mapping program that has provided new insights into the contacts and structural evolution of the major units: (1) the contact between granodioritic plutons in the Okanagan Highlands and the amphibolitic Okanagan gneisses is intercalated and not simple; and (2) the Allendale intrusion, correlated with the Coryell Syenite, contains rafts of deformed amphibolite gneiss. Our examination of volcanic outliers (presumably Eocene) poses several questions regarding east-west correlations across the OVF, and will help constrain the timing and shape of the OVF east of the Okanagan Valley and the mechanism by which the upper plate moved westwards.

Mapping and examination of mineral property drilling records are revealing new information regarding the shape and relative position of the OVF fault surface. Although typically dipping 18° W it is locally greater than 25° W, corresponding with the occurrence of a diorite and dioritic pegmatite body in an area otherwise dominated by typical amphibolite gneiss; we are investigating the relationship between these lithologies. Furthermore, there appears to have been considerable late-stage extension and down-dropping of the OVF and upper plate along NNE-SSW trending, high-angle normal faults. Such faults are readily apparent in the lower plate forming deep furrows in the hillside. Late normal faulting appears to have dropped the OVF and upper plate in excess of 380 m at and immediately west of Okanagan Falls, where the OVF should be expected to be (more or less) at the surface. We are beginning to examine the consequences of this late-stage extension and to attempt to quantify its effects more accurately.

Geologic map of Galore Creek, northwestern British Columbia

Scott Close
NovaGold Resources

The Galore Creek region in northwestern British Columbia has a complex genesis. This region- underlain by Stikine terrane rocks- now rests as an amalgam of volcanic, sedimentary, and plutonic strata forming one of the richest mineral belts along the Canadian Cordillera of North America. The accompanying geologic map displays the interpreted surface geology of the Galore Creek mineral district with diagrams illustrating its chronologic, stratigraphic, and structural evolution.

Geology of the northern Whitehorse trough, Yukon

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The Whitehorse trough is an elongated, northwest-trending Mesozoic marine sedimentary basin that extends some 650 km from just north of Carmacks, Yukon, to near Dease Lake, B.C. It originated as a forearc basin in the Middle to Late Triassic, adjacent to the emerging Lewes River arc, and had received more than 7000 m of clastic deposits by Middle Jurassic time. It is underlain by late Paleozoic and early Mesozoic arc rocks of Stikinia and is structurally overlain, in southern Yukon and northern B.C., by the oceanic Cache Creek terrane. The Whitehorse trough overlies Stikinia at its northern apex, where it is bounded on three sides by metamorphosed mid- to late Paleozoic rocks of Yukon-Tanana terrane.

Mapping of the northern Whitehorse trough near Carmacks was completed in 2006 in support of a seismic reflection survey acquired in the spring 2004. In this region, the Whitehorse trough is comprised primarily of arc-marginal clastic and carbonate rocks of the Upper Triassic Aksala formation (Lewes River Group) and shallow-marine sandstone, conglomerate, mudstone and minor coal of the Lower to Middle Jurassic Tanglefoot formation (Laberge Group). Crystal-rich volcanoclastic rocks of the ca. 187-188 Ma Nordenskiöld formation is locally intercalated with the Tanglefoot formation. The sequence is capped by chert-pebble conglomerate, sandstone and coal of the Middle Jurassic to Lower Cretaceous Tantalus Formation.

Structurally the northern Whitehorse trough is a west-verging fold-and-thrust belt. At this latitude, it is bounded on the east by the west-verging Tadru thrust fault and on the west by the enigmatic Braeburn fault. In seismic profiles, highly reflective but discontinuous packages are correlated with the Lewes River Group based on their up-dip projection to limestone exposures at Eagle's Nest Bluff along Line 1. The shallow seismic images depict broad antiformal and synformal structures punctuated by relatively steep faults where reflectivity is abruptly truncated. The vertical extent of interpreted strata of Lewes River and Laberge groups attains a maximum thickness of 6000-7000 m towards the west side of the Whitehorse trough, with interpreted Laberge Group accounting for up to ~3000 m of this total. Maximum vertical relief is ~4000 m as indicated by the amplitude of the interpreted fold structures, with less structural relief observed along-strike on Line 2.

The Northwest Passage: Incursion of Baltican and Siberian crustal fragments into eastern Panthalassa, and the mid-Paleozoic to early Mesozoic evolution of the Cordilleran margin of western North America

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Paleozoic to early Mesozoic terranes of the North American Cordillera mostly originated from three distinct regions in Paleozoic time: the western peri-Laurentian margin, western Panthalassa, and Baltica-Siberia. A review of geological history, fossil and provenance data for the Baltican-Siberian terranes suggests that they probably occupied an intermediate position between northern Baltica, northeastern Laurentia and Siberia, in proximity to the northern Caledonides, in early Paleozoic time. Dispersion of these terranes and their westward incursion into eastern Panthalassa are interpreted to result from development of a Caribbean/Scotia-style subduction system between northern Laurentia and Siberia in mid-Paleozoic time, termed here the Northwest Passage. Westward propagation of a narrow subduction zone coupled with a global change in plate motion, following the collision of Gondwana with Laurentia-Baltica, are proposed to have led to initiation of subduction along the western 'passive' margin of Laurentia and development of the peri-Laurentian terranes as a set of rifted continental fragments, superposed arcs and marginal ocean basin(s) in mid- to late Paleozoic time. Diachronous orogenic activity from Late Silurian in Arctic Canada, to Early Devonian in north Yukon and adjacent Alaska, Middle Devonian in southeastern British Columbia, and Late Devonian-Early Mississippian in the western U.S. records progressive development of the Northwest Passage and propagation of subduction along western Laurentia.

Metamorphism along the Kettle River fault, Christina Lake, British Columbia

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The Grand Forks Complex is a fault-bounded metamorphic core complex situated in the Omineca Crystalline Belt of southeastern British Columbia. Extending for ~40km north and ~60km south of the US-Canadian Border, it exposes a high grade, upper-amphibolite to granulite facies Proterozoic sedimentary package of North American affinity, possibly correlative with core and cover gneisses of the Monashee Complex. The eastern edge of this complex is bounded by the Kettle River normal fault (KRF), which runs through the Christina Lake, BC, area, the focus of this study. The hanging wall of the Kettle River Fault consists of Paleozoic to Mesozoic calcisilicates, marbles, semipelites, and volcanoclastics of Quesnel affinity, intruded by multiple intrusive phases of the Jurassic Nelson granodiorite suite and syenites of the Eocene Coryell Batholith.

Twenty-two kilometres south of Christina Lake, Rhodes and Cheney (1981) found an exposure of the KRF dipping 20° to the east, across which they estimated a stratigraphic throw of 4.5km. On the northeastern tip of the Grand Forks Complex, the fault appears to be cut by the 51 Ma Coryell suite, constraining the timing of its last movement to the early Eocene. Preliminary exploration along the fault as it exits the north end of Christina Lake reveals a thin, <30m wide

zone separating hornblende-biotite granites of the Jurassic Nelson suite in the hanging wall and Proterozoic calcsilicate gneisses of the core complex.

The core complex (footwall to the KRF) consists of an extensive metasedimentary package including biotite±sillimanite±cordierite±garnet±spinel gneiss, calcsilicate gneiss, marble, and quartzite, intruded by multiple deformed intrusive phases. The presence of garnet or orthopyroxene in hornblende-plagioclase-quartz±garnet±orthopyroxene amphibolite assemblages establishes local development of granulite facies conditions. In the basal sillimanite gneiss unit, 3 samples display garnet-cordierite-spinel-sillimanite±quartz assemblages in which highly-altered cordierite forms coronas around garnet and sillimanite, with spinel inclusions contained within. This is suggestive of core complex decompression and reequilibration following the peak metamorphic event, similar to previous studies in the western portion of the complex.

In the hanging wall, metapelitic hornfels 500m from the contact of a Jurassic Nelson intrusion have developed low pressure (2-4 kbar), amphibolite facies cordierite+andalusite±sillimanite assemblages. Porphyroblasts of cordierite and andalusite are wrapped by the dominant foliation, suggesting peak thermal metamorphism preceded the latest deformational event in the hanging wall. In localized areas east of Christina Lake, there is extensive migmatization of sillimanite-cordierite-bearing, semipelitic country rock up to 600m from the intrusive contacts. Away from the intrusions, the metamorphic grade in the hanging wall appears to be broadly of greenschist facies, with biotite-chlorite- plagioclase-quartz ±actinolite±epidote assemblages in calcsilicate-rich semipelites.

Age, kinematics and significance of the Pootlass high strain zone, Bella Coola, BC

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The Pootlass High Strain Zone (PHSZ) is a corridor of brittle and ductile deformation, at least 2 km wide and up to 30 km long, located in the Coast Belt just northeast of the boundary between the Intermontane and Insular superterrane, which is demarked by the Coast Shear Zone at this latitude (Rusmore et al., 2001). In this poster, we report recent observations from field mapping, and new geochronological and petrological data, from which we place the PHSZ into a regional tectonic framework.

The PHSZ is comprised of volcanic and sedimentary rocks of the Hazelton Formation, and Jurassic to Eocene plutonic rocks varying in composition from granodiorite to diorite and tonalite. The field area has undergone at least three phases of deformation; a folding event that resulted in tight, southwest-verging folds correlated with the regional Late Cretaceous Coast Belt thrust and fold system, intense ductile, sinistral shear, and brittle dextral shear. The PHSZ is defined by a steep foliation, with a very well developed subhorizontal stretching lineation, and southwest-verging folds with the fold axes parallel to the stretching lineation. Many of the intrusive rocks occur as syn-kinematic mafic and felsic sheeted intrusions that are tightly folded and display sinistral kinematics. L-tectonites within the deformed plutonic rocks attest to the weakness of the rocks during deformation and support syn-kinematic magmatism. Zones of highest strain are found within the mafic and felsic sheeted intrusions. Predominantly sinistral ductile shear in the PHSZ is overprinted by brittle, dextral faults. Along strike to the northwest, the high strain zones display both dextral and sinistral ductile shear components. Metasedimentary rocks in the PHSZ reached a maximum of amphibolite facies metamorphism as indicated by the abundance of hornblende. Greenschist facies metamorphism is dominant however, with rocks composed mainly of quartz, chlorite, muscovite and garnet.

Ar/Ar, cooling ages for hornblende and biotite from a folded and sinistrally sheared mafic sheeted intrusion within the PHSZ indicate deformation occurred prior to 62.39 ± 0.40 Ma and 63.04 ± 0.49 Ma, respectively. A step heating method for Ar/Ar dating was used to allow for monitoring of argon release during the analysis. U/Pb analysis of zircons from syn-kinematic, folded and sinistrally sheared felsic sills within the PHSZ returned crystallization ages of 113.8 ± 2.0 Ma and 160.9 ± 4.4 Ma.

The PHSZ may be kinematically related to similar transpressive structures in the western Canadian Cordillera; namely the Grenville, Kitkatla and Principe-Laredo sinistral shear zones to the northwest, that exhibit steep to vertical gneissic foliation in plutonic rock and intense isoclinal folding in supracrustal rocks of lower greenschist to amphibolite metamorphic grade, with estimated temperatures of deformation between 300 and 500°C (Chardon et al., 1999).

Chardon et al., 1999; *Tectonics*, Volume 18, No. 2, p. 278-292.

Rusmore, M.E. et al., 2001; *GSA Bulletin*, Volume 113, No. 8, p. 961-975.

SHRIMP U-Pb ages for 2650 Ma Archean orthogneiss, Mesoproterozoic paragneiss, 695 Ma Neoproterozoic orthogneiss, and 49 Ma Eocene Boulder Creek pluton, Pioneer Mountains, south-central Idaho

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We report SHRIMP U-Pb zircon ages that dictate the Wildhorse Gneiss Complex of the Pioneer Mountains, Idaho, is Archean, and thus likely continuous with the Grouse Creek Terrane south of the Snake River Plain. The Wildhorse Gneiss contains 2600-2700 Ma Archean orthogneiss, and structurally overlying Mesoproterozoic (<1460 Ma) paragneiss that is intruded by Neoproterozoic (695 Ma) orthogneiss. The gneisses are intruded by 49.00 +/- 0.39 Ma monzonite of the Boulder Creek pluton.

One of the structurally lowest units of the Wildhorse Gneiss Complex is a quartz-biotite-feldspar orthogneiss in the Boulder Creek drainage that yields upper concordia intercept ages of 2608 ± 17 and 2674 ± 9 Ma. These late Archean ages overlap those of the Grouse Creek Terrane to the south of the Snake River Plain, and are older than any from the Selway Terrane in southwestern Montana (Foster et al., 2006, CJES). The contact between the Archean Grouse Creek terrane and the Paleoproterozoic Great Falls Tectonic Zone must be north of, or structurally within, the Pioneer Mountains.

Structurally above the Archean orthogneiss are calc-silicate and amphibolitic paragneisses. We obtained SHRIMP U-Pb ages of 1460 to 1850 Ma on detrital zircons from three samples of calc-silicate and quartzitic metasedimentary rocks. Thus, the rocks must have been deposited after 1460 Ma, and be either Meso- or Neoproterozoic in age. This detrital-zircon age mimics the population distribution in the lower Belt Supergroup (Prichard Formation), the suggested protolith. No Grenville-age (1200 to 1000 Ma) grains are present, as would be expected in a Neoproterozoic sandstone.

In the Big Lost River drainage, E. Idaho, a “ghost” Neoproterozoic (650-740 Ma) detrital zircon population makes up 10% population of zircons in Holocene sands. The origin for the “ghost grains” is a 695 Ma felsic orthogneiss exposed in Wildhorse Creek of the Pioneer Mountains. Three samples yield SHRIMP U-Pb zircon upper concordia intercept ages of 692.3 ± 5.2 , 695.7 ± 8.0 , and 696.5 ± 9.0 , Ma. The igneous zircons analyzed were clear, elongate-prismatic oscillatory zoned grains with an average length of 250 microns.

The Neoproterozoic orthogneiss was previously mapped as Paleoproterozoic based on a Rb-Sr whole-rock age from the Wildhorse gneiss complex of about 2 Ga (Zartman, in Dover, 1983). The orthogneiss intrudes the Mesoproterozoic(?) paragneisses.

Since the Neoproterozoic orthogneiss is 695 Ma and contains the same metamorphic fabric as Archean orthogneiss, the metamorphism of the entire Wildhorse gneiss complex must be younger. We obtained a SHRIMP mean Pb/U age of 49.0 ± 0.4 Ma for magmatic non-xenocrystic zircons from the composite monzonite and pyroxenite Pioneer Mountains pluton in the Boulder Creek drainage. On many Neoproterozoic zircon grains bright cathodoluminescent rims, less than 5 microns thick are present, and likely Eocene. Clear magmatic zircon grains from felsic stringers in migmatitic gneiss are also about 50 Ma. This Eocene magmatism is part of the Challis magmatic episode.

The discovery of this Neoproterozoic orthogneiss establishes four locations in Idaho (Pocatello, House Mountain, Edwardsburg, Pioneer Mountains) where Sturtian (750 to 660 Ma) magmatism likely related to Rodinian rifting, is recognized. These plutons provide tie points for reconstructions of the late Neoproterozoic western margin of Laurentia.

The evolving Cordilleran Lithosphere: erosion of the North American plate during orogenesis and terrane accretion

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The Cordilleran orogen in Canada was built on a plate margin with a complex history of contraction and extension prior to the onset of the most recent orogenic development in the late Paleozoic. The record of early Paleoproterozoic and Mesoproterozoic tectonism exists in outcrop and in subsurface data but the influence of earlier activity on Phanerozoic processes is not clear. Phanerozoic orogenesis occurred mostly since the Jurassic. Along the outboard margin of the orogen, tectonic overlap occurred in part by decoupling of relatively thin lithospheric sheets or flakes (crustal scale or less) followed by their overthrusting toward the craton and in some cases over it, or accretion, and in part by tectonic underplating, or subcretion. Stress transmission along subhorizontal decoupling zones appears to be responsible for coeval deformation along the inboard craton side of the orogen. Tectonic accretion was followed by late to post-orogenic extension that may have been a response to subduction roll back at different times (e.g., Triassic-Jurassic, Cretaceous-Eocene). Oblique convergence at the late Mesozoic and Cenozoic plate boundary produced late transcurrent faults and associated transpressional and transtensional structures. The size of these structures, their role in redistribution of crust along strike, and their dynamic link to coeval regional compression and regional extension remain incompletely understood.

Analysis of regional geological and geophysical data acquired during the Lithoprobe study, along with related studies, leads to the conclusion that pre-Cordilleran North American crust and lithosphere project beneath the Cordillera almost as far west as the Coast Mountains. As a result, new material added to the plate by terrane accretion comprises a relatively small amount of the lithosphere today. A consequence of this geometry is that the continental margin prior to Mesozoic Cordilleran terrane accretion extended farther outboard than the present plate margin. Estimates of lateral continental growth, previously suggested to be ~500 km since the Early Jurassic, are thus not supported by available data. Surprisingly, Cordilleran orogenesis appears to

have resulted in a net decrease in plate surface area rather than outward growth by terrane accretion.

Brittle mesostructural kinematics in the Lake Okanagan Fault Zone: Implications for Eocene and younger deformation in the southern Canadian Cordillera

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The Lake Okanagan Fault Zone (LOFZ) is a down to the west extensional detachment cut by steep normal faults. We focus on Eocene and younger mesostructural faulting, using fault and striation attitudes in combination with sense of motion indicators to analyze the regional deformation and stress history. Shallow ductile shear progressively evolved to shallow brittle shear, followed by steep faulting as the structure was tectonically exhumed. This deformational style developed contemporaneously within a rheological domain and sequentially within a rock volume, as it thinned, cooled and was denuded.

Locally the oldest faults are sub-horizontal and developed sub-parallel to mylonitic bands. The initial sub-horizontal faults are cut by a pervasive, sub-vertical, regional joint set (RJS) that is prominent in both Tertiary strata and plutons and which is parallel to Eocene dykes. The RJS is often reactivated by faulting. Neo-form faults are oriented favorably for brittle failure in paleostress fields like those inferred from the reactivated RJS faults. Meso-scale folds are consistent with fault kinematics.

Most stations and faults record both an east-west (E-W) tension and a north-south (N-S) compression. The E-W tension orientation is like that of the ductile fabrics, Eocene dykes, and the general map-scale structure. Some stations and faults indicate an E-W compression, and others a N-S tension, or both. The stress history inferred from mesostructures is variable. Of the individual faults recording multiple strains, 42% indicate that E-W extension preceded N-S contraction, 23% indicate a transition from N-S contraction to E-W extension, 18% indicate either that E-W extension preceded E-W contraction, or that N-S contraction preceded N-S extension. In addition, 15% of the faults recording multiple strains indicate that E-W compression precedes any of E-W extension, N-S contraction or N-S extension, and 2% indicate that N-S contraction preceded E-W contraction.

The observed E-W extension direction is not consistent with previously inferred NW-SE displacement estimates for the LOFZ. The kinematic link between ductile and brittle deformation suggests that the displacement, which remains undetermined, is complicated and accommodated on many ductile and brittle structures. Recent earthquake solutions indicate that southern Omineca Belt “feels” N-S compression and that current E-W tension occurs generally south of 49°N. The inferred paleostress record is dominated by ductile and brittle E-W tension, accompanied by a coeval E-W compression. Both these stress regimes have been overshadowed progressively by the currently dominant N-S compression. The apparent intermingling of the E-W compression with the other stresses supports the interpretation from other studies that thrust fault gouge radiometric ages in the Foreland Belt indicate Eocene and younger thrust motions of undetermined displacement.

Physical Volcanology of the Chilcotin Group basalt: Preliminary Insights on Cordilleran Landscape Evolution

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The south-central interior of the British Columbia cordillera features a landscape dominated by 36,500 km² of plateaux underlain by Chilcotin Group basalt. The landscape largely reflects the effects of the Neogene volcanism superimposed on a Miocene paleo-topography and then modified by Quaternary glaciation. Neogene Chilcotin Group basalts have a range of thicknesses (<5m to ~100 m) and complicated distribution patterns that result from these lavas infiltrating the valleys and river channels established in the Miocene-aged landscape of the Intermontane Belt. Here, the relationships between the paleo-topography and the present-day plateau are explored by detailed stratigraphic analysis of the Chilcotin Group basalts exposed in Chasm Provincial Park.

Within Chasm Provincial Park, the Chilcotin Group basalt overlies rocks of the Permian Cache Creek formation, Eocene Kamloops Group and Miocene Deadman River Formation. Detailed mapping of the Chilcotin Group has identified a variety of subaqueous and subaerial volcanic and sedimentary facies. The facies have been separated into coherent and clastic rocks. Within the coherent rocks, three diverse facies have been described: 1) Plagioclase-phyric basalt (Pp), 2) Aphyric columnar-jointed basalt (Ac); and 3) Aphyric massive basalt (Am). All coherent facies are interpreted as sub-aerial, flat lying basalt lavas. Clastic facies include pillow fragment breccia (Pf) and sandstone to breccia (Sb). The presence of intact pillows, pillow fragments and hyaloclastite within pillow fragment breccia facies provide evidence for a local subaqueous environment. The sandstone to breccia occurs between the coherent lava units, and are interpreted as paleosols that represent volcanic hiatuses during the emplacement of the Chilcotin Group lavas. Field observations have consistently shown that the CG lavas were emplaced into mature paleo-channels containing rivers or lake systems including at Chasm. Further geological mapping and Ar/Ar age-dating throughout the section will provide evidence in order to generate the dimensions of the paleo-channel and constrain volcanic episodes during the emplacement of the lavas.

Layered intrusions and tectonic evolution of the Nootka Sound area (NTS 092E), Vancouver Island, British Columbia

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Layered intrusions identified in Conuma River area consist of alternating, cyclic, ultramafic and mafic units of peridotite and gabbro intruded by diorite and granodiorite. These intrusive rocks form a continuum within the Jurassic Island Intrusive suite. The layered intrusions display fractionate cumulate textures and magma flow structures. Other ultramafic and mafic bodies have been mapped within the area. Detailed petrography and mineralogy of these lithology types is consistent with similar lithology types worldwide known to host Platinum Group Element (PGE) mineralization. The major opaque minerals are magnetite (\pm ilmenite) with variable but relatively minor sulphide minerals. The sulphide minerals are pyrrhotite, pyrite and chalcopyrite. Minfile and regional geochemistry are consistent with minor amounts of PGE mineralization, but

sampling of the magnetite rich layers in the Conuma River area has yielded no appreciable concentrations of Au, Pt or Pd. New Ar-Ar dates (190.1 ± 1.4 Ma; 189.9 ± 2.1 Ma; 176.4 ± 1.3 Ma; 169.3 ± 1.2 Ma) reveal Jurassic ages for some the diorite and peridotite units.

Regional mapping, petrology and geochronology have been used to construct a preliminary crustal-scale cross section of the region. Regional faults are interpreted to be NW trending reverse faults being listric at depth and the N-S trending faults are assumed to be normal faults, possibly with strike-slip component, with kilometre-scale offsets to accommodate relative movement between major thrust blocks.

Most of the observable strain in the area is taken up as brittle deformation in a series of N-NW and SE trending faults (in few cases identified either as normal or reverse drag faults) at outcrop scale. The faults are steeply to moderately dipping and are considered a response to the recent transpressional regime. The lack of regional marker horizons and datable cross cutting units in the map area generally preclude detailed determinations of sense of movement or offset between the various lithologic units.

Grand Teton to Grand Canyon, Pliocene course of the Green River and implications for Cenozoic uplift of the southern Rocky Mountains, USA

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The Green River basin of southwestern Wyoming, currently paying tribute to the Pacific via Colorado River, was captured from a well-established late Miocene connection with a composite Snake-Klamath-Sacramento Pacific northwest drainage system sometime between the latest Miocene and 620 ka. That this diversion included an interval when the Green paid tribute to the Gulf of Mexico via the Platte, already strongly challenged by ichthyologic evidence, is rejected based on a reevaluation of the river gravels in the Great Divide basin of south-central Wyoming. The gravels had previously been interpreted as evidence that the Green was integrated with the Platte as recently as 620 ka. The gravels are reinterpreted as deposits of a river system that flowed south into the Yampa and then into the lower Green.

Diversion of the upper Green from its connection with the Snake and integration with the Colorado probably occurred during the earliest Pliocene. At this time, silicic calderas inflated and blocked the upper Snake River Plain. Thrust loading of the northern Green River basin in concert with extensional uplift of the northern Great Divide basin encouraged drainages of the proto Jackson Hole area to flow south where they quickly integrated with drainages of the upper Colorado. The sudden surge of hydrologic power to the south across the Colorado Plateau caused Lake Bidahochi, which had previously been a high inland sea with only minor inlets, to rapidly fill and spill over the Kaibab uplift, forming the Grand Canyon between 5.5 and 5.2 Ma.

Later Pliocene uplift of the Grand Tetons and formation of Jackson Hole led to the Snake's recapture of northwest Wyoming headwater drainages. The resulting diminished discharge of the combined Green – Colorado system is compatible with models that indicate flow in the lower Colorado was greater during canyon incision and integration with the Sea of Cortez than it is today.

The shift of drainage from northerly flow and integration with the north Pacific to southerly flow and integration with the Sea of Cortez suggests that uplift of the Colorado Plateau and Green River basin progressed to the north during the Neogene. Numerous lines of evidence indicate that uplift of the Green River basin occurred in the latest Miocene and early Pliocene. The timing of uplift of the southern Colorado Plateau, poorly constrained and controversial, was probably achieved mostly in the early Miocene.

Sedimentary provenance of the Paleoproterozoic Wernecke Supergroup, Yukon Territory: project outline and preliminary results

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Wernecke Supergroup is a thick (>13 km) succession of metasedimentary rocks (clastic and carbonate rocks) exposed mainly in the Wernecke, Ogilvie and Richardson mountains, Yukon Territory. The sediments were deposited in two grand cycles prior to 1.72 Ga. Although there is a solid stratigraphic description of the Wernecke Supergroup and a recent detailed regional mapping of the area, little is known about the provenance of these sediments. The goal of this project is: 1) to understand the source of the clastic sediments and the environment of deposition of the carbonate rocks of the Wernecke Supergroup using modern methods of geochronology and geochemistry (dating of detrital zircons, radiogenic and stable isotopes, trace element geochemistry), 2) to understand the evolution of the basin in which the sediments accumulated, 3) to make correlations with other Early and Middle Proterozoic sequences exposed elsewhere in Canada and in the world (e.g., Australia, Baltica, China, Siberia) where sedimentary provenance studies have been extensively carried out. These correlations will be useful for an Early Proterozoic reconstruction of the ancestral North American continent (Laurentia) in a global context. This study is relevant to mineral exploration in the region under investigation because the sequence hosts the Wernecke Breccias, a set of mineralized breccias zones (IOCG occurrences: iron oxides-Cu ±Au±U±Co±Mo), as well as Pb-Zn mineralization and polymetallic vein systems. Knowing more about how the Wernecke basin formed and which continents were proximal to Laurentia at that time will provide an improved geological framework for exploration models.

Subsidence history and tectonic evolution of the Bowser Basin, northwest British Columbia

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The Bowser Basin, located in northwest British Columbia, formed above the Stikine Terrane of the Intermontane Belt between the Middle Jurassic and Late Early Cretaceous. It contains approximately 6 km of marine to non-marine clastic sediments mainly assigned to the Bowser Lake Group, but also includes sediments of the upper Hazelton Group at the base of the succession.

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

Initiation of subsidence in the north was strongly related to tectonic activity associated with rifting. This was the main period of creation of accommodation space. Following the end of volcanism in the Toarcian, the Bowser Basin was the site of pelagic sedimentation in a deep water setting. It remained starved of clastic sediments until the Bathonian when thick turbidite successions were deposited. This corresponds to the second pulse of subsidence in the north and

seems to be entirely correlated with sediment loading. Generation of accommodation space in the south occurred much later and was significantly less important. Fossil-rich shallow marine sediments started to accumulate in the Bajocian above a regional unconformity. Deposition of interbedded tuff and chert beds in the Bathonian corresponds to a period of slow sedimentation similar to the one observed earlier in the north. However, the lack of turbidite deposits above it suggests that the basin never reached great water depth. Backstripping results indicate that the bulk of subsidence observed in the south was tectonic in origin and that the basin remained tectonically active during the entire period of sedimentation. This continuous tectonic input could be related to the proximity of the Skeena Arch which remained an active structural high during sedimentation.

The paleomagnetism of sedimentary rocks from the Ghost Rocks Formation, Kodiak Islands, Alaska

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The Ghost Rocks Formation is the second youngest unit in the accretionary complex that comprise the Kodiak Islands, AK and consists of a sequence of turbidites interbedded with pillow lavas. Most workers agree the Ghost Rocks Formation formed as a result of the passage of trench-ridge-trench triple junction along the Cordilleran margin during Paleocene-Eocene time, but the location where this interaction took place relative to the North American margin is still heavily debated. Plumley et al. (1983) conducted a paleomagnetic study on the pillow lavas of the Ghost Rock Formation at two different localities, Alitak Bay and Kiliuda Bay. The authors concluded the Ghost Rocks Formation formed at a latitude of $\sim 33^{\circ}\text{N}$ (+9/-7) followed by a $>1000\text{km}$ northward translation to their present location. Doubt has been cast on the strength of the conclusions of Plumley et al. (1983) because the site mean directions between the two localities are discordant and a complex fold and tilt correction was used at Alitak Bay. Our new collaborative paleomagnetic and structural study seeks to resolve the debate over the location where the Ghost Rocks Formation formed using more detailed paleomagnetic sampling and structural analyses.

Paleomagnetic samples were taken at a total of 176 sites, from four localities in the Ghost Rocks Formation during the 2006 and 2007 field seasons. This abstract will focus on the 46 sites collected at the Jap Bay locality taken from two different sedimentary units (Unit A and Unit B). Preliminary results from both units show two components of magnetization. Demagnetization paths of Unit A samples are well defined but preliminary analysis do not show an improvement in clustering upon un-tilting suggesting possible remagnetization. Demagnetization paths of Unit B samples are poorly constrained, most becoming unstable between $\sim 280\text{-}350^{\circ}\text{C}$. However, the second-removed component has dual polarity, thus it is likely it was acquired over a geologic time scale, possibly during formation. If the demagnetization paths of Unit B can be better constrained paleomagnetic results may reveal a reliable paleolatitude of formation for the Ghost Rocks Formation. More samples will need to be analyzed before accurate conclusions can be drawn.

Detrital zircon U-Pb provenance of the Upper Purcell Supergroup, southeastern British Columbia, Canada; Implications for Belt-Purcell basin models and paleogeographic reconstructions

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This study reports >400 new detrital zircon U-Pb SHRIMP-II ages from the Mesoproterozoic (~1.4 Ga) Upper Purcell Supergroup of SE BC. The goal of our study is to constrain the depositional, tectonic and paleogeographic setting of the Belt-Purcell basin of the Cordilleran orogen. The Upper Purcell Supergroup consists of, in ascending order, the Nicol Creek, Sheppard, Gateway, Phillips, Roosevelt, and Mount Nelson formations. Samples from the Sheppard, Gateway, Phillips, Coppercrown Creek Member (top of Roosevelt Fm.), and Mount Nelson formations were collected along the eastern extent of exposed Purcell strata; one sample of the Coppercrown Creek Member was collected from the western limit of strata.

Detrital zircon ages from the Sheppard Formation are dominated by 1500, 1700, 1750, and 1850 Ma grains; and contains subordinate Paleoproterozoic and Archean grains. The overlying Gateway Formation is dominated by 1400-1450, 1700, 1850, and 1900 Ma zircon grains; with subordinate Paleoproterozoic and Archean grains. The overlying Phillips, Coppercrown Creek Member (east), and Mount Nelson formations are dominated by detrital zircon ages between 1375-1450 Ma and 1650-1800 Ma, and contain subordinate Paleoproterozoic and Archean grains. Detrital zircon ages from the Coppercrown Creek Member (west) are dominated by 1500-1625 Ma grains and contain subordinate Paleoproterozoic and Archean grains.

Paleoproterozoic and Archean detrital zircon ages from the eastern Upper Purcell Supergroup samples may well have been derived from source terranes within western Laurentia, including the U.S. southwest. The influx of young (~1375-1450 Ma) zircon grains requires syn-depositional magmatism in a nearby source terrane. Anorogenic granites (~1400-1430) and related rhyolites of the U.S. southwest are a possible source of these young ages. However the series of ~1380 Ma granitoid intrusions that make up the Salmon River Arch, and related granitic intrusions into Belt-Purcell Supergroup strata in the US and Canada constitute a potential local source for young zircons. On the contrary, detrital zircons from the western extent of Purcell strata are better matched to Australian source terranes, specifically the Mt. Isa and Forsayth/Yambo provinces of northeastern Australia. ~1576 Ma basement exposed in the Priest River core complex in eastern Washington and western Idaho cannot be correlated with any known autochthonous Laurentian basement and is the likely source of exotic detrital zircon found in the Upper Purcell Supergroup. The Priest River basement is interpreted to be allochthonous with respect to North America, and may represent a stranded fragment of the long since departed cratonic terrane, which formerly constituted the west margin of the Belt-Purcell basin. We interpret the Upper Purcell Supergroup to have been deposited in a transpressional pull-apart basin setting, adjacent to a convergent/translational plate margin bound to the west by terranes now located in eastern Australia.

Testing the channel flow/ductile extrusion model in the southeastern Canadian Cordillera

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Channel flow is a process by which a panel of low-viscosity, mid-crustal rocks flows sub-horizontally down a pressure gradient and leaves its base and lid behind. If the channel flows on an inclined plane, it gets closer to the surface, and this process is referred to as ductile extrusion. The channel flow/ductile extrusion model has received much attention recently and is now largely accepted by the Himalayan community. In the southeastern Canadian Cordillera, various channel flow models have been proposed. However, there is no agreement as to which rocks flowed together, when they were flowing, and whether flow occurred during compression or tension. In this contribution, we critically test the channel flow /ductile extrusion model for the southeastern Canadian Cordillera by using several diagnostic field-based criteria. Notably this panel: 1) records a protracted history of high-grade metamorphism and partial melting throughout the Cretaceous; 2) is bounded above by a suprastructure previously metamorphosed and exhumed in the Jurassic-Early Cretaceous; 3) presents extensive evidence of high strain and melt-present deformation; 4) is bounded above and below by two zones of high strain having opposite shear sense. These shear zones were active together during at least part of their evolution, as indicated by similar U-Pb spot age distributions of zircon in sheared leucosomes; 5) is characterized by a syn-shearing metamorphic fabric at its base that indicates decompression and cooling; 6) comprises a frontal part, northeast of the Monashee culmination, that cooled before its back part, located southwest of the culmination. From these conclusive tests, we conclude that a panel of rocks located within the Selkirk allochthon was exhumed to upper crustal level by ductile extrusion in the Late-Cretaceous. Furthermore, we demonstrate that ductile extrusion occurred during NE-directed compression by comparing pressure-temperature-time paths from the channel and from the underlying Monashee Complex. These paths clearly indicate that the channel was exhumed and cooled in the Late-Cretaceous while rocks of the Monashee Complex were being heated and buried. Although these data strongly suggest that ductile extrusion was the main exhumation mechanism for part of the Selkirk allochthon, the boundaries of the channel are not clearly defined and it is unclear whether or not horizontal channel flow occurred before the extrusion phase.

Bedrock transect across the Mackenzie Mountains at 64.5°N: A new look at crumpled old platform strata

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During 2007 an NTGO-GSC field party conducted regional mapping (nominal 1:50,000 scale) in a 25 km-wide swath across map area 106A (“Mount Eduni”) to better understand the rock units and structure of this part of the Cordilleran fold-thrust belt. This is the second in a

three-year mapping initiative (Sekwi Project) to produce updated and integrated maps and a digital atlas for the Sekwi (105P) and Mount Eduni (106A) areas.

The area is underlain by unmetamorphosed sedimentary strata ranging in age from Neoproterozoic to Upper Devonian. In a general sense Paleozoic formations thicken towards the southwest. In the same direction, a major hiatus beneath Cambro-Ordovician strata diminishes leading to preservation of additional stratigraphic units. This 700 million year record spans events on the supercontinent of Rodinia, the breakup of this supercontinent coincident with Neoproterozoic glaciations, and subsequent passive margin sedimentation on the margin of Laurentia. It was not until mid-Cretaceous folding and thrust-faulting that the region underwent significant deformation.

In the eastern half of the mapped area, mountain-scale box anticlines are cored by Neoproterozoic Katherine Group sandstone flanked by lower Little Dal Group shale and dolostone. A major unconformity separates these units from overlying Cambro-Ordovician to Devonian platformal carbonate (Franklin Mountain, Mount Kindle, Delorme, Bear Rock Hume formations) of the Mackenzie Platform. These northwest-trending ranges are separated by 5 km wide valleys floored by Upper Devonian shale of the Canol and Imperial formations.

The central part of the area features large cylindrical folds of upper Little Dal Group evaporite and carbonate, as well as Rapitan Group glaciomarine strata. These successions are repeated above steeply dipping Paleozoic carbonate formations on the southwest-dipping Plateau thrust and related splays. The Plateau thrust is one of the longest such features in the Cordilleran fold and thrust belt.

The western third of the map area is underlain by large areas of gently dipping strata within the hanging-wall of the Plateau thrust. The oldest units comprise coarse clastic sedimentary rocks of the Neoproterozoic Coates Lake (locally preserved) and Rapitan groups overlain by Cambrian sandstone (Backbone Ranges Formation) and carbonate (Sekwi Formation). Within this area the Cambro-Ordovician to Devonian units of Mackenzie Platform undergo some facies changes that presage their southwesterly transition to time-equivalent shale of Selwyn Basin. These include abundant shaly limestone and chert within the Cambro-Ordovician Franklin Mountain Formation, and the appearance of the Devonian Sombre and Arnica formations (dolostone).

Economically, the region hosts stratabound Cu occurrences within the Coates Lake Group as well as other numerous carbonate-hosted Zn-Pb prospects. Several Ordovician diatremes, and veins containing green beryl and metal sulfides were located during the field season. The Plateau thrust is being evaluated as a hydrocarbon trap, and adjacent Paleozoic formations for their source and reservoir rock potential.

Significance of picritic and tholeiitic lavas within Wrangellia flood basalts on Vancouver Island for the melting history and magmatic evolution of a major oceanic plateau

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Geochemical studies of lavas from the accreted Wrangellia oceanic plateau forming a large part of Vancouver Island (~20,000 km²) in the Pacific Northwest of North America offer a view of the melting history of plume-derived magmas that does not involve continental lithosphere and where source heterogeneity does not play a major role. The Late Triassic Wrangellia flood basalts (~229-226 Ma) are predominantly homogeneous tholeiitic basalt.

However, the lower submarine part of the 6 km-thick stratigraphy, on northern Vancouver Island, contains picritic pillow basalts. These high-MgO (9-20 wt%) lavas are depleted in LREE ($\text{La/Yb}_{\text{CN}} = 0.5 \pm 0.2$), whereas the tholeiitic lavas (6-8 wt% MgO) are LREE-enriched ($\text{La/Yb}_{\text{CN}} = 2.2 \pm 0.3$). Both lava groups have overlapping initial ϵHf ($+10.3 \pm 2.1$) and ϵNd ($+7.7 \pm 1.3$), indicating a common, depleted (but not MORB) Pacific mantle source similar to the source of basalts from the Ontong Java and Caribbean Plateaus. The presence of picritic lavas indicates melting of anomalously hot mantle and, along with the high degree of melting and high melt production rate, provides strong evidence for a mantle plume origin for this oceanic plateau. Estimated primary melts, using PRIMELT1 [Herzberg et al. (2007) G3], contain 15-17 wt% MgO and ~10 wt% CaO and they represent 23-27% melting of peridotite with a potential temperature of ~1490°C. Differences in trace element signatures between the high-MgO and tholeiitic lavas primarily reflect differences in depth of melting. The high-MgO lavas formed without involvement of garnet, whereas the tholeiitic basalts involved melting of both garnet and spinel lherzolite. The evolved tholeiitic basalts underwent significant fractional crystallization (>50%) and the fractionated residues are likely represented by high-velocity rocks beneath Vancouver Island identified from seismic reflection studies [Clowes et al. (1995) CJES].

Kinematic analysis of a Cretaceous thrust zone, Cascade crystalline core, Washington

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The Cascade Crystalline Core of Washington is a fault bounded block of high grade metamorphic and intrusive rocks at the SE end of the Cretaceous Coast Plutonic Complex. Previous workers have disputed if NW translation or SW-vergent thrusting is responsible for regional metamorphism and deformation. Mapping and structural analysis in the Cascade River region displays evidence of 4 deformational events (D1a, D1b, D2, D3), and a new interpretation of mapped units. Units include the ocean floor protolith Napeequa schist, and an accreted Triassic arc: the Marblemount Meta Quartz-Diorite (MMQD), and the Cascade River Unit (CRU). Fluke (1992, WWU MS thesis) mapped imbricate slivers of mylonitic MMQD in the hanging and footwall of a thrust of MMQD over Napeequa. Thin section analysis indicates a clastic protolith for the mylonite and we reinterpret these slivers as CRU. We interpret that the MMQD is thrust over the CRU, and CRU over the Napeequa.

D1a formed S1a foliation across the study area; D1b locally folds S1 and formed new foliation in the southern half of the study area. S1a/b is preserved in isoclinal folds of foliation in hand sample and thin section, and the core of the MMQD. Petrographic evidence indicates D1 took place at a higher grade than D2 and D3. D2 formed a moderately NE dipping foliation with NE plunging mineral lineations within the thrust zone. S2 is axial planar to isoclinal folds of S1b; moderately plunging fold axes range from NW to E. F2 folds are mostly symmetric, however asymmetric folds near the thrust show S to SW vergence. S-C fabric and asymmetric augen in MMQD near the thrust also show top to the S and SW. Preceding and/or concurrent with thrusting was an episode of map scale NW-plunging upright folding of S1 in all units north of the thrust. We argue that D2 is responsible for upright folding, and imbrication of CRU and Napeequa which were thrust beneath the MMQD.

D3 structures are concentrated along the north and south margins of the MMQD. In the south, adjacent to the thrust, asymmetric upright E to NE F3 folds of S2 in Napeequa are N and NW vergent. S-C fabric parallel to SE plunging L3 mineral lineations in the hanging wall of the

D2 thrust also shows top the NW kinematics. In the north, shearing is superimposed upon steep F2/S2 limbs along the originally intrusive MMQD-CRU contact. Dextral and sinistral shear are present within X-Z planes, and reverse sense within Y-Z planes. The data suggest regional SW-vergent thrusting overprinted by transpression with NE-SW shortening and NW-SE shearing. A 94 Ma K-Ar cooling age of MMQD muscovite (Tabor, 1994) limits the age of S1. An Ar-Ar cooling age of biotite within S2 is 72 Ma; two biotites and one muscovite within the D3 shear zone yield ages of 58 & 60 Ma, and 59 Ma respectively. An 81 Ma U-Pb zircon age in the Cyclone Lakes pluton with a sub solidus foliation concordant to S2 provides a possible limiting age of thrusting.

Revision of the Late Paleozoic history of the Alexander terrane

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New data from the Alexander terrane significantly changes interpretations of its Late Paleozoic history.

The Pennsylvanian succession includes unnamed Lower Pennsylvanian bioclastic limestone, Middle Pennsylvanian volcanic debris flows and carbonate of the Saginaw Formation volcanic member, and Middle Pennsylvanian slope, silty carbonate deposits of the Saginaw silty and cherty limestone members. Shallow-water carbonate crops out northeast of the slope deposits, indicating an approximate southwest trending depositional slope during the Pennsylvanian.

The Pennsylvanian rocks are unconformably overlain by immature sandstone and conglomerate with rugose coral bioherms of the Halleck Formation. Wave ripples, channel scour at the base of conglomerates, and reworked Pennsylvanian conodonts indicate abrupt shallowing and erosion preceding this unit. Conodonts from the Halleck Formation are a mixed *Mesogondolella* spp. and *Streptognathodus* spp. Fauna; an Asselian (earliest Permian) age fauna previously found only in the southern Ural Mountains of Russia.

These Pennsylvanian and lowermost Permian rocks are unconformably overlain by Middle Permian (Wordian) carbonate of the Pybus Formation; most of the lower Permian is absent. Middle Permian Pybus rocks also overlie more deformed Mississippian rocks of the Cannery Formation to the east. The abrupt shallowing recorded within the Halleck and the overlap of diachronous units by the Pybus suggests tectonic uplift near the Carboniferous-Permian boundary followed by transgressive onlap of the Pybus. Late Triassic rocks in the region show a depositional slope opposite to that of the Pennsylvanian assemblage, further supporting tectonic reorganization during the Permian. Some of the Pybus was also found to be Late Permian (Wuchiapingian) and Early Triassic (Smithian).

Brachiopods and conodonts in the Halleck and the Pybus generally indicate cool-water settings similar to the Pennsylvanian and Permian of northwestern Pangea. However, the Late Permian conodont *Clarkina* at one Pybus locality indicates warm-water conditions more closely related to the Tethys, suggesting a shift in temperature for the Alexander terrane during the Permian. This mixed paleobiogeographic signature agrees with that found in Mississippian foraminifers for the terrane.

Detrital zircon provenance of Paleozoic pericratonic assemblages of the Kootenay Arc near Revelstoke, British Columbia

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Field investigation and new detrital zircon ages obtained by laser ablation MC-ICP-MS have revealed an interesting twist in the provenance of the westernmost Paleozoic strata that can be tied to the ancient North American plate in the southern Canadian Cordillera. Exposed within the Kootenay Arc between Revelstoke and Trout Lake, British Columbia, are polydeformed Paleozoic strata representing off-shelf equivalents of the miogeocline. A grit layer low in the lower Paleozoic Lardeau Group yielded a typical Cordilleran miogeocline spectrum with peaks at ca. 1.8 Ga and 2.7 Ga. In contrast, strata near the top of the Lardeau Group (age uncertain) and in the overlying Carboniferous Milford Group, have additional components of ca. 1.5 Ga and 1.3-1.0 Ga zircon. The shift is noteworthy because it occurred during deposition of the Lardeau Group and not during a previously hypothesized post-Lardeau Group, pre-Milford Group deformation event. The latter spectra are remarkably similar to detrital zircon characteristics of the nearby Devonian Chase Formation quartzite that underlies the Eagle Bay assemblage to the northwest. The abundance of 'Grenvillian'-age zircon in middle and upper Paleozoic strata is inconsistent with derivation from the east; a western continental source is suggested and some alternatives are considered.

The structural and tectonic history of the Mt. Formidable region, North Cascades, Washington

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Deformation events associated with crustal thickening and exhumation are preserved in the Mt. Formidable region of the North Cascades, a Cretaceous orogen and continental arc. This research examines the mechanisms and chronology of deformation associated with the burial and large-scale exhumation of mid-crustal rocks. The kinematics and timing of deformation during burial, magmatism and amphibolite-facies metamorphism remain controversial. Two models are being tested: a SW-vergent contractional model (McGroder, 1991) and a NW-directed translational model (Brown, 1987).

The study area consists of major supracrustal units and associated metaplutonic rocks that are part of a Triassic arc sequence (Tabor et al., 1989). There are four mappable units: the sub-arc Marblemount Meta-Quartz Diorite, the supra-arc metaclastic and metavolcanic Cascade River unit (CRu), interlayered greenschist and leucogneiss of the Magic Mountain Gneiss (MMG) and the ocean-floor Napeequa Schist (Misch, 1966; Tabor et al., 1989; Brown et al., 1994). These wall rocks are intruded by Cretaceous and younger felsic to intermediate plutons, some of which are metamorphosed and deformed (Tabor et al., 1989). Work to date is in MMG and CRu.

Field work in the Mt. Formidable area has revealed structures recording more than one deformation event. Three phases of folding were found at the outcrop scale, with a possible fourth phase of folding hypothesized at the map scale (Tabor et al., 1989). F1 folds are typically isoclinal, reclined, and are seen in interference with F2 and F3 folds. F2 folds are tight to isoclinal, locally reclined, fold an S1 foliation, and occur in Type I and II fold interference

patterns with F3 folds. In addition, the regional foliation (S2) is axial planar to F2. F3 folds are typically open folds that locally exhibit incipient cleavage (S3) axial planar to F3. Many F3 folds are asymmetric and are inferred to be parasitic on larger folds. More work is being done to identify fold domains and describe the kinematics of folding throughout the Mt. Formidable region.

Planned study of overprinting ductile structures and geochronology (U-Pb and Ar-Ar) of intrusions in the Mt. Formidable region offers the means to assess: 1) the number and age of deformation events, 2) the kinematics and geometry of ductile structures, 3) the most appropriate model for crustal thickening, and 4) exhumation processes and preliminary rates in the Northwest Cascades. The results of this research will be compared with data from different parts of the orogen to test if orogenic processes were spatially or temporally variable across the arc. Cretaceous deformation in the Cascades has important implications for the nature and chronology of processes occurring in active orogens.

Richardson Mountains: Overview of their Tectonic Evolution

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Located at the eastern front of the northern Canadian Cordillera, the Richardson Mountains are a north-trending range that records a long history of structural inheritance. The southern part comprises a seismically active anticlinorium transected by throughgoing faults collectively referred to as the Richardson Fault Array. Few of these faults have been studied in detail; however, those that have reveal more variability than suggested by existing reconnaissance mapping. For example, the Deception Fault, mapped as a steep normal fault, is constrained seismically as an east-dipping thrust fault with displacement on the order of 6 km. The Trevor Fault, also mapped as a steeply dipping normal fault, may be several distinct structures. Where it is exposed near the Dempster Highway, it is a sub-vertical fault with early Tertiary west-side up dip-slip displacement. Elsewhere, it is inferred from seismic data to be a west-dipping thrust fault (Osadetz, pers. comm. 2007). Additional structural mapping is required to clarify the distribution and kinematic significance of the faults in the Richardson Fault Array. The anticlinorium itself is an early Paleozoic extensional sedimentary trough that was inverted (primarily but not entirely) in the Early Tertiary. Locations and trends of some mapped faults may be inherited from Paleozoic normal faults. Seismic refraction modelling indicates a profound change in crustal structure beneath the range (O'Leary et al., 1995). Modern seismicity indicates a dextral strike-slip setting, consistent with current neotectonic models (Lane and Dietrich, 1995; Lundgren et al., 1995; Mazzotti and Hyndman, 2002).

Although more complex geometrically, the northern Richardsons preserve a similar tectonic history. The complex geometry is expressed as a series of en echelon northeast-trending uplifts projecting southwestward along the strike of Jurassic-Cretaceous, rifted Beaufort Sea continental margin. The largest uplift, the Cache Creek-Tununuk high, is a rifted block forming part of the continent-ocean transition. The other uplifts are inferred to have a similar Mesozoic history. Lying along the eastern margin of the Cache Creek uplift, the Aklavik Range is a local structural culmination comprising competent Paleozoic and Jura-Cretaceous strata east of the Donna River Fault, juxtaposed against Early Cretaceous shale and sandstone on the west. Folds and faults in the range typically are spaced less than one kilometre apart and are dominated by northwest structural trends. Most of the faults have steep dips; however, three low-angle east-directed thrust faults are mapped.

The Donna River Fault is a splay diverging northward from the Trevor-Eskimo Lakes fault system. It projects beneath the Mackenzie Delta and marks the eastern margin of the Cache Creek uplift. Where exposed, the fault is a subvertical, throughgoing structure striking 010°, accompanied by a zone of brecciation up to 300 m wide. The Donna River Fault zone preserves evidence of multiple episodes of displacement since Jurassic time. Inferred Jura-Cretaceous rift-related activation has been completely overprinted by Tertiary convergent and dextral strike-slip deformation. However, multiple sets of fault striations are rarely preserved in this zone. The orientations of subsidiary folds and faults, and penetrative fabrics within the DRFZ both indicate dextral strike-slip; whereas the low angle thrust faults and significant uplift of the Aklavik Range both indicate important convergence.

Diatremes and related volcanic rocks of the Lower Paleozoic Misty Creek Embayment, Mackenzie Mountains, NWT

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A comprehensive study of volcanic deposits (Marmot Formation) associated with the lower Paleozoic Misty Creek Embayment (MCE) in the central Mackenzie Mountains, NT, was undertaken to characterize the geochronological, petrographical and geochemical nature of this submarine volcanism in the middle Ordovician. The MCE is a 100 x 150km, northwest trending, rectangular basin bound by Ordovician platformal carbonates with volcanic complexes dominating in the centre and cross-cutting diatremes and associated volcanoclastic deposits along the basin margins. A reconnaissance level sampling program of 16 different exposures of mafic igneous units within the MCE was undertaken in August, 2007, in collaboration with the Sekwi Mountain Project, NTGO.

Igneous deposit types within the MCE comprise diatremes, volcanic vents and related dykes, lapilli tuffs and basaltic lava flows. The diatreme-related volcanic rocks are presumed to be mid Ordovician in age, based on stratigraphic relationships such as cross cutting dykes and their related strata-bound volcanoclastic deposits. Early to Late Ordovician platformal carbonates of the Franklin Mountain and Mount Kindle formations and their basinal equivalents contain the volcanic deposits. The diatremes range from small (~50m in diameter) breccia pipes to large (~700m in diameter) internally complex pipes (e.g., Mountain Diatreme). They generally consist of highly fragmented carbonate±chlorite altered breccia bodies with a modally high percentage of angular to rounded country rock xenoliths. Local zones (e.g., central pipe) comprise phlogopite, chlorite and carbonate altered olivine-bearing pyroclasts in a more homogenous, fine-grained, green groundmass. Lapilli tuffs are commonly observed and are locally strata-bound with brachiopod-bearing carbonate rocks of the Franklin Mountain Formation. The lapilli tuffs are typically phlogopite porphyritic in a green, aphanitic groundmass. Where observed near diatreme centers they contain abundant country rock xenoliths ± phlogopite phenocrysts, and weather rusty orange. Basaltic lavas are commonly observed along the western margin of the basin, including thick deposits (~300m) that are locally pillowed and bedded. These volcanic units are distinct in that they contain fresh olivine and clinopyroxene phenocrysts.

Preliminary interpretations based on field observations and whole-rock geochemistry show that the Marmot Formation comprise ultra-potassic to alkaline mafic volcanic rocks derived from an enriched OIB type asthenospheric mantle source. The Marmot Formation represents volcanism related to a continental margin rift setting (MCE) with a developed carbonate platform on its western and northern margin.

This investigation will provide new insight into the nature of this volcanic activity and characterization of the mantle source. Mineral chemistry on primary mineral phases (e.g. clinopyroxene, spinel, phlogopite and olivine) will provide further insight into the mantle source. ArAr geochronology on phlogopite megacrysts will be used to constrain the timing of emplacement and rifting of the MCE. These new data will provide critical information regarding the evolution of the MCE and the Selwyn Basin.

Sequence stratigraphy and detrital zircon populations in the Neoproterozoic (Cryogenian) Uinta Mountain Group, northern Utah

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A continuous section of mid-Neoproterozoic lower and middle Uinta Mountain Group is exposed in the Kings Peak Quadrangle, Utah on the northeast ridge of Gilbert Peak. It contains the formations of Red Castle, Dead Horse Pass, and Mount Agassiz. Three sedimentary facies associations are recognized: (1) The fluvial and tidal facies is characterized by couples of a) medium to coarse, moderately sorted, arkosic fluvial arenite containing trough cross bedding and b) interbedded tidal (flaser bedded and herringbone cross-bedded) green and red shale and fine sandstone. Shaley halves of the sandstone-shale couples thin upwards through the section, from 15 meters to a few centimeters thick, and are laterally continuous. (2) The marine facies is a fine to medium, moderately to well sorted quartz arenite with planar cross bedding interbedded with shale and siltstone, with shale beds approximately 10-30 meters thick. This facies shows progradational and retrogradational geometries. (3) The arkosic marine facies is a very coarse, unsorted arkosic arenite with parallel laminations and pebble lags.

The upper Red Castle is composed of aggradational fluvial and tidal facies (a highstand systems tract), overlain by an erosional stratigraphic sequence boundary across which paleocurrents and lithologies change abruptly. The formations of Dead Horse Pass and Mount Agassiz contain the two marine facies, which compose a retrogradational-progradational cycle punctuated by four higher order sequence boundaries. The arkosic facies is interpreted to represent near shore lowstand deposits of minimally reworked fluvial sediments. This facies likely indicates a significant lowstand with a near return to fluvial conditions similar to those controlling deposition of Red Castle. Low diversity acritarchs from shales suggest a restricted marine environment.

A suite of 494 individual detrital zircon SHRIMP U-Pb ages were obtained from eleven samples of the <770 Ma Uinta Mountain Group and Big Cottonwood Formation, Utah. These include four new samples and seven previously reported (Dehler et al, in press). These data significantly expand the Mueller et al (2007) report based on four Uinta Mountain Group detrital samples (104 grains).

Archean grains cluster between 2600 and 2800 Ma with peaks derived from the “unmix” utility in Isoplot at about 2555 Ma, 2600 Ma, 2680 Ma, and 2790 Ma. These age distributions are noticeably younger than peak Archean ages from Mesozoic Colorado Plateau sandstones, confirming the intuitive latest Neoproterozoic rift-related unroofing of the Wyoming Craton and the ages of late Archean zircon-rich intrusive phases of the Wyoming Province.

Paleoproterozoic grains continuously span 1650 – 1950 Ma with prominent peaks at about 1670 Ma (Mazatzal), 1750 Ma (Yavapai), 1850 Ma (Mojave), and 1970 Ma (Mojave).

Mesoproterozoic grains continuously span 1360 – 1560 Ma and peak at about 1360, 1410, and 1460 (A-type transcontinental granite province), and 1560 (enigmatic! non-North American) Ma. Eight grains, 2% total population, fall within the North American magmatic gap (1508 – 1600 Ma). The ultimate source for these grains may be Asian, though a more proximate source could be reworked lower Belt Supergroup equivalents.

Grains derived from the Grenville orogenic belt continuously span 1000 – 1250 Ma and peak at about 995, 1070, 1155, and 1255 Ma. The continuous age distribution is similar to that reported by Erikson et al (2003) for modern streams draining the Appalachians, but distinctly younger than peak ages reported by Dickinson and Gehrels (2003) for eolian sandstones of the Colorado Plateau, with a more southern source within the Grenville orogen. These age differences suggest provenance change rather than sediment unroofing.

The Neoproterozoic age population is the least prominent yet most significant as it defines a maximum age of 766.4 ± 4.8 Ma. These grains were derived from a felsic igneous source via fluvial transport from the north or east, or possibly as ashfall from there or a more distant non-Laurentian source. Detrital zircon geochronology has foiled the “Curse of the Proterozoic Sandstone”.

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Direct evidence for active listric detachment faults and craton-normal transfer faults during evolution of the Neoproterozoic Mackenzie Mountains Supergroup, N.W.T., Canada

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Isopach maps for major divisions of the Mackenzie Mountains Supergroup indicate that it was deposited along the arcuate margin of a basin that deepened to the WSW. In marked contrast isopachs of formation-scale units do not run uniformly parallel to the basin margin or deepen gradually or uniformly basinward. Sandstone-dominated, formation-scale units within the Katherine Group exhibit marked inboard thickening between 64° and $65^\circ 30'N$ in four of its seven units. These thickness differences suggest that fluvial facies prograded into sub-basins that formed by large-scale rotational collapse along listric faults formed during basin extension within lower-plate segments of an evolving passive margin. Similarly, in the overlying Little Dal Group, thickness and facies patterns do not conform to the expected pattern for a simple passive margin. The trend and position of the basin-to-platform transition in one carbonate-dominated part of the succession is at a high angle to the basin margin, formation. Member-scale stratigraphic units also exhibit marked along-strike thickness variation. Deep-water reefs have a spatial distribution that is probably fault-related.

All of the above features can be explained if deposition occurred in segmented, syndepositional sub-basins that formed during extension-driven collapse along a lower-plate segment of the Neoproterozoic craton margin. Individual sub-basins, 30 to 100 km in strike length, and 50-70 km wide, were separated by intermittently active transfer faults with both strike-slip and dip-slip components. A number of the major transfer faults appear to have influenced the later tectonostratigraphic evolution of the continental margin, both during basin expansion during deposition of the Rapitan Group, and during Phanerozoic extensional and contractional events. The present-day distribution of base-metal mineralization in the Mackenzie Mountains Zinc District indicates that these structures may have played a direct role in focussing fluid flow into overlying units during later mineralising events.

Structural history of the northwest Skeena Fold Belt, northwest British Columbia

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The Skeena Fold Belt is a region of deformation encompassing the Jurassic-Cretaceous Bowser Basin in northwestern British Columbia. The fold belt is interpreted to have developed between late Early Cretaceous and early Tertiary time. The fold belt is dominated by two major fold sets. Folds trending northeast dominate the western third of the fold belt, while folds trending northwest dominate the eastern two thirds of the fold belt. Locally these fold sets and associated structures are overprinted.

Several areas were mapped across the northwestern fold belt to resolve local timing relationships and develop regional correlations of structural development. In areas where both fold sets are present, F2 northwest trending folds overprint F1 north- to northeast-trending folds, consistent with a history in which early generally northwest-southeast shortening was followed by northeast-southwest shortening. The expression of F1 folds generally becomes subtler towards the east as F2 northwest-trending folds become dominant. Brittle structures such as faults and *en echelon* veins are rarely associated with F1 folds, while they are commonly observed in orientations suggesting development synchronous with F2 folds. Conditions were less ductile during F2 folding, possibly due to progressive denudation of the Bowser Basin as deformation progressed.

Locally there is evidence for a brittle D3 deformation represented primarily by NW-striking dextral and NE-striking sinistral faults with small offsets. This deformation resulted from north-south shortening coupled with east-west extension. These structures may be a manifestation of late dextral deformation interpreted to occur throughout much of the Cordillera.

Preliminary whole rock Ar-Ar geochronology performed on cleaved siltstones collected along the western basin margin yields plateau ages between 128 and 146 Ma, interpreted as the age of cleavage development. This suggests that deformation in the fold belt may have begun in Early Cretaceous time, significantly earlier than previously known.

Stratigraphy, sedimentology, and hydrocarbon reservoir potential of the Lower Cretaceous Jackass Mountain Group, Chilko Lake area, British Columbia

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The Lower Cretaceous Jackass Mountain Group (JMG), near Chilko Lake in south-central British Columbia, is exposed southwest of the dextral Yalakom Fault and has been traditionally considered part of the Jura-Cretaceous Tyaughton Basin. The JMG in this area is over 2 km thick and unconformably overlies the Middle Jurassic Nemaia Formation and mid- to Upper Jurassic Relay Mountain Group. Preliminary data indicate an age range of Hauterivian to Albian. The rocks are exposed in a major east-northeast-trending synclinorium, which permits detailed examination of the lateral and vertical facies variations within the JMG. Detailed stratigraphic and sedimentologic analysis of JMG strata documents extensive shallow marine deposition, contrary to previous interpretations that described the bulk of the JMG as the deposits of deep submarine fan systems. In the northern limb of the syncline, over half of the strata are

interpreted as shelf to shoreface deposits. These strata include extensive, moderately well-sorted sandstone bodies, decimetres thick, with common trough and hummocky cross-stratification, interpreted to represent high energy shoreface environments. Flaser and lenticular bedded facies also suggest that lower energy shoreface environments were widespread. These shallow marine strata are overlain by classic turbidite sequences, suggesting that in this area the basin evolved from shallow marine to outer shelf/slope environments over time. The JMG outcrops in the study area contain many similarities with exposed Cretaceous strata across the Yalakom Fault and 125 km to the southeast; the strata east of the fault dip northward beneath Tertiary basalts which cover subsurface Mesozoic stratigraphy. Assuming correlation with subsurface Lower Cretaceous Nechako Basin strata, the thick and extensive shoreface sandstones of the JMG in the Chilko Lake area provide a new subsurface hydrocarbon target with good reservoir potential, in addition to the previously identified submarine fan sandstone lithofacies. Ongoing geochronologic, geochemical, paleontological, and porosity/permeability analyses will help to constrain basin evolution and reservoir suitability.

Sekwi Mountain Project: Overview of bedrock mapping and collaborative studies in central Mackenzie Mountains, NWT

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The Sekwi Mountain project, initiated by the Northwest Territories Geoscience Office, is a 3-year multidisciplinary study of the central Mackenzie Mountains and is being conducted in collaboration with the Geological Survey of Canada, university researchers and industry partners. The project is aimed at providing an up-to-date understanding of the stratigraphy, tectonic history, metallogeny, geochronology, and geochemistry of Proterozoic and Paleozoic strata exposed in NTS map sheets 105P, 95M and 106A. This presentation will provide an overview of the Sekwi Mountain Project collaborative studies and 5 undergraduate and graduate theses.

Detailed studies in concert with regional mapping include the investigation of: 1) map-scale structures in the footwall of the Plateau Thrust; 2) potential hydrocarbon source and reservoir rocks; 3) stratigraphy of Cretaceous coal-bearing strata, Imperial Formation, Whittaker Formation, Katherine Formation, and Little Dal Group; 4) structural and stratigraphic controls of carbonate hosted Zn-Pb showings; 5) geochemistry of volcanic rocks and associated diatremes; and 6) examination of newly discovered mineral prospects.

Of possible economic interest, we encountered a new occurrence of vein-hosted green beryl, which is currently being investigated as part of a B.Sc. thesis study. The beryl is spatially associated with malachite, chalcopyrite, pyrite, pyrrotite, galena, and sphalerite; however, the genetic relationship between the contrasting styles of mineralization is not clear. Of other economic interest, the commonly Cu-bearing Coppercap Formation was found in previously undocumented locations in NTS 106A. This formation contains and overlies stratabound Cu occurrences in adjacent map areas to the southeast, some of which are currently being investigated by exploration companies. The area is known to host numerous carbonate-hosted Zn-Pb prospects; the structural and stratigraphic controls on many of these prospects are being

investigated as part of a M.Sc. study. Finally, several diatremes in, and west of NTS 106A (including the Mountain diatreme), are being studied as part of a M.Sc. study. Previous reports of diamonds and G-10 garnets derived from the diatremes allow speculation that there may be diamond potential in this part of the Mackenzie Mountains.

The Knob Hill Complex – a Paleozoic supra-subduction zone ophiolite in southeastern British Columbia?

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The Knob Hill Complex, in the Greenwood-Rock Creek area, constitutes a disrupted ophiolite. It is composed of serpentinites, varitextured gabbro, minor sheeted dykes, basalt flows and chert-rich sediments. Stratigraphic relationships between map units are not always clear in the immediate Greenwood area. However, in the Kettle Valley area north of Rock Creek, gabbro and serpentinite pass northwards, and probably upwards, into greenstones, mixed greenstone and chert and finally into cherts and argillites.

The age of the Knob Hill Complex is still poorly constrained. Zircons recovered from pegmatitic gabbro suggest an age of 370.6 ± 5.9 Ma in agreement with a Late Devonian conodont determination from limestone interbedded with volcanics. However, a chert higher in the mixed greenstone-chert section yields good Late Pennsylvanian age radiolaria (~290-295 Ma). 80-100 Ma is quite a long age range for any piece of oceanic crust and suggests a tectonic history that may involve several spreading events.

New and published analyses of basalts from the Knob Hill Complex show the presence of at least 3 magma suites:- a) a N-MORB suite; b) an E-MORB suite and c) a significant IAT (Island Arc Tholeiite) suite. There does not appear to be any apparent spatial nor stratigraphic control on the occurrence of the 3 suites and they seem to be mixed together. The chemistry suggests a complex history for the Knob Hill, perhaps in a fore-arc basin setting.

Throughout the Boundary District, the ophiolitic Knob Hill Complex is sandwiched by thrusts between more complexly deformed quartzite-schist-greenstone sequences – the Anarchist to the south and Kobau to the north. In the Greenwood area, the latter may be represented by the quartzite and schists of the Eholt Creek valley and Mount Roderick Dhu. Despite Tertiary extensional faults disrupting and modifying the thrust sheets, the Knob Hill Complex can be traced westwards from Greenwood into the Ripperno Creek area. Similarly, the Anarchist schist can be traced into the Bridesville-McKinney Creek area before passing westwards into the granitic gneisses of the Okanagan batholith.

West of the Okanagan Fault, the Palmer Mountain Greenstone in Washington comprises mafic flows and pyroclastics with varitextured gabbro and serpentinite that can be correlated with the Knob Hill Complex. These are thrust over “Anarchist Group” (including significant Triassic Brooklyn Formation) and, in turn, are structurally overlain by metamorphics of the Kobau Group.

It is still unclear how the Kobau Group and Anarchist Schist correlate with each other, or with the Knob Hill Complex. They may be the same package structurally repeated or, perhaps, represent opposite sides of a basin (the Knob Hill Complex) that is now closed and telescoped.

Crustal evolution of the western Amazonian margin: zircon U-Pb geochronology and Lu-Hf isotopic constraints from the Peruvian Eastern Cordillera granitoids

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We use a combination of the *in situ* laser ablation (MC) ICPMS U-Pb geochronology and Lu-Hf isotopic tracing of plutonic zircons along the strike of the Eastern Cordillera of Peru to construct a detailed geochronological framework and identify sources of magmatism in order to define cratonic domains and track crustal evolution of the proto-Andean margin of Amazonia. By relating the secular changes in magma sources to the tectonic cycles of continental assembly and break-up over the last 1.1 Ga, we can test both the current geodynamic scenarios for the evolution of the western Amazonian shield, with particular focus on the poorly understood break up of Rodinia, and models constraining the relative contributions of Phanerozoic and Neoproterozoic arc magmatism in the formation of the continental crust. Our data demonstrate the existence of a composite continental margin heavily dominated by three distinct intrusive pulses related to the assembly and break up of Gondwana (middle Carboniferous to late Triassic), together with volumetrically subordinate plutons emplaced during the initiation of the modern Andean cycle of subduction in the early Jurassic. Plutonic remnants belonging to the early Paleozoic Famatinian, middle Neoproterozoic Braziliiano and the late Mesoproterozoic, Grenville-equivalent Sunsás orogens are located in the south central Peru and suggest the presence of the latest Mesoproterozoic crust, 225 km from the present day coast, making them the westernmost exposure of the autochthonous Amazonia in South America. The integrated major chemistry and Hf isotopic record of the Peruvian Eastern Cordilleran batholiths indicate that continental arc magmatism assimilated the preexisting crust as successive batches of subduction derived magma assimilated and mixed with predominantly Paleoproterozoic mid-lower crustal substrate equivalent to the Ventuari-Tapajos (1.8-2.2 Ga) tectonic provinces of the western Central Amazonian craton. Namely, the periods of well documented compressive tectonics correspond to negative mean $\varepsilon_{\text{Hf}_i}$ values of -6.73, -2.43, -1.57 for the Ordovician Puna-Famatinian, Carboniferous-Permian and late Triassic respectively, suggesting the minimum crustal contribution between 74% and 45% by mass. The average initial Hf systematics from granitoids associated with intervals of regional extension such as the middle Neoproterozoic, Permian-Triassic and Cenozoic Andean back arc plutonism on the other hand, are consistently shifted toward the positive $\varepsilon_{\text{Hf}_i}$ values (-0.7 to +8.0) indicating systematically larger inputs of juvenile magma (22% to 49%). Consequently, the sharp boundaries between middle to late Proterozoic tectonic domains, as indicated by Hf isotopic parochialism along the orogenic strike, seem to have been “smeared” by juvenile magmatic inputs and crustal reworking since Mesoproterozoic. A tectono-magmatic model is proposed whereby crustal growth along the proto-Andean margin of Peru, if any, mainly occurred during phases of regional extension as the isotopically juvenile, mantle derived magmas underplated previously attenuated continental crust giving rise to either anorogenic (Neoproterozoic), or post-orogenic granitoids (Permian-Triassic anatectites). In the absence of a recognized phase of collisional tectonics, the time integrated Hf record from the proto-Andean margin of western Amazonia would imply that most of the continental growth took place vertically via crustal underplating of isotopically juvenile, mantle derived magma during intervals of crustal attenuation.

Devolution of Canada's western mountains

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The poster is intended for undergraduates studying regional geology and interested non-geologists and also to be a “straw man” that encourages discussion.

The top tier of the poster consists of three maps of the Canadian Cordillera showing the distribution of: (1) physiographic divisions and present lithospheric plates; (2) metamorphic and granitic rocks; and (3) terranes. Any attempts to explain how the Cordillera formed must account for the distribution of features summarized on the maps. Below is a geological time scale, from the present on the left to Neoproterozoic on the right. Keyed to the time scale, a sequence of maps derived from the tectonic assemblage map of the Canadian Cordillera shows the present surface distribution of rock units and their natures for selected time intervals.

The lower part of the poster comprises “three-dimensional” cartoons - surface and crustal sections - and accompanying texts. Cartoon units are terranes and old continental margin rocks. The sequence attempts to trace devolution of the Cordillera from the present on the left, where the most complete information is available, through generally decreasing amounts of data and increasing amounts of uncertainty farther back in time as younger features overprint and may obliterate older ones. From left to right, the cartoons depict: (1) Neogene, present physiographic units and crust-upper mantle cross-section based on Lithoprobe's southern Canadian Cordillera deep seismic interpretation; (2) Paleogene extension and dextral strike slip faulting; (3, 4) two stages in earliest Paleogene to Middle Jurassic mountain building; (5,6) two stages in the early Mesozoic approach of terranes to the old continental margin; (7) late Paleozoic formation of terranes now in the Cordilleran interior; (8) conversion to an intraplate margin in Middle to Late Devonian time – a major change that persists until today; (9) the early Paleozoic intraplate boundary; and (10) Neoproterozoic-Early Cambrian creation of the continental margin that is the Cordilleran birthplace.

The structurally controlled Zn-Pb-Ag Blende deposit: temporal constraints on regional deformation by sulphide precipitation

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The Blende Zn-Pb-Ag deposit is located approximately 75 km northeast of Keno Hill, Yukon, within the southern Wernecke Mountains. Mineralization is hosted by a dolomitic siltstone of the lower Proterozoic Gillespie Lake Group, the uppermost unit of the Wernecke Supergroup. The Gillespie Lake Group is a shallowing upwards carbonate sequence which represents the transition from a shale-dominated sequence to dolomitic siltstone with stromatolitic and oolitic layers within the upper sections of the formation (Delaney 1981), the uppermost part of which is exposed in the study area. Middle Proterozoic diorite to gabbro sills and dykes of the 1.38 Ga Hart River Intrusive Suite (Abbott 1997) cross-cut the Gillespie Lake Group; all of these units are truncated and unconformably overlain by the Penguicula group.

Regional and detailed mapping shows kilometre-scale open folding has produced a steep southwest-dipping axial planar cleavage. The Blende is situated on a broad, upright, southeast-plunging anticline where mineralized breccias form an anastomosing fabric oriented parallel to

the axial planar cleavage of the anticline, suggesting the cleavage acted as a conduit for the mineralizing fluids.

The bulk of the sulphide mineralization consists of epigenetic sphalerite and galena, with both early and lesser coeval pyrite. Minor sulphide phases include tetrahedrite and chalcopyrite, as well as alteration phases of the above sulphides. Gangue mineralogy consists of fine to coarse grained dolomite and quartz. Mineralized breccias and veins exhibit a clear cross-cutting texture with unmineralized dolomitic siltstone of the host Gillespie Lake Group. None of the sulphide or gangue minerals exhibit evidence of deformation, indicating the last phase of major deformation predates the timing of mineralization. Mineralization has not been found in the overlying Penguicula Group and appears to be genetically unrelated to the Hart River Suite.

The Racklan orogeny is known to have deformed rocks of the Wernecke Supergroup in the Yukon during the Paleoproterozoic. Current evidence indicates the age of mineralization as Mesoproterozoic, with a maximum mineralization age of 1.50 Ga (Robinson and Godwin 1995), postdating a minimum 1.60 Ga (Thorkelson et al. 2005) timing for the Racklan orogeny and suggests that this may be the last major deformational event to have affected the Blende area.

Permo-Triassic orogeny in the northern Cordillera: Sonoma North?

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The Late Permian to Early Triassic Sonoman Orogeny of the western US is characterized by the emplacement of a relatively intact oceanic slab (Golconda Allochthon) eastwards over the Antler overlap sequence. Models proposed for the Sonoman Orogeny include: 1) closure of a back-arc basin behind a W-facing arc; or 2) collision of an E-facing arc with the western edge of the continent. Subsequently, a W-facing Middle Triassic arc was built along the margin. Recent work in the Yukon demonstrates that the timing and style of latest Paleozoic deformation along the Ancestral North American margin is similar to that of the Sonoman Orogeny. In the northern Cordillera, mid-Paleozoic back-arc extension led to formation of the Slide Mountain Ocean (SMO) behind a W-facing arc built on a rifted ensialic fragment (Yukon-Tanana terrane, YTT). The SMO started to close in late Paleozoic time by W-dipping subduction under YTT and the attached remnants of the SMO, generating the Late Permian Klondike arc on YTT. Metaluminous intrusions ranging in age from ~220-185 Ma subsequently intruded YTT. Emplacement of the YTT/SMO allochthon onto North America was previously thought to have occurred in Early Jurassic time. New mapping, structural studies, U-Pb zircon dating and detrital zircon studies, indicate: 1) the Klondike arc rocks range in age from 264-255 Ma; 2) arc rocks were ductily deformed twice by 250 Ma; and 3) detritus from the YTT is first recognized on the western margin of North America by Early Triassic (Smithian) time, well before the previously proposed Early Jurassic time of allochthon emplacement. We argue that latest Permian ductile deformation preserved in the Klondike arc records a collision between the YTT/SMO allochthon and the thinned western edge of the North American plate. By Early Triassic time sediments were being shed from the uplifted and deformed hinterland eastwards across the suture into a peripheral foreland basin built on the remnant Cordilleran miogeocline. The subsequent W-facing mid-Late Triassic magmatic arc in YTT (Quesnellia) is therefore a continent margin arc developed on the new North American continental margin. Our data indicate late Paleozoic tectonism affected both the north and south portions of the Cordilleran margin and suggest Permo-Triassic orogeny was not an isolated event to the southwestern US.

Barrovian and Buchan metamorphism in the central Kootenay Arc, southeastern British Columbia

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Metapelitic rocks in the contact aureole of the Nelson Batholith record metamorphism at low pressure during the Middle Jurassic. Staurolite+andalusite-bearing assemblages indicate intrusion at 3.5-4 kb, equivalent to 12-14 km burial depth.

Along part of its eastern margin, the Nelson Batholith and its contact aureole is truncated by the Gallagher fault, a west-dipping, early Tertiary normal fault. In the footwall of the fault metapelitic rocks contain the assemblages garnet-staurolite-kyanite, garnet-kyanite, garnet-kyanite-sillimanite, garnet-sillimanite and garnet-sillimanite-K-feldspar (all with muscovite, biotite, quartz, plagioclase and accessory minerals). These assemblages indicate metamorphism under intermediate-pressure (6-7 kb) conditions, equivalent to approximately 20-25 km depth.

Contrasts in the metamorphic history of rocks from opposite sides of the Gallagher fault will be demonstrated using composition-specific mineral assemblage diagrams constructed using Theriak-Domino software.

Windy McKinley terrane, Stevenson Ridge area (115JK), western Yukon: composition and proposed correlations, with implications for the Triassic tectonic evolution of the western North American continental margin

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Windy McKinley terrane of western Yukon and eastern Alaska is one of the least well exposed and understood geological elements of the North American Cordillera. Recent mapping in Stevenson Ridge area of western Yukon has characterized the stratigraphy and structure of the rocks included in the terrane as well as their relationships to the surrounding Yukon-Tanana terrane. Three subdivisions of the terrane have been documented, the imbricated upper mantle, lower crustal and, rarely, the supracrustal parts of the undated Harzburgite Peak – Eikland Mountain ophiolite complex; the Mirror Creek formation, a succession of predominantly fine-grained, variably carbonaceous and calcareous metaclastic rocks extensively intruded by Middle Triassic gabbro; and the White River formation, a subdivision comprising felsic metavolcanic and carbonaceous clastic rocks and spatially associated with extensive bodies of undated gabbro geochemically identical to the Middle Triassic gabbro intruding the Mirror Creek formation. When Mesozoic or Tertiary strike-slip faults are restored, the ophiolitic rocks occur generally between the latter two gabbro-bearing subdivisions of the terrane and rocks of Yukon-Tanana terrane, lying to the north, east and south of Windy McKinley terrane. The relationship between the latter two subdivisions of the terrane is not exposed.

The lithological association of Triassic gabbro with felsic metavolcanic rocks and variably calcareous carbonaceous metaclastic rocks found in Windy McKinley terrane is uncommon in the northern Cordillera. This association occurs, however, about 200 km to the northwest along strike, in the Delta VMS District of Alaska. In the Delta District, two stratigraphic successions, the Devonian-Mississippian felsic metavolcanic rock-bearing Jarvis Creek belt and the overlying carbonaceous metaclastic rock-bearing Hayes Glacier belt are extensively intruded by bodies of Triassic gabbro. In addition to being approximately coeval with Windy McKinley gabbro, Triassic gabbro from the Delta District is geochemically similar,

although data are somewhat limited. On the basis of lithostratigraphic similarity and the Devonian-Mississippian age of the Jarvis Creek felsic metavolcanic rocks, the rocks of the Delta District are considered to be part of Yukon-Tanana terrane. The Triassic gabbro, however, distinguish them from typical Yukon-Tanana terrane – and like the Windy McKinley terrane, they are separated from the main extent of the terrane by a fault, the Elting Creek fault.

Neither the correlation nor the tectonic setting of the Harzburgite Peak – Eikland Mountain ophiolite complex are known. It trends toward the Denali fault and it may potentially be the offset equivalent of the Chulitna terrane, a suprasubduction zone ophiolite in the southern Alaska Range which trends into the Denali fault from the south. Any tectonic model for the ophiolite must address its enigmatic position between Yukon-Tanana terrane, and the remainder of Windy McKinley terrane - which, as has been proposed for the Delta District, may be Yukon-Tanana terrane intruded by Triassic gabbro. Several tectonic scenarios are possible but until the ophiolite's age is determined, neither its correlation nor its setting can be evaluated conclusively.

Structural and paleomagnetic revisions of the Ghost Rocks Formation, Kodiak Islands, Alaska

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The Ghost Rocks Formation of Kodiak and surrounding islands, AK, is part of a long-lived accretionary complex, and contains conformably interlayered pillow lavas and turbidites. The lava was deposited anomalously close to the trench (which is typically a cold, a-magmatic region), and is the result of a Paleocene spreading center subducting beneath North America. This trench-ridge-trench triple junction event can be seen along ~2200 km of the southern Alaska margin from Sanak to Baranof islands (the Sanak-Baranof belt), progressively younging in age from the west to the east. Although it is unclear where the Sanak-Baranof belt was originally positioned with respect to North America, the location is important for accurate plate reconstructions. Paleomagnetism can be used to determine the paleolatitude at deposition, if measurable rocks are found.

The Ghost Rocks Formation contains the essential components for a paleomagnetic study of this kind: turbidites for paleohorizontal and paleoup direction, pillow lavas for a single-domain magnetic carrier, very low levels of metamorphism, and controlled structural deformation. A paleomagnetic study was thus conducted, and Plumley et al., (1983), concluded that the Ghost Rocks Formation was formed at $40.2 \pm 6.2^\circ$ north latitude, 25° away from the expected paleolatitude. However, discordant site mean directions between the two major bays studied (Alitak and Kiliuda), a complicated 2-stage structural correction in Alitak Bay, and comparatively low unblocking temperatures has brought the study under scrutiny (Haeussler et al., 2003). This collaborative structural and paleomagnetic study seeks to resolve the location of the Paleocene triple junction by providing modern paleomagnetic methods, and more detailed sampling and structural analysis. Preliminary results from at Alitak Bay are reported.

30 sites from Alitak Bay have been analyzed, and show similar demagnetization behavior to Plumley et al., (1983) cores. Second components were averaged at each site, and 18 sites show reliable data. In-situ mean direction for these 18 sites is improved when corrected for local stratigraphy on a site-by-site basis and averaged with an inclination only mean. These data translate to paleolatitude of ~42 degrees, similar to the original study, but is inconclusive until further sites are processed. Progressive untilting via the Tauxe and Wantson (1994) method shows a peak cluster around 82 percent untilting. This peak location is further improved by

correcting vertical axis rotations of small-scale “blocks” or rigid sections bounded by faults that crosscut bedding. These block locations were determined through field mapping, and are internally coherent, and previously unrecognized.

Geology of the Okanagan Watershed, south-central British Columbia

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The geology of the map-area was compiled from maps at scales of 1:250 000 to 1:10 000 spanning 70 years. Concepts that influenced interpretation of field data evolved considerably over that time. Integration of the diverse maps was challenging; not all elements were resolved. The process was a cautionary reminder of the limitations that bias, model-driven interpretations and changing concepts impose on geological research. Hindering better understanding of the geological evolution is the paucity of age information, despite much modern geochronological work and a continuing search for rare paleontological samples. Most of the many rock units in the area remain undated, their ages inferred by tenuous lithologic correlations. Many tectonomagmatic events are similarly poorly dated. Absence of firm data has not prevented erection of detailed models of depositional environments, orogenic events and plate tectonics, most of which remain founded on plausible but weakly supported hypotheses, including those presented herein.

The watershed extends north from the 49th parallel for 180 km along the western margin of the Omineca Crystalline Belt, and east-west 100 km at its widest part. The nature of the geology changes markedly at Vernon across a zone that extends northwest and east from the town.

North of the zone are low (to the west) and high (to the east) grade strata which can be correlated with somewhat better dated rocks ranging in age from Neoproterozoic to Carboniferous found on the eastern flanks of the Shuswap Metamorphic Complex (SMC) that are considered to be stratigraphically linked to pericratonic successions of North America. High grade equivalents of these strata and their Mesoproterozoic basement comprise the SMC.

South of the zone are low and high grade strata of possible Devonian to Permian ages that differ from coeval North American successions and that have been interpreted as parts of suspect terranes. They are unconformably overlain by Upper Triassic strata and intruded by numerous plutonic rocks possibly as old as Proterozoic but mostly Mesozoic in age. Most of the high grade rocks may be correlatives of the low grade strata and plutons but their ages are poorly defined. This assemblage is presently designated Quesnel Terrane and its presumed high grade equivalents largely east of the Okanagan Valley have been called the Okanagan Metamorphic and Plutonic Complex (OMPC) to distinguish it from the SMC.

The zone itself is highly complex and poses one of the major challenges to understanding of the geological evolution of the region. The current working hypothesis embodied in this compilation is that it represents a broad belt of pericratonic North American and allochthonous Quesnel Terrane rocks tectonically interdigitated during the Permo-Triassic. The collision zone was then unconformably overlain by Upper Triassic strata and overprinted by Late Jurassic to Late Cretaceous deformation and magmatism. This was followed by Eocene extension that resulted in prominent detachment faulting predominantly south of the zone and normal faulting within and to the north of the zone.

The main valley was initially interpreted to contain steep normal faults. Later, mylonite zones and kinematic indicators suggested that a gently west-dipping, top-to-the-west detachment

fault with displacement as much as 100 km affected Eocene and older strata. K/Ar dates indicating an Eocene thermal event restricted to the SMC and OMPC were reinterpreted to date the denudation. Eocene strata dipped at all angles to the detachment.

More recently, some mylonite zones were dated as Mesozoic and some contacts between low and high grade rocks were interpreted to be depositional. Major stratigraphic belts were mapped across the valley in the northern part of the watershed. Eocene volcanics were observed in stratigraphic contact with high grade rocks as well as against steep normal faults. No simple, continuous detachment was evident. In several instances, low-angle faults diverged markedly from the valley.

In the SMC and OMPC one or more episodes of deformation and metamorphism predate Eocene faulting and the ages of many of these events and the protoliths are unknown. In low grade rocks deformation occurred from the Permo-Triassic to Paleogene. Transitions between low and high grade rocks occur east and west of the valley; some are abrupt and clearly faulted. The infrastructure and suprastructure of the Eocene detachments, where they occur, may both contain high and low grade rocks. Mylonite zones seem to occur at several structural levels and cannot all be assigned an Eocene age with confidence. Several discontinuous detachment faults may die away northward into a zone of normal faults and/or descend into high grade rocks east of the valley. Mylonite and brittle fault zones accompanied by extensive hydrothermal systems, formed before, during and after a prolonged episode of Eocene volcanism.

Folding, faulting and metamorphism in rocks on the east flank of the Selkirk Fan; new evidence in support of the re-interpreted Esplanade Thrust Fault and thermochronometric constraints on metamorphism

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The Lower Cambrian Hamill Group and underlying Neoproterozoic rocks equivalent to the Kaza Group and the Mica Creek succession are exposed in the Selkirk Mountains of southeast British Columbia. These rocks lie within the east flank of the Selkirk Fan and were metamorphosed to garnet, staurolite and kyanite grades in the southern limit of the Selkirk – Monashee – Cariboo regional metamorphic complex. The Esplanade Syncline is part of a train of folds with axial planes, and related schistosity, dipping steeply southwest, in a zone immediately northeast of the Selkirk Fan Axis.

The core of the syncline is occupied by a “grit” and pelite equivalent to the lower portion of the Kaza Group. These rocks lie above the Middle Marble, semipelite (with amphibolite) and pelite of the Mica Creek succession that rims the syncline. To the west of the Esplanade Syncline lies a west-dipping panel of the Mica Creek succession, overlain by the Kaza Group and the Hamill Group. The Comedy Creek unit, an interlayered carbonate marker defined earlier within this panel by Grasby and Brown (1993), has now been mapped within the “grits” in the core of the Esplanade Syncline, reinforcing their correlation with the Kaza Group.

The Esplanade Thrust is now traced at the base of the west-dipping panel and travels along the west limb of the syncline in the Esplanade Range. It progressively cuts out the west limb southeastward toward Rogers Pass such that it repeats the west-dipping panel over the same succession in the west-dipping east limb of the syncline. Cooling ages obtained from $^{40}\text{Ar}/^{39}\text{Ar}$ thermochronometry of biotite and muscovite crystals from pelitic rocks range from 120 to 67 Ma. K – Ar dates calculated by Ghent and McKee (1975) of biotite and muscovite crystals from the same area are in the range of 110 Ma. These dates are significantly older than the 57 to 54 Ma cooling ages obtained by Ghent and Villeneuve (2006)

for the Mica Creek Area to the north. This indicates that the rocks in the Esplanade Range cooled to muscovite biotite closure temperatures significantly earlier than in the Mica Creek area. Approximate maximum ages of peak metamorphism obtained from U – Pb chemical dating of monazite crystals in pelites indicate that peak metamorphic temperatures were reached approximately 176 to 107 Ma ago. This is consistent with the fact that the Battle Range pluton of probable mid-Cretaceous age cuts across the Selkirk Fan axis south of Rogers Pass.

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Deformation kinematics and intrusive history at Thor-Odin: A potential link between field scale observations and plate scale tectonics

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Mesoscopic linear features (e.g. fold axes, mineral and stretching lineations) and associated macroscopic folds vary systematically in orientation from shallow to deep structural levels through an exposed W-dipping section of the middle crust in the central portion of the Thor-Odin Dome. Linear structures plunge mostly to the W at the highest level and to the N or S in the deepest domain. At the intermediate level structures tend to plunge towards the SW. Therefore, the lineations vary from a dip-slip to a strike-slip orientation, with respect to an approximately WSW-dipping transposition foliation (S_T), with increasing structural depth.

Interpretation of these observations is complicated by the multi-stage deformation history recorded in the rocks at Thor-Odin. The currently accepted tectonic story involves an early episode of top-to-NNE non-coaxial progressive shear concomitant with the development of S_T , followed by E-W oriented coaxial crustal extension and reactivation of S_T . Temperature may have been uniformly high during at least the latter portion of the former deformation event and the initial portion of the latter deformation event, respectively. Strict separation of these events by their metamorphic fabric development is not simple. There is also evidence of N-directed transcurrent shearing prior to at least one episode of E-W oriented extension. Each deformation event has imparted a portion of the composite kinematic history preserved in the rocks. A further complication is the likelihood that pre-transposition structures imparted a significant control on their subsequent geometric evolution.

The Thor-Odin region preserves several geometrically and compositionally distinct phases of magmatic activity which can be related, by cross-cutting relationships, to specific phases of the deformation described above. Field-based observations of these relationships therefore provide a systematic approach to solving the aforementioned kinematic problem. Although no unique solution can be put forward, our observations at Thor-Odin are consistent with the sequence of plate kinematic evolutionary events that occurred along the margin of western North America through the Late Cretaceous-Early Eocene interval.

Cretaceous Magmatism in the Cordillera: a peek at what's to come!

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Intrusive rocks of mid-Cretaceous age (ca. 124-90 Ma) together with minor extrusive equivalents are widespread throughout the northern Cordillera in the Yukon and adjacent parts of southwestern NWT, and in eastern and east-central Alaska. A large amount of analytical data relating to the age, lithology, geochemistry, and radiogenic isotopic systematics of Cretaceous igneous rocks in the northern Cordillera (particularly the Yukon) has been generated over the past fifteen years by different research groups. These previous studies have led to the subdivision of the intrusions into discrete plutonic suites that are distinguished in terms of geographic distribution, age, composition, and metallogeny. A substantial amount of analytical data pertaining to the Cretaceous magmatism remains unpublished, and a complete synthesis and interpretation of all available data has not yet been undertaken. Our understanding of the nature and origin of the Cretaceous intrusions across the northern Cordillera, and the reasons for the distinctive metallogenic signature of the various plutonic suites, is still limited.

The objective of this study is to characterize granitoid intrusions in southern Yukon and adjacent portions of the NWT using: (a) detailed regional sampling of selected areas with poor sample coverage (completed in 2005 and 2007); (b) filling “data gaps” that exist in the regional age and lithological data sets for all the samples (including geochemical and radiogenic isotopic compositions); and (c) applying several additional analytical techniques that have not been applied systematically (or at all) to Cretaceous igneous rocks in the northern Cordillera. Work completed thus far and currently in progress includes the generation of an extensive set of data for approximately 65 samples from 50 intrusions from throughout the study area (see figure). This includes:

1. major and trace element geochemistry;
2. radiogenic isotopic compositions (Sm-Nd, Rb-Sr, Pb-Pb);
3. approximations of volatile phase concentrations in magmatic fluids (F, Cl, SO₃);
4. stable isotopic compositions of intrusions (S, O) and related mineralization (S);
5. LA-ICP-MS isotopic compositions of magmatic zircon (U-Pb, Lu-Hf); and
6. LA-ICP-MS isotopic compositions of inherited zircon cores (U-Pb).

Data generated during this study will be combined with an extensive dataset presently available in the Yukon Igneous Database, together with unpublished data by Mortensen and previous graduate students. The combined datasets will allow us to evaluate existing models for the petrogenesis of Cretaceous magmatism in south-central Yukon and southwestern NWT, which range from an Andean-style continental margin arc and back-arc setting to mainly crustally derived magmatism possibly associated with an episode of flat-slab subduction.

Ultimately this study will contribute directly to our understanding of this unique period of magmatism and mineralization in the northern Cordillera, but also more generally to our knowledge of the formation elsewhere of large felsic mineralized magmatic provinces at convergent margins.

Stratigraphic and paleotectonic studies of the middle Paleozoic Sicker Group and contained VMS occurrences, Vancouver Island, British Columbia

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Rocks belonging to the Middle Paleozoic Sicker Group are believed to record the evolution of an ocean island arc, and represent the basement of the Wrangellia terrane. The Sicker Group is exposed in four separate structural uplifts on Vancouver Island and the Canadian Gulf Islands; these are the Buttle Lake, Bedingfield, Nanoose and Cowichan Lake uplifts. Sicker Group strata in the Buttle Lake uplift host the producing Myra Falls volcanogenic massive sulphide (VMS) deposit, which is currently the largest producing VMS deposit in western Canada. Other VMS occurrences are known to occur throughout the Sicker Group in at least two of the other uplifts (Cowichan Lake and Bedingfield) and there is thought to be excellent potential for more major VMS targets as well. However, due to a lack of isotopic and fossil age control, a detailed understanding of the stratigraphy of the Sicker Group is lacking. This has not only impeded the development of a robust model to explain the origins of Wrangellia, but has significantly hampered exploration for stratigraphically controlled VMS mineralization. Our research program combines regional and detailed geological mapping with geochronological, biostratigraphic, isotopic, and lithogeochemical studies to better understand the tectonic history and metallogeny of the Sicker Group. Geological mapping will establish contact relationships between rock formations and establish the geological setting of VMS and potential VMS occurrences. Geochronological work will employ U-Pb dating of zircons by laser ablation ICP-MS as well as Ar-Ar dating and microfossil (radiolarian and conodont) biostratigraphy to constrain the ages of major igneous and sedimentary rock units and develop a detailed chronostratigraphic framework for each of the four structural uplifts. Whole rock lithogeochemistry together with Nd and Hf isotopic studies will be employed to constrain the petrogenesis of the Sicker magmatism and test for any possible involvement with the North American margin in the genesis of Sicker Group magmas. Lead isotopic compositions of sulphides from various mineral occurrences will be used to discriminate between syngenetic or epigenetic occurrences, in order to help evaluate the potential for additional large VMS deposits in the Sicker Group. Results of the study will enhance our knowledge of Wrangellian tectonic evolution and metallogeny, and lead to a better understanding of a critical part of the history of crustal growth in the North American continent.

Work on this project to date has concentrated on exposures of Sicker Group rocks in the Cowichan Lake uplift, particularly those in the vicinity of past producing VMS deposits and VMS occurrences. Field mapping indicates that significant revisions to existing regional geological maps are required, particularly to Sicker Group geology exposed in the Alberni-Horne Lake area. Lithogeochemistry of basalt and rhyolite in the Cowichan Lake uplift in the vicinity of the Lenora, Twin J and Lara VMS deposits exhibits light rare earth element (LREE) enrichment coupled with negative Nb and Ti anomalies, typical of calc-alkaline volcanic rocks generated in a subduction setting. Lead isotope analysis of sulphide samples from both stratiform VMS and vein controlled sulphide mineralization in the Sicker Group indicates that some mineralization previously interpreted as stockwork style VMS mineralization is actually younger, non-VMS related epigenetic mineralization. In addition, comparison of lead isotope analyses from volcanogenic massive sulphide occurrences from different stratigraphic levels in the Sicker Group indicates that leads in massive sulphides associated with the oldest, mafic volcanic rock dominated stratigraphic levels have substantially less radiogenic isotopic signatures than leads in massive sulphides associated with younger, bimodal volcanic rocks.

Polyphase deformation and metamorphism in the northwest North Cascades: hypothesis of large-scale shortening during transpression

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Cretaceous deformation and metamorphism in the North Cascades reflects tectonic processes associated with terrane accretion and arc magmatism at the southern end of the Coast Belt. Cretaceous orogenic events affected two terranes; a Triassic arc terrane, consisting of Cascade River unit sedimentary and volcanic strata (CRU), plutons (Marblemount metaquartz diorite, MMQD) and an injection complex between the two (Magic Mountain gneiss, MMG); and an ocean-floor terrane, consisting of a melange of meta-chert, argillite, basalt, and ultramafic rocks. Our work in the Cascade River area builds on that of E.H. Brown and students (Brown et al., 1994), and R.W. Tabor (1961, 2002, 2003).

Field work near Mt. Formidable suggests four distinct folding events, two that created axial planar foliation, and two that post-date metamorphism. Mapping of CRU layers within and adjacent to the MMG indicates the presence of a detailed stratigraphy that outlines several large-scale recumbent F1 folds, and locally observed hingelines suggest either NW or SE vergence. Retrodeformation requires >300% shortening regardless of kinematics. Hand sample and thin section analysis reveals the presence of two periods of high-grade mineral growth in different fabrics within the MMG; these are overprinted by greenschist-grade fabric (S2). The early recumbent folds are overprinted by F2 and F3 folds, with broadly ~EW and NW-SE axes, respectively.

Despite the polyphase deformation, the F4 fold hinges typically plunge gently SE. The presence of gently SE-dipping enveloping surfaces over large areas suggests an initially gently dipping metamorphic fabric. This geometry, together with the large-scale recumbent folds, suggests an early thrust related deformation, with as-yet undetermined vergence.

Strain magnitude and type, as indicated by stretched pebbles, vary widely. In the Formidable area, lineations are weak, strain is low, and in the field of apparent flattening on the Flinn diagram. This contrasts with areas to the northeast and along the Entiat fault, which appear to be dominated by steeply dipping foliation and well-developed gently plunging stretching lineations that plot in the constrictional field. These constrictional, highly strained domains seem to be localized along steep limbs of late upright folds, and are associated with dextral shear fabrics, suggesting a strike-slip overprint. The contrast of steeply and gently dipping fabrics, together with wide variations in strain magnitude and strain type, suggests domains of different deformation style, rheology, or age.

Adjacent areas to the NW across the Entiat fault appear to have a similar history (Griesel and Schermer, this volume) but detailed correlation between phases is as yet unclear. In both regions, alternating NW-SE and NE-SW shortening imbricated and shortened the arc and ocean floor terrane. Deformation occurred beginning pre-~100 Ma and lasted until post-~60 Ma, indicating protracted transpression in the Cretaceous arc.

Linked thrust and infrastructural flow tectonics

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Thrust sheets have zones of ductile deformation. This is true even for seemingly simple sheets in the external portion of fold and thrust belts. For example, isoclinal folds, bed thickening in fold hinges and penetrative cleavage are present in many locations within thrust sheets in the front ranges. The abundance of ductile deformation zones and the importance of internal deformation – a form of flow – within thrust sheets increases from the external to the internal parts of thrust belts in an irregular manner, such that, at depth, in the internal portion, in lower amphibolite facies, thick zones of ductile shear and complex folding are found together with buckle folds and thrust faults with ramps and flats. These thrust faults are sharply defined where units of contrasting lithology and age are juxtaposed, but they are associated with mylonite zones. Such relationships have been documented in the Esplanade Range and other areas in the Selkirk Mountains. In the internal portion of the orogen, locally (e.g. Cariboo mountains and southern Valhalla complex), a transition is preserved from a suprastructure at low metamorphic grade, with upright folds, to an infrastructure, where, at high grade, the same folds are recumbent and accompanied by migmatite and transposition foliation. There is thus a complete transition from foreland fold and thrust style of deformation to “infrastructure” flow under a suprastructure. The implication that these two styles of deformation are two separate, contrasting tectonic models is therefore regrettable. Infrastructural metamorphism and flow may be the same age as suprastructural deformation or it may be younger and overprinted on older structures. The various complex age relationships have to be taken into account.

Where infrastructural flow in the orogenic core is important in orogenic evolution, the flow has to be related to deformation in the thrust belt of the same age, and there are several possible linkages. In the case of detachment flow, infrastructural detachment flow might simply accommodate the accumulated shortening of the thrust belt, or the base of the detachment flow may be carried up over the evolving thrust belt. Similarly with channel flow, there are a number of possible linkages including flow of the channel out from the internal part of the orogen and extending overtop the evolving thrust belt. Where the channel “tunnels”, and has a fixed subsurface tip line, channel flow is limited; only the detachment portion of the flow is readily linked to the evolving thrusts. The forward flow in a tunneling channel could also contribute to increasing the taper of the thrust belt to the critical angle, driving thrust propagation.

P-T evolutions along an E-W transect, in the Thor-Odin dome, from Blanket Mt. to the Thor-Odin detachment (Canadian Cordillera)

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The Thor-Odin dome is the southernmost culmination of the Monashee complex, which is the deepest exposed unit of the Omineca belt, of the Canadian Cordillera. The Thor-Odin culmination consists of Proterozoic North American basement (orthogneisses; paragneisses and migmatites) and of a Proterozoic to Paleozoic meta-sedimentary sequence (quartzites, schists, marbles, calcsilicates and gneisses) and is limited to the West by the Thor-Odin detachment (Johnston et al., 2000; Kruse & Williams 2007). Amphibolite boudins occur within both sequences. Basement and meta-sedimentary sequences have been transposed under HT metamorphic conditions. The transposition is responsible for the formation of the dominant foliation (St) within the dome.

To contribute to the reconstruction of the tectono-metamorphic evolution of the Thor-Odin dome, microstructural, petrographical and mineral chemical analyses have been carried out on metapelites and amphibolite boudins from an E-W transect across the Northern slope of Blanket Mt and the Thor-Odin detachment.

In metapelites Sil, Bt, Kfs and Qtz are parallel to the St foliation. Whereas up to mm-sized Grt are pre-kinematic with respect to St, fine-grained Grt are syn-St, otherwise mm-sized Grt are from pre- to syn-St. Ky crystals, enclosing Bt, locally occur and are partially replaced by Sil. Bt and Qtz symplectites at the mm-sized Grt rim postdate St. The Grt rim is re-equilibrated with these symplectites with higher Fe content and lower Mg content than in the core. Bt parallel to St and enclosed in Ky shows a higher Ti content with respect to the Bt in the symplectites. Wm and Chl filled fractures intersecting St-parallel Sil laths and are locally developed between Grt and Bt.

Amp, Pl, Qtz and minor Bt are parallel to the dominant foliation in Grt-free and Grt bearing amphibolite boudins. In Grt bearing amphibolites Grt and Oamp are interpreted as syn-kinematic to the dominant foliation. Chl and green Amp partially replace Oamp, Amp and Grt. In Grt-free amphibolites Amp parallel to the dominant foliation shows a slight increase of Ti from core to rim; a rim of new simplectitic Amp shows higher Ti and lower Al^{VI} content. The latest Amp, which grew in fractures, shows the lowest content in Ti and Al^{VI}.

Mineral assemblages parallel to superposed fabrics have been used in different bulk rock compositions to infer the Pressure-Temperature-relative time of deformation (P-T-d-t) paths of the polydeformed metamorphic rocks outcropping along the East-West section, 5 km wide from Blanket Mt. to the Thor-Odin detachment, in this northern sector of the Thor Odin dome. Results highlight that the exhumation path has been accomplished under a high thermal regime, exceeding the range limited by the stable continental geotherm and a maximally relaxed geotherm for reasonable heat supply after thrusting. The attainment of such high geothermal gradient is compatible with an extensional tectonic regime.

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Metamorphism and tectonism in the Soards Creek area, Mica Creek, southeastern British Columbia

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Neoproterozoic rocks of the Mica Creek Succession and overlying Kaza Group, are exposed in the northern Monashee Mountains in the Mica Creek area of southeastern British Columbia. These rocks lie near the core of the regional Selkirk-Monashee-Cariboo metamorphic complex, on the northeast flank of the Shuswap complex, and were metamorphosed to kyanite, sillimanite, and sillimanite-K-feldspar grades in the Soards Creek area (52° N, 118° 40' W). The stratigraphy, structure, and isograds appear to be continuous within the Mica Creek area (Simony et al., 1980), and from this area into the Selkirks to the east. The Scrip Nappe (Raeside and Simony, 1983) is a large southwesterly-verging recumbent F1 nappe structure, and the fabrics and metamorphism described here completely overprint this early structure.

Petrographic and geochemical analyses of rocks from the Soards Creek study area (Domain 3 of Crowley et al., 2000) indicate peak metamorphism occurred syn- post-F2 deformation. A lower thermal peak occurred syn- post-F3, causing some garnet growth and recrystallisation of micas. Earlier metamorphic events are not evident in this domain. Geothermobarometry on metasediment and metabasite from the Soards Creek area yields peak metamorphic conditions of 7-8 kbar (700-800 MPa) and 650-750 °C. U-Th-Pb chemical dating of monazites suggests temperatures were this high until late in the Early Cretaceous (monazite's closure temperature is estimated to be 820±30 °C by Parrish (1990), and Spear and Parrish (1996)). The ages of peak metamorphism indicated by monazite chemical dating range from approximately 140 to 90 Ma (this study). 40Ar/39Ar geochronometry indicates cooling to closure temperatures for hornblende and micas, from approximately 650 °C at 63 Ma to 300 °C at 55 Ma, implying rapid exhumation (Ghent and Villeneuve, 2006).

Evidence has shown (eg. Gibson et al., 2005; Crowley et al., 2000; Digel et al., 1998; Parrish, 1995; Sevigny et al., 1990) that multiple tectonic events, spaced over 100 Myr, occurred in the Mica Creek area. Of particular interest is the apparent discrepancy in metamorphic ages across the area. This discrepancy suggests that either the area was tectonically assembled along hitherto unidentified shear zones, or that some parts of a geologically coherent area were metamorphosed at different times from other parts (Gibson et al., 2005; Crowley et al., 2000). Evidence from this study supports the latter conclusion.

Mapping of structure, stratigraphy, and metamorphism has continued to add weight to the interpretation of geologic continuity. The significance of any unmapped fault or shear zone can only be minimal in the Soards Creek area. Rocks in the north of the Soards Creek area show evidence for a strong metamorphic overprint of Mid-Cretaceous sillimanite on Early-Cretaceous kyanite-bearing metasediments. This overprint is not mappable as a distinct contact, but rather as a zone of patchy overprinting, resolving to complete overprint by the later metamorphism farther south in the area. Evidence for an Early-Cretaceous sillimanite isograd has been eliminated, creating a pseudo-continuous series of metamorphic isograds.

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P-T constraints and tectonic evolution of the Wolverine metamorphic complex

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The Wolverine Metamorphic Complex (WMC) is a culmination of garnet- to sillimanite-grade metamorphic rocks exposed within the central Omineca Belt. It lies between rocks of ancestral North America to the east and the accreted Slide Mountain, Quesnellia and Stikinia terranes to the west. Significant crustal shortening, thickening and metamorphism occurred due to the closure of the intervening oceanic/basinal Slide Mountain terrane and collision of the Quesnellia and Stikinia terranes. The rocks are isoclinally folded with transposition of bedding and compositional layering parallel to the axial planes. The Wolverine complex has since been tectonically exhumed via extensional faulting along the southwest dipping Wolverine fault zone. C-S fabrics and mineral lineations suggest northeast-side-up normal movement along the Wolverine fault zone.

Paragneiss and amphibolite from within the complex contain mineral assemblages appropriate for garnet-biotite thermometry, and garnet-sillimanite-quartz-plagioclase (GASP) and garnet-amphibole-plagioclase-quartz (GAPQ) barometry, respectively. Previous garnet-biotite microprobe data have been recalculated using more comprehensive thermodynamic data and

activity-composition models. The new calculations return temperatures between 600° and 630°C for biotite rim-garnet core, -middle and -rim pairs from two different samples.

The paragneiss and amphibolite units contain leucocratic layer-parallel mineral segregations that are cut by discordant leucosomes with graphic intergrowths suggestive of crystallizing from a melt. Textures and field relationships between the leucocratic segregations and the leucosomes are consistent with the leucosomes being anatectic melts originating from greater depths within the WMC.

Structurally controlled iron oxide mineralization in the Iron Range and Mount Thompson region, B.C.

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Iron-oxide mineralization along the Iron Range, near Creston BC, is hosted within the Middle Aldridge Formation of the Belt-Purcell Supergroup and concordant gabbroic sills of the Moyie intrusions. The deposit is structurally controlled; restricted to within and along the Iron Range fault. The Iron range fault is a steeply west dipping normal fault with a protracted history of movement since its development as a growth fault during Proterozoic sedimentation and rifting. Extensive albite-chlorite-quartz alteration occurs along the length of the fault in association with the iron-oxide mineralization. The ore minerals are hematite and magnetite with lesser amounts of pyrite and other trace sulphides. The mineralization occurs as massive lenses and veins in a quartz-albite breccia. Textures in thin section suggest multiple episodes of magnetite, hematite, quartz and pyrite precipitation. Preliminary fluid inclusion studies indicate two dominant fluid inclusion assemblages within predominantly quartz and albite: a two-phase (brine + H₂O-vapour) fluid inclusion assemblage and a two-phase (brine + CO₂-vapour) fluid inclusion assemblage. The microthermometric results indicate that the liquid portion of the fluid inclusions is composed of a concentrated brine solution of over 20 wt % NaCl equivalent. Chlorite thermometry from six microprobe analyses are consistent with temperatures in the range of 275-325 °C. The voluminous early sodic- and relatively limited potassic-alteration accompanied by Fe-oxide-rich and sulfide-poor mineralization in the Iron Range appears to be consistent with the non-magmatic derived, basinal brine fluid source-models for Iron-Oxide-Copper-Gold (IOCG) type mineralization (Barton and Johnson, 2000; 2004).

Provenance of Eocene to Oligocene sandstones of southwest Montana: Evidence from detrital zircons

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Mid-Eocene to early Miocene sedimentary rocks of southwest Montana and east-central Idaho were deposited in a north-trending 'Paleogene rift system' (Medicine Lodge and Cabbage Patch beds) and a broad depositional basin (Renova Formation) to the east of this rift. Amagmatic Paleogene rifting is attributed to gravitational collapse of the over-thickened Sevier

fold-and-thrust belt. Provenance study of sandstones within the region helps constrain the paleogeography of this rift zone.

Detrital zircon SHRIMP geochronology and LA-MC-ICPMS Hf isotope geochemistry characterize several distinct sediment sources. Conspicuous two-mica feldspathic sandstones of the syn-extensional Medicine Lodge beds and the Cabbage Patch beds within the rift were derived from a two-mica source in the Anaconda range. U-Pb zircon ages provide evidence for a ca. 75 Ma age for this source, 20 m.y. older than available K-Ar dates for these granites. Two-mica sandstones consistently contain zircons with Hf epsilon values of -20 to -30, consistent with values from the modern Mussigbrod Creek which currently drains the Anaconda Range. Persistent basin-axial southward flow fed the Medicine Lodge beds and we suggest the two-mica sand of the Cabbage Patch beds was deposited in a series of east-directed fan systems off the Anaconda Range. Other Medicine Lodge sands contain locally derived zircons from both the footwall and hanging wall of the Eocene-Oligocene Muddy-Grasshopper fault. Nearly identical detrital zircon age spectra from sandstone in the southern Medicine Lodge beds and the southern Renova Formation imply derivation from the southern Atlanta Lobe of the Idaho batholith in central Idaho. Hf epsilon values of -8 to -12 further support the interpretation of derivation from the Atlanta Lobe. We suggest that NE-directed drainage with headwaters in central Idaho, far west of the modern continental divide, fed the southern Medicine Lodge beds and the southern Renova Formation.

The type Renova Formation south of Whitehall, MT contains almost exclusively 65 and 80 Ma zircon grains derived from the Boulder batholith and associated volcanic rocks immediately to the west or possibly the Tobacco Root batholith to the southeast.

Anomalous populations of 90-110 Ma grains are present in Eocene and Oligocene sands of the Medicine Lodge beds and the Renova Formation. This apparently reflects recycling through Cretaceous foreland basin and back-arc deposits which contain zircon of this age. The ultimate source of these grains may be an old phase of the Bitterroot Lobe of the Idaho batholith yet to be identified or eroded away. Highly variable Hf isotope values (epsilon -1 to -22) distinguish these grains from grains of the southern Atlanta Lobe of the Idaho batholith.

Could anomalous Cretaceous shortening of the southern Rocky Mountains locate the Cretaceous Kula-Farallon spreading ridge?

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The southern Rocky Mountain Fold and Thrust Belt has been demonstrated by others, through palinspastic restoration, to have more Jurassic to Paleocene shortening than the central and northern Rocky Mountains and the Mackenzie Mountains. Using a model that partial couples the Cretaceous North America to the subducted Kula and Farallon lithospheric plates, it is demonstrated here that the difference in fold and thrust belt shortening may have been caused by where the Kula-Farallon spreading ridge was subducted, and the oblique orientation of that ridge relative to the subduction zone. Key characteristics of the plate coupling model are: 1) the Kula and Farallon plates continued to move away from each other while under the North American plate; 2) the Kula and Farallon plates are partially coupled to the over-riding North American plate; and 3) the North American plate moved over the Kula and Farallon plates partly as a consequence of mantle flow represented by the spreading of the mid-Atlantic ridge. The model controls transform motions in the North American margin. It controls the direction and sense of transform motion with the orientation and the location of the subducted spreading ridge. For

example: if the spreading ridge has a northeast trend, the model would generate dextral strike-slip faults north of the spreading ridge and sinistral transpressional faulting south of the spreading ridge. The dextral motion would result from the northwestward motion of the Kula plate partially coupled to the westerly moving over-riding North American plate. The sinistral motion would result from the southeastward motion of the partially coupled Farallon plate. The sinistral transpression would be a zone of increased margin compression relative to the dextral strike-slip zone to the north. Should the southern Rocky Mountain compression be a consequence of such sinistral transpression then: 1) it would have more compression than equivalent rocks along strike north of the subducted spreading ridge and 2) the position of the transition in the Rocky Mountain Fold and Thrust Belt from high to moderate amounts of shortening would locate the subducted spreading ridge.

Application of the plate coupling model in this way may contradict the Baja BC hypothesis, where large dextral strike-slip motions along the Late Cretaceous North American margin would be responsible for transporting fragments of North America from their pre-70Ma position adjacent to present day Baja California northward into present day British Columbia. Conversely, the Baja BC hypothesis would negate the possibility of the Kula-Farallon spreading ridge being the cause of anomalous Cretaceous shortening of the southern Rocky Mountains: unless the Kula-Farallon spreading ridge jumps from near the Canada-USA border, south to Baja California and back again between 70 and 58 Ma.

Constraining the conditions and timing of deformation and metamorphism of the Yukon-Tanana terrane in the Big Salmon Range of south-central Yukon

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The allochthonous, pericratonic Yukon-Tanana terrane is a northwest-trending belt of polydeformed metasedimentary and meta-igneous rocks that lies within the central portion of the northern Canadian Cordillera. Detailed studies over the past two decades indicate that the Yukon-Tanana terrane contains an internally coherent stratigraphy that represents a system of rifted continental fragments, island arcs and back-arc basins that evolved off the western Laurentian margin between mid-Paleozoic and early Mesozoic time. Yukon-Tanana terrane was subjected to four, and locally five, deformation and associated metamorphic events; however, the regional extent of these events remains unclear because knowledge of bedrock geology in some areas is based on reconnaissance (1:250 000-scale) mapping from the 1970s. For instance, the western Quiet Lake and eastern Laberge areas of south-central Yukon has seen only limited detailed structural and metamorphic analysis. This region holds additional importance because the location of the boundary between the pericratonic Yukon-Tanana terrane and the parautochthonous Cassiar terrane is poorly constrained. Detailed mapping at a 1:20 000-scale initiated during the summer of 2007 and to be completed in 2008 will focus on (1) resolving the location of the terrane boundary; (2) refining the regional structure and stratigraphy; and (3) determining the thermo-structural evolution in western Quiet Lake and eastern Laberge areas.

Preliminary fieldwork in the summer of 2007 indicates that the regional structure of western Quiet Lake and eastern Laberge is characterized by rootless, recumbent to overturned, northeast-verging isoclinal folds that are axial planar to a regional transposition fabric. The isoclinal folds have been re-folded into broad, upright, northwest-verging open folds by a later phase of deformation. Continuing research will further refine the history of deformation and metamorphism within the western Quiet Lake and eastern Laberge areas of Yukon-Tanana terrane. This will be done by using a broad range of analytical techniques. Macro- and micro-

structural analysis in the field and in the laboratory will be used to determine the region's kinematic history of deformation. Backscattered electron imaging (BSE) and X-ray elemental mapping will elucidate compositional and textural zoning to be used for geochronology and geothermobarometry. Monazite and zircon will be analyzed *in-situ* by LA-ICPMS and/or SHRIMP, and when appropriate from mineral separates via ID-TIMS, to constrain the age of individual metamorphic and deformation events within the south-central Yukon-Tanana terrane. In addition, geochemical analyses will be used to better constrain the character of protoliths within the rock sequence. Preliminary results from four amphibolite samples indicate that the region contains at least two distinct types of basalts including E-MORB and arc basalts. Further analyses will help refine interpretation of tectonic setting and may assist in locating the terrane boundary.

Geology of the Nicola Group in the vicinity of the Iron Mask batholith, Kamloops, British Columbia

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The Early Jurassic Iron Mask batholith (IMB), approximately 10 km southwest of Kamloops, British Columbia, is a composite alkalic diorite intrusion approximately 22 km long by 5 km wide at surface that hosts economically viable deposits of porphyry copper-gold-silver. It intrudes Upper Triassic Nicola Group volcanic rocks, where a study is underway to understand the nature, structure, and deformation history of these host rocks, which can aid in locating future exploration targets.

Detailed mapping and structural analysis of the host volcanic rocks have yielded the following new data: units of the Nicola Group are upright folded but generally not deformed penetratively, and thus were deformed in a high level environment characterized by faulting and fracturing. Cleavage, however, is seen northeast of the IMB, where it is steeply dipping to the northeast and axial planar to northwest plunging folds. Nicola volcanic units are locally schistose south of the IMB, where this fabric was observed along the length of the batholith and is stronger to the southeast of the batholith, in a zone referred to as the Cherry Creek tectonic zone by previous workers; An existing white mica Ar-Ar cooling date for the fabric is between 53 and 54 Ma. Approximately 1.5 km south of Goose Lake, exposed volcanoclastic layers are sheared, with a biotite defined mineral lineation plunging approximately 30° toward the southeast.

Previous mapping defined a simplified northwest-striking stratigraphy with much of the Nicola comprising primary volcanic units such as tuff, lapilli tuff, debris flows with large blocks and cobbles, and porphyry flows. From new field observation and petrographic sample analysis, rocks in the area are instead mainly volcanoclastic in origin, and interpreted to be derived from augite- and feldspar-rich original units of the Nicola arc. Only minor augite porphyry flows are interbedded with these volcanoclastic units. Lateral discontinuity and thickness changes of mappable strata create difficulties in definition of a regional stratigraphy as map scale marker horizons do not occur.

The presence of tectonized augite porphyry is rare. Shear sense indicators suggest extension and transport coaxial with the strong southeast trending mineral lineation, possibly resulting from reactivation of high to moderate angle northwest striking faults. Lack of ductile fabrics in the vicinity of and within the IMB leads to the suggestion that most deformation was upper crustal and resulted from pervasive faulting following intrusive events and during a period of Eocene extension that affected the region. Folding of the batholith is not evident.

