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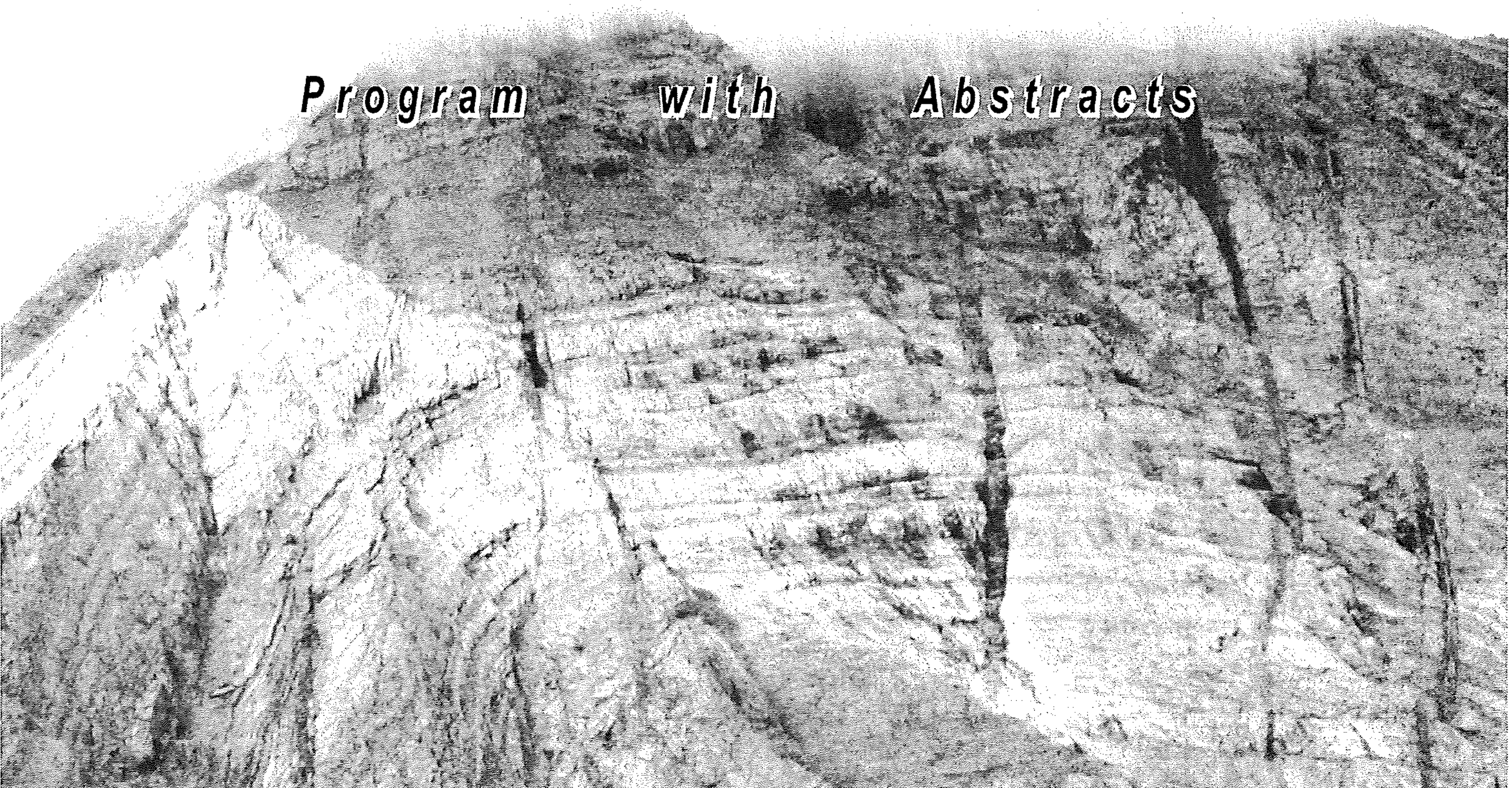
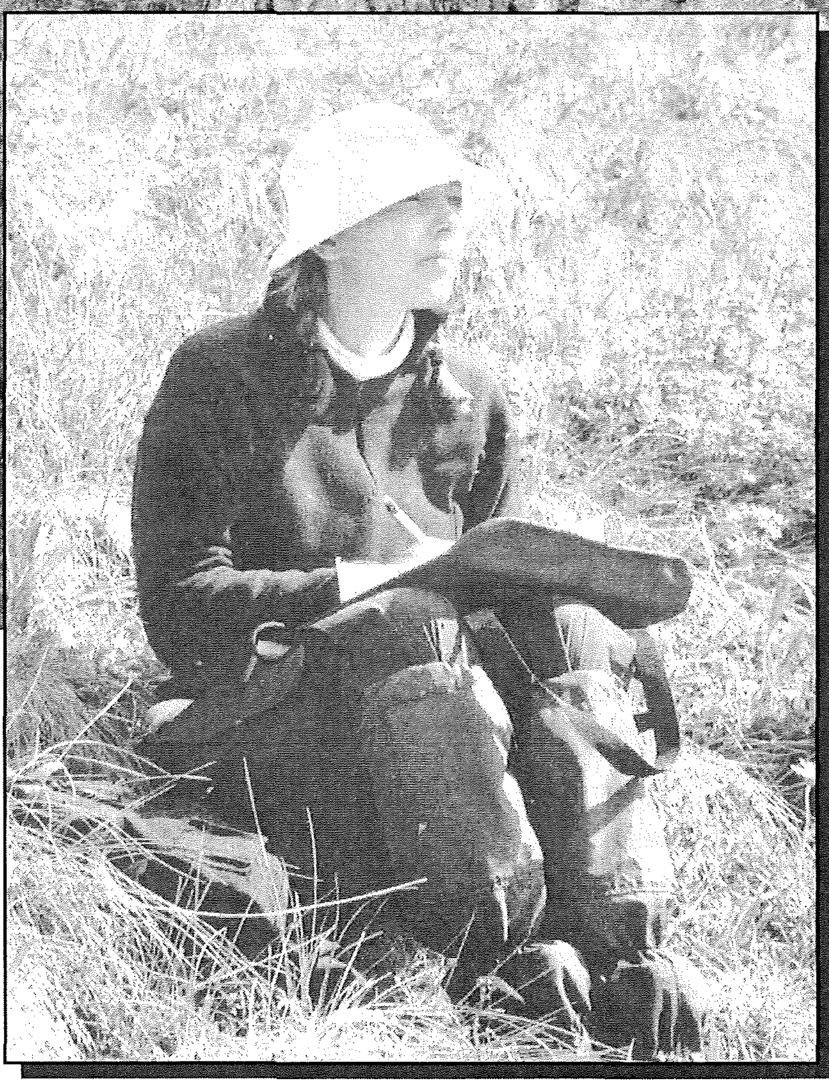


Program with Abstracts

Cordilleran Tectonics Workshop 2006



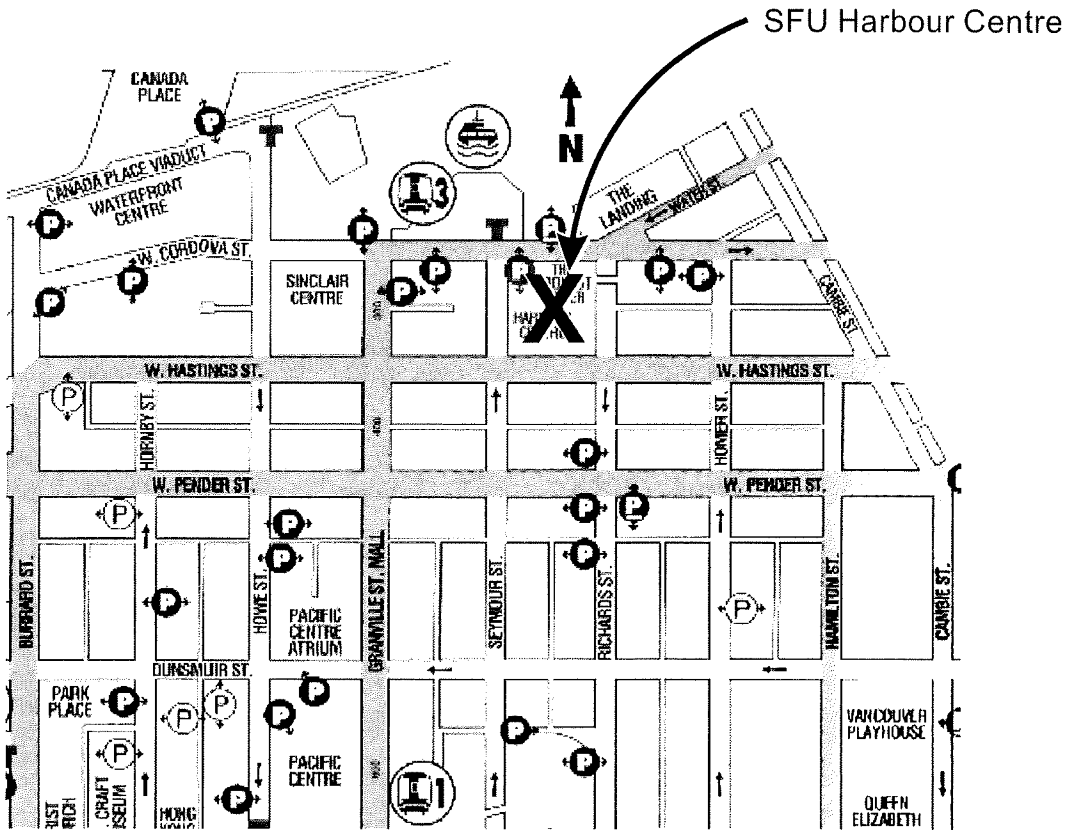
Simon Fraser University
Harbour Centre Campus
Vancouver, Canada

February 17-19, 2006

Cordilleran Tectonics Workshop 2006
Simon Fraser University
Harbour Centre Campus

<u>Abstracts in this volume may be cited as</u>:

(Author names), 2006. (Abstract title). In: Program with Abstracts, Cordilleran Tectonics Workshop 2006. Compiled by Thorkelson, D.J. and Gibson, H.D. Simon Fraser University, Vancouver, Canada, February 17-19, 2006



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Department of Earth Sciences Simon Fraser University	Mineral Deposits Research Unit The University of BC	Geological Survey of Canada Natural Resources Canada

Workshop Program

Friday February 17

7:00 pm - 10:30 pm	Ice-breaker and poster set-up

Saturday February 18

Time	Authors	Title
8:45	Derek Thorkelson	*Opening Remarks*
9:00	Cees van Staal	The accretionary history of the Northern Appalachians prior to Pangea
9:15	Paul Duuring, Steve Rowins, Larry Diakow, Jenni Dickinson, Bradley McKinley	Tectono-magmatic evolution of the Toodoggone district and implications for Early Jurassic Au-Cu±Mo mineralization
9:30	Tony Barresi	A Petrogenetic Model of Prospective Stratigraphy in the Eskay Rift
9:45	Dante Canil, Mitch Mihalynuk, Larry Heaman, Stephen Johnson, Jason Mackenzie, Courtney Charnell	The record for exhumation of ultrahigh pressure (UHP) rocks in the northern Cordillera
10:00	'Lyn Anglin	*Introduction to Geoscience BC*
10:10 – 11:00	*Discussion / Poster Viewing*	
11:00	Dejan Milidragovic, Derek Thorkelson, Dan Marshall	The Early Cambrian Quartet Mountain lamprophyres and their xenoliths: clues to the crystalline basement of Yukon?
11:15	John Mair, Craig Hart	Interplay of Tectonics and Magmatism in the Northern Cordillera of Yukon and Alaska: Implications for Refining Geodynamic Models
11:30	Luke Baranek, Jim Mortensen	Triassic linkages between Yukon-Tanana Terrane and North America: Results from new detrital zircon geochronology, geochemistry, and conodont biostratigraphy
11:45	Jim Mortensen	Is the Windy-McKinley Terrane a Displaced Fragment of Wrangellia? Evidence from New Geological, Geochemical and Geochronological Studies in Western Yukon
12:00 – 1:30	*Discussion / Lunch*	
1:30	Nils Peterson, Kelly Russell, Brian Mahoney	Mantle lithospheric properties via mantle xenoliths: Implications for the tectonic evolution of the British Columbia Cordillera
1:45	Ben Edwards, Kelly Russell	Thermodynamic constraints on mantle sources for mafic alkaline volcanism in the Northern Cordillera Volcanic Province

2:00	Steve Piercey, Maurice Colpron, JoAnne Nelson	Franklin Flashback: The Role of Recycled Mantle Plumes in the Paleozoic Evolution of Rift-Related Magmatism along the Ancient Pacific Margin of North America
2:15	Bert Struik	Computer-assisted Upper Cretaceous reconstruction of the Canadian Cordillera
2:30	Christian Teyssier, Andreas Mulch, Page Chamberlain	Cenozoic elevation of the North American Cordillera based on stable isotope paleoaltimetry
2:45 – 3:45	*Discussion / Poster Viewing*	
3:45	Ken Hickey, Dick Tosdal, S.R. Haynes, R.A. Donelick	Patterns of Cenozoic denudation, sedimentation and volcanism in the western Cordillera of northeastern Nevada; evidence for dynamic re-equilibration of the Sevier hinterland during slab removal
4:00	Scott Close, Dan Marshall, Derek Thorkelson	Geology and Tectonics of the Nootka Island Region
4:15	Ryan Ickert, Derek Thorkelson, Dan Marshall	Petrogenesis of adakie and high-Mg# andesite in the Eocene Princeton Group (BC): remelting of metamorphosed Mesozoic arc basalt in the lithospherica mantle
4:30	Jim Monger, Ned Brown	Tectonic evolution of the southern Coast-Cascade Orogen, northwestern Washington and southwestern British Columbia
4:45 – 5:30	*Discussion / Poster Viewing*	
6:00 – 7:30	Dinner (Old Spaghetti Factory, 53 Water St.) – *be on time to keep reservations*	

Sunday February 19

Time	Authors	Title
8:30 – 9:30	*Poster Viewing*	
9:30	Mike Cooley, Ray Price, John Dixon, Kurt Kyser	Isotope geochemistry of fault zone samples from the Livingstone Range anticlinorium and their significance to the thermal and fluid history of the southern Canadian Foreland Fold and Thrust Belt
9:45	Ray Price	Whence the Southern Canadian Rockies: Palinspastic Restorations Linking Displaced Supracrustal Rocks to Crustal Structure in the Southeastern Canadian Cordillera
10:00	Felix Gervais, Dick Brown	Conflicting data in the core of Frenchman Cap dome, Monashee complex; is the deformation Eocene or Proterozoic?
10:15 – 11:00	*Discussion / Poster Viewing*	
11:00	Andy Parmenter, Paul Williams	Kinematics of deformation along the Cranberry Valley High Strain Zone in the Thor-Odin Dome, Monashee Complex

11:15	Paul Williams, Stefan Kruse	Nature of the contact between the Monashee complex and overlying Middle Crustal Zone
11:30	Phil Simony, Sharon Carr, Alana Hinchey	A 3-D model for nascent channel flow in the infrastructure of a coherent Cordilleran crystalline thrust sheet
11:45 – 12:00	*Discussion*	
12:00	Dan Gibson	*Concluding Remarks / Planning for 2007*

Posters (Saturday - Sunday)

Authors	Title
Bob Anderson, Kirstie Simpson, Vicki McNicholl, J. Loxton	Facies and faults: geological setting, stratigraphy, age, and metallogeny of Middle Jurassic strata correlative to host rocks for the Eskay Creek Mine, eastern Iskut River area, northwestern B.C.
Maurice Colpron	A new tectonic assemblage map for Yukon-Tanana and related terranes in Yukon and northern British Columbia
Maurice Colpron	Geological map of Livingstone Creek area (105E/8), Yukon
Jenni Dickinson, Stephen Rowins, Paul Duuring, Andrew Orr, Stealth Minerals Exploration Staff	Geology of the Pine porphyry Au-Cu deposit, Toodoggone district, BC
Carol Evenchick and sixteen others	Snapshots of new geological framework and energy resource studies in the Bowser and Sustut basins, north-central British Columbia
Carol Evenchick, Margot McMechan, Vicki McNicholl, Sharon Carr	A synthesis of the Jurassic–Cretaceous tectonic evolution of the central and southeastern Canadian Cordillera: exploring links across the orogen
Eric Goergen, Donna Whitney, Paul McNeil, Paul Williams	Metamorphic petrology and P-T-t paths, Thor-Odin gneiss dome, southern British Columbia
Steve Gordey	New maps and cross-sections for the Selwyn basin, Yukon
Stacia Gordon, Donna Whitney, Christian Teyssier	Timing and duration of partial melting in the Valhalla Complex, SE British Columbia
Phil Hammer, Ron Clowes	Lithospheric-Scale Structures Across the Alaskan and Canadian Cordillera: Comparisons and Tectonic Implications
Steve Israel, Amy Tizzard	Bedrock mapping of the Kluane Ranges, southwest Yukon (parts of NTS 115G/2, 3, 5, 6, and 7)
Seth Kruckenberg, Rory McFadden, Christian Teyssier, Donna Whitney	Flow and coupling of the Eocene partially molten crust in the North American Cordillera: Evidence from the Okanogan and Pioneer migmatite domes, USA
Yvon Lemieux, Leanne Pyle	Regional Geoscience Studies and Petroleum Potential, Mackenzie Corridor, Northwest Territories and Yukon
Brad McKinley, Steve Rowins, Paul Duuring, Northgage Exploration Staff	Kemess North porphyry Au-Cu deposit, Toodoggone District, BC

David Moynihan, David Pattison	The Kootenay Lake Metamorphic 'High', S.E. British Columbia
Don Murphy, Jim Mortensen	New bedrock geological map of part of Watson Lake area, southeastern Yukon
JoAnne Nelson, Tony Barresi	New mapping in the Terrace area: Far western Stikinia stratigraphy and structure
Andy Okulitch	Geological map compilation: no vestige of a beginning, no prospect of an end
Kirsten Rasmussen, Jim Mortensen, Hendrik Falck	Geochronological and lithogeochemical studies of intrusive rocks in the Nahanni region, southwestern Northwest Territories and southeastern Yukon
Paul Schiarizza, Rich Friedman	Magmatic and structural controls of Cu-Au-Mo mineralization within Quesnel Terrane, Johanson Lake area, north-central British Columbia
Bert Struik	Computer-assisted Upper Cretaceous reconstruction of the Canadian Cordillera
Jeff Tepper, Kenneth Clark, Melissa Wolfe	Constraints on the Timing and Geometry of Kula-Farallon / Kula-Resurrection Ridge Subduction and Implications for the Eocene Magmatic and Tectonic History
Bob Thompson, Paul Glombick, Philippe Erdmer, Larry Heaman, Yvon Lemieux, Ken Daughtry	Evolution of the Ancestral Pacific Margin, southern Canadian Cordillera: Insights from new geologic maps
Deanne van Rooyen, Sharon Carr, Alana Hinchey, James Lee	U-Pb geochronology and $^{40}Ar/^{39}Ar$ thermochronology studies in the vicinity of Thor-Odin dome, southeastern British Columbia to test tectonic models and characterize the behaviour of $^{40}Ar/^{39}Ar$ systematics in migmatite terranes: A Ph.D. thesis proposal

Abstracts of Oral Presentations

chronological order

The accretionary history of the Northern Appalachians prior to Pangea

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Laurentia's Appalachian margin, north of Long Island, expanded eastwards (present coordinates) during the Early to Middle Palaeozoic (500-370 Ma) due to a protracted history of accretion of suprasubduction zone oceanic terranes and ribbon microcontinents. Normal oceanic lithosphere was rarely, if ever accreted and generally lost during subduction of the main tract of the Iapetus Ocean. The accretion of the Dashwoods, Ganderia, Avalonia and Meguma microcontinents induced the Taconic (500-450 Ma), Salinic (445-425 Ma), Acadian (421-400 Ma) and Neoacadian (395-360 Ma) orogenies respectively, with the locus of collision progressively shifting eastwards. Both the peri-Laurentian Dashwoods and peri-Gondwanan Ganderia microcontinents independently interacted with supra-subduction zone oceanic crust during the Late Cambrian to Early Ordovician on opposite sides of the Iapetus Ocean, prior to their accretion to Laurentia. The accretion of the Dashwoods microcontinent with its arc suprastructure and associated oceanic arc terranes during the Early to Middle Ordovician caused the Taconic orogeny, leading to significant tectonic thickening of the colliding arc terranes. The Taconic orogeny terminated with accretion of all outboard peri-Laurentian suprasubduction zone rocks during the late Ordovician, mainly due to arrival of the leading edge of Ganderia (Popelogan-Victoria-Bronson Hill arc). Closure of the wide oceanicTetagouche-Exploits back-arc basin that separated this ensialic arc from Ganderia's trailing edge, culminated in accretion of the latter with Laurentia during the mid Silurian (433-425 Ma), causing the main phase of the Salinic orogeny. Coincident with Ganderia's accretion to Laurentia, Avalonia started to converge with Ganderia by closing the narrow oceanic seaway that separated them. This convergence produced the Silurian coastal volcanic arc. Inversion of its accompanying back-arc basin (Mascarene-La Poile basin) at c. 421 Ma signals the start of the Acadian collision between composite Laurentia and Avalonia. The timing and mechanism by which Meguma was accreted to Laurentia is still poorly constrained at present. Late Early Devonian (c. 395 Ma) deformation of its Lower Devonian cover is used as a proxy for its time of accretion. Meguma was situated on a shallowly-dipping (flat slab) lower plate and its transfer to Laurentia involved wedging and formation of west-vergent structures.

Tectono-magmatic evolution of the Toodoggone district and implications for Early Jurassic Au-Cu±Mo mineralization

Paul Duuring[1*], *Stephen M. Rowins*[1], *Larry Diakow*[2], *Jenni Dickinson*[1], *Bradley McKinley*[1]
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The Toodoggone district is a 90 km long and 15 km wide, NNW-trending, belt of volcano-plutonic rocks located within the Intermontane Belt in north-central British Columbia. The district contains several significant calc-alkaline porphyry Au-Cu-Mo and epithermal Au-Ag deposits. Specifically, the Kemess South, Kemess North, and Pine porphyry Au-Cu-Mo deposits, and the Shasta, Baker, and Lawyers epithermal Au-Ag deposits. A collaborative 3-year NSERC-CRD grant research project between UBC, Northgate Minerals Corporation and Stealth Minerals Limited in tandem with complementary, ongoing, field studies by the BCGS and airborne geophysical surveys by the GSC, commenced in 2004 to: (1) determine the geological controls over the porphyry and epithermal styles of mineralization in the district by constructing detailed, 3-dimensional, factual deposits models; (2) identify the potential genetic linkages, if any, between the porphyry and epithermal styles of mineralization; (3) use the new deposit models to develop a regional metallogenic model that relates the Cu-Au±Mo mineralization event(s) to the tectono-magmatic evolution of the Toodoggone district; and (4) develop a predictive exploration model with practical applications that may be used in the search for porphyry and epithermal Au-Cu deposits in the Toodoggone district.

The Toodoggone district lies in the ENE margin of the Stikine terrane and comprises submarine island-arc volcanic and sedimentary rocks of the Permian Asitka and Upper Triassic Takla groups that are unconformably overlain by volcanic and sedimentary rocks of the Hazelton Group. Cretaceous continental clastic rocks of the Sustut Group cap the volcanic pile. The volcanic package has experienced up to prehnite-pumpellyite facies regional metamorphism and is intruded locally by Early Jurassic felsic to intermediate plutons and cogenetic dikes of the Black Lake suite. Specifically, plutonism occurred after tectonic uplift and erosion at ca. 200 Ma and continued episodically for 14 million years, ceasing at ca. 186 Ma. Plutons are locally cut by several generations of NNE- to NW-trending dikes of compositions ranging from rhyolite to basalt, with andesite compositions most common.

Mineralization styles in the Toodoggone range from porphyry and skarn occurrences associated with granitoids at depth, to discrete vein systems at shallower levels, and to acid-sulphate alteration zones at the near-surface. Porphyry Au-Cu±Mo mineralization is the earliest metallogenic event in the district (i.e., ca. 202-197 Ma) and is temporally and spatially associated with high-K, calc-alkaline porphyry intrusions that cut the Late Triassic volcano-sedimentary sequence and cause local mineralization in the lower units of the Hazelton Group (e.g., the weakly mineralized ca. 200 Ma Hazelton Group units at the Kemess North and Pine deposits). The distribution and types of magmatic-hydrothermal alteration in monzonite sensu latu are remarkably similar at the Kemess South, Kemess North, and Pine deposits. They include an early, central, core of potassic alteration that is replaced by phyllic alteration to varying degrees. Unlike Kemess North, both Kemess South and Pine have evidence for a second potassic alteration event that replaces phyllic alteration, thereby implying a later, thermally prograding stage of alteration-mineralization. All three porphyry deposits have late-stage, pyrite stringer veins that are cut by successive carbonate-rich, anhydrite-rich, and chlorite-rich veins.

Epithermal Au-Ag and Ag-Au deposits, including the Shasta, Baker, and Lawyers mines, and the Griz-Sickle and Wrich Hill occurrences, are hosted by Hazelton Group rocks located in grabens in the central area of the Toodoggone district volcano-sedimentary package. The timing of epithermal mineralization coincides with the earliest stages of Toodoggone volcanism and continues through to the final stages of post-Toodoggone fault-block subsidence at ca. 185 Ma. Potential high-sulphidation epithermal systems (e.g., Pil South and Nub West) range in age from 201 to 189 Ma, thereby overlapping the 202-197 Ma porphyry event and suggesting a genetic link with porphyry mineralization. Low- to intermediate-sulphidation epithermal occurrences (e.g. Wrich Hill and Shasta) range in age from ca. 196 to 186 Ma, which coincides with the cessation of volcanism at ca. 186 Ma. The nature and source of hydrothermal ore fluids for epithermal mineralization is the focus of ongoing research. Two models for epithermal Au-Ag and Ag-Au mineralization generation are being tested. The first model involves the direct input of fluids and metals from nearby plutons, with transport of the fluids to higher levels of the Hazelton Group sequence abetted by steeply dipping faults. The second model involves basin-wide convective circulation of fluids with mixed parentage (i.e., mixtures of meteoric, metamorphic, and possibly even magmatic fluid) through the Toodoggone volcano-sedimentary sequence. Metals are leached from Toodoggone rocks and perhaps some older porphyry systems (protores?) and deposited during ascent along growth faults bounding both the main and subsidiary basins. This is the classic basin-and-range model of fluid circulation and low-sulphidation epithermal deposit formation. It is possible, and perhaps even probable, that both styles of hydrothermal fluid flow were operative in the Toodoggone district during the Early Jurassic.

The volcano-sedimentary sequence in the Toodoggone district is bounded by kilometer-scale, NNW-trending, steeply dipping faults that likely represent major intra-arc extensional faults that formed within a broader magmatic arc. These structures vary in strike length from outcrop-scale (metre) to district-scale (tens of kilometers). At Kemess South, NW-trending, tight folds and a steeply NE-dipping, axial planar cleavage in well-bedded Asitka Group siltstone are truncated by the Hazelton Group basal unconformity. Overlying Hazelton Group units are not folded and do not display the NW-trending cleavage. Subsequent NW-trending faults offset the Hazelton Group basal unconformity with dextral-normal displacement, suggesting the relaxation of NE-SW shortening, and the translation of deformation styles from ductile to brittle regimes, after the tectonic uplift and erosion of the Kemess South stratigraphy, and the deposition of the Hazelton Group units (i.e. after the ca. 194 Ma depositional age of Hazelton Group units at Kemess). Normal-dextral, NW-trending faults also displace the Kemess North stratigraphy, whereas at the epithermal Shasta deposit, dextral NW-trending and subsidiary WNW-trending faults suggest a transpressional wrench regime at the time of epithermal mineralization. In all areas of the Toodoggone, NE-trending, steeply dipping faults locally cross-cut NW-trending faults. E-W trending faults cut all stratigraphic groups and their timing with respect to NW-trending faults is variable.

Structures control mineralization in the following ways: (i) at Kemess North, NW-trending faults control the emplacement of mineralized plutons and cogenetic dikes, with developing or reactivated faults transporting ore fluids away from plutons; (ii) at Brenda, NW-trending fault zones tap ascending felsic magma leading to the formation of several weakly mineralized NW-trending dikes that cut well-mineralized porphyry and prevent the development of a large continuous orebody; (iii) at Pine, abundant NE-trending, unmineralized dikes cut the mineralized monzonite porphyry and dilute the grade of the potential orebody; (iv) at Shasta, ore fluids are focused into dilational zones within dextral jogs; (v) at Kemess South and Kemess North, EW-trending, post-mineralization faults truncate the respective orebodies, whereas NE- to NW-trending faults cause graben-horst style vertical shuffling of the mineralized stratigraphy; (vi) remobilized orebodies are hosted by shear zones in Hazelton Group units at Kemess South and Kemess North. Volcano-sedimentary rocks of the Hazelton Group most likely formed within intra-arc extensional zones during steep WSW subduction along the eastern margin of Stikinia. Older Asitka and Takla group rocks are now exposed primarily along the NW-trending margins, whereas Hazelton volcano-sedimentary rocks fill a subsiding central rift zone. Conglomerate beds preserved within subsided blocks and the local concentration of thick ash-flow tuff suggest that faulting occurred at the same time as volcanic eruption. Elongate, NW-trending granitoid stocks and dikes have a close spatial and temporal relationship with volcanic rocks of the Hazelton Group, suggesting that syn-volcanic plutons intruded the developing volcanic pile along extensional structures. The plutons potentially provide the fluid and heat for fluid circulation via steeply dipping normal-dextral faults, resulting in the formation of fault-controlled porphyry, skarn, and epithermal mineral systems. Although the Sustut Group sedimentary rocks are unmineralized, they are important as cap rocks that prevent erosion of underlying rocks and contained orebodies.

A Petrogenetic Model of Prospective Stratigraphy in the Eskay Rift

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The Eskay Rift represents a transition during the Late Early to Middle Jurassic, from a sporadic and long-lived period of subduction-related island-arc volcanic activity to a brief period of extensional tectonics accompanied by rift-related volcanism. The rift-related volcanics, unofficially referred to as the "upper Hazelton Group", are the oldest volcanic rocks in the Stikine Terrane, in northwestern British Columbia. They host the world-class Eskay Creek volcanogenic massive sulfide (VMS) deposit, as well as a large number of other VMS prospects. Although the upper Hazelton Group is composed of separate sub-basins, the lithologies, geochemistry and morphologies of far-separated segments correspond closely to one another. The ubiquitous presence of thick piles of pillow basalt in the rift graben suggests that it was a basin which experienced rapid subsidence and quickly filled with mafic lavas. The rapid infilling of the graben with mafic lava overwhelmed the potential for long-lived hydrothermal convection and black smokers, which are essential to the formation of VMS deposits. However, within the graben, narrow intervals of bimodal volcanic and sedimentary rock represent periods in the history of the graben when conditions were highly-favourable for the formation of VMS deposits. While these sequences contain up to 50% pillow basalt, they are characterized by the presence of three distinct lithologies: 1. felsic flows, domes and cryptodomes; 2. sedimentary and volcaniclastic intervals, locally known as pajama beds, which are composed of black pyritic siliceous argillite interbedded on a 5 to 20 cm scale with light coloured felsic tuffs; and 3. a distinct variety of basalt, which has a phaneritic, medium grained texture and forms massive and columnar jointed flow units which are up to 20 m thick. Fine-grained sedimentary rocks within these sequences indicate a time of quiescence when the graben was not being inundated with mafic lavas. Rather, mafic magmas, which were still being generated in the upper mantle, resided in crustal-level magma chambers. During their crustal residence these magmas began to crystallize, emitting heat generated from crystal formation. This heat caused a small degree of partial melting in the upper crust, generating felsic magmas. During tectonic activity new conduits allowed the eruption of felsic lava, uncrystallized mafic lava, and a crystal mush from the crustal magma chambers. According to this model, the co-occurrence of these volcanic and sedimentary rocks mark prospective stratigraphy because: 1. they suggest a time of quiescence in a graben which is normally being inundated with mafic lavas; and 2. they represent periods with the greatest potential for vigorous hydrothermal circulation due to the presence of near-surface, crystallizing, mafic magma chambers.

The record for exhumation of ultrahigh pressure (UHP) rocks in the northern Cordillera

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Ultrahigh pressure (UHP) rocks, now documented in over 20 locations in several mountain belts, are a revelation in our understanding of the depth, scale and tempo of collisional orogeny, and the recycling of continental crust into the mantle. These occurrences share the common structural and lithological characteristic that the UHP conditions are recorded in volumetrically subordinate peridotite and eclogite pods within thin, subhorizontal, fault-bounded slabs, mostly of continental composition. The subduction, burial and exhumation cycles of the UHP terrains show rocks were buried to greater than 100 km depths and returned to the surface in tens of million years or faster Detrital grains of fresh, mantle-derived pyroxenes and garnets were recently recognized in Jurassic-aged coarse pebble conglomerates in the northern Cordillera. An initial study of these grains showed many of them to be of UHP origin, derived from mantle protoliths equilibrated at depths as great as 100 km (MacKenzie et al., 2005, Geology). Geologic evidence for UHP rocks in the northern Cordillera was hitherto unrecognized, but speaks to the involvement of deep-seated unroofing in arc- continent or continent-continent collisions, or to return flow in subduction zones which assembled crust in this mountain belt. The involvement of deeper parts of the lithosphere in the assembly of the Cordilleran orogen contrasts with a recent synthesis based on seismic reflection data, which interprets much of the accretion in the northern Cordillera as thin-skinned flakes over a fixed Precambrian substrate of the western edge of North America involving no basement deeper than ~ 5 km (Cook et al., 2004, Tectonics).

In this contribution, we use field relationships, paleoflow indicators, U-Pb zircon geochronology, petrography and major and trace element mineral chemistry to examine the protolith and provenance of detrital mantle-derived ultrahigh pressure (UHP – 2.8 GPa) minerals in immature clastic sediments of an early Jurassic basin (Laberge Group) in northwestern British Columbia. Our results show fresh mantle detritus in the Laberge Group was derived from mantle lithosphere that equilibrated at greater than 2.8 GPa and temperatures of 850 to 1100 C, exhumed in orogenic massifs and quickly deposited over a restricted time interval (at 185 m.y.). Two models are proposed for the exhumation and denudation of the UHP rocks in either: (1) an arc-continent collision within or between the Stikine and Yukon Tanana terranes, or (2) an exposed forearc and accretionary melange in a convergent margin in Cache Creek terrane. The former model is the most consistent with widespread evidence for rapid uplift of deep-seated rocks of the continental portions of the Yukon Tanana terrane at the required time period for deposition of UHP detritus 185 m.y. ago

The Early Cambrian Quartet Mountain lamprophyres and their xenoliths: clues to the crystalline basement of Yukon?

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The Quartet Mountain ultramafic lamprophyres are volatile-rich alkaline dykes that cross-cut the Wernecke and Mackenzie Mountains supergroups in the Wernecke Mountains of northern Yukon. Preliminary ^{40}Ar-^{39}Ar dates obtained from phlogopite phenocrysts indicate that the dykes were emplaced in the Early Cambrian and are therefore coeval with the Early Paleozoic extension of the northern Cordilleran miogeocline. Numerous small-volume alkalic igneous rocks that range in age from Cambrian to Devonian occur elsewhere in the miogeocline and may reflect a similar tectonic setting. The Quartet Mountain lamprophyres are dark-grey, aphanitic phlogopite±diopside±olivine-phyric, and were likely generated by low-percentage melting of parent mantle, as indicated by highly fractionated REE patterns. The alteration of lamprophyre groundmass to clay, chlorite and carbonate is pervasive, leaving phlogopite and minor opaques as the only surviving primary groundmass minerals. Olivine, where present, has been completely replaced by carbonate, chlorite and opaque minerals.

Two of the lamprophyres contain abundant xenoliths of inferred crustal and/or mantle affinities. More than a dozen zircon grains, with complex morphologies that suggest protracted histories of dissolution, physical erosion and growth under both igneous and metamorphic conditions, were identified in garnet-sillimanite-quartz gneiss xenoliths. Additional zircons were observed in garnet-quartz gneiss and feldspathic gneiss xenoliths. The primary mineralogy of mantle xenoliths has been almost completely altered to serpentine, clay and carbonate, with only minor orthopyroxene and trace clinopyroxene surviving the alteration. One xenolith contains abundant garnet constraining the depth of generation of lamprophyres to at least 90 km.

Interplay of Tectonics and Magmatism in the Northern Cordillera of Yukon and Alaska: Implications for Refining Geodynamic Models.

John L. Mair[1], Craig J.R.Hart[2]*
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2. Yukon Geological Survey

The Early to mid-Cretaceous period in the northern Cordillera of east-central Alaska and Yukon saw the waning of a pronounced phase of orogenesis associated with the closure of marginal basins and the accretion of pericratonic and exotic terranes with the ancestral continental margin. By the late Early Cretaceous (~115 Ma) extensive plutonism commenced forming a broad diffuse magmatic belt greater than 300 km in width. Magmatism ceased by approximately 90 Ma and was followed by a Late Cretaceous transition to right-lateral transcurrent displacement along orogen-parallel faults, which dismembered the mid-Cretaceous configuration of the northern Cordillera. Restoration of displacement on orogen-parallel faults allows the plutonic belts to be evaluated in the mid-Cretaceous tectonic framework.

Of specific interest are the western Selwyn Basin and Yukon-Tanana (YT) Uplands, which lay adjacent in cross-orogen section during mid-Cretaceous magmatism. In a tectonic framework, the YT Uplands represent a collisional zone that comprises underthrust continental margin sequences and overthrust pericratonic, arc and marginal basin rocks. Thermochronologic studies indicate that deep levels of the collisional zone (YT Uplands) were rapidly exhumed in the late Early Cretaceous, coinciding with the onset of voluminous felsic plutonism that perisisted intermittently for approximately 20 My. The western Selwyn Basin, which lay on the cratonward flank of the overthrust zone, did not undergo uplift and exhumation equivalent to that in the YT Uplands, and plutonism was volumetrically restricted to small stocks and dikes, which were emplaced in a narrow time interval at 93 ± 3 Ma.

Numerous workers have interpreted the mid-Cretaceous plutonic belts as the product of NE-dipping subduction under the growing continental margin, in a manner broadly analogous to an Andean style continental magmatic arc. However, petrogenetic studies of mid-Cretaceous rocks from the plutonic belts in question are strongly inconsistent with such interpretations. Strontium and neodymium isotope data indicate that the majority of felsic batholiths of the YT Uplands are consistent with a mid to upper crustal source, with melting induced in response to decompression during uplift of the overthicked collisional zone. Petrogenetic studies of the plutonic belts that intruded the western Selwyn Basin indicate that these differ to both plutons derived from subduction related processes and also differ to those of the YT Uplands. These suites include quartz monzonites, syenites and lamprophyres in isolated plutonic centers. Isotopic studies indicate that these are derived from melts generated in ancient sub-continental lithospheric mantle (SCLM), which have been variably modified by crustal interaction. The characteristics of these plutons are diagnostic of post-collisional magmatism in orogenic environments.

The petrogenetic data can be integrated with structural and geochronologic studies to indicate that the YT Uplands underwent orogenic collapse commencing in the late Early Cretaceous. In the adjacent western Selwyn Basin, the crust did not undergo significant extension, and crustal melting was restricted to upwellings of mafic potassic magma derived from the SCLM, localized along long-lived basement structures. Therefore, this region can be considered as the cratonward flank to the collapsed orogen core, represented by the YT Uplands. Collectively, the plutonic belts formed in response to orogenesis following west dipping subduction of marginal basins, and are inconsistent with models invoking an Andean type continental magmatic arc.

Triassic linkages between Yukon-Tanana Terrane and North America: Results from new detrital zircon geochronology, geochemistry, and conodont biostratigraphy

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New detrital zircon age, whole-rock geochemical, and conodont biostratigraphic data from Triassic sedimentary rocks in the northern Cordillera suggest that the Yukon-Tanana and possibly the Slide Mountain terranes had begun to supply sediment eastward onto the western edge of North America by Early to Middle Triassic time. Although preliminary in nature, these data challenge one of the fundamental concepts of Cordilleran tectonics, namely that terrane accretion in the northern Cordillera did not begin until the Early Jurassic.

The Early Triassic (Smithian; ~245 Ma) type section of the Jones Lake Formation, near Macmillian Pass in the Selwyn Mountains of eastern Yukon, contains early Mississippian (345 Ma) detrital zircons, consistent with U-Pb ages of the Simpson Lake (345-355 Ma) and Tatlmain (336-340 Ma) suites of Yukon-Tanana Terrane. These ages are distinctly younger than other dated Paleozoic igneous units within the Selwyn Basin (all >362 Ma). Whole-rock geochemical data from the Jones Lake Formation also suggests a minor mafic component in the sediment, possibly reflecting input of juvenile material from the Slide Mountain ocean basin.

Middle Triassic (Ladinian; ~235 Ma) sedimentary rocks of the western Selwyn Basin that are exposed along the Sa Dena Hes mine road and the 99 Mile Creek area in southeast Yukon contain Ladinian (236, 242 Ma), mid-Permian (265-270 Ma) and late Mississippian (320-334 Ma) detrital zircons. Permian ages are within error of the oldest ages observed in the Klondike Schist metavolcanic rocks and Sulphur Creek orthogneiss suite (252-264 Ma) of the Yukon-Tanana Terrane.

Late Triassic (Carnian and Norian; ~220 Ma) sedimentary rocks exposed at Clinton Creek, northwest of Dawson City, contain mid-Permian (262-280 Ma) and late Mississippian (320-340 Ma) detrital zircons. Late Paleozoic grains are slightly older than those observed in the Klondike or Sulphur Creek units; however, late Mississippian ages compare favorably with plutonic suites within the Yukon-Tanana Terrane.

Our new data provide strong support for a model in which Early to Late Triassic sediments within the North American miogeocline accumulated in a foreland basin related to initial stages of terrane accretion from the west, rather than simply representing part of the west-facing passive margin sequence as has previously been assumed. Subsidence within this basin occurred in response to loading of the western edge of North America by the Yukon-Tanana and Slide Mountain terranes as they were accreted from the west. These terranes subsequently formed an uplifted hinterland that likely provided much of the sediment now represented by the Triassic sedimentary package.

Is the Windy-McKinley Terrane a Displaced Fragment of Wrangellia? Evidence from New Geological, Geochemical and Geochronological Studies in Western Yukon

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The Windy-McKinley Terrane (WMT) in western Yukon and eastern Alaska is one of the least well understood terranes in the northern Cordillera, owing largely to poor exposure, difficult access and very limited study. New exposures created since 1995 along the Alaska Highway during road construction between Kluane Lake and the Yukon-Alaska border prompted a reconnaissance investigation into the age, composition, and tectonic affiliation of the WMT. The WMT in western Yukon mainly comprises argillites interlayered with massive mafic flows and breccias (greenstones), all of which are intruded by large bodies of gabbro. The eastern end of the terrane consists of massive to sheared harzburgite that previous workers have concluded represents an upper mantle tectonite. Aeromagnetic data for this region suggests that the WMT forms a shallow, E-W trending syncline floored by the sheared harzburgite. Along its southern boundary the WMT appears to structurally overlie strongly foliated quartzite, metapelite, marble and minor felsic metavolcanic rocks that are correlated with the Yukon-Tanana Terrane, and along the northern boundary it is also in uncertain but probably faulted contact with Yukon-Tanana Terrane lithologies. The WMT and Yukon-Tanana Terrane assemblages to the south are stitched together by a ~95 Ma, NW-trending belt of plutonic rocks ranging in composition from gabbro to quartz monzonite. Gabbros and greenstones of the WMT yield very consistent N-MORB and/or BAB compositions, and one gabbro body has given a ~229 Ma U-Pb baddeleyite age. Samples of scarce limestone within the argillite package have thus far not yielded conodonts. Detrital zircon ages (n=60) from a quartz sandstone within the argillite package provide major peaks between 400-600 Ma, 900-1300 Ma, 1500-200 Ma, and 2500-2800 Ma. The absence of Late Devonian and Mississippian zircons, and the abundance of 400-600 Ma grains suggests a close affiliation with the Alexander Terrane rather than the Yukon-Tanana Terrane or the North American miogeocline. The supracrustal rocks of the WMT have not yet been directly dated; however the greenstones are thought to represent the extrusive equivalents of the Late Triassic gabbros. Existing data therefore suggests that the WMT may represent a flap of Wrangellia (mainly equivalent to the Nicolai greenstone and associated sedimentary and intrusive rocks) that was thrust across the future trace of the Denali Fault during mid-Mesozoic terrane amalgamation. If correct this model has important implications for the mineral potential of the WMT.

Mantle lithospheric properties via mantle xenoliths: Implications for the tectonic evolution of the British Columbia Cordillera

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Extensional forces acting on the lithosphere beneath the Cordillera of British Columbia have resulted in numerous small volcanic centres. Many of these centres feature peridotite xenoliths brought from the mantle lithosphere to the surface. Geothermometric studies on individual xenoliths can determine the source depth (ie. temperature) for each of them. Using the source depths and properties of individual xenoliths, a stratigraphic column for the mantle lithosphere may be constructed, identifying changes with depth and their possible tectonic implications. We present a new mantle xenolith locality in the B.C. Cordillera: Mt. Preston (NTS 93E). This site is unique because (1) the relatively young age of the dyke suggests sampling of "near-present-day" mantle lithosphere underlying this portion of British Columbia, (2) the Mt. Preston locality has a unique position geographically and geologically because it is on the western margin of the Intermontane

Belt, within 40 km of Coast Belt rocks, and (3) the BATHOLITHS geophysical project will be imaging the mantle lithosphere in the area of Mt. Preston during their investigation of the Coast Belt.

The Mt. Preston dike crosscuts all stratigraphy and has >100 m exposure on a south facing slope. It is vesicular and features partly melted wall rocks; the former indicating shallow intrusion, the latter indicating sustained magma flow. It is rich in crustal xenoliths, some of which do not correlate with the surrounding country rock. The mantle xenoliths are concentrated in a 5 m interval where they comprise 50-80% of the dike; the dike is narrowest (1 m width) in this interval. These xenoliths are primarily lherzolite, with some dunites and wehrlites. Approximately a third feature planar fabrics at hand sample scale. Future work will constrain composition, density, fabrics, and olivine water contents for individual xenoliths, and apply these characteristics to a stratigraphic column of the mantle lithosphere. Compiled stratigraphic columns based on information from other mantle xenolith occurrences will be used to map large-scale heterogeneities and weak zones within the mantle lithosphere that may relate to Cordilleran assembly.

Thermodynamic constraints on mantle sources for mafic alkaline volcanism in the Northern Cordillera Volcanic Province

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Neogence to Recent, mafic volcanic rocks in the Atlin volcanic district (AVD) have been previously described as representing three distinct magma series: olivine nephelinites, basanites, and alkali-olivine-to-hyperthense normative basalts. Previous workers (e.g. Francis and Ludden, 1995) pointed out trace element differences between the groups and suggested that these different magma series are prevelant throughout the northern Cordilleran volcanic province. Major element and trace element concentrations can be used to distinguish between the nephelinites and the basanites/basalts; however, both sets of data are more consistent with a close genetic connection between the basanites and basalts. Both have similar ranges of major element concentrations and very similar normalized REE concentrations.

We have taken a non-traditional approach to using the compositions of the all three groups of rocks to characterize the source regions of the magmas. Based measured Fe2O3 and FeO in rocks from the AVD, we have estimated oxygen fugacities (fO2) for the source regions using the model of Kress and Carmichael. We have also used the computational package MELTS (Ghiorso and Sack, 1995) to estimate liquidus conditions for the samples as well as activities of major element components in the samples. The results of our calculations are useful for further distinguishing between the nephelinitic/basaltic magma series and the nephelinitic magma series. Clear separation of the samples into two groups is evident on plots of fO2 versus Activity SiO2. The source region for nephelinitic magmas in the AVD is up to 2 log units more oxidized than that for the basanites/basalts as well as have a distinctly lower range of Activities of SiO2. Accepting that our assumptions about the magmas representing source region conditions are valid, these thermodynamic constraints on the source regions clearly indicate two things: the nephelinites and basanites/basalts could not have originated from the same source regions, and the basanites and basalts could have originated from the same source regions. Work is ongoing to further constrain lithospheric vs. asthenospheric source signals for the two magma series in the AVD.

Franklin Flashback: The Role of Recycled Mantle Plumes in the Paleozoic Evolution of Rift-Related Magmatism along the Ancient Pacific Margin of North America

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The mid- to late-Paleozoic evolution of the ancient Pacific margin of North America involves numerous cycles of arc and back-arc magmatism recorded by rocks of Yukon-Tanana (YTT) and Slide Mountain terranes (SMT). Throughout its history, this active margin was the locus of numerous rift events, including continental rift, intra-arc rift, and back-arc rift episodes. An ubiquitous feature of all of these rift events is the occurrence of weakly alkalic mafic magmatism with ocean island basalt (OIB) and enriched-mid-ocean ridge basalt (E-MORB) signatures (Fig. 1) indicative of a recycled oceanic crustal component in their genesis (i.e., Nb/Th_{mn} and Nb/La_{mn} >1; mn – primitive mantle normalized; Fig. 2). In the modern and ancient geological record, rocks with these types of signatures are commonly a manifestation of magmatism associated with mantle plumes. Their presence in rocks of YTT and SMT suggest that mantle plumes contributed to the magmatic development of the ancient Pacific margin of North America. However, the direct involvement of a mantle plume in the genesis of these rift rocks fails a number of critical tests, including: 1) the rift magmatic events are associated with low volumes of magmatism; 2) they lack evidence for topographic uplift and shallowing of sedimentary facies in spatially associated sedimentary rocks; 3) they do not occur within an intraplate tectonic setting (e.g., analogous to modern ocean islands, ocean plateaus, or continental flood basalt environments); and 4) would require a plume exist within the YTT and SMT for over 150 million years.

The occurrence of plume-like geochemical attributes, yet no plume-like geological features, suggests that the plume signatures were inherited from the lithospheric mantle source region to the alkalic basalts. We propose that this plume like material was initially related to the Neoproterozoic ((~770-720 Ma) Franklin-Gunbarrel large igneous province (LIP) event. It is envisioned that the plume-related magmatism associated with the Franklin-Gunbarrel event intruded and froze as dykes within the northern Cordilleran lithospheric mantle fertilizing it with plume-like material. These veins of plume-related material resided in the northern Cordilleran cratonic lithosphere until subsequent rift events in the Paleozoic recycled them in lithospheric mantle-derived rift-related magmas. The presence of Neoproterozoic Nd and Hf isotope depleted mantle model ages within the alkalic basalts of YTT and SMT strongly supports this hypothesis and suggests that these younger alkalic basalts are "flashbacks" from this ancient LIP event.

Computer-assisted Upper Cretaceous reconstruction of the Canadian Cordillera

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A reconstruction of the terrane map for the Upper Cretaceous Canadian Cordillera was made from the terrane map of the Canadian Cordillera (modified from Wheeler et al. 1991). The computer graphics program, Adobe Illustrator*, was used to constrain the movement and distortion (un-deformation) of the terranes. The amount and senses of motions required to view pre-strike-slip faulting and the pre-compression and extensional folding and faulting terrane configurations were derived from various current overview publications and from interpretation of terrane map patterns. Fourteen steps in the reconstruction are illustrated, covering the time interval of primarily large amounts of dextral translation and thrust-belt compression.

The reconstruction steps illustrate how 450km of dextral motion along the Tintina Trench Fault can be accommodated by distributed Tertiary dextral strike-slip faulting and crustal extension through the southern Canadian Cordillera. It also illustrates how the Bridge River and Cache Terranes were likely one entity in the Upper Cretaceous. Similarly, the tri-partite terrane distribution of Quesnel / Cache Creek / Stikine (east to west) in central British Columbia would also have existed to the south in what is now southern British Columbia and northern Washington State. Three of the transform components of Adobe Illustrator* were used to make the reconstruction: moving blocks of terranes linked as groups, rotating the groups, and rectilinear stretching of the groups with the scale tool. The amounts of motion and stretching were controlled using the software's rulers and the map scale. Stretches done with the scale tool to remove the effects of folding and thrusting, provided some unexpected configurations, primarily distorting what would have been long-lived crustal boundaries. Crustal boundaries such as the Pinchi-Teslin fault were used as group boundaries to minimize their distortion from current examples of subduction arcs or great circle transform faults.

* Adobe Illustrator is a registered trademark of Adobe Systems Incorporated, San Jose California.

Reference

Wheeler, J.O.; Brookfield, A.J.; Gabrielse, H.; Monger, J.W.H.; Tipper, H.W.; and Woodsworth, G.J. 1991: Terrane Map of the Canadian Cordillera / Carte des Terranes de la Cordillère Canadienne; Geological Survey of Canada, Map 1713A.

Cenozoic elevation of the North American Cordillera based on stable isotope paleoaltimetry

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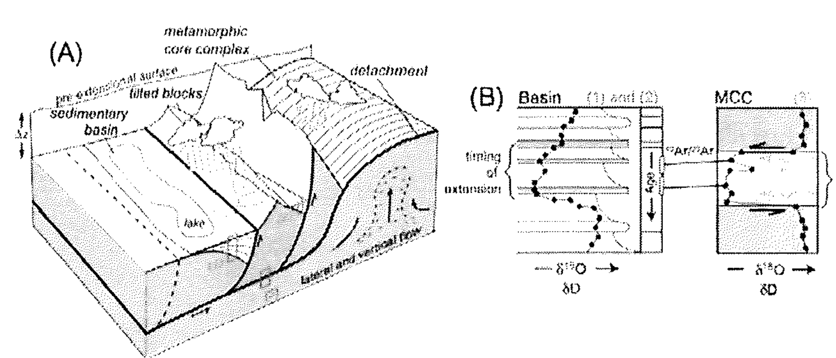
Surface elevation is one of the most important characteristics of the continental crust in that it reflects the distribution of mass and heat inside the Earth, controls drainage patterns, and influences atmospheric currents and therefore climate. Yet, paleoelevation is one of the most elusive parameters in the paleorecord. Recent developments in paleoaltimetry applied to the North American Cordillera shows promising results. By combining stable isotopic, structural, and sedimentological studies of metamorphic core complexes and their adjacent sedimentary basins, we can reconstruct the Cenozoic paleoelevation of the Cordillera and test multiple hypotheses regarding the driving forces of extension/orogenic collapse.

Methodology: Stable isotope paleoaltimetry is based on the observation that precipitation and surface waters become depleted in ^{18}O and D with increasing elevation. The isotopic depletion is principally caused by Rayleigh distillation of ^{18}O and D from precipitation and water vapor as air masses rise orographically and condense rain and snow as they pass over a mountain range. This "altitude effect" has been recently quantified using a theoretical thermodynamic approach that allows us to place quantitative bounds on the elevation of past mountain ranges. This approach has been used to determine topographic histories from coupled basins/metamorphic core complexes (Fig. A) in the Cordillera. Authigenic minerals found in intermontane basins (Figs. A, B, 1&2) and recrystallized mica in mylonite zones (Fig. B) carry the meteoric water signal that allows reconstruction of paleoelevation.



(A) Cartoon of coupled extensional basins/metamorphic core complexes; (B) stable isotope data obtained from authigenic minerals in basins (1&2) and mica fish in detachment mylonites (3); meteoric fluids penetrate the upper crust and participate in synkinematic mica crystallization in the detachment.

Results: Paleoaltimetry results based on ^{18}O and D have been obtained from several metamorphic core complexes, Thor-Odin (BC), Kettle dome (E. WA), Anaconda (MT), Pioneer (ID), Raft River (UT), Ruby Mountains (NV), and associated basins. Results suggest that the Northern Cordillera (north of the Snake River) collapsed rapidly at ~50-45 Ma, from an elevation at least 1,000 to 2,000 m higher than the present-day highest peaks. South of the Snake River, Eocene elevation was also likely high, but evidence is masked by a high surface elevation signal, in excess of 4,000 m, in Miocene time (18-16 Ma).

Patterns of Cenozoic denudation, sedimentation and volcanism in the western Cordillera of northeastern Nevada; evidence for dynamic re-equilibration of the Sevier hinterland during slab removal

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Pre-Cenozoic rocks from the east Tuscarora, Independence and Cortez mountain ranges in the Sevier hinterland of NE Nevada preserve Cretaceous apatite fission-track (AFT) ages. Thermal modelling of AFT data suggest that this region underwent its last major phase of denudation (30-270m/My) in the Late Cretaceous during the Sevier orogeny. By ~70 to 60 Ma, the rate of denudation slowed (12-40m/My), marking the effective end of surface deformation associated with the Sevier orogeny in NE Nevada. From this time onward, the region remained an elevated, low-relief plateau with little tectonically driven exhumation.throughout most of the Cenozoic

From ~46Ma to ~37Ma, a broad, asymmetric depression, the Elko basin, developed as a series of large half-grabens above a shallow west-northwest dipping growth fault on the west flank of the modern Ruby Mountains-East Humboldt Range (RMEH). Syn-extensional fluvial-alluvial and lacustrine sedimentation initiated at ~46 Ma in the eastern part of the basin. By 42Ma the fluvial sedimentation had extended northwestward to the area of the modern Tuscarora Mountains. From ~40.4-39.7 Ma explosive volcanic eruptions filled the western part of the basin. In contrast, lacustrine sediments continued to fill the basin further east. After 39.7 Ma explosive volcanism in the western Elko basin ceased and pervasive rotational extensional faulting began to break up the basin in that area. The emplacement of high-level Eocene intrusions and the extrusion of andesite-dacite flow-dome complexes accompanied this latter phase of extension. Lacustrine sedimentation in the east stopped at ~38.9 Ma. Rotational extensional faulting extended into the eastern part of the basin shortly thereafter and was similarly associated with extrusion of andesite flow-dome complexes.

The initial stage of regional Eocene extension was largely accommodated on widely spaced growth faults and was characterized by low rates of subsidence. The pervasive, mainly west dipping, domino-style faults that sliced the Elko basin into mainly NE- to N-trending fault blocks from ~39.7Ma represent an increased rate of extension. Slip was relatively homogeneously distributed and total extension was ~15-30%. Formation of the closely spaced normal faults broke up the upper-crust, such that Eocene magmas could more readily access the surface, reducing their residence time in the upper-crust. This new extensional regime resulted in a switch from rhyolitic volcanism to the extrusion of numerous relatively small andesite-dacite flow/dome complexes.

The period of upper-crustal Eocene extension in the NE Nevada was synchronous with, but decoupled from, mid-crustal extension in the RMEH metamorphic core complex; the latter having undergone relatively uniform exhumation from ~85 Ma to the Miocene. Eocene extension was probably a dynamic readjustment of the thickened Sevier hinterland to the reduction in shear stress at the base of the lithosphere associated with the floundering of the Farallon plate and a rise in gravitational potential energy induced by the reintroduction of asthenosphere at the base of the Cordilleran lithosphere. The location and kinematics of extension was possibly controlled by the geometry of the Proterozoic rift margin in the lower crust.

Geology and Tectonics of the Nootka Island Region

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Nootka Island exists as a sliver of crust amidst crustal-scale shear zones along the western coast of Vancouver Island, British Columbia. This area lies within the Insular Belt of the Canadian Cordillera, considered to be the remains of an exotic terrane(s) accreted near the Jura-Cretaceous boundary. Nootka Island contains a heterogeneous assemblage of volcanic flows and sediments intruded by a plutonic suite. This package is regionally metamorphosed to greenschist grade, exhibiting higher grades near shear zones and within contact aureoles. Correlation of Nootka rocks with adjacent Wrangellian stratigraphy is made difficult by the lack of recognizable stratigraphic markers and general absence of geochemical similarity with other components of Wrangellia. This work describes the geology of Nootka Island and hypothesizes a regional petrogenetic model based on available evidence.

We recognize two groups of volcanic rocks on Nootka Island. Group 1 contains tholeiitic hyaloclastites and aphyric basalts with epidotized clasts that have within-plate / E-MORB element signatures. Group 2 consists of calc-alkaline, arc-like basalts and basaltic andesites. Limestones, calc-arenites, siltstones, sandstones, and marine tuff comprise the sedimentary strata. The plutonic rocks on Nootka Island share similar geochemistry with Group 2 volcanics, the oldest of which are hornblende gabbros, followed progressively by more felsic, hornblende diorites and diorites resulting in zoned igneous complexes. Fractional crystallization models among the intrusions suggest diorites are the daughters of older magmas with limited contamination from an external source. Contacts among all varieties are primarily co-magmatic and mesozonal with country rock. Some hornblende gabbros and hornblende diorites have cumulate textures, and one outcrop displays layering of hornblende crystal fractionate. More primitive than the diorites, the hornblende gabbros and hornblende diorites have Mg#'s from 50-70 and display modest enrichment of the large-ion lithophyle elements (LILE). The diorites have greater enrichments in the LILE's with lower Mg#'s. Cognate basalt dykes crosscut the diorites and gabbros.

Whole-rock, Ar-Ar dating of a Group 2 aphyric basalt dyke has a crystallization age of 168 +- 4.0 Ma, and of a hyalocalstite from Group (1) an age of 158 +- 6.0 Ma but considered reset from alteration. Plagioclase-hornblende and aluminum-in-hornblende geothermobarometery give maximum metamorphic pressures and temperatures of 6 kbar (+- 0.5) and 750 degrees Celsius on a dynamically-metamorphosed amphibolite striking NW-SE along the western margin of Nootka Island.

In general, rocks from Group 1 resemble those of the Karmutsen volcanics and appear to be overlain and intruded by those of Group 2. This latter group displays lower overall REE enrichment than any other volcanic group in Wrangellia- being most analogous to the Talkeetna volcanics. Additionally, moderate enrichment in the fluid-mobile trace elements, depletion in the incompatible trace elements, abundant pegmatitic segregations and occurrences of epidote and rutile within intrusions- indicating high volatile content- suggest derivation above a subduction zone from a depleted, hydrated mantle wedge with modest enrichment from a subducting slab. Structural relationships throughout Nootka Island indicate tectonism (accretion?) after emplacement of the intrusions evidenced by field observations and heterogeneous, orogen-parallel, ductile-to-brittle deformation styles.

PETROGENESIS OF ADAKITE AND HIGH-MG# ANDESITE IN THE EOCENE PRINCETON GROUP (BC): REMELTING OF METAMORPHOSED MESOZOIC ARC BASALT IN THE LITHOSPHERIC MANTLE

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The Princeton Group is part of the Eocene Challis-Kamloops belt, a product of intense magmatic activity that extended from central British Columbia south to Oregon and Idaho. Much of the volcanic activity took place in a regime of strike-slip and normal faulting. Although the majority of volcanic rocks have a calc-alkaline affinity and are similar to lavas erupted in continental arcs, some assemblages have unusual chemical signatures. These signatures include intraplate, alkaline signatures, and especially in the Princeton Group, adakites and high Mg# andesites. This compositional diversity has fuelled controversy over the tectonic setting of the Challis-Kamloops belt, with some workers preferring an origin as a subduction related volcanic-arc, and some workers appealing to intraplate extension and asthenospheric upwelling. We report a detailed field, geochemical, petrologic, and isotopic study of the Princeton Group, an Eocene suite of adakitic rocks from southcentral BC, that contribute to this debate.

The Princeton Group is an assemblage of terrestrial volcanic and clastic sedimentary rocks stretching from the Canada-United States border north to Merritt, coeval with transtensional movement along major early Tertiary faults such as the Fraser Fault and the Boundary Fault. The volcanic rocks were largely deposited as cinder cones and composite volcanoes, and are composed of calc-alkaline basaltic-andesite, andesite, dacite, and rhyolite. New $^{40}Ar/^{39}Ar$ dates indicate that magmatism took place from 53-47 Ma, making the Princeton Group synchronous with the rest of the Challis-Kamloops belt. New $^{143}Nd/^{144}Nd$ measurements, and previously published data, indicate the Princeton Group are juvenile additions to the continental crust, with εNd_{50} = 1.2-6.4. This range in $^{143}Nd/^{144}Nd$ ratios is similar to published values for the basement but distinct from some nearby alkaline volcanic centres in the Penticton Group which have a more evolved signature.

Major and trace element abundances of Princeton Group rocks resemble those of many modern continental arcs. An adakitic trace element signature is present in the full range of bulk-compositions, including high Mg# (~70) basaltic andesite which is inferred to have been in near-equilibrium with mantle peridotite. Adakites are an unusual volcanic rock with high La/Yb, Sr/Y, and low Y and Yb often associated with the partial melting of garnet-amphibolite at high pressure, in particular in subducted oceanic crust. Trace element modelling and Nd isotopic ratios indicate that the signature is not generated by slab melting, but from an already enriched "arc-like" source. This source may have been basaltic dykes that were emplaced into the lithospheric mantle during Mesozoic arc magmatism, metamorphosed to amphibolite, and partially melted in the Eocene during an event of lithospheric heating. Reaction of the resulting adakitic melts with peridotite of the lithospheric mantle shifted the melt composition to high-Mg# andesite which subsequently differentiated into a range of compositions, all of which bear an adakitic signature. The heating may have been caused by upwelling asthenosphere related to a slab window or slab tear.

Tectonic evolution of the southern Coast-Cascade Orogen, northwestern Washington and southwestern British Columbia

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Early Cenozoic and older bedrock geology of the North Cascade ranges of northwestern Washington forms the southern end of a discrete mid-Cretaceous to early Cenozoic orogenic system that also underlies the Coast Mountains of British Columbia and southeastern Alaska and which herein we call the Coast-Cascade Orogen (CCO).

In the region that straddles the boundary between North Cascades and Coast Mountains, three groups of late Paleozoic and/or Mesozoic terranes existed prior to their mid-Cretaceous incorporation in the CCO. Group 1 consists of Bridge River, Methow and Cadwallader terranes in the southeastern Coast Mountains, eastern Cascades, and metamorphosed, in the Cascade crystalline core. All three terranes were founded on oceanic basements, overlapped by Late Jurassic clastics, and flanked the Early Cretaceous continental margin. Group 2 contains Wrangellia, Nooksack-Harrison and Chilliwack arc-dominated terranes in the southwestern Coast Mountains and structurally lower parts of the northwest Cascades and San Juan Islands. They were together in the Jurassic and by the Early Cretaceous lay oceanward of group 1 terranes. Group 3 comprises Late Jurassic-Early Cretaceous ophiolite, mélange and clastic rocks in structurally high parts of the northwest Cascades, San Juan Islands, and southernmost Cascade crystalline core that resemble some rocks in the western Klamath Mountains and elsewhere in western California.

The CCO formed in the upper plate of a long-lived convergent margin, and emerged between latest Early Cretaceous (~105 Ma) to early Cenozoic (~45 Ma) time as a discrete tectonic entity characterized by widespread plutonic and metamorphic rocks and associated structures. Its latitudinal position within the Cordillera ~coincides with the limits of Wrangellia and Alexander terranes which lie oceanward of it. In Middle (?) and Late Jurassic to mid-Cretaceous time (~170-87 Ma) terranes of Group 2 and to a lesser extent those of Group 1 moved relatively southward relative to the craton. Terminal southward movement is recorded by sinistral strike-slip faults and folds and thrusts formed by orogen-parallel compression; the latter carried terranes of Group 3 over those of Groups 1 and 2. In the mid- to early Late Cretaceous time (105-86 Ma) orogen-normal compression formed folds and reverse faults, in places overprinting the earlier-formed structures. In the Late Cretaceous and early Cenozoic (93-45 Ma), the entire CCO and the probably the hinterland to the east moved relatively northward, and in this time interval dextral transpressional structures were succeeded locally in the early Cenozoic (~45 Ma) by transtensional structures. Although there is some overlap in the times that structures formed, the sequence probably reflects changes in the direction of plate convergence between North American and (presumably) Farallon and Kula plates: from oblique with a southerly, sinistral component; through orthogonal; to oblique with a northerly, dextral component. The present tectonic regime began in the latest Eocene (>35 Ma) when the Cascade magmatic arc was emplaced across the entire southern CCO.

Isotope geochemistry of fault zone samples from the Livingstone Range anticlinorium and their significance to the thermal and fluid history of the southern Canadian Foreland Fold and Thrust Belt

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The first fluid-flow event documented in the Livingstone Range anticlinorium is represented by pre-deformation quartz/dolomite/calcite+/-fluorite+/-sphalerite veins, with associated alteration halos, that cut perpendicular to and parallel with bedding. Calcite crystals in these veins have radiogenic strontium isotopic ratios and strongly depleted oxygen isotopic compositions that suggests a Paleoproterozoic basement-derived source. Strontium and oxygen isotopic compositions of most dolomitized Paleozoic carbonates show a trend of increasing radiogenic Sr and ^{18}O-depletion that indicates regional dolomitization may have been caused by the infiltration of basement fluids.

During the early stages of Cretaceous/Tertiary deformation, the undeformed Upper Paleozoic strata that would eventually become the Livingstone Range anticlinorium became buried by a >5km-thick succession of shale-dominated foreland basin deposits. The insulating effect of the sediment raised temperatures in the underlying strata at a geothermal gradient of ~33°C/km. The regional effect of the increased temperatures caused hydrocarbon maturation, the possible recrystallization of magnetic minerals that reset paleomagnetic signatures, and increased vitrinite reflectance values of coal. The eastward-migrating blanket of foreland basin sediments was systematically deposited ahead of the deformation front, which caused an eastward-migrating hot thermal anomaly to pass through the foreland basin ahead of the deformation.

The initial stage of deformation of the Livingstone Range anticlinorium caused extensive fracture dilation in the Paleozoic rocks during fault-propagation folding. This caused fluids to be drawn into the fractures and faults. ENE-trending cross faults that developed in the Mount Head Formation and deeper strata in the cores and limbs of anticlines drew in formation fluids from the adjacent rock, as indicated by veins with weakly-enriched $\delta^{18}O$ compositions relative to host rocks. However, thrust faults at the same structural level contain veins with relatively weakly-depleted $\delta^{18}O$ compositions that are interpreted to represent infiltration of small amounts of strongly isotopically depleted fluids that equilibrated with the host rocks at high temperatures. Isotope geothermometry of calcite, dolomite +/- quartz in veins in one cross fault and two thrust fault samples indicate that these early veins precipitated at temperatures of >250 °C. This temperature is 60-80 °C higher than that expected from temperatures extrapolated from the coal rank in the Jurassic/Cretaceous Kootenay Formation which lies ~1000 metres stratigraphically above. The anomalous high temperatures recorded by these early veins document the infiltration of hot fluids derived from the underlying Paleoproterozoic basement, which migrated into the anticlinorium when the Livingstone thrust cut through steep ENE-trending reactivated faults that were conduits for the basement fluids. A basement-derived source for the fluids is supported by anomalously radiogenic strontium isotopic ratios of the early syn-deformation veins relative to adjacent host rocks.

As thrusting continued, the Livingstone Range anticlinorium underwent additional deformation and became elevated and affected by erosion. Faults exposed at surface allowed the deep infiltration of cool meteoric water that circulated through the strata and cooled the rocks to a geothermal gradient of 12 - 17 °C/km. Veins in thrust faults that cut through the Mount Head Formation and younger strata have strongly-depleted $\delta^{18}O$ values (<-10‰PDB) which is interpreted to represent a component of meteoric water in these veins, which implies that meteoric water infiltrated the system from above and was unable to penetrate the "blind" faults that cut through deeper strata in the core of the anticlinorium.

The widespread occurrence of strongly $\delta^{18}O$-depleted veins in thrust faults in the Front Ranges and Foothills of the southern Canadian Foreland Fold and Thrust Belt is attributed to regional infiltration of meteoric fluids, which swept through the deformed rock from west to east along with the deformation. As new, undeformed, deeply buried and hot material became incorporated into the leading edge of the thrust and fold belt it became deformed, transported, elevated, eroded and rapidly cooled by infiltration and circulation of meteoric water.

Whence the Southern Canadian Rockies: Palinspastic Restorations Linking Displaced Supracrustal Rocks to Crustal Structure in the Southeastern Canadian Cordillera

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The Cordilleran foreland thrust and fold belt of southern Canada and adjacent northern U.S.A. is a critical-taper, "thin-skinned" accretionary wedge. It consists of supracrustal rocks that have been scraped off the under-riding crystalline basement of the western edge and external margin of the Paleozoic Laurentia craton and accreted to the over-riding rocks of Intermontane terrane (a tectonic collage of oceanic volcanic-arc and ocean-basin rocks that was accreted to Laurentia during several hundred km of variable Early Jurassic to early Paleocene oblique convergence between Laurentia and subduction zones that were situated on the west side of Intermontane terrane). The total shortening (horizontal displacement) across the foreland thrust and fold belt varies along strike from >200 km in the central part of the segment to <100 km at the southern and northern ends. Most (~75%) of this shortening is expressed as large displacements along a small number of large thrust faults.

The detached and displaced supracrustal rocks comprise six broad tectonostratigraphic assemblages that represent six different tectonic settings and five different intervals of geological time: (1.) The Mesoproterozoic (1500-1400 Ma) Belt-Purcell Supergroup accumulated in a very deep (15-20 km) intracontinental rift-basin within a Paleoproterozoic supercontinent of which Laurentia contains the largest surviving fragment. (2.) The late Neoproterozoic (750-600 Ma) Windermere assemblage accumulated to thicknesses of a few km, and locally > 5 km, in a rift-basin that truncated but partly overlapped the Belt-Purcell basin. This basin has been interpreted both as and intracontinental rift and as the eastern margin of an ocean basin. The eastern margin of the Windermere basin defined most, but not all, of the eventual configuration of the western margin of the Paleozoic Laurentia craton. (3.) The thick (10-15 km) EoCambrian to Middle Jurassic (600-180 Ma) Cordilleran miogeocline assemblage was deposited mainly over and outboard of the Windermere assemblage, but also inboard and over part of the Belt-Purcell assemblage. It was as a westward prograding continental margin terrace wedge that marked the interface between the Paleozoic Laurentia craton and the adjacent proto-Pacific ocean basin. (4.) The laterally equivalent thinner Laurentian cratonic platform assemblage accumulated on the adjacent part of the Paleozoic Laurentia craton, over-lapping both the older (Archean-Paleoproterozoic) crystalline basement rocks of Laurentia and much of the Belt-Purcell basin (in the region known as Montania). (5.) The Late Jurassic to late Paleocene Cordilleran foreland basin assemblage, which accumulated above the cratonic platform assemblage, in front the of the northeastward prograding accretionary wedge of the thrust and fold belt, was partly incorporated in and cannibalized by the evolving thrust and fold belt.

Most of the stratigraphic record bearing on the nature, amount, and timing of the subsidence and sediment accumulation in these basins, and on the relationships among the basins is preserved within the detached and displaced supracrustal rocks that make up the thrust sheets and slices of the foreland thrust and fold belt. Because this record pertains to the locality from whence they came and not to the locality where they occur now (which is commonly hundreds of km to the northeast) palinspastic reconstruction of the foreland thrust and fold belt is a prerequisite for the elucidation of the tectonic relationships among these basins and between them and the Proterozoic crystalline basement that extends into the Cordillera from the Canadian shield. Hence this study.

A new palinspastic map of a 900-km-long segment of the foreland thrust and fold belt extending from northern Montana (~48^0 N) into northeastern B.C. (~55^0 N) is linked to palinspastic reconstructions of six previously published balanced regional structure sections. Each cross-section has been reconstructed to illustrate along-strike variations in the relationships among the Laurentia craton, the Belt-Purcell basin, the Windermere basin, the EoCambrian-Middle Devonian part of the Cordilleran miogeocline, and the Upper Devonian to Middle Jurassic part of the miogeocline. The palinspastic map shows where the rocks that are now exposed along the hanging walls of the major thrust faults were situated before they were detached and displaced by late Jurassic to early Paleocene thrusting and folding and deformed by the ensuing late Paleocene-early Eocene regional dextral transtension. Thrust faults were deflected upward along basin-margin frontal and lateral ramps. Hanging wall ramps that were tectonically inverted during thrusting as they were displaced over the relatively flat surface of the Laurentian craton formed frontal and lateral ramps of structural culminations. Migrating-hinge fault-bend folds developed in thrust sheets as they moved over footwall ramps. Broad regional structural culminations and depressions that are evident at the scale of the Wheeler and McFeeley tectonostratigraphic assemblage map of the Canadian Cordillera can be correlated with rift-basin-margin structures of Mesoproterozoic (1500-1400 Ma), and Neoproterozoic (750-600 Ma) age, and with EoCambrian to Middle Devonian (600-390 Ma) block-fault basin-margin structures that were situated within and at the edge of the evolving Cordilleran miogeocline. The most conspicuous of these latter structures, the Crowsnest Pass cross-strike discontinuity, marks a 220 km dextral offset in the boundary between the Laurentia craton and the Cordilleran miogeocline. In the palinspastic restoration, this aligned with magnetic anomaly signature of the Vulcan structure, a Paleoproterozoic suture that marks the northwestern edge of the Archean Medicine Hat block in the basement of southern Alberta. Intermittent reactivation of the Vulcan structure during deposition o the Cordilleran miogeocline accounts for the stratigraphy along the offset. Reactivation of the Vulcan structure also influenced the development of the Belt-Purcell and Windermere basins.

Isopach maps of the estimated total thickness of the palinspastically restored Belt-Purcell assemblage, the Windermere assemblage and the EoCambrian to Middle Devonian strata of the Cordilleran miogeocline illustrate the overlap and truncation relationships among the three basins. The major negative Bouguer gravity anomaly of the southeastern Canadian Cordillera coincides with the area of thrust overlap of the Cordilleran miogeocline relative to the basin-margin ramp that separated the miogeocline form the craton. The Vernon monocline, the south-southwest facing crustal scale “flexure” along which the boundary between Intermontane terrane and North American rocks is deflected southeastward from the Okanogan Valley to the Kootenay arc, and across which Lithoprobe seismic reflection imaging outlined a 15 km high south-facing ramp in the Monashee décollement, coincides with the palinspastically restored location of the boundary between the carbonate bank and adjacent deep shale basin in the Cordilleran miogeocline. The palinspastically restored locations of the Windermere “high” and the Dogtooth “high”, two eastward titled west-facing fault blocks within the miogeocline, are close to the Okanogan Valley. The thick EoCambrian siliciclastic successions that occur in the Kootenay arc and the Selkirk Mountains were deposited in the area west of the Okanogan and North Thompson valleys. The deeper water facies Paleozoic rocks and associaede Devono-Carboniferous magmatic arc rocks came from farther outboard in an area that is now a structurally low region along the west flank of the Omenica belt. This Early Paleozoic ocean-basin domain may have been underlain by oceanic and/or very thin continental crust.

CONFLICTING DATA IN THE CORE OF FRENCHMAN CAP DOME, MONASHEE COMPLEX; IS THE DEFORMATION EOCENE OR PROTEROZOIC?

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Frenchman Cap dome is one of two major culminations within the Monashee Complex of the southeastern Omineca Belt. This dome is mantled by migmatitic metasediments and cored by migmatitic orthogneisses. A Cordilleran strain gradient decreasing with depth has previously been mapped at the upper structural level of the basement. A suite of granitic dykes that are completely transposed near the contact with the cover sequence, but only slightly deformed at deeper levels best illustrates this strain gradient. These dykes and other crosscutting pegmatites were dated by in-situ LA-ICP-MS at 1850 Ma, which suggested that basement rocks remained strong throughout the Cordilleran orogeny and the following extension. However, field relationships from the deepest structural level of the dome suggest that the emplacement of the granitic suite, the emplacement of hornblende diabase and anatexis of host orthogneisses are all coeval and linked with an E-W ductile stretching event. An Eocene age for this event is suggested from the strain field and from a preliminary Eocene titanite age from a leucosome. Furthermore, the apparently robust 1850 Ma age is now complicated by new petrological investigations of the granitic dykes that reveal complex textural relationships between the 1850 Ma monazites and presumably Eocene allanites. A multiple working hypothesis approach is used to assess the conflicting data, and viable tectonic models are proposed.

Kinematics of deformation along the Cranberry Valley High Strain Zone in the Thor-Odin Dome, Monashee Complex

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A set of approximately N-striking lineaments defines the Cranberry Valley High Strain Zone (CVHSZ), a diffuse and anastomosing deformation zone in the Cranberry Mountain region of the Thor-Odin dome, Monashee Complex. The CVHSZ is roughly coincident with a N-trending periclinal (antiformal) basement-cored structure mantled by a discontinuous sequence of marble, paragneiss, quartzite, calc-silicate, and amphibolite tentatively correlated with the Monashee 'cover' assemblage. The zone is postulated to extend southward along the western flank of Thor-Odin slightly oblique to the dome axis. Continuation of the CVHSZ northward is less traceable due to poor exposure.

The CVHSZ represents a zone of tectonic transition across the dome. East of the CVHSZ a train of N-verging F3 folds with steeply north-dipping enveloping surfaces, shallowly south-dipping long limbs, and shallowly E- and W-plunging fold axes characterize the macroscale structure. N-trending upright open F4 folds, locally accompanied by a weakly developed sub-vertical axial planar foliation, and E-dipping top-to-the-E shear bands, overprint and complicate this structure. The penetrative effects of F4 increase westward towards and into the CVHSZ. West of the CVHSZ the S_T fabric dips moderately to the WSW. The foliation is re-activated by SW-side-down movement, and also overprinted by steeply dipping SW-side-down shear bands. Within the zone itself, the S_T fabric also generally dips moderately towards the west, however, the frequency of development of steeply W- to SW-dipping W-side-down shear bands is markedly increased. Fold axes are concomitantly rotated into a steeply plunging orientation; their distribution defining a steeply WSW-dipping girdle. Steeply plunging slickenside striae preserved on some shear planes strengthen the argument for dip-slip movement, however, sub-horizontal to shallowly S-plunging striae locally preserved on steeply-dipping N-striking dislocation planes require a component of strike-slip motion as well. Tight to isoclinal upright N-trending F4 folds with well developed axial planar fabrics are also characteristic of the CVHSZ.

West of the CVHSZ, the western margin of the Thor-Odin dome is characterized by the N-striking, W-side-down-normal Greenbush Lake Shear Zone (Johnston et al. 2000), and the N-striking, dextral transcurrent Victor Creek Fault (Kruse and Williams, in press). The CVHSZ is interpreted as a similar 'weak' zone that has undergone components of both dip- and strike-slip movement. It is unclear whether these movements can be explained by a single protracted event or if it was characterized by a number of discreet episodic pulses. The long-lived nature of major transcurrent boundaries, e.g. the San Andreas Fault Zone, may argue for the latter. These observations may also have very important implications for the Baja B.C. hypothesis.

Nature of the contact between the Monashee complex and overlying Middle Crustal Zone

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The contact between the Monashee complex (MC) Basement zone and the overlying Middle Crustal Zone (MCZ) has been interpreted previously as a northeasterly directed ductile thrust

(Monashee décollement) (e.g. Read & Brown, 1981; Brown et al., 1991; Cook et al. 1992; Crowley et al., 2000) and the presence of a discontinuity is supported by a hiatus in peak-of-metamorphism ages (Carr, 1991). Local discontinuities are common, but they generally ramp down to the NE, and detailed mapping in Thor - Odin (T–O) has failed to reveal any structure that can be interpreted as a regional thrust. Instead, mapping and structural analysis indicate a progressive non-coaxial flow (F_1, F_2, F_3) throughout the MC and the MCZ that resulted in a regionally homogeneous transposition foliation (S_T). Flow was top-to-the-NE in the MC and the lower part of the MCZ, but was more complex in the upper part of the MCZ where early flow was top-to-the-NE and later flow was top-to-the-SW. The boundary between the two zones is similar to that within the MC between the core and its unconformable cover, both boundaries are gradational. Rocks belonging to the three units are inter-layered at all scales by the transposition, and there is a gradual change from mostly MC core rocks to MC cover rocks to MCZ rocks in going from E to W, or N to S, but no sharp boundaries between the three.

A weak shear zone, the Greenbush Lake shear-band zone (GBLSZ), overprints F_3 folds, and occurs within the transitional zone between the MC and the MCZ (Johnston et al., 2000). It does not separate the two units however, there being MC rocks both sides of the shear zone (McNeill et al., 2004). It outcrops along the W flank of T–O and is a W-dipping normal structure. We interpret it as a continuation of the S-dipping Slate Mountain high strain zone wraping around the S end of T–O, which has previously been interpreted as a normal shear zone (SMZ) (Carr, 1991).

The Monashee Reflector (MR), on Lithoprobe seismic sections from S of T–O, has been interpreted previously as the down-plunge continuation of the Monashee décollement (e.g. McNicoll & Brown, 1994), but it can as readily be interpreted as the continuation of the GBLSZ–SMZ combined zone. In support of this interpretation, the geometry of the MR is that of a normal structure, not a thrust, and the seismic section closely mimics the regional geological section through the GBLSZ. Metamorphic pressure data further supports this interpretation with higher pressures in the MC than in the MCZ. A vertical displacement of ~5 km on the ~1 km wide zone would be consistent with all of the geological and geophysical evidence, including the regional persistence and continuity of Upper Crustal Zone rocks, which predate the extension.

Brown, R.L., Carr, S.D., Johnson, B.J., Coleman, V.J., Cook, F.A., Varsek, J.L. 1991. *In* Thrust Tectonics. *Edited by* McClay, K.R. Chapman Hall, pp. 344 – 347. **Carr, S.D**. 1991. CJES, **28:** 2003 – 2023. **Cook, F.A.,** Varsek, J.L., Clowes, R.M., Kanasewich, E.R., Spencer, C.S., Parrish, R.R., Brown, R.L., Carr, S.D., Johnson, B.J., Price, R.A. 1992. Tectonics, **11:** 12 – 35.
Crowley, J.L., Brown, R.L., and Parrish, R.R. 2000. JSG, **23:** 1103 – 1121. **Johnston, D.H.,** Williams, P.F., Brown, R.L., Crowley, J.L., Carr, S.D. 2000. JSG, **22:** 603 – 625. **McNeill, P.D**., Kruse, S., and Williams, P.F. 2004. www.unb.ca/frederiction/science/geology/monashee
McNicoll, V.J. and Brown, R.L. 1994. JSG, **17:** 17 – 30. **Read, P.D.** and Brown, R.L. 1981. CJES, **18:** 1127 – 1145.

A 3-D model for nascent channel flow in the infrastructure of a coherent Cordilleran crystalline thrust sheet

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The infrastructure of the southeastern Canadian Cordillera is exposed in two adjacent core complexes in southeast British Columbia. It terminates eastward at a "tip-line" in the subsurface of the internides of the Rocky Mountain thrust belt. In the region within and/or near the Monashee complex, four different models have been proposed suggesting channel flow, with a detachment near the top of the infrastructure, such that the channel flowed eastward ahead of its suprastructure, particularly in the Late Cretaceous – Paleogene.

The Late Cretaceous Gwillim Creek shear zone, exposed to the south, in the core of the Valhalla complex is a 5 – 7 km thick, easterly verging, ductile thrust zone. It was active after ca. 90 Ma and during anatexis (800°C and 800 MPa), and its base was refrigerated from below at ca. 60 Ma by thrust translation onto a cold footwall. Eocene extensional shear zones of the Valkyr – Slocan Lake – Champion Lakes shear zone system are younger than the Gwillim Creek shear zone, and they do not significantly disrupt a coherent edifice of Middle Jurassic, Cretaceous and Eocene plutons that effectively bolted a Middle Jurassic suprastructure to a Late Cretaceous – Paleocene infrastructure. There is no evidence of channel flow or ductile extrusion. Instead, a 30 km thick, coherent sheet was translated on the Gwillim Creek shear zone, which at depth, was linked to the Foreland thrust and fold belt such as to form a large composite crystalline thrust sheet. North of the Valhalla complex, in the region of the Monashee complex, the infrastructure was thicker and hotter than it was to the north or south.

Channel flow could have evolved within the infrastructure of the crystalline thrust sheet by activating an upper detachment and lateral transition zones such that the thicker, hotter, weaker channel material flowed ahead of its overlying suprastructure and its surrounding infrastructure. The channel would have been "tunneling," and its incremental forward flow would have introduced additional volume to the "tip line" region that would have to have been accommodated by a combination of structures in that region. These considerations suggest a 3-D model for a channel set within an infrastructure with a "tip line" (Figure 1). The channel has a thickness, T, between the lower and upper detachments, a length, L, in the dominant flow direction, and a width, W, between the lateral transition zones. The channel proposed for the Monashee complex region may have had a width of 250 - 300 km and a thickness of 10 - 20 km. Preservation of older structures within the channel, near its margins, as well as the absence of obvious flow balancing structures in the tip line region, suggest quenching at a nascent stage.

Abstracts of Poster Presentations

alphabetical order by first author

Facies and faults: geological setting, stratigraphy, age, and metallogeny of Middle Jurassic strata correlative to host rocks for the Eskay Creek Mine, eastern Iskut River area, northwestern B.C.

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New studies concerning the distribution, age, correlation, modes of deposition, structural and tectonic setting, and composition of the Middle Jurassic Salmon River Formation (SRF) have identified prospective areas for the discovery of other enclosed mineral deposits similar to the Eskay Creek Au-Ag Mine.

SRF volcano-sedimentary strata were deposited in marine sub-basins developed in the backarc portion of a west-facing Middle Jurassic arc system. This followed development of a separate Early Jurassic arc, and preceded onset of Middle and Late Jurassic successor basin sedimentation. The Jurassic arcs developed on a basement of multiple and spatially-overlapping

Devonian, Carboniferous and Triassic arc assemblages and predate intrusion and uplift of the Paleogene Coast Plutonic Complex.

The volcanic facies and facies associations in the thick sequences of Middle Jurassic SRF sedimentary and bimodal volcanic rock, are typical of complex submarine volcanic successions and contain coeval eruptive centres and associated mineral deposits. The western Eskay facies is best known from the Eskay Creek Mine, Pillow Basalt Ridge, Willow Ridge Complex, and Treaty Glacier areas. Aphyric to clinopyroxene- and/or plagioclase-phyric tholeiitic pillowed lavas, locally in thick successions, are intercalated with rhyolitic flows, domes, sub-volcanic intrusions, and re-deposited felsic sequences. Ammonite- and radiolarian-bearing sedimentary rocks interbedded with and locally overlying the volcanic rocks indicate an Aalenian to Bajocian age for the Eskay facies. Economic mineral deposits (Eskay Creek Mine) and important prospects (SIB, HSOV, and Treaty Gossan) occur in this facies. A felsic volcano-sedimentary facies, to the east along the valleys of the Salmon and Bowser rivers, is coeval and consists of re-sedimented and re-worked deposits typical of a more distal or depocentre type of environment. This facies lacks rhyolite flows, domes and sub-volcanic intrusions (all indicative of volcanic centres) and pillowed tholeiitic lavas as well as the significant enclosed mineral deposits of the Eskay facies to the west.

New SHRIMP and TIMS U-Pb data for felsic rocks in both facies indicate a range of ages from 179-174 Ma which agree with paleontological age constraints. Most of the new dates are exactly coeval with the published 175 ± 2 Ma age for the rhyolitic host for the Eskay Creek deposit. A newly-recognized succession of Bathonian and younger alternating radiolarian-bearing black chert and white felsic volcanic siltstone (so-called "Pajama beds") has correlatives throughout the Bowser Basin to the east.

The Middle Jurassic Eskay facies accumulated in a series of fault-bounded, pull-apart, sub-basins. One fault system, including faults in Forrest Kerr and Harrymel creeks and along the South Unuk River, has kinematic and other indicators for trans-current (commonly sinistral) displacement. Bimodal dyke swarms and nearby pillowed mafic lavas (compositionally similar to the mafic dykes) are adjacent the faults. These associations suggest that the Middle Jurassic magmatism developed in a trans-tensional setting.

A new tectonic assemblage map for Yukon-Tanana and related terranes in Yukon and northern British Columbia

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

Tanana terrane and likely represent a marginal (back-arc) ocean that formed as the arc front of the Yukon-Tanana terrane rifted and retreated away from North America in mid- to late Paleozoic time. This poster presents a new compilation map for Yukon-Tanana and related terranes showing the distribution of the newly defined tectonic assemblages.

Geological map of Livingstone Creek area (105E/8), Yukon

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The Livingstone Creek area, in south-central Yukon, is the “type area” for the ‘Teslin suture zone’ of Tempelman-Kluit (1979; later renamed 'Teslin tectonic zone' by Stevens et al., 1996; and 'Teslin zone' by de Keijzer et al., 1999). It is underlain by Paleozoic rocks of Yukon-Tanana terrane northeast of the Big Salmon fault and by late Paleozoic – early Mesozoic rocks of possible Stikine terrane affinity in the Semenof Hills, southwest of the Big Salmon fault (described in Simard and Devine, 2003). Yukon-Tanana terrane in the Livingstone Creek area comprises five successions of metasedimentary and metavolcanic rocks which range in age from pre-Upper Devonian to Lower Mississippian. They are correlated with Lower Mississippian and older strata in the Glenlyon and Finlayson Lake areas. Yukon-Tanana rocks are intruded by at least five plutonic suites, ranging in age from Late Devonian to Late Cretaceous. The structural style of the area is dominated by a transposition foliation which is axial planar to isoclinal folds of an earlier foliation. The transposition foliation is itself folded by northeast-verging open folds. The d’Abbadie fault zone, a one-kilometre-wide zone of imbricate fault slices in the eastern part of the area, is characterized by multiple generations of ductile fabrics overprinted by younger cataclastic breccia zones. Deformation along d’Abbadie fault is in part constrained by syn-tectonic emplacement of a ca. 96 Ma granite along the western margin of the fault zone. Rocks east of d’Abbadie fault were previously considered part of Cassiar terrane; they are here re-interpreted as part of Yukon-Tanana terrane because (1) they are intruded by Early Mississippian granitic orthogneiss; and (2) a quartzite unit yielded latest Devonian detrital zircons; both are characteristics of Yukon-Tanana but not Cassiar terrane. As suggested by de Keijzer et al. (1999) in the Teraktu Creek area to the north, the structural geometry of the Livingstone Creek area is the result of complex, superposed deformation between late Paleozoic and Cretaceous time, rather than progressive deformation in a crustal-scale suture zone. Only the earliest (Permian?) deformation may have occurred in or near a subduction zone.

References

de Keijzer, M., Williams, P. F. and Brown, R. L., 1999, Kilometre-scale folding in the Teslin zone, northern Canadian Cordillera, and its tectonic implications for the accretion of the Yukon-Tanana terrane to North America: Canadian Journal of Earth Sciences, v. 39, Paper p. 479-494.

Simard, R.-L. and Devine, F., 2003, Preliminary geology of the southern Semenof Hills, central Yukon (105E/1,7,8), *in* Emond, D. S. and Lewis, L. L., eds., Yukon Exploration and Geology 2002: Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 213-222.

Stevens, R. A., Erdmer, P., Creaser, R. A. and Grant, S. L., 1996, Mississippian assembly of the Nisutlin assemblage: Evidence from primary contact relationships and Mississippian magmatism in the Teslin tectonic zone, part of the Yukon -Tanana terrane of south-central Yukon: Canadian Journal of Earth Sciences, v. 33, Paper p. 103-116.

Tempelman-Kluit, D. J., 1979, Transported cataclasite, ophiolite and granodiorite in Yukon: evidence of arc-continent collision: Geological Survey of Canada, Paper 79-14, 27 p.

Geology of the Pine porphyry Au-Cu deposit, Toodoggone district, BC

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The Pine porphyry Au-Cu deposit (40 Mt @ 0.57 g/t Au and 0.15% Cu) is located 17 km north of the Kemess North deposit and within 3 km of the Fin Cu-Mo-(Zn) porphyry and Mex Au epithermal/porphyry prospects. Gold-Cu mineralization at Pine is best developed within a 1 km2 core of potassically altered, porphyritic quartz monzonite and is surrounded by broader phyllic and propylitic alteration halos. The quartz monzonite is locally underlain by a weakly mineralized monzodiorite and bordered to the east by epidote-pyrite-altered Toodoggone Formation dacite ash flow tuff. Three generations of monzonite dykes cut the mineralized quartz monzonite with the earliest dykes locally mineralized. Vein and alteration events, from oldest to youngest, include: (i) early pervasive potassic (K-feldspar±magnetite) alteration, (ii) massive quartz-magnetite stringer veins, (iii) comb-textured quartz-magnetite-pyrite±chalcopyrite veins with intense phyllic (quartz-sericite±chlorite) alteration, which are responsible for the bulk of the Au-Cu mineralization, (iv) massive quartz-pyrite±chalcopyrite veins also associated with phyllic alteration halos (v) pyrite±chalcopyrite±quartz stringer veins with a second potassic (K-feldspar) alteration, and (vi) post-mineralization veins (epidote-chlorite, zeolite, anhydrite-gypsum, and calcite-dolomite). Stable and radiogenic isotope data will constrain the source and timing of the mineralizing fluids with insight into the physicochemical conditions of mineral deposition provided by fluid inclusion studies.

Snapshots of new geological framework and energy resource studies in the Bowser and Sustut basins, north-central British Columbia

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New research in the Bowser and Sustut basins of the northern Canadian Cordillera includes geological mapping and a suite of energy resource related thematic studies. The new work provides advances on a number of fronts. New apatite fission track (AFT) data are consistent with the regional levels of thermal maturation as defined by vitrinite reflectance studies. Thermal maturity studies show that large areas were at temperatures above AFT resetting temperatures. The primary cooling histories recorded by the AFT data are Cenozoic. Similarly, paleomagnetism reveals widespread Late Cretaceous or Paleogene post-tilting remagnetization. Following the remagnetizing diagenesis, at least part of the basin rotated counterclockwise. The thermal maturity is highly variable, but the variation is independent of stratigraphic level. The northern Bowser Basin and western Sustut Basin are in the early oil to condensate-dry gas generation stage of thermal maturation, making these areas the most prospective for petroleum generation and preservation. Fieldwork and analysis of molecular crude oil samples has led to identification of at least 4 effective petroleum systems in the Bowser and Sustut basins, and has identified sub-Bowser strata as one of the sources. Interpretation of regional potential field data and measurements of density and magnetic susceptibility of rocks from the region provide new information on the depth to basement and possible basement structures. First-break travel time picks for parts of the LITHOPROBE SNORCLE deep reflection profile in the northwest Bowser Basin were inverted using a crossing-ray tomographic method to estimate bulk P-wave speed within the uppermost 2 km of crust. New geological mapping has significantly revised the distribution of lithofacies assemblages of the Bowser Lake Group, and has elucidated structural geometries. The shallow marine and submarine fan assemblages, both widespread in the central basin are present in the southern basin. The style of deformation, including involvement of Stikinia strata, overturned folds, and development of cleavage, is also common in the southern Bowser Basin. Analysis of detrital zircons from sandstone samples from Bowser Basin strata contribute to interpretation of the depositional history of the region. The results, based on over 750 U-Pb SHRIMP analyses of detrital zircons from 14 sandstone samples of Bowser Lake Group show that Bowser Basin was receiving detritus from sources of Early Triassic age to as young as the depositional age of the rock. Biostratigraphic studies also contribute to understanding of the evolution of the Bowser and Sustut basins.

A synthesis of the Jurassic–Cretaceous tectonic evolution of the central and southeastern Canadian Cordillera: exploring links across the orogen

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Field and analytical studies of the central Intermontane Belt highlight the origin and evolution of the Jura–Cretaceous Bowser Basin, the mid- to latest Cretaceous Sustut Basin located east of it, and the Early Cretaceous to latest Cretaceous/earliest Cenozoic Skeena Fold Belt. Integration of the evolution of these tectonic elements with other tectonic elements is achieved by restoration of movement on Mesozoic–Cenozoic strike slip faults to the east. The restored paleogeographic context permits comparison of data sets from both western and eastern sides of the orogen, and recognition of the interplay between coeval crustal thickening and basin evolution across the orogen, thus providing constraints for tectonic models of the southern Canadian Cordillera.

Onset of Bowser Basin sedimentation occurred in response to Early–Middle Jurassic terrane accretion events preserved in the Omineca Belt. Coeval Late Jurassic and Early Cretaceous sedimentation in the Bowser Basin and in the Alberta Foreland Basin was a response to crustal loading resulting from progressive crustal shortening and northeastward translation of a thickened Omineca Belt highland above a through going basal detachment. Provenance of detritus in these basins, as well as in the Sustut Basin, reveals uplift and drainage-migration patterns in the intervening Omineca Belt highland throughout the Late Jurassic and Cretaceous.

The presence of synchronous and compatible tectonic events in the adjacent central Intermontane Belt and southern Omineca and Foreland belts suggests that they were kinematically connected above a lower crustal detachment from late Early Cretaceous to early Cenozoic time.

Metamorphic petrology and P-T-t paths, Thor-Odin gneiss dome, southern British Columbia

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In the Thor-Odin gneiss dome, British Columbia, rocks with similar Mg-Al-rich bulk composition display different reaction textures as a function of structural position in the dome. Kyanite in gedrite-cordierite rocks near the margin of the dome is only incipiently replaced by sillimanite, and is surrounded by a reaction texture dominated by cordierite + elongate corundum. Kyanite in structurally deeper regions of the dome is extensively replaced by sillimanite, and spinel is abundant in the symplectitic reaction rims, along with blocky corundum + cordierite + anorthite. The modal amount of spinel positively correlates with the degree of transformation of kyanite to sillimanite, and anorthite occurs only in the rocks from the core of the gneiss dome. Phase diagrams calculated for Thor-Odin gedrite-cordierite rocks show the sequence of reactions that produced the reaction textures occurred during isothermal decompression. The topology of the pseudosections calculated using the bulk compositions derived from symplectitic domains suggests the same overall P-T trajectory (isothermal decompression) for rocks from both the margin and the core of Thor-Odin dome. The margin rocks, however, may have cooled more rapidly through the sillimanite stability field following initial decompression. The dependence of the formation of spinel on the transformation of kyanite to sillimanite may indicate this rate dependence for the evolution of the texture. These results show how metamorphic textures can be understood in a tectonic context by considering structural position and P-T-t paths.

NEW MAPS AND CROSS-SECTIONS FOR THE SELWYN BASIN, YUKON

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Much of Sheldon Lake and Tay River areas (105J, K) is underlain by uppermost Proterozoic and Lower Paleozoic basinal strata that formed in a re-entrant along the outer margin of ancestral North America known as the Selwyn Basin. The oldest exposed strata consist of latest Proterozoic to Cambrian turbiditic quartz sandstone and maroon slate (2500+ m thick) succeeded by local Cambrian shale capped by a widespread basinal limestone and siltstone of Cambro-Ordovician age (300 m). A starved sequence of shale, chert and siltstone with local volcanics was deposited during Ordovician to Middle Devonian time (450 m). Regional sub-Upper Cambrian and other local unconformities suggest intermittent extension and syn-depositional faulting. In the Silurian and Devonian the basin was flanked on the southwest by shallow water carbonate and clastics of McEvoy Platform. Large stratiform zinc-lead deposits are known in Lower Cambrian (Faro) and Early Silurian (Howards Pass, to east of area) strata.

In the Late Devonian turbiditic quartz-chert sandstone, and chert pebble conglomerate were deposited in submarine fan complexes as shale deposition transgressed far northeastward onto the ancestral margin. The coarse clastics, 1200(?) m in aggregate thickness, were derived from elevated fault blocks of Selwyn Basin strata to the north and west, including latest Proterozoic gritty quartzose clastic rocks and Ordovician-Silurian chert. An extensional or transtensional event is indicated by an absence of compressional deformation, local felsic volcanism, and widespread stratiform barite (+/- lead-zinc) occurrences (e.g. Tom, Jason to east of area). A regional unconformity occurs beneath upper Upper Devonian strata.

Succeeding Lower Mississippian to Triassic carbonate and siliciclastic sediments (1700 m) were likely deposited on a muddy, shallow marine shelf. A regional unconformity occurs beneath Middle Triassic, and possibly beneath Upper Mississippian strata.

Rare Lower Cretaceous chert-bearing clastic rocks (120+ m), the first signal of Jura-Cretaceous orogenic uplift to the west, disconformably overlie Upper Triassic strata.

In the Early Cretaceous, northeast-southwest compression led to northwest-trending, regional scale folds and extensive, shallow-dipping thrust faults. Incompetent Ordovician to Devonian shale and chert are complexly deformed above a regional, flat-lying, buried detachment. Shortening in Cambro-Ordovician to Devonian strata is at least 50%, indicating that the paleogeographic width of the Selwyn Basin was twice as much as is currently represented. Folds and faults ultimately root in a basal detachment that extends beneath the region and across the entire deformed belt. Upper Paleozoic oceanic rocks of the Slide Mountain terrane, and metasediments of the Yukon-Tanana terrane, were emplaced as thrust sheets during this deformation. Deformation is bracketed by Early Cretaceous strata, post-tectonic intrusion of the mid-Cretaceous Selwyn Plutonic Suite and eruption of dacitic pyroclastics of the coeval South Fork Volcanics. The plutons are regionally associated with tungsten-copper skarn (e.g. Mactung) and base metal vein occurrences.

Cretaceous-Tertiary dextral slip along Tintina Fault zone, which transects the southwest part of the area, amounted to at least 430 km. Pull-apart basins along the fault zone accumulated fluvial clastics and bimodal volcanic rocks that host epithermal precious metal veins (e.g. Grew Creek).

Timing and duration of partial melting in the Valhalla Complex, SE British Columbia

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During orogeny, partially molten crust is significant for heat and mass transfer by both vertical and lateral flow during crustal thickening and collapse. Evidence of former melt is commonly exposed in migmatite-cored gneiss domes and core complexes, but we don't yet know the timescale and duration of melting, the relationship between melting and crustal flow, and how melting and flow couples with other processes (e.g., extension). To determine the timing and duration of partial melting and evaluate the role of melt in the evolution of a gneiss dome/core complex, we dated zircon and monazite from six migmatite samples of the Valhalla complex using the UCLA ion microprobe. Furthermore, Ar-Ar thermochronology on biotite, muscovite and hornblende was performed in order to establish the cooling history from ca. 500 °C to 300 °C. The Valhalla complex is the southernmost in a series of migmatite domes along the eastern detachment of the Shuswap metamorphic core complex, southeast BC. As in the other Shuswap domes, Valhalla consists of a migmatitic core mantled by gneiss and granite. The complex includes 2 domes: Valhalla and Passmore. Previous geochronometric investigations of Valhalla have inferred prograde metamorphism at ca. 70 Ma, with a peak at 60 Ma and conditions of 820°C, 8 kbar. In our results, leucosome crystallized in a boudin neck from the central Passmore dome has U-Pb zircon ages of 61- 57 Ma. From the same locality, a grt-sil-kfs schist yielded two *in situ* Th-Pb monazite ages of 64.2 ± 0.7 and 59.5 ± 0.7 Ma. A migmatitic gneiss located between the 2 domes has a Th-Pb monazite age of 57.5 ± 0.6 Ma. A grt-sil schist from the Valhalla dome yielded an *in situ* Th-Pb monazite age of 59.9 ± 1.9 Ma. Also from the Valhalla dome, a migmatite gave younger monazite ages from 54.7 to 49.7 Ma. Finally, a boudin neck leucosome from the eastern detachment revealed U-Pb zircon ages from 62 to 59 Ma and a single Th-Pb monazite age of 52.9 ± 0.3 Ma. The ages from the metasedimentary rocks are consistent with previous investigations, supporting peak metamorphism at ca. 60 Ma. Our results further show that partial melting was coeval with high-grade metamorphism and continued for nearly 10 m.y. until ca. 50 Ma. Moreover, the argon thermochronology results yield integrated ages from 54.3 ± 0.4 Ma to 53.8 ± 1.6 Ma for hornblende and muscovite, respectively. The biotite results reveal a slight younging trend from west (54.4 ± 0.8 Ma; Ladybird leucogranite) to east (48.2 ± 0.6 Ma; boudin neck leucosome from the eastern detachment). The thermochronology ages overlap with partial melting and indicate rapid cooling following melt crystallization. The range of dates from the complex, including observations that melt was involved in deformation both within the domes and in the eastern detachment, suggest a protracted history of metamorphism and melting that terminated with crystallization at 50 Ma, marking the end of orogeny in the region.

Lithospheric-Scale Structures Across the Alaskan and Canadian Cordillera: Comparisons and Tectonic Implications

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The Cordillera of Alaska and western Canada has been traversed by three multidisciplinary transects: a) the LITHOPROBE Southern Cordillera transect (1000 km; 48°-50° N), b) the overlapping ACCRETE and LITHOPROBE SNORCLE transects (1800 km; 54°-63° N), and c) the Alaskan TACT program (1200 km; 145°-150° W). Carried out over the last two decades, these studies integrate coincident and coordinated geological, geochemical and geophysical studies. Seismic reflection and refraction experiments contribute profiles of crustal and lithospheric mantle structure, providing a unifying framework for integrating the investigations and for advancing models of orogen structure and evolution. The resulting lithospheric-scale models enable along-strike comparison of large-scale structures, the style of accretion and deformation, and the influence of post-orogenic tectonics. Primary observations include the following three points. 1) A characteristic feature of the Canadian and Alaskan Cordillera is a crustal-scale decollement that acts as a tectonic accretion surface and separates the accreted terranes from the underlying, ancestral North American crust. All three trans-Cordillera profiles exhibit an unconformity or decoupling zone that dips outboard (westward beneath the Canadian Cordillera and southward beneath the Alaskan Cordillera) from the thrust and fold belt to the lower-most crust or Moho. Ancestral North American crust extends below 30-50% of the Alaskan and Canadian Cordillera. The observations require that the Mesosoic accretionary phase involved substantial delamination and subduction or subcretion of the allochthonous lithosphere. 2) The Moho remains remarkably flat and shallow (33-35 km) despite the variety of ages, orogenic styles and tectono-magmatic deformations that are spanned by the seismic corridors. The only major deviations are: a) just inboard of the transcurrent portion of the margin where the crust shallows to 20-25 km depth; and b) two crustal roots in the Alaskan Cordillera (50 km beneath the Brooks Range, and 60 km associated with the deformation and tectonic underplating that result from the attempted subduction of the Yakutat terrane). The shallow, flat Moho must be an active, near-solidus, deformation zone that represents a young, re-equilibrated crust-mantle boundary beneath much of the orogen. 3) Convergence and transcurrent motions have dominated Cordilleran development. The active subduction zones in Cascadia and southern Alaska exhibit similar structure. However, contradictory interpretations exist for teleseismic and controlled-source profiles. Resolution of these discrepancies will provide an improved understanding of dehydration metamorphism in these regimes and may influence analyses of megathrust earthquake hazard. The along-strike displacements of the accreted terranes remain one of the primary unsolved problems in Cordilleran development. The seismic data have been interpreted to show that four major strike-slip fault systems (the Queen Charlotte-Fairweather fault, the Denali fault, the Coast Shear Zone, and the Tintina fault) are crustal-penetrating.

Flow and coupling of the Eocene partially molten crust in the North American Cordillera: Evidence from the Okanogan and Pioneer migmatite domes, USA

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The potential for partially molten crust to undergo flow during orogeny has been well documented by numerical modeling and is consistent with observations from both active and exhumed orogens. Relatively few studies have focused on constraining the kinematics of flow within the partially molten crust and how this flow is coupled with extensional processes in the upper crust during coeval deformation.

Two domes, the Okanogan dome (southern Omineca Belt, central Washington state) and the Pioneer metamorphic core complex (south-central Idaho), are part of a chain of migmatite-cored gneiss domes exhumed in the hinterland of the North American Cordillera during Eocene extension of thickened crust. In both domes, metasedimentary rocks mantling a core of anatectic migmatite are exposed below crustal detachments. Structural observations from migmatites in both domes, such as leucosome in inter-boudin regions, melt-filled shear bands, and cross-cutting relationships, indicate that deformation in the migmatites took place in the presence of melt and was coeval with Eocene extension. From the level of migmatite to detachment, lineation orientations, fold hinges, and kinematics in both domes are consistent with a single deformational regime in which flow of the migmatites is contemporaneous with extensional deformation affecting the upper crust.

In the Okanogan dome, both mid to lower crustal rocks and upper crustal units record NW-SE extension; evidenced by a series of en echelon graben that are nearly coeval with the development of magmatic to solid-state fabrics of NW orientation in the gneissic units. Progressive deformation and overprinting relationships in Okanogan migmatites indicate that flow was likely coupled to deformation in the upper crust. In the Pioneer complex, extensional structures in the migmatite unit are oriented dominantly W-NW whereas fabrics above the detachment are highly oblique, a structural characteristic in contrast to the Okanogan, potentially reflecting decoupling of flow in the partially molten crust or extrusion during development of the Pioneer complex.

Regional Geoscience Studies and Petroleum Potential, Mackenzie Corridor, Northwest Territories and Yukon

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Oil and gas potential of the Mackenzie Corridor and surrounding areas is the focus of a Northern Energy project under the Energy Supply program of the Geological Survey of Canada. The main objective of this multidisciplinary project is to assess the hydrocarbon resource potential of the Mackenzie Valley using quantitative and qualitative geoscience data. The study is a collaboration between the Geological Survey of Canada, the Northwest Territories Geoscience Office, the Yukon Geological Survey, industry, universities, and northern communities.

The Northern Canadian Sedimentary Basin extends between 60° and 70° north latitude and 115° and 136° west longitude and includes much of the Interior Platform, Mackenzie Arc, and eastern portion of the Northern Yukon Fold Complex. The eastern portion of the study area (i.e., the Interior Platform) is underlain by a gently westward-dipping Proterozoic and Phanerozoic sedimentary succession resting unconformably on the westward extension of the Canadian Shield. The Interior Platform includes Paleozoic carbonates, evaporates, and siliciclastic rocks overlain by a blanket of Mesozoic and Tertiary siliciclastic rocks. The western part of the study area (i.e., Mackenzie Arc and Northern Yukon Fold Complex) encompasses the northern Canadian Cordillera and is characterized by diverse structural trends, fold bundles and extension, contraction, and transcurrent faulting. Mackenzie Arc and Northern Yukon Fold Complex consist of deformed Proterozoic to Cretaceous strata; post-Devonian strata are generally absent from Mackenzie Arc region.

Although significant hydrocarbon discoveries have been made along the Mackenzie Valley, such as the Norman Wells oil field in Mackenzie Plain and large gas fields in Liard Plateau, several exploration regions are still poorly understood. Insufficient stratigraphic, structural, and geochemical data preclude a comprehensive assessment of some areas. Several exploration plays have been identified and will be the focus of future work, such as the Plateau Thrust play in the central part of the Mackenzie Mountains, fault traps within Cambrian and Devonian sandstones and carbonates, and stratigraphic and structural "foothills" plays in Mackenzie Arc. Fieldwork in 2006-2007 will be conducted to 1) examine stratigraphic sections and evaluate potential source and reservoir facies, 2) collect samples for organic geochemistry analysis, 3) study the role of structural features as hydrocarbon conduits, and 4) assess the viability of probable structural and stratigraphic traps. Reconnaissance field studies in Peel Plateau and Plain in 2005 provided preliminary data including total organic carbon/Rock-Eval values, Ordovician to Devonian conodonts for biostratigraphy, and conodont colour alteration indices.

Kemess North porphyry Au-Cu deposit, Toodoggone District, BC

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The Kemess North (407 Mt resource @ 0.41 g/t Au and 0.22% Cu) porphyry Au-Cu deposit is associated with a suite of Early Jurassic calc-alkaline granitoids that are emplaced into coeval, arc-related, volcano-sedimentary rocks that fill a northwesterly elongated intra-arc basin. The different stages of vein formation and related alteration types were studied in this deposit in order to help understand hydrothermal fluid evolution and its potential to generate late-stage epithermal Au-Ag mineralization. Early magnetite stringer veins and slightly younger quartz-magnetite-pyrite±chalcopyrite±molybdenite veins are responsible for potassic alteration and the bulk of Au-Cu mineralization in the 202.7 Ma monzonite porphyry. These veins and alteration assemblage are cut by quartz-pyrite±chalcopyrite±molybdenite and pyrite-chalcopyrite veins, which have strong chloritic-sericitic alteration halos. Late anhydrite±pyrite veins and carbonate-rich veins cut earlier veins.

Based on the orientation of acute vein angles to core axes in unoriented core, all vein types at Kemess North dip 30° to 40° to the horizontal. An E-W striking, steeply S-dipping fault truncates the northern extremity of the ore body and structurally juxtaposes mineralized monzonite and Takla Group andesite against poorly mineralized Toodoggone volcaniclastic rocks to the north. Elsewhere at Kemess North, flat-lying strata are displaced vertically by NW- to NE-striking faults, resulting in graben-and-horst block relationships. In peripheral areas to the main ore body, fault zones cutting Takla Group andesite and ~199.1 Ma Toodoggone volcaniclastic rocks are the main host to Au-Cu mineralization.

The Kootenay Lake Metamorphic 'High', S.E. British Columbia

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Work in progress is aimed at identifying the processes responsible for the presence of a narrow belt of anomalously high metamorphic grade in the central Kootenay Arc of S.E. British Columbia.

The Kootenay Arc comprises metamorphosed and deformed sedimentary and volcanic rocks deposited on, or close to, the western margin of ancestral North America, as well as numerous Jurassic (~165-175 Ma) and mid-Cretaceous (~100 Ma) granitic bodies. Two main phases of deformation have been recognised throughout the central Kootenay Arc. D1 resulted in formation of a large, isoclinal, westward-closing recumbent fold, which was coaxially refolded around gently-plunging F2 axes. S2 foliation dips gently- to moderately-steeply west and is axial planar to tight, overturned F2 folds. L2 intersection and stretching lineations are parallel to F2 fold axes. A broad culmination in the central part of the Kootenay Arc is outlined by a reversal in the plunge of D2 linear structures (F2 axes, L2 lineations). Later (F3) folds are inconspicuous in much of the area, but are well-developed around the crest of the culmination. F3 folds north of the culmination crest plunge SW whereas those further south plunge NW. The structural culmination is approximately coincident with the centre of an elongate regional metamorphic 'high'. Metamorphic grade ranges from biotite zone on the fringes to sillimanite zone in the core of the 'high'. Peak regional metamorphism took place under intermediate-pressure (Barrovian) conditions and was approximately coincident with D2 (Middle Jurassic) deformation.

North of the culmination axis, the western margin of the amphibolite-facies belt is marked by the west-dipping Gallagher Fault, which juxtaposes chlorite-grade phyllite in the hangingwall against staurolite (±vein kyanite) -bearing schist. Footwall pelites have well-developed S-C' fabrics with SW-plunging crenulation axes. These indicate oblique normal sense (west-side-down) shearing, consistent with asymmetric strain shadows on porphyroblasts. The (D3?) footwall fabrics are particularly well-developed close to the metamorphic boundary, but are ubiquitous in pelites throughout the amphibolite-facies belt, over an interval several km thick.

Existing K/Ar and $^{40}Ar/^{39}Ar$ muscovite cooling data reveal a contrast between young (Tertiary) cooling ages in the amphibolite-facies belt and older (Cretaceous and Jurassic) ages in the greenschist-facies regions. The age transition is gradational on the eastern side of the amphibolite-facies belt, but appears to be sharply defined on the western margin. Two existing cooling ages from either side of the Gallagher Fault vary widely (131 Ma in hangingwall v. 56 Ma in footwall), though it remains to be explicitly demonstrated that this change in apparent age coincides with the structural/metamorphic boundary.

These relationships suggest that normal faulting and distributed shearing played an important role in the formation of the isograd pattern. Future field work, petrology and geochronology will clarify these relations and assess along-strike continuity of the Gallagher Fault.

New bedrock geological map of part of Watson Lake area, southeastern Yukon

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Mesozoic and Cenozoic faulting has broken Watson Lake area into 6 geological domains. The southwestern-most domain comprises coal-bearing Tertiary sedimentary rocks deposited in a trans-tensional graben in the Tintina Fault zone. To the northeast is a domain underlain by imbricated Devonian to Permian meta-sedimentary and meta- igneous rocks of Yukon-Tanana terrane. The central part of the area, between the Simpson Lake Fault and the Inconnu Thrust Fault, comprises Upper Paleozoic chert of Slide Mountain terrane and unconformably overlying Permian conglomerate and basalt. With the exception of a klippe of Missisippian eclogite-bearing rocks of Yukon-Tanana terrane, the eastern part of the map area comprises two domains of Upper Proterozoic to Upper Triassic rocks of the North American continental margin sequence. The eastern-most domain is made up of the oldest rocks in the area, sandstone, grit and slate of the Upper Proterozoic to Lower Cambrian Hyland Group. These rocks lie in the footwall of the Hyland Valley Fault, a Cretaceous normal fault.

The occurrence of rocks of Yukon-Tanana terrane between Slide Mountain terrane and rocks of the North American continental margin sequence is unique to the Watson Lake map area. This geometry, and other features of the Finlayson Lake belt, hints at a cryptic history of strike-slip faulting between Yukon-Tanana and Slide Mountain terranes; geological considerations suggest that episodes of both dextral and sinistral strike-slip occurred in the Permian and Late Triassic or Early Jurassic, before the early Middle Jurassic thrusting of the amalgamated terranes onto the North American continental margin.

New mapping in the Terrace area: Far western Stikinia stratigraphy and structure

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A new 1:50,000 geological map of the Usk area along the Skeena River northeast of Terrace, B.C. (Fig. 1; Nelson et al. 2006a) profiles the geological history of this far western edge of Stikinia. There are important contrasts as well as commonalities with other parts of this terrane, for instance in the Iskut River and Toodoggone areas, which represent northern and eastern Stikinia respectively.

The oldest exposed rocks, of well-constrained Permian age, include a volcaniclastic unit and a limestone. We propose the name Zymoetz group for these strata, after the main exposures in the valley of the Zymoetz River (Nelson et al., 2006b). Two circumstances favor the application of this local name. First, this isolated Permian inlier near Terrace occurs 250 kilometres south of the nearest Paleozoic exposures in the Iskut River area. Second, the current collective name for Devonian to Permian stratigraphic units in northwestern Stikinia, the "Stikine assemblage", is not in accordance with the North American stratigraphic code, and should be re-evaluated.

The Zymoetz group is overlain paraconformably by a very condensed section of Upper Triassic chert, argillite and minor limy argillite that contains halobia (G. Woodsworth, personal communication 2005). The thin-bedded, dark grey to black Triassic strata are less than 100 metres thick. This section is age-equivalent to the Stuhini and Takla groups. However, it lacks the thick, augite- and plagioclase-phyric volcanic and volcaniclastic strata that generally characterize Stikinia in Late Triassic time. Perhaps this area represents part of a back-arc region of the Stuhini-Takla arc.

The Permian and Triassic strata were thrust-imbricated and eroded prior to deposition of the lowermost Jurassic Telkwa Formation. Extensive polymictic conglomerates at the base of the Telkwa Formation contain clasts of Permian limestone and volcanic rocks and, locally, clusters of black, flinty clasts derived from the Triassic sedimentary strata. Also present are well-preserved plagioclase-phyric clasts identical in texture and composition to lapilli within the Telkwa Formation itself.

The Telkwa Formation is a very thick accumulation of andesite, basalt, dacite and rhyolite flows and fragmental units. Its lower part, south of Kleanza Creek, is dominantly volcaniclastic. It is overlain by the flow-dominated unit that occupies much of the map-area. This, however, is not a simple succession: the lower unit dips homoclinally and moderately (45-50 degrees) to the east, whereas the more northerly flow-dominated unit dips shallowly north where it overlies the lapilli tuffs, and in more northerly panels dips both to the southwest and to the northeast. We infer that the volcaniclastic lower unit represents early, basin-filling accumulation that was succeeded and onlapped by flows originating at a centre that spans the middle and northern parts of the area. The Telkwa Formation near Terrace contains about 25% felsic volcanic products, a higher percentage than is typical for the Early Jurassic throughout Stikinia. Most notable is the Kitselas volcanic unit, which is dominated by rhyolite to rhyodacite pyroclastic flows, along with minor basalt. It has been dated as circa 195 Ma by U-Pb methods on zircon; one of the two concordia plots shows strong Precambrian inheritance(Gareau et al., 1997a).

The main Telkwa Formation is intruded by the ca. 200 Ma Kleanza pluton (Gareau et al:, 1997a, b), an anastomosing complex intrusion with many phases of a broad range of compositions and textures. Parts of it are probably subvolcanic, and it is interpreted as the feeder system to the upper Telkwa flows.

An ongoing Ph.D. study by Barresi aims at evaluating the geochemistry of the Telkwa Formation, both to characterize it as a mature arc accumulation and as a baseline for comparison with younger bimodal volcanic successions within the Middle Jurassic Eskay rift.

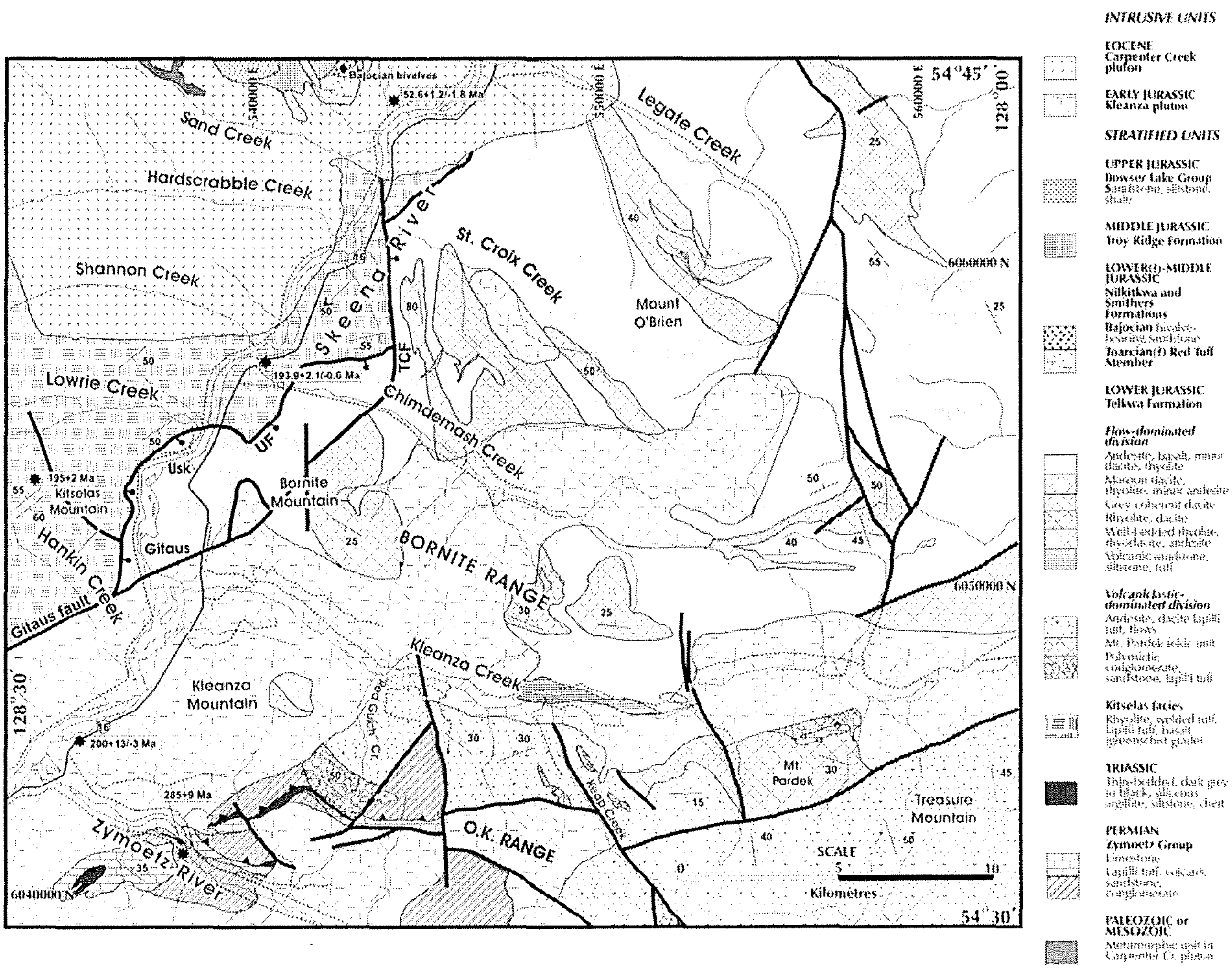
References

Gareau, S.A., Friedman, R.M., Woodsworth, G.J., Childe, F. (1997a): U-Pb ages from the northeastern quadrant of Terrace map area, west-central British Columbia; *in* Current Research, *Geological Survey of Canada*, Paper 1997-A/B, p. 31-40.

Gareau, S.A., Woodsworth, G.J., Rickli, M. (1997b): Regional geology of the northeastern quadrant of Terrace map area, west-central British Columbia; *in* Current Research, *Geological Survey of Canada*, Paper 1997-A/B, p. 47-55.

Nelson, J.L., Barresi, T., Knight, E. and Boudreau, N. (2006a): Geology of the Usk map area (193I/09); *B.C. Ministry of Energy, Mines and Petroleum Resources* Open-File 2006-3, 1:50,000 scale.

Nelson, J.L., Barresi, T., Knight, E. and Boudreau, N. (2006b): Geology and mineral potential of the Usk map area (193I/09) near Terrace, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources* Paper 2006-1, p. 117-134.



GEOLOGICAL MAP COMPILATION: NO VESTIGE OF A BEGINNING, NO PROSPECT OF AN END

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Geology is a science of all scales, from the atomic to the planetary. To bring such a huge range of natural objects within the human scale, we employ maps. We begin with mental maps, created from our experience and our expectations. These guide our acquisition of data in the laboratory and the field. New data are compiled as we map, altering our preconceptions, our models and our syntheses. At the conclusion of a particular research project, we make "final" compilations and conclusions and move on.

What many of us consider map compilation is merely an extension of the gathering, ordering and publication of data, usually at some different, often smaller, scales. It permits integration of information from a larger volume of the earth's crust and from a larger, more diverse dataset derived from more disciplines. In turn, such compilations and syntheses lead to new insights and the recognition of new problems, and these can bring about a return to gather yet more data.

Until recently, maps were compiled on paper, and reduction in scale meant loss of detail, which was accomplished by informed, but sometimes arbitrary decisions by the compiler as to which information was important enough to be retained and which was not essential and could be eliminated. Sometimes, overlays or sets of multiple maps and other diagrams would be used to retain as much information as possible. In the modern world of digital maps and linked databases, all data can be preserved, viewed and integrated. It is no longer correct to speak of scales, but of data densities. The latter are presently limited only by the resources needed to convert previous maps and geologic data to digital form and to establish data models to gather and organize new data.

The maps in this poster display, demonstrate the transition from the paper to the digital world. Although initially compiled for paper publication, the embedded digital cartography (AutoCAD) was organized for later conversion into geographic information systems (ArcInfo) following data models under development and in use by the Geological Survey of Canada and presently being adopted by several of our provincial and territorial partners. As noted in the notes accompanying the legends, the maps themselves are compilations of earlier maps spanning half a century and incorporate such diverse datasets as seismic and well core information, newer paleontological and isotopic data and detailed stratigraphic and sedimentological studies. These maps will be used in mineral assessments, land use planning, native peoples' land settlement agreements and hydrocarbon exploration. These compilations, as others before them, and still others underway, will be enhanced by digital datasets and assembled into other compilations such as the first geological map of the Northwest Territories, the circumpolar geology map for the International Polar Year and the new Geological Map of Canada. In turn, these compilations will lead to remapping and further research. Thus, the title of this abstract.

Geochronological and lithogeochemical studies of intrusive rocks in the Nahanni region, southwestern Northwest Territories and southeastern Yukon

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A study of intrusive rocks and the potential for related mineralization in the Mackenzie and Selwyn mountains of the southwestern Northwest Territories and southeastern Yukon was initiated as one component of the 2004-2006 Nahanni Mineral and Energy Resource Asssessment (MERA). Intrusions within the MERA area comprise the southeastern extent of the Tintina Gold Province (TGP), an elongate band of mid- and Late Cretaceous intrusions that extends northwest from the study area across Yukon and into central Alaska and that is characterized by precious and base metal deposits and occurrences spatially and genetically related to Mid-Cretaceous intrusions. Magmatism within the MERA area is generally spatially associated with tungsten mineralization and/or Au-Cu-Sb-Bi-Zn-Pb metal occurrences. Intrusions are subalkaline, typically granitic to granodioritic, and consist of several textural variations, ranging from fine-grained dioritic porphyry to crowded potassic feldspar megacrystic syenite. The intrusions range from large composite batholiths to small stocks or plugs, and evidence for evolution of highly evolved phases within the magma bodies include miarolitic cavities, aplite and pegmatite dykes, quartz veins or stockworks, and sub-vertical sheeted gossanous fracture sets. Initial U-Pb geochronology (ID-TIMS) combined with Ar-Ar geochronology reveals mid-Cretaceous ages of 97.5-95 Ma with short (0.5-1.5 m.y.) cooling periods. The exception to this is the Mine Stock intrusion associated with the Cantung W-(Cu-Au-Bi) skarn orebody, which cooled over a relatively long period (~3 m.y.). New U-Pb geochronology (LA-ICP-MS) has identified several intrusions of Tombstone plutonic suite age (95-89 Ma) in the MERA area, which has significant implications with respect to the potential for local intrusion-related mineralization. Magmatism in the area has previously been interpreted as crustally derived; however, the rare earth element primitive-mantle normalized profile reveals negative Nb, Ta, and Ti anomalies suggesting an arc-type setting. Furthermore, the intrusions typically lack volumetrically significant and primary peraluminous mineralogies and compositions

characteristic of S-type granites (e.g. muscovite, garnet, or aluminosilicates; moderate to strong peraluminous geochemical signature; etc.).

Magmatic and structural controls of Cu-Au-Mo mineralization within Quesnel Terrane, Johanson Lake area, north-central British Columbia

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The Quesnel magmatic arc terrane near Johanson Lake is represented by Upper Triassic volcanic and volcaniclastic rocks of the Takla Group, together with numerous intrusions. The intrusive rocks are subdivided into 3 main suites: a Late Triassic ultramafic-mafic suite of Alaskan-type bodies and related dioritic rocks (new U-Pb zircon dates of 223.7±0.8 Ma, 219.5±0.6 Ma and 211.4±0.7 Ma); an early Middle Jurassic quartz monzonite-monzodiorite-diorite suite (new U-Pb zircon dates of 173.7±0.7 Ma and 173.7±2.5 Ma); and a suite of Early Cretaceous granites, granodiorites and tonalites that includes rocks comprising the north end of the Hogem Batholith (new U-Pb zircon dates of 136.6±0.7 Ma, 130.7±0.3 Ma and *ca* 135 Ma; new U-Pb titanite date of 134.0±2.5 Ma).

The volcanic, volcaniclastic and plutonic rocks in the Johanson Lake area are cut by steeply-dipping north to northwest striking dextral strike-slip faults that are probably related to the Late Cretaceous-early Tertiary Ingenika fault just to the west of the map area. North to northwest trending folds occur between, and are locally truncated by, dextral strike-slip faults. These may be broadly contemporaneous with the dextral faulting or be vestiges of older deformation events. The oldest structures in the area are northwest-striking sinistral shear zones that are spatially associated with Late Triassic ultramafic-mafic plutons which show marked elongation parallel to the faults. It is suspected that sinistral faulting was broadly contemporaneous with plutonism and therefore with construction of the Takla volcanic-plutonic arc. Inboard of these sinistral faults, southeast of the Johanson Lake map area, are east-directed thrust faults that formed during the latter stages of arc magmatism and juxtapose Quesnel Terrane above adjacent miogeoclinal rocks. Together, these fault systems may reflect transpressive deformation during construction of the Quesnel magmatic arc, perhaps reflecting oblique sinistral convergence between the arc system and a subducting oceanic tract to the west.

Cu-Au mineralization, as veins, disseminations, and magnetite-pyrite-chalcopyrite skarns and replacements, is associated with dioritic rocks of the Late Triassic suite. Cu-Mo porphyry mineralization is associated with the Middle Jurassic quartz monzonite suite, and porphyry Mo occurrences are in Early Cretaceous granitic rocks. Structurally controlled Au-bearing quartz veins are associated with dextral strike-slip fault systems of probable Late Cretaceous-early Tertiary age.

Constraints on the Timing and Geometry of Kula-Farallon / Kula-Resurrection Ridge Subduction and Implications for the Eocene Magmatic and Tectonic History of the Pacific Northwest

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Subduction of the Kula-Farallon / Kula-Resurrection Ridge System (KFR) beneath western North America during the Eocene is constrained in space and time by ages of basalts in the WA-OR Coast Ranges and by ages of scattered centers of adakite and near-trench magmatism in WA and Vancouver Island. These data reveal: (1) a slow general northward migration of magmatism, accompanied by: (2) repeated examples of age overlap among rocks at different latitudes. Both of these observations require left-stepping offsets of the KFR, which would have led to multiple ridge-trench intersections and the development of a series of fraternal slab windows (Thorkelson, 1996). Combining these geologic constraints on KFR location and offsets with published plate motion vectors makes it possible to reconstruct the evolving geometry of the KFR slab window beneath WA-OR-BC from ~60-35 Ma. When the effects of Basin and Range extension are incorporated, the NW-migrating KFR slab window provides an explanation for the wide distribution and northwestward migration of Challis "arc" magmatism in WA. Other Eocene phenomena in the Pacific NW that appear to correlate in space and time with passage of the KFR slab window include tholeiitic dike swarms in central WA, high-temperature metamorphism and unroofing in the core of the North Cascades, S- and A-type plutonism in WA and BC, and development of sedimentary basins. Subsequent establishment of the modern Cascade arc at ~39 Ma correlates with a decrease in subduction rate and probable steepening of the subducting slab beneath OR/WA as the Farallon slab foundered. The KFR slab window may have served as the leading edge along which foundering was initiated.

Evolution of the Ancestral Pacific Margin, Southern Canadian Cordillera: Insights from new Geologic Maps

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We postulate an ancestral margin configuration that differs in three important respects from previous accretion models: 1) a block of North American continental crust at least 200 km wide and several hundred long, the Okanagan high, defined the outboard side of the ancestral continental margin during the Neoproterozoic and early Paleozoic; 2) upper Paleozoic and lower Mesozoic rocks comprising so-called accreted crust (Quesnel and Slide Mountain terranes) were stratigraphically rather than tectonically emplaced, and 3) Proterozoic North American continental crust is within ~5 km of the present day surface between Upper Arrow Lake and the Fraser fault.

These postulates are derived from the recognition of Devonian-Mississippian stratigraphy that traverses from the "accreted" realm into the miogeoclinal realm, tying them together long before postulated mid-Jurassic accretion. Across Vernon map area, few Meso- and Neoproterozoic rocks are present, implying profound stratigraphic omission, and subsequent structural thinning, between the Upper Paleozoic succession and underlying >1.5 Ga schist and gneiss.

The basal unit of the Devonian-Mississippian succession is a calcareous quartzite, the Chase Formation. It contains Silurian detrital zircon as young as 405 Ma (at Chase), 444 Ma (at Mara Lake), and 412 Ma (at Upper Arrow Lake); at Chase, the unit is intruded by 354 Ma diorite. Stratigraphic position of the quartzite, beneath the Silver Creek Formation, the Bruen phyllite (new informal map unit), and the Tsalkom, Sicamous, and Eagle Bay formations, constrains the age of these map units to Upper Paleozoic. The Bruen phyllite is intruded by a 359 Ma quartz-feldspar-porphyry, further constraining its age and that of underlying units. Stratigraphic contacts are interpreted as gradational; it is likely that all units are uppermost Devonian-lowermost Mississippian. Near Upper Arrow Lake, 200 km farther east, latest Devonian microfossils and 359 Ma detrital zircon have been recovered from carbonaceous rocks homotaxial with the Bruen phyllite and overlying the Chase and Silver Creek formations. Some map units in southwest Seymour Arm map area which were originally assigned Neoproterozoic and early Paleozoic ages are likely upper Paleozoic because they are on-strike continuations of this Vernon map area stratigraphy.

The search for Cordilleran terrane boundaries (obduction surfaces) at the base of the Upper Triassic Slocan Group and at the base of the Mississippian-Permian Harper Ranch Group is complicated by a combination of Middle Jurassic to Late Cretaceous penetrative deformation and regional upper amphibolite-facies metamorphism related to crustal thickening and Late Cretaceous to Early Eocene extensional flow related to orogenic collapse. The weight of evidence supports stratigraphic rather than tectonic emplacement, which is consistent with stratigraphic relations exposed farther east, where Triassic and Upper Paleozoic successions are in stratigraphic contact with each other and with lower Paleozoic miogeoclinal strata.

The belt of intense folding and faulting along the Kootenay arc and western Selkirk Fan is interpreted as inversion of Proterozoic- and Paleozoic sedimentary basin between continental crust of the Okanagan high and the cratonic margin. The arcuate surface trace of this fold belt is thought to reflect the subsurface eastern face of the Okanagan high.

U-Pb geochronology and $^{40}Ar/^{39}Ar$ thermochronology studies in the vicinity of Thor-Odin dome, southeastern British Columbia to test tectonic models and characterize the behaviour of $^{40}Ar/^{39}Ar$ systematics in migmatite terranes: A Ph.D. thesis proposal

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This project is designed to carry out detailed mapping, U-Pb geochronology and $^{40}Ar/^{39}Ar$ thermochronology studies in the vicinity of the Thor-Odin dome to characterize thermotectonic domains from different structural levels, and address the significance of the apparent boundaries between them. The Thor-Odin dome, of the southern Monashee complex, is the deepest exposed structural level in the southern Omineca belt. It comprises Paleoproterozoic basement rocks, infolded with Proterozoic and/or younger metasedimentary rocks that have all undergone penetrative deformation and anatexis in the Paleocene – Eocene and were rapidly exhumed in the Eocene. The Thor-Odin dome is surrounded by medium to high-grade rocks to the west and south that show Late Cretaceous to Paleocene deformation and metamorphism, and by rocks, to the east, that were deformed in the Middle Jurassic and generally cooled by the Jurassic or Early Cretaceous.

Unresolved problems in the area include: i) timing constraints on P-T paths, particularly across the southern flank of the Thor-Odin dome; ii) the location and nature of the boundaries between areas of different metamorphic grade; and iii) the mechanisms and processes responsible for the current tectonic configuration of the area. Different models include: i) crustal thickening due to thrusting followed by Eocene extensional exhumation; ii) Eocene diapirism; iii) channel flow and extrusion; iv) channel flow and fold interference causing doming; v) localized nascent channel flow within a crystalline thrust sheet; vi) unconformities between different domains; and others. One way to discriminate between tectonic models is to address and characterize the cooling histories of different domains in conjunction with structural studies. This project will build on previous studies and characterize timing of deformation and cooling along transects through adjacent domains. The transects will cover basement in the Thor-Odin dome, structurally intermediate rocks of the Gold Ranges, to the south, and structurally highest rocks to the east, in the hanging wall of Columbia River Fault, with a focus on their apparent boundaries. (For example, is there a boundary with significant displacement at Cariboo Alp between the Thor-Odin dome and overlying rocks? Is there significant displacement on the Columbia River fault system?) Samples will be collected as part of an integrated U-Pb geochronology (monazite and zircon) and $^{40}Ar/^{39}Ar$ thermochronological (hornblende, biotite and muscovite) study. The thermochronological study, in particular, will be specifically targeted at gaps in the data set and at the boundaries between domains in order to characterize their cooling histories. This will make it possible to determine the nature of each boundary; for example, cooling of a premetamorphic boundary will have a different $^{40}Ar/^{39}Ar$ profile than that of an extensional fault.

This study will also address the behaviour of argon systematics in migmatite terranes. Previous studies have yielded an apparent contradiction between cooling and deformation ages as obtained from $^{40}Ar/^{39}Ar$ thermochronology and U-Pb geochronology in migmatite terranes (e.g. in Thor-Odin and the Bergen arc of Norway), with $^{40}Ar/^{39}Ar$ dates being older than dates obtained with U-Pb methods. This study will determine whether these apparent contradictions are widespread in such terranes or analytical artefacts.