

COLPREN

CORDILLERAN TECTONICS WORKSHOP

February 27-29, 2004

Calgary, Alberta



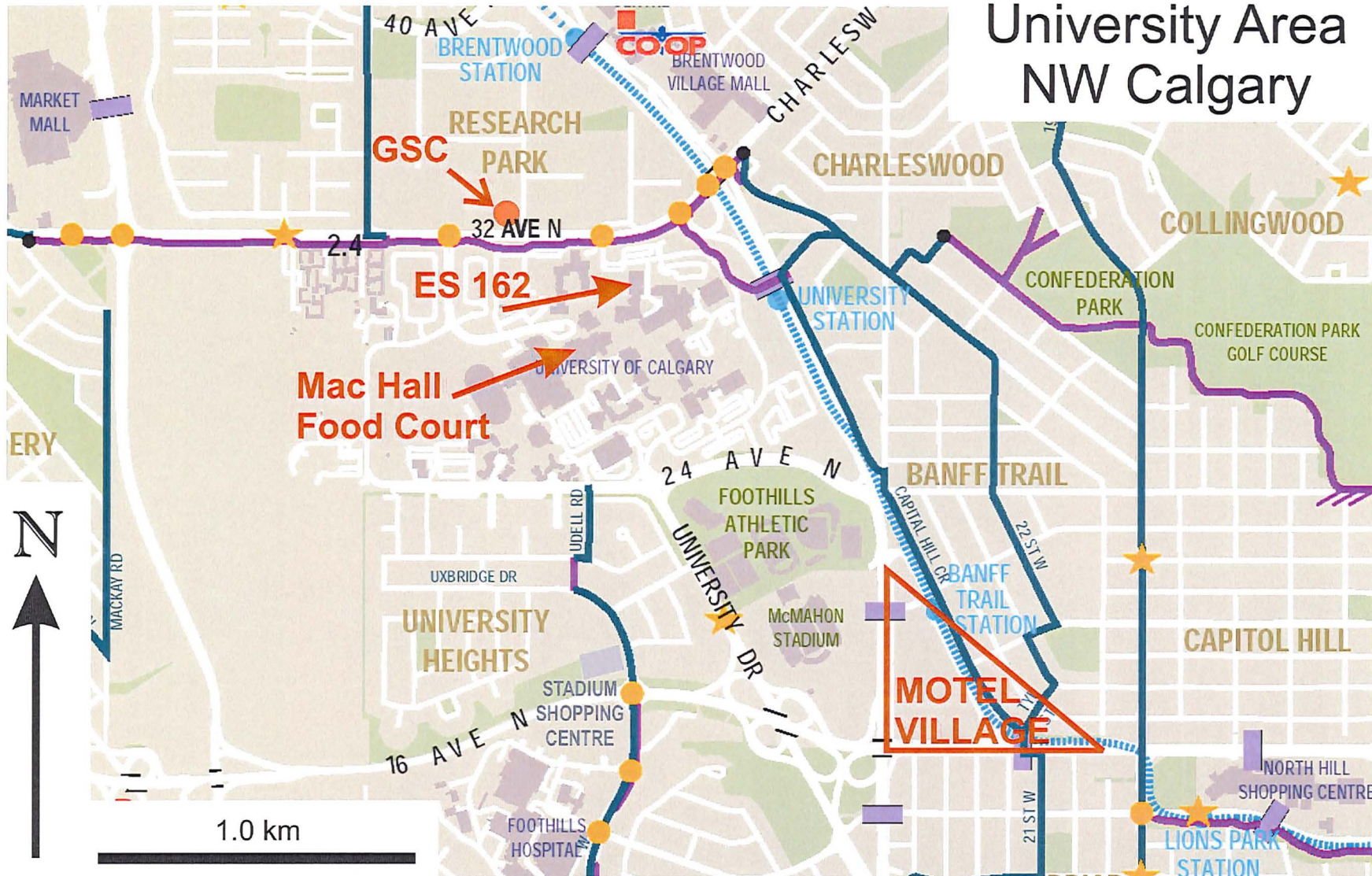
Geological Survey of Canada
and
University of Calgary

Earth Sciences Building
Lecture Theatre ES-162
Registration and Posters ES-149

PROGRAM AND ABSTRACTS VOLUME

Edited by Larry S. Lane

University Area NW Calgary



LIST OF PARTICIPANTS

Katherine Boggs, University of Calgary	Paul McNeill, University of New Brunswick
Richard Brown, Carleton University	Vicki McNicoll, GSC Ottawa
Jean-Paul Callot, Institut Français du Pétrole	John Moore, Simon Fraser University
Sharon Carr, Carleton University	Joanne Nelson, BC Geological Survey
Maurice Colpron, Yukon Geological Survey	Todd Noble, Queen's University
Fred Cook, University of Calgary	Kirk Osadetz, GSC Calgary
Nadine Cook, University of Calgary	Andy Parmenter, University of New Brunswick
Michael Cooley, Queen's University	Steve Piercey, Laurentian University
Lisel Currie, GSC Calgary	Lee Pigage, Yukon Geological Survey
Fionnuala Devine, Carleton University	Ray Price, Queen's University
Jarda Dostal, Saint Mary's University	Leanne Pyle, Queen's University
Philippe Erdmer, University of Alberta	Kirsten Rasmussen, University of Calgary
Carol Evenchick, GSC Vancouver	Leslie Reid, University of Calgary
Karen Fallas, GSC Calgary	David Repol, University of Calgary
Jean-Luc Faure, Institut Français du Pétrole	Kevin Root, Encana Corporation
Felix Gervais, Carleton University	Tyler Ruks, Laurentian University
Ed Ghent, University of Calgary	Jim Ryan, GSC Vancouver
Laurent Godin, Queen's University	Renée-Luce Simard, Dalhousie University
Steve Gordey, GSC Vancouver	Philip Simony, University of Calgary
Alana Hinchey, Carleton University	Dave Snyder, GSC Ottawa
Jurgen Kraus, Sunwing Energy	Jolane Sorge, University of Calgary
Yvette Kuiper, University of Waterloo	Deb Spratt, University of Calgary
Justin Laberge, University of Calgary	Vern Stasiuk, GSC Calgary
Malcolm Lamb, University of Calgary	Glen Stockmal, GSC Calgary
Larry Lane, GSC Calgary	Sarah Travis, University of Calgary
Kyle Larson, Queen's University	Arie Van der velden, University of Calgary
Yvon Lemieux, University of Alberta	John Waldron, University of Alberta
Darrel Long, Laurentian University	Paul Williams, University of New Brunswick
Lisa McCluskey, University of Calgary	
Stacia McLeod, University of Calgary	

ACKNOWLEDGEMENTS

We thank the management of the Geological Survey of Canada, Calgary; and the Geology and Geophysics Department at the University of Calgary for supporting the meeting and providing the facilities.

Numerous volunteers, helped to organize this meeting. Their contributions are very much appreciated! In particular we want to thank Sarah Travis for organizing the billets and the team of Graduate Students who organized the icebreaker.

Larry Lane and Deborah Spratt,
Convenors

Volunteers:

Andrew Couch
Megan Crockett
Karen Fallas
Felice Hardjowirogo
Lisa McCluskey
Stacia McLeod
Kirsten Rasmussen
Jolane Sorge
Sarah Travis
Arie van der Velden

PROGRAM

Friday 27 February

7:00 pm - 11:30pm

Registration; Poster set-up; Icebreaker
Earth Sciences Building, Room: ES-149

Saturday 28 February - Morning Sessions 8:00 - 12:00

8:00 - 8:30 - Registration

- 8:30 **U-Pb SHRIMP ages of leucosome in Thor-Odin basement rocks, Monashee complex: evidence for one Eocene melting event** *Alana Hinchey, Carleton University, Ottawa*
- 9:00 **Paleozoic Basements of Quesnellia in SE BC, Jurassic and Cretaceous Thrust Tectonics and Canada – Quesnellia Relations** *Philip Simony, University of Calgary*
- 9:30 **Detrital zircon geochronology and tectonic implications of a middle Paleozoic metasedimentary rock succession, southeastern British Columbia** *Yvon Lemieux, University of Alberta, Edmonton*
- 10:00 - 10:30 Coffee and Posters
- 10:30 **Channel Flow And Extensional Collapse In The Southern Canadian Cordillera** *Dick Brown, Carleton University, Ottawa*
- 11:00 **Unravelling the metamorphic contrast across the Granby fault: implications for Eocene extension in southeastern British Columbia** *Justin Laberge, University of Calgary*
- 11:30 **General Discussion on the Morning's topics**
- 12:00 - 1:30 **Lunch and Posters** (Lunches are available at the MacEwen Hall food court, a short walk from the workshop site, see map, p. 3.)

Saturday 28 February - Afternoon Sessions 1:30 - 6:00

- 1:30 **Architecture of an accretionary orogen: Interpretations of crustal lithology and structure in the northern Canadian Cordillera based on SNORCLE lines 2a and 2b** *Dave Snyder, GSC, Ottawa*
- 2:00 **Structural styles and evolution of the southern extent of the Agrio Fold and Thrust Belt, Neuquen province, Argentina** *David Repol, University of Calgary* (also presented as a poster)
- 2:30 - 3:00 Coffee and Posters
- 3:00 **Stratigraphy, structure, and deformational timing at the southern termination of the Western Ranges and Main Ranges of the Southern Canadian Rocky Mountains near Cranbrook, British Columbia** *Kyle Larson, Queen's University, Kingston*
- 3:30 **Fault-Propagation Folding in the Livingstone Range of Southern Alberta: Faulting, Folding and Fluids in a Hangingwall Ramp Anticline** *Michael Cooley, Queen's University, Kingston* (also presented as a poster)
- 4:00 **Structural Evolution and Seismic Modelling of Fold-Thrust Structures Developed in Analogue (Centrifuge) Models** *Todd Noble, Queen's University, Kingston* (also presented as a poster)
- 4:30 - 6:00 Discussion and Posters

Sunday 29 February - Morning Sessions 8:30 - 12:00

- 8:30 **Cordilleran terranes in theory and practice** *JoAnne Nelson, BC Geological Survey, Victoria, and Maurice Colpron, Yukon geological Survey*
- 9:00 **Petrology and Tectonic Significance of K-feldspar Augen Granitoids in the Yukon-Tanana Terrane, Stewart River, Yukon Territory** *Tyler Ruks, Laurentian University, Sudbury*
- 9:30 **Tectonic evolution of Yukon-Tanana Terrane in the Stewart River area, western Yukon** *Jim Ryan, GSC, Vancouver*
- 10:00 - 10:30 Coffee and Posters
- 10:30 **Late Paleozoic-Early Mesozoic arc and back-arc volcanism in the Semenof Hills of south-central Yukon, northern Canadian Cordillera** *Renée-Luce Simard, Dalhousie University, Halifax*
(also presented as a poster)
- 11:00 **Terminal Neoproterozoic (Ediacaran) evolution of the Cordilleran margin: Integrated correlation of the Upper Windermere Supergroup, northwestern Canada** *Leanne Pyle, Queen's University, Kingston*
- 11:30 **General Discussion on the Morning's topics**
- 12:00 - 1:00 Lunch (Lunches are available at the MacEwen Hall food court, a short walk from the workshop site, see map, p. 3.)
- 1:00 - 5:00 Posters
- 5:00 Poster takedown

POSTERS

- | Poster
Number | Title | Authors |
|------------------|--|---|
| 1. | Geology of Yukon-Tanana terrane in the Stewart River area, western Yukon | <i>Steve Gordey, Jim Ryan, Mike Villeneuve and Steve Piercey</i> |
| 2. | Late Paleozoic-Early Mesozoic arc and back-arc volcanism in the Semenof Hills of south-central Yukon, northern Canadian Cordillera | <i>Renée-Luce Simard, Jarda Dostal, Maurice Colpron and George Gehrels</i> |
| 3. | Tectonostratigraphic framework and a preliminary compilation map for Yukon-Tanana and related terranes in southern Yukon and northern British Columbia | <i>M. Colpron, C.F. Roots, J.L. Nelson, D.C. Murphy and N. Massey</i> |
| 4. | The geological setting and tectonic implications of retrograded eclogite and jade in the southern Campbell Range, Finlayson region, Yukon | <i>Fionnuala Devine, Don Murphy, Reid Kennedy, Amy Tizzard and Sharon Carr</i> |
| 5. | The Aplitic dykes of the Cantung Mine, NWT: Petrography, Geochemistry and relationship to the Orebody | <i>Kirsten Rasmussen, David Pattison, Hendrik Falck and Bill Mann</i> |
| 6. | Mississippian volcanic rocks conformably overlying Cordilleran miogeoclinal strata along the Turnagain River in northern British Columbia: part of Quesnellia, and back arc of a Slide Mountain-Angayucham basin? | <i>Philippe Erdmer, Mitchell Mihalymuk, Hubert Gabrielse, Larry Heaman and Robert Creaser</i> |
| 7. | Results Of Recent Geoscience Research In The Bowser and Sustut Basins, British Columbia | <i>Carol Evenchick, Fil Ferri, Kirk Osadetz, Vern Stasiuk, Nick Wilson, Margot McMechan, Randy Enkin, Vicki McNicoll, Dave Snyder, Peter Mustard and Thomas Hadlari</i> |
| 8. | Effective Petroleum Systems and Crude Oil Compositions in Bowser Basin | <i>Kirk Osadetz, Chungqing Jiang, Carol Evenchick, Fil Ferri, Vern Stasiuk, Nick Wilson and Mark Hayes</i> |
| 9. | An 1800-km cross section of the lithosphere through the northwestern North American plate: Lessons from 4.0 billion years of Earth's history | <i>Fred Cook and Philippe Erdmer</i> |

- | Poster
Number | Title | Authors |
|--------------------------|---|--|
| 10. | Gneiss domes of the Monashee complex, southeastern Canadian Cordillera: Contrasting tectonic models, conflicting data and possible tests | <i>Felix Gervais</i> |
| 11. | A New Geological Map of the Thor–Odin Culmination, Monashee Mountains, Southeastern BC | <i>Paul McNeill, Stefan Kruse and Paul Williams</i> |
| 12. | Metamorphism of the Mount Roberts Formation in the Rossland-Trail area, southern British Columbia | <i>Lisa McCluskey, Ed Ghent and Philip Simony</i> |
| 13. | Triangle zone and gravity slide tectonics at the southern limit of the Main Ranges, southern Canadian Rockies | <i>Kevin Root</i> |
| 14. | Fault-Propagation Folding in the Livingstone Range of Southern Alberta: Faulting, Folding and Fluids in a Hangingwall Ramp Anticline | <i>Mike Cooley, Ray Price, John Dixon and Kurtis Kyser</i> |
| 15-16. | Structural Evolution and Seismic Modelling of Fold-Thrust Structures Developed in Analog (Centrifuge) Models | <i>Todd Noble, John Dixon, Susan Pfister and Don Lawton</i> |
| 17. | Structural Style And Evolution Of The Southern Extent Of The Agrio Fold And Thrust Belt, Neuquen Province, Argentina | <i>David Repol and Deborah Spratt</i> |
| 18. | Towards a new crustal scale cross section along the 49th parallel: Constraints on deformation and potential reconstructions of the western margin of North America | <i>Sarah Travis and Fred Cook</i> |
| 19. | Kinematic and petroleum modelling of the Alberta foothills and adjacent foreland, west of Calgary | <i>Jean-Luc Faure, Frédéric Schneider, Kirk Osadetz, François Roure and Jean-Paul Callot</i> |

ABSTRACTS

(alphabetically)

Channel Flow And Extensional Collapse In The Southern Canadian Cordillera

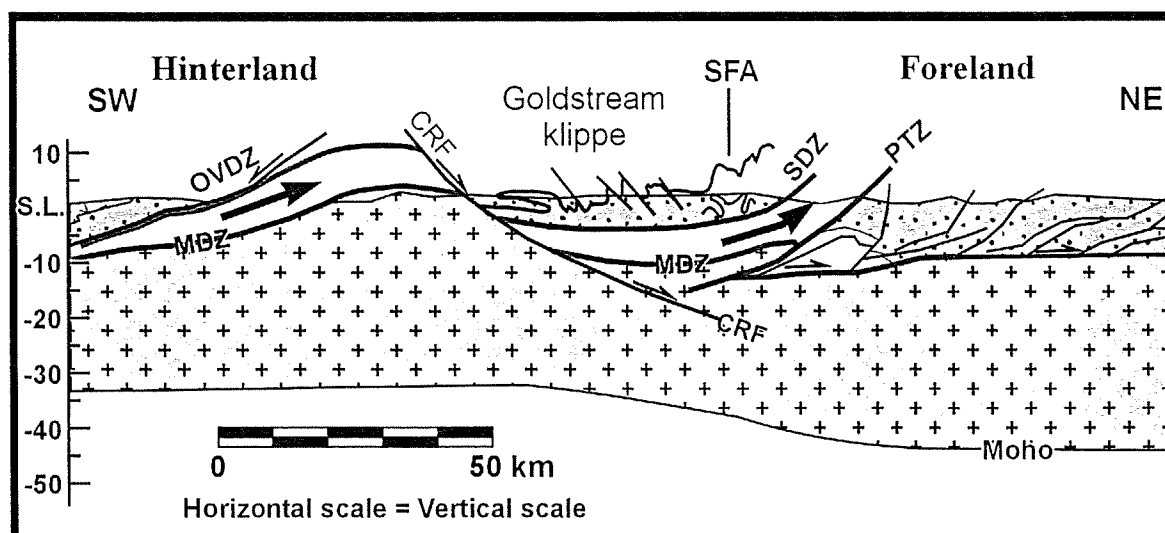
Richard L. Brown

Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada

Dan Gibson

Department of Geosciences, University of Massachusetts, Amherst, MA, USA

In the Cretaceous, crustal thickness in excess of 60km together with high heat flow, suggest the existence of a high plateau to the southwest of the Rocky Mountain Thrust and fold Belt. Structural, metamorphic and geochronology studies indicate that a low strength middle crust underlay the plateau region. Rocks within the low strength layer flowed northeastward and upward to higher structural levels; older structures were refolded and a new transposition fabric developed. A crustal thickness of 10-20 km was involved in the high temperature ductile flow. The lower boundary of the ductile zone includes basement rocks of the Monashee complex, but this boundary splays upwards to the northeast where it closely coincides with highly strained rocks in the hanging wall of the Purcell thrust system. The upper boundary in the Selkirk Mountains is the Selkirk detachment zone, which has been traced northwestward to the Columbia River where it is displaced in the hanging wall of the Columbia River extensional fault system. The Selkirk detachment system is above the erosion surface of the Monashee complex and roots to the west in the Okanagan-Eagle River fault system. During final stages of flow the Precambrian basement gneisses, which form the footwall of the channel, became domed and exhumed to upper crustal levels.



**An 1800-km cross section of the lithosphere through the northwestern
North American plate: Lessons from 4.0 billion years of Earth's history**

Frederick A. Cook

*Department of Geology and Geophysics
University of Calgary, Calgary, AB T2N 1N4*

and

Philippe Erdmer

*Department of Earth and Atmospheric Sciences
University of Alberta, Edmonton, AB T6G 2E3*

The Lithoprobe SNORCLE (Slave Northern Cordillera Lithospheric Evolution) study across northwestern North America, in combination with related crustal studies, has provided an 1800-km long cross-section of the lithosphere that is constrained by high resolution geophysical data (seismic reflection, refraction, electromagnetic, potential fields) and detailed bedrock geology. The primary conclusion of the study is that, during all major orogenic episodes recorded from Archean to present in that part of Earth's lithosphere, the crust, and perhaps much of the mantle, was reorganized and redistributed rather than being differentiated from the mantle at the time of orogenesis. The observed subsurface geometries of relict subduction zones, accretion boundaries and magmatic arcs all lead to the inference that the crust includes a dominant proportion of recycled material. A similar conclusion appears applicable for the origin of subcrustal lithosphere in the region – i.e., that much of the lithosphere, whether Archean in the Slave Province or Proterozoic in the Cordillera, is old and thus that the amount of “new” lithosphere added to the plate during orogenesis is surprisingly small. A corollary is that many accreted rocks at surface that record orogenic complexity are detached from their originally underlying lithosphere and were emplaced upon unrelated crust and mantle during deformation.

Fault-Propagation Folding in the Livingstone Range of Southern Alberta: Faulting, Folding and Fluids in a Hangingwall Ramp Anticlinorium

Michael A. Cooley* Raymond A. Price, John M. Dixon, and T. Kurtis Kyser

*Queen's University, Kingston, ON
cooleym@students.geol.queensu.ca*

A series of balanced cross sections through the southern Livingstone Range outline the morphology of the Livingstone Range anticlinorium. The anticlinorium is located above a large (~1000 m) frontal ramp along which the Livingstone thrust cuts abruptly up-section from a regionally extensive detachment in the Upper Devonian Palliser Formation to a regional detachment in the Jurassic Fernie Group. Minor deviations of the frontal ramp, where the thrust changed from bedding-parallel to across-bedding, have resulted in the formation of multiple folds in the hangwall. The anticlinorium consists of two or three parallel and closely-spaced fault-propagation fold anticlines with associated thrust faults that have splayed upward from the underlying Livingstone thrust and which die-out upward in the core of concentric flexural-slip folds. During flexural slip folding, as the fold limbs rotated toward steeper dips, interstratal slip was transferred to the thrust faults. Enigmatic fault-fold relationships in the attenuated core of the Centre Peak anticline, which have been studied in detail, can be attributed to a combination of interstratal slip during flexural-slip fold-limb rotation about a fixed hinge, and concurrent forelimb extension as the thrust propagated and the fold tightened.

Stable isotope geochemistry of veins from the blind thrusts in the cores of the north-northwest-trending fault-propagation anticlines indicates a partially meteoric source for the fluids. Steeply-dipping faults that cut northeast across the folds have a formation-fluid signature. This isotopic pattern is also exhibited in larger structures such as the Daisy Creek fault system which comprises a back thrust and an underlying fore-thrust that are linked by a tear fault. The back thrust has meteoric isotopic signatures and the connected tear fault has formation fluid signatures. The strongly meteoric signature of veins from the Daisy Creek back thrust indicate local infiltration of meteoric waters occurred during thrusting.

A regional dolomitization event that altered the rocks prior to deformation may have occurred as late as the Upper Carboniferous, as inferred by the presence of quartz+calcite+dolomite veins in the Etherington Formation and underlying Mount Head and Upper Livingstone Formations. Jasperoid quartz in these veins commonly contain inclusions of euhedral dolomite rhombs that occur as trails along vein margins and as single crystals surrounded by quartz, implying that dolomitization preceded local silicification and quartz precipitation. Geochemical analyses of the quartz+calcite veins indicate that the veins have a hydrothermal signature and contain anomalous lead and zinc.

The Geological Setting and Tectonic Implications of Retrograded Eclogite and Jade in the Southern Campbell Range, Finlayson Region, Yukon

Fionnuala Devine¹, Donald C. Murphy², Reid Kennedy³, Amy M. Tizzard⁴, Sharon D. Carr¹

¹ *Department of Earth Sciences, Carleton University, Ottawa.*

² *Yukon Geological Survey, Whitehorse, Yukon*

³ *Department of Geology and Geophysics, University of Calgary*

⁴ *School of Earth and Ocean Sciences, University of Victoria*

Occurrences of eclogite in Yukon-Tanana Terrane (YTT) provide insight into its Late Paleozoic tectonic development. Based on geological relationships Permian-age eclogites in central Yukon can reasonably be interpreted to mark the suture of YTT and North America. Eclogites with Mississippian ⁴⁰Ar-³⁹Ar cooling ages on white mica occur near this boundary as well. These rocks were exhumed in an east-dipping subduction zone along the western margin of YTT in the early Mississippian and were subsequently carried over YTT on thrust faults active in Early Permian time.

Retrograded eclogite with a ⁴⁰Ar-³⁹Ar age of 344 ± 1 Ma on white mica occurs in the southern Campbell Range of the Finlayson region in southeastern Yukon (Erdmer et al., 1998). Coarse-grained quartz-muscovite schist with lenses of metabasite (retrograded eclogite) occurs within serpentinite mélangé and is in fault contact with greenschist facies Tuchitua River and Money Creek metasedimentary rocks.

Stratigraphy in the greenschist facies metasedimentary rocks is deformed by at least two syn- to post-Early Permian folding events which correlate with Early Permian age regional shortening and thrust faulting of YTT. Northwest-trending, high-angle faults of probable post-Late Triassic age (Inconnu-age) imbricate the folded metasedimentary package with sheets of serpentinite.

Nephrite jade at the King Arctic Jade is also related to the post-Late Triassic faulting event. Microcrystalline tremolite partially to completely replaces Tuchitua River formation chert-pebble conglomerate and serpentinite along the faulted contacts of the two units in regions where the conglomerate overlies massive Tuchitua River limestone.

Mississippian volcanic rocks conformably overlying Cordilleran miogeoclinal strata along the Turnagain River in northern British Columbia: part of Quesnellia, and back arc of a Slide Mountain-Angayucham basin?

Philippe Erdmer¹, Mitchell G. Mihalynuk², Hubert Gabrielse³, Larry Heaman¹ and Robert A. Creaser¹

¹ *Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2E3*

² *British Columbia Ministry of Energy and Mines, P.O. Box 9320 Stn. Prov. Govt., Victoria, British Columbia, Canada V8W 9N3*

³ *Geological Survey of Canada, Pacific Division, 101-605 Robson Street, Vancouver, British Columbia, Canada V6B 5J3*

The outboard part of the Cordilleran miogeocline in northern British Columbia consists of Neoproterozoic to middle Paleozoic platformal and off-shelf sedimentary strata. Ophiolitic and volcanic arc-dominated rock successions occur to the west and are locally thrust over them. Together with the absence of stratigraphic links, that relationship has supported the general interpretation of oceanic and arc rocks in the Cordillera as terranes representing offshore crust accreted to the North American plate. Geological relationships in the region east of Dease Lake have been highlighted as examples of the interaction between accreted rocks and the ancestral margin. The proposed accreted rocks in that region were assigned to the Quesnel and Stikine arc terranes (or Quesnellia and Stikinia, respectively) and the Cache Creek and Slide Mountain oceanic terranes. Rocks of the Sylvester allochthon, a klippe overlying Paleozoic strata of the ancestral North American margin, were also included in the Slide Mountain terrane.

In the same region, however, low grade Paleozoic to Triassic metavolcanic rocks were reported in conformable contact with miogeoclinal strata for a strike length of more than 15 km. That observation is significant because, if the contact is locally stratigraphic, it precludes an accreted origin of some volcanic rocks. In order to test the initial interpretation of the contact, and thus, whether volcanic rocks could represent an outboard facies linked to the miogeocline and the North American plate, we carried out a more detailed study of geological relationships. The poster presents lithologic and structural field data, U-Pb, Sm, Nd, Pb, Rb and Sr isotopic data and whole rock geochemical data collected along a ~10 km transect across the exposed contact between miogeoclinal and volcanic rocks southeast of the Turnagain River, approximately 70 km east of Dease Lake.

We report that 1) the contact is marked by interlayering of finely laminated phyllites on the scale of centimetres, 2) volcanic rocks of Mississippian age with isotopic characteristics more primitive than the underlying miogeoclinal strata, and arc to back-arc composition, grade upwards from the transition zone and 3) the contact is folded at the outcrop scale into tight folds intruded by Early Jurassic granodiorite. The results support

the interpretation of a stratigraphic contact and the existence of a local middle Paleozoic facies transition within the ancient margin. Two conclusions are that 1) the presence of arc rocks does not necessarily define the boundary between accreted and autochthonous parts of the Cordillera and 2) the general inference that any rocks in the Cordilleran hinterland are far-travelled if they have an oceanic or arc origin is unjustified.

The data are compatible with the existence of a continental margin arc and possibly an associated back-arc basin. They may provide a link with similar successions along strike in British Columbia and Alaska included in the Slide Mountain and Angayucham assemblages, respectively.

Results Of Recent Geoscience Research In The Bowser and Sustut Basins, British Columbia

C. A. Evenchick, *GSC, Vancouver*
F. Ferri, *B.C. Ministry of Energy and Mines, Victoria*
K.G. Osadetz, L. Stasiuk, N.S.F. Wilson, M. McMechan, *GSC, Calgary*
R.J. Enkin, *GSC, Sidney*
V.J. McNicoll, D. Snyder, *GSC, Ottawa*
P.S. Mustard, *Simon Fraser University*
T. Hadlari, *Carleton University*

Regional mapping in the Bowser and Sustut basins since the mid 1980's has resulted in fundamental changes in the understanding of their stratigraphic and structural frameworks. Resolution of stratigraphic issues of rocks at the boundary between the Hazelton and Bowser Lake groups, and the recognition that basin rocks, as well as strata of underlying Stikinia, are part of a regional fold and thrust belt have immediate implications for mineral exploration in strata bounding the Bowser Basin. More recently, GSC and BC MEM focus in the Bowser and Sustut basins has shifted to applying the updated geological framework to understanding their potential energy resources. The northern Bowser Basin has been the focus of exploration for coal periodically since the early 1900's. Petroleum exploration began in the late 1950's but was significantly hindered by a poor knowledge of the regional geological framework considering the very large area to be explored.

Recent GSC/BCMEM collaborative research in the Bowser and Sustut basins resulted in a profound shift in perceptions of the organic maturity of strata in the basins (Evenchick et al., 2002). This was the first regional reflectance dataset for these basins, and it illustrates that large areas, including the lowest stratigraphic levels of the Bowser Basin, have sufficiently low organic maturity levels to be favourable for the formation and preservation of a significant petroleum resource. This result is a fundamental change from previous views that considered the high thermal maturity of some of the stratigraphically highest coals as a negative indication for hydrocarbon potential in all stratigraphic levels of all regions of the basin, and is the impetus for new studies in the Bowser and Sustut basins.

Current research on energy resource potential of the Bowser and Sustut basins includes identifying effective petroleum systems, increasing geographic coverage of thermal maturity data, initiating paleomagnetic studies, and geological mapping. Crude oil samples extracted and characterized from four locations yield results that confirm the revised thermal maturity model for the region and identify potential petroleum systems with sources in the Stikine Assemblage and younger strata (Osadetz et al., 2002). Identification of Stikinia sources and recognition of possible reservoirs in the Hazelton Group indicates that strata below the Bowser Lake Group might also be prospective for petroleum accumulation. Paleomagnetic sampling of Permian to Late Jurassic strata has the capacity to recognize several periods of deformation, burial history, igneous heating and fluid migrations. New mapping in McConnell Creek area significantly revises distribution of upper Hazelton Group clastic rocks, assigns lithofacies assemblages to Bowser Lake Group strata, and modifies Sustut Group map distribution and structures.

Architecture of an accretionary orogen: Interpretations of crustal lithology and structure in the northern Canadian Cordillera based on SNORCLE lines 2a and 2b

Carol A. Evenchick & Hubert Gabrielse

Geological Survey of Canada, 101-605 Robson St., Vancouver, BC V6B 5J3, Canada

D. B. Snyder

Geological Survey of Canada, 615 Booth St., Ottawa ON K1A 0E9, Canada

Seismic reflectors at shallow crustal levels in the Northern Canadian Cordillera can be reconciled with many stratigraphic and structural elements known from geological mapping: the crustal penetrating Northern Rocky Mountain Trench Fault, the several kilometres thin slices of Slide Mountain (Sylvester Allochthon) and Cache Creek terranes, and the northward dipping Hotailuh fault are examples. At deeper crustal levels, the seismic profiles provide new information on the geometry of the interface between Stikinia and the bounding terranes to the northeast and east; the thickness of Stikinia; the crustal penetrating Northern Rocky Mountain Trench Fault and the prominent layering, broad folding and local imbrication of the thick, lower crustal rocks across the entire profile. Of fundamental significance is a southwesterly tapering wedge of continental crust overlain in its distal part by the allochthonous terrane Stikinia and, northeast of Thibert Fault, by a thick, probably structurally thickened sequence of sedimentary rocks and the extensive granitic Cassiar batholith. The top of this wedge is interpreted as a tectonic accretion surface resulting from collision of Stikinia with Cache Creek Terrane and Ancestral North America. The mid-crust accretion surface has an apparent southwest dip, whereas the surface expression of accretion is detached northeast dipping faults such as the King Salmon and Hotailuh faults. Despite the new estimates of relatively small volume occupied by terranes such as Slide Mountain, Cache Creek, and Quesnellia in the Northern Cordillera, their composition and history remain fundamental to understanding the accretionary history of the orogen. Stikinia is a crustal scale block which underlies a large part of the western Cordillera.

East of the Northern Rocky Mountain Trench this deep southwest-tapering wedge consists of at least 20 km of either Mesoproterozoic and Neoproterozoic sedimentary strata, or layered crystalline basement, or a combination of the two. Interpretations of proportions of Proterozoic sedimentary rocks and crystalline basement (ca. >1.8 Ga) in the deeper part of the crust in the eastern part of the SNORCLE transect (line 2b) depend critically on assumed models for sediment deposited along the paleo-continental margin. Our sedimentological and structural interpretations coupled with the observation that the Muskwa Assemblage is weakly rather than strongly reflective lead to our bias that most of the crust beneath SNORCLE line 2b is underlain by crystalline basement.

On a regional scale, the relative abundance of Proterozoic sedimentary rocks and crystalline North American basement in the lower crustal reflective wedge remains contentious. It is important to note here that the reconstructed geography of the part of the Cordillera covered by all SNORCLE transects extends nearly 1000 km along regional

strike from the end of SNORCLE line 3 at MacMillan Pass (Cook et al. 2003) to the Bowser Basin near Stewart. Projections of Selwyn Basin strata into SNORCLE line 3 suggest that Proterozoic strata such as the Wernecke Mountains Supergroup occupy 60-90% of the crust near MacMillan Pass. Similar projections along SNORCLE line 2a&b suggest a much greater proportion of crystalline basement within the reflective wedge.

Recent paleo-reconstructions of Siberia and North America may provide a ready explanation for this geographic difference in crustal composition. Sears and Price (2002) argue that Proterozoic Siberia rifted away from the part of the Cordillera today in British Columbia, whereas the Yukon part may have been an open continental margin during this same period. This potentially explains the apparently restricted occurrence of Mackenzie Mountain Supergroup and Muskwa Assemblage strata in the north and south, respectively, and the greater abundance of continental margin sequences in the north. The actual boundary may be a failed rift oriented east-west at 60°20' N where an east-west trending facies boundary in lower Paleozoic rocks coincides with a prominent magnetic anomaly (Gabrielse and Blusson 1969; C. Lowe personal communication 2003). This may approximate the southern extent of the Mackenzie Mountain Supergroup. Analogue models described by Schellart et al. (2002) provide a possible mechanism of intimately interfingering ridges of crystalline basement and Proterozoic sedimentary basins jointly shortened during the Mesozoic.

References

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- Schellart, W.P., Lister, G.S., and Jessell, M.W., 2002. Analogue modelling of arc and backarc deformation in the New Hebrides Arc and North Fiji Basin. *Geology*, **30**; 4, 311-314.

Kinematic and petroleum modelling of the Alberta foothills and adjacent foreland, west of Calgary

J.L. Faure¹, F. Schneider¹, K. Osadetz², F. Roure¹ and J.P. Callot¹

1: IFP, 1-4 av Bois Préau, 92852 Rueil Malmaison cedex, France ;

2: Geological Survey of Canada 3303-33 Rd St, NW Calgary, Alberta, T2L 2A7

We have used the CERES software to model the temperature and the fluid flow histories as well as the hydrocarbon migration along a well studied transect of the Canadian Rockies foothills. However, the use of this tool implies a backward restoration approach. Although backward restoration is fully appropriate for modelling an extensional basin, in a compressional setting, it may become difficult to constrain successive intermediate evolutionary stages, as far as the topography and thrust geometry are concerned. An appropriate methodology for basin modelling in a complex area has been defined and tested during the Subtrap Consortium and is recalled in the 'workflow' section. The process, based on 3 main steps, consists of: (A) Defining and restoring the initial section; (B) Constructing a reasonable kinematic scenario; and (C) Modelling the heat transfers, the pressure, the maturity of the organic matter, and the fluid flows, using the geometric scenario defined in step B. This workflow has been successfully used to model the hydrocarbon generation, flow and trapping in the Alberta front ranges and foothills west of Calgary. To test the sensitivity of our results on the source rock hypothesis, several runs were performed, differing only by the location and TOC of the source rocks. Our results show clearly that the main source of hydrocarbons are located in the Banff-Exshaw formations and that the Cretaceous and Triassic source rocks do not contribute significantly to the present day hydrocarbon reservoirs. The importance of the secondary cracking in the internal part of the belt is also emphasized.

Gneiss Domes Of The Monashee Complex, Southern Canadian Cordillera: Contrasting Tectonic Models, Conflicting Data and Possible Tests

Felix Gervais

*Department of Earth Sciences,
Carleton University & Ottawa Carleton Geoscience Centre, Ottawa*

The Monashee complex is characterized by two broad (>25 km of diameter) domes cored by Precambrian basement migmatitic para- and ortho-gneisses of North American affinity. An extensive data base has been compiled from the numerous field-based studies conducted in this area in the last 25 years. However, instead of converging toward a uniform tectonic model for the formation of the Thor-Odin and Frenchman Cap domes, several conflicting interpretations are currently being debated in the literature. These interpretations range from diapiric emplacement of extensively melted and highly mobile lower and middle crust, to boudinage of relatively competent lower crust. Other suggested dome-forming tectonic models include polyphase folding, thrust stacking, channel flow and extension-related warping.

Available data and current models are reviewed in the poster. As part of my Ph.D. thesis, field based tests are proposed that aim to reduce the number of viable tectonic models. Issues that will be investigated in the course of this project include: i) a clearer distinction between Precambrian and Cordilleran deformation and metamorphism in the core of the Frenchman Cap dome; ii) identification of Cordilleran structural patterns, metamorphic assemblages/textures, and amount of Tertiary anatexis in the core of the Frenchman Cap dome; iii) evaluation of the ductility contrast between rocks of the core and cover of the Frenchman Cap dome at the time of doming; iv) consider the possible contribution of a regional quartz C-fabric analysis in the basal quartzite that delineates the domal shape of both the Thor-Odin and Frenchman Cap dome; v) inclusion geothermobarometry of garnets showing inclusion-rich cores and inclusion-free rims in order to refine P-T-t paths of the core and cover of the Frenchman Cap dome; iv) using the most recent database together with new field studies in the Thor-Odin core area, determine the principal differences between the Frenchman Cap dome and that of Thor-Odin.

Geology of Yukon-Tanana terrane in the Stewart River area, western Yukon

Steve Gordey and Jim Ryan, *GSC, 101-605 Robson Street, Vancouver, B.C. V6B 5J3*

Mike Villeneuve, *GSC, 601 Booth Street, Ottawa, Ontario, K1A 0E8*

Steve Piercey, *Mineral Exploration Research Centre, Department of Earth Sciences,
Laurentian University, Ramsey Lake Road, Sudbury, Ontario, Canada, P3E 2C6*

A widespread tract of Paleozoic Yukon-Tanana Terrane (YTT) in western Yukon represents a succession of arcs built upon a siliciclastic substrate. The entire sequence is affected by high-strain structural transposition, and one or more amphibolite-facies metamorphisms.

The lowest structural level comprises widespread, continentally(?) derived psammite and quartzite, with lesser pelite. The youngest detrital zircon grains from rare conglomerate and a quartzite yield U-Pb ages of Devonian and early Mississippian age respectively. Intermediate to mafic amphibolite derived from volcanic or volcanoclastic protoliths, interdigitates with and lies stratigraphically(?) above the siliciclastic rocks. Coarse crystalline marble, inferred to have been fringing reefs or local carbonate buildups, occurs as members within both successions. Orthogneiss of diorite, tonalite, granodiorite, monzogranite and K-spar megacrystic granite protolith intrudes both the siliciclastic and amphibolitic assemblages. Preliminary zircon ages demonstrate they are latest Devonian to early Mississippian (363-345 Ma) in age, in part coeval with the siliciclastic sedimentation. The metavolcanic and metaplutonic rocks have lithological and geochemical affinities to an arc succession, which rests above the siliciclastic substrate and which is coeval with back-arc basin rocks represented in the Finlayson Lake VMS district of southeastern Yukon. A poorly dated unit of graphitic quartz-rich metasedimentary rocks (Nasina), distinguished by abundant carbonaceous phyllite, and lack of amphibolite, rests structurally(?) above the non-carbonaceous siliciclastic rocks typical of the area.

A suite of mid-Permian (263-255 Ma) augen granites and their probable volcanic equivalents, represent a younger arc succession built upon the mid-Paleozoic one. Widespread amphibolite facies metamorphism and high-strain structural transposition were synchronous with the Permian magmatism.

The YTT rocks are intruded by post-transposition Jurassic to Cretaceous plutons and Eocene rhyolite, and overlapped by Lower Cretaceous conglomerate (Tantalus Fm.) and Upper Cretaceous volcanic rocks (Carmacks Gp). YTT was emplaced in the Jurassic-Cretaceous when it was delaminated from its basement and thrust as a thin(?) sheet above the ancestral North American margin.

U-Pb SHRIMP ages of leucosome in Thor-Odin basement rocks, Monashee complex: evidence for one Eocene melting event

Alana M. Hinchey and Sharon D. Carr

*Ottawa-Carleton Geoscience Center, Department of Earth Sciences
Carleton University Ottawa, ON K1S 5B6
ahinchey@connect.carleton.ca*

Migmatitic basement gneisses are exposed in Thor-Odin dome in the Monashee complex of southeastern British Columbia. Both ortho- and paragneiss contain ubiquitous stromatic leucosome as well as discrete phenocrystic and pegmatitic vein-type leucosome. Leucosome is interpreted to have formed as a result of in situ melting. Detailed mapping in the Saturday Glacier area reveals that leucosome production was ongoing during the formation of at least part of the penetrative foliation, F2, F3 and F4 folds and D5 extensional shear bands. Leucosomes that are deformed by and crosscut folds were carefully selected for U-Pb geochronology studies in order to constrain the ages of the structures. Zircons from three samples were imaged, and selected crystals were dated using SHRIMP (Sensitive High Resolution Ion Microprobe) in situ techniques. Zircon from all three samples show systematic oscillatory zoning, interpreted to represent crystal growth in contact with a melt. SHRIMP $^{206}\text{Pb}/^{238}\text{U}$ ages range from ca 55 to 52 Ma. The zircons commonly contain discrete cores with sharp contacts; in some cases the outer core contact truncates internal zoning. $^{207}\text{Pb}/^{206}\text{Pb}$ ages from cores range from ca. 1.8 to 2.5 Ga, although data are discordant. There is no evidence of zircon growth between 1.8 Ga to 55 Ma. The cores are interpreted as detrital grains within the host paragneiss that acted as nucleation sites for zircon in the leucosome during anatexis.

These field and geochronology data indicate that anatexis and the production of abundant leucosome, part of the foliation, significant penetrative deformation including F3 and F4 folding and D5 extension occurred in the Eocene at ca. 55 to 52 Ma. Anatexis coincided with the peak of metamorphism in the Eocene; the high fertility of the basement rocks during this event indicates that the rocks are unlikely to have undergone a prior anatexis event.

Unravelling the metamorphic contrast across the Granby fault: implications for Eocene extension in southeastern British Columbia

J.D. Laberge and D.R.M. Pattison

*Department of Geology and Geophysics
University of Calgary
Calgary, AB T2N 1N4*

The Canadian Cordillera was mainly assembled and shaped by compressional tectonics during the Mesozoic to Early Cenozoic. The end of the orogeny was marked by a period of tectonic extension in the Tertiary, responsible for the unroofing of the mountain belt and the present crustal architecture. This Tertiary event caused rapid tectonic exhumation of mid-crustal rocks, now exposed at the surface as culminations of high-grade metamorphic rocks referred to as metamorphic core complexes.

The Grand Forks metamorphic complex is located in the southern Omineca Belt of southeastern British Columbia. It is bounded by two outward-dipping normal faults, the Kettle River fault to the east and the Granby fault to the west. The Granby fault is exposed as a west-dipping zone of brittle deformation 50 to 1000 metres in apparent thickness, and is generally characterized by millimetre- to metre-scale bands of fine-grained cataclasite within cataclastic breccia. Faulting appears to be at least in part, synchronous with the emplacement of syenitic to monzonitic dykes of the Coryell plutonic suite. The Granby fault juxtaposes medium-grade meta-sedimentary and meta-volcanic rocks in the hanging-wall to high-grade pelitic and psammitic gneisses in the footwall. Supracrustal rocks of the hanging-wall were metamorphosed to lowermost amphibolite facies as indicated by the occurrence of hornblende in meta-volcanic rocks. The metapelitic migmatites are characterized by the mineral assemblage $Sil + Bt + Crd + Grt + Pl + Kfs + Qtz + L$, indicative of the transitional upper-amphibolite to granulite facies. They are closely associated with medium-grained to pegmatitic leucogranite, as a result of partial melting, emphasizing the metamorphic contrast across the fault.

From P-T stability of contrasting mineral assemblages, a minimum temperature contrast across the Granby fault of $\sim 200^{\circ}\text{C}$ appears reasonable. The metamorphic pressure contrast across the fault as yet to be quantified by petrological studies. Assuming a single peak metamorphic event for both domains, affected by the same perturbed geothermal gradient, a minimum throw of 4 km for the Granby fault is suggested by the temperature contrast. For the observed fault dip of 30° , this represents close to 7 km of horizontal E-W displacement. Timing of metamorphism on both footwall and hanging-wall would further constrain the tectonic implications regarding the amount of normal displacement on the Granby fault.

Stratigraphy, structure, and deformational timing at the southern termination of the Western Ranges and Main Ranges of the Southern Canadian Rocky Mountains near Cranbrook, British Columbia

Kyle P. Larson and Raymond A. Price
Queen's University, Kingston ON, K7L 3N6

At the latitude of the Trans-Canada Highway, the Southern Canadian Rockies comprise five distinct physiographic subprovinces that are characterized by stratigraphy, structural level of exposure, and structural style as well as distinctive topography. From east to west these subprovinces include: the Foothills, the Front Ranges, the Eastern Main Ranges, the Western Main Ranges, and the Western Ranges. The Rocky Mountain subprovinces are continuous belts that can be followed >225 km southward from just north of the Trans-Canada Highway at Golden, to the vicinity of Crowsnest Pass where the distinction between the Western Ranges and the Main Ranges subprovince becomes subdued and the Main Ranges and Western Ranges subprovinces terminate against enigmatic, northeast-southwest trending segments of complex faults. The termination coincides with the Crowsnest Pass Cross-Strike Discontinuity (CPCSD), a northeast-southwest trending tectonic feature marked by unusual, northeast-trending transverse dextral-reverse faults in the Purcell and western Rocky mountains. These faults, which have reactivated older structures that were downthrown to the northwest, are marked by profound changes in Paleozoic and Proterozoic stratigraphy and in the orientation and style of thrusts, related folds and normal faults. They coincide with an eastward encroachment of Mid-Cretaceous granitic plutonism and Cambro-Ordovician mafic volcanism into miogeoclinal strata within the Rocky Mountains. The CPCSD coincides with a 230 km right-hand offset in the boundary between the Paleozoic Cordilleran miogeocline and the cratonic platform from near the Alberta- B.C. border to near the Columbia River in northeast Washington.

The Wild Horse River area is situated adjacent to the CPCSD, approximately 40 km northeast of Cranbrook, British Columbia. It encompasses the southern termination of the Western Ranges subprovince and it extends into the Main Ranges subprovince. Detailed geologic mapping in the Wild Horse River area has outlined: stratigraphic anomalies between both the Western Ranges and Main Ranges and the rest of the Canadian foreland thrust and fold belt, elucidated enigmatic Cambro-Ordovician volcanics, and clarified the temporal relationship between orogenic deformation and mid- Cretaceous granitic plutonism.

Lower to Middle Cambrian stratigraphy in the Wild Horse River area differs from that characteristic of the Southern Canadian Rockies in that the mid-Upper Cambrian Ottetail Limestone is missing and the Chancellor and Ottetail Formations are replaced by a succession of deep-water carbonates and slope deposits known locally as the "Tanglefoot unit". Middle and Lower Cambrian rocks also vary markedly within the Wild Horse River area between the Western Main Ranges and the Western Ranges, in which the Cambro-Ordovician McKay Group is separated from and underlying thin sequence of Lower

Cambrian siliciclastic rocks by a thick succession of unfossiliferous dolomite comprising the Jubilee Formation. This suggests that the intervening Lussier River fault may separate segments of the miogeocline that are far-traveled with respect to each other. Anomalous mafic volcanic rocks are intercalated with the Cambro-Ordovician McKay Group and the Ordovician-Silurian Beaverfoot Formation. Mapping and characterization of these volcanic agglomerates, and local mafic flows suggest they are likely related to the scarce but regionally widespread diatremes, which may, in turn, be controlled by antecedent basement structures. Both the small mid-Cretaceous granitic plutons that extend eastward into the miogeoclinal strata of the Wild Horse River area and their associated metamorphic aureoles have been shown to cross-cut the structural fabric in the area, including both the west-verging thrusts and folds in the Western Main Ranges and the Lussier River fault. Preliminary $^{40}\text{Ar}/^{39}\text{Ar}$ dating of the granitic plutons at ~110 Ma (D.A. Archibald, pers. comm., 2004) implies that the thrusting and folding in this part of the western Rocky Mountains in southern Canada is no younger than early Albian. Displacement on the next major thrust fault to the east of the Wild Horse River area, the Bourgeau thrust fault, is probably younger than the late Cenomanian to Santonian Alberta Group strata (95-85 Ma) that occur in the Fernie synclinorium which formed along its footwall. There appears to have been a hiatus of more than 20 Ma between the thrusting in the Western Rocky Mountains and Purcell Mountains and that nearby in the Front Ranges of the Southern Canadian Rocky Mountains.

**Detrital zircon geochronology and tectonic implications of a middle
Paleozoic metasedimentary rock succession, southeastern
British Columbia**

Yvon Lemieux

*Department of Earth and Atmospheric Sciences, University of Alberta, 1-26 Earth Sciences
Building, Edmonton, Alberta, T6G 2E7 (e-mail: ylemieux@ualberta.ca)*

Robert I. Thompson

*Geological Survey of Canada, Pacific Geoscience Centre, 9860 West Saanich Road,
Sidney, British Columbia, V8L 4B2*

Antonio Simonetti and Philippe Erdmer

*Department of Earth and Atmospheric Sciences, University of Alberta, 1-26 Earth Sciences
Building, Edmonton, Alberta, T6G 2E7*

Recent field investigation in southeastern British Columbia has revealed the existence of a succession of middle Paleozoic quartzite, marble and schist that has been traced for more than 150 km along strike, from the Adams Lake-Chase area northwest of Vernon, eastward and southward to the western margin of the Kuskanax Batholith along Upper Arrow Lake, i.e. from previously interpreted accreted terranes to the outer miogeocline. This belt is locally dissected by north-south trending, steeply dipping normal faults, such as the Okanagan Valley and Columbia River fault zones. The succession comprises at its base a distinctive Devonian calcareous quartzite marker unit that is correlated with the Chase Quartzite; in the Chase area, this unit yielded 405 and 424 Ma detrital zircons (concordant $^{207}\text{Pb}/^{206}\text{Pb}$ ages) and is, in turn, cut by a late Devonian granodiorite. To the east, correlation of this succession with similar rocks outcropping in the Upper Arrow Lake area were, up to recently, solely based on field observations. New detrital zircon ages were obtained by LA-MC-ICPMS from various exposures of the calcareous quartzite between Vernon and Upper Arrow Lake. Several concordant or slightly discordant (<5%) grains were recovered and their $^{207}\text{Pb}/^{206}\text{Pb}$ age show a distribution of zircon populations of ~1.0-1.3 Ga, 1.6-2.0 Ga (with abundant 1.6-1.7 Ga grains) and 2.5-3.0 Ga. Moreover, a sample outcropping east of the Pinnacles yielded a 402 Ma zircon (concordant $^{207}\text{Pb}/^{206}\text{Pb}$ age). These preliminary results suggest that 1) most of the grain populations are of North American affinity, the ages (except for the 1.0-1.3 Ga Grenvillian-age grains) resembling those of dated basement rocks of the southern Alberta craton, and 2) the occurrence of an early Devonian grain is consistent with the regional correlations of this marker succession. These results imply that this mid-Paleozoic succession, which was previously interpreted as part of the pericratonic Kootenay Terrane, demonstrate a definite relation with respect to North America. Thus the boundary between allochthonous terranes and rocks having a North American affinity must lie outboard (west) of the present study area.

Metamorphism Of The Mount Roberts Formation in The Rossland-Trail Area, Southern British Columbia

L. McCluskey, E. Ghent and P. Simony

Department of Geology and Geophysics, University of Calgary, Calgary T2N 1N4

Metamorphism of the Pennsylvanian to Triassic Mount Roberts Formation is an important element of the metamorphic evolution of southern Omineca Belt because it lies between the Valhalla and Kettle-Grand Forks Cordilleran core complexes. Little work has been done on its metamorphic petrology because it lacks the useful pelitic assemblages. The area west of Columbia River, between Trail, Rossland and Castlegar has been chosen for study as it lies on the southwest flank of Valhalla complex and it provides a transect from low to high grade.

The Mount Roberts Formation consists mainly of fine grained meta-sandstone, meta-siltstone, conglomerate lenses, schist and minor marble layers. It lies unconformably on the Devonian Trail gneiss and is overlain unconformably by the Early Jurassic Rossland Group, an island arc assemblage of Quesnel Terrane. The formations are intruded by the Middle Jurassic Trail and Mackie plutons as well as by the mid Cretaceous Kinnaird pluton and the early Eocene Coryell Batholith. Lower structural levels of the Mount Roberts Formation and Trail gneiss are intruded by the Paleocene-Eocene Ladybird granite of the Valhalla complex and Mount Roberts strata continue into the complex. In the study area metamorphic boundaries trend N-S, a local departure from the WSW-ENE trend in this portion of southern Kootenay Arc. Chlorite and biotite zones lie on the west side, at the highest structural level. Garnet appears structurally lower and, to the east and at yet deeper levels, sillimanite occurs adjacent to, and within the Valhalla complex. Biotite and quartz is a pervasive assemblage. This renders establishing of grade and mapping of isograds difficult. In the sillimanite zone the assemblage sillimanite-garnet-biotite-plagioclase is found and locally, rare muscovite is present. Local occurrence of cordierite and gedrite and of sillimanite pseudomorphs after andalusite indicates a lower pressure stage in the metamorphic evolution. The Middle Jurassic plutons have minor hornfels zones and clearly cross-cut the garnet and lower grade assemblages which are therefore Middle Jurassic or older and post-date the Early Jurassic Rossland Group. Jurassic folds that are cut by the plutons have gentle axial plunges and trend N-S. At deeper structural levels, adjacent to the Valhalla complex, west trending lineations overprint the Jurassic folds and fabrics. Late Cretaceous, high grade metamorphism with west-trending linear fabrics is well documented in Valhalla complex and some of the younger fabrics and sillimanite grade metamorphism in the Mount Roberts Formation may also be Late Cretaceous.

A New Geological Map of the Thor–Odin Culmination, Monashee Mountains, Southern BC

Paul McNeill, Stefan Kruse and Paul Williams

*Dept. of Geology, University of New Brunswick
Fredericton, NB.
(P.McNeill@unb.ca)*

A new geological map of the Thor–Odin culmination, of Southern BC is presented. It is based on mapping from a variety of scales from 1:500 to 1:50,000 and presented on 1:20,000 TRIM digital topographic data at a scale of approximately 1:35,000. It is, to our knowledge, the only map of the area to be compiled at this scale and to present this level of detail.

The map represents the combined efforts of many researchers. Primarily data is taken from mapping by researchers at the University of New Brunswick and augmented by published data from other researchers. The map is therefore a compilation of geological research in the Gold Range area of the Monashee Mountains over the past forty years or more.

The structural history of the map area is partially evident from the map. The area exposes the contact between Paleoproterozoic, North American basement and the Proterozoic to Paleozoic sedimentary cover. It is apparent from the map that both of these units are intimately, interfolded and deformed into isoclinal folds that persist for up to 35 km and with amplitudes estimated up to 6 km. These structures are refolded by, at least, two generations of later more open folds, which interfere to produce dome-like features within the culmination and, indeed, define the culmination. All structures are cut by late shear bands and faults, some with significant displacements.

We suggest that this map will be beneficial to current research topics and help answer questions such as: What is the affect of late faults to the geometry and structure of the eastern Shuswap? What is the relationship between North American basement and its cover during orogenesis? What is the significance of recent geochronological studies to the eastern Shuswap relative to structural level in the orogen? What characterises the deepest, exposed, structural levels of the orogen? What mechanism is responsible for the production of dome-like features in the southern Omineca belt? How are high-grade fabrics formed? Are there variations in fabric with structural depth? Is there evidence of economic mineral deposits?

Cordilleran Terranes in Theory and Practice

JoAnne Nelson¹ and Maurice Colpron²

¹*B.C. Geological Survey, 1810 Blanshard St., Box 9333, Stn Prov Govt, Victoria, B.C. V8W 9N3; joanne.nelson@gemsl.gov.bc.ca;*

²*Yukon Geological Survey, P.O. Box 2703 (K-10), Whitehorse, YT Y1A 2C6; Maurice.Colpron@gov.yk.ca*

Detailed mapping of Yukon-Tanana and neighbouring terranes in the course of the 1998-2003 Ancient Pacific Margin Natmap project has identified, traced out, and shown relationships among a series of assemblages of regional extent and significance. These *tectonic assemblages* are defined on the basis of the age range of their components (stratigraphic units) and characterized according to their tectonic or depositional setting (*cf.* Gabrielse et al., 1991 – DNAG, p. 24). They form the basis for a new map of the Paleozoic pericratonic realm in northern B.C. and Yukon. They are the fundamental building blocks of a tectonically active, stratigraphically complex set of interacting crustal units – the terranes.

Key pericratonic tectonic assemblages are:

- **Snowcap assemblage** - pre-Late Devonian metasedimentary rocks, typically intruded by Devonian-Mississippian plutons. Distal continental margin assemblage that forms the basement to arc assemblages of Yukon-Tanana terrane.
- **Finlayson assemblage** - the stratified volcanic, sedimentary and associated intrusive rocks that make up the Late Devonian – Early Mississippian arc system of Yukon-Tanana terrane.
- **Klinkit assemblage** - volcanic arc rocks and associated clastic and carbonate strata of Late Mississippian – Early Permian age; characteristic of Paleozoic Quesnellia (Harper Ranch) but also occurring as onlaps on older Yukon-Tanana units. Most prominent in southern Yukon – northern B.C.
- **Slide Mountain assemblage** - oceanic strata (chert, argillite, basalt) and ultramafic and gabbroic intrusions; characteristic of Slide Mountain terrane but also occurring depositionally on the Yukon-Tanana and older parts of Slide Mountain terrane in the Finlayson Lake district.
- **Klondike assemblage** - Middle to Late Permian volcanic and intrusive arc rocks; most prominent in western Yukon.

Adjacent tectonic assemblages are typically separated either by unconformities or faults. They are commonly dissected by younger faults, but stratigraphic linkages between adjacent fault panels and assemblages are locally well documented. The relationships shown by these assemblages run counter to the original definition of *terranes* as fault-bounded bodies of rocks which preserve a geological record distinct from that of adjacent

terrane (*cf.* Gabrielse et al., 1991 – DNAG, p. 25). In the original development of the terrane concept, linking assemblages were limited to late, post-tectonic or post-amalgamation overlaps. Recent work by ourselves and others show that different type of linkages now exist between adjacent assemblages and terranes and that they are commonly time-dependent in nature. Contiguous terranes are now known to share (1) early, rift assemblages; (2) overlapping arc assemblages and shared plutonic suites; (3) syn-depositional linkages; as well as (4) post-amalgamation clastic overlaps and stitching plutons. In some cases, terranes shared an early depositional history, were then separated by rifting and evolved independently, and were finally later re-amalgamated during convergence.

This new tectonostratigraphic framework effectively eliminates some of the paleogeographic uncertainties that were previously inferred between adjacent terranes and their constituent assemblages. The relationships between Yukon-Tanana and its neighbouring terranes remind us of other anomalies that have developed within the framework of terrane studies, such as: (1) the Pennsylvanian pluton that links the Alexander and Wrangellia terranes; (2) the onlap of Slide Mountain assemblage on the Kootenay terrane; (3) Cambrian stratigraphic linkages between Kootenay terrane and Ancestral North America; (4) late Paleozoic and Triassic ties between Stikinia and Yukon-Tanana; and (5) the Early Jurassic plutonic suite that is shared by Stikinia, Yukon-Tanana and Quesnellia. This emerging pattern of relationships between established terranes requires either a wholesale revision of the major Cordilleran terranes and their boundaries, or a redefinition of the term terrane and its underlying concept.

Because the major terranes, entities such as Quesnellia, Yukon-Tanana, Stikinia, Cache Creek, Alexander and Wrangellia, are well entrenched in the Cordilleran culture, it appears wiser to preserve their identities. These terranes are widely recognized on the basis of their distinctive (although internally variable) geologic history, clear geographic extent, and spatial relationship to neighbouring terranes. They are useful, large-scale, fundamental tectonic entities upon which actualistic tectonic models of the Cordilleran orogen must rely. We therefore advocate revising the definition of a terrane to accommodate unconformities as terrane bounding features and to acknowledge that although a terrane has a distinct geological record, it is not necessarily unrelated to that of adjacent terranes. Under this loosened definition, a terrane may be bounded by faults for part of its history and then onlap onto its neighbour at a later stage. Such is the case between Yukon-Tanana and Slide Mountain terranes in the Finlayson Lake district, which shared a transform plate boundary in the Carboniferous until Slide Mountain (Campbell Range) basalt onlapped onto Yukon-Tanana terrane in Early Permian time.

A corollary of the proposed new definition is that it is now possible to identify groups of terranes (composite terranes?) for which internal paleogeographic affinities are suspected. The paleogeographic evolution of most of these large-scale entities involved significant mobility with respect to the North American craton. Five large-scale composite terranes or terrane affinity groups make up the Canadian Cordillera:

- **Ancestral North America:** its craton and miogeocline; includes Cassiar and parts of Kootenay terranes.
- **The "Central Cordilleran terrane group",** including Yukon-Tanana, Quesnellia, Stikinia, Slide Mountain and related smaller terranes. This represents the active mid-Paleozoic continental margin, parts of which rifted away and parts of which remained; the marginal ocean basins that came to separate them; the Late Paleozoic to early Mesozoic arcs that subsequently developed in part on the rifted pieces. The relationships of this terrane group to North America and relationships between its component terranes varied through time. Overall, it contains the complex and evolving history of the western margin of the continent, in the same sense that southeast Asia does for the Asian continent today.
- **The Cache Creek terrane group,** which represents the outer, accretionary edge of the continental margin. It contains several subterranes, tectonic slices that meet the original pure definition in their integrity and isolation: oceanic plateaus, melange belts, a primitive island arc (the Kutcho), as well as belts of high pressure metamorphic rocks. Contained Permian fossils indicate an exotic, western Pacific origin for at least some of the component slices.
- **The Insular terrane group,** including Wrangellia and Alexander. Contained Silurian and Permian faunas that indicate an exotic, Arctic origin for these terranes; and they depict igneous and deformational/metamorphic events without parallels on the western North American margin.
- **Pacific terrane group,** an accretionary belt along the present west coast that represents the late Mesozoic to present Pacific margin of the continent, as the Cache Creek terranes represented the earlier margin.

The revisions proposed here will likely mark a shift in Cordilleran tectonics research. Traditionally, the terrane concept has highlighted the differences between adjacent terranes. The renewed concept advocated here will hopefully focus future research toward the shared history of many of the terranes and resolution of the paleogeographic evolution of the large-scale composite terranes.

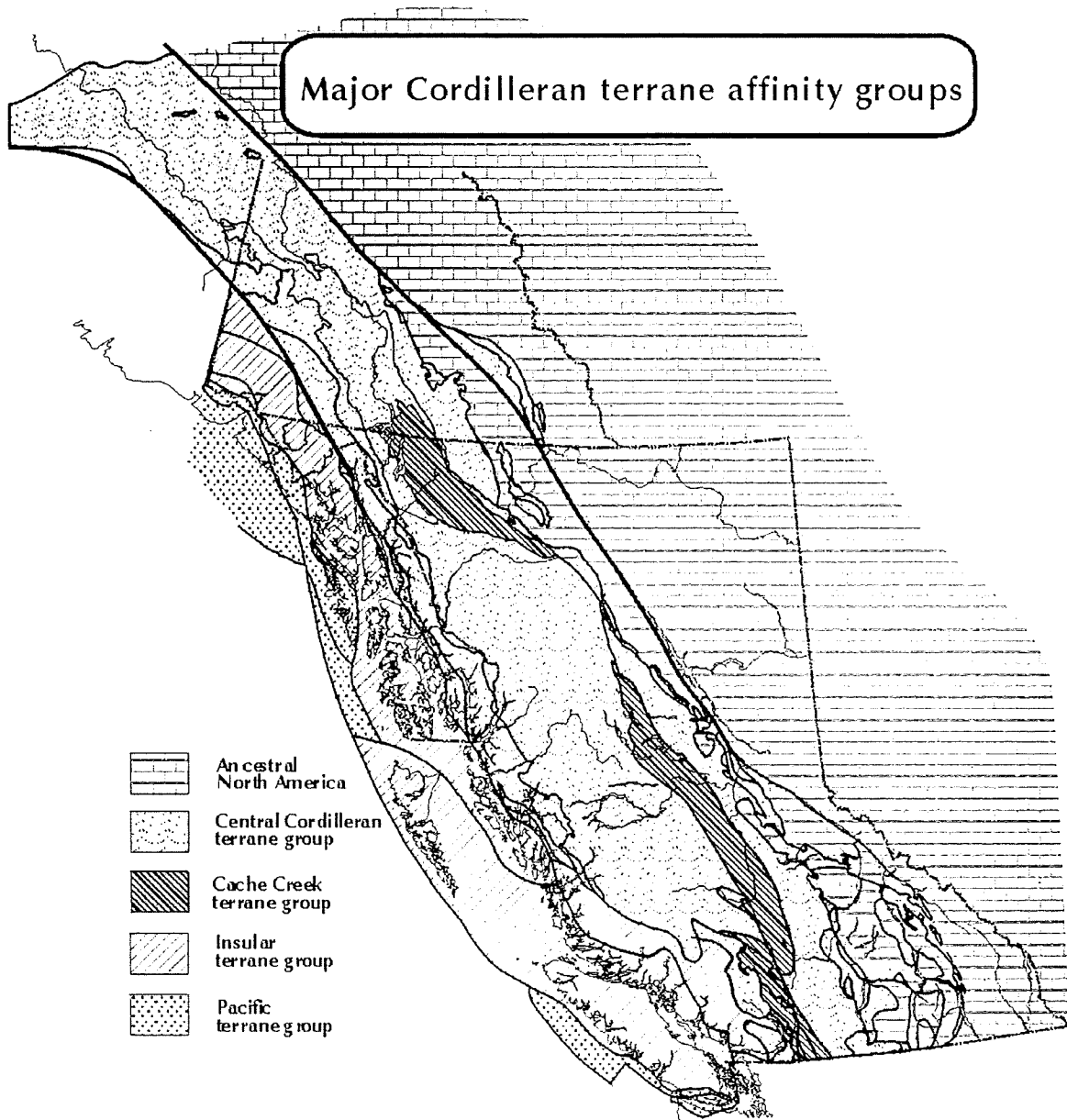


Figure 1

Structural Evolution and Seismic Modelling of Fold-Thrust Structures Developed in Analogue (Centrifuge) Models

T. E. Noble¹, J. M. Dixon¹, S. Pfister² and D. Lawton³

¹*Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, ON, Canada, K7L 3N6*

²*C-CORE, St. John's, NF, Canada, A1B 3X5*

³*Department of Geology and Geophysics, University of Calgary, Calgary, AB, Canada, T2N 1N4*

We investigate the structural evolution of fold-thrust systems by analog scale modelling carried out in a large geotechnical centrifuge at C-CORE, St. Johns, NF. In accord with scaling theory, the experiments replicate models previously deformed in the smaller but higher-*g* centrifuge at Queen's University. Multilayer models of foreland stratigraphic sequences are constructed of plasticine and silicone putty and shortened horizontally to simulate the nucleation and progressive growth of fold-thrust structures and fold-thrust systems as a whole.

Plane-layered models composed of five internally laminated stratigraphic units of alternating bulk competency deformed in the C-CORE centrifuge develop geologically realistic fold and thrust structures that offer insight into the timing of different deformation mechanisms that contribute to the development of an individual overthrust. Individual fold-thrust structures develop in the following progression: a buckle-fold train pervades a competent unit; small reverse faults (shear bands) localize in the forelimb of each buckle fold; a thrust ramp then cuts through the forelimb of the fold and the hanging-wall panel is displaced over the footwall ramp. The models clearly display an evolutionary relationship between folding and thrusting and the ramp spacing in model duplex structures is inherited from the buckle fold train that pervades the competent unit. During the structural evolution of the overthrust structures we interpret that the fault tip cuts both up-section towards the foreland through the forelimb of the fold in the competent unit, and down-section towards the hinterland into the underlying incompetent unit.

Fixed-offset and multi-offset physical seismic data have been collected from a deformed centrifuge model of a large fault-bend fold. Migrated sections correctly image the major reflection boundaries within the model, demonstrating the potential for using model seismic surveys for refining seismic processing and interpretation techniques in areas of complex structure.

Effective Petroleum Systems and Crude Oil Compositions in Bowser Basin

**K.G. Osadetz(1), C. Jiang(2), C.A. Evenchick(3), F. Ferri(4), L.D. Stasiuk(1),
N.S.F. Wilson(1) and M. Hayes(4)**

(1) *Geological Survey of Canada, Calgary, 3303 - 33rd St. N.W., Calgary, Alberta
T2L 2A7, kosadetz@nrcan.gc.ca*

(2) *Humble Geochemical Services Division, 218 Higgins Street, Humble, Texas 77338
U.S.A., djiang@humble-inc.com*

(3) *Geological Survey of Canada, Pacific, 101 - 605 Robson Street, Vancouver, B.C.
V6B 5J3, cevenchi@nrcan.gc.ca*

(4) *Oil and Gas Emerging Opportunities & Geosciences Branch, BC Ministry of Energy
and Mines PO Box 9323, 6th Flr. 1810 Blanshard St., Victoria, British Columbia, Canada,
V8W 9N3, Fil.Ferri@gems3.gov.bc.ca*

Crude oils extracted from Bowser Basin rocks indicate that at least three petroleum systems have been effective in generating crude oil, which is preserved as stains and fluid inclusions. The three petroleum systems are distinguished by molecular biomarkers that are controlled by biological evolution in marine and lacustrine environments. Through Phanerozoic time marine organisms have progressively selected to use a shorter cholesterol-like molecule in preference to the longer cholesterol-like homologues, except in lacustrine environments. As a result the ratio of the C28/C29 steranes in crude oils is observed to increase progressively through Phanerozoic time, from much less than one in the Paleozoic, to about unity at the Late-Early Cretaceous boundary, to more than one in the Present. This variation serves as a molecular clock that dates when the source rock of a given crude oil was deposited, regardless of where the has migrated to. In the Bowser Basin some oils have low C28/C29 sterane ratios, indicating that they were derived from Stikinine assemblage rocks, while other oils have high a C28/C29 sterane ratio indicating that they were derived from either the Hazelton or Bowser Lake groups. A third group of oils have sterane compositions, C27:C28:C29, that indicate a lacustrine source rock. The presence, in Bowser Lake Group reservoirs, of oils derived from the Stikine Assemblage is consistent with, and provides additional evidence for, previously inferred large lateral variations in the thermal maturity of the Bowser Basin. This also suggests that potential reservoirs in the Hazelton Group might contain petroleum -- a concept not considered previously. Therefore, the molecular composition of crude oils from Bowser Basin rocks both confirms and extends the petroleum prospectivity of the region.

Terminal Neoproterozoic (Ediacaran) evolution of the Cordilleran margin: Integrated correlation of the Upper Windermere Supergroup, northwestern Canada

Leanne J. Pyle, Guy M. Narbonne, Noel P. James, and Robert W. Dalrymple

Department of Geological Sciences and Geological Engineering, Miller Hall, Queen's University, Kingston, ON Canada K7L 3N6; lpyle@geol.queensu.ca

Terminal Neoproterozoic (Ediacaran Period, ca. 600 to 543 Ma) strata of the northern Canadian Cordillera (Mackenzie and Wernecke Mountains) contain deposits related to the rifting of Rodinia and the subsequent post-rift, passive-margin evolution of northwestern Laurentia. Strata of the upper Windermere Supergroup (Sheepbed, Gametrail, Blueflower and Risky formations) in the Mackenzie Mountains contain an exceptional Ediacaran biostratigraphic and isotopic (C and Sr) record, while the sequence stratigraphic record is subtle throughout this predominantly deep-water succession. Coeval strata in the Wernecke Mountains can be correlated with the succession in the Mackenzie Mountains on a formational level. In contrast to the deep-water setting of the Mackenzies succession, the Werneckes succession preserves a predominantly shallow-water succession amenable to detailed sequence stratigraphy. The siliciclastic and carbonate sediments, deposited along the margin of the proto-Pacific Ocean, record accumulation in continental slope, neritic, and terrestrial paleoenvironments. Previously, there have been only reconnaissance-style studies in the Wernecke Mountains that resulted in conflicting interpretations of the stratigraphy. Integrated lithostratigraphy, chemostratigraphy, biostratigraphy, and sedimentology partitions the Wernecke Mountains succession into five depositional sequences and constrains intrabasinal correlation with strata in the Mackenzie Mountains. Distinctive temporal chemostratigraphic and biostratigraphic attributes allow these strata to be correlated regionally and globally to other key Ediacaran successions (e.g., Namibia, Siberia). Integrating sequence stratigraphy with these attributes is a robust, yet under-utilized correlation tool and is a step toward erecting a more detailed working Neoproterozoic chronostratigraphy. Many controversies still surround the evolution of the western, proto-Pacific passive margin of Laurentia. It appears that rifting likely occurred in several phases from 780 Ma to 570 Ma, with an increase in abundance of sequence boundaries through the upper Windermere Supergroup indicating a renewed phase of uplift as young as 545 Ma.

The Aplitic Dykes of the Cantung Mine, NWT: Petrography, Geochemistry and Relationship to the Orebody

Kirsten Rasmussen, *University of Calgary*

Dr. David Pattison, *University of Calgary*

Hendrik Falck, *C. S. Lord Northern Geoscience Centre*

Bill Mann, *Consultant*

The Cantung mine in the Mackenzie Mountains, Northwest Territories, is one of the world's highest-grade scheelite deposits (minor Cu-Bi-Au), and has a past production of 4.6 million tons (grading 1.6% WO₃) with remaining reserves of 7.3 million tons (0.77% WO₃). The orebody occurs in two distinct zones: the Open Pit on the upper limb of the overturned anticline (mined from 1962-1974), and the underground E-zone along the hinge zone of the anticline (mined 1974-1986, 2002-2003). The pyrrhotite-scheelite mineralization occurs in garnet-diopside, amphibole, and biotite skarn, hosted within a Lower Cambrian marble. The skarn is spatially and genetically related to two adjacent mid-Cretaceous (91.6 +/-2.6 Ma; K-Ar biotite) granitic stocks of the Selwyn Suite, one of which underlies the mine workings. A series of 'aplitic' dykes crosscuts the country rocks and the underlying intrusion. They are concentrated around the underlying intrusion's margins and have an intimate spatial relationship to the orebody, and may also be highly mineralized themselves. The dykes intruded along pre-existing faults, fractures, and joints, often in predictable orientations. The dykes are peraluminous to metaluminous ($A/CNK = 0.90-1.30$). Immobile trace element ratios reflect a primary granite composition similar to the stocks, and the dykes appear to have undergone a low degree of fractionation with respect to the underlying granite. Varying degrees of alteration (e.g., potassic, sericitic, Na-Ca propylitic) within the dykes reflect incursions of later fluids. Strain features within the dykes are the result of the late faulting that cuts the underlying pluton and surrounding country rock, and this faulting may also be responsible for the release of fluids at depth in the cooling pluton. Scheelite occurs in intimate association with sulphides and is often found within, and in contact with, dykes that have undergone Ca-Na metasomatism as a result of Na-rich fluids in a Ca-rich host rock, manifested as considerably higher plagioclase and epidote contents and an absence of potassium feldspar. This indicates that the mineralizing fluids followed the emplacement of the dykes, some of which may have acted as a focus of injection for the gradually cooling magmatic fluids.

Structural styles and evolution of the southern extent of the Agrio Fold and Thrust Belt, Neuquen province, Argentina

David G. Repol and Deborah A. Spratt

*Department of Geology and Geophysics
University of Calgary
Calgary, AB T2N 1N4*

The Agrio Fold and Thrust Belt is a classic example of a thick and thin-skinned fold belt. Located in the Andean foothills of northern Patagonia, this belt is the result of the inversion of a Jurassic extensional basin during the Tertiary, Andean Orogeny. Due to different structural styles, the southern extent of this folded belt is divided into two main domains. The Internal domain is thick-skinned, whereas the External Domain is thin-skinned. The degree of shortening for the Agrio Fold and Thrust Belt (<30%), obtained from restored balanced cross-sections, demonstrates consistency with a fold belt resulting from the inversion of a previous extensional system.

The southern extent of the Agrio Fold and Thrust Belt contains evidence for two major episodes of intense tectonic activity. The Eocene was the time of the formation of the Internal Domain, through the inversion of the Jurassic half-graben system, under a dominant right-lateral strike-slip motion component. During the Neogene a renovated pulse of compression was responsible for development of the External Domain, resulting from a stress field that favoured dip-slip fault motion. Both tectonic episodes coincide with periods of high rates of convergence between the Nazca and the South American plate.

Triangle zone and gravity slide tectonics at the southern limit of the Main Ranges, southern Canadian Rockies

Kevin Root

EnCana Corporation, Calgary, Alberta, kevin.root@encana.com

The Fernie – Bull River area of southeastern British Columbia is located within a regional transverse structural zone, the Crowsnest Pass Cross-Strike Discontinuity [Price, 1994]. This area is one of the most geologically complex regions of the southern Canadian Rocky Mountains, and displays anomalous structural trends and significant lateral changes in stratigraphic character. A new structural interpretation of the area is proposed, based on 2003 fieldwork and on reinterpretation of existing geological maps (e.g., Leech, 1958; Benvenuto, 1978), wherein the Moyie-Dibble Fault is a regionally significant, eastward-directed thrust fault with more than 30 km of displacement. The Moyie-Dibble Thrust is well defined at surface in the Dibble Creek region to the west of the Bull River, but is interpreted as a blind thrust to the east where it enters a major triangle zone, herein called the Bull River Triangle Zone, that has the Moyie-Dibble Thrust as the lower detachment and the Gypsum Fault as the upper detachment. The tip of the triangle zone wedge – i.e., the line of convergence between the Moyie-Dibble and the Gypsum faults - is interpreted to be exposed in the Lime Creek area, a region that was described by Geoff Leech (1962) as a “veritable sinkhole of disappearing faults”.

Previous studies described the Hosmer Thrust as the major thrust fault in the region (e.g., Henderson and Dahlstrom, 1959; Thompson, 1962; Benvenuto and Price, 1979; Price, 2000), and concluded that additional structures such as the Moyie-Dibble and Gypsum faults are subsidiary splays associated with the Hosmer Thrust (Benvenuto and Price, 1979). The present study interprets the Trinity and Hosmer segments of the Hosmer Thrust as klippen that developed as superficial gravity glide structures when portions of the triangle zone roof succession slid off of the structurally elevated, southeastern and eastern regions of the triangle zone. The displacements on these faults are thus not considered to be directly related to tectonic shortening within the thrust belt. The Lizard segment of the Hosmer Thrust is considered to be unrelated to the Trinity and Hosmer segments, and is likely a northeasterly-directed thrust that formed due to Cordilleran contraction. The Trinity segment gravity slide klippe appears to truncate the Lizard Thrust, and thus apparently is younger.

The arcuate structural fabric of the region, with generally northerly strikes and trends north of the confluence of Bull River and Sulphur Creek, and generally southwesterly strikes and trends in the region to the south, is interpreted to reflect the shape of the eastern, frontal surface of the Moyie-Dibble Thrust Sheet. The sheet is interpreted to have a northerly-striking leading surface in the north, and a southwesterly-striking lateral edge along its southern limit. Southwest-trending Mesozoic structures in the vicinity of the southern portion of the Moyie-Dibble thrust sheet may have developed due to a component of convergence across the southern lateral edge of the sheet – i.e., eastward-directed movement across a southwesterly-trending edge. Alternately or additionally, these anomalous structures may have formed as the result of gravity-driven

stresses due to lateral spreading of the Moyie-Dibble Thrust Sheet as it was displaced eastward.

The southern limit of the Western Main Ranges of the Canadian Rockies coincides with the southern limit of the Moyie - Dibble Thrust Sheet, as the 6 km thick Lower Paleozoic succession that typifies the Main Ranges is carried within the thrust sheet, and is juxtaposed across the lateral edge with a 0 – 200 m thick Lower Paleozoic succession to the south. The development of the southern lateral edge of the Moyie-Dibble Thrust Sheet is interpreted to be the result of Mesozoic tectonic inversion of Paleozoic extensional (and left-lateral) faults that are inferred to have separated the Montana paleohigh from the deeply subsided Paleozoic 'shale basin' to the north. Two west-southwest-striking reverse faults near the southeastern limit of the Moyie-Dibble Thrust Sheet juxtapose structural panels that have significant differences in the levels of erosion below the sub-Devonian unconformity that indicate that these faults may have had down-to-the-northwest extensional displacements on them prior to the Middle Devonian. These faults thus may be part of the family of faults that formed the southern boundary of the Lower Paleozoic shale basin. Both faults are now reverse faults, and are suggested to have undergone contractional inversion during Mesozoic Cordilleran tectonism as the Moyie-Dibble Thrust Sheet was emplaced into the triangle zone.

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

Tyler W. Ruks¹, Stephen J. Piercey¹, James J. Ryan², Steven P. Gordey², Michael E. Villeneuve³ and Robert A. Creaser⁴

1- Mineral Exploration Research Centre (MERC), Department of Earth Sciences, Laurentian University, Ramsey Lake Road, Sudbury, ON, P3E 2C6

2- Geological Survey of Canada, 101-605 Robson Street, Vancouver BC, V6B 5J3

3- Geological Survey of Canada, 601 Booth Street, Ottawa ON, K1A 0E8

4- Department of Earth and Atmospheric Sciences, University of Alberta, 1-26 Earth Sciences Building, Edmonton, Alberta, T6G 2E3

Augen granitoids are critical rocks for understanding the architecture and evolution of the Yukon-Tanana Terrane (YTT). Devonian-Mississippian potassic feldspar augen granitoids mark the onset of magmatism in the Stewart River area, forming a roughly northwest by southeast trending belt from Alaska to southeast Yukon. The Stewart River area hosts a Permian population not recognized elsewhere in the YTT. Field mapping, geochemical and Sm-Nd isotopic studies of both age suites aim to understand the evolution of the YTT in the Stewart River area, with emphasis on characterizing the basement of the YTT throughout the late Paleozoic.

The Devonian-Mississippian augen granitoids have been divided into three geographic groups: 1) Fifty Mile Batholith; 2) Mt. Burnham Orthogneiss; and 3) proximal to dated augen granitoids near the Stewart River. The Permian suite is divided into three geographic groups: 1) a linear belt of augen granitoids in the western portion of the Stewart River map sheet; 2) undated samples that are part of the latter belt; and 3) samples in the eastern portion of the Stewart River map sheet that are likely related to the Permian Sulphur Creek Orthogneiss. Relative to primitive mantle, both age suites have very consistent and similar calc-alkaline trends characterized by LREE enrichment ($La/Yb_{avg} = 12.4$), and negative Nb and Ti anomalies, indicating derivation from upper crust-like sources within a continental arc environment.

Samarium-neodymium isotope data for both suites yield ϵNd_t (Devonian: -5.4 to -12.6; Permian: -8.8 to 2.3) and T_{DM} ages (Devonian: 1.49 to 2.26 Ga; Permian 1.37 to 2.08 Ga) that suggest influence from ancient continental crustal materials of Proterozoic age. These characteristics are similar to other YTT rocks and the western side of the North American craton. Neodymium crustal index values indicate that Devonian-Mississippian augen granitoids have a larger crustal component (65 to 87%) relative to the Permian granitoids (39 to 72%) which are interpreted to have a greater mantle component. Collectively these data suggest that the YTT evolved an episodic Paleozoic magmatic belt, underlain by Proterozoic crust of probable western North America affinity.

Tectonic evolution of Yukon-Tanana Terrane in the Stewart River area, western Yukon

James J. Ryan¹, Steven P. Gordey¹, Michael E. Villeneuve², Stephen J. Piercey³ and Tyler W. Ruks³

1 - Geological Survey of Canada, 101-605 Robson Street, Vancouver, B.C., V6B 5J3,

2 - Geological Survey of Canada, 601 Booth Street, Ottawa, ON, Canada K1A 0E8,

3 - Department of Earth Sciences, Laurentian University, Sudbury, ON, P3E 2C6

Four years of regional bedrock mapping have been completed in the Stewart River area (see Gordey et al, this volume), focused on a widespread tract of Paleozoic rocks of the pericratonic Yukon-Tanana Terrane (YTT). The YTT rocks were intruded by younger plutons (Jurassic, Cretaceous and Eocene), and overlapped by middle to late Cretaceous conglomerates and volcanic rocks. Deciphering the protoliths, and tectonic evolution of the YTT rocks required unraveling two high-strain structural transposition episodes, and one or more amphibolite-facies metamorphisms. To this end, the mapping has been complimented by multi-method geochronology, whole rock geochemistry and isotopic geochemistry, allowing us to make farther-reaching interpretations of the history of these highly deformed and metamorphosed rocks.

Metasiliciclastic rocks occur throughout the map area. They are dominated by psammite and quartzite, with lesser pelite and rare conglomerate. The youngest detrital zircon grains of a conglomerate and a quartzite yield preliminary U-Pb SHRIMP ages of late Devonian and early Mississippian respectively, with a compliment of Archean to Proterozoic grains of similar ages to those recovered from the Precambrian of the western North American miogeocline. The older zircons may have experienced multiple sedimentary cycles.

Intermediate to mafic composition amphibolite, likely derived from volcanic to volcanoclastic protoliths, interdigitates with and lies stratigraphically above the siliciclastic rocks. The amphibolites locally have very coarse metamorphic grain size, but commonly preserve significant, cm-scale, compositional heterogeneity interpreted as recording primary volcanic to volcanoclastic heterogeneity. Preliminary trace element geochemical data for the amphibolites indicate three groupings, in order of prevalence: 1) island arc tholeiites; 2) light rare-earth element (LREE)-enriched IAT; and 3) non-arc, mid-ocean ridge basalts (MORB). We interpret the few non-arc specimens to represent a transitional signature from arc magmatism to ocean floor magmatism (probably rifting in the back-arc region). The amphibolites are essentially devoid of felsic metavolcanic rocks, demonstrating that this portion of the arc was mafic dominated, and as such, does not allow us to readily date the volcanic 'stratigraphy'. Marble horizons within both the amphibolite and siliciclastic rocks represent fringing reefs or local carbonate buildups. Analysis of several carbonate samples for microfossils has been unsuccessful, likely due to the degree of metamorphism and strain.

A complex of dominantly metaluminous orthogneissic rocks composed of diorite, tonalite, granodiorite and monzogranite protoliths, intrudes both the siliciclastic and amphibolitic assemblages, and is spatially coincident with the amphibolites. We believe this association lends support of a magmatic link between the arc metavolcanic rocks and the plutons, which represent the subvolcanic intrusive complex of the arc. Preliminary geochemical analysis of the metaluminous plutonic rocks show calcalkaline arc signatures, with a couple of more mafic samples tending towards tholeiite. Across the northwest-trending structural grain of the map (and the region), the amphibolite and orthogneiss complex is between 55 and 60 km wide. While we recognize that this width is the result of significant structural modification, the scale is consistent with the scale of well documented younger magmatic arcs in the Cordillera (e.g. Eocene in the Coast Belt), and may provide a glimpse at the original width of the arc. Preliminary U/Pb zircon geochronology of the metaluminous plutonic rocks range in age from ca. 355-345 Ma, the younger of which is similar to the youngest population of zircon from a quartzite specimen. This indicates a complex history involving intra-arc unconformities in which Mississippian plutons intruding older parts of the siliciclastic succession were uplifted, eroded and shed detritus into younger parts of the siliciclastic basin, synchronous with Mississippian arc magmatism. A Mississippian unconformity is evident in other areas of YTT (e.g., Glenlyon), and may be of regional extent.

Peraluminous, potassic feldspar, augen granite orthogneiss bodies abound in the map area, and can be divided into two age groups: 1) Devonian (ca. 360 Ma); and 2) Permian (ca. 260 Ma). These are not easily differentiated in the field, however, follow-up analyses are elucidating their makeup and geographic separation (see Ruks et al., this volume). The Devonian augen granite bodies are restricted to the northeastern and middle parts of the map, and a region northwest of our mapping. There does not seem to be a direct spatial association between the augen granites and metaluminous plutons, an observation that has important implications when deciphering the tectonic and magmatic development of the arc (see below). Devonian plutons hosted by siliciclastic rocks demonstrate that some siliciclastics are Devonian or older. Permian bodies occur in two main northwest-trending swaths in the southwest and northeast parts of the map, and represent the most widespread region of Permian plutonic activity anywhere in the YTT. They are spatially associated with Klondike schist, derived from a combination of the plutons and their probable volcanic counterparts. The Permian Klondike schist and plutons represent a separate arc event, built unconformably upon the Devonian-Mississippian arc. The ca. 260 Ma rocks exhibit the amphibolite facies transposition foliation, which is cross-cut by a ca. 253 Ma intrusion. Metamorphic overgrowths on detrital zircons from the meta-conglomerate yielded SHRIMP ages of ca. 260 Ma, indicating that the main transposition event is syn-magmatic with the Permian arc magmatism. Because there is no collision event recorded in Permian stratigraphy along the exposed North American miogeocline, we interpret the transposition event to have occurred in an intraoceanic environment, wherein the arc "collided" with its own subduction zone.

Isotopic data from the meta-igneous rocks not only helps differentiate magmatic suites, but also sheds light on the make-up of the basement of the magmatic arc(s). The ca. 360 Ma suite of augen granites show highly evolved isotopic signatures and largely Paleoproterozoic model ages. This data combined with their highly potassic, peraluminous composition is consistent with late Devonian melting of, or melt interaction with, Paleoproterozoic continental basement. Isotopic signatures of the calcalkaline metaplutonic rocks (355-345 Ma) are less evolved. The mafic-dominated island arc tholeiites are largely juvenile. We interpret this data to reflect the magmatic evolution of the arc, and alteration of its basement. We suggest that the earliest phase of subduction zone related magmatism interacted with thin, stretched continental crust, of possible western North America affinity. As the arc evolved, it was sourced more directly from the mantle. This may have been due to armoring of igneous conduits, or further thinning and removal of continental basement from the arc axis (consistent with extensive arc related extension, ultimately leading to back arc extension). The Permian rocks show a renewed, highly evolved isotopic signature, similar to that of the Devonian granites, indicating that as a new arc developed on the old, Proterozoic crust was at least locally still present in the basement.

After allowing for Cretaceous-Tertiary offset along Tintina Fault (425 km), the Stewart River area lies directly westward of the Finlayson Lake VMS district. The arc magmatism and subsequent extension inferred for the Stewart River amphibolites may therefore represent a western, more central part of the arc, coeval with the Devono-Mississippian back-arc magmatism recorded at Finlayson Lake. En masse, the YTT was ultimately emplaced in the Jurassic-Cretaceous when it was delaminated from its basement and thrust as a thin(?) sheet above the ancestral North American margin. There seems little chance of finding regions of YTT still tied to its Devono-Mississippian, or older, basement.

Late Paleozoic-Early Mesozoic arc and back-arc volcanism in the Semenof Hills of south-central Yukon, northern Canadian Cordillera

Simard, R.-L.^{1*}, Dostal, J.², Colpron, M.³, and Gehrels, G.E.⁴

¹*Department of Earth Sciences, Dalhousie University, Halifax, NS, B3H 3J5,*

²*Department of Geology, Saint Mary's University, Halifax, NS, B3H 3C3, Yukon*

³*Geological Survey, P.O. Box 2703 (K-10), Whitehorse, Yukon, Canada, Y1A 2C6,*

⁴*Department of Geosciences, University of Arizona, Tucson, Arizona, 85721, USA.*

The poorly-known volcano-sedimentary sequences of the Semenof Hills in south-central Yukon lies within the belt of pericratonic terranes that extends between ancestral North America, and the accreted oceanic and arc terranes of the northern Canadian Cordillera. Recent bedrock mapping and new geochronological studies of the southern Semenof Hills reveals the presence of four exceptionally well preserved volcano-sedimentary sequences that spread from Late Paleozoic to Early Mesozoic age.

The Moose Formation, Devonian in age, is composed of massive to pillowed fine-grained basaltic lavas of N- and E-MORB composition, overlain by discontinuous quartz-feldspar-phyric felsic volcanic rocks of earliest Mississippian age. These rocks are probably related to the development of a back-arc system.

Unconformably overlying the Moose Formation, is the Semenof Formation, composed in the south of thinly bedded fragmental volcanic rocks interbedded with a few calcareous horizons which yielded detrital zircons with Devonian to Late Triassic ages, and in the north of massive plagioclase- and clinopyroxene-phyric, locally amphibole-phyric andesitic lava flows interbedded with minor clastic layers and volcanic conglomerates intercalated with minor porphyritic andesitic lava flows. These flows have chemical characteristics of calc-alkaline rocks of island-arc suites. The northern part of the Semenof Formation represents very proximal facies within the arc system with abundant porphyritic lava flows and volcanic conglomerates. The southern part represents a more distal part with the thinly bedded fragmental volcanic rocks interpreted as megaturbidite sequences typical of an unstable volcanic environment.

The third sequence, thrust on top of the Semenof Formation, consists of massive to pillowed basaltic lavas and mafic volcanoclastic rocks, overlain by discontinuous fossiliferous Upper Pennsylvanian to Early Permian limestone. The volcanic facies observed in the mafic volcanic rocks suggest submarine volcanism, probably related to ocean-floor spreading or back-arc basin formation.

The last sequence, the Boswell Formation, is mainly composed of clastic rocks, sandstone and chert-rich conglomerate, with minor volcanoclastic rocks, overlain by fossiliferous Pennsylvanian limestone. This sequence probably represents marginal basin sedimentation.

The Semenof Hills rocks record an unique succession of back-arc and island-arc volcanism from Late Devonian to Early Jurassic. The back-arc successions of Devonian and Pennsylvanian to Early Permian age are likely equivalent to those found in the pericratonic Yukon-Tanana terrane. The Early Jurassic island-arc volcanic rocks are more likely part of the Mesozoic Stikine or Quesnel terrane. Therefore, the pericratonic Yukon-Tanana terrane is probably the basement of parts the Mesozoic Stikine and/or Quesnel terranes in central Yukon.

Paleozoic Basements of Quesnellia in SE BC, Jurassic and Cretaceous Thrust Tectonics and Canada – Quesnellia Relations

P. Simony, *University of Calgary*

J. Sevigny, *Iridium Consulting Inc.*

J. Mortensen, *University of British Columbia*

The nature of the basement on which the Triassic-Jurassic arc assemblages of Quesnellia rest varies from location to location in southern British Columbia. Two contrasting types of relationships can be identified. In a belt extending westward from the northern Kootenay Arc, recent work has suggested Quesnellia rocks are linked depositionally and geochemically to North American stratigraphy and basement. North of this belt, Quesnellia rocks have been shown to lie on thick packages of oceanic Slide Mountain Terrane and these were thrust, prior to ~ 165 Ma onto strata that are linked to Canadian stratigraphy. In a belt north of Latitude 49°N, Quesnellia arc rocks lie unconformably on rocks not linked to ancient cratonic crust but showing possible links to Kootenay Terrane.

Major mid.-and Late Cretaceous shear and thrust zones dip westward under Quesnellia and the rocks on which it lies stratigraphically and/or tectonically. It is thus clearly allochthonous in the thrust-tectonics sense with respect to cratonic North America. Yet, the thrust geometry and the margin geometry of ancient North America have conspired to preserve locally, remnants of the original depositional margin of Triassic-Jurassic Quesnellia on ancient western Canada. Elsewhere more outboard portions of Quesnellia that were built on deformed Paleozoic Oceanic rocks and on stumps of the arc that fringed western North America in the Devonian, were thrust onto Canadian strata in the Jurassic. Nowhere in the region discussed here is there likely to be Quesnellia lower crust or mantle. Igneous rocks younger than Early Jurassic are unlikely to contain xenoliths or geochemical signatures derived from ancient Quesnellia lower crust or mantle.

**Towards a new crustal scale cross section along the 49th parallel:
Constraints on deformation and potential reconstructions of the western
margin of North America**

Sarah J. Travis and Frederick A. Cook

*Department of Geology and Geophysics
University of Calgary, Calgary, AB T2N 1N4*

For more than 20 years, geological and geophysical studies in the southern Canadian Cordillera have provided a wealth of data on the crustal structure and tectonic evolution. One of the key components to any reconstruction is the development of balanced and retro-deformed cross sections. Data and resources are now available to construct a continuous, crustal scale seismic reflection profile in southern British Columbia and northeastern Washington that: 1) is orthogonal to regional strike, 2) is geometrically constrained by surface geological mapping and 3) crosses the Cordillera where post-compressional extensional faults are minimal. This section allows for a unique view of the orogen and implications for its development, and in combination with previous research, will provide a more complete 3D view of the western margin of North America and its evolution to present day geometries.

The section demonstrates an ability to track Proterozoic Belt-Purcell strata beneath the Kootenay Arc and accreted Quesnel terrane to the western edge of the Belt-Purcell basin, now located at, and perhaps having controlled the initiation of, the Kettle River Fault. North American Neoproterozoic and Early Paleozoic strata are exposed within the Grand Forks, Tenas Mary and Okanagan core complexes along the line of section. These strata provide important limits on the geometry of the obduction surface and associated Quesnel strata, restricting present day thickness to less than ~5 km.

The Gwillim Creek Shear Zone (GCSZ) is also projected downplunge into the section line to beneath the Kootenay Arc at an approximate depth of 12 km. The presence of this Late Cretaceous ductile shear and its potential linkage to deformation in the foreland implies that it is a major structure that projects along the section, and perhaps much farther west. The trajectory of the GCSZ can either remain within the upper crust; represented by a package of laterally correlative reflectors at 3-4 seconds (~9-12 km depth) with a crustal scale ramp to the west of the section, or it can step down into the middle crust along a west-dipping ramp within the section. In either scenario, the GCSZ must accommodate large amounts of transport, potentially carrying pre-Purcell crystalline rocks to surface within the core complexes. The latest contractional structure (representing the base of deformation, the Rocky Mountain Basal Detachment - RMBD) must accommodate early Eocene thrusting in the foreland, and is interpreted to remain deep within the crust, at greater than 30 km.

The extent to which ductile flow within the middle and deep crust of the section characterized the deformation style is not yet resolved. For the purposes of restoration of the structures, discrete, though not necessarily brittle, deformation zones are assumed. The integration of other deformation models involving mobility of crustal layers is expected to aid in future efforts to reconstruct the deformational history.

