XIX Cordilleran Tectonics Workshop
Queen's University, Kingston, Ontario
February 19-21, 1993

Final Program

Friday, February 19

7:00-10:00 p.m. Registration and Welcoming Reception (cash bar).
Queen's Faculty Club (168 Stuart Street, Kingston -- just west of the south end of University Avenue.) Posters may be set up in Miller Hall this evening if desired.

Saturday, February 20

8:30-9:00 a.m. Registration and Poster set-up.
Miller Hall Lobby

Oral Presentations (Miller Hall, Room 105)

9:00-9:10 a.m. Opening Remarks by John M. Dixon (Queen's University)

9:10-9:30 a.m. Philippe Erdmer (University of Alberta)
The SNORCLE Transect - Present status, objectives and opportunities.
(P. Erdmer, E.R. Kanasewich, F.A. Cook, H. Helmstaedt, A.G. Jones & W.A. Padgham)

9:30-9:50 a.m. Robert Stevens (University of Alberta)
Tectonic evolution of the Teslin Suture Zone, a major plate boundary in south-central Yukon Territory.

9:50-10:10 a.m. Tekla Harms (Amherst College)
News and views from the Thirtymile Range: Stratigraphy, structure, and possible correlations in the Dorsey Terrane.

10:10-10:40 a.m. Coffee Break

10:40-11:00 a.m. Liz Turner (Queen's University)
Giant Neoproterozoic reefs from the Little Dal Group, Mackenzie Mountains, NWT: Filling the ecological gap between Precambrian and Paleozoic reef communities.

11:00-11:20 a.m. Guy Narbonne (Queen's University)
Integrated bio- and chemo-stratigraphy of the Neoproterozoic Windermere Supergroup, northwestern Canada.
(G.M. Narbonne, A.J. Kaufman & A.H. Knoll)

11:20-11:40 a.m. Troy Rasbury (University of Texas at Austin)
Ages of cross-cutting plutonic rocks in the Yellow Aster Complex, North Cascades, Washington.

11:40 a.m. - 12:00 p.m. Discussion

12:00-1:30 p.m. Lunch Break

1:30-1:50 p.m. Guowei Zhang (McGill University)
Strike-slip faulting and block rotation in the McConnell Creek Area, north-central British Columbia.

1:50-2:10 p.m. Rob Scammell (Queen's University)
High-temperature thermochronologic and barometric constraints on the mid-Cretaceous exhumation regime, Monashee Mountains, B.C.

2:10-2:30 p.m. Paul Williams (University of New Brunswick)
Deformational and metamorphic history of the Blanket area of the Thor-Odin culmination of the Monashee Complex. (P.F. Williams, R.L. Brown & R.N. Spark)

2:30-3:00 p.m. Coffee Break

3:00-3:20 p.m. Philip Simony (University of Calgary)
The remaining shreds of the Trail Gneiss - fragments of a Devonian continental margin.

3:20-3:40 p.m. Randy Parrish (Geological Survey of Canada, Ottawa)
The Monashee Complex as a tilted crustal section.

3:40-4:00 p.m. Ray Price (Queen's University)
Eocene crustal stretching, south-central Canadian Corillera: passive upper crustal response to ductile boudinage of the lower crust above a fluid upper mantle.

4:00- Poster Discussions

Saturday evening is open for dinner, poster discussions and other entertainment (to be arranged).

Sunday, February 21

9:00-9:20 a.m. Richard L. Brown (Carleton University)
Comparison of the Selkirk fan structure with mechanical models: Implications for palinspastic reconstructions of the Southern Canadian Cordillera. (R.L. Brown, C. Beaumont & S. Willett)

9:20-9:40 a.m. Stephen Grasby (University of Calgary)
New correlations of the Hadrynian Windermere Supergroup in the northern Selkirk Mountains, British Columbia. (S.E. Grasby & R.L. Brown)

9:40-10:00 a.m. Maurice Colpron (Queen's University)
Relationship between the emplacement of high-level Middle Jurassic plutons and the regional SW-verging deformation of the Illecillewaet synclinorium, N. Selkirk Mountains, B.C.

10:00-10:30 a.m. Coffee Break

10:30-10:50 a.m. Charles Ferguson University of Calgary)
The suprastructure-infrastructure transition of the hinterland and its role in the initiation of thrusting in the foreland of the Canadian Cordillera.

10:50-11:10 a.m. Marian Warren (Queen's University)
Stratigraphic relationships in the Horsethief Creek and Hamill Groups of the W. Purcells: Implications for Late Proterozoic/Early Paleozoic evolution of the N. American margin.

11:10-11:30 a.m. Gerry Ross (Institute of Sedimentary and Petroleum Geology)
Geochronology of sub-Fairholme granitic detritus (Bull River, B.C.): The case of the missing miogeocline.

11:30 a.m. - 1:00 p.m. Lunch Break

1:00-1:20 p.m. Sebastien Castonguay (Queen's University)
Evolution of a steep oblique hangingwall ramp near the southern termination of the Misty Thrust Rocky Mountain Front Ranges, Kananaskis country, Alberta. (S. Castonguay & R.A. Price)

1:20-1:40 p.m. Greg Soule (University of Calgary)
The Triangle Zone and Foothills structures, Grease Creek Syncline area, Alberta.

1:40-2:00 p.m. Peter Fermor (Shell Canada Limited)
Some aspects of the three-dimensional structure of the Alberta Foothills.

2:00-2:40 p.m. Daniel Lebel (McGill University)
Numerical modelling of thin-skinned thrust systems - Insights on the propagation of faults and the thrust transfer zone problem. (D. Lebel & E.W. Mountjoy).

2:40-3:00 p.m. Concluding Remarks and Plan for 1994 Workshop.

3:00 p.m. Coffee, Poster Discussions and Adjournment.

Posters

Doug Oliver (Southern Methodist University)
Structural and kinematic evolution of the Teslin Suture Zone, Little Salmon Lake, Yukon.

Paul Schiarizza (British Columbia Geological Survey Branch)
Structural and stratigraphic relationships between Cadwallader and Bridge River terranes, and Tyaughten and Methow basins, eastern Coast Belt, southwestern British Columbia.

Charles Ferguson (University of Calgary)
Structural geology of northern Cariboo Mountains, B.C.

Doug Archibald (Queen's University)
A $^{40}Ar/^{39}Ar$ transect of the Monashee Decollement.

Robert Spark (University of New Brunswick)
Structural relationships within the Thor-Odin culmination of the Monashee Complex, southeastern British Columbia. (R.N. Spark & P.F. Williams)

Maurice Colpron (Queen's University)
Relationship between the emplacement of high-level Middle Jurassic plutons and the regional SW-verging deformation of the Illecillewaet synclinorium, N. Selkirk Mountains, B.C.

Pat Stinson (University of Calgary)
Geology and structure of the eastern margin of the Coryell Batholith, southeast British Columbia. (P. Stinson & P. Simony)

Joel Jansen (Queen's University)
A mid-Cretaceous-to-Paleogene tectonothermal history for the Kootenay Arc and Purcell anticlinorium derived from $^{40}Ar/^{39}Ar$ age spectra of K-feldspar. (J. Jansen & D.A. Archibald)

Ted Doughty (Queen's University)
The Purcell Trench normal fault, northern Idaho, U.S.A. (P.T. Doughty & R.A. Price)

Marian Warren (Queen's University)
Stratigraphic relationships in the Horsethief Creek and Hamill Groups of the W. Purcells: Implications for Late Proterozoic/Early Paleozoic evolution of the N. American margin.

Melanie Kells (Queen's University)
Thermobarometry of Horsethief Creek Group pelites from the contact aureole of the Glacier Creek Stock, western Purcell Range. (M.P. Kells & D.M. Carmichael)

Colin Zelt (Geological Survey of Canada, Ottawa)
Crustal structure across the Omineca-Rocky Mountain fold and thrust belt transition, southeastern Canadian Cordillera.

Shumin Liu (University of Calgary)
Three-dimensional character of Foothills structures in Grande Cache area. (S. Liu, D.C. Lawton & D.A. Spratt)

Daniel Lebel (McGill University)
Structure of a segment of the eastern Front Ranges and Foothills between Athabasca and Brazeau Rivers, Alberta. (D. Lebel & E.W. Mountjoy)

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Note concerning travel grants: Graduate students presenting an oral or poster paper will be reimbursed 75% of APEX or other discounted air fare, provided that the fare was paid by the student personally (not reimbursed from a research grant). Ticket stub or original receipt required; these may be submitted to John Dixon at the meeting or by mail by March 8, 1993.

Abstracts, XIX Cordilleran Tectonics Workshop (1993)

A $^{40}Ar/^{39}Ar$ transect of the Monashee decollement.

D.A. Archibald
Department of Geological Sciences, Queen's University, Kingston, Ontario, K7L 3N6

$^{40}Ar/^{39}Ar$ age spectra for biotite, muscovite and hornblende from an E-W transect of the western Frenchman's Cap dome near Ratchford Creek indicate a simple thermal history involving:

1. Late Cretaceous-to-Paleocene overprinting of rocks in the footwall of the Monashee decollement to temperatures near the closure temperature of hornblende (ca. 500°C), and
2. Eocene (ca. 47-48 Ma) cooling through the closure temperatures of biotite and muscovite (ca. 280 and 350°C, respectively) in both the footwall and hangingwall.

Most spectra record the presence of some excess argon but the effect appears to be greatest in micas at the maximum structural depth sampled for this study north of the Bourne glacier.

COMPARISON OF THE SELKIRK FAN STRUCTURE WITH MECHANICAL MODELS; IMPLICATIONS FOR PALINSPASTIC RECONSTRUCTIONS OF THE SOUTHERN CANADIAN CORDILLERA.

Richard L. Brown, Department of Earth Sciences, Carleton University, and Ottawa-Carleton Geoscience Centre, Ottawa, Ontario K1S 5B6, C. Beaumont, S. Willett, Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, B3H 4J1.

Physical sandbox and numerical finite element models demonstrate that a uniform Coulomb crustal layer that deforms under basal boundary conditions, which correspond to asymmetric detachment and underthrusting (subduction) of the underlying substrate (mantle lithosphere), develops as a crustal scale structural fan. The fan has a broad "prowedge" of thrusts and folds that verge toward the direction of convergence and a narrower "retrowedge" of thrusts and folds that develop above the stationary lithospheric plate.

The Selkirk fan of the Canadian Cordillera has a similar structure to the models and we infer that it originated during Jurassic accretion of terranes to the western boundary of cratonic North America by processes analogous to those reproduced by the models. Palinspastic restoration of the Selkirk fan places it within the present geographic limits of the Coast Belt during the Jurassic. By implication the North American plate extended this far west in Early Jurassic time.

Reference to LITHOPROBE profiles supports this interpretation and suggests that lower crust underlying the Intermontane Belt and the eastern edge of the Coast Belt is the relict of the pre-Jurassic North American plate. If correct it implies that the accreted terranes that overlap this plate boundary by approximately 200 km are crustal slivers that were detached from their subducted lithosphere, deformed in the manner of the models, and obducted onto the North American plate.

EVOLUTION OF A STEEP OBLIQUE HANGING WALL RAMP NEAR THE SOUTHERN TERMINATION OF THE MISTY THRUST FAULT, ROCKY MOUNTAIN FRONT RANGES, KANANASKIS COUNTRY, ALBERTA

Castonguay, Sébastien and Price, Raymond A., Department of Geological Sciences, Queen's University, Kingston, Ontario K7L 3N6

The hanging wall of the Misty thrust fault follows a décollement within the lower part of the Upper Devonian Palliser Formation over an interval of 25 km extending to the south end of the Misty Range. There, the fault cuts abruptly upward through 2 km of Upper Paleozoic and Triassic strata to another décollement within the Jurassic Fernie Group. It follows this décollement southward for 6 km to its termination in the core of a small fold in strata of the Kootenay Group. Over most of this interval the footwall comprises Kootenay and Fernie strata, and the fault is essentially planar. The hanging wall ramp is marked by an oblique, southeast-plunging fault-bend fold, within which are two small oblique back thrusts. These backthrusts show that the Misty thrust propagated laterally into a tectonic wedge structure, forming an oblique 'triangle zone' that was partly over-ridden by the thrust sheet.

The Lewis thrust fault, which overlaps the south end of the Misty thrust, is not folded by the oblique, hanging wall-ramp anticline in the Misty thrust sheet. The Lewis thrust follows a relatively planar décollement in the Mississippian Livingstone Formation along its hanging wall, but it has an oblique ramp along its footwall where it crosses the fault-bend fold in the underlying Misty thrust sheet. These relationships show that displacement along this part of the Lewis thrust fault occurred after displacement on the underlying Misty thrust.

The configuration and evolution of the oblique hanging wall ramp at the south end of the Misty Range provides an actualistic model for the interpretation of lateral ramps marking the ends of the oil and gas reservoir structures in the Foothills belt that are concealed by overlying deformed Mesozoic rocks.

Relationship between the emplacement of high-level Middle Jurassic plutons and the regional SW-verging deformation of the Illecillewaet synclinorium, N. Selkirk Mountains, B.C.

COLPRON, Maurice, Dept. of Geological Sciences, Queen's University, Kingston, Ontario, K7L 3N6

Four plutons of Middle Jurassic age intrude rocks of the Lower Paleozoic Lardeau Group exposed in the Illecillewaet synclinorium, a west-facing fold in the southwest flank of the Selkirk Fan structure. The plutons are aligned along a west-northwest trend that is discordant with the regional northwest-trending, southwest-verging structures. The two larger stocks are porphyritic granites, whereas the smaller plutons are quartz monzonites. All four stocks contain epidote that exhibits textural characteristics suggestive of a magmatic origin. The contact aureoles surrounding these plutons are generally characterized by retrograded andalusite porphyroblasts, indicating pressure of emplacement of less than 4 kbar.

In their immediate wall rocks, the plutons truncate southwest-verging fold structures and the dominant northwest-striking foliation; but, on a regional scale, the axial surfaces of the southwest-verging folds are deflected conspicuously between and around the larger plutons as a result of strain that occurred after the plutons had consolidated. The Downie Creek fault, a major southwest-verging thrust fault in the southwest flank of the Illecillewaet synclinorium, carries in its hanging-wall folds of the dominant phase that are deflected to an easterly trend along the north side of the Fang stock. This same fault extends into, and is congruent with the southwest-verging Durrand Glacier anticline, which is a major component of the Illecillewaet synclinorium. The Downie Creek fault is, therefore, locally discordant with dominant structures deflected around the Fang stock, but is regionally congruent with the dominant deformation in the Illecillewaet synclinorium. These structural relationships indicate that the granitic plutons were emplaced, consolidated and then responded as rigid bodies, during a same episode of progressive deformation that resulted in the development of the dominant, regional, northwest-trending, southwest-verging folds and thrust faults.

THE PURCELL TRENCH NORMAL FAULT, NORTHERN IDAHO, U.S.A.

DOUGHTY, P. T., and PRICE, R. A., Geological Sciences., Queens University, Kingston, Ontario K7L-3N6

Recent attempts to locate the elusive Purcell Trench fault have discovered evidence for two en echelon normal fault segments, one mainly brittle and the other more ductile, within the Purcell Trench. The two normal faults overlap en echelon near the intersection of the Purcell Trench with the Hope fault. The Hope fault is a major, southeast trending normal fault which appears to play an important role in accommodating changes in structural style along the Purcell Trench fault system.

The northern segment is an east-dipping, mostly brittle, normal fault which is exposed for 4 km near Bonners Ferry, Idaho. A 3-5 meter wide zone of cataclastic ductile mylonite and chloritic microbreccia dips eastward at nearly 60°and records top-to-the-northeast displacement. The fault separates west-dipping amphibolite-facies metasediments in the footwall from hornblende-biotite granites in the hanging wall.

The southern segment is not exposed; however, mylonitic shear zones occur in the mountains flanking the west side of the Purcell Trench where they dip steeply eastward. These shear zones record top-to-the-northeast normal displacement. This and a juxtaposition of metamorphic grade across the Purcell Trench provide permissive, but not compelling, evidence for a largely ductile normal fault along the southern segment of the Purcell Trench normal fault system.

The SNORCLE Transect - Present Status, Objectives and Opportunities

ERDMER, P. & KANASEWICH, E.R., Department of Geology, University of Alberta, COOK, F.A., Department of Geology and Geophysics, University of Calgary, HELMSTAEDT, H., Department of Geological Sciences, Queen's University, JONES, A.G., Geological Survey of Canada, Ottawa, PADGHAM, W.A., Indian and Northern Affairs, Yellowknife.

The Slave - Northern Cordillera Lithospheric Evolution (SNORCLE) transect is one of two new transects proposed in Phase IV of LITHOPROBE. Its purpose is to study the deep structure and growth cycles of continental lithosphere in the only region of Earth where the rock record spans 90% of Earth's history. The oldest known rocks on Earth are from the Slave Province, a relatively small Archean craton in the Northwest Territories. For about 1,200 km to the southwest, in Yukon and northern British Columbia, progressively younger rocks and structures record accretionary and transpressional tectonic processes that continue until the present day, resulting in the westward growth of the North American continent.

From east to west, the SNORCLE transect crosses a series of orogens including the Archean Slave Province (4.0-2.5 Ga), the Proterozoic Wopmay Orogen (2.1-1.9 Ga), the southern projection of the recently discovered Mid-Proterozoic Racklan Orogen (1.3-1.1 Ga) mostly buried beneath Proterozoic cover, and the Cordillera, which records a complex history of crustal extension (1.5-0.37 Ga) followed by crustal accretion (0.37 Ga to Present). Some of the questions to be addressed are:

- What kind of deep crust and mantle underlie the oldest rocks on Earth?
- Did plate tectonics operate in the Archean?
- Is the tectonic style of early Archean protocontinental nuclei unique?
- How have 4 Ga-old cratons been modified since the Archean?
- Are deep structural and stratigraphic characteristics of Proterozoic orogens fundamentally different from those of Phanerozoic orogens? If so, why?
- How have deep Precambrian structures been significant in controlling the stratigraphic and structural evolution of Phanerozoic orogens?
- Why is the 2,500 km-long foreland basin of the Cordillera much more extensive, both areally and vertically, in southern Alberta than in northwestern Canada?
- Why do inter-related tectonic characteristics of the Canadian Cordillera such as lithospheric extension, intracontinental strike-slip and craton-ward contraction, change from south to north?
- How were outboard Cordilleran terranes assembled to produce the present distribution of exotic elements enveloped by terranes of apparent North American affinity?

THE SUPRASTRUCTURE-INFRASTRUCTURE TRANSITION OF THE HINTERLAND AND ITS ROLE IN THE INITIATION OF THRUSTING IN THE FORELAND OF THE CANADIAN CORDILLERA.

FERGUSON, Charles A., Department of Geology and Geophysics, University of Calgary, Calgary, Alberta T2N 1N4 Canada

At 53° north latitude, the northwest-strikinig Columbian orogen consists of two 100 km wide belts: a foreland fold-thrust belt, and an intensely folded metamorphic hinterland. The youngest folding event in the hinterland is related to the propagation of thrusts at the western edge of the foreland. Thrusts in the western foreland feed into a detachment that merges into the infrastructure-suprastructure transition of the hinterland. Thrusts of the eastern foreland feed into the basal detachment that extends into the lower portion of the infrastructure.

Folding and peak metamorphism of the hinterland's infrastructure occurred before the intrusion of a Middle Jurassic pluton. Thrusting in the foreland was not initiated until the Early Cretaceous. The oldest structural fabric in the suprastructure is a chlorite porphyroblast-bearing foliation (S_1) oriented at low angles to bedding. S_1 records peak metamorphism in most of the suprastructure and may be contemporaneous with the Middle Jurassic metamorphism of the infrastructure.

A 40 km wide fold belt at the eastern edge of the hinterland's suprastructure overprints the S_1 fabric. A younger structural fabric, associated with this folding, extends into the western edge of the foreland where it is associated with eastward thrusting. The fold belt at the eastern edge of the suprastructure is inferred to be the same age (Early Cretaceous) as thrusting in the western foreland. This is at least 20 million years younger than deformation in the underlying infrastructure.

SOME ASPECTS OF THE THREE DIMENSIONAL STRUCTURE OF THE ALBERTA FOOTHILLS

Peter Fermor, Shell Canada Resources Ltd.

The principle review articles on the structure of the Alberta Foothills were based upon single-fold reflection seismic data. In the quarter-century since their writing, the acquisition of thousands of kilometers of stacked data, initial 3-D surveys, and the drilling of several hundred additional wells has provided a basis for pursuing a three dimensional analysis of structures involving the Paleozoic carbonate structural "skeleton". Subsurface information indicates that:

1) In one field structure where several horizons can be mapped with confidence, the structure appears "balanced" to within the resolution of subsurface control, supporting the local applicability of this method of structural analysis.

2) Within individual thrust sheets (where it can be documented) displacement changes smoothly, but the displacement gradient along strike may be considerable, up to about .44 per unit of length in one major thrust sheet. This implies considerable rotation (20°-30° or more) of portions of these thrust sheets during translation.

3) Certain thrust sheets inferred from surface mapping to be separate entities (e.g. the McConnell and Livingstone) are one and the same, and so are longer than previously supposed, invalidating previous interpretations of their displacement profiles.

4) Lateral ramps are more common than previously realized, producing complex three dimensional linkages between thrust sheets at structural levels at which they were previously considered separate, with concomitant abrupt changes in displacement where these linkages occur. These linkages can be difficult to detect, and are apt to cause errors in structural interpretation.

5) Thrust sheets constituting the leading edge of deformation at re-entrants become interior structural elements in the principal salient of the Alberta Foothills by the development of more exterior thrust sheets which appear to be terminated abruptly along strike at lateral ramps, which link them with the thrust sheets in the more interior positions.

6) The existence of connecting lateral ramps implies that displacement occurred simultaneously on portions of the thrust faults connected by the ramps. Since the ramps extend twenty or more kilometers downdip, it follows that displacement occurred simultaneously on structures occupying relatively interior and exterior positions.

NEW CORRELATIONS OF THE HADRYNIAN WINDERMERE SUPERGROUP IN THE NORTHERN SELKIRK MOUNTAINS, BRITISH COLUMBIA

Stephen E. Grasby and Richard L. Brown

ABSTRACT

The Horsethief Creek Group in the northern Selkirk Mountains is subdivided into six informal maps units: Semipelite-Amphibolite, Middle Marble, Basal Pelite, Comedy Creek, Clastic, and Upper Pelite. The Comedy Creek unit is correlated with the Old Fort Point Formation of the Miette Group, "the marker" in the Kaza Group, and the Baird Brook division in the Horsethief Creek Group of the Purcell Mountains. These correlations help define the Windermere basin, and place constraints on the southern extent of the Plesant Valley Thrust.

A mid-Cretaceous-to-Paleogene tectonothermal history for the Kootenay Arc and Purcell anticlinorium derived from $^{40}Ar/^{39}Ar$ age spectra of K-feldspar.

J. Jansen and D.A. Archibald, Department of Geological Sciences, Queen's University, Kingston, Ontario, K7L 3N6

Eight new $^{40}Ar/^{39}Ar$ age spectra for micas reveal a simple cooling history for mid-Cretaceous granitoid plutons from the Purcell anticlinorium. Typically the spectra have well-defined plateau segments; however, some show evidence of minor post-emplacement thermal overprinting.

In contrast, K-feldspar age spectra show increasing age with fraction of ^{39}Ar released during step heating. In some cases the maximum age reaches the biotite plateau date for the same rock. In detail, the form of the spectra is similar to those studied by Lovera (1988) which suggests that these samples contain multiple domains of different sizes. Using Lovera's algorithm (1992), we modelled five age spectra and calculated closure temperatures corresponding to domain ages inferred from the spectra. The temperatures ranged from 184 to 298°C; samples with the youngest dates yielded the lowest closure temperatures. The age-temperature results for the K-feldspar samples were combined with estimated closure temperatures and available ages for K-Ar and Rb-Sr mica samples and fission-track apatite dates to constrain 1-DT models of the Purcell Anticlinorium.

Two models corresponding to mid-Cretaceous pluton emplacement at tectonic levels of 12 and 20 km were tested. These models incorporated:

1. Simple cooling of the Purcell Anticlinorium east of Kootenay Lake from 110 to 70 Ma,
2. A significant thermal event at ca. 70 Ma occurring at deeper crustal levels now exposed west of Kootenay Lake, and
3. rapid Eocene uplift.

We attribute the convergence of the model cooling curves at ca. 50 Ma to normal faulting along the Purcell trench. This movement juxtaposed the two tectonic levels and was concordant with regional Eocene extension.

NUMERICAL MODELLING OF THIN-SKINNED THRUST SYSTEMS. INSIGHTS ON THE PROPAGATION OF FAULTS AND THE THRUST TRANSFER ZONE PROBLEM

Daniel Lebel and Eric W. Mountjoy, Department of Earth & Planetary Sciences, McGill University, 3450 University St, Montréal, Québec, H3A 2A7

The overlapping mechanism provides a means of explaining how the inhomogenous displacement observed along each fault from a population of contiguous thrust faults translates into the relatively homogeneous shortening described in most thrust belts of the world. Transfer zones as initially described by Dahlstrom (1969) are artifacts of the final deformation and cannot be used to elaborate a simple model of evolution leading to a uniform shortening of a thrust belt. Rather, thrust faults propagate by means of local stress buildup (due to inhomogeneous shortening along the thrust belt) and its eventual relaxation through the slip of a single fault. Hence, in an area with a series of fault traces overlapping each other in map view, the fault which is situated in the most critical position will slip. If there is no fault placed in a critical area that needs shortening, new faults will be created. This alternative slip of a series of overlapping thrust faults in a series of slip episodes is termed the overlap mechanism.

Two computer programs have been developed to illustrate the overlap mechanism. These programs use algorithms based on the equations of fault propagation of Walsh & Watterson (1988) and provide simulations from which one can observe the kinematic evolution of analog single faults or large thrust belts. The programs are useful for simulating a number of common geometric situations encountered in thrust belts. They also are useful for determining the influence of rheology on the propagation of faults, by allowing to change the rheological variables values of the fault propagation equations.

FOOTHILLS BETWEEN ATHABASCA AND BRAZEAU RIVERS, ALBERTA

Daniel Lebel and Eric W. Mountjoy, Department of Earth & Planetary Sciences, McGill University, 3450 University St, Montréal, Québec, H3A 2A7

A kinematic model of emplacement of the external part of the Rocky Mountain thrust and fold belt is derived from regional mapping and a series of balanced cross-sections. In the Foothills, an early set of faults are cross-cut by the later more dominant and through-going thrusts. These early thrusts are structurally equivalent to the Mesozoic-Paleozoic detachment described by Bally et al. (1966) from southwestern Alberta.

Structural analysis of the Nikanassin thrust sheet shows that internal deformation during emplacement was accomodated by means of both brittle and ductile deformations. Minor thrusts and tear faults do not account for all the internal deformation involved in the differential movement between the center and the lateral terminations of the thrust sheet. Rather, an array of subtle shear veins observed in the field appear to reflect shearing parallel to the transport direction and extension perpendicular to it. This internal deformation is reflected by the overall bowed shape of the thrust sheet and curved fold axis geometry. The Nikanassin thrust sheet has been subjected to a number of deformational episodes with opposite sense of shear. These episodes resulted in the curvature of major folds and faults as observed on a regional map. This curvature is interpreted to result from piggyback thrusting and the overlap mechanism of thrust propagation. The structure is illustrated with a 1: 100 000 scale geological map and a series of cross-sections.

THREE-DIMENSIONAL GEOMETRY OF ROCKY MOUNTAIN FOOTHILLS STRUCTURES IN NORTHERN ALBERTA

S. Liu, D.C. Lawton and D. A. Spratt, Department of Geology and Geophysics, The University of Calgary, Calgary, Alberta, T2N 1N4

Our knowledge about thrust geometry, fold geometry, and thrust and fold interaction in the Rocky Mountain fold and thrust belt has been improved through detailed studies along closely-spaced 2-D sections. The objective of this study is to use available seismic, geological and well data in northern Alberta to study these structures in three-dimensions. Here, we present the preliminary results and discuss some structural features we have observed.

The study area is located in northern Alberta and encompasses an area of 36 km x 125 km (~4500 square kilometers). The long axis of the rectangular study area is oriented northwest-southeast, parallel to the regional geological strike. A total of 1925 line-km of dip-lines, 464 line-km of strike lines and 138 line-km of oblique lines in the study area have been made available to the project from the two sponsoring companies. These data include vintages from the mid 1970's through the early 1990's. The average distance between dip lines is 2 km, and generally ranges between 1 km and 3 km. Strike lines are widely spaced (>5 km) but provide good ties between the dip lines. There are about 54 wells in the study area. Among these, there are about 37 wells that have sonic logs from which we have generated synthetic seismograms. There are about 5 wells in the study area with check shot surveys that provide us with more accurate control of formation seismic velocity. Our balanced section construction is performed using GEOSEC -- a structural modelling computer package which enables us to place rigorous constraints on the interpretation.

The structure in the study area is very complex. There are five detachment levels which lie in the Wapiabi Formation, blackstone Formation, Fernie Group, Exshaw/Banff Formation and Lower Devonian. These structural decollements change structural position or die out along strike, which results in significant structural differences within the study area. Generally, there are more detachments in the south than in the north. In the south, the uppermost detachment gently flattens into undeformed rocks of the Plains, a geometry which is a typical feature of the southern Canadian Rocky Mountain Foothills triangle zone. In the north, however, the upper detachment is folded by the lower structures, and the strata above the roof thrust do not gently flatten into the Plains. Rather, there is a sharp kink along the eastern edge of the disturbed zone. Structural contour diagrams show how the horizontal separation of thrusts varies along strike, and the contour highs and lows in the upper sheet coincide very well with those in the lower sheet. These give us an indication of the 3-D deformation of thrust sheet.

Acknowledgments

We thank both sponsoring companies (Imperial Oil Resources Limited and Mobil Oil Canada) for permission to present the research in this workshop. The project is jointly financed by the two companies and NSERC under a Collaborative Research Agreement. S. Liu is grateful for the help and stimulating discussions provided by the employees of the two companies: L. Germain, T. Kubli, A.J. LaRiviere, F. Montandon, J. D. Thomson, and many others.

EOCENE CRUSTAL STRETCHING, SOUTH-CENTRAL CANADIAN CORDILLERA: PASSIVE UPPER CRUSTAL RESPONSE TO DUCTILE BOUDINAGE OF THE LOWER CRUST ABOVE A FLUID UPPER MANTLE

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Stretching of the continental crust in the southern Canadian Cordillera produced a series of regional north-northeast trending structural culminations (crustal boudins) and depressions (neck zones) that are 20 - 40 km wide and 100 - 300 km long. The direction of stretching recorded by tectonite fabrics in the zones of normal faulting is perpendicular to these regional structures. It is inclined at about 45 degrees to the axis of Jura-Cretaceous and Paleocene crustal thickening; but it is kinematically congruent with large-scale, right-lateral, strike-slip faults marking major displacements between the North American craton and the Cordilleran accreted terranes.

Lithoprobe seismic reflection imaging of the Moho between the Monashee complex and the Fraser River fault shows that the base of the crust is essentially planar and slopes uniformly from 12.0 s in the east to 10.5 s in the west; whereas, there is more than 25 km of structural relief along the top of the stretched lower and middle crust. Thus, inhomogenous stretching of the lower crust is compensated by reciprocal stretching of the upper crust, and the total thickness is nearly uniform at about 35 km.

Palinspastic reconstruction of the foreland belt shows that the hinge zone marking the edge of the rifting that separated the platform and the miogecline coincides with the west flank of the Early Proterozoic rocks in the Monashee culmination. Radiometric dating of the latest northeast-verging thrusting on the Monashee décollement as < 59 Ma but > 58 Ma shows that it is coeval with, and therefore, the tectonically unroofed and isostatically uplifted western continuation of the regional basal décollement that extends under the foreland belt to the eastern edge of the Foothills. This implies that the Early and Middle Eocene crustal stretching removed about 25 km of upper crustal rock, and induced an en masse isostatic uplift of the Monashee décollement, and of the lower crust and the Moho, by about 20 km. Accordingly, it also leads to the conclusion that there was no significant thickening of the Early Proterozoic basement beneath the Monashee complex during the Jura-Cretaceous and Paleocene compressional deformation that produced the foreland thrust and fold belt, and no significant lateral flow of lower crustal rock into the region beneath the crustal boudins during stretching.

TECTONIC EXHUMATION DURING MID-CRETACEOUS OROGENY IN THE NORTHERN MONASHEE MOUNTAINS, SOUTHERN OMINECA BELT: THERMOCHRONOMETRIC, BAROMETRIC AND STRUCTURAL EVIDENCE FROM FORMER MIDDLE CRUST

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High-grade metamorphic rocks in the hanging-wall of the Monashee décollement, and north of the Monashee Terrane, preserve a high-T cooling history that predates Eocene horizontal extension and associated cooling of crust within the southern Omineca Belt. This high-T cooling history is inferred from U-Pb ages of metamorphic monazite, titanite and rutile, and $^{40}Ar/^{39}Ar$ plateau ages from metamorphic hornblende. It has two stages marked by: (1) rapid cooling (~17-100°C/Ma) from ~700°C at 100 Ma to 600°C at 94 Ma, and (2) moderate cooling rates (~5°C/Ma) from ~600°C at 94 Ma to 400°C at 52 Ma. Thermobarometric techniques have been applied to Sil-grade migmatitic schists and Qtz-saturated Grt-amphibolites in order to provide a depth dimension to the cooling path. Although application of these techniques to the high-grade schists is not straight forward, simultaneous solution of the Grt-Bt thermometer and the Grt-Al_2SiO_5-Qtz-Pl barometer leads to systematic trends in garnet core and rim P-T estimates. These rim and core P-T estimates have independent support in similar P-T estimates using Qtz-Grt-Al_2SiO_5-mica and Hbl-Grt-Pl-Qtz thermobarometry, respectively. When considered together these thermobarometric data indicate a reasonable estimate of former peak conditions is ~700°C and 7.4 kb or more, and former garnet rim P-T conditions is ~600°C and 4.7 kb.

Integration of these data leads to the conclusion that 9.5-10 km of overburden was removed from ~100 to 94 Ma (assuming a standard baric gradient of 3.5-3.7 km/kb for intermediate to felsic continental crust), and implies a time-averaged exhumation rate of 1.6-1.7 km/Ma. Although erosion must have contributed to exhumation at this time, the high rate strongly suggests that tectonic denudation was a contributing, and possibly a dominating mechanism. Operation of tectonic exhumation contrasts with the inference that the dominant structural elements in this part of the thrust sheet are related to processes that produced large-scale crustal thickening, and operated from before ~135 Ma to after 97 Ma, and possibly as recently as 57 Ma (based on crystallisation ages of leucogranites, and structural relationships of these leucogranites to penetrative contraction structures). Consideration of these inferences leads to the hypothesis that tectonic exhumation was coeval with mid-Cretaceous convergence. Structural data indicate that this mid-Cretaceous tectonic exhumation was in part accomplished by 'dynamic spreading' within the middle crust, and possibly through the formation of relatively discrete normal faults in the upper crust.

THE REMAINING SHREDS OF TRAIL GNEISS-FRAGMENTS OF A DEVONIAN CONTINENTAL MARGIN

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The Trail Gneiss of Devonian (and older?) age is present in an area of at least 300 km² in the Rossland Trail - Castlegar area. Much of its volume, however, consist of younger (Jurassic, Cretaceous, Eocene) magmatic material and almost everywhere, its fabrics are Jurassic and Tertiary. The exposed portion of the Trail Gneiss corresponds to a zone of Jurassic and Cretaceous laccoliths and sheets which also guided the emplacement of Tertiary granitic sheets. Only in the southwest corner of the Trail Gneiss outcrop are remnants of its Devonian geology decipherable. An older layered mafic-felsic complex is intruded by Devonian trondjhemite sheets cut by abundant Mississippian? mafic intrusions. Much of the relatively massive mafic component of other portions of the Trail Gneiss may also be the Mississippian? intrusions.

This Paleozoic geology of the Trail Gneiss compares readily with that of the Devonian continental margin to Kootenay Terrane proposed by Schiarizza. This suggests that the Rossland portion of Quesnell Terrane was an arc built in part on fragments rifted from the Devonian continental margin.

The Triangle Zone and Foothills Structures; Grease Creek Syncline area, Alberta.

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The Triangle Zone, the structure commonly formed at the eastern edge of the southern Alberta Foothills, is formed by the delamination of foreland basin strata and the eastward wedging of a blind duplex into the delaminated horizon. This structure is shown to have an *en echelon* surface expression in the Grease Creek Syncline area. The along strike structural variations of the blind duplex which cause the apparent *en echelon* surface geometry are investigated.

Four east-dipping backthrusts or 'upper detachment' surfaces were mapped east of the surface expression of the Triangle Zone in Silver Creek. These faults verge to the west and, at outcrop scale, cut up-section in the direction of transport through east-dipping strata. Displacement on these faults is difficult to estimate as there are few stratigraphic markers in the Brazeau Group. However, as there is no interformational offset the displacement is probably on the scale of 10's or 100's of metres. The offset can not be resolved using palynological zones also suggesting smaller offsets, on the order of 10's or 100's of metres. The narrow spacing of the east-dipping faults, approximately 200 m to 250 m, also indicates small offsets on the faults. Alternatively, these may be small splays of a more significant fault.

STRUCTURAL RELATIONSHIPS WITHIN THE THOR-ODIN CULMINATION OF THE MONASHEE COMPLEX, SOUTHEASTERN B.C.

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The Monashee Complex consists of early Proterozoic core gneisses of the North American basement and unconformably overlying late Proterozoic to early Cambrian platformal cover metasediments exposed through a tectonic window in the Selkirk Allochthon. Thor-Odin is a major structural culmination within the southern part of the complex. The complex has been variously interpreted as a gravitationally uplifted mantled diapir, a northerly-directed thrust duplex and fold interference pattern, and a tectonically denuded antiformal crustal scale duplex.

The present structural style of Thor-Odin may result from a combination of compressional deformation involving the northeasterly-directed Monashee décollement and crustal extension along brittle-ductile normal sense shear zones. Mapping has revealed both types of fabric as well as slices and in-folds of cover gneiss throughout the centre of the culmination without any appreciable strain gradient. Compressional fabrics include a complex array of at least three fold generations. F_1 folds occur as extensive isoclinal structures that fold both core and cover gneisses at all scales up to km-scale. This early deformation event produces a transposition foliation (S_1). F_2 folds are ubiquitous as cm-scale minor asymmetric folds (northeasterly to easterly verging) with axes that are moderately to steeply plunging and have cascading parasitic folds possessing shallow east-west plunging fold axes. Late F_3 folds may be involved with doming and occur as northeasterly-verging chevron-like folds and associated shears. Extensional down-to-the-west steep brittle normal faults and brittle-ductile chloritic shears overprint folding. Boudinage and associated neck folding is common everywhere. Cut-offs locally resemble compressional duplexes; however, this may represent a composite fabric forming by the combined effect of early thrusting and late extension.

Mineral lineations within the study area are strongly aligned in an east-west orientation. Pelitic metamorphic mineral assemblages exhibit an overprinting of kyanite by sillimanite; the oldest is folded by F_2. Younger sillimanite is axial planar to F_2 and forms a stretching fabric with low-grade partings. Field data suggest that Thor-Odin tectonic interpretations should include fold interference, transposition and boudinage.

TECTONIC EVOLUTION OF THE TESLIN SUTURE ZONE, A MAJOR PLATE BOUNDARY IN SOUTH-CENTRAL YUKON TERRITORY

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The Teslin suture zone, part of the Yukon-Tanana terrane of southern Yukon and east-central Alaska, marks the fundamental boundary between deformed autochthonous North American rocks of the Omineca Belt to the east and accreted terranes of the Intermontane Belt to the west. In parts of the Laberge, Quiet Lake and Teslin map areas the Teslin suture zone includes schist, quartzite, phyllite, marble, greenstone, meta-tonalite to quartz-diorite and metagabbro all metamorphosed under greenschist to lower amphibolite facies conditions. The largest unit, a siliceous schist and quartzite unit, is part of the Nisutlin Allochthonous Assemblage and is intruded by Late Devonian to early Mississippian hornblende-bearing tonalite to quartz diorite plutons.

Two deformation phases affected the area. The earlier and stronger phase, produced lineated protomylonite and mylonite over much of the area. Mineral and/or stretching lineations defined mostly by phyllosilicates, amphiboles and quartz are considered to be parallel to the local movement direction in the rocks. Shear-sense indicators such as strain-insensitive Sa/Sb fabric, strain-sensitive C/S fabric, asymmetrical extensional shear bands and pressure shadows have developed and help to delineate the kinematics of this early deformation phase. The second and weaker phase produced widespread crenulation, hand-specimen scale folding and local cleavage development. Shear sense can be determined locally by the crenulation asymmetry between cleavage surfaces. Strain partitioning is common, and is primarily controlled by rock type. Rock type also influences the type of fabrics that develop (e.g. mineral vs. fold lineation).

Detailed mapping along three structural transects revealed that the suture zone includes many domains of contrasting structural style with different foliation and lineation fabric orientations. The following structural characteristics are present in 14 domains identified along the transects and elsewhere in the map area; 1) steeply northeast- and southwest-dipping mylonitic fabrics, 2) normal and reverse oblique shear on both the northeast- and southwest-dipping fabrics; 3) an overall subhorizontal, suborogen-parallel crenulation axis; 4) open to tight handspecimen-scale folds with axes parallel to mineral lineations; and 5) a local spaced (10-30 cm) crenulation cleavage that dips northeast or southwest. Folding is not responsible for the two dip directions displayed by the mylonitic fabrics.

Existing models for formation of the suture zone propose that the rocks were deformed within the deep-seated portion of a west dipping Permo-Triassic subduction complex outboard from ancient North America. The rocks were subsequently thrust eastward onto North American strata during the Early Jurassic, and the Teslin suture zone would represent the root zone of the obducted package. However, the lack of deformation under subduction zone metamorphic conditions and the presence of northeast-dipping mylonitic fabrics with apparent top-to-the-west reverse shear, seen in this study, are difficult to accommodate into the existing model. In addition, it would be difficult to transport, down the subduction zone, a Devono-Mississippian pluton from the study area that is at least 6 km wide and 10 km long, without it recording this transport.

It is proposed that the evolutionary model include early subduction zone deformation, followed by development of a transpressive environment and formation of a two-sided orogen. This revised model accounts for the lack of widespread subduction zone metamorphism and for the existence of east- and west-verging thrust and normal shear and orogen-parallel fold axes. Sheets of suture zone rock thrust to the west are interpreted to have been translated northward on post-accretionary dextral strike-slip faults.

GEOLOGY AND STRUCTURE OF THE EASTERN MARGIN OF THE CORYELL BATHOLITH, SOUTHEAST BRITISH COLUMBIA

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The Coryell Batholith is a large (about 400 km² outcrop area) syenitic intrusion located between the towns of Rossland and Christina Lake. Field mapping of the eastern third of the batholith during the summer of 1992 revealed that it is made up of several varieties of quartz syenite, syenite, and monzonite. The most extensive intrusive phase is a slightly porphyritic coarse grained quartz syenite with a locally developed, weak magmatic foliation. Contacts with the country rock are generally sharp with minimal contact metamorphic effects. A large roof pendant and the shallow dip of most of the eastern contact indicates that the level of exposure in the map area is towards the roof of the batholith.

Along the northeast margin of the batholith a screen of dark monzonite seperates the main intrusion from a late, concordant sheet of megacrystic syenite. Foliations parallel to the monzonite screen (and the batholith contact?) are well developed in the syenites in this area. In the megacrystic syenite sheet the foliations are inferred to be magmatic, but are solid state in the main syenite, possibly indicating strain during emplacement.

The western edge of the map area is defined by a deep north-south valley. In the southern portion of the valley east-dipping screens of Rossland Group volcanics are separated by sheets of a variety fine-grained porphyritic syenites and monzonites. Discrete zones of ductile deformation parallel these sheets. Kinematic indicators suggest a down-dip normal movement along these zones. This deformation appears to postdate the intrusion of the main syenite, while the fine-grained syenite sheets are late-deformational. A more steeply east dipping north-south brittle fault zone cross-cuts all other structures. Extension in this area is probably related to the regional Eocene extensional event, but its local significance is not yet understood and will be one focus of future study.

GIANT NEOPROTEROZOIC REEFS FROM THE LITTLE DAL GP., MACKENZIE MOUNTAINS, N.W.T.: FILLING THE ECOLOGICAL GAP BETWEEN PRECAMBRIAN AND PALEOZOIC REEF COMMUNITIES

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Although Precambrian reefs are nominally considered to be stromatolitic in nature, evidence from the Little Dal Group, Mackenzie Mountains, N.W.T. indicates that evolution of a Paleozoic-style reef community from stromatolite reef-builders began in the Neoproterozoic. Giant microbial reefs (to several kilometres in plan dimension and to 300 m thick) are contained in the "basinal assemblage" of the Little Dal Group, which has been dated at approx. 880 Ma. The buildups are constructed by a consortium of calcified microfossils, most of which are interpreted to be of microbial origin, and which are morphologically analogous to common Paleozoic reef-building organisms. While the stromatolitic growth pattern of the dominant organisms is Proterozoic in aspect, the calcified preservation of the microbes and their similarity to much younger reef-building organisms is more Paleozoic in nature. These reefs thus demonstrate that there existed a reef-building community intermediate in style and complexity between Proterozoic stromatolite reefs and the more complex, obviously calcified Paleozoic microbial-metazoan reefs.

Stratigraphic relationships in the Horsethief Creek and Hamill Groups of the western Purcells: Implications for the Late Proterozoic/ Early Paleozoic evolution of the North American margin

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Newly defined map units in the Horsethief Creek and Hamill Groups, west of Duncan Lake, B. C., reveal conspicuous stratigraphic contrasts from east/ south to west/ north. In Jumbo Creek, diamictite of the Toby Formation is conformably overlain by the Horsethief Creek Group. The Upper Proterozoic Horsethief Creek Group is characterized by a marble/ pelite unit at the base, a lower graded sandstone/ pelite unit, a middle coarse clastic unit dominated by grits and conglomerates, with rare volcaniclastic material, and an upper fine clastic unit. The Horsethief Creek Group exposed to the northwest in Howser Creek comprises a lower clastic unit of thick feldspathic grits and interbedded pelite, a middle carbonate/ pelite unit, and an upper quartz- and carbonate-rich clastic unit containing greenstones. The base of the Horsethief Creek Group is not exposed in this drainage. However, the thickness of the Howser Creek section is greater than that of the complete section exposed to the southeast in Jumbo Creek.

The Lower Cambrian Hamill Group exposed in upper Glacier and Hamill Creeks comprises a coarse basal unit which is transitional from the underlying Horsethief Creek Group to mature quartzite of the lower Hamill Group. The lower Hamill Group is overlain by a middle immature clastic unit, which thickens and coarsens to the west, where it locally contains greenstones. The upper Hamill Group comprises mature quartzite and interbedded pelite, which grades upward into the Mohican Formation. Only the middle and upper Hamill Group units, and overlying younger strata, are exposed within the Kootenay Arc immediately to the west. The lower part of the Hamill Group is thin or absent in the westernmost part of the Purcell anticlinorium, suggesting that it may be absent entirely beneath the Kootenay Arc.

Stratigraphic relationships within the Horsethief Creek Group suggest that a significant portion of the lower part of the Jumbo Creek section may have been removed prior to deposition of the upper part of the Horsethief Creek Group, whereas a thick lower sequence was preserved in a deeper basin to the north and west. Stratigraphic relationships within the Hamill Group imply syn-tectonic sedimentation and vulcanism, perhaps preceded by local uplift and tilting during depostion of the lower part of the Hamill Group. In contrast to the thick sequence in the western Purcells, Lower Cambrian rocks are absent or very thin in the eastern Purcells. Overlying Lower Paleozoic strata in the eastern Purcells indicate that this region continued to experience intermittent uplift until the middle Devonian, while Lower Paleozoic strata containing several immature clastic units (Lardeau Group) accumulated in a basin to the west. The "Windermere High," therefore, acted as a high-standing crustal block during intermittent episodes of regional extension, which may have begun as early as Late Proterozoic time. This time span is clearly longer than can be accounted for by models of a single continental rifting event.

Deformational and metamorphic history of the Blanket area of the Thor-Odin culmination of the Monashee Complex.

Williams, P.F.[1], Brown, R.L.[2], & Spark, R.N.[1]

The Thor-Odin culmination of the Monashee Complex comprises Early Proterozoic core gneisses and Late Proterozoic to early Cambrian cover metasediments. The cover sequence begins with a quartzite whose contact with the core is marked by remarkable occurrences of sillimanite after kyanite suggesting a possible fossil regolith. This assemblage of core and cover is isoclinally folded at centimetric to kilometric scale throughout the area by D_1 folds. D_1 structures comprise more than one generation of folds; they were probably a product of progressive deformation and resulted in a transposition foliation (S_1). Competent layers are boudinaged on the limbs of these folds and deep in the culmination the folds are overprinted by a statically grown assemblage including biotite, garnet, diopside and spherulitic kyanite and gedrite,

D_1 folds are overprinted by a complex array of folds that we divide into two generations. F_2 folds occur at all scales up to kilometric, are markedly asymmetrical and verge northerly to northeasterly. They have long, gentle, south dipping limbs and short steep limbs with cascades of recumbent parasitic folds. F_3 folds have north-trending, upright axial planes and are generally fairly open structures with kink-like appearance. Both F_2 and F_3 appear to overprint the kyanite. Locally there is a sillimanite lineation parallel to F_3 which may be pseudomorphous after kyanite. It is believed to have developed by rotation of the earlier formed kyanite.

The three early generations of folds are overprinted by a deformation that produces a strong alignment of minerals trending approximately east/west. Relic kyanite spherulites indicate that this lineation developed by straining of the earlier formed metamorphic assemblage presumably under conditions that were still conducive to their existence. Our work so far has concentrated on the western half of the culmination and in that area fourth generation structures are best developed along the western edge i.e. in the upper levels of the complex. In that part of the area fold hinges tend to be aligned approximately parallel to the mineral lineation and they are generally dismembered and locally, but rarely, sheath like. Cut-offs are common and locally give the impression of compressional duplexes; we interpret this fabric however, as a composite fabric resulting from a combination of early thrusting and late extension. Boudinage at microscopic to metric scale is common. There are the boudins related to the D_1 folds; they are oriented with their long axes parallel to the sillimanite lineation and many of them are fold hinges. There are also younger boudins whose neck folds are aligned perpendicular to the lineation. These younger boudins overprint the earlier ones. The above generations of ductile structures are all overprinted by two sets of brittle normal faults. There is a steep down-to-the-west set and a shallowly dipping down-to-the-east set. Moderate to steeply dipping Lamprophyre dykes in the area trend approximately north south and are therefore approximately perpendicular to F_2 fold axes suggesting a possible relationship. Similar dykes elsewhere in the region are believed to be of Eocene age. Fanning of the dykes, about a north-south axis, suggests that they may be rotated by F_3, thus placing constraints on the age of both F_2 and F_3.

In the centre of the culmination (structurally deepest level within the area of study) practically all kyanite is replaced by sillimanite, so for example, we see decimetre long crystals with kyanite form, replaced by spherulitic sillimanite. Higher in the culmination relic kyanite becomes increasingly common and then in the highest, strongly lineated F_4 zone kyanite is absent.

A kilometric scale boudin, deep in the culmination, has approximately east-west trending neck folds. It is overprinted by a large F_2 fold and is therefore interpreted as a D_1 structure. Pegmatite from a pull-apart within the boudin has been dated within the Early Eocene (V. McNicoll, pers. comm.) indicating that F_2 and younger structures are no older than Early Eocene and that D_1 deformation must have persisted until that time. The age of the commencement of D_1 remains open ended. We tentatively interpret the metamorphic history as follows. A high pressure post-kinematic event (M_1) occurred in response to crustal thickening resulting from a thrusting event that produced D_1 structures. This metamorphism was a static event and was younger than the dated pegmatite; i.e. younger than Early Eocene. It was followed by F_2, emplacement of the lamprophyres and F_3. Chilled margins to the dykes suggest that temperature dropped between D_1 and F_2. After F_3 there was a vertical thinning of the crust due to the F_4 event and a gradual rise in temperature (M_2). Whether these two events were coeval or not is not known at this time. M_2 resulted in the conversion of kyanite to sillimanite. The conversion was essentially complete in the deeper parts of the culmination, but left relics at shallower depths. The lack of kyanite relics in the shallowest part of the culmination, in the outermost F_4 zone, can be explained in two ways. It may simply represent a more complete conversion of M_1 kyanite to M_2 sillimanite in the most strongly deformed rocks (due to the effect of strain energy) whereas meta-stable kyanite was preserved in less deformed rocks, at intermediate depths. Alternatively, there may never have been any kyanite in the upper sillimanite zone. The early thrust related metamorphism may have been temperature inverted and the sillimanite that we now see at that level may be coeval with the M_1 kyanite rather than coeval with the M_2 sillimanite seen at greater depth.

The scenario presented above is internally consistent, but is not compatible with our understanding of the tectonics of the region. More work is required to reconcile all of the data.

Crustal structure across the Omineca-Rocky Mountain fold and thrust belt transition, southeastern Canadian Cordillera

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An interpretation of an east-west wide-angle seismic profile extending 350 km across the Omineca Crystalline belt and the Rocky Mountain fold and thrust belt is presented. The central part of this 1990 Lithoprobe profile is coincident with 1985 Lithoprobe seismic reflection lines and 1987 Magnetotelluric measurements. An array of 270 seismographs recorded eight in-line shots spaced at 50 km intervals. Refracted and reflected arrivals from the wide-angle data were interpreted for 2-D crustal and upper mantle P-wave velocity structure using a traveltime inversion technique incorporating constraints provided by amplitude modelling. Images of dipping structures within the lower crust were obtained by traveltime inversion of anomalous wide-angle reflections. The main features of the wide-angle model include (i) relatively low velocities at all depths, including average crustal and uppermost mantle velocities of 6.2 and 8.0 km/s, (ii) a crustal thickness increase of 7 km over 85 km distance beneath the Rocky Mountain trench and fold and thrust belt, (iii) evidence for the extension of the Slocan Lake fault into the lower crust with a 15–20° dip, (iv) a transition in lower crustal velocities across the Slocan Lake fault from an anomalously low 6.4 km/s beneath the fold and thrust belt to 6.7 km/s beneath the Omineca belt, and (v) a decreased upper mantle velocity beneath the Omineca belt relative to the fold and thrust belt. The relatively low crustal velocities are generally consistent with relatively high regional heat flow measurements and suggest a recent thermo-tectonic event. A mid-crustal boundary at ~20 km depth imaged by wide-angle reflections corresponds to a sharp drop in vertical-incidence reflectivity interpreted as a basal detachment in the coincident reflection data. Lateral variations in lower-crustal velocity, crustal density, vertical-incidence reflectivity and lower-crustal conductivity generally coincide with the Omineca-Rocky Mountain fold and thrust belt transition or the Slocan Lake fault at depth. These results suggest (i) the Slocan Lake fault is a major crustal feature extending to at least 35 km depth separating crustal blocks with distinct properties, and (ii) proposed "thin-skinned" tectonic models for the region should be reconsidered.

THERMOBAROMETRY OF HORSETHIEF CREEK GROUP PELITES FROM THE CONTACT AUREOLE OF THE GLACIER CREEK STOCK, WESTERN PURCELL RANGE

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Thermobarometry was applied to Horsethief Creek Group pelites from the contact aureole of the Glacier Creek Pluton, which is situated just east of 116°50′ and north of 117°20′ in the Purcell Range.

Metamorphic assemblages of the pelites involving the minerals; chlorite, biotite, muscovite, staurolite, garnet, plagioclase (averaging An 35), sillimanite, ankerite, and ilmenite identify two metamorphic zones: the sillimanite zone within 500m of the pluton, and the staurolite zone further to the southwest. Minerals were compositionally analyzed on the electron microprobe and stoichiometric formulas and ideal activities were obtained using DMC's Mineral Software. P-T diagrams were calculated using GEOCALC software.

Preliminary results indicate a range of pressures from 3.5 - 5.5 kilobars and temperatures of 500C - 600C. Textural evidence demonstrates that lower grade regional metamorphism has overprinted the contact metamorphism at the outer edge of the aureole.

XIX Cordilleran Tectonics Workshop (1993)
Participants

Name	Organization	Paper	Poster
Doug Archibald	Queen's		x
Dick Brown	Carleton	x	
Dugald Carmichael	Queen's		
Sharon Carr	Carleton		
Sebastien Castonguay	Queen's	x	
Maurice Colpron	Queen's	x	x
James Crowley	Carleton		
Lisel Currie	Carleton		
John Dixon	Queen's		
Ted Doughty	Queen's		x
Philippe Erdmer	U. of Alta.	x	
Charles Ferguson	U. of Cal.	x	x
Peter Fermor	Shell	x	
Stephen Grasby	U. of Cal.	x	
Tekla Harms	Amherst	x	
Andrew Hynes	McGill		
Joel Jansen	Queen's		x
Brad Johnson	Carleton		
Dennis Johnston	U.N.B.		
Melanie Kells	Queen's		x
Daniel Lebel	McGill	x	x
Shumin Liu	U. of Cal.		x
Jochen Mezger	U. of Alta.		
Eric Mountjoy	McGill		
Guy Narbonne	Queen's	x	
Jeff Nazarchuk	Carleton		
Andrew Okulitch	I.S.P.G.		
Doug Oliver	S.M.U.		x
Dinu Pană	U. of Alta.		
Randy Parrish	G.S.C.	x	
Ray Price	Queen's	x	
Geoff Rait	Queen's		
Troy Rasbury	UT-Austin	x	
Kenneth Richards	Chevron		
Kevin Root	Shell		
Gerry Ross	I.S.P.G.	x	
Rob Scammell	Queen's	x	
Paul Schiarizza	BC-GSB		x
Philip Simony	U. of Cal.	x	
Greg Soule	U. of Cal.	x	
Robert Spark	U.N.B.		x
Deborah Spratt	U. of Cal.		
Robert Stevens	U. of Alta.	x	
Pat Stinson	U. of Cal.		x
Bob Thompson	G.S.C.		
Elizabeth Turner	Queen's	x	
Marian Warren	Queen's	x	x
Paul Williams	U.N.B.	x	
Colin Zelt	G.S.C.		x
Guowei Zhang	McGill	x	