CANADIAN TECTONICS GROUP WORKSHOP
CAPE BRETON ISLAND
2015

October 3rd and 4th

Convened by Deanne van Rooyen

(Cape Breton University)

CANADIAN TECTONICS GROUP WORKSHOP
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SCHEDULE:

Friday, October 2nd

~8 pm and later: Informal gathering, drinks at the Crown and Moose bar in the Holiday Inn.

Saturday, October 3rd:

7:30 am: Meet at Holiday Inn, leave for Cabot Trail (coffee stop on the way out of town).
All day: Cabot Trail trip, return to Holiday Inn around 6 – 6:30 pm.

7 pm: Drinks, posters, workshop dinner and annual CTG business meeting after dinner at the Holiday Inn.

Sunday, October 4th:

8:30 am at Holiday Inn: Talks, posters, coffee break around 10:30, lunch ~1pm. Airport drop-offs for early flights.
2 pm: Optional drive to Louisbourg to see Mira Terrane Proterozoic volcanic rocks of the Main-a-Dieu Group. Airport drop-offs for late flights.

SCHEDULE OF TALKS

Paleozoic Orogens

8:30 Laurent Godin, Lindsay Waffle, Lyal B. Harris, Rohanna Gibson
Influence of inherited Indian basement cross-strike structures on the evolution of the Himalayan middle and upper crust.

8:50 Dawn A. Kellett, Neil Rogers, Cees van Staal, and Reg A. Wilson
Timing of progressive Salinic D_1/D_2 deformation by in situ $^{40}Ar/^{39}Ar$ dating of cleavage domains within the Tetagouche-Exploits back-arc basin, New Brunswick Appalachians.

9:10 Shoufa Lin, Guangfu Xing, Changqing Yin, Meiling Wu, Don Davis, Bill Davis
An Appalachian-style multi-terrane accretion/collision model for the assembly of South China.

9:30 Willem Langenberg

Structural setting and vitrinite reflectance fabrics of Kootenay coal in the Crowsnest Pass area, Alberta.

Structural analysis

9:50 Dazhi Jiang, Mengmeng Qu, Xi Lu

Multiscale structural analysis: a micromechanical perspective.

10:10 John W.F. Waldron

Introducing geologic structure in a prairie landscape: the Geoscience Garden, an outdoor teaching installation.

10:30 COFFEE

Proterozoic Orogens (the well-behaved ones…)

11:00 W.M. Schwerdtner, Toby Rivers and Sydney Page

Field evidence for penecontemporaneous ductile flow and brittle fracture in granulite- to amphibolite-facies metamorphic rocks, Grenville Province of central and southeast Ontario.

11:20 Deanne van Rooyen, David Corrigan and Celine Porter

Orogenic architecture and phases of deformation in the Kuujjuaq – Tasiujaq area of the Paleoproterozoic New Quebec Orogen.

Cryptic orogenic components (the mysteries…)

11:40 Derek Thorkelson Francesca Furlanetto, Alexander Nielsen, John Laughton, Kirsti Medig, Jacob Verbaas.

Hidden within breccia: the tale of Bonnetia and its Precambrian obduction onto northwestern Laurentia.

12:00 David Corrigan

Structure is in the eye of the beholder: a new look at the Paleoproterozoic Folster Lake Group, Nunavut.

12:20 J. Brendan Murphy, John W.F. Waldron and R. Damian Nance

Interpretation of ophiolite complexes: a tweeter in woofer's clothing?

12:40 LUNCH, 2pm: Optional drive to Louisbourg.

POSTERS

Travis McCarron and Chris McFarlane
***P-T-t* Evolution of Metasedimentary Rocks in the Western Cape Breton Highlands.**

Chris White, Sandra Barr, Deanne van Rooyen, Lisa Slaman, and John Shute
A revised geological interpretation of the Chéticamp area, western Cape Breton Island, Nova Scotia, Canada.

LIST OF PARTICIPANTS

Sandra Barr	Acadia University
David Corrigan	Geological Survey of Canada
Laurent Godin	Queen's University
Dawn Kellett	Geological Survey of Canada
Dazhi Jiang	University of Western Ontario
Willem Langenberg	University of Alberta
Shoufa Lin	University of Waterloo
Travis McCarron	University of New Brunswick, Fredericton
Andrea Mills	Geological Survey of Newfoundland and Labrador
Brendan Murphy	Saint Francis Xavier University
Celine Porter	University of New Brunswick, Fredericton
Fried Schwerdtner	University of Toronto
John Shute	Acadia University
Derek Thorkelson	Simon Fraser University
Deanne van Rooyen	Cape Breton University
John Waldron	University of Alberta
Chris White	Nova Scotia Department of Natural Resources

Special thanks to Sandra Barr and Chris White for invaluable field trip resources and help with everything from the abstract volume to driving to expert scientific leadership!

ABSTRACTS

STRUCTURE IS IN THE EYE OF THE BEHOLDER: A NEW LOOK AT THE PALEOPROTEROZOIC FOLSTER LAKE GROUP, NUNAVUT

David Corrigan
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The Folster Lake formation unconformably rests on Archean basement of the Prince Albert Group on Melville Peninsula, Nunavut, above a regolith that locally includes corestone. Its stratigraphic base is up to a few metres thick and consists of a polymictic pebble conglomerate that is dominated by quartzite and iron-formation clasts. Locally, the conglomerate is overlain by specularite- and hematite-rich iron-formation in quartz-rich arenite. This is overlain by marl, up to a few tens of metres thick, likely derived from arkosic arenite and siltstone with carbonate cement. The marl is interlayered with arkosic arenite that shows decimetre to metre-scale trough cross-beds. The marly layers give way up section to thick arkosic arenites sequences that feature giant (up to 30 m thick) foreset beds separated by metres-thick topset and bottomset beds. The arkosic sandstone beds are overlain by relatively more quartz-rich arenites containing heavy mineral layers. Paleo-environment of deposition is equivocal, but could possibly represent either a high-energy deltaic complex or tidal sandwaves such as those found in the South Betic in Spain, for example. The entire sequence is deformed into upright open folds with a steeply-dipping cleaveage, the latter visible mainly in the more metamorphically fertile marly layers, and a likely effect of the Trans-Hudson (*ca.* 1.80 Ga) orogeny. U-Pb SHRIMP dating of detrital zircon from the lower conglomeratic to arkosic basal sequence shows a dominantly local provenance from a source with a 3.25 to 2.61 Ga age range, and a major population at *ca.* 2.705 Ga. Stratigraphically higher beds yield zircon populations ranging from *ca.* 3.77 Ga to 1.91 Ga, with major age peaks at *ca.* 2.50 Ga, 2.49 Ga, and 1.99 Ga. The youngest concordant age of 1905 ± 8 Ma provides an upper age limit for deposition. The contemporaneous uplift and exhumation observed along the western and southern margins of the Rae Craton (Thelon-Talston and Snowbird orogenies, respectively) may have provided topographic high and hence a source of detritus for the Folster Lake formation, compatible with the observed zircon age peaks. In this talk, we examine the structures, of both primary and tectonic origin, that have led to conflicting interpretations of paleo-flow indicators, originally interpreted to have been east-to-west.

INFLUENCE OF INHERITED INDIAN BASEMENT CROSS-STRIKE STRUCTURES ON THE EVOLUTION OF THE HIMALAYAN MIDDLE AND UPPER CRUST

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The Himalaya is the result of on-going convergence and collision of India and Asia. Knowledge of the configuration of the Indian plate prior to collision with Asia is often over-looked, despite its importance in controlling the subsequent evolution of the orogen. Three fault-bounded northeast-trending paleotopographic ridges of Precambrian Indian basement underlie the Ganga Basin south of the Himalaya. Analysis of spectrally filtered Bouguer gravity data and edges in its horizontal gradient at different source depths suggests that they extend as far north as the underplated Indian lithosphere beneath the Asia crust (Bagong suture), and as deep as the base of the Indian lithosphere. Along-strike diachronous deformation and metamorphism within the Himalayan metamorphic core in west-central Nepal, documented by U-Th/Pb geochronology, as well as lateral ramps in the foreland thrust belt, spatially correspond to faults in the Indian basement bounding the subsurface Faizabad ridge.
Analogue centrifuge modeling confirms that offset along such deep-seated basement faults can affect the location, orientation, and type of structures developed in the mid- and upper crust at various stages of orogenesis. Our models suggest that (1) deep-seated, reactivated basement faults can localize structures in the upper crust during different stages of orogen evolution, and (2) it is mechanically feasible for movement along a basement fault to influence the mid- and upper crust and for strain to propagate through a low-viscosity medium.
We suggest that these major orogenic cross-strike structures may have affected the ramp-flat geometry of the basal Main Himalayan thrust, in turn partition the Himalayan range into distinct zones, and ultimately contribute to lateral variability in tectonic evolution along the orogen's strike. Our interpretation also suggests that south Tibet graben are spatially related to deep-seated lithospheric-scale faults rooted in the underplated Indian crust.

TIMING OF PROGRESSIVE SALINIC D_1/D_2 DEFORMATION BY *IN SITU* ^{40}AR/^{39}AR DATING OF CLEAVAGE DOMAINS WITHIN THE TETAGOUCHE-EXPLOITS BACK-ARC BASIN, NEW BRUNSWICK APPALACHIANS.

Kellett, D.A.[1], Rogers, N.[1], van Staal, C.[2], and Wilson, R.A.[3]
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Dating specific deformation events in poly-deformed rocks is a critical step in reconstructing the evolution of an orogen, and placing its metallogenic development into a tectonic framework. Nevertheless, linking radiometric age data to deformation remains challenging, due to complex overprinting relationships, isotopic mobility (thermal-, deformation- and fluid-induced), and recrystallization. Here we integrate white mica microstructure, high spatial resolution *in situ* laser ^{40}Ar/^{39}Ar and mineral chemistry data to date D_1 and D_2 cleavage domains in poly-deformed blue- and greenschist-facies rocks of the Bathurst Mining Camp, situated within the Tetagouche-Exploits back-arc basin. The white mica formed at low temperature, and records progressive syn-deformation growth and recrystallization rather than cooling ages. Our integrated data constrain the timing and duration of D_1 and D_2 deformation and guide interpretation of the significance of regional white mica ^{40}Ar/^{39}Ar step heating results.
Salinic D_1 deformation occurred during 455-439 Ma, with phengite growth during blueschist-facies metamorphism, and marks subduction and underplating of back-arc seamounts to the composite Laurentian margin. Acadian D_2 deformation occurred during 421-415 Ma in response to accretion of Avalonia to composite Laurentia.
Whereas bulk crystal dating techniques, such as ^{40}Ar/^{39}Ar step heating, are widely applied to metamorphosed and deformed rocks, this study demonstrates how they can mask important deformation-controlled age variations preserved at the microstructural or single crystal scale. Step heating analyses from this study present a homogenization of ages obtained from the *in situ* laser analyses and thus fails to resolve the distinct deformation events and duration of white mica growth. This suggests that different generations of white mica can have similar Ar retentivity during step heating, resulting in plateau ages that do not have an actual geological significance. Our study highlights the value of high spatial resolution ^{40}Ar/^{39}Ar age data in place of, or at least as a complement to step heat data for defining the duration of long-lived, polyphase tectonic events.

MULTISCALE STRUCTURAL ANALYSIS: A MICROMECHANICAL PERSPECTIVE

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The past fifty years have seen great advance in Structural Geology due to the application of materials science. However because Earth's lithosphere is rheologically heterogeneous over a wide range of characteristic lengths, the classical continuum-based approach cannot address the multiscale nature of lithospheric deformation and fabric development effectively. This has led to a disconnection between structural geology and tectonics for many decades. The inability of the classical continuum-based approach is also responsible for a noted disconnection between kinematic and mechanical analysis in modern Structural Geology.

We have established a micromechanics-based approach principally based on an extension of Eshelby's theory to power-law viscous materials and the idea of embedding inhomogeneities within inhomogeneities. The extended Eshelby theory provides a general means for handling flow field partitioning in heterogeneous rocks. The "inhomogeneities within inhomogeneities" idea allows consideration of multi-hierarchical levels of flow field partitioning and hence multiscale deformation and fabric formation. As our approach is fully based on mechanical principles, it combines rigorously kinematic analysis with mechanical analysis in structural studies.

We review the application of Eshelby's approach in geology and the general principles of our recent self-consistent MultiOrder Power Law Approach (MOPLA) by a number of recent research examples. The extended Eshelby's theory has been used to understand porphyroclast-bearing mylonites, mica fish microstructure, and small-scale ductile shear zones. The MOPLA approach has been applied to relate lineation patterns in the Cap de Creus area Spain and the Cascade Lake shear zone in the east Sierra Nevada of California to relate Structural Geology observation to regional tectonic evolutions.

STRUCTURAL SETTING AND VITRINITE RELECTANCE FABRICS OF KOOTENAY COAL IN THE CROWSNEST PASS AREA, ALBERTA

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Mapping in the Crowsnest Pass area of southwest Alberta is described and balanced cross sections are presented. The vitrinite anisotropy of the Grassy Mountain and Tent Mountain coal deposits are explained. In undeformed sedimentary basins, the minimum reflection axis (R_{min}) of uniaxial negative reflectance ellipsoids is oriented near-perpendicular to bedding. This indicates that the vitrinite fabric was acquired through coalification during sedimentary burial, when compression is assumed to have been essentially vertical. Reflectance axes should fan across fold axes if the coal-bearing strata were deformed after coalification. Coals with biaxial reflectance patterns are reported from strongly folded or faulted strata, suggesting that tectonic stresses are responsible for the biaxial symmetry. In biaxial negative coals, R_{int} is closer in magnitude to R_{max} than to R_{min}, whereas in biaxial positive coals, R_{int} is closer in magnitude to R_{min}. Biaxial positive patterns indicate stronger deformation. For coals with biaxial reflectance patterns, axial directions are commonly sub-parallel to fold axes and other structural lineaments.

Classical exposures of structurally thickened coal of the Crowsnest Pass deposits show that coal moved into the hinges of folds both perpendicular and parallel to the fold axes. The biaxial positive anisotropy of vitrinite indicates components of syn- and post-tectonic coalification. This conclusion is supported by the fact that the R_{max} axes line up with the fold axes.

AN APPALACHIAN-STYLE MULTI-TERRANE ACCRETION/COLLISION MODEL FOR THE ASSEMBLY OF SOUTH CHINA

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South China is traditionally interpreted to have formed by the collision of two blocks, the Yangtze and the Cathaysia. The proposed timing of collision varies from Proterozoic to Mesozoic, corresponding to that of the various tectonothermal events documented in South China. A better understanding of South China is important not only for the assembly of Asia, but also for the reconstruction of supercontinents (e.g., Rodinia). In this contribution, we propose, as an alternative interpretation, that the evolution of South China involved accretion/collision of multiple terranes (i.e. more than two blocks) and each of the major tectonothermal events corresponds to an accretional/collisional event. The Cathaysia Block has been divided into two parts, West and East, with contrasting histories. New and available age data indicate that the boundary between West and East Cathaysia is not the Zhenghe-Dapu fault as previously thought, but lies ~20 km to its west. In our model, West Cathaysia is a composite terrane formed by amalgamation of multiple terranes/arcs at ~1.0–0.88 Ga. Arc magmatism in the Shuangxiwu, Wuyi and Yunkai areas, metamorphism in the Tianli schist and emplacement of the Xiwan ophiolite were related to the process. West Cathaysia and the Yangtze Block collided at ~825–815 Ma along the NE Jiangxi fault/suture zone, following westward subduction (current coordinate) that generated a ~860–825 Ma arc–back-arc system preserved in the Jiangnan belt. The resulting Yangtze-West Cathaysia continent collided with a postulated continent to the east at ~460–440 Ma, leading to high-grade metamorphism in part of West Cathaysia (the down-going plate) in this “Caledonian”-aged orogen. East Cathaysia, characterized by a ~1.87–1.86 Ga basement and ~250–230 Ma high-grade metamorphism, possibly originated from an “Indosinian” orogen in the Paleo-Tethyan regime to the south. It accreted to the east of West Cathaysia in the Mesozoic, possibly through large-scale strike-slip movement. Before or during the process, the eastern part of the Caledonian-aged orogen and the postulated continent moved away from South China through rifting and/or strike-slip motion. Such a multi-terrane accretion/collision model is similar to what has been proposed for the Appalachian orogen.

_P-T-t_ EVOLUTION OF METASEDIMENTARY ROCKS IN THE WESTERN CAPE BRETON HIGHLANDS

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In an effort to understand tectonic complexities in the Western Cape Breton Highlands, metasediments of the Jumping Brook Metamorphic Suite (JBMS) have been the subject of an integrated *P-T-t* study. The JBMS is a low- to high-grade Barrovian sequence of pelitic, semi-pelitic and psammitic schists and gneisses within the Aspy terrane of Cape Breton Island. Pseudosection modeling with Theriak-Domino and isopleth thermobarometry applied to garnet cores indicate that initial conditions of garnet growth range from 500 to 550°C and 4.5 to 7.0 kbar within the field area. Assuming average crustal densities, initial conditions of garnet growth indicate geothermal gradients of 25-40°C km^{-1} during prograde metamorphism. Forward modeling results with the Theria_G software, which simulates prograde garnet growth along any specified *P-T* path, indicates that garnet growth occurred along steep clockwise *P-T* paths. Statistical analysis of the distribution of garnet porphyroblasts in three-dimensions suggests that metamorphic crystallization was controlled by detachment-attachment processes at the garnet-matrix interface.

To determine the age, provenance and timing of metamorphism in the JBMS, detrital zircon and metamorphic monazite were dated *in situ* via LA-ICP-MS within a medium-grade Corney Brook schist and high-grade Fishing Cove River schist respectively. Although the detrital zircon dataset is currently small (n = 50), peaks were observed at ~1.06 Ga, ~755 Ma, ~625 Ma, ~590 Ma, ~550 Ma, ~490 Ma, ~460 Ma and ~410 Ma. These data constrain deposition of the JBMS to sometime after ~460 Ma as the ~410 Ma age is interpreted to represent metamorphism rather than sedimentary provenance. Backscatter electron imaging of monazite revealed distinct cores and rims that yield ages of 406 ± 2 Ma and 397 ± 2 Ma respectively. The former likely represents subsolidus crystallization during prograde metamorphism while the latter is likely associated with the onset of partial melting. All together the data suggest that the JBMS was deposited sometime after ~460 Ma, that the JBMS in part was locally sourced from the adjacent Bras d'Or terrane, and that the JBMS underwent metamorphism along steep clockwise *P-T* paths over a protracted interval from ~406 to 397 Ma.

INTERPRETATION OF OPHIOLITE COMPLEXES: A TWEETER IN WOOFER'S CLOTHING?

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Typically, the oldest crystallization age obtained from supra-subduction zone (SSZ) ophiolites is interpreted to reflect the onset of subduction associated with convergence, possibly leading to closure of the oceanic tract in which the ophiolite was formed. But there are no adequate mechanisms to explain why SSZ ophiolites are obducted so soon after the ocean they formed in originated. For example, subduction in both the Iapetus and Rheic oceans, the two Paleozoic oceans whose closure produced the Appalachian-Caledonide-Variscan orogen, began relatively soon after their opening. Vestiges of the oceanic lithospheres of both oceans are preserved as SSZ ophiolites and related mafic complexes.

Published Sm–Nd isotopic data from these complexes indicate (i) derivation from highly depleted (HD) mantle with time-integrated depletion in Nd relative to Sm, (ii) that the extent of this depletion requires a melting event that occurred before either ocean existed, which implies (iii) that the HD mantle source was inherited from an older ocean (e.g. the Paleopacific) and captured within these Paleozoic oceans. Variation in density produced by Fe-Mg partitioning during this melting event would have rendered the older lithosphere more buoyant than the surrounding lithosphere, facilitating both its transfer from the older Paleopacific to the younger Paleozoic oceans, and the preferential development of oceanic arcs and future ophiolite complexes around this buoyant core. Such lithospheric capture is broadly analogous to the Mesozoic–Cenozoic capture of the Caribbean plate by the Atlantic realm, and may be the preferred site for oceanic arc development and ophiolite obduction. More generally, this mechanism of "plate capture" may (i) be an artifact of the geometry of supercontinent breakup, and (ii) explain the onset of subduction in an ocean soon after its formation. This analysis suggests that there is an important earlier history in many ophiolite complexes that has been previously unrecognized.

FIELD EVIDENCE FOR PENECONTEMPORANEOUS DUCTILE FLOW AND BRITTLE FRACTURE IN GRANULITE- TO AMPHIBOLITE-FACIES METAMORPHIC ROCKS, GRENVILLE PROVINCE OF CENTRAL AND SOUTHEAST ONTARIO.

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According to modern textbooks, the brittle-ductile transition zone is typically situated at depths of approximately 13-18 km, and comprises the strongest part of the Earth's crust. Below this zone, the natural deformation of common crustal rocks is supposed to be perfectly ductile. Field observations and recent analogue modelling suggest, however, that penecontemporaneous ductile flow and fracturing can take place at various depths ranging from the shallow crust to the upper mantle. Some workers have attributed deep-level fracturing of ductile metamorphic rocks to solution- and/or melt-enhanced embrittlement due to the positive ΔV reaction of dehydration and dehydration-melting processes causing a build-up of tensile effective stresses at depth. Others, however, have shown in model experiments at room temperature and atmospheric pressure that nonporous multi-layered materials can fracture systematically during ductile flow. Regardless of physical conditions and mechanical mechanisms, penecontemporaneous ductile flow and fracturing can account for many types of mesoscopic structure in migmatites and other high-grade metamorphic rocks. This principle is illustrated by means of field photographs showing mid-crustal granulite- and amphibolite-facies rocks including (i) metasedimentary marble containing brecciated interbeds of clastic rocks and (ii) leucocratic grey gneiss with disrupted mafic layers. The case for penecontemporaneous flow and fracture of deformed mafic layers in leucocratic grey gneiss is particularly strong where clouds of amphibolite or pyribolite fragments mimic the shape of pinch-and-swell structures (incipient lenticular boudins). Similarly, brecciated buckle folds in strongly veined grey gneiss and mafic granulite attest to the general importance of metamorphic fluids/melt on the mechanical behaviour of common metamorphic rocks in the middle crust.

HIDDEN WITHIN BRECCIA: THE TALE OF BONNETIA AND ITS PRECAMBRIAN OBDUCTION ONTO NORTHWESTERN LAURENTIA

Derek Thorkelson, Francesca Furlanetto, Alexander Nielsen, John Laughton, Kirsti Medig, Jacob Verbaas.

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During the Paleoproterozoic, collision of continental blocks and island arcs led to the formation of Ancestral North America, alternatively called Laurentia. This landmass may have been part of a larger continent, variably called Nuna or Columbia. For many years, western Laurentia was thought to have undergone a series of extensional events between 1.8 and 0.5 Ga, but little else, resulting in a long-lived continental margin characterized by unconformity-bounded sedimentary successions. Our work in Yukon Territory since 1992 has progressively revealed a more complicated history involving magmatism, deformation, metamorphism and hydrothermal brecciation. Over the past few years our work has taken an unexpected turn and we now propose that northwestern Laurentia was involved in a Wilson cycle during the late Paleoproterozoic to early Mesoproterozoic. Starting at ca. 1.7 Ga, Laurentia rifted and drifted apart from other continents, probably Australia and South China. The intervening ocean basin collapsed by 1.60 Ga and led to the obduction of an arc terrane named Bonnetia and collision with Australia. Bonnetia may have originated as a fringing arc to eastern Australia. The emplacement of Bonnetia was followed shortly by violent surges of hydrothermal fluids which led to foundering of megaclasts of the terrane deep into zones of breccia. Except for these megaclasts, Bonnetia was entirely removed by erosion prior to the next cycle of basin formation starting at ca. 1.5 Ga. The resulting successions include unit PR1 of the Fifteenmile Group in Yukon, the Belt-Purcell Supergroup in southwestern Canada and the northwestern United States, and related successions as far south as Arizona. Detrital zircon populations from these basins reflect sediment derivation from Australia and possibly East Antarctica.

OROGENIC ARCHITECTURE AND PHASES OF DEFORMATION IN THE KUUJJUAQ – TASIUJAQ AREA OF THE PALEOPROTEROZOIC NEW QUEBEC OROGEN.

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The New Québec orogen (NQO) is a Paleoproterozoic belt in the southeastern Churchill Province of the Canadian Shield made up of autochthonous rocks deposited adjacent to the Archean Superior craton, tectonically overlain by allochthonous metavolcanic and metasedimentary assemblages accreted to the cratonic margin. The NQO is bound by two Archean cratons, to the west by the Superior craton, and to the east by the Core Zone. Current models infer early terrane accretion to the Superior margin at ca. 1.82 Ga, followed by terminal collision with the previously amalgamated Core Zone – North Atlantic Craton block, in a bulk dextral transpressional regime at ca. 1.80 Ga. Metamorphic grade changes from upper greenschist facies at the edge of the Superior craton, to granulite facies in the Core Zone and associated rocks. The primary structural features of the NQO in the Kuujjuaq – Tasiujaq area are SW-verging thrust faults that imbricated the foreland and hinterland zones over the Superior craton. Between thrust faults the rocks dip to the NE, in tight to isoclinal folds with steep NE-dipping axial planes. All the allochthonous rocks of the NQO, as well as extensive intrusive and extrusive mafic packages associated with them are affected by these folds, constrained only to be younger than ca. 1.85 Ga. The predominant sense of shear in the NQO rocks is a dextral top-to-the-southwest motion, with a general trend from homogenous flattening in the north to elongation in the southeast, interpreted here are a result of protracted oblique transpressional collision. New in-situ U-Pb zircon geochronology on granulite to upper amphibolite facies metamorphic rocks on both sides of the proposed suture between the Core Zone and NQO record a protracted period of metamorphic zircon growth between ca. 1.88 Ga and 1.84 Ga, indicating that high temperature metamorphism and accretion was already under way than previous interpretations suggested. Monazite growth in the rocks of the NQO immediately adjacent to the Core Zone occurred as two distinct phases at ca. 1.77 Ga and ca. 1.73 Ga, with preliminary data suggesting a link to fluid circulation during extensional deformation. These data indicate that there are significant unresolved questions with respect to linking deformation and metamorphic ages to specific packages of rocks within the orogen; the NQO may preserve more extensive period of orogenic activity than previously thought.

INTRODUCING GEOLOGIC STRUCTURE IN A PRAIRIE LANDSCAPE: THE GEOSCIENCE GARDEN, AN OUTDOOR TEACHING INSTALLATION.

John W.F. Waldron

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Thinking in three dimensions is a major hurdle in the teaching of geoscience to undergraduate students, which is traditionally addressed using paper map exercises, 'synthetic' indoor lab exercises, and local field trips. Most universities also run intensive residential field schools where these skills are put into practice. However, instructors have remarked upon the difficulty that students have in translating their theoretical, classroom and laboratory-based experiences into hands-on mapping skills in the outdoor environment. These problems are particularly apparent in central Alberta, where outcrops are rare, and the local bedrock geology is dominated by uniform, flat-lying strata of the Western Canada Sedimentary Basin. For many students, field school in the Rocky Mountains is their first experience of working outdoors on deformed rocks; challenges of terrain, weather, and wildlife act as distractions that further hamper the application of knowledge learned in the classroom.

The Geoscience Garden is an installation, made possible by the University of Alberta Teaching and Learning Enhancement Fund, that employs large (up to 18 t) boulders emplaced in controlled orientations in a campus environment to assist the transfer of classroom skills to the field. In contrast to other installations of its type, the simulated outcrops are separated so that their field relationships are not immediately apparent; students must make observations and informed decisions so as to group the rocks into mappable units and deduce a geologic history. Measurements made by students in the Garden provide practical experience in simple structural calculations, including finding the net slip on a fault, and finding the axis and axial surface of plunging folds in a slate belt using spherical projection. Surveys carried out during the installation of the Garden and its incorporation into 2nd-year teaching showed that it improved students' perception of the usefulness of classroom-based instruction as preparation for field school.

A REVISED GEOLOGICAL INTERPRETATION OF THE CHÉTICAMP AREA, WESTERN CAPE BRETON ISLAND, NOVA SCOTIA, CANADA

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Geological mapping, U-Pb (zircon) dating, and petrographic, geochemical, and structural studies in the Chéticamp area have resulted in a revised geological interpretation of the western part of the Aspy terrane. Some of the oldest units in the area are the metamorphic rocks of the ca. <530 Ma Jumping Brook Metamorphic Suite (JBMS). This suite includes a lower N-MORB-affinity mafic metavolcanic unit (Faribault Brook formation), overlain by turbiditic metasedimentary and metatuffaceous rocks (Barren Brook and Dauphinee Brook formations) and related metaconglomerate (Rocky Brook formation). To the northeast, the higher metamorphic grade equivalents(?) of these units are included in the Corney Brook and Fishing Cove River formations. A large area of amphibolite (George Brook amphibolite) is associated with these higher grade rocks. The lower metamorphic grade rocks in JBMS have a shallow foliation (S_1) subparallel to bedding (S_0). This foliation is parallel to the axial surfaces of rare isoclinal folds in shear zones. Fold axes (F_1), crenulation fold axes (F_2), and S_0/S_1 intersection lineations are parallel and plunge gently to the north. An unresolved problem is the absence of similar deformation in the associated plutonic rocks, even those that appear to be older than the JBMS. The former "Chéticamp pluton" has been shown to consist of three units: Grand Falaise granodiorite (ca. 564 Ma), Pembroke Lake monzogranite (ca. 564 Ma), and Chéticamp River tonalite (ca. 490 Ma). The MacLean Brook granodiorite and Lavis Brook quartz diorite are both Early Silurian (ca. 440 and 438 Ma). A cordierite-bearing metamorphic contact aureole is well-developed around these Silurian plutons. A small area of syenogranite at French Mountain is dated at ca. 409 Ma. The bimodal Devonian Salmon Pool Pluton intruded along the boundary between the low- and high-metamorphic grade rocks in the JBMS. All the pre-Devonian plutonic units have petrographic and chemical characteristics consistent with calc-alkaline affinity and emplacement in a volcanic-arc tectonic setting, indicating a long history of subduction-related magmatism in the area. The ca. 564 Ma plutonic units are chemically similar to ca. 575-550 Ma Andean-type plutons that are characteristic of the Bras d'Or terrane. In addition, the metasedimentary Stewart Brook formation in the southern part of the map area is lithologically similar to parts of the George River metamorphic suite, supporting the interpretation that these rocks may be a fragment of the Bras d'Or terrane. The younger Lavis Brook and MacLean Brook plutons show similarity to Silurian igneous units of the Aspy terrane, and may be further evidence of a Silurian arc and back-arc system. How and when these units became juxtaposed in their present configuration remains uncertain.