Abstract Volume 23
Canadian Tectonics Group Meeting
2004

Saint John, New Brunswick

List of Participants

Name	Affiliation	Email Address
Austin, Nicholas	MIT, Boston	naustin@mit.edu
Baker, Chris	U. of New Brunswick (SJ)	chris_baker29@hotmail.com
Battler, Melissa	U. of New Brunswick	Melissa.battler@unb.ca
Bradley, James	U. of Alberta	jbradley@interbaun.ca
Brem, Arjan	U. of Waterloo	ajbrem@sciborg.uwaterloo.ca
Danyluk, Terry	Potash Corp.	terry.danyluk@potashcorp.com
Dimitrov, Ivan	U. of New Brunswick	d7z85@unb.ca
Downey, Matt	U. of Waterloo	downtowndowney@hotmail.ca
Durling, Paul	Corridor Resources	pdurling@corridor.ns.ca
Elliott, Colleen	U. of Montana	celliott@mtech.edu
Fueten, Frank	Brock U.	ffueten@brocku.ca
Henrichsen, Michael	Geodex Minerals	hmichael@nb.sympatico.ca
Jutras, Pierre	St. Mary's U.	pierre.jutras@smu.ca
Knowles, Grant	Encana Corp.	grant.knowles@encana.com
Kraus, Jurgen	Pan-China Resources	jkraus@sunwing.com
Kruse, Stefan	U. of New Brunswick	q09ay@unb.ca
Kuiper, Yvette	U. of Waterloo	ykuiper@uwaterloo.ca
LaFontaine, John	U. of New Brunswick	r5szu@unb.ca
LaFrance, Bruno	Laurentian U.	blafrance@nickel.laurentian.ca
Langenberg, Willem	Alberta Geo. Survey	willem.langenberg@gov.ab.ca
Lemieux, Yvon	U. of Alberta	ylemieux@ualberta.ca
Lin, Shoufa	U. of Waterloo	shoufa@sciborg.uwaterloo.ca
MacKinnon, Paula	Independent	
McCutcheon, Steven	New Bruns. Geo. Survey	steve.mccutcheon@gnb.ca
McNeill, Paul	U. of New Brunswick	p.mcneill@unb.ca
Park, Adrian	U. of New Brunswick	apark@unb.ca
Parmenter, Andy	U. of New Brunswick	a228k@unb.ca
Roulston, Brian	Potash Corp.	brian.roulston@potashcorp.com
Schwerdtner, Fried	U. of Toronto	fried.schwerdtner@utoronto.ca
Simony, Philip	U. of Calgary	pssimony@ucalgary.ca
St. Peter, Clint	New Bruns. Geo. Survey	clint.st.peter@gnb.ca
Wallace, Ken	U. of Alberta	kwallace@ualberta.ca
Wickens, Chris	Encana Corp.	chris.wickens@encana.com
Williams, Paul	U. of New Brunswick	pfw@unb.ca
Wilson, Lucy	U. of New Brunswick (SJ)	lwilson@unbsj.ca
Wilson, Paul	U. of New Brunswick	g258a@unb.ca
White, Joseph	U. of New Brunswick	clancy@unb.ca
Vetter, Sabine	U. of New Brunswick	d31yw@unb.ca

CTG 2004 Schedule of Events

Friday, October 22nd

7:30 pm **Meet and Greet in the Delta Hotel Hospitality Suite (Room 100)**

Saturday, October 23rd

7:00 am **Breakfast in the McAvity room at the Delta Hotel**

8:30 am **Presentations at the New Brunswick Museum**

8:30 am **Opening remarks**

8:40 am **Willem Langenberg**
Folding, thrusting and fracturing on Turtle Mountain near Frank Alberta.

9:00 am **Ken Wallace**
Deformation history of the Windermere Supergroup of east-central British Columbia: from soft-sediment to tectonic deformation.

9:20 am **Yvon Lemieux, Robert I. Thompson, Philippe Erdmer**
Does the Columbia River Fault really exist?

9:40 am **Philip Simony**
3-D mapping of a tectonic-metamorphic front; structural relations and difficulties.

10:10 am **Coffee and discussion**

10:40 am **Yvette Kuiper and Shoufa Lin**
Pure shear/simple shear partitioning along Aiken River deformation zone, Superior Boundary Zone, northern Manitoba

11:00 am **Matt Downey, Shoufa Lin, Christian Bohm**
Structural geology, kinematics and timing of deformation at the Superior craton margin, Gull Rapids, Manitoba.

11:20 am **Fried Schwerdtner and Andrei Yakovenko**
Structure of the Mesoproterozoic, TTG gneiss dome in SE Ontario and the nautre of Archean crustal deformation.

11:40 am **Paul Durling**
Fault Patterns from 3D Seismic Data in the McCully Gas Field.

12:10 pm **Lunch and poster viewing**

1:10 pm **Pierre Jutras**
Synopsis of post-Acadian deformation in the circum-Chaleur Bay area of eastern Quebec and northern New Brunswick.

1:30 pm	**Adrian Park** Deformation and cleavage development in mudrock: Weldon Formation, Lower Carboniferous (Tournaisain) at Weldon Creek and Belliveau Village, southeastern New Brunswick.
1:50 pm	**James Bradley** Timing of deformation in the Humber Arm Allocthon, Newfoundland.
2:20 pm	**Coffee and discussion**
2:50 pm	**Nicholas Austin and B. Evans** The role of stress on grain growth kinetics in calcite, with implications for strain localization.
3:10 pm	**Frank Fueten** Nucleation and growth of "hard" grains during simple shear deformation of norcamphor.
3:40 pm	**Poster session**
	Bruno LaFrance, Jerry C. DeWolfe, Greg M. Scott Evolution of the southern margin of the Wabigoon Subprovince, Beardmore-Geraldton Belt, SW Ontario.
	Arjan Brem, Shoufa Lin, Cees R. van Staal, D.W Davis and Vicky J. McNicoll Deformation in and age constraints on the Cabot Fault and the Little Grand Lake Fault in western Newfoundland.
	Ivan Dimitrov, Paul F. Williams, Steven McCutcheon Stratigraphic and structural evidence for Middle Silurian tectonic activity in northern New Brunswick.
	Paul McNeill and Paul Williams Cumulonimbus Structure: Description, Mechanism of Formation and Geological Significance.
5:00 pm	**Annual GAC/STGD buisness meeting at Tapps Brew Pub (second floor)**
6:00pm -ish	**Supper at Tapps Brew Pub (second floor)**

Sunday, October 24th

7:00 am	**Breakfast in the McAvity room of the Delta Hotel**
8:30 am	**Departure for field trip from the Delta Hotel lobby.** **Field trip ending sometime mid-afternoon near Sussex.**

Folding, thrusting and fracturing on Turtle Mountain near Frank, Alberta

C. Willem Langenberg
Alberta Geological Survey/EUB
4th Floor, 4999-98 Avenue, Edmonton, Alberta, T6B 2X3

Turtle Mountain forms part of the Livingstone Thrust sheet of the Foothills in Southwest Alberta and consists of Paleozoic carbonates and Mesozoic clastics. The dominant geological structures on Turtle Mountain are the Turtle Mountain Anticline and the Turtle Mountain Thrust. The Turtle Mountain Thrust is a splay of the Livingstone Thrust. The rocks forming the top of the mountain are Paleozoic carbonates of the Banff, Livingstone, Mount Head and Etherington formations. Strata below the Turtle Mountain Thrust include clastics of the Fernie, Kootenay (which is coal bearing) and Blairmore groups.

A detailed geological map of the South Peak area allows the construction of down-plunge cross sections perpendicular to the trend of the fold axis, which display the various structures. For this purpose several cylindrical domains were established. The Turtle Mountain Anticline changes geometry along its trend. Near the top of South Peak it forms a type of box fold with a 5 degrees SSW plunging fold axis. Near Drum Creek (south of South Peak) the fold is tighter and the fold axis plunges 16 degrees to the SSW. The change in geometry is described by the conical nature of the anticline, where a southward closing cone with a half-apical cone angle of 5 degrees can be fitted to the folded surfaces.

The Turtle Mountain Anticline is a modified fault-propagation fold and can be described as a break-thrust fold. Initially, a detachment fold formed above the Livingstone Thrust. At a later stage the Turtle Mountain Thrust broke through the eastern limb of this fold. Eventually folded limestone layers with down-slope dips were situated above almost vertical sandstone, shale and coal layers. The Hillcrest Footwall Syncline below the Turtle Mountain Thrust is a remainder of the original detachment fold.

The rocks are extensively fractured. The Paleozoic carbonates are of most interest for the stability of the mountain and are only considered here. The majority of fractures are extension fractures with accompanying shear fractures related to the anticlinal fold. Type I fracture sets (in the ac geometric plane) and Type II fracture sets (in the bc geometric plane) can be distinguished. The west limb of the anticline on the crest of South Peak shows the best Type II fracture sets, which are also represented by the most prominent fissure direction (roughly parallel to the Turtle Mountain ridge) near South Peak. The east limb, on the eastern slope of the mountain, shows more prominent Type I fracture sets, which are represented by the less prominent fissures on South Peak and which are roughly perpendicular to the trend of the ridge.

The down-slope dipping layers of the east limb are prone to sliding down the mountain, where jointing provides the removal of lateral restraint for the rock, as observed in the disastrous landslide of 1903. The continuing instability of South Peak has been studied and monitored with interruptions since 1930. In early 2003, the Alberta Government announced an initiative to install a state-of-the-art monitoring system on South Peak. Installation is planned to be complete by March 2005.

Deformation of the Windermere Supergroup, Castle Creek area, east-central BC: Soft-sediment vs. tectonic

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

The Neoproterozoic Windermere Supergroup has been identified as an ancient turbidite system comparable in size and setting to those which develop along modern day passive margins. Detailed stratigraphic mapping of an area ~ 3 x 7 km of excellent outcrop continuity is being carried out in the Cariboo Mountains, 35 km SW of McBride British Columbia. The stratigraphic succession of the Castle Creek area consists of sand-rich basin-floor turbidites (Kaza Gp) to mud-rich slope facies (Isaac Fm) is the target of detailed investigation by the Windermere Consortium in order to improve understanding of passive margin deep-water turbidite systems and reduce the risks associated with offshore exploration. Obscuring sedimentological observations are deformation structures of debatable origin (soft-sedimentary or tectonic?), particularly in the mud-rich slope facies. Furthermore, although sedimentary structures have been well preserved, they have been moderately distorted by secondary deformation.

Debris flow deposits identified in the area are among the most evident resedimented deposits that display deformation of soft-sedimentary origin. They are generally characterized by a silty-mudstone matrix with abundant, dispersed, poorly sorted quartz (sand to pebbles), locally-sourced folded stratified mud clasts and partially disintegrated sandstone blocks as well as shelf-derived shallow-water carbonate blocks. Debris flow deposits commonly incise into zones of movement. Internally, movement zones are characterized by rotated bedding, folded strata and truncation planes that are oblique to bedding. The bases of these units commonly truncate bedding with orientation consistent with local bedding. The strong spatial association of debris flows with movement zones, in combination with the above observations suggests that deformation associated with movement zones may be the result of soft-sedimentary sliding on the continental slope, rather than the sole result of tectonic deformation.

Besides local soft-sediment deformation, the deep-water sedimentary rocks of the Castle Creek area are folded at map scale, cleaved and display stretched pyrite crystals that locally define a strong lineation. Furthermore, cleavage planes are overprinted by at least two generations of kinks. As a preliminary investigation to test the sedimentological reliability of paleocurrent distributions, the Fry method is applied to the cross-sections of dewatering pipes on steeply dipping bedding planes, based on the assumption that these markers were initially evenly distributed. The finite strain ellipse on bedding planes is determined to have an ellipticity of 1.5, long axis oriented roughly along strike. Therefore, sedimentary structures on bedding planes have suffered only moderate distortions, and paleocurrent distributions are still meaningful for paleoflow analysis.

Does the Columbia River Fault zone really exist?

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

Robert I. Thompson
Geological Survey of Canada, Pacific Geoscience Centre, 9860 West Saanich Road, Sidney, British Columbia, V8L 4B2

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

The Columbia River Fault zone, southeastern British Columbia, was originally defined as an Eocene, brittle, east-dipping normal fault overprinting a much more significant ductile mylonite zone (termed as the "*Monashee décollement*"). Displacement on the fault zone was loosely constrained to be between 1 and 10 km. Over the years, however, the term "Columbia River Fault zone" has often been used to describe both the brittle zone and the mylonitic zone that juxtapose high-grade, footwall rocks of the Shuswap Metamorphic Complex against lower-grade rocks of the Kootenay Arc to the east. We suggest that the use of the term "Columbia River Fault zone" should be restricted to the brittle structure.

During the past three summers, field work was conducted along Upper Arrow Lake to investigate the nature, timing and significance of the Columbia River Fault zone. Detailed mapping reveals that the Columbia River Fault, although scarcely exposed in the Upper Arrow Lake area, is always defined by a fault zone a few metres thick, at most, and marked by discrete slip planes, fault breccia and gouge. Footwall to hanging wall stratigraphic offset is negligible. Minor offset of the metamorphic gradient across the fault is also consistent with small dip-slip displacement. Regional field work shows that a succession of Middle Paleozoic quartzite, marble and schist can be traced for more than 150 km along strike, from the Adams Lake-Chase area northwest of Vernon, eastward and southward to the western margin of the Kuskanax Batholith along Upper Arrow Lake, i.e., across the Columbia River Fault zone, and from previously interpreted accreted terranes to the outer miogeocline. This Middle Paleozoic succession includes at its base a distinctive calcareous quartzite marker that is of Late Devonian age. Field work suggests that this marker unit is also correlative with rocks mapped as part of the Milford Group, at Tenderfoot Lake, located ~40 km east of Upper Arrow Lake. Thus, new structural and stratigraphic constraints suggest a few kilometres, at most, of stratigraphic offset across the Columbia River Fault zone at the latitude of Upper Arrow Lake. Moreover, exposures of cataclastic rocks in the study area are compatible with the existence of several, moderately- to steeply-dipping brittle small fault zones.

3-D mapping of a tectonic-metamorphic front; structural relations and difficulties

Philip S. Simony
Dept. of Geology and Geophysics, University of Calgary, Calgary, AB
T2N 1N4, pssimony@ucalgary.ca

Mid-crustal levels exhumed from beneath the magmatic arc in the hinterland of the southern Canadian Rocky Mountain thrust belt expose the transition from upper levels where Jurassic metamorphism and structures are preserved to deeper levels where older structures are completely over printed by Late Cretaceous deformation, metamorphism and melting. The upper portion of a major shear zone is exposed at the deepest levels. The "front" of Cretaceous metamorphism and deformation is a warped and faulted, gently dipping surface. It is cryptic in a folded and metamorphosed sequence of thinly bedded sandstone, siltstone and shale but its mapping in 3-D is made possible by abundant plutons and minor intrusions of Middle Jurassic, Early Cretaceous and mid Cretaceous age that cross-cut the Jurassic structures and are themselves ductily deformed at deeper levels.

The observed downward progression is as follows:

- local weak foliation near contacts and enclaves
- pervasive, weak (biotite) foliation, igneous textures preserved
- local zone of intense foliation and lineation with ribbon quartz
- only lenses of weakly foliated rock preserved locally
- all rock pervasively and strongly lineated and foliated
- thin, discontinuous layers of mylonitic gneiss
- deformed, streaky, leucosome and pegmatite in mylonitic gneiss.

The line drawn to connect the tectonic "front" in the plutons roughly coincides with a zone within the metasediments where axial planes of folds change from dipping steeply west to dipping gently west at depth and where west-plunging lineations and fold hinges appear. In general, older fabrics are rotated and reactivated.

The analysis and interpretation of the Late Cretaceous tectonic front is complicated by evidence that some fold style changes with depth formed in the Jurassic, that there may have been some Early Cretaceous deformation and that sheets of Eocene leucogranite and associated Eocene shear, cross-cut the Late Cretaceous front obliquely.

Pure shear/simple shear partitioning along the Aiken River and Assean Lake deformation zones, Superior Boundary Zone, northern Manitoba.

Yvette D. Kuiper and Shoufa Lin
Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, N2L 3G1
(email: ykuiper@uwaterloo.ca)

The Superior Boundary Zone in northern Manitoba separates the Neoarchean Pikwitonei Granulite Domain or Superior Province to the southeast from the Paleoproterozoic amphibolite-grade Kisseynew Domain or Trans-Hudson Orogen to the northwest. The Split Lake Block is part of the Pikwitonei Granulite Domain and is bounded by the Assean Lake deformation zone (ALDZ) to the north and the Aiken River deformation zone (ARDZ) to the south. A Mesoarchean (pre-3.0 Ga) slice of crustal material (Assean Lake Crustal Complex) exists north of the ALDZ.

Movement was dextral, southeast-side-up on the ALDZ and dextral, north-side-up on the ARDZ, which caused uplift of the Split Lake Block. The latest movement on both deformation zones occurred under greenschist-facies metamorphic conditions and is presumed to be Paleoproterozoic. Because undeformed mafic dykes exist in the ARDZ, but not in the ALDZ, the ALDZ is interpreted as having been active until a later time. The possibility exists that the deformation zones were also active at an earlier time, e.g. in the Neoarchean.

The ARDZ is a one to one-and-a-half kilometre wide zone of well-developed mylonite. Rocks of the Split Lake Block are deformed by upright, moderately to steeply southeast-plunging, open to tight folds. The following modifications of these folds occur progressively towards the ARDZ,: (1) folds tighten; (2) shear fabrics develop on the fold limbs but not the fold hinges; (3) fold axes start rotating, which is the initiation of sheath fold development; and (4) dextral, north-side-up shear fabrics are pervasive and sheath folds are present. Tightening of folds along the mylonite zone that experienced dextral, north-side-up shear suggests that a flattening zone exists along the ARDZ that is wider than the simple shear zone. This is consistent with the conclusions of previous studies along other shear zones, that the pure shear component of a transpressive shear zone is accommodated over a wider area than the simple shear component (e.g. Lin et al., 1998).

Close to the 050°-trending ALDZ, the mylonitic foliation of the east-trending ARDZ rotated towards the orientation of the ALDZ. Similarly, east-trending, upright folds in the Assean Lake Crustal Complex seem to have rotated towards 050°. Rotation of structures could only be caused by drag along the ALDZ if shear on the ALDZ would be sinistral. However, shear bands, asymmetric clasts and Z-folds consistently indicate dextral (and southeast-side-up) movement. Therefore it is suggested that the reorientation of structures close to the ALDZ is caused by flattening along the ALDZ. If true, then the pure shear component of the ALDZ is accommodated by a wider area than simple shear component, similar to the ARDZ. Furthermore, if the mylonitic foliation of the ARDZ is indeed deformed by the ALDZ, then movement on the ALDZ outlasted movement on the ARDZ.

The structural geology, kinematics, and timing of deformation at the Superior craton margin, Gull Rapids, Manitoba

Matthew W. Downey, Shoufa Lin
Department of Earth Sciences, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, N2L 3G1
Christian Böhm
Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, 360 – 1395 Ellice Avenue, Winnipeg, Manitoba, R3G 3P2

The Gull Rapids area, northern Manitoba (NTS 54D/6), is host to a spectacularly exposed sequence of multiply deformed Archean supracrustal and basement rocks that have been extensively studied over the past two years. This area lies on the Superior craton margin and forms part of the Superior Boundary Zone (SBZ), a major collisional zone between the Archean Superior craton to the south and the adjacent Paleoproterozoic Trans-Hudson Orogen to the north. The study area is thus of importance for the development of a model of the tectonic evolution of the SBZ.

There are five main rock assemblages at Gull Rapids: 1) basement granodiorite gneiss (2780 Ma up to 3165 Ma), possibly related to the adjacent Split Lake Block (Pikwitonei high-grade gneiss terrane); 2) mafic metavolcanic rocks; 3) metasedimentary rocks (~2700 Ma); 4) late-stage granitic intrusive rocks; and Paleoproterozoic mafic dikes (2073 Ma). A detailed structural analysis of the Gull Rapids area revealed at least five generations of ductile and brittle structures, termed G_1 to G_5, with associated foliations, lineations, folds, and shears/faults. G_1 is characterized by a regional S_1 gneissic to schistose foliation and by a regional L_1 stretching lineation. S_1 foliation is bedding-parallel in supracrustal rocks, and is locally boudinaged. Rare occurrences of tight to isoclinal, upright F_1 folds are observed within supracrustal rocks only. G_2 is characterized by pervasive tight to isoclinal, meso- and macro-scale folding of S_1 and S_1-parallel granitic injection dikes and dikelets, throughout the supracrustal rocks. Locally an F_2-axial planar foliation is preserved. F_2 folds are refolded by the third generation of structure. G_3 is characterized by open to tight folding of S_1 foliations and F_2 axial planes and fold axes. Shearing is late and comprises the structural generations G_4 and G_5. G_4 shearing cuts all structures except mafic dikes. Shear-zone kinematics during G_4 reveal mostly south-side-up, dextral and sinistral movement along shear surfaces throughout the map area, and G_4 shear zones are reactivated by the G_5 shearing event. G_5 shearing cuts all structures and mafic dikes. The mafic dikes are only affected by the G_5 event, which may be related to Hudsonian tectonothermal activity. Shear-zone kinematics during G_5 reveal mostly strike-slip, dextral and sinistral movement.

The relative timing of deformation at Gull Rapids is constrained by using crosscutting relationships between structures and felsic intrusive phases. Radiometric U/Pb dating is currently underway on selected samples of felsic intrusive phases to obtain absolute ages for a number of the structural generations. Crosscutting granite sheets and dikes are interpreted to be late syn-G_1 to early syn-G_2, as they cut S_1 yet are folded by F_2. Some granitic dikes are interpreted to be syn-boudinage, where the boudinage is also late syn-G_1 to early syn-G_2. Other granitic dikes are interpreted to be syn-G_4/G_5 shearing. Peak metamorphism (granulite facies) is synchronous with G_1, and retrograde metamorphism to amphibolite facies is post-G_2. G_4 shearing is synchronous with amphibolite facies metamorphism, and G_5 shearing is synchronous with retrogression to greenschist facies.

Structure of a Mesoproterozoic, TTG gneiss dome in SE Ontario and the nature of Archean crustal deformation

W.M. Schwerdtner and Andrei Yakovenko
Department of Geology, University of Toronto, Toronto ON M5S 3B1
fried.schwerdtner@utoronto.ca

Some geologists believe that plate tectonics started in the upper Paleoproterozoic, ca. 2.0 Ga ago, and that prior deformation of the earth's crust was due mainly to the buoyant diapiric rise of large tonalite-trondhjemite-granodiorite (TTG) gneiss domes into overlying mafic metavolcanics and associated dense rocks. Although TTG gneiss domes are by no means restricted to present-day relics of ancient crust, their structural origin and tectonic significance may differ, nonetheless, between the Archean-Paleoproterozoic and the subsequent era of plate tectonics.

The configuration and strain pattern of Archean TTG gneiss domes have been studied carefully, in several ancient cratons, but less attention seems to have been paid recently to the structure of apparent counterparts formed after 2.0 Ga. This hinders attempts at making detailed comparisons between the structure and strain pattern of Archean domes and those of younger counterparts formed early in the plate tectonics era. To expedite such comparisons, we have started a field-based structural analysis of the 700 km_ Weslemkoon dome, better known as the Weslemkoon batholith or the ca. 1.2 Ga Weslemkoon tonalite. The dome has a heart-shaped map pattern with a crooked southern tail. According to published geological maps, the main part of the dome is composed of oval to crescentic, second-order structures. Apart from its eastern flank near Mazinaw Lake, the dome is mantled mainly by highly strained metavolcanics and weakly deformed metagabbro of the Grenvillian Composite Arc Belt. Field work in 2004 focused on easily accessible parts of the dome, as well as the western contact zone and the heterogeneously strained, metavolcanic-metagabbroic mantle. Preliminary results of the 2004 field work are listed in the following paragraph.

1. Weakly strained, intrusive features such as TTG sheets within jointed metagabbro characterize the southwestern contact zone of the dome, but the northwestern contact is marked by a flattened subvertical unit of mylonitized alaskitic granite (augengneiss).
2. The shape fabric of mineral constituents such as mafic clots indicates that the TTG is weakly to moderately strained, at most localities in the western half of the dome. 3. TTG gneiss is subhorizontally lineated rather than subvertically foliated, in the northwestern quadrant of the dome. 4. Except in highly strained rocks of the contact zone, the mineral-shape lineation plunges gently to the east or east-northeast. 5. Other than the mylonitic fabrics at the northwestern contact, we found no structural feature in the Weslemkoon dome that does not occur also in the well-studied Archean domes of the Wabigoon and Winnipeg River subprovinces (northwestern Ontario).

Earmarks of model diapirs such as subvertical extension lineations seem to be absent from the interior of the Weslemkoon dome. In places, we noted subhorizontally lineated TTG, apparently devoid of foliation and possibly situated in narrow hinge zones of tight higher-order folds. The sum of structural evidence gathered in 2004 is entirely explicable by repeated ductile deformation related to multi-order folding and north- to northwest-directed ductile thrusting in the collisional Grenville Orogen.

Fault Patterns from 3D Seismic Data in the McCully Gas Field

Paul Durling
Corridor Resources Inc., 5475 Spring Garden Rd., Halifax, Nova Scotia, B3J 3T2

The McCully natural gas field is located 11 km northeast of Sussex, in the southwestern part of the Moncton Basin. The field is approximately 12 km long and 4 km across. It is a combination structural-stratigraphic trap consisting of a NE-SW striking, doubly plunging, anticline which is truncated on the NW side by a major angular unconformity. Above the unconformity is a relatively undeformed sequence of red and grey, fine-grained clastic rocks of the Moncton Group. Below the unconformity are folded and faulted rocks assigned to the Horton Group.

Interpretation of 2D and 3D seismic data reveals an intricate pattern of faults within the Horton Group. The fault interpretation is based on mapping of the top of the Frederick Brook Member, a thick oil shale unit in the middle part of the Horton Group. The main fault identified is a straight, east-northeast striking fault showing down to the south displacement. At least two southeast striking, listric normal faults branch from the main fault forming splay faults. Other minor faults with limited strike length and throws are identified. When considered in the aggregate, these faults form a map pattern that matches a dextral strike-slip model of simple shear. All of these faults appear to terminate at depth within a low frequency, high amplitude seismic horizon interpreted as a decollment layer near the base of the Frederick Brook Member.

Below the Frederick Brook Member occur reflections that likely represent older Horton Group strata, such as the Dawson Settlement Member and the Memramcook Formation. These appear to be cut by low angle faults. A fold in the hanging wall of the upper fault suggests it is a thrust with south over north sense of motion.

The Moncton unconformity is largely not affected by the deformation in the Horton Group, indicating that the faulting occurred prior to unconformity development. It appears to mark a major change in sediment distribution patterns. Below the unconformity, the Horton Group rocks were deposited in a half-graben setting with the master fault(s) being located on the southeast side of the basin. In contrast, the Moncton Group was deposited in a broader basin that thins to the southeast and oversteps the Horton basin to the northwest.

Synopsis of post-Acadian deformation in the circum-Chaleur Bay area of eastern Quebec and northern New Brunswick.

Pierre Jutras
Department of Geology, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada
(*e-mail: pierre.jutras@smu.ca)

The Chaleur Bay area of eastern Quebec and northern New Brunswick was long thought to have been spared from the upper Paleozoic deformations that affect the rest of southeastern Canada. Recent work on upper Devonian to Pennsylvanian units of this area shows that the latter was affected by several episodes of deformation in post-Acadian (post-Middle Devonian) times. First, post-Acadian molasses of the Frasnian Miguasha Group were folded by NW-SE compression prior to deposition of the Upper Devonian Saint-Jules Formation in extensional or transtentional grabens. A swarm of large N-S striking mafic dykes was emplaced shortly after deposition of the Saint-Jules Formation. Their orientation with regards to the faults that bound the Saint-Jules graben-fill suggests that they might be the pull-apart result of sinistral motion along these faults in response to N-S compression. The Tournaisian is a hiatus in the stratigraphic record of the Chaleur Bay area, but several episodes deformation are recorded in units of the Viséan Percé Group prior to the Namurian in response to NW-SE compression. An E-W dextral strike-slip system responding to this stress is thought to have controlled deposition of the middle Viséan La Coulée Formation and the upper Viséan Bonaventure Formation. However, the two units are separated by an event of broad crustal flexuring, which caused the partial erosion of the La Coulée Formation and the synchronous deposition of the Cap d'Espoir Formation, and by an event of faulting, which caused the partial erosion of both the La Coulée and Cap d'Espoir formations, prior to burial of their erosional remnants by the Bonaventure Formation. These events are thought to represent periods of readjustment within the dextral shear system as it was experiencing prolonged NW-SE compression. On the north shore of Chaleur Bay, rocks as young as early Namurian experienced transpressional deformation in response to paleostresses that were gradually rotating clockwise from NW-SE trends to NE-SW trends. At the same time, on the south shore of Chaleur Bay, basin inversion occurred and Mississippian clastic rocks sourced a Pennsylvanian succession that shows a rotation of paleocurrent vectors that corresponds well with the suite of transpressional deformations that is recorded in Mississippian rocks of the north shore. This Pennsylvanin transpression is thought to reflect the onset of Alleghanian deformation to the southwest, whereas Upper Devonian to Mississippian deformation is interpreted as a transtensional response to the ongoing closure of the Theic Ocean to the southwest in the period spanning between the Acadian and Alleghanian orogenies.

Deformation and cleavage development in mudrock: Weldon Formation, lower Carboniferous (Tournaisian) at Weldon Creek and Belliveau Village, southeastern New Brunswick.

Adrian F. Park
Department of Geology, University of New Brunswick, P. O. Box 4400, Fredericton, NB, E3B 5A3

Tournaisian mudrocks in southeastern New Brunswick are part of an upward fining red-bed sequence (part of the Moncton Group) commencing with the Round Hill Formation (largely conglomerates, breccias and coarse sandstones), and succeeded by the Weldon Formation (mainly red sandstones, siltstones and mudrocks). This succession is contained within the east-west trending Hillsborough syncline. Through much of the Weldon Formation, mudrocks are interbedded with sandstone and siltstone, but in the middle and upper part of this succession there are thick sequences of mudrock without interbedded siltstone or sandstone, where deformation has removed any vestige of bedding. Deformation of these units on the regional scale is defined by broad, open, upright folds, but locally there is evidence of an earlier, mainly bedding parallel deformation related to thrusts. At two localities (Belliveau Village and Weldon Creek) large and continuous exposures of these red mudrocks reveal two different but related responses to deformation in these mudrocks. Both sections are located in the limbs of large synclines. At Belliveau Village a near-chaotic arrays of fractures represent accommodation in the limb of a fold, and offsets of bedding reveal at least four sets of these fractures. Offset direction on individual fractures appears to be random, but the overall pattern is consistent with fold geometry. Very locally, closely spaced fractures resemble a fracture cleavage, and several sets break up the mudrock with a pencil structure along their intersections. In the Weldon Creek section the fractures are more organized, with two penetrative fracture cleavages developed perpendicular to bedding. A clear cross-cutting sequence is present here, with the second cleavage progressively transposing the first. The first cleavage develops a slicken-lineation as it is rotated by this transposition. Bedding is largely undisturbed by either cleavage, implying that any movement on these two cleavages was bedding parallel.

The Weldon Formation red mudrocks are interbedded with sandstones that commonly retain some primary cement, and they overlie kerogenous shales (Albert Formation) that have only liberated wet gas and condensates. These features place constraints on the conditions under which cleavages developed: namely a maximum depth of burial in the 1 - 2 km range, and temperatures no higher than 120EC. These are the common conditions of early diagenesis. While the geometry of cleavages at Weldon Creek suggest a relationship to early bedding-parallel deformation, those at Belliveau relate to accommodation in a large fold limb.

Timing of deformation in the Humber Arm Allocthon, Newfoundland.

James Bradley, John W. F. Waldron and Peter Reynolds
Department of Earth and Atmospheric Sciences, University of Alberta, 1-26 Earth Sciences Building, Edmonton, Alberta, T6G 2E7

The Humber Zone of the Canadian Appalachians is divided into internal and external parts. The external Humber Zone contains a record of the eastern margin of Laurentia, which includes rocks that represent rifting, passive margin development, and margin destruction. Margin destruction resulted in thrusting and obduction of off-shelf sediments and oceanic crust in the form of a series of allochthons. The Humber Arm Allochthon was initially emplaced during the Taconian orogeny, which has been dated stratigraphically, using foreland basin units, as Early to Middle Ordovician. Additional emplacement of the allochthon occurred during the Acadian Orogeny, which is stratigraphically constrained, also in the foreland basin, as Devonian. The Middle Silurian Salinian Orogeny is recorded by isotopic evidence from the internal Humber Zone. Foreland basin units are present to the west and are observed on Port au Port Peninsula and in seismic sections.

Mapping has been completed in an area along the Humber Arm and near the city of Corner Brook. Relative timing between generations of structures in the Humber Arm Allochthon indicate that there are several episodes of deformation after the initial Taconian emplacement. In particular, there are two generations of Post-Taconian structures that are associated with low temperature mica crystallization in this area. Argon-Argon age dates were obtained using whole rock step heating methods. Two main groups of ages resulted from the analyses, which are interpreted as the time of tectonic mica crystallization for the mica fabrics in the area. Using the isotopic age of these structures, it is possible to place them in the stratigraphically and isotopically defined, framework of orogenic events in the region. These age dates have resulted in an isotopic age correlation to Late Ordovician Foreland basin units and also provide evidence for the style of deformation involved in the Silurian orogenic event.

The role of stress on grain growth kinetics in calcite, with implications for strain localization

N.J. Austin, and **B. Evans**
MIT

One common mechanism proposed for strain weakening and consequent strain localization is for grain size reduction by dynamic recrystallization to lead to a transition from grain size insensitive dislocation creep to grain size sensitive diffusion creep (Covey Crump, 1998; Rutter, 1999). A potential problem with this model, as has been pointed out by several authors (eg. Karato, 1989), is that, in the diffusion creep field, grains will tend to grow in order to minimize free energy, thus driving deformation into the dislocation creep field. It has, therefore, been proposed that deformation will tend to occur in some field between dislocation creep and diffusion creep (eg. Schimizu, 1998; de Bresser et al., 2001; Hall and Parmentier, 2003; Montesi and Hirth, 2003). What is absent from these models is knowledge of the relative kinetics of grain growth during diffusion creep and grain size reduction during dislocation creep. The relative magnitudes of these rates will determine the equilibrium grain size during deformation, and consequently the relative contributions of dislocation creep and diffusion creep to the overall strain rate. To date, however, there is no clear agreement as to the influence of stress on grain growth kinetics.

To gain insight into the kinetics of grain growth during diffusion creep in calcite, synthetic reagent grade (>99.4% pure) calcite was hot isostatically pressed (HIPed) for 15 minutes at a temperature of 650^{o}C and a confining pressure of 300 MPa in a Paterson-type, gas-medium apparatus. Immediately following the HIP, samples were either HIPed for a further 1 or 10 hrs, or were deformed at differential stresses of 10 MPa or 20 MPa for 1, 5, or 10 hrs. These stresses are known to be within the diffusion creep field for calcite at the temperature and for the grain sizes of interest (Walker et al., 1990). At the conclusion of each experiment, samples were thin sectioned, and grain size was measured using the linear intercept method on optical micrographs. In all samples, normal grain growth is observed, and there is no microstructural evidence of dislocation creep.

The results of these experiments indicate that stress has no influence on grain growth kinetics in calcite, while deformation is accommodated by diffusion creep. For calcite deforming under the conditions investigated here, therefore, it appears that the theories of static grain growth kinetics can be applied to samples deforming by diffusion creep. Due to the negligible influence of stress on grain growth kinetics during diffusion creep, however, other processes that may alter grain growth kinetics, including solute drag, must be accounted for in modeling the grain size, and thus strength, evolution of shear zones, and in determining the relative contributions of dislocation creep and diffusion creep to the overall strain rate.

Nucleation and growth of hard grains during the simple shear deformation of norcamphor

Frank Fueten
Dept. of Earth Sciences, Brock University
St. Catharines, On, L2S 3A1
ffueten@brocku.ca

A suite of simple shear deformation experiments of norcamphor were performed using a Urai-type deformation rig and the rotating polarizer stage. During these experiments the norcamphor displays the expected development of a lattice preferred crystallographic orientation and recrystallization by grain boundary migration. Also evident is the nucleation of grains of consistent crystallographic orientation, at a high angle to the orientation of the surrounding grains. Nucleation sites are at the boundaries between existing grains. The crystallographic orientation of these grains leads to the interpretation that the resolved shear stresses on the slip systems of these grains are at a minimum. During the growth phase of these grains, their shape remains low aspect ratio. The grains retain a constant shape and crystallographic orientation for some time during the deformation. When they do change, both changes in shape and crystallographic orientation occur simultaneously.

The grains are interpreted as nucleating and growing as hard grains and remain hard until rotated. A preliminary survey indicates that similar grains can be identified within natural quartz mylonites.

Evolution of the southern margin of the Wabigoon Subprovince, Beardmore-Geraldton Belt, SW Ontario

Bruno Lafrance[1], Jerry C. DeWolfe[1] and Greg M. Stott[2]

[1]Mineral Exploration Research Centre, Department of Earth Sciences, Laurentian University, Ramsey Lake Road, Sudbury, ON P3E 2C6
[2]Precambrian Geoscience Section, Ontario Geological Survey, Willet Green Miller Centre, Ramsey Lake Road, Sudbury, ON P3E 6B5
Email: blafrance@nickel.laurentian.ca

The Beardmore-Geraldton belt occurs along the southern margin of the Wabigoon granite-greenstone subprovince, Archean Superior Province, SW Ontario. The belt consists of interleaved shear-bounded panels of ca. 2725 Ma, mafic to intermediate, metavolcanic rocks of MORB, island arc, and back-arc geochemical affinity, and ca. 2696 Ma to 2691 Ma turbiditic sandstone and polymictic conglomerate. The metasedimentary rocks, which potentially correlate in age with turbiditic sandstone of the adjacent metasedimentary Quetico subprovince to the south, were likely deposited in a foreland basin that developed south of a southward advancing orogenic front. The basin was subsequently imbricated from 2696 Ma to 2691 Ma during D1 thrusting and accretion of the Wabigoon, Quetico, and Wawa subprovinces.

Post-accretion <2691 Ma D2 deformation produced regional F2 folds that transposed lithological units parallel to the axial plane S2 cleavage of the folds. During regional D3 dextral transpression, the folds were overprinted by a regional S3 cleavage oriented anticlockwise to F2 axial planes, and lithological contacts and S2 were reactivated as planes of shear within dextral regional shear zones that generally conform to the trend of the belt. Similar D1 to D3 structures occur across the Wabigoon, Quetico, and Wawa subprovinces. Gold occurrences in the Beardmore-Geraldton belt and Shebandowan belt, Wawa subprovince, are associated with folds and dextral shear zones that formed during the regional dextral transpression event.

Deformation in and age constraints on the Cabot Fault and the Little Grand Lake Fault in western Newfoundland

A.G. Brem[1], S. Lin[1], C.R. van Staal[2], D.W. Davis[3], and V.J. McNicoll[2]
[1]Department of Earth Sciences, University of Waterloo, 200 University Avenue West Waterloo, N2L 3G1;
[2]Geological Survey of Canada, 601 Booth Street, Ottawa, K1A 0E8;
[3]Earth Science Department, University of Toronto, 22 Russell Street, Toronto ON, M5S 3B1.

The Cabot Fault Zone and the Little Grand Lake Fault in the Newfoundland Appalachians are two structures that separate three tectono-stratigraphic units, each of which has a different plutonic, stratigraphic, structural and metamorphic history. Understanding the evolution of these two structures is an important aspect in unravelling the Early Paleozoic tectonic history of the region.

The Cabot Fault Zone (CFZ), separating the Humber Zone (Laurentian margin) from the Dunnage Zone (oceanic domain), is a crustal-scale structure that has experienced at least 3 different deformation events (D_1 – D_3). The late Middle Ordovician (ca. 460 Ma) D_1 -event is characterized by amphibolite facies tectonites that exhibit a strong gneissic foliation and ambiguous kinematic indicators, and only outcrop locally along the trace of the CFZ. The Late Silurian (ca. 418 Ma) D_2 -event is the best-recognized event along the trace of the CFZ, which is characterized by greenschist facies mylonites, with NNE strike, steep SE dips, and shallow SSW-plunging mineral and stretching lineations. Associated kinematic indicators in the mylonites suggest a dextral sense of shear, implying that the Humber Zone moved up- and northward relative to the Dunnage Zone. The Carboniferous D_3 -event is characterized by high crustal level brittle faults and cataclasite zones that are spatially associated with the D_2 greenschist mylonites. Steeply WNW dipping siliciclastic beds, brittle normal faults and associated slickensides with down-slip striations indicate that this Carboniferous sedimentary basin is extensional in nature.

The Little Grand Lake Fault in the Dunnage Zone separates the Dashwoods Subzone from the Notre Dame Subzone, and it has experienced one pronounced deformation event under greenschist facies conditions. Kinematic indicators associated with steep SE-plunging mineral lineations in steep south-dipping mylonite zones show that the lower amphibolite facies assemblage of the Dashwoods Subzone has moved up- and westward with respect to the lower greenschist facies assemblage of the Notre Dame Subzone. Complementary $^{40}Ar/^{39}Ar$ geochronology suggests that movement took place in Late Ordovician (ca. 445 Ma), which is post -D_1 and pre -D_2 in the CFZ.

Stratigraphic and structural evidence for Silurian tectonic activity in northern New Brunswick

Ivan Dimitrov[1], Paul F. Williams[1], Steven McCutcheon[2]
[1] Department of Geology, University of New Brunswick, P.O. Box 4400, Fredericton, NB, E3B 5A3
[2] New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 50, Bathurst, NB, E2A 3Z1

The Silurian Chaleur Group was deposited after the Ordovician Taconian Orogeny and before the Middle Devonian Acadian Orogeny; thus, it was traditionally believed that this Group was affected only by Acadian deformation. Inverted stratification was recorded in the Silurian rocks along the coast near Petit Rocher but this inversion, as well as some outcrop-scale, pre-cleavage folds, were attributed to syn-sedimentary slumping or early-stage, recumbent Acadian folding. However, sedimentological and stratigraphic data, as well as detailed mapping, indicate that significant tectonic activity took place in the Wenlock - Ludlow time interval. A well-exposed section at Limestone Point, near Petit Rocher serves to demonstrate this.

At the southern tip of Limestone Point, an angular unconformity exists between black limestone of the LaVieille Formation (late Llandoverian to Wenlockian) and overlying greenish gray clastic rocks of the Simpsons Field Formation (elsewhere known to be Ludlovian). Upsection from this unconformity, pre-cleavage folds are absent but downsection, pre-cleavage (F_1) folds are present. The F_1 folds have been traced by studying sandstone marker beds with abundant cross bedding, as well as other sedimentary structures, which indicate inversion of the stratification. Steeply plunging F_2 folds have refolded the F_1 folds, which are clearly overprinted by the regional cleavage. Since the entire Silurian section beneath the unconformity is affected, the F_1 folding event is interpreted as deformation of regional significance and is attributed to the "Salinic disturbance". However, this deformation is pre-Ludlow and thus, older than the typical Pridolian age reported elsewhere for the Salinic unconformity. This suggests that the Salinic disturbance was diachronous rather than confined to the latest Silurian as generally believed.

*Funding provided by Elmtree Resources Ltd., Bathurst, NB, E2A 3T7 and Collaborative Research and Development Grant **261082 - 02** - Project (CRDPJ) from NSERC*

Cumulonimbus Structure: Description, Mechanism of Formation and Geological Significance

Paul McNeill (P.McNeill@unb.ca) **and Paul Williams** (PFW@unb.ca)
University of New Brunswick, Fredericton, NB, E3B 5A3

A structure observed in migmatitic gneiss at the boundary of two lithological layers is characterized by a granitic melt that has an aspect resembling Cumulonimbus clouds. Mafic and felsic components are well differentiated on a millimeter to centimeter scale within the mafic host, which easily facilitates identification. The structure is at the boundary of two units, occurs periodically, and commonly has a broad base, tapering away from the base of the structure to form a, generally, wedged shaped feature. In other specimens the structure continues across the host layer until both sides of the host layer are bridged by leucosome. In well-developed specimens, this feature produces a new layering that is at a high angle to the original lithological layering.

We consider this structure to be the result of fracturing of a competent layer adjacent to a second, less competent layer, in the presence of a granitic melt. This happens at metamorphic conditions that are consistent with continued anatexis. Locally, shear along the boundary of two units of contrasting competency causes the more competent layer to produce fractures or microfractures into which localized granitic melt flows. Continuing to open the fractures, possibly assisted by the melt, through corrosive action at fracture tips, cause further dilatency and further differentiation of melt and restite. This process may occur to varying degrees at different places along the boundary but continues as long as anatectic reactions produce melt and dilatent sites are propogated. The process is arrested when either of these requirements is not met or changes in the deformation path results in the deformation and destruction of the structures.

Cumulonimbus structure, and the process of its formation, are important to structural work in migmatitic rocks: It is a structure that indicates crustal anatexis; it postdates the ductile fabrics developed in the host gneiss; a new foliation is formed locally that is at a high angle to the lithological layering; it indicates the synchronous processes of fracturing and melt migration at high grade metamorphic conditions.