THE 10th ANNUAL MEETING
CANADIAN TECTONICS GROUP

Shoufa Lin

October 19-21, 1990

ABSTRACTS WITH PROGRAM

Organised by The Centre For Deformation Studies

Universtiy of New Brunswick, Fredericton, N.B.

CANADIAN TECTONICS GROUP MEETING
Liscombe, October 19-21, 1990

PROGRAMME

Friday, 19th October .... Arrive Liscombe Lodge.
Dinner a la carte at your own convenience.
Your dinner is paid for but drink must be purchased.

POSTERS - Posters should be set up as soon as possible to give the maximum time for viewing. There will also be time during breaks and at the end of the afternoon on Saturday.

20:30 MIXER - There will be an informal mixer around the posters. Limited drink will be provided and further drinks can be purchased from the Bar. They will be delivered free of charge to the Conference Room.

Saturday, 20th October

7:00-8:30 am Breakfast a la carte.

TECHNICAL SESSIONS

8:30 - 10:30 **Chairman - Dr. P. Simony**

8:30 - 8:50	**CULSHAW, N.G.**	Evidence for a Duplex in the ductile mid-crust, Central Gneiss Belt, Grenville Province, Georgian Bay, Ontario.
8:50 - 9:10	**NADEAU, L.**	Tectonic, thermal and magmatic evolution of the Central Gneiss Belt, Huntsville Region, Southwestern Grenville Orogen.
9:10 - 9:30	**VAN GOOL, J.**	The Grenville Front Fold and Thrust Belt in southwestern Labrador: A tectonically inverted continental margin.
9:30 - 9:50	**GOODWIN, L.**	Strike-slip motion along the Baie Verte Line, Newfoundland.
9:50 - 10:10	**MILLER, B.**	Structural and tectonic evaluation of the Blair River Complex, Cape Breton Highlands, Nova Scotia.
10:10 - 10:50	**WALDRON, J.W.F.**	Reactivation of Taconian structures at the Acadian Thrust Front, Port au Port Peninsula, Newfoundland.

C O F F E E   B R E A K
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TECHNICAL SESSIONS

11:00 - 13:00 **Chairman - Dr. J. Starkey**

11:00 - 11:20	**BORRADAILE, G.**	Experimental strain of isothermal remanent magnetization in ductile sandstone.
11:20 - 11:40	**PUUMALA, M.A.**	A progress report on anisotropy of complex magnetic susceptibility: A new method of rock fabric analysis.
11:40 - 12:00	**LAFRANCE, B.**	Oblique-cleavage folds: A critical discussion with examples from the Canadian Appalachians.
12:00 - 12:20	**LIN, S.**	The origin of ridge-in-groove slickenside striae and associated steps in an S-C mylonite.
12:20 - 12:40	**MAWER, C.K.**	Migration of granitoid magmas: Diapirs, dykes, or disconnected dribbles?
12:40 - 13:00	**SAWYER, E.W.**	Rapid melt segregation during anatexis - Effect of deformation on leucosome location and composition.

L U N C H
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14:00 - 16:00 **Chairman - Dr. G. Borradaile**

14:00 - 14:20	**STARKEY, J.**	Orientation diagrams revisited.
14:20 - 14:40	**COOK, D.G.**	Three phases of reactivation of an earlier fault; two compressional, one extensional.
14:40 - 15:00	**ELLIOTT, C.G.**	The tectonic evolution of Tasmania and its disharmony with the Tasman-Transantarctic orogen.
15:00 - 15:20	**HENDERSON, J.R.**	Geology of the Whitehills-Tehek Area: A remnant of an Archean "greenstone" Belt in the Northern Churchill Province.
15:20 - 15:40	**PARK, A.**	Geometrical aspects of a major crustal shear zone segment, Mace's Bay, New Brunswick.
15:40 - 16:00	**SIMONY, P.**	Jurassic interfolding of highly strained Devonian basement with cover in Quesnel Terrane of southeast British Columbia and some implications for Tertiary extension.

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TECHNICAL SESSIONS

16:30 - 17:30 **Chairman - Dr. C.K. Mawer**

16:30 - 16:50	**WRIGHT, T.O.**	Transpressional collapse and deformation of an extensional basin in the Archean James River Belt, Bathurst Inlet Area, NWT, Canada.
16:50 - 17:10	**BARDOUX, M.**	Tectonic Controls of the McWatters Mine in the vicinity of the Cadillac Break near Rouyn: A reappraisal.
17:10 - 17:30	**CRUDEN, A.R.**	The 2680 Ma old Lebel Stock and the Larder Lake Break, S.W. Abitibi.

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17:30 - 19:30 - **POSTERS**

20:00 - **CONFERENCE DINNER** (Seafood / Roast Beef).

Sunday, 21st October

7:00 - 8:00 Breakfast a la carte.

8:30 - **FIELD TRIP** begins and participants will be delivered to Airport in time for their departures.

CANADIAN TECTONICS GROUP MEETING
Liscombe, October 19-21, 1990

POSTERS

Corrigan, D., Culshaw, N.G. and Mortensen, J.K.
Geology and geochronology of the Key Harbour Area, Britt Domain, southwest Grenville Province.

Fueten, F., Robin, P.-Y. and Stephens, R.
Development of quartz C-axis fabric in a coarse-grained granulite-grade gneiss.

Girard, R. and Madore, L.
Structural data management on spreadsheet software.

Hanmer, S.
Snowbird Tectonic Zone, northern Saskatchewan: A geological window onto a 3000 km long geophysical anomaly.

Hubbard, M.S. and Mancktelow, N.S.
Range-parallel transport in the Western Alps.

Lachapelle, R. and Goulet, N.
Les zones cataclastiques situées à la limite sud du Bouclier Canadien, region de Québec.

Setting of cataclastic zones at the southern margin of the Canadian Shield, Québec region.

Langenberg, W.
Cross sections through the Outer Foothills in the Coalspur Area, Alberta.

Malo, M.
Dextral transpression during Middle Devonian Acadian Orogeny in the Gaspé Region, Quebec Appalachians.

Ralser, S. and Park. A.F.
Tectonic evolution of the Archean rocks of the Tavani Area, Keewatin, N.W.T.

Redmond, D.
Quartz C-axis fabric variations across the Grenville Front Tectonic Zone, Carlyle Township, Ontario.

Rousell, D.H.
Strain determination in layer-thickened folds.

Schrader, F.
Lineation patterns on garnet-quartz nodules from the Grenville Front Tectonic Zone.

POSTERS (continued)

Schrader, F.
Structural analysis in the Stolz Fault Zone on Whitsunday Bay, Axel Heiberg Island (N.W.T.)

Tella, S., Roddick, J.C., Park, A.F. and Ralser, S.
Geochronological constraints on the tectonic history of the Archean and Early Proterozoic rocks in the Tavani - Rankin Inlet - Chesterfield Inlet regions, N.W.T.

Underschultz, J.R. and Erdmer, P.
Tectonic loading in the Canadian Cordillera as recorded by mass accumulation in the foreland basin.

West, D.P., Jr.
Late Paleozoic-Early Mesozoic tectonism along the Norumbega Fault zone, southwestern Maine.

Wodicka, N., Jamieson, R.A. and Culshaw, N.G.
Contrasting tectono-metamorphic histories within the Parry Sound shear zone and interior Parry Sound domain, southwestern Grenville Province, Georgian Bay.

Wunapeera, A.
Stratigraphy, structure, metamorphism, and tectonics of the Cape North and Money Point groups, northern Cape Breton Highlands, Nova Scotia: A preliminary report (funded by Canadian International Development Agency (C.I.D.A.)).

EVIDENCE FOR A DUPLEX IN THE DUCTILE MID-CRUST, CENTRAL GNEISS BELT, GRENVILLE PROVINCE, GEORGIAN BAY, ONTARIO

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Wallace, P., and Wodicka, N., Department of Geology,
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The late Proterozoic Grenville orogen is a compressional orogen comparable in scale to recent mountain belts. The Central Gneiss Belt is adjacent to the Grenville Front Tectonic Zone at the edge of the Orogen and is exposed for 140 km across tectonic strike along Georgian Bay. The high grade transect affords an extensive window in which orogenic processes of mid to deep crustal levels can be documented using metamorphic petrology, structural analysis and geochronology.

The gneisses can be grouped into associations of specific lithologies. While the boundaries of the units often coincide with shear zones, their primary characteristic is that they are sharply defined and separate gneisses with distinct, incompatible histories of mafic dyke emplacement, granitoid plutonism, and metamorphism, implying they can be neither stratigraphic nor plutonic boundaries, but must be tectonic. Furthermore, these boundaries are all associated with tectonically modified anorthosite, gabbro (some with eclogitic affinity), and rare pyroxenite bodies, suggestive of an exotic tectonic origin. A cross-section treating these boundaries as discrete thrust surfaces shows a large duplex-like structure. This has a floor thrust more than 100 km long, below which there are polycyclic, para-autochthonous rocks that include parts of the Britt and Go Home (sub-) domains in which locally preserved pre-Grenville granulite facies assemblages are reworked under Grenvillian amphibolite facies conditions. Within the three sheets of the duplex only Grenvillian metamorphism can be recognized. This occurred in at least two stages, an early stage (ca 1160-1120) produced granulite and amphibolite facies assemblages in the uppermost sheets of the Parry Sound domain. The later development of the duplex produced widespread amphibolite facies metamorphism (ca 1040-1020) in the lower levels and the footwall of the duplex. This must have, in part, postdated the assembly of the duplex and accompanied the formation of large (>30 km axial traces) subhorizontal, sheathoid folds, and subhorizontal extensional shear in the leading edge of the duplex.

The duplex model can be extended from the transect to include the whole Parry Sound domain and adjacent rocks within the Britt and Muskoka domains.

TECTONIC, THERMAL AND MAGMATIC EVOLUTION OF THE CENTRAL GNEISS BELT, HUNTSVILLE REGION, SOUTHWESTERN GRENVILLE OROGEN

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Mid- to deep crustal, northwest-directed, breakback ductile thrust structures of a wide range of scales dominate the Grenvillian tectonic architecture of the southwestern Central Gneiss Belt. The structural and geochronological data presented here demonstrate a southeastward migration, with time, of the approximate northwestern limit of active thrusting at the scale of the belt. This trend is reflected in the Huntsville area by the breakback nature of the Seguin thrust and the breakback thrust assembly of the underlying Algonquin thrust stack.

Thrust related ductile flow in the Huntsville region does not conform to a simple picture, either in space or in time. Although regional tectonic flow conforms to northwest-directed thrusting, a zone of northeast-southwest transpression developed near the base of the Huntsville thrust zone against a culmination in its footwall topography. Moreover, U-Pb dating demonstrates that thrusting at high structural levels triggered renewed tectonic movement at deeper levels. Finally, the thrust related flow fabric is disrupted by mesoscopic, high temperature extensional shears. These extensional shears represent mid-crustal collapse structures resulting from gravitational instability in an overthickened cooling pile. Such shears are widely distributed in the southwestern Central Gneiss Belt.

The thermal evolution of the southwestern Central Gneiss Belt is marked by a major crustal thickening event in the ca. 1350-1170 Ma range. Independent minimum age limits for attainment of granulite and uppermost amphibolite facies peak metamorphic conditions are provided by late-stage breakback thrusting ca. 1160 Ma and ca. 1100 Ma in the Parry Sound and Huntsville areas, respectively. Post-thrusting regional cooling to 700°C occurred ca. 1067 Ma at the level of the present erosional surface. Such thermal history is consistent with the late-orogenic, regional scale, breakback thrust stacking. It demonstrates that the late-stage thrusting ca. 1060-1030 Ma of the Central Metasedimentary Belt onto the Central Gneiss Belt is not the primary cause of high grade metamorphism in the Central Gneiss Belt. Therefore, if the crustal thickening and high grad metamorphism in the Central Gneiss Belt resulted from the accretion of the Central Metasedimentary Belt, docking and the deformation of the latter must predate ca. 1160 Ma.

The pre-Grenvillian history of the southwestern Central Gneiss Belt is marked by ubiquitous plutonism with ages in the ranges 1700-1620 Ma and 1480-1420 Ma. Plutonism in the older range is coeval with that in the 1710-1620 Ma Labrador and 1800-1630 Ma Central Plains orogens of the extreme east and south-west of Laurentia, whereas plutonic rocks of the 1480-1420 Ma suite are correlative with the ca. 1510-1430 Ma eastern granite-rhyolite terrane of the subsurface of central North America. These plutonic ages and the absence of significant volumes of plutonic rocks of Grenvillian age indicate that the cratonization of the Central Gneiss Belt was completed more than 100 Ma prior to the Grenvillian Orogeny.

THE GRENVILLE FRONT FOLD AND THRUST BELT IN SOUTHWESTERN LABRADOR: A TECTONICALLY INVERTED CONTINENTAL MARGIN

van Gool, Jeroen, Memorial University of Newfoundland, St. John's, Nfld., A1B 3X5

The Grenville Front Tectonic Zone in southwestern Labrador is a thin-skinned fold-and-thrust belt which emplaces Lower Proterozoic metasediments of the Labrador trough and their crystalline basement on the Superior Province foreland to the northwest. The belt forms part of the parautochthonous Gagnon terrane and is tectonically overlain to the southeast by orthogneisses of the Molson Lake terrane. Development of the thrust belt took place under elevated metamorphic conditions, ranging from lower greenschist facies close to the Grenville Front, to amphibolite facies near the boundary with the Molson Lake terrane to the southeast.

The geometry of the belt diverges from the generally accepted thrust belt models in the fact that the amount of basement incorporated in the thrust sheets increases toward the foreland rather than toward the interior of the orogen. Thrust sheets exist on two scales: i) sediment dominated sheets of a few hundred metres in thickness, locally incorporating thin slices of strongly deformed basement, and ii) thrust sheets up to several kilometres in thickness of low strain basement rocks.

A model for the tectonic development of the belt involves tectonic inversion of a basin on a block-faulted continental margin. Two processes dominate in the model: i) Emplacement of a major thrust wedge on top of the continental margin, which caused deformation and metamorphism of the sediments of the Gagnon terrane, with local detachment of the sediments from the basement. ii) Compressional reactivation of pre-existing extensional faults in the basement, causing the development of the kilometre-size basement dominated thrust sheets and related deformation in the overlying sediments. Microstructures indicate that fault reactivation may have been facilitated by chemical weakening along pre-existing extensional faults.

STRIKE-SLIP MOTION ALONG THE BAIE VERTE LINE, NEWFOUNDLAND

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The Baie Verte Line, which separates the Humber and Dunnage Zones in northern Newfoundland, was a tectonically active boundary from the Ordovician to at least the Carboniferous. Steep foliations within and adjacent to the Baie Verte Line are the most prominent of the structures that record this long deformational history. Field and petrographic studies indicate that these foliations developed through westward-directed thrusting followed, or accompanied, by motion with a strong strike-slip component. A transect across the Baie Verte Line shows a subhorizontal lineation in the more deformed centre of the Line, and a moderate to steep plunging lineation away from the Line. Formation of quartz and quartz-carbonate veins typically accompanied shearing, indicating the presence of significant amounts of fluid. Strike-slip movement was characteristically associated with the development of phyllonites and a shear band foliation. Macroscopic and microscopic sense-of-shear indicators record both dextral and sinistral motions, with both thrusting and normal components. The oldest foliations containing sense-of-shear indicators suggest dextral movement while the youngest motions identified are sinistral.

Many faults studied in Newfoundland and elsewhere exhibit features similar to those described above, and record similar sequences of events. The implications of these observations are: 1) older structures (in this case thrust zones) must be modified, or obliterated, by strike-slip movement, 2) the pre-strike-slip histories of adjacent tectonostratigraphic terranes are unlikely to be similar, and 3) strike-slip motion was critical in determining the present distribution of both lithologic units and structural domains with the Appalachian orogen. We suggest that both dextral and sinistral strike-slip motion must be accommodated in any model of terrane accretion in the northern Appalachians.

STRUCTURAL AND TECTONIC EVALUATION OF THE BLAIR RIVER COMPLEX, CAPE BRETON HIGHLANDS, NOVA SCOTIA

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The Blair River Complex (BRC) forms the northwestern corner of a "collage" of lithotectonically distinct packages on Cape Breton Island (CBI). This collage is considered by some workers to expose various levels of erosion of the Avalon Terrane, or to represent several components of the Avalon Composite Terrane. In both cases the BRC would be Avalonian basement. However, other workers consider CBI to display a compressed assemblage of separate terranes, correlatable with other Northern Appalachian terranes from New Brunswick to Newfoundland. In this case, the BRC would represent the Grenvillian (Humber Zone) component of the orogen. Irrespective of these differing interpretations, the BRC exposes lithologies unique to Nova Scotia.

The BRC consists of three distinct packages of rock types. The Pollets Cove River Group gneisses are perhaps the oldest rocks of the BRC and are comprised predominantly of multiply deformed quartzo-feldspathic gneiss, although amphibolite bodies locally make up a significant proportion of the unit. The Lowland Brook syenite and its equivalents intrude the Pollets Cove Brook gneiss and are typically medium to coarse grained and locally record a single deformational event represented by a gneissic foliation. Marble xenoliths in this body host the Meat Cove Zinc occurrence and other sulfide mineral showings. This syenite has produced a U/Pb-zircon age of c. 1040 Ma. The Red River Anorthosite Complex and its equivalents are comprised of anorthosites and anorthositic gabbros, both of which preserve cummulate textures. They intrude the Pollets Cove River Group, based on the presence of anorthositic dikes within the gneiss. Deformation of the anorthositic complex is only locally intense, suggesting largely post-deformational emplacement. The anorthosite compositionally and petrologically resembles massif-type anorthosites of the Grenville and Nain provinces, suggesting a genetic linkage.

The BRC is bordered by shear zones, the Red River Fault to the south and the Wilkie Brook Fault to the east. The Red River Fault rotates into parallelism with proximity to the Wilkie Brook Fault. Both are cut by Devono-Carboniferous plutons and late brittle faults and were overlain by sediments before they met. Geometrically these zones might imply a positive flower structure, however this is not supported by presently available kinematics. Foliations within these shear zones are generally steeply dipping with sub-horizontal mineral lineations where these are discernable. Sense of shear kinematic indicators were inconclusive in the field but are being investigated in thin section.

The presence of massif-type anorthosites coupled with the c. 1040 Ma minimum age of the BRC suggest it to be of Grenvillian affinity. Tectonic models for the Appalachian Orogen must take into account the presence of this Grenvillian component in northwestern CBI.

REACTIVATION OF TACONIAN STRUCTURES AT THE ACADIAN THRUST FRONT, PORT AU PORT PENINSULA, NEWFOUNDLAND

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The Acadian thrust front, marked by a triangle zone in seismic profiles offshore of western Newfoundland, is exposed on land in the Port-au-Port Peninsula, where it swings abruptly westward. At the west coast of the peninsula, Ordovician platform carbonates of the St. George and Table Head groups are affected by northwest-vergent major folds and thrusts, in contrast to the relatively flat lying strata farther east. The structures also affect Late Ordovician to Late Silurian sediments of the Long Point Group and Clam Bank Formation, but not the unconformably overlying Carboniferous units. They are therefore of Acadian age.

At the top of the platform succession, spectacular Middle Ordovician limestone conglomerates of the Cape Cormorant Formation are confined to the region of folds and thrusts along the west coast of the peninsula. They are overlain by foreland basin sandstone turbidites (Goose Tickle Group). Traced inland to the east, these coarsen and become conglomeratic, including large rafts derived from the Humber Arm Allochthon. A fault of Victors Brook separated this clastic package from a domain in which the foreland basin succession is thinner and has largely been incorporated structurally into the Humber Arm Allochthon.

The Acadian deformation zones coincide with the abrupt facies changes in the Taconian syntectonic sediments. This indicates that Taconian basin-bounding faults were reactivated in a reverse sense in the Acadian orogeny, inverting the Taconian basins. The non-cylindrical character of the structures on Port-au-Port Peninsula resulted from reactivation of faults oblique to the thrust front. Farther east, in the Stephenville area, comparable reactivation may have led to incorporation of basement rocks into the thrust belt.

EXPERIMENTAL STRAIN OF ISOTHERMAL REMANENT MAGNETIZATION IN DUCTILE SANDSTONE

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A macroscopically ductile sandstone, to which a homogeneous IRM was applied, has been deformed at 150 MPa confining pressure and constant strain rate of $10^{-5} s^{-1}$. Hydrostatic compaction does not produce a deflection of the IRM vector although it is reduced in intensity. Pure shear producing shortening in the range 2% to 35% steadily reduced the intensity of magnetization but also homogeneously rotates the remanence vector toward the plane of flattening. The amount of rotation is slightly less than that expected for a non-material line undergoing homogeneous strain.

During deformation a weak viscous remanent magnetization (DVRM) is acquired from the pressure vessel. This is different from a conventional VRM in that it is not acquired when the specimen is subject to hydrostatic confining pressure alone, even for periods three times longer than the longest deformation test. Previous erratic changes in NRM are explained by the selective removal of weakly coercive components of remanence by deformation.

A PROGRESS REPORT ON ANISOTROPY OF COMPLEX MAGNETIC SUSCEPTIBILITY: A NEW METHOD OF ROCK FABRIC ANALYSIS.

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Anisotropy of magnetic susceptibility (AMS) has become a widely used method of fabric analysis in rocks. Use of anisotropy of COMPLEX magnetic susceptibility (ACMS) is a new concept, in which the imaginary, or out of phase A. C. component of an induction coil used for the measurement of magnetic susceptibility is used to delineate rock fabric. COMPLEX magnetic susceptibility is a function of electrical conductivity. Thus, this method has potential for the analysis of sulphide-rich rocks, which tend to be reasonably conductive, but may not be suitable for regular magnetic susceptibility analysis.

Preliminary measurements were performed on highly conductive aluminum test specimens of differing shapes to determine the relationship between shape anisotropy and ACMS. The resultant fabrics were "inverse". Thus oblate specimens exhibited prolate anisotropy and vice versa.

Experimental triaxial deformation studies on loose pyrrhotite aggregates at 150 MPa (1.5 kbar) have been compared to those of AMS and strain. Once again, inverse fabrics were observed, with maximum complex susceptibilities approximately parallel to the maximum magnetic susceptibility directions in all cases.

In specimens of massive pyrrhotite, the relationship may be different due to the presence of tight boundaries and a weak crystallographic conductivity anisotropy.

OBLIQUE-CLEAVAGE FOLDS: A CRITICAL DISCUSSION WITH EXAMPLES FROM THE CANADIAN APPALACHIANS

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Examples of transected folds from three localities in Notre Dame Bay, north central Newfoundland are presented and analyzed. The term 'oblique-cleavage folds' is introduced as a geometric term to describe folds with a cleavage oblique to their hinges. Both d-type and Δ-type transection geometries are observed; they are the result of overprinting of the folds by the cleavage in two of the three localities, and the result of overprinting of the cleavage by the folds in the third locality. Consequently, oblique-cleavage folds need not form more or less synchronously with the oblique cleavage. An axial plane cleavage associated with the folds may be completely obliterated by the oblique cleavage or may never have existed.

Models proposed to explain the formation of oblique-cleavage folds are generally based on the orientation of the cleavage and folds with respect to the strain ellipsoids on the scale of the deforming zones or on the scale of layers of alternating competence. A different approach is followed; transected fold models and the geometry of oblique-cleavage folds are discussed in terms of the progressive development of the folds and cleavage.

Since oblique-cleavage folds are usually reported from zones undergoing non-coaxial progressive deformation and from polyphase zones, we suggest that oblique-cleavage folds may generally be a product of overprinting. Several alternative models are possible to explain the formation of folds with the geometry of transected folds; it is therefore necessary to show 1) whether the oblique cleavage and the folds formed during the same deformation event or during two separate deformation events, and 2) whether the oblique cleavage formed pre- syn- or post-folding.

THE ORIGIN OF RIDGE-IN-GROOVE SLICKENSIDE STRIAE AND ASSOCIATED STEPS IN AN S-C MYLONITE

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Surfaces with all the characteristics of classical slickensides are exposed by parting primarily along C-surfaces in S-C mylonites developed in the Eastern Highlands shear zone in Cape Breton Island, Nova Scotia. On the slickensides, striae of the "ridge-in-groove" type and steps of both congruous and incongruous types are developed. These surfaces are nevertheless a product of ductile deformation. The striae are parallel to and controlled by the trace of the stretching lineation on C- and, locally, on S-surfaces, and their length cannot be directly related to the magnitude of displacement along C-surfaces. Incongruous steps are smooth and usually coated by mica films. They are the result of parting along S-surfaces. Congruous steps are rough and not coated by mica. First-order congruous steps, typically inclined to S-surfaces by angles approaching 90 degrees, are formed by fracturing between individual C-surfaces, while second-order congruous steps form by breaking off of the tips of the dihedra between S- and C-surfaces. Thus, the "smoothness-roughness" technique can be used to determine the sense of shear. In strongly deformed rocks, where the angle between S- and C-surfaces is too small to be recognized in the field, this may prove to be a useful shear sense indicator.

MIGRATION OF GRANITOID MAGMAS:
DIAPIRS, DYKES, OR DISCONNECTED DRIBBLES?

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The emplacement of granitoid magmas, as bodies of batholithic proportions in the mid- to upper crust, is a major mechanism for vertical continental differentiation and can be a symptom of major continental growth by underaccretion. We can ask: 1) how is granitoid magma collected and extracted from partly-molten fertile generation zones?; 2) how does granitoid magma move from these deep levels (ca. 30 km or greater) to emplacement levels (commonly 0.5-10 km); 3) why does granitoid magma collect at emplacement sites at all? Why doesn't it always breach the surface, to be erupted as silicic volcanic rock?; and 4) what is the rate-limiting step for the process of granitoid magma migration?

Plausible answers for all these questions will be advanced, though we concentrate on 2) and 3) above. The only feasible mechanism by which large volumes of granitoid magma can be transported from deep generation levels to shallow emplacement levels, through thick and essentially undisturbed crustal sections, is by dyking. Geological evidence for large-scale diapiric transport of granitoid magmas is absent in amphibolite-granulite terrains of all ages. Porous flow/compaction is mechanically and thermally ineffective for transporting major volumes of granitoid magma vertically through many kilometres of cooling crust. We show that dyke transport of granitoid magma is not only possible, but effective and impressively rapid - an upper crustal batholith of 2000 km^3 could be inflated by a single dyke 1 km x 3 m in plan in about 900 years, assuming conservative magma viscosities and densities.

Emplacement of granitoid magmas must be wholly structurally controlled, and therefore the present geometry of a pluton tells nothing about its magma ascent mechanism. Emplacement occurs into dilatant sites, generally late or very late in the history of a orogenic cycle during relaxation of thickened crust, and commonly into extensional or strike-slip structures. Therefore, with due regard to appropriate terminology, it can be concluded that granites are generally syntectonic; distinctive feeder dyke geometry should distinguish each case. Emplacement levels seem to be directly controlled by roughly horizontal anisotropies or extremely weak and/or dilatant rock types (to catastrophically lower k at propagating dyke tips).

RAPID MELT SEGREGATION DURING ANATEXIS - EFFECT OF DEFORMATION ON LEUCOSOME LOCATION AND COMPOSITION

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Many model P-T-t paths indicate that the deeper levels of regional metamorphic belts may have been at temperatures high enough to cause partial melting for periods of as long as 1-10 Ma. The production of melt over this period depends on the type of melting reaction. For discontinuous reactions melt production is episodic, but for continuous dehydration melting reactions, such as those involving hornblende breakdown in mafic rocks, melt production is a gradual process that occurs as long as the temperature rises. It therefore keeps pace with heat input.

The generation of small volumes of melt under hydrostatic conditions produces patchy or nebulitic migmatites, but, if melt migrates under matrix compaction then layers of melt may form. It is very unlikely that there will be no deformation over a long melting interval of 1-10 Ma, and indeed most migmatite terranes contain abundant evidence of deformation during partial melting. In the Grenville Front (Quebec) migmatites, for example, the distribution of leucosomes is structurally controlled. Most occur in small-scale, low-pressure dilatant structures, such as shear bands and boudin necks, that have developed in a banded, anisotropic palaeosome during syn-melting deformation. In many cases the rocks enclosing the leucosomes are depleted in melt components and closed-system migmatisation with melt migration distances of 10-20 cm can be demonstrated.

The leucosomes in the small-scale dilatant structures are depleted in the high field-strength elements (HFSE) relative to the palaeosomes. Typically they are Zr-undersaturated by a factor of 2 to 10 relative to a melt that is in chemical equilibrium with its source, i.e. they are disequilibrium melts. Other leucosomes with vein-like morphologies in the same terrane have, in contrast, compositions enriched in the HFSE (like granites) and are Zr-saturated. These are equilibrium melts. In equilibrium melting the melt and solid are in contact long enough for complete chemical equilibrium to be reached between melt and the whole volume of solid. If melt and solid are separated before equilibrium is reached then melts depleted in the slowest diffusing elements result; these are disequilibrium melts. Thus, deformation during melting affects both leucosome location and composition.

It is suggested that in most migmatite terranes the principal type of leucosome present, that is, those in dilatant structures with HFSE-depleted compositions, formed when the melt segregated from its source and migrated to the low pressure sites at a rate faster than that at which melt equilibrates with its restite. Calculations indicate that chemical equilibrium for Zr should be reached in less than 800 a at 675° and 20 a at 775°C.

In the Grenville Front migmatites, where dehydration melting occurred through a continuous reaction involving hornblende breakdown, melt production was probably slow because it was controlled by the regional heat input. Melting took place under non-hydrostatic conditions and the rate at which melt segregated from the source, and collected in nearby low pressure dilatant sites was rapid because the process of segregation is driven by the imposed deformation rate and not by the regional heat input. Because the residence time for melt in the matrix was short, disequilibrium melt compositions resulted, and it follows that the volume of melt at any one time in the deforming matrix must also have been small, as any excess volume over the threshold permeability (perhaps 1-5% melt) would have been immediately drained off to the nearest low-pressure site.

ORIENTATION DIAGRAMS REVISITED

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In 1977 it was demonstrated how meaningful contoured orientation diagrams could be prepared from samples of different sizes. The relationship between the percentage of empty space in a contoured sample and the area of the projection occupied by the parent population was derived. It was also shown that the areas occupied by the various point concentrations were established at quite small sample sizes. The preferred orientation patterns used in this analysis were defined by limiting the areas in which the data occurred but within these areas the distribution was random.

A similar analysis has been extended to measured quartz c-axis data. Comparing the area of empty space with the maximum point concentration present in a pattern reveals that the maximum is higher in the measured than in the computer simulated preferred orientations. In other words, not surprisingly, the data in the measured patterns are clustered rather than randomly distributed within the areas of concentration.

Analysis of large numbers of computer generated random patterns shows that the standard deviation of the area of empty space about the mean (and theoretical) value decreases with sample size. For a sample size of 200 the standard deviation is less than 2% of the area. For a sample size of 500 it is about 1%. There is no significant improvement with larger sample sizes. For patterns of preferred orientations it is anticipated that the standard deviation would be less for a given sample size, since the distribution of the data is more predictable.

Contouring the measured patterns incrementally as data are accumulated reveals variations in the areas of the different point concentrations and in the maximum concentration present. However, beyond a certain sample size no further significant variation is observed. This sample size is a small multiple of the maximum concentration present (perhaps 5 times).

The purpose of this analysis is to attempt to relate the size of sample with the precision with which it is likely to describe the parent population from which it is drawn. In terms of the parameters discussed here it appears that the sample sizes which are commonly used (usually 200+) are sufficient to identify the maximum point concentration, to determine the area of empty space within 2% and to determine the areas of higher point concentrations to better than 2%, with a probability of .66.

Starkey, John 1977. The contouring of orientation data represented in spherical projection. Can. J. Earth Sciences v. 14 p. 268-277.

THREE PHASES OF REACTIVATION OF AN EARLIER FAULT; TWO COMPRESSIONAL, ONE EXTENSIONAL

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Seismic data across Belot Ridge in the Colville Hills of northwestern Canada reveal a Precambrian-basement thrust block which has been reactivated during subsequent Proterozoic and Phanerozoic events. Phase I faulting rotated a large block, consisting of basement and overlying strata believed to correlate with the Hornby Bay Group on the Canadian Shield some 200 km to the east. This correlation implies that deformation occurred after 1663 Ma but well before emplacement of the Coppermine basalts dated at 1267 Ma, and may be related to the Racklan Orogeny, of the northern Cordillera, dated no more accurately than pre-1268 Ma. The fault block, was displaced vertically at least 4.5 km, was subsequently peneplained at a regional unconformity, and is overlain by strata believed to correlate with clastics and platform carbonates of the Dismal Lakes Group. Syndepositional reactivation of the fault (phase II) recorded by thinning of the basal Dismal Lakes Group across the structure, resulted in further uplift of about 0.5 km and consequent deformation of the unconformity. A third, extensional phase is marked by the offset and rotation of a key Dismal Lakes Group marker into a 40 km long half-graben localized by the large early structure. This phase is probably related to extension represented by the 1270 Ma Mackenzie Dyke swarm and the Coppermine flood basalts. Alternatively, because age constraints are poor, it could relate to the 778 Ma Hayhook event in the northern Cordillera. Subsequent peneplanation of the Proterozoic was followed by a Cambrian marine incursion and development of a remarkably stable, mainly carbonate platform which endured through Devonian time. Cretaceous clastics complete the rock cover. Phase 4, post-Cretaceous compression, assumed to be related to Laramide orogenesis in the Cordillera to the west, generated the isolated anticlinal ridges of the Colville Hills. One of these, Belot Ridge, closely overlies the subsurface trace of the basement fault and is clearly a product of reactivation.

THE TECTONIC EVOLUTION OF TASMANIA AND ITS DISHARMONY WITH THE TASMAN-TRANSANTARCTIC OROGEN

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The island of Tasmania is the southernmost exposure of the Tasman Orogen, a composite fold belt in eastern Australia that was an active plate margin of eastern Gondwanaland throughout the Paleozoic Era. In pre-Cretaceous plate-tectonic reconstructions the Tasman orogenic belt aligns with the Transantarctic Mountains and the southern Cordillera of South America to form one mountain belt thousands of kilometres long. Tasmania is a small part of this picture, but forms the keystone of the Tasman-Transantarctic (and probably New Zealand) reconstruction. In the last twenty years Tasmania has been correlated with mainland Australia in at least four different ways, and at least three different ways with Antarctica. There are widespread lithostratigraphic units, like Devonian and Carboniferous granitoids and Permian glacigenic rocks, that are common to all three continental masses. However, similar rocks of similar age are also common to Lower Paleozoic fold belts around the world, and do not serve any special purpose in accurately correlating tectonic terranes.

In detail, Tasmania has a stratigraphy and structural style distinct from anywhere else in the orogen. the island can be divided into two lower Paleozoic terranes - East and West Tasmania. East Tasmania is underlain by Ordovician and Devonian meta-turbidites that have been folded into east facing, recumbent folds and overprinted by upright folds. West Tasmania has a complex lithologic assemblage. The oldest components are late Proterozoic quartzitic blocks of all sizes, found scattered throughout this terrane, but only found in this part of the Tasman orogen. Latest Proterozoic and Cambrian active shelf sequences are overlain by Late Cambrian to Early Devonian, shallow water, siliciclastic and carbonate rocks. Both East and West Tasmania are intruded by Devonian to Early Carboniferous granitoids and overlain by Permian continental deposits and a voluminous sheet of Jurassic dolerite.

Traditional models attribute the present configuration of West Tasmania to the opening and closing of small rift basins within stable, rooted, Precambrian basement (and therefore with little regional tectonic transport) during the Paleozoic. However, my mapping indicates that locally the margins of Precambrian blocks are major faults, and some blocks are completely fault bounded. At least one block -the Badger Head block - is allochthonous. There are more than four generations of faults in western Tasmania, including foreland-style thrusts along which Paleozoic and Precambrian rocks have been telescoped. Thrust transport in northern Tasmania was west-directed and opposite in sense to that reported for mainland Australia and Antarctica. Steep late faults may be responsible for the present "trough"-like distribution of Paleozoic rocks.

Paleozoic stratigraphy and structure do not correlate between Tasmania and mainland Australia or Antarctica, but they correlate well between the latter two. I therefore believe that Tasmania is an exotic composite terrane that shared tectonic events with the rest of Gondwana, but was not contiguous with the exposed Tasman-Transantarctic orogen until Mesozoic times. If this is true, Tasmania must be bounded by movement zones that were active in Mesozoic times. No faults of the expected orientation or magnitude are exposed in Tasmania, but may be located beneath Cenozoic cover in southeast Australia or the flanking continental margin basins. These faults might have controlled the location of rift basins that formed during the breakup of Gondwanaland.

GEOLOGY OF THE WHITEHILLS-TEHEK AREA: A REMNANT OF AN ARCHEAN "GREENSTONE" BELT IN THE NORTHERN CHURCHILL PROVINCE

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Supracrustal rocks in the area are intruded by 2.6 Ga batholiths (Ashton, 1988) which are not penetratively deformed. We believe therefore that all of the folding and cleavage development in the region is Archean, although the area is within the Churchill Structural Province and is inferred to be the hinterland of the early Proterozoic Amer fold-thrust belt (Patterson, 1986) located less than 40 km to the north.
Lithologies recognized in the Whitehills-Tehek belt can be assigned an order of structural superposition in an area where they form a homocline, but the relative thickness of lithologic units varies regionally and the stratigraphy is uncertain.

1. Mainly Intermediate Metavolcanic Rocks form the base of the pile. The most common lithology is fine grained, massive metadacite (2786 Ma U-Pb zircon date; H. Chapman, pers. com., 1990).
2. Mainly Metagreywacke structurally overlies the intermediate metavolcanic rocks in the south of the belt, and contains 2770 Ma detrital zircons (U-Pb date; H. Chapman, pers. com., 1990).
3. Banded Iron-formation (quartz-magnetite, quartz-silicate and quartz-carbonate facies) occurs above the metagreywacke and hosts gold mineralization.
4. Mafic-Ultramafic Metavolcanic Rocks overlie the banded iron-formation. Spinifex textured komatiite locally appears to form the base of this unit. Where ductile talc schist is against brittle banded iron-formation, gold-pyrite and gold-pyrrhotite bearing quartz veins fill hydraulic fractures in the iron formation.
5. Quartzite and Quartz-Muscovite Schist appears to structurally overlie mafic and ultramafic metavolcanic rocks. The unit is very massive and contains abundant quartz veins (commonly >50%). Bedding has not been recognized, but some metapelite lenses have been observed.
6. Felsic Metavolcanic Rocks (quartz-feldspar porphyry) are found locally throughout the sequence.

In outcrop generally two secondary fabric elements can be measured: S_1 pressure solution cleavage and S_2 crenulation cleavage. Bedding is rarely defined, and S_1-related folds in bedding were rarely identified, but in the north of the region S_1 dips south more gently than bedding, and a north-directed D_1 thrusting is inferred. Recumbent folds and subhorizontal S_2 crenulation cleavage characterize D_2, and several macroscale north-vergent D_2 folds were documented. Gold values are greatest in fractured iron formation in the short, steeply-dipping limb of an F_2 fold pair.

Like most Archean greenstone belts in the Slave and Superior structural provinces, basement rocks to the Whitehills-Tehek belt have not been recognized, and the supracrustal rocks are preserved as roof pendants in late-stage batholiths.

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GEOMETRICAL ASPECTS OF A MAJOR CRUSTAL SHEAR ZONE SEGMENT, MACE'S BAY, NEW BRUNSWICK

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On the south coast of New Brunswick the late Precambrian (Hadrynian??) to ?Cambrian metasediments and a suite of intruded felsic rocks (Golden Grove Suite), have been pervasively deformed. The most extensive continuous outcrop of these rocks lies around Mace's Bay, between Barnaby Head and Pocologan Harbour. To the north they are bounded (apparently) by the Pocologan fault, and have an ambiguous relationship to the highly deformed rocks of the Coldbrook Group and the included Kingston dyke swarm. On Barnaby Head, a reverse, low-angle fault juxtaposes mylonitic gneisses derived from granite and supracrustal rocks, with overturned, but relatively little deformed, lower Carboniferous shales and sandstones with plant fossils.

Age constraints on the timing of deformation in the crystalline rocks are poor, and the relationship between the very high strain deformation, the post-Carboniferous faulting and the Pocologan fault (a major orogen parallel strike-slip zone) remains unresolved. One dominant foliation (S_a) and a related mineral lineation (L_a) dominate the crystalline rocks, and L_a has a remarkably consistent orientation throughout the Mace's Bay area, despite the highly variable orientation of S_a. Distribution of lower strain enclaves, changes in orientation of S_a, and lithological patterns reflect the presence of mega-boudins, essentially prolate bodies consisting largely of granite. L_a lies parallel to the long axes of these bodies whose aspect ratio approximately to 1:2:>10.

Mylonites are scattered throughout the exposed crystalline material, but at the lowest exposed structural levels, they dominate the rock, reaching a thickness in excess of 50 m. At what appear to be the highest structural levels, exposure is dominated by little deformed granite, gabbro and diorite with mafic dykes and supracrustal enclaves. The large mylonites are considered to represent the base of a flat-lying shear zone. Above it, some 500 m to 1 km of highly deformed supracrustal rocks and granitoids are dominated by megaboudins. S_a deflects around these bodies, producing, on a small scale, alternate steep zones and flat zones. The deformation related to the Pocologan fault is an overprint on one of these steep zones.

The crystalline rocks contain a number of fabrics and structures overprinting S_a: these include a sporadically developed and locally intense second foliation (schistosity, S_b), a crenulation with related folds (S_c, F_c), and several generations of small-scale ductile to semi-ductile shear zones. One set of these later structures involves normal dip-slip motion on south-dipping fault planes, followed by reverse dip-slip reactivation. This reactivation probably relates to the post-Carboniferous movements, usually used to determine the position of the "Variscan front". Later sets of brittle fault-planes, with hematized slickensides and wall-rock reddening probably relate to Triassic-Jurassic events associated with the development of the Lepreau and Bay of Fundy half-grabens. This later history of fault movement serves to isolate the crystalline rocks of southernmost New Brunswick as a segment of a major, pre-Carboniferous, crustal shear zone.

JURASSIC INTERFOLDING OF HIGHLY STRAINED DEVONIAN BASEMENT WITH COVER IN QUESNEL TERRANE OF SOUTHEAST BRITISH COLUMBIA AND SOME IMPLICATIONS FOR TERTIARY EXTENSION

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Between Trail and Castlegar in southeast British Columbia, early Paleozoic basement gneisses were intruded by a Devonian trondhjemite pluton and subsequently by mafic dikes. These were overlain unconformably by the late Paleozoic and Jurassic island arc assemblage typical of Quesnel Terrane and thus are the basement of Quesnellia.

Two strips of the Pennsylvanian Mount Roberts Formation within the gneisses represent two very tight synclines where the cover has been deeply infolded into the basement. The Devonian pluton is intensely deformed and the plutonic fabric virtually completely replaced by gneissic fabric and a gneissic banding. That gneissic fabric controlled the emplacement of Mid-Jurassic laccolithic granodiorite plutons. These plutons do, however, on a large scale, cross-cut the infolds, showing that there was intense Jurassic deformation.

The Eocene Valkyrie Shear Zone obliquely cross-cuts the Jurassic fabric and the Jurassic plutons in such a way that it can be shown that:

(a) the shear zone cuts from a higher structural level to a lower level in the direction of eastward tectonic transport which is consistent with its extensional transport.

(b) while it is a zone of intense and heterogeneous shear, there is no complete uncoupling of the upper plate from the footwall structures.

(c) the Jurassic plutonic structure exerted some control on the Eocene strain field.

TRANSPRESSIONAL COLLAPSE AND DEFORMATION OF AN EXTENSIONAL BASIN IN THE ARCHEAN JAMES RIVER BELT, BATHURST INLET AREA, NWT, CANADA

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The supracrustal succession exposed in the belt is dominated by distal turbidites and siltstones with lesser amounts of volcanic, volcaniclastic and intrusive rocks mostly of intermediate composition, chemical sediments (ironstones) and locally derived pebble to cobble conglomerate. These lithologies are present in a >15 km thick steeply-dipping east-facing homoclinal panel except for a locally west-facing package of turbidite near Turner Lake. The conglomerate contains abundant clasts of felsic volcanic rocks, ironstone and minor quartz and sedimentary rocks, all indistinguishable from flows or shallow intrusions, ironstone beds and sedimentary beds in the sequence. Thick sequences of turbidite both underlie and overlie the section containing the conglomerate beds, ironstones and most of the volcanic rocks, but the two turbidite sequences are distinctly different. Both the conglomerate and volcanic rocks rapidly pinch-out both north and south along strike within 35-40 km, replaced by turbidite, siltstone, and minor volcaniclastic rocks. Ironstone horizons extend further along strike, but also decrease in importance away from the conglomerate. These relationships suggest the former presence of an active volcanic island within the filling rift basin.

Structural and metamorphic elements include soft-sediment folding and local unconformity development associated with conglomerate horizons, regional eastward homoclinal tilting, one period of peak metamorphism, one cleavage-forming episode and two periods of folding, the first having nearly vertical fold hinges and the latter nearly horizontal hinges. Uniform metamorphic grade, both across section/strike and along structural plunge imply homoclinal tilting occurred prior to attainment of peak metamorphism, while the absence of cleavage fabrics within porphyroblasts implies cleavage and folding episodes occurred after peak metamorphism. Cleavage in the entire belt is clockwise relative to bedding. Mapped folds rarely exceed 2km in wavelength. At least one granitic pluton cuts the section and carries the regional cleavage, however, most of the granitic rocks surrounding the belt do not have a fabric, and intruded passively after deformation events.

These relationships are incorporated into a working model that begins with an extensional basin that locally contained a volcanic island. This basin underwent eastward subduction, eventually being collapsed between two blocks of sialic crust. Thermal relaxation after collision caused initial growth of porphyroblasts under nearly static conditions. Regional build-up of sub-horizontal residual stress placed the rocks under sinistral compression which caused the regional cleavage fabric to over-print the porphyroblasts and also caused the small-scale folds with steep to vertical axes. Granitic plutonism began prior to cleavage but mostly followed cleavage and folding events. Radiometric age dates from volcanic flows, conglomerate cobbles, foliated granite and unfoliated granites are expected to test and place rates on predictions of this model, as will PT information from the metamorphic minerals.

TECTONIC CONTROLS OF THE McWATTERS MINE IN THE VICINITY OF THE CADILLAC BREAK NEAR ROUYN: A REAPPRAISAL

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The McWatters gold mine was the first gold producer in the Abitibi region (Hanley, 1934). Located east of Rouyn, mine drifts cross the footwall of the Cadillac-Larder Lake shear zone (CLLSZ) and display tectonic traps for gold mineralization.

The host rocks are composed of mafic and ultra-mafic units, confined to the tectonic corridor of the CLLSZ (Gauthier, 1990). Detrital sequences associated with the Timiskaming Group overlie the volcanics which consist of calc-alkaline basalts, andesites and agglomerates. Conglomerates associated with the Timiskaming sequence (Goulet, 1978) contain fragments of sulfide and gold quartz vein, indicating an early, pre-concentration event.

The tectonic evolution of the area comprises an early phase of normal faulting suggested by a pervasive stretching lineation and the development of mylonites and microshear bands. Rock sequences in the vicinity of the mine are overprinted by a pervasive E-W schistosity that is axial planar to large open folds, refolding old mylonitic shear zones. A later set of local kink folds trend NE-SW and are probably associated with a Grenvillian event. Late brittle normal and reverse faults dissect the entire zone and cut Proterozoic diabase dikes.

The gold mineralization occurs in two domains (1) along thick tourmaline-quartz veins near a stratigraphic contact south of the CLLSZ and (2) along highly silicified horizons on both sides of CLLSZ. These two settings display significant geochemical and mineralogical differences. Near the CLLSZ, a mylonitic "flow ore" (Kishida and Kerrich, 1987) consists of banded pyrite-carbonate, folded by the younger CLLSZ. Horizontal tension cracks cut this unit and are mineralized at the vein intersections.

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THE 2680 MA OLD LEBEL STOCK AND THE LARDER LAKE BREAK, S.W. ABITIBI

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Fabric development in the ca. 2680 Ma old Lebel Stock has been studied to assess the relative timing of pluton emplacement and establishment of the Larder Lake Break (LLB), south-east of the Kirkland Lake gold camp. Preliminary results indicate that forceful emplacement of the Lebel Stock predates ductile deformation related to the LLB. Early south-side-up motion on the LLB must therefore have started less than 2680 Ma ago.

The Lebel Stock is a 6 km wide, sub-circular syenite intrusion. Its age is inferred from recent U/Pb dating of the petrologically similar Otto Stock exposed 2 km to the south-west. The stock intrudes ultramafic and mafic volcanics, quartzites and lean iron formations of the ca. 2705 Ma old Larder Lake Group. These rocks are concordant to the east, west, and south margins of the stock up to 2 km from the contact. The stock appears to have imposed a strong transposition foliation, with a down-dip lineation, and amphibolite facies contact metamorphism on its wall rocks. The stock's north margin is bound by metasediments, "trachytic" flows and sills of the steeply south dipping Timiskaming Group. An east-west trending belt of strongly foliated sericite schists, strained conglomerates and discontinuous "green carbonate" schists is exposed immediately north of the stock, and is indicative for the LLB.

A strong planar magmatic fabric occurs throughout the stock. This fabric, defined by the preferred orientation of rectangular K-feldspars and hornblende laths, is concordant to the east, south, and west margins of the stock. It shows steep inward dips at the margins which become gradually shallower approaching the interior of the stock. The steep north-south trending magmatic fabric in the northern part of the stock is abruptly terminated by the LLB deformation zone. Here, a poorly exposed, <10m wide band of syenite gneiss is developed. Composite coplanar fabrics in the gneiss indicate a south-side-up shear sense. Thin discrete ductile shear zones, showing apparent dextral and sinistral horizontal offsets, also occur in the stock, up to 1 km south of the LLB. The geometry of these shear zones is also consistent with north-south flattening of the north margin of the stock.

CANADIAN TECTONICS GROUP MEETING
Liscombe, October 19-21, 1990

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Fueten, F., Robin, P.-Y. and Stephens, R.
Development of quartz C-axis fabric in a coarse-grained granulite-grade gneiss.

Girard, R. and Madore, L.
Structural data management on spreadsheet software.

Hanmer, S.
Snowbird Tectonic Zone, northern Saskatchewan: A geological window onto a 3000 km long geophysical anomaly.

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Range-parallel transport in the Western Alps.

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West, D.P., Jr.
Late Paleozoic-Early Mesozoic tectonism along the Norumbega Fault zone, southwestern Maine.

Wodicka, N., Jamieson, R.A. and Culshaw, N.G.
Contrasting tectono-metamorphic histories within the Parry Sound shear zone and interior Parry Sound domain, southwestern Grenville Province, Georgian Bay.

Wunapeera, A.
Stratigraphy, structure, metamorphism, and tectonics of the Cape North and Money Point groups, northern Cape Breton Highlands, Nova Scotia: A preliminary report (funded by Canadian International Development Agency (C.I.D.A.)).

GEOLOGY AND GEOCHRONOLOGY OF THE KEY HARBOUR AREA, BRITT DOMAIN, SOUTHWEST GRENVILLE PROVINCE

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In the key Harbour region, Grenvillian deformation (D3) is localized into shear zones, forming anastomosing arrays enclosing elongate zones of lower and more homogeneous strain. Crosscutting relationships preserved only in the inter-shear domains permit the establishment of a field chronology, and reveal an extensive series of pre-Grenvillian events. This chronology has been tested by U-Pb isotopic dating.

Leucogranite dated at 1684 Ma intruded previously deformed, locally migmatitic gneisses, including garnet amphibolites in which granulite facies assemblages are locally preserved (M1-D1). After the emplacement of mafic dykes, plutonism accompanied by high-level deformation and partial melting of country rock (M2-D2) occurred between 1456-1442 Ma. This event was followed by a second episode of mafic dyking, including the 1238 Ma Sudbury swarm. Monazite in K-feldspar-kyanite-sillimanite paragneisses yields a U-Pb age of 1035 +/-1 Ma, interpreted as a minimum age for upper-amphibolite grade Grenvillian metamorphism (M3). Rocks of the Key Harbour area cooled through the titanite blocking temperature between 1001 Ma and 1004 Ma. Zircons from syn-tectonic leucosomes developing in the neck of internal boudins indicate that ductile deformation continued at least until ca. 1015 Ma. E-W trending pegmatites dated by U-Pb zircon at 990 Ma intruded at high angle to the regional fabric while the host gneisses were still capable of ductile deformation.

It is proposed that the Grenville orogen in the Key Harbour area consists of reworked Mid-Continental crust, as suggested by recent models.

DEVELOPMENT OF QUARTZ C-AXIS FABRIC IN A COARSE-GRAINED GRANULITE-GRADE GNEISS

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Abstract - Quartz c-axis fabrics in granulite-grade coarse-grained layered gneisses reveal a strong pattern, with three perpendicular maxima, which can be interpreted in terms of syntectonic recrystallization and growth. Mapping of the distribution of the c-axes within a thin section demonstrates that the fabric is domainal. Domains are on the scale of millimetres and are associated with individual quartz ribbons. No single domain exhibits the fabric for the complete section. Within each domain, weighting of the c-axis fabric by the area of each quartz grain demonstrates that the largest grains have their c-axes preferentially at the maxima.

A model is presented to account for the development of this fabric. Grains which can keep their stored strain energy to a minimum by the use of a single favourably oriented glide system grow at the expense of other grains. The largest, most successful grains deform by glide on only one of either the basal <a> or the prism <a> systems, depending on the crystallographic orientation of the grain. Each domain develops its own glide direction by cooperation of the glide systems of its constituent grains. The successful grains in a domain are those which can accommodate that direction. The bulk strain of the rock is achieved by the addition of the strains distinct to each domain.

STRUCTURAL DATA MANAGEMENT ON SPREADSHEET SOFTWARE

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Drawing a stereographic projection is a two-fold process: A) selecting the data to be plotted, B) plotting them. Most, if not all, available stereographic projection software deals with plotting the data already selected and performing complex calculations (eigen vectors, contouring, etc). However, as a regional mapping survey can yield thousands of structural data points of many kinds, selecting them to produce meaningful diagrams became a time-consuming task. Data-managing software packages are commercially available, but putting them in interaction with stereographic projection packages is a fastidious task. Spreadsheet software, one of the most popular data-managers among scientists, have a built-in graphic capability, which can be used to draw stereographic projections. Then the database and the projection became fully interactive in both ways.

A data-base is set-up, including structural measurements and as many characteristics (comments, rock type, geographic, structure type) as needed. The measurements, which are in azimuth co-ordinates, are transformed into XY co-ordinates through the usual algorithms, plotting of which draws the projection. By processing the Y co-ordinates with a logical algorithm involving the characteristics associated with the data, selection is performed prior to plotting. Including the geographic location in the database provides a means to isolate map domains. The same polygonization process is feasable backward onto the projection plot in order to isolate clusters of data. The projection can be drawn with multicolor pen plotters, or exported to drafting software. The selected data subset can also be extracted and formatted for use with standard stereographic software packages.

SNOWBIRD TECTONIC ZONE, NORTHERN SASKATCHEWAN: A GEOLOGICAL WINDOW ONTO A 3000KM LONG GEOPHYSICAL ANOMALY

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Linear anomalies in the potential fields of the Canadian Shield mark the Snowbird Tectonic Zone (Hoffman 1988) which extends 3000km from the Canadian Rockies to N. Quebec. They also define an elliptical area (300 by 100 km) at whose NE end lies Stony Rapids. There, the Snowbird Tectonic Zone is triangular in shape and comprises a hanging wall panel of shallowly to steeply dipping granulite mylonites and a footwall of steeply dipping granulite to amphibolite facies mylonites. Lineations in the granulite panel trend northeast-southwest to east-west; those in the footwall trend southwest, but 'porpoise' about the horizontal. Mylonites are penetratively developed throughout.

Protoliths represent a dismembered layered mafic complex and a pile of monotonous pelitic metasediments, intruded by batholiths of tonalite and I-type (s.l.) granite and thick gabbro sheets. Further I-type granite sheets and mafic dykes were emplaced during mylonitisation. This lithological association is suggestive of the deep roots of a magmatic arc. There are no direct age constraints on the geological history of the Snowbird Tectonic Zone, north of the Athabaska Sandstone.

Syntectonic mineral assemblages in granulite facies mylonites of both the hanging wall and footwall suggest transitional metamorphic conditions circa 800°C at 700-800 MPa. The granulite mylonites of the hanging wall contain no visible shear criteria. However, if they are contemporaneous with the granulite and amphibolite facies mylonites of the footwall, then the hanging wall mylonites are thrust related. The eastern half of the footwall contains exclusively sinistral shear criteria, whereas the western half contains dextral shear criteria. Qualitatively, the volumes of rock affected and intensity of the deformation are of equal importance in both the sinistrally and dextrally sheared parts of the footwall. Thus, the progressive deformation of the footwall appears to reflect large-scale boundary conditions approximating to pure shear. Shear sense criteria in mylonites derived from granites which were emplaced syntectonically at the base of the hanging wall panel indicate post-granulite extensional displacement of the hanging wall, down towards the west and south. Magmatic intrusion along the trailing edge of the upper plate of an extensional shear zone strongly suggests a causal relationship whereby deformation creates a zone of potential dilation and the soft, recently emplaced granites localises continued tectonic displacement.

In the eastern part of the Snowbird Tectonic Zone, extensive, strongly annealed hornblende-bearing mylonites are associated with a gravity high and a densely packed mafic dyke swarm. It is possible that mafic magma has assisted in the introduction of hydrous fluids into hot mylonites.

Whereas the eastern margin of the Snowbird Tectonic Zone is associated with sinistral shear along a southward plunging extension lineation in the Stony Rapids area, the upper greenschist to lower amphibolite facies Virgin River shear zone (C. Saskatchewan) shows dextral shear along a northward plunging lineation (Carolan and Collorson 1988. 1989). One might therefore speculate that the geophysically defined ellipse represents the lower part of a continental scale "island" of still material, subjected to a major component of a regional scale pure shear.

RANGE-PARALLEL TRANSPORT IN THE WESTERN ALPS

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Though major deformation in the western Alps is clearly the result of N-NW directed thrust tectonics, there is evidence suggesting that deformation with a NE-SW trend may have been important in the late tectonic history of the western Alps. We propose that this NE-SW trending deformation includes: 1)SW-directed normal fault movement along the Simplon line; 2) a diffuse zone of dextral strike-slip deformation along the Rhône valley between Visp and Martigny, Switzerland, continuing between the Mt. Blanc and Aiguille Rouge Massifs, through the Belledonne Massif; and 3) SW-directed thrusting in the Embrunais-Ubaye and Digne nappe systems of southeastern France. Existing dates from Simplon Pass and the Digne nappe support a Neogene age for this late deformation (Mancktelow, 1985; Clauzon et al., 1987).

Evidence for top-to-the-SW normal fault deformation (stretching lineation ≈30° S60W) in the vicinity of Simplon Pass has been demonstrated from quartz fabrics with estimates of displacement at ≥12-15km (Mancktelow, 1985). We correlate Simplon deformation with the dextral movements and SW-directed thrusting in the western Alps based on evidence of transport direction and relative timing. North of the Rhone valley in Switzerland evidence for NE-SW transport comes from mineral fiber growth around pyrite grains in limestones (Steck, 1984; Dietrich and Durney, 1986; Burkhard, 1986). Together, calcite texture analysis, dextral stepping of fibers (-10° to 10°N40-60E) on slip surfaces, and fibers around pyrite grains suggest dextral movement between the Mt. Blanc and Aiguille Rouge massifs (Chamonix Syncline), along the ≈S40W trending medial syncline of the Belledonne massif, as well as at the internal contact of the Belledonne. The crystalline Belledonne is also cut by a series of ≈S60W trending mylonite zones and dextral offset which totals a minimum of ≈15km. Further to the SW the fault trend turns roughly 90° and transport becomes SW-directed thrusting in the Embrunais-Ubaye and Digne nappes. Fibers on slip planes below the Digne thrust are oriented ≈45°N30E and stepping indicates thrust sense movement.

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LES ZONES CATACLASTIQUES SITUEES A LA LIMITE SUD DU BOUCLIER CANADIEN, REGION DE QUEBEC

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Des brèches hydrauliques ou créés par effondrement délimitent le contact entre le Bouclier canadien (Province de Grenville) et les roches sédimentaires du Paléozoique. La bréchification présente dans les roches du bouclier recoupent les métasédiments du Groupe de Grenville et les séries intrusives granitiques et anorthositiques. Les failles normales taconiques utilisent ces anciennes zones de faiblesses tardi-Précambriennes.

Ces zones de brèches suivent un réseau de fractures conjuguées en échelon (NE et E-O) et marquent l'origine de l'ouverture de l'Océan Iapetus. Ces brèches d'une épaisseur décimétriques à décamétriques sont caractérisées d'une part par la présence de pseudotachylite et d'autres part par des ciments chloriteux et carbonatés. Ces derniers remplissent les réseaux de fractures en bordure du bouclier alors que les brèches à chlorite ont été identifiées jusqu'à environ 12 km à l'intérieur de la limite du bouclier.

Formées dans un système en distension, les brèches sont initées par une fracturation cassante intense (1-5% expansion), pour ensuite former à partir du mur une brèche en mosaique (5-20% expansion) et une zone d'expansion accrue (plus de 50%) formant une brèche de type monolithologique (sauf dans le cas où elle intersecte un contact lithologique). Les fragments sont généralement anguleux à sub-anguleux et varient de 1mm à 1m de diamètre. Le pendage de la zone bréchique est généralement fort vers le sud-est à sub-vertical.

THE SETTING OF CATACLASTIC ZONES AT THE SOUTHERN MARGIN OF THE CANADIAN SHIELD, QUEBEC REGION

The southern limit of the Canadian Shield (Grenville Province), in the Quebec city area is characterised by breccia zones produced by hydraulic fracturing or by faulting. Taconic normal faults in the area exploited these old, weak, late Precambrian structures that crosscut Grenville Group metasediment and granitic and anorthositic intrusive rocks.

The breccias follow a network of <u>en échelon</u> conjugate fractures (NE and E-W) and are related to the origin of the opening of the Iapetus Ocean. The breccias vary in thickness from approximately 10 cm to 50 m. They are characterised by pseudotachylite and by chloritic and carbonate cements. The carbonate cement filled fractures are located at the edge of the shield whereas the chloritic cement is found up to 12 km inside the shield itself.

In an extensional system, the breccia shows disaggregation progressing from crackle breccia (1-5% expansion) to a mosaic breccia (5-20% expansion) with fragment detachment. In the most expanded in-situ breccia (up to 50%), a rubble breccia of monolithologic type is found (except those that crosscut the contact between two lithologic units). Fragments are generally angular to sub-angular and vary from 1 mm to 1 m in diameter. The breccia zone is generally steeply SE dipping to sub-vertical.

CROSS SECTIONS THROUGH THE OUTER FOOTHILLS IN THE COALSPUR AREA, ALBERTA

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Upper Cretaceous and Tertiary strata are known from outcrop in the study area, while older rocks were encountered in oil and gas wells. The major structures of the area are, from north to south, the Pedley Thrust and Coalspur Triangle Zone (formerly called Coalspur Anticline), Entrance Syncline, Mercoal Thrust, Brazeau Flats, Brazeau Thrust, Brazeau Syncline and Cadomin Syncline. The economic coal seams of the Coalspur Formation are present in the area in three parallel bands in the Entrance Syncline and Coalspur Triangle Zone. The Mercoal band is the southernmost, contains the Mercoal Project of Manalta and dips about 30 degrees to the northeast. The Coalspur band is in the middle and contains the structurally thickened Coal Valley pod east of the map area and dips generally to the southwest. The Robb band is the northernmost band and contains northeast dipping strata and is less deformed than the Coalspur band. In the Entrance Syncline, the Coalspur coals are buried at various depths (up to 1 km) and may form exploration targets for coal-bed methane.

The Pedley Thrust appears to have at least 1 km of southwest directed displacement. This fault defines the Coalspur Triangle Zone. The Mercoal Thrust may have about 2 km of southwest directed displacement and defines a triangle zone that probably formed before the Coalspur Triangle Zone. The Brazeau Thrust shows at least 3 km of northeast directed movements and places Blackstone shales on top of the Brazeau Formation. The Brazeau Syncline has an overturned southwest limb and is a tight fold.

DEXTRAL TRANSPRESSION DURING MIDDLE DEVONIAN ACADIAN OROGENY IN THE GASPE REGION, QUEBEC APPALACHIANS

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The Québec Appalachians have been shaped by two major orogenies: the Middle to Late Ordovician Taconian orogeny and the Middle Devonian Acadian orogeny. Thrust faults and nappe structures characterized the Taconian deformation throughout the Québec Appalachians. However, structural styles pertaining to the Acadian orogeny differ from the Eastern Townships to the Gaspé Peninsula in rocks east of the Baie Verte-Brompton Line. The Acadian deformation in the Québec Appalachians produced northwestward-directed thrust faults in the Eastern Townships region and strike-slip faults in the Gaspé region.

In the Gaspé region, the Siluro-Devonian rocks of the post-Taconian cover sequence are divided into three major structural zones, from north to south: the Connecticut Valley-Gaspé synclinorium, the Aroostook-Percé anticlinorium and the Chaleur Bay synclinorium. In the Aroostook-Percé anticlinorium, several Acadian structural features are controlled by three subparallel longitudinal strike-slip faults: Grande Rivière, Grand Pabos and Rivière Garin. These easterly strike-slip faults follow bands of intense deformation corresponding to zones of high strain which contrast with the mildly to moderately deformed intervals that separate them. The overall sense of shear indicated by the observed kinematic indicators is dextral. Major strike-slip faults, rotated oblique regional folds and cleavages, subsidiary riedel-type faults, small-scale shear sense indicators and offsets of markers can be integrated in one progressive transpressive deformation that operated in brittle-ductile conditions.

Acadian strike-slip faulting, in the eastern Québec Appalachians, could be interpreted in terms of a continental collision along the irregular Paleozoic margin of North America during Devonian time.

THE SAINT-MAURICE TECTONIC ZONE
a major structure of the central Grenville orogen, Québec

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The Saint-Maurice tectonic zone is a regional-scale easterly dipping mid- to deep crustal ductile shear zone that separates the allochthonous monocyclic belt (AMB) on the west from the Laurentides park plutonic complex, part of the allochthonous polycyclic belt (APB), to the east.

A section across this structure shows that its eastern margin is a steeply dipping zone of sub-horizontal sinistral shearing. Further to the west, the shear zone dips gently to the east and projects structurally above the AMB. Kinematic constraints suggest that the shear zone is the product of northwest-directed compression. However, the large-scale tectonic flow pattern is complex and reflects changing boundary conditions.

Published regional interpretations of the southwestern Grenville orogen show the AMB to be overthrusted onto the APB. Although overthrusting is well established in western Québec and Ontario, our observations at the Saint-Maurice tectonic zone indicate that the history of the eastern border of the AMB does not fit such a simplified model.

TECTONIC EVOLUTION OF THE ARCHEAN ROCKS OF THE TAVANI AREA, KEEWATIN, N.W.T.

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The Late Archean Rankin-Ennadai greenstone belt extends from northern Saskatchewan to Rankin Inlet. Detailed stratigraphic amd structural mapping in the northeastern end of the belt (800 km southwest of Rankin Inlet) show a complex depositional and structural history occurring within a relatively short time frame. The principal conclusions of the study are:

1. A complex sedimentary history involving felsic and mafic volcanic, volcaniclastic and sedimentary rocks is observed. Two major packages of rocks are recognized; a lower Kasigialik group and an upper Tagiulik formation. The Kasigialik group is subdivided into a lowermost Atungag formation, dominated by pillow basalts; a middle Akliqnaktuk formation, consisting of volcanic rocks, epiclastic and pelagic sediments, with felsic volcanic rocks and epiclastites predominant at the top and mafic to intermediate material dominating the lower parts; amd an uppermost Evitaruktuk formaton, consisting largely of quartz-bearing turbidites. The Tagiulik formation consists of psammitic and semipelitic, feldspathic and quartz-poor, volcaniclastic turbidites.

2. The Kasigialik group and Tagiulik formation are separated by a shear zone representing a major decollement. The Tagiulik formation is entirely contained within a nappe lying above the Kasigialik group, and its depositional and chronological relationship to the Kasigialik group is unknown.

3. The structure is dominated by open, upright F_2 folds and D_2 shear zones. D_1 features, including cleavage and minor fold developments, do not produce any major changes of facing, indicating a lack of large scale F_1 folds throughout most of the area. Only in the relatively well-bedded Evitaruktuk and Tagiulik formations is an interference pattern between F_1 and F_2 folds developed.

4. Metamorphism can be related to structure in that the various structural domains in the area coincide with metamorphic domains. Overall, greenschist facies or locally lower grade assemblages dominate, with areas of higher grades, including amphibolites and migmatites, appearing to the north, west, and south-east. Shear zones can carry both prograde and retrograde mineral assemblages. Metamorphic aureoles exist around some of the late tectonic granitoids.

5. The timing of these events is constrained in the north of the mapped area. A syn-D_1 granitoid is dated at 2,677 ± 2 Ma(U-Pb zircon). Preliminary dates on two post-tectonic granitoids give emplacement ages of approximately 2,666 ± 3 Ma(U-Pb zircon). A quartz-feldspar porphyry which may be coeval with felsic volcanism is dated at 2,666 ± 9 Ma(U-Pb zircon). This contrasts with the Rankin Inlet area where the deformation is no older than 2.63 Ga, and in the Chesterfield Inlet area, 170 km to the north, where the age for the deformation is 2.5 Ga or younger.

The age dating suggests that deposition of the sedimentary sequence and subsequent deformation occurred within a timespan of less than 20 million years, and that deformation occurred at different times in different parts of the greenstone belt. Such time scales for deposition and orogeny are comparable with modern orogenies.

QUARTZ C-AXIS FABRIC VARIATIONS ACROSS THE GRENVILLE FRONT TECTONIC ZONE, CARLYLE TOWNSHIP, ONTARIO

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The Grenville Front Tectonic Zone is an area of intense deformation and variable metamorphic grade. The rocks in this area were deformed during the Grenvillian Orogeny approximately 1.1 Ga.

Quartz c-axis were measured from 15 locations in the area. All c-axis fabrics display distinct definable fabrics and several regional variations in fabric type are present. The sense of asymmetry present in some samples was used as a kinematic indicator and confirmed the regional sense of shear.

The c-axis fabrics display evidence for glide along the prism plane in both the <a> and <c> axis direction, as well, glide along the basal and rhomb plane in the <a> axis direction.

Quartz ribbons are found in several samples in the area. The presence of ribbons can be correlated to the appearance of a strong c-axis maximum at the kinematic Y position which is attributed to prism <a> glide. This crystallographic orientation of quartz ribbon is independent of the crystallographic orientation of matrix quartz.

STRAIN DETERMINATION IN LAYER-THICKENED FOLDS

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The total strain, as well as the buckle and flow components, can be determined in profile sections of layer-thickened folds provided: (1) the original orthogonal thickness can be measured; (2) strain is uniformly distributed throughout the folds; and (3) the bulk strain is plane strain.

Select a segment of a folded layer of length L, arc length La and orthogonal thickness r and determine the area. The final length L', after strain removal , is L'=area/t. The total strain in terms of stretch is St = L'/L, the buckling component is Sb = La/L, and the flow component is Sf = L'/La. The same values of Sb and Sf can be obtained by reversing the sequence of strain removal.

If the layers outside the folds have undergone some layer-parallel thickening then the strain in the folded section represents an additional incremental strain. If the strain in the folded section is not uniformly distributed then the method yields an absolute value of St but only relative values of Sb and Sf. The presence of a stretching lineation parallel to fold hinges indicates strain is not plane in which case Sf and St are underestimated.

LINEATION PATTERNS ON GARNET-QUARTZ NODULES FROM THE GRENVILLE FRONT TECTONIC ZONE.

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In the River Valley area (Ontario), Grenville mica schists contain competent nodules of garnet-quartz composition that reach diameters of up to 10 cm (Dressler 1979). The nodules can be removed from their rock matrix with ease. Their surfaces show a pattern of lineations with geometric polarity, which resembles that on pitted and striated pebble surfaces in deformed conglomerates (Schrader 1988). The lineations on the nodules are uneven grooves in the nodule material, or consist of aligned mica-flakes in the enveloping matrix. They are akin to stylolites and crystal-growth fibers on carbonate pebbles in non-metamorphic rocks.

The lineation patterns of nodules and pebbles are similar: from opposite poles connected by the axis of divergence AD (Fig. 1), lineations spread in all directions and terminate on the plane of convergence (PC), which contains the intermediate axis (AI) and the axis of convergence (AC). The three axes need not be orthogonal, and their angles appear to depend on the proportion of pure to simple shear in the deformation symmetry. Axial directions and symmetry of the lineation pattern are related to large-scale displacements in the Grenville Fault Zone.

Fibers of actinolite within the mica fabric lack preferred orientation but transect the mica alignment in garnet-quartz nodules. Thus the linear mica fabric developed under high-grade metamorphic conditions prior to actinolite growth at late stages of deformation.

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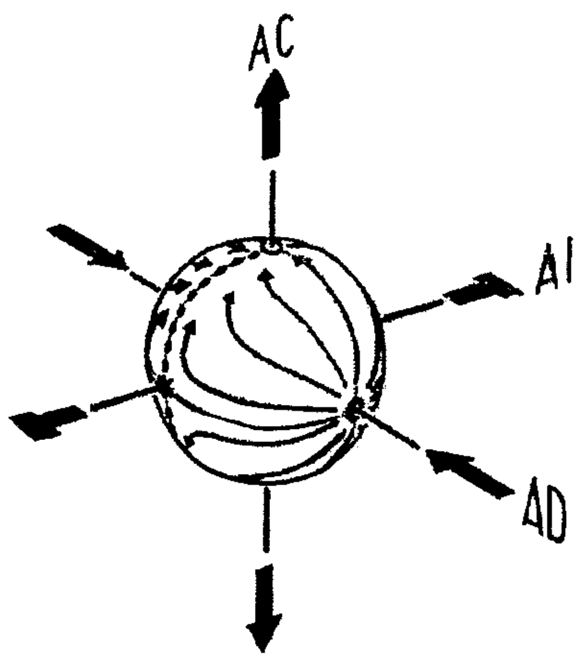
Fig. 1



STRUCTURAL ANALYSIS IN THE STOLZ FAULT ZONE ON WHITSUNDAY BAY, AXEL HEIBERG ISLAND (N.W.T.)

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Slip striae and oriented fibres on small faults and pebble surfaces were measured within post-Carboniferous strata deformed by the Stolz fault. The combined fabric pattern of both linear elements was evaluated by using the methods outlined in the companion abstract (Schrader 1990). The principal axes of stress and strain correspond to those of the fabric pattern only where the deformation is irrotational. The most important axis of the fabric pattern is the axis of divergence (AD, Schrader 1990), the direction in which fault blocks or adjacent pebbles approach each other (equivalent to $\sigma 1$ or A3, resp.). AD indicates the approach direction of the large-scale tectonic units.

The surface geology merely shows that the fault segment examined dips steeply towards the west, whereby thrusting and/or strike-slip motions (Miall 1985, Schwerdtner & Osadetz 1983) are possible. The fabric patterns indicate that the fault blocks of the southern Stolz structure approached each other in a perpendicular direction at most localities. This means, that the fault segment examined has dominantly thrust character. Complications occur where the fault is curved and adjacent to the Whitsunday Bay diapir.

In the Tertiary Eureka orogen, the horizontal traces of large-scale thrusts form a triangle. Complicated motions can therefore be expected for the tectonic units along single thrusts throughout the orogen.

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GEOCHRONOLOGICAL CONSTRAINTS ON THE TECTONIC HISTORY OF THE ARCHEAN AND EARLY PROTEROZOIC ROCKS IN THE TAVANI - RANKIN INLET - CHESTERFIELD INLET REGIONS, N.W.T.

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Archean and early Proterozoic supracrustal and granitoid rocks are exposed west of Hudson Bay in three regions - Tavani, Rankin Inlet, and Chesterfield Inlet. In the Tavani region, U-Pb zircon ages from the felsic volcanic rocks pre-or early tectonic (subvolcanic) intrusions, and from the late volcanism through deformation to granite emplacement took place within a 20-30 m.y. span. The felsic volcanic rocks are dated at 2681 Ma., the pre-or early syntectonic (D1) granites and a subvolcanic quartz-feldspar porphyry intrusion at 2677 +/- 2 Ma and 2666 +/- 9 Ma respectively. Post tectonic granites are dated at 2666 +/- 2 Ma and 2663 +/- 4 Ma. Another post tectonic granite yields a poorly constrained age in the range 2660-2650 m.y. Two regional phases of Archean deformation under sub-greenschist to greenschist facies conditions resulted in the development of northeast trending folds and associated ductile high-strain zones. In contrast, in the Rankin Inlet region (70 km. to the northeast) the felsic volcanism (ca. 2629 +/- 15 Ma) is at least 40 m.y. younger than the volcanism and 20 m.y. younger than the emplacement of post-tectonic granites to the south. Subsequent Archean deformation and regional metamorphism under greenschist to amphibolite facies in the Rankin Inlet region produced F1 isoclinal folds and interleaving of tectonic slices refolded by southeast plunging F2 folds. The deformation in the Rankin Inlet region did not affect the structures in the Tavani region. Both regions are in tectonic contact with an intervening ca. 2.72 Ga. amphibolite-granulite terrane. Farther to the north, in the Chesterfield Inlet region, U-Pb geochronology, structure, and thermobarometric data reveal that a 2.73 - 2.63 Ga amphibolite-granulite gneiss terrane is composed of three different crustal segments, and that the contacts between adjacent segments are marked by ductile, high-strain zones. Deep-crustal rocks structurally overlie rocks from mid-crustal levels. The tectonic juxtaposition of these crustal levels took place in the early Proterozoic prior to emplacement of 1.86 Ga. fluorite granites. We suggest that a general northeasterly transport of mid-and-deep-crustal rocks in the region north of Rankin Inlet produced events of crustal extension and synchronous reactivation of Archean shear zones in the hinterland that posts dates deposition and deformation of an early Proterozoic clastic shelf sequence (Hurwitz Group). Northeast trending mineral stretching lineations, kinematic indicators, and U-Pb geochronology are consistent with this interpretation. A U-Pb baddeleyite age of 2.09 Ga (Patterson and Heaman, 1990, GAC Abstracts,v.15, p.A102) from a gabbro sill in the Hurwitz Group provides a maximum age for these events. Structural and thermobarometric data together with the geochronological constraints are used to construct a schematic crustal section along a 400 km N-S coastal transect between Tavani and Chesterfield Inlet in this part of the Churchill Structural Province.

TECTONIC LOADING IN THE CANADIAN CORDILLERA AS RECORDED BY MASS ACCUMULATION IN THE FORELAND BASIN

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The geometry of the Alberta foreland basin is controlled by lithospheric loading in the adjacent Cordillera. Sedimentation within the Foreland basin was quantified by calculating mass accumulation rates to constrain loading events in time and space. Rates of mass accumulation for Cretaceous units in the basin can be classified into low, moderate, and high categories and related to deformation events in the Canadian Cordillera. The rates of accumulation show a distinct cyclic pattern when plotted against time.

There were two major episodes of deformation from early Aptian to late Campanian time, each preceded by a period of relative quiescence. The first lasted from approximately 115 to 110 Ma. It shows a succession of rapid, moderate, and rapid deformation events. The second episode of deformation lasted from approximately 95 to 90 Ma, and is characterized by three rapid deformation events separated by short intervals of quiescence.

Order-of-magnitude changes in sediment accumulation in the Foreland basin can be related directly to major deformation events in the Cordillera. Furthermore, the deformation can be located in time and space and evaluated in terms of its relative intensity. This delineation of deformation indicates that the docking of foreign terranes does not necessarily coincide with their final accretion and the associated tectonic loading.

(**Keywords:** Tectonic loading, foreland basin, mass accumulation, Canadian Cordillera.)

LATE PALEOZOIC-EARLY MESOZOIC TECTONISM ALONG THE NORUMBEGA FAULT ZONE, SOUTHWESTERN MAINE

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The Norumbega Fault Zone is a major anastomosing fault system over 400 km in length that extends from New Hampshire across southern and east-central Maine to New Brunswick. It consists of a complex series of NE-trending, post-metamorphic shear zones and faults which likely reflect a protracted history of ductile and brittle displacement. The sense of displacement along individual faults in the system has been previously described as dextral, sinistral, and normal. In southwestern Maine a part of the Norumbega Fault Zone, the Flying Point fault (FPf), marks the boundary between two distinct lithotectonic assemblages, a change in the style of metamorphism, as well as a remarkable time-temperature discontinuity. These contrasting features across the FPf most likely reflect significant displacements during Late Paleozoic-Early Mesozoic time.

West of the FPf rocks of the Falmouth-Brunswick sequence consist of uniformly high-grade (upper amphibolite facies), extensively migmatized quartzo-feldspathic gneisses and amphibolites. $^{40}Ar/^{39}Ar$ hornblende ages suggest that these rocks were subjected to a Late Paleozoic thermal event (290-265 Ma). $^{40}Ar/^{39}Ar$ muscovite and biotite ages of 250-245 Ma reflect later post-metamorphic cooling. In sharp contrast, east of the FPf, rocks of the Saco-Harpswell sequence consist of a variably metamorphosed (upper greenschist to amphibolite facies) sequence dominated by meta-sedimentary rocks. $^{40}Ar/^{39}Ar$ hornblende ages from these rocks are substantially older (355-324 Ma) than those recorded west of the FPf. Likewise, muscovite and biotite cooling ages of 305-295 Ma reflect much earlier cooling east of the FPf.

The time-temperature data suggest that the rocks currently juxtaposed along the FPf experienced quite different thermal histories during the Late Paleozoic. Muscovite and biotite ages suggest that a significant thermal contrast existed across the FPf until at least 250 ma ago. The presently observed age discontinuity is interpreted to reflect the Late Paleozoic-Early Mesozoic juxtapositioning of two rock sequences which must have been temporally and spatially distinct during the Late Paleozoic. Future work will involve detailed examination of displacement sense indicators along the FPf in order to determine the sense and history of offset. Additionally, further constraints on the pressure-temperature-time paths of the juxtaposed sequences may provide insight as to the timing and magnitude of displacement.

CONTRASTING TECTONO-METAMORPHIC HISTORIES WITHIN THE PARRY SOUND SHEAR ZONE AND INTERIOR PARRY SOUND DOMAIN, SOUTHWESTERN GRENVILLE PROVINCE, GEORGIAN BAY

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The Parry Sound shear zone (PSSZ) in the southwestern Grenville Province is widely regarded as representing a major deep crustal shear zone that developed during thrusting of granulite facies rocks of the interior Parry Sound domain (IPSD) onto an amphibolite facies terrane. Recent work and detailed mapping in this area, however, provide evidence suggesting that PSSZ rocks are lithologically, structurally, and metamorphically distinct from IPSD rocks. The PSSZ is characterized by a distinctive succession of supracrustal rocks with subordinate metaplutonic rocks, whereas the IPSD is dominated by metaplutonic rocks. Mineral reaction textures and microstructures in semipelitic gneisses suggest that the rocks in the PSSZ and in the IPSD experienced different tectono-metamorphic histories. Granulite facies rocks (sillimanite-hypersthene-quartz) in the northern part of the IPSD, i.e. close to the PSSZ, display retrograde metamorphism and significant grain-size reduction in high-strain zones. Conversely, supracrustal rocks in the PSSZ are metamorphosed at upper amphibolite facies conditions and high-strain zones are characterized by the growth of sillimanite at the expense of kyanite and by relatively coarse granoblastic textures. Metasupracrustal rocks in the PSSZ preserve no record of granulite-grade conditions. Preliminary geothermobarometry results and mineral assemblages suggest that the shear zone rocks experienced peak metamorphic conditions of ≈ 700-750°C and >850 MPa, whereas P-T studies in the IPSD indicate slightly higher conditions of 700-800°C and 900-1100 MPa.

Our data, therefore, provide evidence for the existence of a thrust surface (Parry Sound Thrust) between the PSSZ and IPSD, which represents a lithologic and metamorphic discontinuity. The data also suggest that the PSSZ and IPSD followed parallel but distinct P-T-t paths. The preliminary P-T-t paths suggest nearly isothermal decompression, in contrast to previously published results for this area. The timing and tectonic significance of this decompression have yet to be determined.

STRATIGRAPHY, STRUCTURE, METAMORPHISM, AND TECTONICS OF THE CAPE NORTH AND MONEY POINT GROUPS, NORTHERN CAPE BRETON HIGHLANDS, NOVA SCOTIA: A PRELIMINARY REPORT (FUNDED BY CANADIAN INTERNATIONAL DEVELOPMENT AGENCY (C.I.D.A.))

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Rocks assigned to the Cape North Group are semipelitic, pelitic, and calc-silicate gneisses, with minor amounts of amphibolite, marble, and mylonite. The major lithologies in the Money Point Group are mafic (amphibolite and hornblende-biotite schists) but there are also significant proportions of less mafic semipelites, pelites, and calc-silicates and rare marbles. These two groups have been abundantly intruded by granitic dykes, sheets, and pegmatites (e.g. Wilkie Sugarloaf granite which is probably a Devonian pluton).

The Cape North and Money Point Groups appear to have been deformed together throughout the Aspy terrane. In all areas where the two units are exposed in close proximity, they display similar fabric development and similar late-stage structural effects. At least three different phases of folding have been recognized. F_1 folds are moderately inclined to upright isoclinal folds with axial planar cleavage. F_2 folds are upright, tight to isoclinal and approximately coaxial with F_1 folds. F_3 folds are open to tight with chevrons and associated kink band sets.

The metamorphic grade increases rapidly from east to west across the Cape North peninsula. The semipelitic and pelitic rocks display the effects of amphibolite facies Barrovian metamorphism (a sequence of zones involving staurolite, kyanite, biotite, and sillimanite). Low-grade assemblages also include cordierite, garnet, biotite, and chlorite. To the east of the Aspy Fault, metamorphic grade increases from west to east, from a narrow belt of staurolite-kyanite zone rocks into a zone of kyanite-bearing lithologies. Sillimanite-zone rocks underlie the areas to the south. Many samples from the Cape North and Money Point Groups contain large, coarse-grained muscovite, indicating a period of mid-amphibolite facies retrograde metamorphism.

The Cape North and Money Point Groups appear to be Silurian or older. They have been extensively intruded by varied granitic rocks which range in age from Silurian to early Carboniferous (?). Many of these show characteristics of crustal-derived plutons and appear to be related to crustal thickening and post-collision extension.

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