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Aller au sommaire du numéro

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Résumé de l'article

The 1988 Colloquium of the Atlantic Geoscience Society was held at the Best Western Claymore Inn and Conference Centre, Antigonish, Nova Scotia on February 5-6, 1988. A workshop organized by the APICS Geology Committee was held on Friday afternoon, February 5, on "Computers in Geology." A special session on "The Age and Style of Faulting in the Canadian and Northern Appalachians" dedicated to the memory of Gao Ruixiang was held on Friday evening. General sessions and poster sessions were also held on Friday evening and on Saturday.

On behalf of the Atlantic Geoscience Society we thank Brendan and Cindy Murphy, other faculty members and students of Saint Francis Xavier University, and all others involved in the organization of the meeting and workshop for organizing and running such a successful and enjoyable Colloquium.

In the following pages we publish the abstracts of talks and poster sessions given at the meeting.

ATLANTIC GEOSCIENCE SOCIETY

ABSTRACTS

1988 COLLOQUIUM
ANTIGONISH, NOVA SCOTIA

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MARITIME SEDIMENTS AND ATLANTIC GEOLOGY
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Remote Sensing Research Over Plutonic Bodies of Nova Scotia

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Transfer of geologic data and superimpositioning of Landsat imagery and digital airborne gamma-ray spectrometric data was conducted to extract useful geological information related to exploration targets and to detect geologic associations suitable for mineral emplacement. A multilayer database was created. Three radioelements: equivalent Uranium (eU), equivalent Thorium (eTh) and percent Potassium (%K) as well as U/Th and Th/K ratios constituted the digital airborne geophysical data. MSS and TM Landsat coverage comprised the spaceborne imagery utilized in this database. Conventional geologic data were digitized, transferred and registered to the database for reference purposes.

Four major plutonic bodies located in southeastern Nova Scotia were selected as test sites to examine the utility of such a database in humid, heavily vegetated regions. These include the Guysborough Plutons, the Liscomb Pluton, Musquodoboit and South Mountain Batholith. The integration technique permitted the extraction of spectral relationships controlled by the existing geology of the region, detection of plutonic phases, and the delineation of lineament distribution. Exploration target areas were selected on the basis of the detection of above threshold values for radioelements and ratios, as well as the intersection of lineaments and other geologic characteristics.

A limited field investigation was conducted over these test sites. The primary purpose of this field work was to study the lithology and structural framework of this area and to compare the remote sensing observations with the in situ geologic conditions. It is admitted that our field work is of reconnaissance nature and there is a need for systematic field investigation including geologic, geophysical and geochemical sampling.

Geological Mapping of Northern Cape Breton Island, Nova Scotia

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and
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Mapping of the igneous and metamorphic rocks of the highland areas of northern Cape Breton Island from 1983-87 has resulted in the production of a compilation of all or parts of ten 1:50,000 map sheets. Approximately forty metasedimentary and metavolcanic units and sixty intrusive units have been distinguished. The mapping, compilation and on-going petrological and radiometric dating studies have permitted the identification of three contrasting tectonostratigraphic zones in northern Cape Breton Island. The Northwestern Highlands Zone is characterized by upper amphibolite- to granulite-facies, quartzofeldspathic and mafic gneisses, and deformed anorthosite, gabbro and syenite bodies which appear to be a portion of Grenvillian basement. The Aspy Zone contains middle to upper amphibolite-facies gneissic and metavolcanic and metasedimentary units intruded by compositionally varied granitoid plutons. The main tectonometamorphic and plutonic event occurred in the Devonian, and was followed by rapid uplift. The Bras d'Or Zone displays low pressure, upper amphibolite-facies, gneissic basement, a widespread carbonate-clastic sequence, and Late Precambrian to Cambrian dioritic, granodioritic, and granitic plutons. In the northern part of the zone, dioritic to granodioritic plutonism is particularly extensive. The boundaries between the zones are represented by mylonite zones, many of which have been retrograded under greenschist-facies conditions.

Metavolcanic and Granitoid Rocks of Southeastern Cape Breton Island and Southern New Brunswick: A Comparison

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Metavolcanic and granitoid rocks of southeastern Cape Breton Island and the Caledonian Highlands in southern New Brunswick are generally accepted to be Late Precambrian in age and typical of the Avalon Composite Terrane of the northern Appalachian Orogen. However, detailed integrated field and petrological studies in these two areas have been lacking, so quantitative comparison could not be made. As a result of two major projects now in progress in southeastern Cape Breton Island and in the central and eastern Caledonian Highlands of New Brunswick, both including field mapping (scale 1:25,000), petrological studies and dating, preliminary comparisons can be made.

Volcanic rocks in both areas include abundant flows and both pyroclastic and epiclastic units. Metamorphic grade is typically subgreenschist to greenschist, and generally somewhat lower in Cape Breton Island than in New Brunswick. Epiclastic and arkosic sedimentary rocks are much more abundant in New Brunswick than in Cape Breton Island, and they appear to lie below many of the volcanic rocks in the stratigraphic succession. Chemical data show that the volcanic rocks in both areas formed in a volcanic-arc environment on a continental margin. The volcanic rocks in New Brunswick are dominantly tholeiitic whereas those in southeastern Cape Breton Island appear to change from tholeiitic in the southeast to calc-alkalic in the northwest.

Granitoid rocks in both areas form typical "I-type" calc-alkalic suites ranging in lithology from diorite to granite. In general they do not appear to be co-genetic with the volcanic host rocks. Most of the granitoid units give radiometric ages of about 570-600 Ma. Scattered gabbroic intrusions occur in both areas and are probably younger than the granitoid rocks.

Gravity Modelling of the Liscomb "Satellite" Pluton

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The Liscomb "Satellite" Pluton is a small granitoid mass located 3 km northwest of the main Liscomb Complex in Central Nova Scotia. Detailed gravity data have been obtained over the smaller pluton, and from the surrounding area. Due to the density contrast that normally exists between intrusive bodies and their metamorphosed hosts it is possible to model the subsurface geometry of the intrusive body using Bouguer gravity data.

During this study 96 gravity stations were surveyed over 22 km with an average station spacing of 200 m. Over approximately 22 km of the survey gravity data were collected on a regional scale at a station spacing of 200 to 1000 m. Approximately 11 km of the survey was conducted on, or in the immediate vicinity, of the Liscomb "Satellite" Pluton using a station spacing of 100 to 200 m. For most of the survey the error in elevations is ±5 mm. The error in the gravity data due to the gravimeter is on the order of ±0.05 mgal. A conservative estimate of the error in the Bouguer gravity data is ±0.1 mgal.

Bouguer gravity contours show a -1.2 to -1.4 mgal anomaly over the Liscomb "Satellite" Pluton. Preliminary gravity modelling suggest a bowl-shaped cross-section for the Liscomb "Satellite" Pluton. Gravity modelling results indicate that the Liscomb "Satellite" is not connected to the larger Liscomb Complex to at least a depth of 1.0 km.

The Maritimes Basin: Basin, Epieugeosyncline, Taphrogeosyncline, Horst-Graben, Wrench, Rift, Successor, Aulacogen, Pull-Apart, Transpression? -Basins, Subbasins? -Just a Problem of Semantics?

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Upper Paleozoic rocks in Atlantic Canada have been described and interpreted in a rapidly evolving series of sedimentological and tectonic models over the past 60 years. This has resulted, especially in the past 20 years, in the proliferation of a complex terminology of geological-geographical basin and subbasin names as well as genetic names based on sedimentological and tectonic-structural models. The confusion in terminology (particularly for nongenetic application) arises from several factors: (1) vague definition and intent, (2) subsequent minor to radical redefinition or adaptation, (3) conflicting interpretations of constituent features both spatially and genetically, (4) mixed terminology, (5) rapid evolution in tectonic models and (6) excessive generalization. Any solution to the problem involves the co-operative establishment of a coherent, adaptable and flexible system of nomenclature. The nomenclature could be organized into two independent systems based upon application and with appropriate definitions and guidelines: (1) a nongenetic nomenclature (with geographic name priority) describing present-day features without genetic implications, to be used for general reference typically in a nongenetic sense; (2) a genetic nomenclature (independent of the above) applied to interpretive features based upon tectonic, structural, sedimentological and geophysical models. To eliminate mixing of genetic and nongenetic terms, features formally named in the two systems may not have the same geographic identifier. The name Maritimes Basin, as introduced by Roliff(1962), is proposed as a nongenetic general term applicable in the geographic sense to all Upper Paleozoic rocks in Atlantic Canada. Consideration and discussion by interested workers of outstanding problems in name corruption, definition and hierarchy, as well as options for possible solution will be important in reconciling the present situation.

Application of Airborne Gamma Spectrometer Surveys to Mineral Exploration in Northern New Brunswick

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The successful application of airborne radiometric surveys to the search for uranium deposits over the past two decades has, ironically, created barriers to the perception and acceptance of the method as an exploration tool for other metals. New applications of high sensitivity, gamma-ray spectrometric data include regional and detailed characterization (mapping) of bedrock lithologies and mineral deposit studies.

Much of northern New Brunswick has been flown by the Geological Survey of Canada with 1 km line spacing and the data published as a series of line contour maps showing total count, K, eU, and eTh concentrations and eU/eTh, eU/K and eTh/K ratios at a scale of 1:50,000. Visual presentation of data has been enhanced by recent advances in compilation procedures such as ternary radioelement techniques. Four examples illustrate applications of these maps to precious metal exploration in northern New Brunswick by identification of favourable geological environments:

(1) Potassic alteration zones within felsic pyroclastic horizons associated with epithermal deposits. Local thorium- depletion and chalcophile metal-enrichment are characteristic of potassium specialization zones.
(2) Uranium-thorium haloes associated with auriferous intrusions in iron carbonate alteration zones.
(3) Radiometric anomalies associated with buried or unmapped feldspar porphyry intrusions.
(4) Potassic alteration zones in sedimentary basins.

The first three examples have direct application to exploration in the Chaleur-Tobique Zone (Siluro-Devonian). The significance of the last feature has not been tested but it may be important for precious metal exploration in the Matapedia Zone (Ordovician-Silurian).

The Multistage Development of the Dover Fault in Northeastern Newfoundland: The Late Stages

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A detailed study of the Dover Fault was carried out in order to unravel the history of the Gander-Avalon boundary in northeastern Newfoundland. As presently defined the fault is narrow, usually less than 200 m, and there are relatively few outcrops. It crosses the Hare Bay Gneiss and we believe that it is only a minor portion of a broader, older deformation zone associated with the juxtaposition of the Gander and Avalon terranes. However, our discussion here is restricted to this late structure which might be referred to as the Dover Fault sensu stricto.

The relationships that can be observed indicate four stages of development. The oldest stage preserved is a dextral strike-slip movement in the ductile regime while the rocks were at lower greenschist metamorphic facies. This stage was followed by a period of complex movement in the brittle-ductile field with normal, reverse and dextral displacements. Breccias associated with the fault are coeval with at least part of this later deformation. Finally, the breccias are overprinted by brittle, dextral faults.

Caprock and Stratabound Bioepigenic Sulphur in Nova Scotia

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Worldwide, all commercially important deposits of native sulphur originated as bioepigenic replacements of gypsum or anhydrite. Native sulphur deposits occur in two distinct geological settings: (1) caprock deposits overlying salt diapirs and (2) stratabound deposits within evaporite sequences.

Two occurrences of native sulphur have been documented from mainland Nova Scotia: (1) from the underground workings of the Canadian Salt Company at Pugwash, Cumberland County, and (2) from exploration drilling near Hilden, Colchester County. The Pugwash occurrence has characteristics in common with salt dome, caprock deposits in southeast Texas and Louisiana. The Hilden occurrence is similar to the stratabound deposits of western Texas and northern Iraq. Bioepigenic sulphur deposits are associated with dominantly marine evaporite sequences in sedimentary basins where structural controls have supplied extensive plumbing to allow for long-term mixing and flushing of artesian meteoric water through hydrocarbon-bearing strata and the evaporite deposit. Flushing promotes the growth of sulphate-reducing bacteria, which obtain energy through the oxidation of hydrocarbons.

These occurrences indicate that, at least on a limited scale, conditions necessary for the formation of bioepigenic native sulphur existed within the Windsor Group evaporite sequence of Nova Scotia. Detailed exploration and evaluation will determine the resource potential.

Al-Rich Pyroxenes in Granulite Xenoliths From Tangier: Implications to Lower Continental Crust, Eastern Meguma Zone, Nova Scotia

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A wide assortment of rounded to angular xenoliths ranging in size from <1 cm to >100 cm occur in a post-Acadian NNW-trending spessartite dyke at Tangier. These xenoliths may be assigned to two groups: (A) graphite- and garnet-bearing and (B) devoid of these minerals. Group A xenoliths containing orthopyroxene (opx) have abundant spinel and aluminosilicates. Those containing clinopyroxene (cpx) have Al-rich sphene, apatite and amphibole. Other minerals common in Group A include quartz, sapphirine, mesoperthite, corundum, plagioclase, rutile, biotite, chlorite and muscovite. Mg values (100 $Mg/Mg+Fe^{+2}+Fe^{+3}+Mn$) for Group A opx range from 32-74 and total Al in opx ranges from 0.10 to >0.80. Clinopyroxenes from Group A xenoliths are of diopside to salite composition, with total Al ranging from 0.05-0.15.

Xenoliths of Group B include 2-pyroxene granulites and opx-amphibole and cpx-amphibole granulites. Other mineral phases are quartz, K-feldspar, plagioclase, phlogopite, calcite, chlorite and sphene. Mg values for Group B opx range from 84 to 88 and total Al in opx ranges from 0.10-0.20. Clinopyroxenes in Group B xenoliths are exclusively of endiopside composition, with total Al ranging from 0.20-0.40.

Assessment of pyroxene composition in terms of components such as Ca:Mg:Fe+Mn and Al^{iv}-Al^{vi} reveals that Tangier dyke pyroxenes: (1) are atypical of those found in igneous rocks of various affinities, (2) are markedly different from those found in regional granulite terrains ranging in age from Archean to Hercynian and (3) are vastly different from pyroxenes of mantle origin. Furthermore, peak temperature (1030-1166°C) and pressure (14.2-14.8 kb) estimates are unlike those reported from regionally metamorphosed granulite terrains and suggest that the Tangier pyroxenes are indicative of lower crustal origin.

We consider it unlikely that doubly thickened crust could provide a mechanism to explain these P-T conditions and propose, alternatively, that heating of a single crustal plate through mantle magmatism could provide a more appropriate explanation. Links have recently been established between mafic plutonism, of which the Tangier dyke is a local manifestation, and "Acadian" granitoid plutonism with associated diapiric emplacement of high-grade gneissic rocks (e.g., Liscomb Complex). These links in space and time suggest application of this model to a significant portion of the lower crust beneath the Meguma Zone.

Application of Structural-Metamorphic Patterns and Absolute Time Constraints to Tectonics in Southwest Newfoundland

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Southwest Newfoundland is a complex polyphase deformed and metamorphosed terrane which is partitioned into terranes (C, I, and II) along the major Carboniferous Long Range and Devono-Carboniferous Cape Ray faults. Individual terranes are characterized internally by rational structural-metamorphic patterns and by coherent rock assemblages, which may suggest but not prove several general tectonic scenarios for each terrane. Further detailed structural and metamorphic (P-T-path) studies, and bio/geochronological data in individual terranes and parts of terranes will test, modify, and reformulate these geological models. The general framework of spatial, geometric and metamorphic patterns will, however, continue to be of value in choosing critical areas and problems, in deciphering such details as overprinting information (may be important in kinematic studies), and in providing regional context and alternative hypotheses compatible with the current data array for the region. Some of the important elements of the framework of southwest Newfoundland will be summarized below.

Terrane C, the fossil-bearing Carboniferous sedimentary terrane northwest of the Long Range Fault, characterized by open, upright enechelon folds, steep faults and minor thrusts related to a dextral (oblique-slip) wrench system (Knight 1983); it is a terrane of low metamorphic rank against which the pre-Carboniferous, ophiolite-based Terrane I of up to granulite grade has been uplifted along the Long Range Fault with a strong, high-angle-reverse component associated with a horst. The Carboniferous rocks give a Visean (Early Carboniferous) age to this late fault movement, perhaps only the final stage of a longer-lived fault.

Terrane I, between the Long Range and Cape Ray faults, exposes extensive ophiolite, and metasedimentary-metavolcanic cover either related to the ophiolite or Grenvillian in age, intruded by tonalite and later gabbroic to granitic plutons. A steep fault/shear zone internally juxtaposes two different ophiolite and cover packages, forming a domain (=subterrane) boundary. The terrane, as well as both domains, show extreme variations in strain intensity and metamorphic grade. Shallowly dipping and plunging structures are preserved in the cover rocks, which commonly record the highest strain and metamorphic grade; these are overprinted by retrogressive, steeply dipping foliations, shear zones and faults related to movements on the major terrane and subdomain boundary faults. The structural geometry and metamorphic pattern outlined so far suggests high temperature thrust zones focussed in the ophiolitic (and/or Grenvillian) cover rocks, overprinted by the steep fabrics associated with horsting and oblique-slip displacement along the terrane/domain boundary faults. Terrane I is overlain directly and unconformably along the southeast bounding Cape Ray Fault, by the Early-Middle Devonian Windsor Point Group, itself further deformed on the Cape Ray Fault, giving and Early? to Late Devonian age to the major movements of the Cape Ray Fault.

Terrane II, between the Cape Ray and Grand Bruit faults, contains metavolcanic, metasedimentary and meta-igneous rocks, all imprinted with intense, northeasterly to easterly striking, steep foliations and shear zones, and gently northeasterly plunging lineations. These predominant structures are syn-metamorphic and generally the second regional fabric recorded, post-dating pre-metamorphic recumbent isoclines. The major Cape Ray Fault, along which the fossiliferous Windsor Point Group was deposited and deformed, evolved from this deformation stage; this and other geochronological data suggest it overlapped the Early to Middle Devonian. The effects of this major deformation were in turn affected by a later event, consisting essentially of differential bulging, juxtaposing rocks of different metamorphic history along steep, dextral oblique-slip and high-angle-reverse faults which form the internal domain or subterrane boundaries. The uplifts of one such domain is well calibrated by Late Devonian to Early Carboniferous Ar/Ar cooling ages and the reverse fault impingement of mid- to upper-amphibolite-facies rocks against the greenschist-facies Windsor Point Group along the southwest segment of the Cape Ray Fault. This is in contrast to the dextral oblique-slip deformation of the group along the northeast segment of the fault, where it lies unconformable on another Terrane II domain with early Devonian Ar-Ar cooling ages. The pattern as a whole suggests early recumbent folds and/or nappes followed by a major period of transpression, the latter beginning with sinistral? oblique-slip shear evolving into faulting and ending with differential bulging and dextral oblique-slip as the system "locked."

Diagenesis of the Albert Formation, Moncton Subbasin, New Brunswick

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The Late Devonian to Early Carboniferous Albert Formation of the Moncton Subbasin in southern New Brunswick is an ancient lacustrine and associated fluvial deltaic deposit. It forms the reservoir of the only oil and gas field in onshore Atlantic Canada.

A detailed diagenetic study has revealed as a primary depth, control on the occurrence of authigenic phases of ankerite, albitization of feldspars and mixed layer illite-smectite. Dominant authigenic minerals occur as porefill and porelining and include calcite, ankerite, quartz overgrowth, chlorite and illite. Carbon and oxygen isotope analyses of carbonate cements and veins suggest inorganic derivation, with minor contribution from bacterial oxidation at shallow depth and skeletal material in deeper burial. Two sets of fractures were observed. Hydrocarbon migration postdates the fracturing events.

Reservoir sandstones are fine to medium grained, subarkosic to sublitharenite in composition, and moderate to tightly packed. Porosity in these sandstones is mainly secondary, ranging from 10-20% and due largely to dissolution of detrital feldspars and carbonate cements. Microporosity in authigenic chlorite may constitute about half of the total porosity. Most of the sandstones are tight and permeability is highly variable reaching a maximum of 10 mD.

The End of the Avalon Zone in Southern New Brunswick

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Major ductile dextral-slip on northeast-trending marginal zones accompanied emplacement of the Late Precambrian Kingston dyke complex. Geological and chemical data suggest this motion was a continuation of oblique plate motions after closure. Emplacement of the dyke complex shows motions were at least temporarily transtensional, while presence of contemporary, northwest-trending, sinistral faults suggests a transpressional component. Old zones of weakness were repeatedly sites for minor normal and transverse brittle offset during lower Paleozoic time, resulting in a complex set of sedimentary outliers. These zones were also used during emplacement of the Devonian Saint George batholith, and in part by Carboniferous thrust movements along the Bay of Fundy. Confusion about the age of faulting has resulted in complete misinterpretation of the tectonics of the Avalon zone, which acted essentially as an internal crystalline massif during the Paleozoic.

Geology and Structure of the "A-C-D" Zones, Heath Steele Mines, New Brunswick

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The "A", "C", and "D" zones at Heath Steele Mines, New Brunswick, are base metal sulphide deposits that are spatially associated with a horizon of Lower Palaeozoic sediment, in a succession dominated by volcanics and volcaniclastics. The host sequence has been subjected to prograde metamorphism of low grade, and penetrative polyphase deformation. Five phases of deformation have been distinguished on the basis of systematic overprinting criteria on the mesoscale. The earliest tectonic event (D_1) that can be recognized is characterized by tight to isoclinal, upright folds of a compositional layering. These folds commonly have a differentiated axial plane cleavage (S_1), and were locally refolded about, on average, gently dipping axial planes (S_2) during phase two. S_2 is marked by a cleavage, and in detail shows a dome and basin pattern due to two events of upright folding with axial plane cleavages S_3 and S_4. Both cleavages were gently reoriented during a stage of shortening along a vertical axis (D_5). Cleavage and fold patterns throughout the area illustrate an increasingly heterogeneous distribution of strain, and diminishing overall deformation intensity during the five stages of development of the present fold complex.

Macroscopically, the "A", "C" and "D" sulphide zones are planar to tabular bodies, the geometry of which reflects D_1 folding. The presence of the largest sulphide masses of highest sulphide grades in D_1 fold hinges normally rules out post-D_1 epigenetic sulphide zone formation, but secondary growth of at least some sulphides can be demonstrated mesoscopically.

The Geological Highway Map of Nova Scotia: A Second Edition

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Eight years ago the Atlantic Geoscience Society published the Geological Highway Map of Nova Scotia for the 1980 GAC/MAC Halifax meeting. The press run was 16,000 maps; now less than 2,000 remain. The map has been used by visitors, residents, geologists, students and teachers. In many schools and some university courses it is part of the curriculum. With the low numbers of maps remaining and the many advances in the geological understanding of Nova Scotia, another edition was needed. In early 1987 an AGS committee was formed to begin preparation of another edition. The Committee has a broad base of experience with its members: Howard Donohoe (N.S. Mines and Energy); Robert Grantham (N.S. Museum); Gordon Fader (Atlantic Geoscience Centre); John Martell (Dartmouth High School); and Robert Raeside (Acadia University). This second edition of the map will be more "user friendly" than the preceding one. On the front, the geological map will be correctly oriented geographically and will have the same increased size as the newer edition of the Nova Scotia Tourism Highway Map. We will be working toward integrating relief and geology on the map so that users will understand how the geology of an area has affected the landscape. Block diagrams will be used both on the front in place of cross-sections and on the back for discussion of local areas. Other novel ideas for stronger and more graphic presentations of geology and landforms are being discussed. These include "exploded" views of an area using a layered effect: the bedrock layer, surficial deposits layer and surface cultural features and landforms layer. Mining and the mineral industry in Nova Scotia will be emphasized through panels on the back and locations of mines on the front map. We feel that the new edition of the map will be able to show users more about the geological history, mineral resources, rocks and fossils and landform development with less complication and fewer words.

Movement History of the Cobequid Fault Zone, Cobequid Highlands, Northern Nova Scotia

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The Cobequid Fault Zone (CFZ) is a complex linear feature defined by numerous, generally E-W faults that cross northern Nova Scotia between Cape Chignecto and northeast of Truro. In this sense the Cobequid Highlands massif, which is bounded, broken and cut by the E-W faults, is part of this large fault zone. The CFZ is the Carboniferous and Mesozoic manifestation of movement between the Avalon Composite Terrane and the Meguma Terrane that began in Devonian or earlier time as the

Minas Geofracture. From the Late Devonian to the Late Carboniferous, movement on the CFZ: (1) deformed rocks in some fault blocks, (2) isolated rock units, (3) influenced sedimentation, (4) facilitated the extrusion of three to six kilometres of bi-modal volcanic rocks (Fountain Lake Group), and (5) acted as a locus for Devonian and Carboniferous plutonism. Sedimentation was episodic and mainly influenced by relative vertical movements on the CFZ. The Fountain Lake volcanics are found across the Highlands in fault controlled outcrops. Flow directions and slices of volcanic rock in the CFZ indicate that the volcanic rocks covered much of the area south of the Highlands. Emplacement of plutons was part of an intrusive process in shear zones analogous to examples in the South Armorican Shear Zone of Brittany. The transcurrent movement was episodic and appears to be mainly confined to the Early Carboniferous, although additional movements took place during Late Carboniferous and Triassic-Jurassic times, coupled with vertical movement. The result of the Namurian movement was the isolation and deformation of a large block of (?) Early Carboniferous siltstone/wacke (Greville River Formation) and smaller blocks of Fountain Lake Group rhyolites, Hadrynian aged Jeffers Group mafic volcanics and Windsor Group limestones and sediments. The mylonitization and truncation of several Early Carboniferous-aged plutons by active faults and the subsequent emplacement and deformation of the Pleasant Hills Pluton date this episode of transcurrent movement at c. 330 Ma. The estimated composite horizontal movement is 80 to 120 km minimum for Namurian time; younger movements are not as well documented. By Westphalian A time most of the faults along the northern side of the CFZ had been overstepped by sedimentation and movement was concentrated on the southern side of the Cobequid Highlands. Continued horizontal motion on the CFZ during the latter part of the Carboniferous has complexly deformed the Middle Carboniferous-aged Cape Chignecto Pluton. At this location the CFZ changes its orientation from E-W to WSW; what was mostly horizontal movement on the E-W CFZ became more transpressive with the accompanying development of thrusts and low-angle shear zones. The Pluton has large areas with near horizontal mylonites that are not found elsewhere in the same-aged rocks. This episode began in (?) Westphalian time and continued until the cessation of thrusting in the Saint John, New Brunswick region (late Westphalian). The southern part of the CFZ, mainly south of the Highlands, became active again during rifting in Middle Triassic time. Dip-slip movement continued intermittently between Triassic and Early Jurassic time along the locus of the Minas Geofracture. Some horizontal motion appears to have deformed Late Triassic sediments along the Cobequid Fault. The CFZ was an active boundary between the two terranes for a long period of time and represents an impressive record of movement.

Geochemistry of the Lower Crust Beneath the Eastern Meguma Zone, Nova Scotia

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Xenoliths occurring in a spessartite dyke near Tangier (Nova Scotia) can be subdivided into two distinct mineralogical groups. Group A includes sapphirine-orthopyroxene and garnet-orthopyroxene granulites and most of them have abundant graphite, aluminosilicates and spinel. Group B xenoliths are devoid of graphite and aluminosilicates and include two-pyroxene, orthopyroxene-amphibole and clinopyroxene-amphibole assemblages. Both groups give peak P-T estimates of 12-14 kb and 1000-1100°C.

Group A xenoliths have high Al_2O_3 ($\bar{x}$=22.5 wt. %) but very variable SiO_2 (46-67 wt. %). They have an overall major-element chemistry within the range of average shale but contrast sharply with Meguma Zone, low grade metasediments. Most Group A xenoliths are corundum-normative (3.5-18%), but some have normative diopside (aluminosilicate free) indicating a more calcareous protolith for the latter. Group B xenoliths have a narrow range in silica (50.46-51.31 wt. %) but a wide range in CaO (6.93-12.80 wt. %) and MgO (7.70-16.73 wt. %). Together with the high and variable compatible trace element abundances of Cr ($\bar{x}$=923) and Ni ($\bar{x}$=122) this reflects extensive crystal accumulation (cpx, opx, amph) of the igneous (basaltic) protolith. The K/Rb ratios for both groups ($\bar{x}$=321) are similar to average Archean crust (approx. 300). Some trace element ratios, such as Th/U and Zr/Nb, are very similar for both groups, averaging 3.5 and 14 respectively. However, they can be clearly distinguished by their Ti/V and Ti/Zr ratios (Group A: Ti/Zr<40, Ti/V>25 and Group B: Ti/Zr>40, Ti/V<25).

Both groups show LREE-enriched patterns but the total of 12 REEs is characteristically high for Group A xenoliths (106-248 ppm) when compared to Group B xenoliths (47-84 ppm). None of the REE patterns show positive Eu anomalies as is typical for the meta-tonalite-trondjemite-granodiorite suite of regional granulite terrains.

The most remarkable feature of both xenolith groups is their high abundance of LIL elements, compared to rocks from other granulite-facies terrains. This rules out significant melt extraction or loss of LIL elements during CO_2 flushing or prograde dehydration reactions. The lower crustal xenoliths are therefore unlikely source rock candidates for the Devonian-Carboniferous granitoids of Nova Scotia.

We infer that the lower crust beneath the Meguma Zone is composed of shales, calcareous shales, mafic cumulates and gabbros.

Metamorphism Within the Fournier Group Oceanic Fragment

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The Fournier Group is a variably metamorphosed basic inlier with minor intermediate and ultrabasic rock associations. The complex outcrops along the southwest margin of the Baie des Chaleurs, 25 km north of Bathurst in northern New Brunswick. The complex comprises a lower gabbroic unit which is intruded and, in places, overlain by diabase and minor trondhjemitic dykes and sills (together referred to as the Devereaux Formation). These lithologies are unconformably overlain by a greywacke and slate olistostrome, containing pillow lava olistoliths, which are in turn overlain by a basal pillow lava sequence followed by greywacke, slate and minor limestone (referred to as the Pointe-Verte Formation). The Fournier Group as a whole is surrounded by Silurian sediments. Graptolites and conodonts extracted from the Pointe-Verte Formation yield an Ordovician Llandeilo age which indicates a minimum primary age for the igneous complex.

The association of gabbros, sheeted diabase dykes, pillow lavas and sediments suggests that the Fournier Group represents the remains of a fragment of oceanic crust. No mantle tectonite or ultrabasic cumulate units have been found. Metamorphic effects within the complex are varied. They range from a pervasive sea-floor type hydrothermal alteration, realized under essentially static conditions (zeolite through prehnite-pumpellyite to greenschist facies), where igneous textures and mineralogies can still be discerned, to complete metamorphic overprinting in the amphibolite facies under dynamic conditions. The latter effect is restricted to discrete east-west trending shear zones which show the development of pronounced mylonitic, schistose and gneissose textures within what are otherwise statically metamorphosed, greenschist facies metagabbros. The shear zones are interpreted to represent fossil oceanic transforms or ridge-related fractures.

The Stoney Creek Oil and Gas Field; Its Bearing on the Lower Carboniferous Paleogeography of the Moncton Subbasin

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The Stoney Creek Oil and Gas Field is a producing field in the Late Paleozoic Moncton Subbasin of New Brunswick. The field is located 16 km south of Moncton and occurs within lacustrine/fluvial-deltaic sandstones of the Lower Carboniferous Albert Formation. The field lies along the south flank of the Westmorland Uplift, a granitoid complex around which the eastern part of the Moncton Subbasin is bifurcated.

The Albert Formation at Stoney Creek dips toward the south. Red beds of the Hillsborough and Weldon Members of the Moncton Formation overly the Albert Formation throughout the field and thicken quickly to the south as a wedge between the Albert Formation and the unconformably overlying Enrage Formation.

The lacustrine shales and siltstones of the Albert Formation thicken from the north to the south across the Stoney Creek field. Sandstone sequences interbedded with the shales and siltstones also thicken towards the south and presumably into the deeper part of the Moncton Subbasin. The Albert sandstones within the field and in the Irving/Chevron Hillsborough No. 1 well, 5 km to the south, are subarkosic and conspicuously lacking in volcanogenic detritus. The thickening of the Albert Formation away from the Westmorland Upland indicates that the uplift had a controlling influence on the accumulation and facies distribution of the Albert Formation sediments.

It has, in the past 25 years, been tentatively argued that the provenance of the sandstones at Stoney Creek lies to the south, perhaps as far south as the granitic terrains of Nova Scoita. However, surface paleocurrent measurments to the east of the field indicate south and southwest transport directions for the sands. The new paleocurrent data imply the existence of a local depocenter to the southwest of the Stoney Creek Field. The increase in quantity and thickness of sandstone to the south and southwest provide supporting evidence. The absence of volcanic detritus in the Stoney Creek sandstones strongly implies that the crystalline volcaniclastic and volcanic terrains of the Caledonian Uplift to the south, did not supply sediment to the field. Presently available data suggest that the source of the Albert sandstones at Stoney Creek was to the east and/or northeast, probably from the largely granitic Westmorland Uplift.

Seabed Characteristics and Sediment Mobility at CAS Study Sites on the Inner Scotian Shelf

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Wave gauges, current meters and other instruments were deployed in early 1986 on a transect across the inner Scotian Shelf east of Halifax as part of the Canadian Atlantic Storms Program (CASP). The resulting measurements of the near-bottom flow regime have been combined with core and sample data, sidescan and shallow seismic records, ROV video imagery, and diver observations of seabed scour and accretion, to provide a detailed picture of bottom characteristics, scour potential, and sediment mobility on the inner shelf.

The study area (in 20-37 m water depth) is characterized by irregular bathymetry and a complex distribution of bottom types, including sand, gravel, cobble-boulder lag surfaces, and bedrock. Anomalous depressions up to 2.4 m deep and 30 m across are present at a site in 30 m of water where mud is exposed at a break in the overlying sand veneer. A 4.3-m vibracore (87042-033) obtained nearby contains an upper 0.8-m marine sand unit (with 0.1 m of gravel at the base), underlain by 3.5 m of fossiliferous sand, silt-sand, and silt-clay interpreted as estuarine. A TOC sample from mud at the seafloor depression site has yielded a radiocarbon date of 6790±80 years BP (Beta-19587).

Large-scale symmetrical ripples in gravel, with wavelengths up to 2 m or more and relief up to 0.4 m, occurring in discrete patches and ribbons, reveal the localized nature of gravel mobility. The gravel in the ripples is multimodal, with dominant modes of the order of 10 mm and larger, and is mobilized frequently during winter storms. The sand in the area is well sorted with a modal size of about 0.2 mm. It occurs in thin patches with horizontal dimensions of the order of 100-1000 m.

Maximum observed values of scour during CASP were less than 0.1 m. Computations of sand load (depth-integrated concentration) and transport, based on a model in which the load is related to the excess normalized shear stress, have been used with a scour model based on continuity arguments to estimate scour rates of the order of 1 mm/h under moderate storm conditions at the 20-m site. These results are generally compatible with the observed scour.

Stratigraphic Relationships in Atlantic Canada

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Stratigraphic units are related in space and time. Absolute ages have previously been used in this project to illustrate the stratigraphic relationships by depicting the units in range-chart format. The charts are a useful synoptic display, but the absolute age ranges ascribed create several problems in relation to the known stratigraphy. The lithologic units of Atlantic Canada are taken from Volume VI of the Lexicon of Canadian Stratigraphy (Williams *et al.*, ed.). A simplified base of standard fields (LEXFILE) was abstracted for computer use.

Spatial relationships are now being compiled in six categories: Conformable; Unconformable; Intrusion; Faulting; Lateral; Equivalent. Each individual relationship is between two units. The last two categories usually represent some sense of synonymy. The first four represent a clear sense of sequence, which relates an "earlier" unit to a "later" one. Preliminary results indicate each unit has been related on average to 3 other units. The network resulting from this degree of branching is complex, and we are examining the significance. Sub-networks for local regions or terranes may be a way to simplify the results. If so, the spatial charts may illustrate the reported stratigraphy in a topological sense, resolve some of the problems of the age-range charts, provide more detail and point to future stratigraphic problems.

Stratigraphic Constraints on the Timing of Fault Movements in New Brunswick

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New Brunswick has been divided into several tectonostratigraphic terranes based on the uniqueness of their stratigraphy and structural history. These are from north to south: Elmtree (Ordovician back-arc oceanic crust), Miramichi (Ordovician

back-arc intracontinental volcanics), St. Croix (Cambro-Ordovician slope sediments deposited on thinned continental crust), Mascarene (Cambrian? mafic schist overlain by Siluro-Devonian volcanic rocks), and Avalonian (Precambrian basement overlain by Cambro-Ordovician platformal rocks). The movement history along their faulted boundaries and age of overlapping cover rocks demonstrate that these terranes were accreted to the North American craton between the Late Ordovician and Devonian.

The Rocky Brook-Millstream Fault, a prominent dextral transcurrent fault displacing strata as young as Carboniferous, has previously been used as the boundary between the Elmtree and Miramichi terranes. Recent structural studies by the Geological Survey of Canada suggest that this boundary may more accurately be represented as a series of southward-directed thrusts, which accompanied early folding. The age of this thrusting is no younger than Late Silurian since conglomerate of that age unconformably overlies, and contains deformed pebbles derived from Middle Ordovician volcanics of the Tetagouche Group.

The Fredericton Fault, which transects Silurian rocks of the Fredericton cover, has generally been considered to mark the boundary between the Miramichi and St. Croix terranes in New Brunswick. Carboniferous basalt has been downthrown 700 m to the southeast across the trace of this fault. Its extension into Maine, the Norumbega Fault, dextrally displaces Devonian granite with a total offset of no more than 30 km.

A recent seismic survey across southern Maine indicates that extensive earlier southeastward-directed thrusting, involving Siluro-Devonian cover rocks, occurred prior to granite emplacement in the Devonian. As a consequence, high-grade metamorphic rocks of Miramichi aspect are, locally, found to the southeast of the Norumbega Fault, where they structurally overlie black slates of the St. Croix Terrane. No ancient oceanic crust was found to be present in this region. Vergence of folds in the Fredericton cover rocks in New Brunswick is consistent with southeastern thrusting on the Honeydale Fault, transporting these cover rocks over the St. Croix Terrane.

The Pendar Brook Fault, which defines the northern extent of the Mascarene Terrane, is truncated by the Devonian Saint George Batholith. Seismic evidence suggests that the equivalent Turtle Head Fault in Maine is a steep structure penetrating the lower crust. The Wheaton Brook Fault, which marks the northern exposed limit of the Avalonian Terrane, also pre-dates the Saint George granite, but the parallel Belleisle Fault to the south displaces Carboniferous strata.

The widespread occurrence of southeastward-directed thrusts to the north of the Precambrian Avalonian Terrane, suggests that northwestward-directed subduction was responsible for terrane accretion between the Late Ordovician and Early Devonian. The older thrusts in the north have been related to subduction of back-arc oceanic crust during the latter stage of the Taconian orogeny. The younger thrusts in the south can be related to Acadian subduction of subcontinental lithosphere that generated Late Silurian to Early Devonian calc-alkaline volcanics within the Matapedia cover sequence.

Tectonic Influence on Late Carboniferous Sedimentation in the Coal-Bearing Sydney Basin, Nova Scotia

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The Morien Group of Westphalian B to Stephanian age shows a series of NE-trending synclines and anticlines. Early workers attributed these structural elements to an "Appalachian" orogenic phase, but later workers invoked synsedimentary differential subsidence, based principally on studies of the coals.

Quantitative analysis of 20 coastal sections totalling 3600 m of strata in the Sydney Mines Formation (upper Morien Group) shows that the Emery-Hub Seam interval in the Glace Bay Syncline differs in thickness and character from coeval strata across the adjacent Bridgeport and Perce Anticlines. The thicker Glace Bay strata show a higher proportion of coal, carbonaceous shale, limestone and grey strata, but virtually no redbeds. The adjacent anticlinal areas show a higher proportion of channel sandstone (individual channel fills are also significantly thicker), red beds and pedogenic duricrusts.

These results suggest that the Glace Bay Syncline formed a persistent topographic low where high groundwater levels favoured lake and swamp deposits. The adjoining anticlinal areas formed topographic highs where lower groundwater levels favoured alluvial plains with red, oxidized strata and active pedogenesis. Topographic relief was gentle, however, because many coal seams cover both synclinal and anticlinal areas.

Paleoflow was NE, subparallel to the fold axes, throughout deposition of the Morien Group. Paleoflow during deposition of the basal Morien strata diverged strongly around anticlinal areas but later became more uniform.

The structural elements were sufficiently pronounced to exert a strong influence on sedimentation. Aeromagnetic maps show that the elements commonly correspond to the topography of the underlying basement (pre-Late Devonian). Basement fragmentation, with active vertical and horizontal motion of blocks, took place during the Early Carboniferous. Gentle, and progressively decreasing, differential motion continued to influence sedimentation during the Late Carboniferous.

The Tobeatic Fault Zone - Post-Visean Sinistral Fault Movement in Southern Nova Scotia

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The Tobeatic Fault Zone (TFZ) comprises a zone of shear extending from the Wedgeport area of extreme southwestern Nova Scotia, northeasterly through the Vaughan-New Ross district where it cuts granitoid rocks of the South Mountain Batholith (SMB), to connect with post-Visean fault systems defining the northern limits of the Shubenacadie Basin. Geological, geophysical and paleomagnetic evidence points to approximately 110 kilometres of post-Visean sinistral displacement on the TFZ. With a strike length of up to 700 km including possible extension into the Gulf of Maine, the Tobeatic Fault Zone is of considerable significance to the understanding of the tectonic history of southern Nova Scotia.

Reconstruction realigns the Shubenacadie and Windsor Basins, creates an elliptical plutonic complex comprising the SMB, the Musquodoboit Batholith and the Liscomb Complex, and merges areas of Bouger gravity lows and radiometric highs in southern Nova Scotia. It also realigns Meguma slate belts of anomalous radio-element character.

The reconstruction juxtaposes and explains the close similarity of igneous rocks within the north-central SMB and the western Liscomb Complex. It also provides an important genetic rationalization for the distribution of many metallogenic domains of granophile character along the trace of the TFZ.

Stratigraphic evidence limits the movement history of the TFZ to post-Visean time, whereas tenuous paleomagnetic data provide a younger limit of pre-Triassic. Fault deformation of the firmly dated Wedgeport Pluton documents movements younger than 315 Ma, i.e., Westphalian or younger.

Lithochemical Evidence for the Provenance of the Meguma Group, Southern Nova Scotia[1]

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The whole rock composition of grewackes of the Goldenville Formation of the Meguma Group is not consistent with the interpretation of the source being a continental area of shield dimensions. This interpretation was based on the mineralogy of framework grains, the petrography of rock fragments (slate, quartzite, and granitic gneiss) and uniformity of clast petrography throughout the Meguma. The chemical composition of Goldenville greywackes indicates that most of the matrix is derived from volcanic rock fragments of intermediate (andesitic) composition and mineralogy.

A large set of whole rock chemical analyses of Meguma Group rocks has been collected while investigating the nature of the changes between its two formations. The major element distribution for greywackes of the Goldenville Formation show that they are clearly comparable to other Lower Paleozoic greywackes. Al_2O_3/SiO_2 for greywackes of similar grain size and similar sedimentological position within a bedding unit indicate only moderate sedimentological fractionation compared to greywackes deposited adjacent to a known passive continental margin. Relatively immobile TiO_2, total Fe, and MgO indicate that any magmatic component is of intermediate composition and consistent with sediment production from on an active continental margin. Alkali element distribution in the same samples indicates only moderate pre-erosion weathering and intermediate andesitic feldspar compositions.

The source of the sediment for the Goldenville Formation is a mix of an active magmatic arc and the continent within which the arc is being emplaced. Lithochemical variation within the Goldenville Formation is low and the Halifax Formation also contains evidence of andesitic component in the source area. The top of the Goldenville Formation however, contains greywackes with major element distribution indicating a period of decreased andesitic influence on the composition of the sediment.

This interpretation is consistent with U/Pb dates reported by others from zircon and sphene and K/Ar dates reported from muscovite of both 2500 my (continent component - zircons) and 600 my (magmatic arc component - zircons; sphene; and muscovite).

[1]Contribution to the Canada-Nova Scotia Mineral Development Agreement 1984-89. Project carried by Geological Survey of Canada, Economic Geology and Mineralogy Division.

The Role of Organic Carbon in Formation of Carbonate Carbon in the Meguma Group, Southern Nova Scotia

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The interaction of organic matter and minerals during diagenesis has been demonstrated by carbon isotopic studies in the Meguma Group metasedimentary rocks of southern Nova Scotia. Carbonate in diagenetic concretions in sandstone beds toward the top of the psammitic Goldenville Formation and carbonate cements in the basal units of the Halifax Formation have a restricted range of $\delta^{13}C_{PDS}$ of -14.8 to -22.2 per mil. A carbonate rim surrounding a bituminous bleb at Eastville is similarly depleted in $\delta^{13}C$.

Strong depletion in ^{13}C is considered indicative of carbonate formation from oxidation of organic material as opposed to precipitation from normal seawater. The oxidation of organic matter to produce authigenic carbonate minerals is thought to be an important process in the diagenesis and early metamorphism of organic carbon-bearing sedimentary rocks and in the genesis of metalliferous sediment.

Similar carbon isotope ratios have been obtained from carbonate minerals in scheelite and gold bearing veins in the Meguma Group indicating the role of organic carbon component in the vein-forming fluids.

Subhorizontal Injection of Magma Forming the Popes Harbour Dyke

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At the time of injection, magma that formed the 15 m wide Popes Harbour dyke on the eastern shore of Nova Scotia carried with it pelitic xenoliths predominantly up to 1 m in length. Both the size and volume of xenolith material increase toward the center of the dyke, observations attributable to flowage differentiation processes. Xenocrysts of needle-like sillimanite are scattered throughout the dyke as a result of partial assimilation and disaggregation of the xenoliths. The sillimanite needles have resisted weathering and project from outcrop surfaces allowing accurate measurement of their orientations. On average they strike northwest-southeast and plunge 20° to the southeast. Their orientation is parallel to the direction of magma movement indicating that the magma was injected in a subhorizontal direction toward the northwest. It is apparent that petrofabric analysis can be very useful in ascertaining the direction of magma flow in dykes. A preliminary literature review shows that subhorizontal movement of magma in mafic dykes (usually inferred using other approaches) is much more common than subvertical movement. It appears that dykes generally form through the lateral injection of magma.

Fine-Grained Storm Deposits on the Inner Shelf of the Canadian Beaufort Sea

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The inner shelf of the Canadian Beaufort Sea is characterised by a seaward succession of seabed fine-grained facies. Seaward of shoreface sands and silts, the surficial facies show the following sequence: (i) thin-bedded silt and clay couplets (<1 cm thick); (ii) massive to graded, medium to thick-bedded silt beds (up to 20 cm thick); (iii) thin silt beds (<2 cm thick) with thick interbeds of bioturbated silty clay; (iv) bioturbated silty clay with no silt beds. The massive to graded, medium to thick-bedded facies occurs between water depths of 4.2 m and 5.5 m and is interpreted to result from major resuspension events in a zone of maximum wave energy during large storms. Oceanographic measurements support this interpretation: a nearbed maximum of suspended sediment concentration (SSC) is observed centred at the 5 m isobath and increases in intensity during moderate storms. Time series of nearbed SSC and wave heights at 5.9 m water depth record strong resuspension resulting in SSC values of 4000 mg/l during strong storm conditions. The thin-bedded silt and clay facies found shoreward of this strong resuspension

zone can be interpreted to result from attenuation of wave energy in the resuspension zone. The amount of resuspension, therefore, decreases shoreward resulting in thinner beds. Seaward of the strong resuspension zone, the frequency of bottom sediment resuspension decreases with water depth, reflecting the lower frequency of very large storm waves. This is also reflected in the deeper water facies where bioturbated clay becomes the dominant facies, with thin silt beds representing infrequent bottom resuspension during the largest storms.

Primary and Secondary Structural Features in the Eastern Portion of the South Mountain Batholith; Implications for Regional Stress Orientations During Intrusion

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Schlieren banding, megacryst-xenolith alignment and biotite parallelism, indicative of primary magma flow, displaying concentric, random and linear patterns in the South Mountain Batholith (SMB) reflect intrusive geometry. In the eastern-most part of the batholith patterns reflect differential flowage near intrusive contacts. However, in the east-central portion of the batholith preferred linear trends may, in part, reflect syn-tectonic stress during intrusion.

Statistical evaluation of 3600 joints within the eastern portion of the SMB has identified six distinctive joint sets (trends), all steeply dipping: Trend 1, 040°; Trend 2, 056°; Trend 3, 063°; Trend 4, 128°; Trend 5, 146°; Trend 6, 164°. The dominant joint sets, trends 3 and 5, form a nearly orthogonal pattern and are ubiquitous to the study area. All other trends are submaxima of one of the dominant trends and do not occur in all areas. Trends 4 and 6 form a conjugate pair about trend 5. Trend 1 is restricted to the east-central portion of the SMB and is related to northeast shearing within the East Dalhousie Fault Zone. Quartz veins and some dyke orientations parallel Trend 5 joints. Trends 3 to 6 are interpreted as resulting from northwest horizontal compression during syn-magmatic deformation.

Mineralization within the SMB is strongly controlled by the regional fracture patterns. Uranium mineralization is generally associated with hematitized Trend 3 joints while polymetallic vein-greisen mineralization is associated with Trend 5 joints.

Implications of Superimposed Shear Zones in Shelburne-Barrington Area

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Six generations of deformation have been recognized in the study area, two pre-metamorphic and four post-metamorphic. Upright tight folds (F2) have been interpreted from the bedding plane distribution. Axial planar slaty cleavage or schistosity (S1) is cogenetic with the folding. The F2 deformation is recognized from the regional crenulation cleavages (S2). The S1 and S2 planes are overprinted by lower amphibolite metamorphism.

Post metamorphic deformations are characterized by variable shear along bedding planes. Dextral strike-slip faults (F3) are reactivated by sinistral faults (F4). Dextral faults tend to show ductile behaviour. Both ductile and brittle behaviour is seen within the sinistral strike-slip faults. These faults (F3 and F4) clearly affect the porphyroblasts and regional crenulation cleavages, indicating that they are post-metamorphic. A new foliation is developed within the fault zone. Subvertical striations occur on bedding-parallel slickenside planes (F5) and overprint sinistral strike-slip faults. Finally, kink-bands (F6) and the northwest-trending faults overprint all of the above structures. The northwest-trending faults have been interpreted as being a product of deformation as are the kinkbands.

Faults related to F3, F4 and F5 generally strike NNE and are numerous throughout the area. They profoundly influence the regional structure and merit more attention then they generally receive.

The Geology and Significance of North Mountain in the Bras D'Or Zone, Cape Breton Island

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The greater part of North Mountain (southern Cape Breton Island) is underlain by granitoid plutons which have intruded the Lime Hill gneissic complex and the George River Group carbonate-clastic sequence. The Lime Hill complex consists of polydeformed migmatitic paragneisses, orthogneiss and minor marble, amphibolite and calc-silicate rocks that have been metamorphosed to low pressure, upper amphibolite facies. These rocks have been intruded by a variety of granitic to mafic dykes. Stratiform sphalerite mineralization at the Lime Hill zinc showing is hosted by dolomitic marble of the gneissic complex. Analysis of phase relationships suggests that the migmatites formed at temperatures above 650°C and pressures below 400 MPa; geothermobarometry indicates peak conditions at about 750°C and 350 MPa. In fault contact with the Lime Hill gneissic complex are low-grade rocks of the George River Group. These include slate, phyllite, quartzite, fine to coarsely recrystallized

calcareous to dolomitic marbles and minor mafic metavolcanic rocks. Because of complex folding, the internal stratigraphy of the George River Group remains uncertain.

The granitoid rocks have been subdivided into three major units. Most extensive is the Marble Mountain hornblende-biotite granodiorite which has intruded and contains several large xenoliths of George River Group rocks. It is weakly foliated and ranges in composition from tonalite to granodiorite. K/Ar dating of hornblende separates indicate an age of 526±21 Ma. The Big Brook hornblende-biotite granodiorite and the West Bay hornblende-biotite monzogranite, have intruded the Lime Hill gneissic complex. The Big Brook granodiorite is massive and varies in composition from granodiorite to tonalite. The West Bay monzogranite is typically highly fractured, coarse grained and K-feldspar porphyritic. Plagioclase has been completely replaced by albite. Younger cogenetic granophyric and porphyritic dykes intrude the granite. The Marble Mountain and Big Brook units display typical I-type characteristics whereas the West Bay monzogranite can best be described as highly felsic I-type.

The geology of North Mountain is typical of the Bras d'Or Zone, displaying a low pressure gneissic basement, platformal sedimentary rocks and intruded by I-type granitoid rocks.

Plant Fossils from the Fisset Brook Formation of Cape Berton Island, Nova Scotia

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Archaepteris, a genus of Upper Devonian progymnospermous plants, is reported from the Fisset Brook Formation of Cape Breton Island, Nova Scotia. This is the first known occurrence of Upper Devonian plants from the province. Plants assigned to *Archaeopteris* are arborescent, leafy, spore-producing and woody. the specimens collected represent branchlets of sterile and fertile foliage and petrified wood. The sterile foliage falls within the *A. halliana* complex. The petrified wood "*Callixylon*" is well-preserved and consists of tracheids and ray parenchyma. The tracheids show the typical Callixylon pattern of grouped, circular-bordered pits. This is the easternmost occurrence of *Archaeopteris-Callixylon* in the northern Appalachians, and correlative units include the Perry Formation (Maine) and Escumanic Formation (Quebec).

Geochemistry of Alkali Feldspars, South Mountain Batholith, N.S.: Implications For Petrogenesis

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The geochemistry of granitoid rocks is a poor approximation of the bulk composition of the melt from which the constituent minerals crystallized. A multitude of processes (e.g., filter pressing, accumulation, adcumulate growth, subsolidus fluid interaction) may act singularly or collectively to modify the original bulk composition of the melt and crystals. One way to circumvent this problem is by direct analysis of mineral phases which have retained their primary, magmatic compositions. Assuming that melt-crystal evolution for a given element (K_D) remained constant during magmatic crystallization, then mineral chemistry should provide a more direct and reliable means of evaluating the goechemical evolution of magmatic systems.

Alkali feldspar (Kf) separates from the South Mountain Batholith, representing the most primitive to most evolved members, were analyzed for major and trace (Rb, Sr, Ba, Li, Ga, Pb, Cs, Nb, Mo, Zr, Th, U, W, Y, REE) elements to examine the geochemical evolution of the batholith. Results are summarized as follows: (1) bulk, magmatic compositions and calculated minimum temperatures (for 1 Kbar) for the major units are: granodiorites (grnd) Or_{70-75}, 650-725°C; monzogranites (mnzg), Or_{58-65}, 650-700°C; pegmatites, Or_{68-78}, 525-<400°C; (2) there is a consistent trend of increasing phosphorous (wt.%) in Kf from grnd (0.05-0.1) to mnzg (0.18-0.35), to pegs in mnzg (0.44-0.52) to large pegs (0.56-1.08); (3) all samples conform to single, well-defined trends on Rb vs. Sr and Rb vs. Ba plots suggesting a crystal chemical control and constant K_D's; (4) Kf from grnds show large variations (ppm) in Sr (350-220), Ba (7000-3500), Eu/Eu* (4-13) and ΣREE (19-36), but similar Rb, Ga, Cs and Pb contents; (5) Kf from some mnzgs have more primitive chemistry than Kf from grnds, and significant chemical differences between mnzg suites occur (e.g., Halifax vs Harrietsfield suites); (6) ΣREE and Eu/Eu* decrease consistently from grnd to pegs, but Yb_N values remain very similar in grnd and mnzg; (7) Kf from pegs are chemically the most variable, reflecting primarily the degree of fraction of their parent melt.

Some important conclusions that provide constraints for petrogenesis of the batholith are: (1) grnds do not represent homogeneous parental melts; (2) grnds cannot be parental to all mnzgs; (3) some significant chemical differences between mnzg suites occur indicating multiple, co-existing melts; (4) P behaves as an incompatible elemental during fractionation with late-stage enrichment in pegs; (5) LREE's decrease systematically during fractionation mainly due to sequestering of LREE into accessory phases and Eu into feldspar; (6) trace element (Rb, Cs, Li, REE)

contents of pegmatitic Kfs are excellent indicators of degree of fractionation (and mineral potential).

In addition to the above, one of the more significant results of this study that will be demonstrated is that chemical differences between suites not readily apparent using whole rock chemistry is more obvious utilizing mineral chemistry. This is due mainly to the lack of dilution which occurs during whole rock analyses of granites which typically contain 30-45 vol.% quartz.

Sulphur Isotopic Composition of Sulphides in Meguma Gold Deposits: Implications for Genetic Models

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Base metal sulphides (Fe, Cu, Zn, Pb) are a persistent, although volumetrically minor phase in auriferous quartz veins hosted by the Cambro-Ordovician Meguma Group metasediments of southern Nova Scotia. The paragenesis of the sulphides is such that they bracket the gold mineralizing event, providing therefore an opportunity to examine the ambient physiochemical conditions of the ore fluid during mineralization. In this study, 45 sulphides (16 py, 4 po, 1 galena, 24 arspy) from eight deposits in the eastern Meguma Terrane have been analyzed for $\delta^{34}S$, with 32 analyses for the Beaver Dam deposit (3 million tons, 0.29 oz/ton).

$\delta^{34}S$ values for sulphides from Beaver Dam are as follows: py (N=16) = 9.9±1.1°/oo; po (N=4) = 9.9±0.2°/oo; arspy (N=11) = 10.5±0.4°/oo; galena = 9.4°/oo. No systematic variation of $\delta^{34}S$ was noted for any sulphide regardless of paragentic stage or morphology. For the remaining 7 deposits, 13 arspy analyses range from 9.8 to 25.0°/oo with small intra-deposit variations (e.g., Fifteen Mile Stream 12-14.8°/oo for 3 analyses). Additional analyses by Sangster (1987) for a further 3 deposits shows a similar provinciality for $\delta^{34}S$ values for sulphide mineralization.

The sulphide assemblages of the gold deposits, in addition to organic C in the wall rocks and CO_2-bearing fluid inclusions hosted by quartz, indicate ambient oxidation conditions below the H_2S/SO_2 boundary prevailed. Thus, $\delta^{34}S_{mineral}$ is a good approximation of $\delta^{34}S_{fluid}$. The tight intra-deposit clustering of data indicates fO_2 remained below this boundary condition and excursions related to changing Eh, pH and/or T°C were either short lived or nonexistent.

The $\delta^{34}S$ fluid (9-25°/oo, average 15°/oo) for the Meguma gold deposits and provinciality of the data provides constraints for potential source reservoirs and, therefore, genetic models. The syngenetic, exhalative model is considered unlikely and direct magmatic emanations can be eliminated as the dominant source of sulphur; the latter conclusion being similar to that reported earlier by Sangster (ibid.). A model involving incorporation of variable proportions of greywacke- and shale-derived sulphur from Meguma sediments is preferred with greywacke sulphur more abundant. The small intra-deposit variability of $\delta^{34}S_{fluid}$ is interpreted to reflect high fluid/rock ratios, a feature also suggested by extensive alteration haloes. This latter feature may favour a non-Meguma Group reservoir as the ultimate source of the fluids.

Kinematic Analysis of the Pocologan Mylonite Zone

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The record of ductile movement in the rocks of the Pocologan Mylonite Zone in southern New Brunswick was studied using the techniques of kinematic analysis. The record of the overprinting brittle faulting was also studied, using the techniques of brittle microtectonics analysis.

The mylonitic fabric involves (1) a strong subhorizontal stretching lineation trending NE-SW, parallel to the fault trace and the strike of the principal mylonitic foliation, C; (2) mylonitic C foliations (shear planes), and C' foliations (shear bands) dipping steeply to the SE and striking 060° and 095° respectively; and (3) a variety of kinematic indicators indicating dextral shear in the ductile regime.

The brittle microtectonics analysis shows that most of the minor faults trending NE had dextral displacement, while most of the faults trending NNW had sinistral displacement. If this analysis is indicative of the regional stress operative during faulting, then the NE-trending Pocologan Mylonite Zone was overprinted by brittle dextral faulting. The age of mylonitization is interpreted as Early Devonian (Acadian Orogeny), and the age of brittle faulting as Carboniferous (Alleghenian Orogeny).

The Volcanism and Geochemistry of Parts of the Endeavour Segment of the Juan de Fuca Ridge System and Associated Seamounts

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During the 1987 GSC cruise to the Endeavour Ridge, the northernmost segment of the Juan de Fuca Ridge system, limited dredging was carried out in West Valley. West Valley is spreading at 5.8 cm/year and is physiographically similar to slow-spreading centres such as the MAR. Basaltic rocks were recovered from two locations along the axial valley of West Valley and a third from the west wall of the valley. These sample sites were augmented with rocks collected from the Heck and Heckle seamount chains, the Sovanco Fracture Zone, and West and Middle Ridges by Barr between 1969 and 1971, and from the Endeavour Ridge south of the Endeavour Offset by the GSC in 1986. The purpose of sampling was (1) to determine spatial and temporal variations in the physical and chemical characteristics of the volcanism of the study area and compare this with adjacent ridge segments and other mid-ocean ridge systems in the Atlantic and Pacific oceans, and (2) to determine the relationships between West Valley volcanism, the associated seamount chains, and the Sovanco Fracture Zone. Rocks were analyzed for physical characteristics and degree of alteration, modal mineral content and mineral chemistry, and major-, trace- and rare-earth-element geochemistry of whole rock and fresh glass samples.

Rocks collected from the axial valley of West Valley have fresh glass, indicating that volcanism is young and suggesting that the valley is actively spreading. Samples from the valley wall are covered with a Mn-crust reflecting the older age of these rocks. The rocks range from primitive ($Mg^{\#}$=68) to differentiated ($Mg^{\#}$=54) compositions. Primitive lavas contain anorthitic plagioclase (with rim compositions up to An 89), forsteritic olivine (Fo 88) and chrome spinel (Cr_2O_3 25-30%). The phenocryst assemblage of the most differentiated lavas is plagioclase (rim compositions as low as An 65), olivine (Fo 77) and clinopyroxene; spinel is absent. The Endeavor Ridge samples are chemically similar to ridge systems to the north and south in that they are enriched in the incompatible elements and LREE (T-type MORB). The West Ridge, West Valley, and Middle Ridge samples are depleted in these elements (N-type MORB) compared to the Explorer and Juan de Fuca ridges and are similar in compositional diversity to lavas of the FAMOUS area of the Mid-Atlantic Ridge. The seamount samples are also N-type MORBs. The samples from the Sovanco Fracture Zone are mostly intermediate in composition between these areas. The seamount samples, although not obviously chemically distinct, exhibit flow structures indicative of low extrusion viscosities, to a degree not observed at the other sample sites. The explanation for these low viscosities is under investigation.

Recent Aeromagnetic Surveys Off The East Coast

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The GSC Program of Aeromagnetic Surveys was extended in 1982 over the eastern Gulf of Main and Georges Bank. In 1985 offshore surveys were carried out in the Laurentian Channel area between Cape Breton and Newfoundland and also northeast of Newfoundland. In 1987, high-resolution coverage south of Newfoundland was completed, while regional mapping was undertaken over the Newfoundland Basin. A compilation of these new offshore surveys, together with earlier surveys over Nova Scotia and Newfoundland, represents a substatial coverage of the northern terminus of the Appalachian orogenic belt.

A number of "suspect terranes" of unknown origin have coalesced to for the Appalachians as a result of the opening and subsequent closure of the Iapetus Ocean during an earlier phase of ocean-floor spreading and continental drift. Some of these terranes can be traced using aeromagnetic (and other geophysical) evidence. The new data is thus contributing to the delineation of different zones and the reconstruction of their development in time and space.

Newfoundland and the area to the northeast demonstrate a reasonably clear picture of converging continental margins separated by remnants of the old ocean floor. Cape Breton geology is much more complicated and it is not possible to make a clear connection between different suspect terranes across the Laurentian Channel. In addition to Meguma which occurs only in Nova Scotia and the surrounding offshore, it is postulated that at least one other suspect terrane is present in Cape Breton.

Leucogranite and Leucomonzogranite in the Southern Mountain Batholith, Southwestern Nova Scotia

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Light-colored, chemically evolved, post-tectonic granitoid rocks (LCGR) are frequently found to be spatially associated with Sn, W, U, (+/- polymetallic) deposits in many Paleozoic fold belts of the world. In fact, LCGR's are often considered to be the progenitors in these terrains. Thus, it is important to have a well-defined system for identifying and describing these LCGR's which can be readily and meaningfully applied in regional geological mapping programs.

Traditionally, such terms as leucogranite, alaskite, leucomonzogranite and leucoadamellite have been used interchangeably to describe LCGR's of the South Mountain Batholith (SMB) of Nova Scotia. Most publications have noted the "relative absence" of mafic minerals and have summarized some of the petrographic and geochemical characteristics of these rocks, but prior to this study no definition of leucogranite has been proposed.

A classification scheme based upon the abundance of mafic minerals (i.e., biotite, chlorite replacing biotite, cordierite and garnet) has been developed for the geological mapping of the SMB. Leucogranite and leucomonzogranite are presently defined as rocks containing 0-2% and 2-6% mafic minerals, respectively. Both rock types contain appreciable amounts (generally 3-10%) of muscovite and may contain accessory andalusite, fluorite, topaz, tourmaline and opaques (sulphides). Recent geological mapping indicates that the eastern portion of the SMB contains approximately 1% leucogranite, 10% fine- to medium-grained leucomonzogranite and 25% medium- to coarse-grained leucomonzogranite.

In this study we focus on the modes of occurrence and associated mineralization of the leucogranitic rocks. Leucogranites occur: (1) as discrete intrusive bodies (<1-5 km^2) and as dykes, small plugs (<100 m) and isolated outcrops. These leucogranites are hosted primarily by leucomonzogranite and, to a lesser extent, by monzogranite and granodiorite; textures include equigranular, porphyritic, aplitic, pegmatitic and seriate. Sharp intrusive contacts with host rocks (exposed and inferred) and the rare occurrence of xenoliths of other granitoid phases indicate that these leucogranitic rocks were of magmatic origin; (2) as alteration zones (i.e., via conversion of biotite to white mica) within fine- to medium-grained leucomonzogranite bodies; textures are primarily equigranular or porphyritic and reflect the texture of the host rock; associated greisenization and/or hematization are common; leucogranite occurs throughout leucomonzogranite bodies, and also in embayments and near granite/granite or granite/metasediment contacts.

Numerous mineral occurrences/deposits (e.g., East Kemptville, Long Lake, Millet Brook) are spatially and presumably genetically associated with leucogranitic rocks. However, the apparent absence of these rocks (at the present level of erosion) at other occurrences/deposits implies that leucogranite may not always be an essential ingredient for mineralization in the SMB.

The Horton Bluff Formation: A Tectonically Influenced Fluvial-Lacustrine Basin Fill

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The Lower Carboniferous (Tournaisian) Horton Bluff Formation includes the first strata deposited in the Windsor Subbasin following the Acadian Orogeny. The Windsor Subbasin contains the best exposures of the Horton Group found on the Meguma Terrane. In the Hantsport (type) area, the Horton Group comprises the Horton Bluff Formation (divided into three members, the Lower, Middle, and Upper) and the overlying Cheverie Formation.

The Lower Member is 100 m thick and composed mainly of minor siltstone and medium- to very coarse-grained pebbly sandstone shed from a granitic and Meguma Group source. The deposits are of a braided-fluvial origin.

The Middle Member is divided into two units. The lower unit is a 160 m thick package of coarsening-upward cycles of siltstone to fine sandstone, and near the top of the unit, of horizontally bedded sandstone. This unit represents the progradation of a delta into a relatively deep lake. The upper unit is 180 m thick and composed of thick "deep-water" shale at the base and coarsening-upward cycles of shale, and interbedded shale/very-fine sandstone near the top. These cycles are commonly capped by carbonate, and were deposited in offshore and marginal lacustrine environments.

The Upper Member in the Hantsport area is 100 m thick and contains two types of coarsening- and shallowing-upward cycles. The first resembles the cycles of the upper Middle Member, but are thinner, and contain more sand and better developed soil horizons. The second type of cycle coarsens upward into coarse-grained, cross-bedded sandstone, interpreted as delta mouth-bar deposits. The member represents interdeltaic and deltaic deposits prograding into a relatively shallow lake.

The basin-fill succession of braided, deltaic, open lacustrine, deltaic, and fluvial (Cheverie Formation) documents a major lake transgression followed by a gradual filling (regression) of the basin. Transgression in a tectonically subsiding basin reflects initial basin subsidence outstripping sediment input; regression occurs after subsidence slows.

The thickness of the Horton Bluff Formation and of its individual cycles increase northeastward. Basin subsidence was greatest in that area, possibly due to penecontemporaneous motion along the Cobequid Fault. Similar basin-fill successions of the Horton Group throughout the Maritimes Basin suggest regional tectonic events.

Embayed Volcanic Quartz: A Product of "Cellular Growth" Rather Than Resorption

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Textural evidence from felsic volcanic rocks of the Late Devonian (previously Early Carboniferous) Piskahegan Group, in southwestern New Brunswick suggests that embayed quartz phenocrysts were originally optically-continuous, microglomerocrysts that subsequently coalesced. Examples of crystals with embayed faces, but with crystal corners intact, show that resorption did not occur. Furthermore, there are optically continuous quartz glomerocrysts with deep embayments and/or patches of groundmass between the constituent crystals. These glomerocrysts are clearly a growth feature. If growth had continued the polycrystalline nature of the glomerocrysts would have been obliterated leaving large crystals with embayments and/or inclusions filled with groundmass material.

Optically-continuous quartz glomerocrysts strongly suggest the crystallographic orientation of their constituent crystals was pre-determined by magma structure. In other words, the magma was strongly polymerized such that "liquid crystal" domains existed within it. Embryonic crystals or "cells" nucleating within such domains would have had the same optical orientation, and the greater the number of cells, the more likely they would have coalesced. This is because a single large crystal has a more energy-efficient surface to volume ratio than several small ones comprising the same volume.

Type-C and Type-M Pumice Pseudomorphs: Compaction Versus Welding in Ancient Pyroclastic Rocks

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The Late Devonian (previously Early Carboniferous) Piskahegan Group in southwestern New Brunswick is dominated by subaerial pyroclastic rocks. These rocks contain two, mutually exclusive, types of pumice pseudomorphs. Type-C or cryptocrystalline pseudomorphs are characterized by greenish colors and submicroscopic micaceous intergrowths. Type-M or microcystalline pseudomorphs are characterized by reddish colors and micrographic intergrowths.

Eutaxitic foliation defined by Type-C pseudomorphs is the result of mechanical compaction under relatively low temperatures, whereas eutaxitic foliation defined by Type-M pseudomorphs is due to welding processes. Unflattened "fossil pumice," which is caused by calcitization or silicification of vesicular pumice texture prior to compaction, commonly occurs with Type-C pseudomorphs.

Type-C pseudomorphs could conceivably occur in air-fall or even subaqueous tuffs, and therefore are not indicative of a particular eruptive mechanism or a particular depositional setting. In ancient pyroclastic rocks, one should not assume that all eutaxitic foliation is the result of welding processes, or that all rocks exhibiting eutaxitic foliation are pyroclastic flows.

The Seismic Stratigraphy of Sable Island Bank; Scotia Shelf: Application to the Understanding of Shelf Processes

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The seismic stratigraphy of Sable Island Bank provides a model for continental shelf sandbody accumulation. The Holocene Sable Island sandbody is located 227 km offshore from Halifax, Nova Scotia. It covers an area of approximately 6500 km on the outer Scotian shelf and contains a sand volume of 98 km. This region at 44 N experiences both high energy North Atlantic storms and high velocity tidal currents. Relative sea level has risen from depths of a least 50 m at 11 ka and continues to rise by 33 mm/yr.

The Holocene shelf sandbody was derived from the transgressive reworking of Pleistocene proglacial sediments that were deposited during the most recent Late Wisconsinan low sea level stand. The subaerial Sable Island sandbody is lens shaped, 50 km long, 2 km wide and up to 51 m thick. The island extends subaqueously into asymmetric spits, each over 30 km long and 45 m thick. South and west of Sable Island lies a system of shoreface-connected and shoreface-detached ridges which results from storm reworking.

Sediment transport in the early phase of transgression resulted from shoreface retreat and shoreface ridge reworking within Sable Island Bank. Transport was directed NE to accumulate in the Sable Island region, forming a coarsening-up sandbody. Modern reworking results from both tidal and storm processes. Shoreface ridges migrate SE and continue to work Pleistocene sediments south and west of Sable Island. Further reworking of the Holocene sandbody is also taking place now by the migration of shoreface ridges. Sediments are transported NE towards East Bar, NW towards Northern Spur and north over West Bar. Tidal and storm currents rework sediments arriving on both East and West Bar producing bidirectional sediment transport to the north and to the south.

The major Sable Island sand accumulation has developed during the Holocene in an isolated outer shelf setting. It illustrates the importance of sea level and transgressive reworking to sandbody accumulation. The variety of morphologic and stratigraphic features present in the sandbody indicate the complexity of sand transport processes in the continental shelf setting.

Stratigraphy and Physical Volcanology of the Eastern Portion of the Devonian Volcanic Belt of Passamaquoddy Bay, Southwestern New Brunswick

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A 55 km^2 portion of the belt of Devonian volcanic and sedimentary rocks exposed within the vicinity of Passamaquoddy Bay was mapped at a scale of 1:10,000. The area was divided into 26 lithologic units, for the purpose of determining the stratigraphy, geochemistry and tectonic setting of the area. Lithologies within the area are interbedded basaltic and rhyolitic lava flows and pyroclastic rocks, with minor sedimentary rocks. Various small intrusive bodies also occur. In the lower third of the stratigraphic section basaltic and rhyolitic rocks are equally represented. Through the rest of the section rhyolitic rocks become volumetrically more important. The environment of eruption and deposition is interpreted to be subaerial to littoral, based on presence of littoral sedimentary rocks, coarse tuff breccias and welded pyroclastic flows. It is also indicated by absence of reworked volcanic deposits, pillowed lavas and hyaloclastite. Hawaiian, Strombolian, Vulcanian and Plinian eruptive systems are represented. The mafic units form mainly lava flow and peperitic breccia deposits, although mafic pyroclastic deposits also occur. Felsic units were emplaced as lava flow deposits, welded and nonwelded pyroclastic flow and airfall deposits and rare pyroclastic surge deposits. The majority of pyroclastic felsic deposits resulted from Vulcanian-type eruptions. Preliminary geochemical results indicate that the sequence is bimodal and subalkaline.

Discovery and Significance of Lower Permian Vertebrate Trace Fossils In the Red Beds of Southwestern Prince Edward Island

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In Megacyclic Sequence II red beds at Prim Point in southwestern Prince Edward Island, vertebrate trace fossils occur as casts of tetrapod trackways belonging to three distinct ichnospecies. The living tetrapods were associated with a rich invertebrate fauna in an area of sparse vegetation and occupied out-of-channel river sediments, most likely crevasse splay deposits.

The ichnospecies *Crenipes abrectus*, previously reported only from the Lodeve region of southern France is well represented at Prim Point. *Crenipes abrectus*, here interpreted as the track of a cotylosaur, together with an ichnogenus closely resembling *Gilmoreichnus-kablikae*, a captorhinomorph (possibly a juvenile pelycosaur), facilitates the strict stratigraphic assignment of an upper Lower Permian (Autun) age to the strata. The third set of footprints, those of a small herbivorous pelycosaur, resemble *Ichniotherium willsi*.

The pelycosaur-cotylosaur community recognized by footprints in Prince Edward Island red beds occurs in sediments time-stratigraphically equivalent to those hosting similar ichnofauna in the English Midlands and central Europe. This community occupied piedmont valley-flat red beds within the molasse facies of Variscan uplands.

A Progress Report on the Geology of the Eastern Cobequid Highlands

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The oldest rocks in the eastern Cobequid Highlands belong to the Late Precambrian Bass River and Mount Thom complexes. They consist of ortho- and paragneisses overlain by a sequence of orthoquartzites, marble and muscovite- biotite schists. The contact between these sequences is a ductile shear zone which obscures the original relationships. This sequence is unconformably overlain by a Late Precambrian mafic volcanics and turbidites which may be a correlative of the Jeffers Group and displays within-plate alkalic-tholeiitic affinities. Two phases of Late Precambrian deformation are recognised: an early phase involving sinistral transtension and a later phase of dextral transpression. It is tentatively suggested that this may represent the opening and closure of a back-arc basin. Late Precambrian intrusions include granite gneiss (which is probably syn-tectonic with at least part of the deformation in the Bass River Complex) granite and appinitic gabbro and diorite which appear to be post-tectonic with respect to late Precambrian deformation.

Late Ordovician-Silurian rocks consist of fossiliferous siliciclastics, similar to the Arisaig Group. Late Devonian-Carboniferous rocks are dominated by bimodal volcanics and are intruded by granite, diorite and gabbro of Devonian and Carboniferous age (see Turner *et al.*). The entire area was deformed locally by thrusts and isoclinal folds subsequent to the deposition of Tournaisian strata, but synchronous or prior to the Namurian.

Seismic Stratigraphy of Part of the Upper Nova Scotia Continental Slope

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Fifteen seismic profiles, shot by Petro-Canada and released by COGLA, totalling 350 kms with some well control from Petro-Canada, are being used to study the Late Mesozoic and Cenozoic seismic stratigraphy of part of the upper continental slope of central Nova Scotia. Thirteen seismic lines shot in 1980 by Texaco are closely spaced (about 4 km), migrated, and oriented in a north-south direction. Two additional unmigrated stacked lines shot by Texaco in 1981 in an east-west direction were used to tie the reflectors. The area, covering about 1400 square kms, lies between latitudes 42° 34' to 42° 49' N and longitudes 62° 50' to 63° 30' W. Well logs and cuttings from the Petro-Canada and Texaco Albatross B-13 exploratory well were analyzed.

Five major sequences, defined by seismic unconformities, are present that reveal a general basinward shift and progradation of the paleoslope environment. At the base of the study interval, major unconformity E occurs at the top of the Abenaki platform. It can be traced basinward along the Jurassic(?) paleoslope by onlapping reflectors. It separates carbonates of the Abenaki Formation and their time-equivalents from dominantly clastic sediments above. The overlying Sequence 5 exhibits an updip onlap whose angle over unconformity E progressively increases up the paleoscope. The top of Sequence 5 is a strong seismic event, has considerable relief, and is interpreted as unconformity D.

Sequence 4 overlies unconformity D and exhibits a variety of onlapping seismic facies deposited at the shelf edge that imply Peter Vails's "low stand systems tract." The base of a possible paleoslope may contain a "front-slope-fill facies". Reflectors further upslope onlap the paleoslope at a moderate angle which decreases shoreward. A third facies above has continuous reflectors and blankets the area. The top is prominent erosional unconformity C, as indicated by truncated reflectors.

The seismic reflection configuration of Sequence 3 overlying unconformity C suggests Vail's "high stand systems tract." Its basal termination basinward is a low-angled downlap surface. Above unconformities B and C, Sequence 2 is composed of a variety of facies implying another "low stand systems tract." It is bounded above by unconformity A. Sequence 1, which may be Quaternary in age, is above unconformity A, is wedge-shaped, thins basinward, and has continuous reflectors that are divergent and onlap shoreward.

Petrography of Gneissic Xenoliths from the Popes Harbour Dyke, Nova Scotia: Fragments of the Basement to the Meguma Group

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Fragments of the probable basement to the Meguma Group occur as xenoliths in a lamprophyric dyke at Popes Harbour, Nova Scotia. The xenoliths comprise a heterogeneous assemblage of (meta)plutonic rocks and gneisses. The gneissic xenoliths comprise disequilibrium mineral assemblages which include relicts of an early, granulite facies event, and a younger, higher temperature overprint attributed to the lamprophyre. Most of the gneissic xenoliths are quartz-poor metapelites and garnet + orthopyroxene-bearing, quartzofeldspathic gneiss. Textural features suggest that the pre-dyke pelitic assemblage included poikiloblastic garnet, biotite, kyanite, oligoclase and quartz. Kyanite is largely replaced by sillimanite. Available data for mineral core compositions indicate metamorphic conditions of ca. 600°C (gt-bi and opx-gt thermometers) and 500-600 MPa (g-Al_2SiO_5-pl-aq and gt-opx-pl-qz barometers). The kyanite- and sillimanit-forming events are not clearly distinguished by these data. Features attributed to the thermal imprint of the dyke comprise texturally-overprinting assemblages including, in the pelites, sapphirine, spinel, corundum and/or rutile (all the anatectic (?) calcic, plagioclase and ternary feldspar rims). Calcic rims on plagioclase and pyrope-rich overgrowths on garnet characterize thermal metamorphism in both the pelites and quartzofeldspathic gneiss.

The polymict assemblage of xenoliths in the Popes Harbour dyke testifies to the heterogeneity of the basement to the Meguma Group.

Petrology and Geochemistry of the Jeffers Brook Dioritic Complex

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The Jeffers Brook dioritic complex occurs just north of the Cobequid fault. It outcrops in the upper portion of the main branch of Jeffers Brook, in a small section on Henry Brook and on scattered woods roads in between. It consists of gabbro, hornblende diorite (locally pegmatitic), quartz dioritic, tonalite and granodiorite, all cut by late-stage felsic pegmatites and aplites. A well-developed thermal aureole with biotite and amphibole surrounds the complex.

The more felsic phases of the pluton, and in particular the granodiorite, are very rich in mafic enclaves. The enclaves may represent either the solid residue from the source mantle or early crystallized phases, or alternatively they come from mingling of a mafic and a felsic magma. On the basis of their textural and petrographical characteristics, the two magma hypothesis is preferred.

The mafic rocks of the plutonic complex show chemical characteristics transitional between tholeiitic and alkali basalts and they are similar to the late dykes associated spatially with the volcanic centres of the Jeffers Group. The felsic rocks show many chemical characteristics ascribed to I-type granites and to volcanic-arc granites.

Early Palaeozoic Deep-Water Flysch Ichnocoenoses

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Traditional and currently-held views and models of Early Palaeozoic flysch trace fossil assemblages (ichnocoenoses) emphasize low diversities in comparison to their neritic counterparts. Such models predict between as few as 1-3 forms for Cambrian, 4-8 forms for Ordovician and 4-8 forms for Silurian flysch sequences. Such low diversities are equated to the gradual build-up and development of behavioural patterns through the Phanerozoic concomitant with the establishment of deep-water benthic epifaunal and infaunal taxa. Superimposed on this gradual build-up, according to the models, is a rapid diversity

increase at the start of the Mesozoic, which is generally equated to the coeval but rapid development of calcareous and foraminiferal oozes and, or, the growth of cellulosic debris that reached the ocean floor.

Over the last decade or so, several Early Palaeozoic flysch sequences have been examined with respect to their contained ichnofossils. These sequences comprise a wide range of interpreted deep-sea flysch environments and therefore, presumably, exhibited considerable variation in primary environmental parameters responsible for the distribution of their associated benthic organisms, as revealed by the preserved ichnotaxa. Four Early Palaeozoic flysch sequences from eastern Canada and their associated ichnotaxa are considered here: the Cambro-Ordovician Meguma Group of Nova Scotia (basin/fan/slope), and from New Brunswick, the Middle Ordovician-Early Silurian Matapedia Group (slope) and Grog Brook Group (?channel) and the Early Silurian Siegas Formation (canyon). These sequences contain (at the ichnogeneric rather than ichnospecific level, on which the models were based) relatively diverse ichnotaxa, respectively 18, 22, 16 and 18 ichnogenera. The trace fossil diversity of each of these sequences is therefore not in accord with existing models which suggests that such models should be regarded with caution and are in need of serious revision. It is likely that Early Palaeozoic deep-sea trace fossil diversity cannot be obtained simply by plotting totals for various flysch formations and that the real patterns are masked, amongst other things, by local environmental and preservational factors.

A Review of Recent New Evidence for an Extensive Late Wisconsinan Ice Advance on the Scotian Shelf

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Accelerator mass spectrometry radiocarbon dating of mollusc shells in glaciomarine sediments on the continental shelf and slope off Nova Scotia has provided new evidence for extensive Late Wisconsinan ice advance. Series of dates in cores that can be acoustically correlated increase systematically in age down section, providing confidence that the material dated has not been reworked or contaminated.

On the Scotian Slope in the Verrill Canyon area, work with D.C. Mosher has shown that glacial ice extended to the shelf break between 26 and 21 ka. In Emerald Basin, work with M. Gipp has shown that the top of the glacial till that underlies the entire basin dates from 17.5 to 18 ka, and the youngest till tongue dates from about 15 ka. Off St Pierre Bank, work with D. Bonifay shows that there was a glacial surge from the Avalon Peninsula, through Halibut Channel to the shelf break, at about 12 ka.

Although this new evidence indicates that Late Wisconsinan ice was more widespread than previously thought, the marine data also shows that the Early Wisconsinan ice advance was even more extensive.

Carboniferous Faulting, Deformation and Igneous Intrusion in the Western Cobequid Hills

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Igneous rocks of the western Cobequid Hills preserve a record of complex tectonic events of Devono-Carboniferous age. A series of granitoid plutons with minor gabbros are intruded just north of the Cobequid Fault. Rb/Sr isochrons yield ages of 340 to 356 Ma. These plutons appear intruded at a high structural level and show the geochemical character of within-plate (rift-related) granites.

Much of the Cape Chignecto pluton at the western end of the Cobequid Hills is moderately to highly mylonitically deformed with a foliation that generally dips gently north or south and an approximately north- or south-trending mineral lineation. Available kinematic indicators indicate a consistent northward sense of overthrusting. Similar moderate deformation occurs at the extreme southern margin of plutons west of the Cape Chignecto pluton and is characterised by an east-west trending mineral lineation. The North River and West Moose River plutons also have flat-lying, brittle thrust zones marked by mafic sills.

The Fountain Lake Group volcanics of the western Cobequid Hills yield similar isochron ages to the plutons; are similar geochemically; and nowhere are in intrusive or unconformable contact with the plutons. These volcanics are interpreted as extrusive equivalents of the plutons. They show only minor brittle deformation.

Sets of dykes, some composite mafic and felsic, intrude some of the plutons, and in some cases are deformed along with the host granite. These dykes are geochemically similar to the Fountain Lake volcanics. Dyke sets of similar composition cut Late Precambrian basement rocks near the Cobequid Fault and locally pass into sills. Most are undeformed, but locally are cut by small thrust faults or show mylonitic deformation. Dyke orientations are interpreted as related to motion on the Cobequid Fault. Locally, dyke complexes mark the filling of extensional pull-aparts along the Cobequid Fault.

The localization of rift-related plutons of Early Carboniferous age along the Cobequid Fault reflects a fundamental extensional environment, in which rapid rise of mafic magmas was also possible. The great extent of mafic plutons in the central Cobequids may reflect greater pull-apart, associated with the intersection of the Hollow and Cobequid Faults. Dyke sets are common only within a few kilometres of the Cobequid Fault. They and the plutons appear associated with the Fountain Lake volcanics. Local compression is indicated by the mylonitic deformation of the Cape Chignecto Pluton, and the abundance of small thrusts offsetting granitic sills.

Carboniferous to Triassic Fault-Styles and Sedimentation, Southern New Brunswick

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Mississippian to Triassic sediments exposed on the south coast of New Brunswick between Emerson Creek and St. Martins provide a detailed record, both of fault-movement on the margins of the Cumberland Basin, and resultant sedimentation. Windsor Group (Visean) marine limestone rests unconformably on Precambrian (Coldbrook Group) basalts and is unconformably overlain by coarse Hopewell Group (Namurian) conglomerates, deposited on SE-prograding alluvial fans sourced from the upfaulted basin margin. Coarse grey sandstones of the Boss Point Formation (Westphalian A) were deposited by relatively low-gradient ?meandering rivers flowing to the S and SE. Their relationship to the underlying Hopewell is unknown but suggest reduced topographic relief. Boss Point sandstones pass conformably up into red siltstones and sandstones of the Tynemouth Creek Formation. This formation coarsens upward into sandstones and conglomerates sourced from the SE. The Carboniferous strata were deformed into large-scale N-S to SW-NE trending recumbent folds that verge to the W, NW and SE. Folding was accompanied by thrusting towards the W and NW which locally emplaced Precambrian basalts over Boss Point and Tynemouth Creek strata. Depositional patterns changed radically in Late Westphalian A to B time when NW-directed thrusting began on the southern margin of the basin. NW-prograding alluvial fans (Tynemouth Creek Fmn.) were shed off the advancing thrust sheets, which eventually over-rode their own detritus. Following Late Pennsylvanian-Permian erosion, the area underwent major subsidence (possibly on reactivated normal faults on the northern margin of the basin) and thick alluvial sandstones and conglomerates were deposited during the Triassic. A post-Triassic extensional regime, related to Atlantic rifting resulted in normal faulting on at least one reactivated Carboniferous thrust fault.

A New Fission Track Dating Facility at Dalhousie University: Results from the Alberta Basin and Nova Scotian Margin

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Fission track dating is a relatively new geochronological method, the theoretical ground work for which was established in the 1960's. Recent advances including the use of known age standards, have established the technique on equal footing with other geochronological methods. Fission tracks are damage zones in crystals caused by the spontaneous fission of uranium-238, and are retained in minerals below a closure or annealing temperature range (70-120°C for apatite; 170-220°C for zircon). Apatite and zircon recovered from sedimentary and crystalline basement rocks have been found to be particularly useful in determining the amount and timing of unroofing.

The FTD facility was set up as part of a thesis project and is now funded by a 3-year NSERC grant. A workshop by Randy Parrish (GSC) in 1984 established our laboratory techniques, and we are now regularly producing apatite and zircon fission track dates.

In the Alberta Basin, samples were collected from Cretaceous Mannville, Viking and Belly River strata in wells along a transect from Edmonton to the foothills. Apatite fission track ages of 26 to 68 Ma are the result of the overprinting effects of differing depths of burial, hot migrating fluids and the timing of uplift throught the 100°C geotherm.

Apatite fission track dates from onshore Nova Scotia all indicate a major thermal event during the Triassic, with subsequent uplift and erosion. Results from the offshore Scotia Margin indicate good agreement with existing data on the thermal history from vitrinite reflectance, aromatization-isomerization, and bottom hole temperatures.

Petrography and Geochemistry of Anhydrite from the Pugwash Salt Mine, Pugwash, Nova Scotia

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Evaporites exposed in the workings of the Canadian Salt Co. mine at Pugwash Nova Scotia have been the subject of a number of studies, but only limited petrographic and geochemical work has been done on anhydrite from the deposit. Based on internal characteristics observed in both the mine workings and drill core, three anhydrite units are recognized macroscopically and have been informally termed the shaft, borate and third anhydrites.

The shaft anhydrite is characterized by the following textures: (1) microcrystalline, associated with minor blocky, felted, aligned-felted and lath shaped crystals; (2) nodular, showing displacive growth within carbonate and dolomite laminae; and (3) laminated, with alternations of carbonate and anhydrite. The shaft anhydrite has dark organic-rich laminae crosscut by veinlets filled with coarse, crystalline anhydrite.

The borate anhydrite exhibits three separate habits that do not show intimate association as in the shaft anhydrite. The habits are: (1) microcrystalline, (2) felted and (3) aligned-felted. Peculiar to the borate anhydrite is the arrangement of coarse, ragged laths of anhydrite in fibroradiate groups and the presence of small, round, opaque aggregates of danburite crystals is unique to this unit.

The third anhydrite is texturally similar to the borate anhydrite, exhibiting felted and aligned-felted textures. However, the third anhydrite does not contain borate nodules and possesses more consistent and well defined alignment of anhydrite laths within aligned-felted portions. The highly ordered alignment of anhydrite laths in this unit is very distinctive and has not been observed in the other two anhydrites. In contrast to the shaft and borate anhydrite units, where nodules are invariably surrounded by carbonate, nodular mosaic portions of the third anhydrite contain microcrystalline nodules surrounded or rimmed by aligned-felted anhydrite crystals.

Statisitical analysis of geochemical data shows that each unit exhibits distinct chemical characteristics. The shaft anhydrite is the most inhomogeneous, contains the highest concentrations of several trace and minor elements and has the highest carbonate content. The third anhydrite is the most homogeneous, with low concentrations of almost all elements and the highest gypsum content. The borate anhydrite is intermediate in composition but has the highest halite content.

The Weekend Dykes: A Newly-Recognized Dyke Swarm Cutting the Meguma Metasediments on the Eastern Shore of Nova Scotia

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A significant series of mafic dykes has been newly-recognized along the Eastern Shore of Nova Scotia from Halifax to Country Harbour. These dykes have appeared on individually published and unpublished maps over a period of 90 years, but have been largely ignored in favour of the Meguma metasediments and their entrained gold deposits; they have not been previously recognized as comprising a related series of dykes.

The generally vertical "Weekend Dykes" strike about 330° and show an abundance of hydrous mafic minerals, carbonate and apatite indicating an origin in an alkaline magma. They post-date the folding of the Meguma Group as well as the gold mineralization. They pre-date Carboniferous faulting in the Meguma. Abundant xenoliths of gneissic and probable pre-Meguma Group rocks are found in half the known dykes and these will be important to ascertaining the nature and age of the Meguma Terrane basement.

A platinum mineral occurrence appears to have been associated with one of the Weekend Dykes.

Deformation of the Stellarton Basin, Nova Scotia

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The Stellarton Basin of northern Nova Scotia comprises the Late Carboniferous clastic sedimentary and coal-bearing sequences of the Stellarton Group and is bounded by the eastern Cobequid and Hollow fault zones. Four equivalent deformation generations are recognized within the boundary fault zones. D_1 produced penetrative S_1 cleavage and both asymmetrical and en echelon folds, F_1. Localized S_2 axial planar fracture and crenulation cleavages were produced during D_2. D_3 formed pervasive Riedel shears, while D_4 generated tensional normal faults and fractures. All deformation generations record a transcurrent, dextral sense of fault movement. Within the basin, the geometry of secondary faults, right-step en echelon NE-SW trending folds and calculated principal stress orientations are also consistent with a dextral wrench faulting regime.

Mineralogical changes during cleavage development involve a progression from chlorite porphyroblasts to chlorite-muscovite stacks and finally muscovite grains. Both S_1 and S_2 cleavages are defined by the preferred orientation of muscovite grains. Intragranular deformation of the porphyroblasts and stacks significantly influences the initiation of cleavage, while pressure solution effects dissolution and precipitation of material along the incipient cleavage zones.

The quartz-chlorite-muscovite-biotite-calcite mineral assemblages indicate low-grade metamorphism within the boundary fault zones. A metamorphic maximum of approximately 400°C is achieved locally within the eastern Cobequid Fault, based on the first appearance of biotite. The boundary fault metamorphism is of distinctly higher grade than that within the basin, where vitrinite reflectivity of coals indicates basin temperatures between 200°C and 250°C.

*This presentation is abstracted from the M.Sc. thesis of R.X. Gao.

Cumberland Basin Stratigraphy: The Classic Joggins Section of Logan and Fletcher, and Windsor Group Correlation

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The Joggins shore section is located in the western part of the Cumberland Basin. It contains a superb, almost completely exposed cross-section through parts of the Minudie Anticline and the Athol Syncline extending 55 km from Mill Cove (Minudie) in the north to Squally Point in the south. The section is made up of over 5000 m of gently-dipping strata, ranging in age from Visean to Westphalian D, which are only locally disturbed by faults. Rocks of the Canso, Riversdale and Cumberland groups are well exposed in cliffs and wavecut platforms along the shore. The Canso Group strata can be divided into the red sandstones and siltstones of the Middleborough Formation and the grey sandstones and red shales of the Shepody Formation. The Riversdale Group is represented by the conglomeratic Claremont Formation and the overlying grey sandstone-dominated Boss Point Formation. The Boss Point Formation may in turn be subdivided into the Dogfish Reef, Boss Quarry, Bacon Ledge and North Reef members based on sand/silt ratios. The Cumberland Group is divided into the Joggins, Springhill, Ragged Reef and the Malagash formations. The Joggins Formation and the Springhill Formation constitute the fine grained strata that contain exploitable coal resources. The Ragged Reef Formation, although coal-bearing, is dominated by pebbly sandstones and fine conglomerates with only thin shale and coal interbeds. The Malagash Formation also contains significant coal beds, however it can be distinguished from other strata by the predominance of red coloration and age. Although not present in outcrop at Mill Cove, the Windsor Group (B Subzone) section is dominated by redbeds with at least three distinct marine carbonate units. These units are recognized and correlatable in outcrop over 60 km from Pugwash across the basin to Minudie. Younger Windsor Group carbonate members are apparently not widespread in the Cumberland Basin due to nondeposition or erosion. The carbonates may be facies equivalent to continental red beds analogous to equivalent rocks in southern New Brunswick where marine carbonates are rare and the section is dominated by continental red beds.

Sedimentation, Tectonics and Carboniferous Basin Evolution Adjacent to the Cobequid Highlands Massif, Northern Nova Scotia

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The Cumberland Basin and the northern part of the Minas Basin constitute part of the Maritimes Basin, the erosional remnant of a large Carboniferous Basin which covered much of Atlantic Canada. The Maritimes Basin is interpreted as a series of interrelated basins (horsts and basins?) which at various times underwent differing rates of subsidence and uplift. The Carboniferous strata adjacent to the Cobequid Highlands Massif comprise three packages which are interpreted to reflect major tectonic events with possible paleo-climatic influences. The three sedimentary allocycles are: (1) the Upper Devonian to Lower Namurian, Fountain Lake Group and Lower Canso Group; (2) the Upper Namurian to Westphalian A, Upper Canso Group and Riversdale Group; and (3) the Westphalian B to Lower Permian, Cumberland and Pictou groups. Each of the allocycles record an initial rapid basin subsidence and/or highland uplift, followed by a decelerating subsidence rate. The initial rapid subsidence (and/or uplift) resulted in deposition of fanglomerates at the basin margins which are succeeded by a transition to fluvial, lacustrine, and in one case a marine basin-fill. The later episodes of the basin infilling are recorded by laterally extensive blanket-like units which overstep the basin margins onto the basement rocks. The allocycles are interpreted as alternating periods of (1) strike-slip related subsidence in tilted fault wedge basins (subbasins) and (2) regional flexural subsidence occurring throughout the basin. This three cycle sequence does not appear to be consistent with a single pull-apart and subsequent thermal subsidence model proposed by various workers for the Maritimes Basin. Carboniferous-age wrenching along the suture zone between the Meguma Terrane and the Avalon Terrane was probably the driving force which resulted in the development of the allocycles within the adjacent basins.

Crustal Warping and Sediment Supply as Controls on Recent Coastal Development in Newfoundland

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Differential postglacial rebound has produced a wide range of Holocene relative sea-level (RSL) responses across Newfoundland, with profound effects on coastal evolution. Raised postglacial marine features are found throughout the island, except in the southeast, where submergence is though to have prevailed since the early Holocene, as suggested by published models invoking marginal forebulge collapse. The models imply a zonation from southeast to northwest, where isostatic uplift has resulted in ongoing emergence, at least until very recently. Evidence from the Strait of Belle Isle, including a raised beach-ridge sequence that terminates seaward in an active transgressive storm ridge, suggests that even in this area RSL may now be stationary or rising.

The pattern of Holocene RSL on the northeast coast is not well known. Recent evidence suggests that the wide beach-ridge plain at Doting Cove may be of considerable age: indurated and stained beach-ridge sand between -0.1 m and +2.3 m above present MWL is mantled by freshwater peat up to 2.8 m thick. No large onshore sediment supply is identifiable in this area, in contrast to the situation at many other large beach-ridge deposits on the island.

In St George's Bay where RSL has been rising from a mid-Holocene minimum, large amounts of glacigenic sand and gravel have been removed from 40 km of coastal exposures and transported northward to form a 15-km long spit complex at Flat Island. The oldest freshwater peats on this barrier date to 1.36 ka BP. In the southeast, at Placentia on the Avalon Peninsula, a large glacigenic source has provided the sediment source for the extensive gravel beach-ridge plain on which the town is constructed. The oldest basal peat here dates to 2.11 ka BP. In contrast, small barriers at a number of other sites on the Avalon, where glacigenic sources are more limited, show a pattern of earlier beach-ridge progradation followed by transgressive storm-ridge development involving reworking of the earlier barrier sediment. Both regressive and transgressive phases have occurred within the context of rising RSL and the change in the pattern of barrier development is believed to have been triggered by a decrease in sediment supply as erodible material along the shore was progressively depleted.

"Crack-Seal" Veins in Meguma Lode Gold Deposits: Hydraulic Fracturing or Replacement Phenomenon

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Auriferous quartz veins hosted by Lower Paleozoic turbiditic sediments of the Meguma Group have produced in excess of 1,000,000 oz. of gold from approximately 60 districts. Essentially all of this production has come from shallow development (<300 metres) between 1860-1940 using antiquated mining techniques.

Numerous vein types occurring at all gold deposits exhibit differing morphology, texture, mineralogy and relative age which, in many areas, can be related to the variability of local wall-rock texture and composition. Most veins display complex, composite textures which suggest episodic fluid emplacement along structurally favorable dilatant zones. Of these, the most problematic of the vein types, in terms of genesis, are the "crack-seal" or "laminated" quartz veins which carried much of the recovered historical gold. Recently, separate studies have suggested several distinct mechanisms for their origin, including:(i) syn-sedimentary siliceous oozes; (ii) pre-fold, hydraulic fracture filling induced by high pore-fluid pressure and (iii) variable wall-rock replacement. The absence of any convincing evidence of syn-sedimentary vein formation severely limits the first theory, while relative structural age relationships suggesting that stratigraphy was locally upright prior to initial vein formation raises problems with regards to the second hypothesis.

Underground geological mapping of the Beaver Dam gold deposit suggests that relatively constant stratigraphic thickness is maintained regardless of the amount of vein material present. In some greywacke beds, irregular granular-textured quartz veins are formed by wall-rock replacement representing the end products of extreme silicification. In slate lithologies, vein textures are generally dominated by either massive, crystalline white quartz, "crack-seal" laminated type quartz or a combination thereof. It is not uncommon to observe replacement veins in greywacke interconnecting with "crack-seal" type veins in adjacent slate beds, but in such cases relative age relationships become obscured. Because no significant thickening in the stratigraphy occurs in areas of quartz veining, we conclude that "crack-seal" type veins are formed in part or in whole by selective wall-rock replacement. Petrographic studies of these vein types lend corroborating evidence and indicate that the fine, dark laminae typical of these veins are stylolitic in nature. As the model proposed herein predicts, the laminae in the "crack-seal" veins represent the most insoluble wall-rock residue.

Events of the Late Wisconsinan-Holocene Transition in Nova Scotia

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Deglaciation is recorded in Nova Scotia by deltaic glaciofluvial and glaciomarine sediments. Shell dates on bottom-set beds of a delta at Spencers Island range from 14,300 - 12,600 yr B.P. The Spencers Island delta records a prominent ice marginal stand. A second ice margin was present on the lowlands north of the Minas Basin. It is marked by ice contact stratified drift, a series of lakes, pinch-out of a distinctive till sheet, and a terminal moraine in a valley a few km north of the Parrsboro outwash delta. The margin has not yet been directly dated, but the age is estimated to be between 12,500 yr B.P. and 10,000 yr B.P.

The age of complete deglaciation of Nova Scotia is still unknown. Peat beds were deposited during an interval, dated at 11,800 yr B.P. to 10,500 yr B.P. Pollen in these peat beds record the migration of spruce into the region indicating climatic warming, and a subsequent deterioration of climate recorded by the return of tundra-like flora. The peat beds are overlain by a variety of deposits including fluvial gravel and sand, lacustrine sand, silt and clay, and till-like diamictons. At Collins Pond, on the shore of Chedabucto Bay, a diamicton overlying the peat bed is characterized by strong fabrics parallel to the trend of ice flow landforms in the region. The evidence suggests that at least some of these deposits are glacigenic, indicating that glaciers were active in Nova Scotia until 10,000 yr B.P.

Energy and Shock Effect of a Recent Meteor Impact, South Mountain, Nova Scotia

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An oval feature measuring 350 meters by 420 meters on the granite of the South Mountain Batholith is identified as a meteor impact doublet of probable postglacial age. It is designated "ASTRID," the acronym of its file designation. The crater is characterised by a flat, depressed inner floor sharply ringed by a discontinuous low bedrock wall, and a broad upwarped welt external to the rim. The composite feature is situated within a broader fen flanked by wooded hills along sharp linear boundaries. Both the fen and the crater interior are blanketed with holocene fluvio-lacustrine sediments. Microscopic study of

specimens taken from the rim wall reveals diaplectic shock reduction of orthoclase lattices (Maskelynite), induction of gridiron twinning, and pervasive systematic fresh microfractures, microfaults, polygonization and lattice distortion of all minerals. Impact melt is indicated by a thin veinlet of glass in one specimen. Biotite kink-bands and quartz Boehm lamellae are rare, and shatter cones have not yet been found. Data from analysis of nuclear explosion craters and from lunar and terrestrial impact craters indicate that the ASTRID feature was caused by the simultaneous impacts of two objects (bolide fragments?) 105 meters apart, resulting in the oval doublet rim shape. Energy scaling laws indicate that each object was about 760 tonnes mass, 7 meters diameter (if Fe-Ni), and that each carried as much as 92_{TNT} kilotons (3.86×10^{21} ergs) energy equivalent.

The ASTRID site is flooded and frozen at present, making possible the current magnetometer survey on the ice. This data is expected to reveal the extent of shock remagnetization. Microscopic and X-ray diffraction studies of the shocked granite continue, and seismic, coring, and downstream sedimentologic projects are planned.

Application of Interactive Automated Image Analysis and Electron Microprobe Analysis to Geological Materials

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In August 1986 a JEOL 733 microprobe was installed at RPC. The microprobe was completely interfaced to a Kontron SEM/IPS automated image analyzer (AIA). The microprobe which is completely automated has four wavelength spectrometers, (WDS) and a Tracor-Northern energy dispersive spectrometer (EDS).

The unique feature of this system is the complete interfacing of the image analysis system with the microprobe. This configuration allows for images and spectral data produced by the electron microprobe to be acquired and processed by the image analysis system. The AIA can control the EDS operation, image acquisitions, X-ray mapping and stage position.

Most minerals can be distinguished from one another by their relative brights in a backscattered electron image (BEI). The AIA which discriminates phases according to their brightness (grey level) can classify a BEI of a polished thin section or grain mount into various mineral phases. Once this is accomplished various measurements can be made for each phase. For example: area, size, shape, orientation and liberation.

In some cases minerals have the same brightness in the BEI and they must be analyzed by either X-ray mapping of the entire field or by EDS analysis of individual particles. The spectral data can be combined with the image so that individual phases can be classified and their physical characteristics measured.

Low magnification images can be produced by storing adjacent images and putting them together as a mosaic. This is particularly useful when working with coarse-grained material such as potash ore.

This system has been used to determine the grain size distribution and liberation of mill products from several types of mines the modal analysis of ore and rock samples, and to search for gold in mill products and rock samples.

Several examples will be displayed at the poster session.

Preliminary Results of Bromine Distribution and Partitioning in Salt Deposits at Sussex, New Brunswick

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Barren zones or salt horses are areas within the potash ore that are predominantly halite. The barren zones vary in size, location and extent. Underground mapping carried out by the mines has indicated that they are formed by a replacement mechanism after deposition of the sylvinite beds. From a mining point of view, it is important to be able to predict and map these areas. Therefore, a knowledge of the genesis of the barren zones would greatly aid in the endeavor.

In April 1985, a study of the potash deposits was started under funding from the New Brunswick-Canada Mineral Development Agreement. During this program samples of the barren zone were collected from both of the potash mines in the Sussex area. The most consistent and unique feature observed was the Br concentration in the samples of the barren zones as compared to samples of ore and stratigraphic halite (halite which is part of the stratigraphic sequence as opposed to halite in the barren zones).

In the ore the concentration of Br increases with K to a maximum of 1200 ppm. The Br concentration in the stratigraphic halite is less than 150 ppm and in the barren zones is between 160 and 300 ppm. This indicates that the barren zones were formed by a different mechanism than that which formed the stratigraphic halite. After these data were compiled it was decided to analyze the minerals for Br by electron microprobe to determine partitioning of Br between halite and sylvite. This data will be compared to published models of Br partitioning in salt systems. The preliminary data supports the initial findings. The microprobe analysis is continuing and only the preliminary results will be presented.

Deep Crustal Structure and Plate Tectonic Development of the Canadian Appalachians: Insights From Marine Deep Seismic Reflection Profiling

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Approximately 1600 km of marine deep seismic reflection data, gathered northeast of Newfoundland in 1984 and within the Gulf of St. Lawrence and Cabot Strait in 1986, have provided remarkable insights into the deep crustal structure underlying the familiar tectonostratigraphic zones of the Canadian Appalachians. These new data, coupled with recent geologic interpretations, encourage a re-examination of simple models of the plate tectonic evolution of the orogen.

The seismic data, which sample the crust and upper mantle to depths of the order of 50 to 60 km, demonstrate the existence of at least three discrete, lower crustal blocks which underlie the five well-known tectonostratigraphic zones. The western block is the North American craton that formed the western margin of the Iapetus Ocean; it underlies the Anticosti basin, the Humber Zone, and the western portion of the Dunnage Zone. The central block, inferred to be the eastern margin of the Iapetus Ocean, underlies the eastern portion of the Dunnage Zone and the Gander Zone. The eastern block underlies the Avalon Zone and possibly the Meguma Zone. The zone boundaries defined on the surface are not underlain by analogous mid- to lower crustal structures, except in the case of the boundary between the Avalon and Gander zones (represented by the Dover and Hermitage Bay strike-slip faults in Newfoundland). Rather, the data suggest that much of the orogen is allochthonous with respect to the lower crust.

These observed and inferred upper crustal to lower crustal relationships are remarkably consistent from one seismic line to another, over along-strike distances of up to 500 km. This internal consistency enables us to interpolate between lines and to infer the three-dimensional configurations of the lower crustal blocks, based on isolated, two-dimensional seismic observations. For example, these data strongly support long-standing suspicions that the ancient, Iapetan rifted-margin of the North American craton is mimicked by the St. Lawrence promontory and the Quebec reentrant of the Appalachian orogen.

By treating the lower crustal blocks as semi-rigid "plates," we can palinspastically restore their relative motion along selected major fault systems. Specifically, we examine the implications of restoring motion on major Carboniferous faults which were linked through the Magdalen Basin, and on a major hypothesized fault zone, believed to have been active primarily during the Acadian orogeny, which lies orthogonal to the regional trend of the Appalachians and separates Cape Breton Island from the mainland. These reconstructions also have important implications for the emplacement of the Meguma Zone.

Syn-late Metamorphic Fluid Focussing in the Formation of Turbidite Hosted Gold-Quartz Veins in the Archean Yellowknife Basin, Slave Province, N.W.T.; A Meguma Analogue?

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Structural mapping of the Gordon Lake 'refold,' within the Burwash metaturbidite formation of the Yellowknife Supercrustal Basin, has delineated at least three deformational events (D1, D3, and D4) and four veining episodes. Early upright isoclinal folds (F1) are transected by a regional N-W trending cleavage (S3). This cleavage has a strong vertical stretch lineation (L3) which is syn-metamorphic, and is probably related to granite emplacement tectonics. The S3 cleavage and a crenulation cleavage (S4) are spatially related to the development of the 'refold.'

Based on past and present mining activities gold mineralization in the Burwash formation appears preferentially distributed in lower-greenschist-grade terranes. In the Gordon Lake region gold is associated with the syn- to post-D3 veins. Bedding-parallel veins formed early in the deformational history and are folded by the D1 and D3 events. Syn-D3 veins display brittle fracture characteristics in the wackes, but are more abundant in the siltstones where they formed parallel to S3. Late-D3 horizontal veins cut the L3 lineation and are probably related to late extension parallel the vertical stretch. Syn-D4 veins lie parallel to the S4 crenulation cleavage. Concentration of late veining occurs within regions of crenulation in the core of the 'refold,' resulting in quartz brecciation zones.

The Meguma Terrane of Nova Scotia and its gold-bearing quartz veins represent a similar, but younger, geological setting of metaturbidites intruded by granites. A protracted history of folding and veining has resulted in the formation of spatially superimposed early bedding-parallel, late sub-parallel and discordant quartz veins. These veins have a similar mineralogy, and preference for lower grade greenschist environments. The most recent Nova Scotian mining activities have been concerned with these later sub-parallel veins that are associated with late fold

limb shearing and localized along anticlines, some of which are overturned.

In both metasedimentary environments the late vein concentration is dependent on the availability of late metamorphic fluids, the presence of lithological contrasts and earlier formed rock anisotropies, and focussing by a late structural event.

Lead Isotope Studies of Volcanogenic Sulphides: Applications to Paleotectonic Interpretations of the Newfoundland Dunnage Zone

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Lead isotope data from 25 volcanogenic sulphide deposits in the Newfoundland Dunnage Zone define three distinct fields on conventional lead isotope diagrams: (1) a field of relatively radiogenic lead representing Llanvirnian-Llandeilian island arc-related deposits of the Exploits Zone; (2) a field of slightly less radiogenic lead representing Cambrian island-arc deposits of the Exploits Zone; and (3) a field of non-radiogenic lead representing Tremadocian to Arenigian island arc and ophiolitic deposits of the Notre Dame Zone. There is no overlap between the fields and they are readily interpreted in terms of the recently-proposed tectonostratigraphic subdivision of the Dunnage Zone.

Lead in the Cambrian arc deposits, the oldest known volcanogenic sulphide deposits in the Dunnage Zone, plots in a tight field on or near the crustal growth curves of theoretical multi-stage lead models. Lead from the Llanvirnian-Llandeilian arc sequences plots in a steep linear trend, the base of which is near the Cambrian deposit field. This trend is interpreted as a mixing line between the Cambrian arc-deposit lead and lead from a more radiogenic source, perhaps continental crust which lay to the south and east of the Hermitage Flexure. The Cambrian arc sequences may, therefore, have been basement to the younger arc activity. Lead in the Notre Dame Zone deposits is markedly less radiogenic, possibly reflecting a predominant mantle contribution and/or lead from very non-radiogenic crustal sources (perhaps the Grenville Orogen).

The clear contrast in the lead isotope composition of volcanogenic sulphides in the Exploits and Notre Dame zones respectively, supports the concept of a fundamental structural break between them. The arc magmatism in the two zones apparently occurred in very different tectonostratigraphic settings. It is tentatively suggested that the Notre Dame Zone represents the "traditional" central Newfoundland island arc/back arc system related to the widely - postulated, east-dipping subduction zone. Sequences in the Exploits Zone represent a different, although in part coeval, tectonostratigraphic environment, and perhaps a completely different subduction system. The two may have been unrelated in space prior to their juxtaposition in the Mid- to Late-Ordovician.

Lead in deposits on the Burlington Peninsula and New World Island (i.e., the north and northeast extremities of the Notre Dame Zone) is more radiogenic than in the rest of the Zone, suggesting that further subdivision may be necessary.

Timing of Sulphide Mineralization, Faribault Brook Area, Western Cape Breton Highlands

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Two sulphide associations, distinguished on the basis of mineralogy, style, and timing relative to metamorphism, are recognized in the vicinity of Faribault Brook near Cheticamp, Cape Breton Island. Early polymetallic Zn-Cu-Pb mineralization is associated with felsic volcanogenic metasedimentary rocks of probable Silurian age. Metamorphic textures indicate that galena, sphalerite, chalcopyrite, and pyrite were present prior to Late Silurian - Early Devonian regional metamorphism, and were probably deposited during or soon after their host rocks. Later arsenopyrite-pyrite-chalcopyrite mineralization overprints the polymetallic style. This arsenopyrite-dominated association occurs disseminated with rare, deformed felsic intrusions, disseminated in felsic metasediments, and as disseminated grains and in veins hosted by biotite- and chlorite-rich shear zones in metabasites. Arsenopyrite commonly forms post-foliation porphyroblasts, and is rarely found as inclusions in garnet, although it is intergrown with garnet rims in some localities. These textures suggest that the arsenopyrite-dominated association formed during the later stages of Late Silurian-Early Devonian regional metamorphism. The pattern of mineralization is complicated by mobilization and deformation of earlier-formed sulphides during post-metamorphic deformation. The abundance of arsenopyrite-bearing shear zones near the metabasite-metasediment contact, and the close association of arsenopyrite and gold, suggest that a structural analysis of this transition zone would be useful for future mineral exploration.

The Devono-Carboniferous and Carboniferous Plutons of the Eastern Cobequid Highlands

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The Folly Lake and Economy River plutons of probable Devono-Carboniferous age are complexes of mostly early fine- to coarse-grained gabbro intruded by porphyritic and equigranular diorite. The Folly Lake pluton is intruded by the Hart Lake-Byers Lake pluton. The latter pluton together with Pleasant Hills pluton are the youngest plutons in the eastern Cobequid Hills, previously radiometrically dated as Early Carboniferous. These plutons are principally granites, they have chilled margins hundreds of metres thick consisting of porphyritic and/or equigranular granophyric granite and are cut by late pegmatitic veins, many of which are mineralized with magnetite, chalcopyrite, pyrite, tourmaline and siderite.

The Folly Lake and Economy River plutons consist of gabbro, diorite and granodiorite. The gabbros have a subophitic texture produced by large crystals of augite and prismatic feldspars. They also contain hornblende, biotite, actinolite, sphene, opaques, apatite, zircon and penninite. The diorites are porphyritic and equigranular. They consist of plagioclase, hornblende, opaques, minor amounts of quartz, alkali feldspar, apatite, epidote, zircon and sphene. The granodiorites resemble the diorites and their distinction is made on the basis of the ratio of plagioclase to quartz and alkali-feldspar.

The main phase in the Pleasant Hills pluton is a porphyritic granite with a microcrystalline, generally granophyric, groundmass and phenocrysts of perthite, quartz, plagioclase and biotite. The main phases in the Hart Lake-Byers Lake pluton are: (1) a fine- to medium-grained pink granite with a granitic or graphic texture, consisting of alkali feldspars, quartz, plagioclase, biotite, hornblende and rare riebeckite; and (2) a coarse-grained, leucocratic, pink granite with < 5% ferromagnesian minerals. Modally, these granites fall in the "granite" and "alkali feldspar granite" fields of the IUGS classification. Their differences in textures and mineralogy reflect differences in their local crystallisation and subsolidus histories.

A New Look at the Structural History of the Silurian Chaleurs Group in Northern New Brunswick: Evidence for a Complex Polyphase Deformation History and Dextral Shear Associated with F_3 folding

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The Silurian rocks that are exposed north of Bathurst were previously considered to contain only one generation of structures. These structures include km-scale, upright, fairly symmetrical folds and a cleavage that generally transects the folds. In fact these Silurian rocks define one of the type localities of transecting cleavage. An angular unconformity was interpreted to be present between the Silurian and Ordovician rocks on the basis of their contrast in structural history.

Detailed structural analysis of the Silurian rocks near Limestone Point and Nigadoo revealed the presence of a more complex deformation history than previously assumed, comparable to the one in the Ordovician. The large, upright structures that dominate the Silurian rocks refold locally rare, small scale, isoclinal folds (F_1), and are therefore labelled as F_2. Some of the large F_2 folds are downward facing, indicating the possible existence of large F_1 structures.

The origin of the earlier F_1 folds is still enigmatic although they fold thin, coral-rich limestone layers, which suggest deformation after lithification of the rocks rather than a soft sediment origin.

The regional cleavage in the Silurian rocks commonly crosscuts both limbs of F_2 folds. This transecting cleavage is locally axial planar to mesoscale folds, which have a consistent Z-asymmetry irrespective of the F_2 limb they occur on. These overprinting relationships indicate that the transecting cleavage and associated Z-folds represent a younger generation of structures (F_3) rather than being coeval with F_2, as has previously been suggested. The rare presence of an S_2 axial plane cleavage crosscut by S_3 also support such an interpretation. The S_3 and older structures are locally overprinted by north trending F_4 kink-bands and an associated S_4 fracture cleavage.

The S_3 cleavage in the Silurian rocks is statistically coplanar with S_3 in the adjacent Ordovician rocks. At the northernmost tip of Limestone Point, where Silurian calcareous sandstones can be seen to conformably rest on Ordovician siltstones at low tide, S_3 passes without significant refraction from Ordovician into Silurian rocks. Going from north to south across the 5 km wide belt of Silurian rocks north of Bathurst the trend of S_3 changes gradually from northeast to east-northeast in a clockwise fashion then turns back to the northeast in an anticlockwise fashion. The apparent sense of rotation of S_3 is the expected behaviour of a passive marker in a transcurrent, dextral shear zone. Strong dextral refraction of S_3 on a small scale, shallow-plunging extension lineations, NW-SE trending Riedel shears (R^1), the Z-

asymmetry of F_3 folds and the consistent anticlockwise orientation of S_3 with respect to the ENE-WSW trend of the Silurian rocks in combination also indicate a dextral sense of shear, approximately parallel to the boundaries of the ENE-WSW trending belt of Silurian rocks. This narrow, approximately 5 km-wide belt of Silurian Chaleurs Group sediments is therefore interpreted as the site of a dominantly transcurrent dextral shear zone during the F_3-related deformation.

Contrasting Thermal Histories Across a Portion of the Norumbega Fault Zone, Southwestern Maine: Evidence From $^{40}Ar/^{39}Ar$ Mineral Ages

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The Norumbega Fault Zone (NFZ) consists of a series of high-angle, NE trending subparallel faults extending across eastern and southern Maine and into New Hampshire. To the northeast it correlates with the Fredericton Fault in New Brunswick and to the southwest it may be related to the Clinton-Newbury/Lake Char Fault system in Massachusetts.

The NFZ is widest in southwestern Maine where several faults displace the metamorphosed Late Precambrian (?) to Early Ordovician (?) volcanic and volcaniclastic sedimentary rocks of the Casco Bay Group. The most significant of these faults appears to be the Flying Point Fault (FPF). The FPF divides the Casco Bay Group into two distinct lithotectonic packages. The high-grade migmatized Falmouth-Brunswick (FB) sequence lies to the northwest and the lower grade unmigmatized Saco-Harpswell (SH) sequence lies to the southeast of the fault.

Over 25 hornblendes from amphibolites were dated using the $^{40}Ar/^{39}Ar$ incremental heating method. These samples are from a 120 km long NE trending transect which is bisected by the FPF. In the FB sequence plateau ages show a systematic decrease from 367-377 Ma in the NE to 270-290 Ma in the SW. Several samples from the middle portion of the transect have intermediate ages (325-350 Ma) and disturbed release spectra, suggesting ^{40}Ar loss. In the SH sequence no strong spatial pattern is recognized for hornblende ages (324-368 Ma).

The time-temperature histories of rocks exposed on either side of the FPF differ substantially. Numerous hornblende samples west of the fault did not close to ^{40}Ar loss until about 285 Ma ago whereas all hornblendes east of the FPF had closed to ^{40}Ar loss by 324 Ma. Plateau ages of hornblendes collected on opposite sides of the FPF (less than 10 km apart) show differences of up to 65 Ma. This suggests that the time-temperature histories of the two sequences were distinctly different until at least Early Permian time.

Possible explanations for the contrasting thermal histories are: (1) a discrete Late Paleozoic metamorphism which only affected rocks northwest of the FPF, (2) juxtaposition of the two sequences by strike-slip faulting subsequent to 280 Ma ago, (3) juxtaposition of the two sequences by dip-slip faulting less than 280 Ma.

Microstructures From Potassium Feldspar Rocks, Hemlo, Ontario

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Samples from two K-feldspar-rich units associated with the Hemlo, Ontario gold deposit have been examined by transmission electron microscopy. In hand specimen, unit M1 is a clean, white K-feldspar, vanadian mica schist, while unit M2 has a classically altered appearance, with red K-feldspar plus quartz, chlorite, calcite and sphene. The present state of these rocks has been interpreted by several workers to result from potassium metasomatism contemporaneous with the formation of the ore deposit. TEM shows that the feldspar occurs as twinned and untwinned regions, often in the absence of optically visible twins. There is a transition from a heterogeneous, low density twin texture in larger grains to more homogeneous twinning, involving larger crystal volumes, in the recrystallized matrix grains. Early stages of this progression involve transformation of Pericline twins to Albite twins. Untwinned, as well as twinned, regions are triclinic (C1) and electron diffraction indicates that twinning occurred solely in the triclinic state and not during the monoclinic to triclinic transition. In contrast to the twinned regions, untwinned feldspar has high densities of voids (fluid inclusions), free dislocations and dislocation networks. Collectively, the TEM microstructures suggest formation and deformation of untwinned K-feldspar during potassium metasomatism, with progressive transformation to twinned microcline. Crystallography of the feldspars requires that feldspathizing fluids have temperatures less than the monoclinic-triclinic transition temperature. This would favour ore formation during a post-peak-metamorphic deformation event.

Geochemistry and Tectonic Significance of Siluro-Devonian Mafic Volcanic Rocks in the Chaleur and Tobique Zones, New Brunswick

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Representative samples of Siluro-Devonian mafic volcanic rocks from five areas within the Tobique and Chaleur zones of the Matapedia Cover Sequence in northwestern New Brunswick have been analyzed for major and trace element content. Submarine mafic volcanic rocks, interbedded with marine sedimentary and (predominantly) subaerial felsic volcanic rocks, were erupted on inferred continental crust of the Miramichi Terrane. In the Tobique Zone, subalkalic basalts and andesites from the Wapske-Odell, Stickney and Millville areas show close chemical similarities and calc-alkaline affinities, whereas basalts from the New Denmark area are somewhat less evolved and show a weak iron-enrichment trend. In the Chaleur Zone, Silurian and Lower Devonian calc-alkaline suites include subalkalic (and locally alkalic) basalts and andesites with major- and trace-element chemistry similar to mafic volcanic rocks of the Tobique Zone.

Immobile trace element data, plotted on discrimination diagrams, commonly used to define tectonic setting, are consistent with an orogenic (volcanic-arc) environment, and MORB-normalized trace-element variations show close similarities with active, continental margin, orogenic basalt patterns. High values of the incompatible elements K, Rb, Ba, and Th are typical of orogenic, i.e., subduction-related basalts of both oceanic and continental settings. The observed enrichment in Nb, Zr, P, and particularly Ti closely parallels that documented in active, continental margin, volcanic provinces such as Chile or the western United States. Cr and Ni values are relatively high in the Tobique Zone compared to typical orogenic basalts, and may be due to (1) the absence of extensive fractionation suggested by average Mg* values for the various suites, ranging from 56 to 62; or (2) to high levels of these elements in the parent magma.

Partial melting of enriched, subcrustal lithosphere has been proposed as the source for the high values of Zr, Ti, P and Nb in continental margin, mafic volcanic rocks, whereas K, Rb, Ba and Th enrichment during subduction of oceanic crust or to contamination by continental crust. These processes can be interpreted to have played a role in the genesis of orogenic calc-alkaline volcanic rocks in the Tobique and Chaleur zones.

Northwestward subduction of decoupled subcontinental lithosphere during Acadian continental collision is suggested as a possible mechanism for generating the observed geochemical signatures.

Late Carboniferous Development of the Stellarton Graben, Nova Scotia: Variation and Significance of Syn-tectonic Sedimentation Styles

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Stellarton Graben, which contains the Late Westphalian Pictou Coalfield, lies between the Cobequid and Antigonish Highlands in northern Nova Scotia. It is bounded by the eastern Cobequid and Hollow faults. Detailed structural analysis shows that Late Westphalian movement on these faults was dextral. Facies changes and coarsening of clastics toward the faults, and localization of conglomerates adjacent to them, indicates that they were a major control of Late Carboniferous sedimentation.

Before graben formation, conglomerates and sandstones of the Westphalian B Cumberland Group were shed northerly, away from the eastern Cobequid-Hollow fault system as alluvial fan deposits. Within the graben, grey and red lacustrine and deltaic shales and sandstones, with oil shales and economic coals of the Westphalian C-D Stellarton Formation were deposited disconformably on Cumberland and unconformably on older strata. The Stellarton Formation contrasts with the grey and red fluvial sandstones and shales of the Merigomish Formation (Pictou Group), deposited at the same time north of the graben. Predominance of fine-grained clastics, except near the graben margins, indicates that graben subsidence was gradual, with relatively little relief developed. Three cycles of basin subsidence and infill recognized in the Stellarton Formation suggest three syn-sedimentary pulses of faulting.

Comparison of coalification curves for the Stellarton and Merigomish coals corroborates observations of anomalously high heat flow within the graben. This accounts for the high rank of the lower Stellarton coals, compared to other northern Appalachian coals.

Stellarton Graben is the youngest of an array of pull-apart graben within the Maritimes Carboniferous Basin, the Hercynian successor basin complex of the northern Appalachians. These graben developed along E- and NE-trending strike-slip faults in response to regional SE-NW compression as the West African craton collided with eastern North America during the Alleghanian-Hercynian Orogeny. The end of subsidence in Stellarton Graben signals the end of this orogeny in the Canadian Appalachians.