ATLANTIC GEOSCIENCE SOCIETY

ABSTRACTS

1992 SYMPOSIUM
"DEVONO-CARBONIFEROUS MAGMATISM, DEFORMATION, METAMORPHISM, AND RELATED MINERALIZATION IN THE ATLANTIC PROVINCES"

1992 COLLOQUIUM
"CURRENT RESEARCH IN THE ATLANTIC PROVINCES"

FREDERICTON, NEW BRUNSWICK

The 1992 Symposium and Colloquium of the Atlantic Geoscience Society were held at the Fredericton Motor Inn, Fredericton, New Brunswick on January 31 and February 1, 1992. On behalf of the Society we thank L.R. Fyffe of the New Brunswick Department of Natural Resources, R.K. Pickerill of the University of New Brunswick, and all others involved in the organization of this excellent meeting.

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

The Editors

ATLANTIC GEOLOGY
28,193-212 (1992)

0843-5561/92/020193-20$4.00/0

Meguma Terrane in southern Cape Breton Island?

S.M. Barr, C.E. White
Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0, Canada
and
M. Graves
Cuesta Research Limited, 154 Victoria Road, Dartmouth, Nova Scotia B3A 1V8, Canada

Fault-bounded slivers of variably deformed to mylonitic amphibolite, garnet schist, and granite occur on Isle Madame, Petit-de-Grat Island, and Green Island in southernmost Cape Breton Island. Although the amphibolite on Green Island was previously recognized, the outcrops on the other islands were considered to be mainly volcanic rocks and were included in the late Precambrian Fourchu Group of southeastern Cape Breton Island. New mapping and petrographic work show that these outcrops are mainly amphibolite-facies rocks that commonly display mylonitic textures with highly variable foliations and stretching lineations trending east or west with moderate plunges. Like the amphibolites on Green Island, they are characterized by a distinctive pleochroic blue-green amphibole; some layers also contain abundant garnet and/or muscovite, and muscovite-bearing granitic sheets and dykes. They are similar to some amphibolitic and gneissic units preserved in faulted slivers in the Melrose area, south of the Minas Geofracture in the Meguma Terrane, suggesting an affinity between the Isle Madame area and the Meguma Terrane. This interpretation is also supported by a published Devonian $^{40}Ar/^{39}Ar$ (hornblende) date from amphibolite on Green Island. Devono-Carboniferous(?) granite on Petit-de-Grat Island and Isle Madame has within-plate (A-type) characteristics. The metamorphic and granite rocks are also similar to mylonitic metasedimentary rocks and granites exposed farther north along the Strait of Canso at Porcupine Mountain. Interpretation of the Isle Madame-Strait of Canso area places constraints on tectonic models correlating Cape Breton Island and the remainder of the northern Appalachian Orogen.

Coastal zone mapping in New Brunswick

D. Bérubé and J.J. Thibault
New Brunswick Department of Natural Resources and Energy, Mineral Development Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

In the early 1970's, the Mineral Resources Division of the New Brunswick Department of Natural Resources and Energy undertook a coastal zone management study of the eastern coast of the Province (Airphoto Analysis Consultants Limited, 1975). This study provided abundant geoscientific data some of which was used to change legislation and control extraction of material from marine beaches. A similar but more detailed survey of the Fundy coast was done for the Department (Hunter and Associates, 1982).

In 1990, a 1:10 000 coastal zone mapping program was initiated by the Division. The objective of the program is to map the geomorphological and sedimentological aspects of the terrain located between the normal low water and the higher high water. Through an emphasis on fieldwork, the program aims to update and refine the present information base and lead to a better understanding of the physical processes responsible for the evolution of the coast.

The work plan also includes the analysis of recent and selected historical aerial photographs, the preparation and maintenance of an extensive annotated collection of slides and photographs describing coastal processes and features, and the preparation of technical reports designed to help interpret and enrich the map product.

Work has begun at the New Brunswick/Nova Scotia border on the Northumberland Strait shoreline and is proceeding northerly toward the Bay of Chaleur. The eventual goal is to integrate the coastal terrain information into a CARIS-based coastal zone geographic information system based on the LRIS 1:10 000 digital map series.

Geology of a mineralized belt along the southeastern contact aureole of the Pokiok Batholith

A. Caron
Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 1519, Sussex, New Brunswick E0E 1P0, Canada

The Pokiok Batholith lies at the boundary of the Miramichi Terrane and the Fredericton Cover Sequence in southwestern New Brunswick. The present investigation is confined to a mineralized belt along the southeastern contact of the intrusion. This entire belt lies within turbidites of the Fredericton Cover Sequence. The Lake George Antimony-Gold Deposit is the largest known deposit in the area.

The turbidites of the Fredericton Cover Sequence are composed of medium- to thick-bedded, medium to dark grey calcareous greywacke intercalated with thin beds of black

slates. The outer contact aureole is reddish brown due to the presence of biotite. The inner contact aureole is also reddish brown and is characterized by biotite and micaceous aggregates replacing andalusite and/or cordierite. The most calcareous turbidite beds in the contact aureole have been replaced by skarn and are more common within the andalusite and/or cordierite isograd.

On the southwestern side of the Saint John River, the turbidites are deformed by open folds with interlimb angles of 80° to 90° that plunge either to the north or south. The cleavage strikes approximately north-south, dips steeply either to the east or west, and appears to transect the axial surfaces of the mesoscopic folds at a small angle. The main cleavage on the northeastern side of the Saint John River strikes more northeasterly and, locally, is overprinted by a second cleavage striking approximately north-south and dipping 30° to 60° to the east. The second cleavage overprints the retrogressed porphyroblasts in the contact aureole, suggesting that this cleavage postdates the emplacement of the batholith. However, no deformation has been found in the batholith.

The Lake George Antimony-Gold Deposit lies within the contact aureole of a monzogranite cupola fringing the Pokiok Batholith. Tungsten and molybdenum are associated with skarn alteration whereas the antimony-gold mineralization is associated with younger sericite alteration. The gold is associated with arsenopyrite-bearing zones within areas of sericitic alteration. Tungsten-gold mineralization in the Coac Stream area northeast of Lake George occurs in quartz veins associated with an east-west-trending shear zone. Gold occurrences in the contact aureole near Springfield are hosted by an east-west-trending hydrothermal breccia zone.

The use of fold nucleation as a shear sense indicator

A. Caron
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 1519, Sussex, New Brunswick E0E 1P0, Canada

The development of shear sense indicators is controlled by the vorticity of the flow in the rocks. Vorticity is a measure of the average rate of rotation of the material lines. In shear zones there are two important parameters that control the formation of folds: (1) conservation of vorticity related to local variation in shear strain rate; and (2) a shortening component of deformation parallel to the shear plane. A rotation of the slip plane in the same sense as the vorticity of the deformation must accompany a slower strain rate on a portion of the shear plane in order to conserve the vorticity of the flow. This can occur if: (a) the shear plane is planar, parallel-sided, and of infinite extent; (b) the flow field is progressive simple shear; (c) the material in the zone is mechanically homogeneous; (d) the material obeys a linear viscous flow law. It has been demonstrated experimentally that kink-bands form when a shear plane is undergoing a shortening. In natural folds, nucleation in shear zones is controlled by a combination of shortening parallel to the foliation and the need to conserve vorticity. The folds preferentially nucleate at the point where a fast strain rate caused by foliation-parallel-slip decreases to the bulk shear strain rate. The fold develops an asymmetry that is consistent with the sense of shear and the axial plane lies in the extensional field of flow so that the fold can be amplified with continuing strain. The fold nucleates to conserve vorticity and maintain strain compatibility in the deforming material. The sense of shear is indicated by the side that contains the acute angle between the axial plane of the fold and the shear plane.

The occurrence of primary magmatic layering within the Big Indian Lake pluton, Hants County, Nova Scotia

M.C. Corey
Nova Scotia Department of Natural Resources, P.O. Box 698, Halifax, Nova Scotia B3J 2T9, Canada

Geological observations of drill core combined with preliminary petrographic observations and microprobe analysis suggest that the Big Indian Lake pluton is in part a layered peraluminous granite. The pluton occurs within the South Mountain Batholith approximately 40 km northwest of Halifax. It is comprised of four texturally variable granitic facies, which in order of decreasing abundance are: (1) megacrystic to moderately equigranular monzogranite and leucomonzogranite; (2) porphyritic biotite monzogranite; (3) equigranular leucomonzogranite; and (4) microgranite. The most compelling evidence of igneous layering is provided by intersections of a plagioclase-rich rock containing 50 to 90% euhedral plagioclase crystals and millimetre- to centimetre-thick, modally-enriched bands of biotite and apatite. Intersections of the plagioclase-rich rock within the drill core range from <1 to 45 m thick and are separated vertically by sections of granodiorite and biotite-monzogranite. Contacts of the plagioclase-rich rock with other facies of the pluton are usually gradational and are marked by a progressive increase in biotite and decrease in euhedral plagioclase crystals. Rare, sharp contacts with granodiorite are marked by biotite-rich metasedimentary(?) xenoliths. Similar xenoliths occur within the plagioclase-rich rock restricted to discrete xenolith-rich zones. The occurrence of discrete zones of desilicification, chloritization, and saussuritization within the plagioclase-rich rock indicate infiltration by late- to post-magmatic fluids.

The drill core shows a transition from thick, massive plagioclase-rich rock near the surface to progressively lesser plagioclase-rich rock and more abundant granodiorite and biotite monzogranite into predominately leucomonzogranite and microgranite at depth. The plagioclase crystals are characterized by well-developed normal and oscillatory zoning, and preliminary microprobe analyses have revealed core compositions of An_{51}. The plagioclase crystals are supported by a framework of interstitial minerals including: quartz, K-feldspar, albite, biotite, apatite, cordierite, muscovite, chlorite, and sphene. Their modal abundance ranges from 50% to <5%. The interstitial minerals are commonly euhedral and have sharp grain boundaries with the plagioclase crystals. Detailed petrographic and geochemical studies to determine the origin and significance of the aforementioned features are currently in progress.

Middle Paleozoic granite plutonism in southern Newfoundland

W.L. Dickson, S.J. O'Brien, and A. Kerr
Newfoundland Department of Mines and Energy, P.O. Box 8700, St. John's, Newfoundland A1B 4J6, Canada

Granitic and associated intermediate to mafic plutonism of Devonian to Early Carboniferous age is well represented in southern Newfoundland where the Burgeo and North Bay intrusive suites have intruded late Precambrian to Late Silurian gneisses, sedimentary and volcanic rocks. The batholiths are dominated by syn- to late tectonic biotite ± hornblende granodiorite and granite and late to post-tectonic muscovite-biotite granite. A radiometric age of 396 Ma (U-Pb zircon) was obtained from a late phase of the North Bay Granite Suite. Syn- to late tectonic phases of the Burgeo Intrusive Suite have been dated at 428 and 415 Ma (U-Pb zircon), respectively. A brecciated granite from the Ramea Islands has been dated at 417 Ma (U-Pb zircon).

Completely post-tectonic granites extend along the south coast for 200 km. These texturally-variable biotite granites rarely contain hornblende. They cross-cut all the major tectonic features that define the various terranes. The granites are highly evolved, contain miarolitic cavities and gas breccias, and were emplaced at high structural levels. These granites display geochemical and lithological layering and the François Granite comprises two overlapping, composite, ring complexes. The Chetwynd Granite is dated at 390 Ma (U-Pb); the François Granite at 378 Ma (U-Pb); the Harbour Breton Granite at 340 Ma (Rb-Sr); the Ackley Granite at 367 to 353 Ma (Ar-Ar).

Geochemical variation in the Silurian-Devonian composite batholiths indicates calc-alkaline trends from gabbro through tonalite and granodiorite to granite. The highly evolved granites are all high-silica granites (average 72-76% SiO_2) with the more evolved phases displaying very high Rb:Sr ratios (>100). Epsilon Nd ratios indicate that the granites within the Avalon Zone have positive ε Nd, whereas the Dunnage-Gander Zone granites are negative. This has been interpreted as reflecting major differences in the crust. This change coincides with the Hermitage Bay Fault but not perfectly with the Dover Fault.

Mineralization is mainly associated with the high-silica granites. The Mo deposits at Rencontre Lake and Sn-W-Mo greisens at Sage Pond lie along the southern margin of the Ackley Granite. The François Granite features highly anomalous radioactivity although no significant U or Th values or alteration have been found. The Chetwynd Granite is adjacent to the Hope Brook gold mine and may have been involved in the remobilization of gold. The Burgeo Intrusive Suite may be the source of extensive W + base-metal-bearing quartz veins at Grey River. Extensive Mo-W mineralization, at Granite Lake, occurs within an extensively altered phase of the North Bay Intrusive Suite and also in epithermal quartz-wolframite veins in adjacent granodiorite.

Geology of the Stirling volcanogenic massive sulphide deposit, southeastern Cape Breton Island, Nova Scotia

M. Doyon and N.A. Van Wagoner
Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0, Canada

The Stirling Zn-Pb-Cu-Ag-Au volcanogenic massive sulphide deposit is part of the late Proterozoic Stirling Belt, a mixed sedimentary and volcanic sequence belonging to the Avalon Terrane. Field work in 1991 was concentrated on the northeastern part of the belt, hosting the Stirling deposit. Two main stratigraphic units occur in this area: a lower unit of felsic volcanic rocks, laminated siltstones and carbonates; and an upper unit of epiclastic volcanic rocks. Numerous fine- to coarse-grained, mafic to felsic intrusive rocks cut this sequence.

Mining of the Stirling deposit has yielded 1.06 million tons (≈ 1 million tonnes) of ore grading 6.3% Zn, 1.5% Pb, 0.74% Cu, 2.15 oz./ton Ag (74 g/t), and 0.033 oz./ton Au (1.1 g/t). Composition of the ore places the Stirling deposit in the Zn-Pb-Cu group of volcanogenic massive sulphide deposits along with Kuroko deposits. The Stirling deposit is cut by a fault that has obliterated many of the primary textures of the ore. The ore zone is overlain by siltstone with local pyrite laminae, two felsic pyroclastic units, chert, and carbonates. Mafic and felsic dykes average 30% of the volume.

The River Framboise Middle showing, found during the summer of 1991, lies 2 km northeast of the mine, on top of the same rhyolite flow that occurs at the mine site. It displays a sericite and pyrite alteration zone in the rhyolite underlying bedded pyrite.

Re-interpreted contact relationships of the Ordovician Cookson Group, southwestern New Brunswick

L.R. Fyffe
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

The enigmatic contact relationships between the Ordovician Cookson Group and adjacent younger rocks in the St. Croix area have led to considerable controversy in regard to the tectonic history of southwestern New Brunswick. The interpretation of a conformable contact in the north and an unconformable contact in the south, first put forward during mapping in the late 1800's, was accepted until the 1960's. Since that time workers have claimed that both contacts represent significant erosional breaks. However, detailed mapping of the St. Croix area between 1989-91 tends to support the original point of view that sedimentation was continuous in the north.

The Cookson Group (including the Calais, Woodland, and Kendall Mountain formations) was previously considered to be unconformably overlain by lithic wacke and slate of the Digdeguash Formation along its northern flank. However, recent mapping suggests that the Digdeguash Formation gradationally overlies quartzite and slate of the Caradocian Kendall Mountain Formation, and is likely to be Ashgillian or possibly Llandoverian in age rather than Late Silurian or Early Devonian as previously assumed. The Digdeguash Formation, therefore, occupies a stratigraphic position similar to the Point Leamington Formation in the Exploits Subzone of Newfoundland. Calcareous sandstone, siltstone, and slate of the Sand Brook and Flume Ridge formations conformably overlie the Digdeguash Formation.

The Late Silurian Oak Bay Formation lies with profound unconformity on Tremadocian black shale of the Calais Formation along the southern flank of the Cookson Group. The presence of deformed clasts of quartzite and slate together with rare Wenlockian limestone clasts in the Oak Bay Formation indicates that uplift of the Cookson Group took place between the Wenlockian and Pridolian. This uplift is contemporaneous with the age of emplacement and deformation of the syntectonic Mohannes pluton (U-Pb date of 420 ± 5 Ma), which intrudes the Kendall Mountain Formation. The intense deformation, metamorphism, plutonism, and uplift along the southern boundary of the Cookson Group may be related to mid-Silurian collision of Avalon with North America.

Revised stratigraphy of Early Paleozoic rocks in the Piskahegan Stream-Mount Pleasant area of southwestern New Brunswick

L.R. Fyffe
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

Recent mapping in the Piskahegan Stream-Mount Pleasant area of southwestern New Brunswick has resulted in significant revisions to the Early Paleozoic stratigraphy in the area. A thick-bedded feldspathic wacke sequence in the eastern part of the area, previously included in the Waweig Formation, is now assigned to the Digdeguash Formation. A sequence of calc-silicate beds, intervening between the Digdeguash Formation and overlying calcareous rocks of the Flume Ridge Formation, is included in the newly established Sand Brook Formation.

The Digdeguash Formation is comprised largely of medium grey, medium- to thick-bedded feldspathic wacke interstratified with dark grey slate. Thicker bedded sections (70 cm to 1 m thick) appear to possess a higher feldspar-to-quartz ratio (3:2 compared to 4:1) and a lower proportion (less than 20%) of interbedded slate than thinner bedded sections (10 to 50 cm thick). Thicker beds locally grade downward to a coarse grit containing abundant rock fragments, whereas thinner beds grade upward into a dark grey siltstone. Sole marks are locally observed on the base of thick wacke beds. In order of abundance, the wackes contain angular quartz grains, feldspar, volcanic and granophyric fragments, and muscovite flakes set in a silty matrix comprising approximately 50% of the rock. Thick-bedded, light grey quartz wackes, which occur locally in the southern part of the area, contain single and polycrystalline grains of quartz set in a 15% silty matrix. The Digdeguash Formation is unfossiliferous but is assigned a Late Ordovician/Early Silurian age on the basis that it underlies the probable Silurian Flume Ridge and Sand Brook formations and overlies the Early to mid-Ordovician Cookson Group.

The Sand Brook Formation comprises 2 cm- to 1 m-thick beds that grade upward from light green feldspathic wacke to a laminated green and maroon siltstone top about 5 cm thick. Although commonly present as laminations, maroon siltstone locally attains bed thicknesses from 2 to 20 cm. Slump folds indicate a downslope direction toward the northwest. Wackes of the Sand Brook Formation contain a higher feldspar-to-quartz ratio (about 1:1) and less matrix (typically 15% compared to 50%) than wackes of the Digdeguash Formation. The abundance of epidote and actinolite, indicative of a calc-silicate composition, is responsible for the light green colour of the Sand Brook Formation in contrast to the grey colour of the Digdeguash Formation. Dark grey slate becomes a significant component of the Sand Brook Formation on strike to the west along the Magaguadavic River. Still farther west, light green beds typical of the Sand Brook Formation are absent and the Flume Ridge Formation lies directly on dark grey wackes of the Digdeguash Formation. It thus appears that the Sand Brook Formation thins by interfingering westward with the upper part of the Digdeguash Formation, whereas it thickens eastward toward Mount Pleasant and the Sand Brook area. The lower contact between the Sand Brook and Digdeguash formations on Piskahegan Stream appears to be conformable and rather abrupt, although one thin calc-silicate bed was observed within the Digdeguash Formation just below where the contact has been placed along the Magaguadavic River. The Sand Brook Formation is considered to be Early Silurian in age since it grades conformably upward into the Flume Ridge Formation.

The Flume Ridge Formation typically comprises light grey, thin- to medium-bedded (5-15 cm in thickness), fine-grained, micaceous, calcareous wacke and siltstone interstratified with light to medium grey, non-calcareous slate. The calcareous wacke beds contain approximately 40% calcite, 30% quartz, 5% feldspar plus muscovite, and 25% silty matrix. Local sequences of well-graded, non-calcareous, lithic wacke in beds up to 25 cm thick, separated by 5 cm-thick beds of non-calcareous siltstone, contain abundant volcanic fragments. Within a few metres of its contact with the underlying Sand Brook Formation, the Flume Ridge Formation contains alternating thin beds of calcareous and non-calcareous wacke; the contact with the Sand Brook Formation is placed at the base of the lowest calcareous bed. The Flume Ridge Formation is considered to be Silurian in age because of the gradational nature of its contact with graptolite-bearing wackes of the Silurian Burtts Corner wackes farther to the northwest.

A U-Pb date on the Mohannes pluton of southwestern New Brunswick

L.R. Fyffe
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada
M.L. Bevier
Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada

A geochronological study of the syntectonic Mohannes pluton in the St. Stephen area was undertaken to better constrain the time of deformation within the Tremadocian to Caradocian Cookson Group of southwestern New Brunswick. Four generations of folds have been recognized in the Cookson Group: northeast-trending, tight to isoclinal F_1 folds vary in attitude from upright to recumbent; close to open F_2 folds are associated with a penetrative crenulation cleavage dipping gently to the northwest or southeast; open to chevron-style F_3 and F_4 folds trend, respectively, to the northeast and northwest.

The Cookson Group is intruded by the foliated Mohannes pluton and by the massive St. Stephen and Baring plutons. The rapid increase from chlorite- to garnet-grade metamorphism across the Cookson Group from the northwest to southeast appears to be associated with emplacement of these syn- to post-tectonic plutons. The steep, northeast-trending cataclastic fabric in the Mohannes pluton is defined by the preferred orientation of plagioclase and alkali feldspar augen set in a fine-grained matrix of granulated quartz. Biotite and hornblende mosaics overprinting the cataclastic fabric may represent contact effects of the nearby post-tectonic plutons. Cordierite porphyroblasts in the vicinity of the Mohannes pluton show evidence of growth during deformation. However, the presence of randomly-oriented andalusite and staurolite porphyroblasts within large sedimentary rafts suggest that metamorphism within the interior of the Mohannes pluton outlasted deformation.

Results on three zircon fractions yield a preliminary U-Pb date of 420 ± 5 Ma for the Mohannes pluton. The time of emplacement and synchronous deformation of the pluton is, therefore, restricted to near the Wenlockian-Ludlovian boundary. Evidence for contemporaneous uplift associated with deformation is provided by the presence of Cookson Group detritus and Wenlockian limestone clasts in the Late Silurian Oak Bay conglomerate, which unconformably overlies the Cookson Group to the southeast. Indications of uplift are not evident along the northwestern margin of the Cookson Group suggesting that uplift may have been related to southward-thrusting over the Avalon Platform.

Granitoid-related mineral deposits, Antinouri Lake-Nicholas Dénys area, northern New Brunswick

W.W. Gardiner
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada
J. Walker and S.R. McCutcheon
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 50, Bathurst, New Brunswick E2A 3Z1, Canada

Felsic magmatism in the Antinouri Lake-Nicholas Dénys area, located about 15 km northwest of Bathurst, includes the Nicholas Dénys Granodiorite (381.0 ± 4 Ma), the Antinouri Lake Granite (372.0 ± 4 Ma), quartz-feldspar porphyry (QFP) dykes including the Nigadoo Porphyry, and feldspar porphyry (FP) dykes. The QFP dykes are interpreted to be of

Late Devonian age, whereas the FP dykes are probably Early Devonian. Each intrusive phase has associated mineralization that, at least for the larger intrusive bodies, exhibits a distinct metal zonation.

The Nicholas Dénys Granodiorite contains significant Mo and minor Cu occurring in stockworks of fracture and quartz veins. Copper increases in abundance toward the edge of the stock and into the hornfels where W (as scheelite) becomes locally important. Outside of the Cu-W zone is a zone of stratabound magnetite-base-metal (Pb-Zn-Cu-Ag-Cd) skarn and vein deposits developed primarily within limestone of the LaVieille Formation. Outside of this base metal zone and, for the most part, the biotite hornfels aureole, are a number of massive, coarse-grained, As-base metal-Au veins. Sb and Cd are frequently enriched in the base-metal occurrences.

The Antinouri Lake Granite contains minor Mo, F, and Cu in quartz veins with thin sericitic rims. Minor greisenization occurs along the southern edge of this pluton. Within the biotite hornfels aureole, a number of contact metasomatic deposits occur in limestones or calcareous argillites of Ordovician and Silurian age. These deposits are primarily Pb-Zn occurrences but may also contain Cu, Ag, Sn, Bi, Sb, and Cd.

The Nigadoo Porphyry and other QFP dykes are associated with Pb-Zn-Ag veins that, at depth, contain the granophile elements Sn, F, Bi, and W. These veins also grade laterally away from the dykes into Ag-rich zones. Some of these veins have historically been base-metal producers, e.g., Nigadoo and Keymet mines. The Nigadoo Porphyry, itself, contains elevated levels of the granophile elements and has good potential for endogranitic Sn at depth.

The FP dykes are of two types. The first type carries minor quartz phenocrysts, is magnetic, and contains disseminated pyrrhotite and/or chalcopyrite. Quartz-pyrite-Au veins are spatially associated with this type and veins may also grade into Pb-Zn-Ag veins away from the dykes. The second type contains miarolitic cavities and exhibits flow-banding. These dykes are commonly associated with arsenopyrite disseminations and stringers in metasedimentary rocks that also carry Au.

Metallogeny of the Jacquet River area, northern New Brunswick

W.W. Gardiner
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

Post-Acadian (Lower Devonian) extensional tectonics resulted in the development of a large half-graben structure infilled by sedimentary and mafic to felsic volcanic and volcanoclastic rocks. The basement to the graben is floored by folded Silurian (and locally) Ordovician metasedimentary rocks. The volcanic rocks were brought to the surface along extensional fractures in proximity to the main graben fault zones. Small felsic domes (flows and agglomerates) were extruded into a subaerial to very shallow marine environment along these graben structures. Mafic volcanism produced extensive flows and tuffs capping the rhyolite domes and filling the floor of the half-graben structure. The mafic flows interfinger with overlying calcareous shales and limestones and are succeeded in turn by a second generation of felsic volcanism.

The half-graben structure is bordered by several reverse faults in the western part of the half-graben and a number of extensional fractures developed to the east in proximity to a monoclinal fold (down-warp) along the hinge zone of the half-graben. These contrasting structures are reflected in differing styles of base-metal mineralization across the half-graben.

Base-metal-bearing fluids appear to have been introduced during the late stages of the first period of felsic volcanism. Along the western margin of the half-graben, epithermal base-metal sulphides (primarily Pb, Zn, Ag, and minor Cu) occur within quartz-carbonate vein-stockworks and breccia (agglomerate) matrices. Minor banded, massive lenses of sulphides in the agglomerates and tuffs indicate that the metalliferous brines reached surface. The banded sulphides were preserved from rapid oxidation by a quick capping of mafic volcanic flows. Along the eastern margin of the half-graben, metalliferous brines permeated the hinge zone of the half-graben along the extensional fractures developed during the down-warping. Minor contemporaneous felsic and mafic dykes are also associated with this zone. Base metals occur in wide extensional quartz veins and in stratabound skarn (manto) deposits where fluids and dykes have intersected Silurian limestones. Continuing epithermal activity during the extrusion of the mafic volcanic rocks produced minor mineralization and alteration (e.g., celadonite) within the mafic flows. A second minor epithermal event at the end of the mafic volcanism resulted in deposition of Cu-Ba-bearing veins in the mafic flows and Cu disseminations and veinlets within the uppermost flow-top breccias and intercalated sedimentary rocks.

Petrogenesis, age and economic potential of gabbroic intrusions in southern New Brunswick and southeastern Cape Breton Island

A.L. Grammatikopoulos and S.M. Barr
Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0, Canada

The Mechanic Settlement and Duck Lake plutons in southern New Brunswick are layered intrusions that range in composition from olivine pyroxenite to diorite; the smaller Devine Corner pluton is composed entirely of gabbro. The relationship of the Hamilton Lake diorite exposed southwest of the main body of the Mechanic Settlement pluton is not clear due to poor exposure. However, the diorite may compose the upper part of the pluton. Layering in the Mechanic Settlement pluton trends northeast and dips southeast and consists of mineral layering on the hand-specimen scale and interlayering of rock types on outcrop scale. Cumulate textures are well developed in most samples in both the Mechanic Settlement and Duck Lake plutons with cumulate phases including spinel (only in Duck Lake), chromite, olivine, clinopyroxene, orthopyroxene, and plagioclase. Abundance of hydrous minerals indicates that crystallization probably took place under relatively high water pressure. Major- and trace-element data show that olivine and pyroxene dominated the crystallization sequence and that the plutons are tholeiitic.

Gabbroic rocks of the St. Peters area in Cape Breton Island vary in composition from olivine gabbro to gabbro to hornblende-bearing gabbro. Other gabbroic plutons in southeastern Cape Breton Island occur near Baleine, Cape Breton, Louisbourg, Black Rock, and Gabarus. They consist of clinopyroxene and plagioclase with minor amphibole, biotite, quartz, apatite, and magnetite. Olivine occurs only in the St. Peters gabbros. Major- and trace-element data indicate that the St. Peters gabbros are alkaline and formed in a within-plate setting. In contrast, the other gabbros are tholeiitic but their tectonic setting is uncertain.

The age (or ages) of these plutons is still uncertain but may be Devonian.

Current projects of the Geoscience Information System (GSIS)

R.R. Irrinki and M.P. Rennick
Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

The Geoscience Information System was established to manage the information collected by the Mineral Resources Division. Funding provided from the C-NBCAMD and the Innovation and Technology subagreement was used to purchase GIS hardware and to customize GIS-CARIS (Computer Aided Resource Information System) for geoscience applications. The hardware configuration of the system consists of one SPARC 370 SERVER, with 32 megabytes of memory and 1.5 gigabytes of hard-disk storage, one SUN4 workstation with 16 megabytes of memory and 700 megabytes of hard-disk storage, two 19" colour monitors, one E-size pen plotter, one E-size digitizer, one USL controller, and one Tektronics screen dump. UNIX is the operating system; CARIS is the GIS software used to manage the graphic database; and INGRES is the relational database management system.

After the successful completion of the GSIS pilot project, the following projects are in progress: (1) digital base-map maintenance for most parts of New Brunswick; (2) geoscience data compilation for priority areas; (3) digital geological data maintenance for current mapping projects; (4) geophysical and geochemical data maintenance for most parts of New Brunswick; and (5) mineral-deposit data. The pilot projects on the claim management system, coastal zone mapping, and peatland management are being planned for next year.

The hand-held computer for geological field data maintenance was built by Advanced Systems Design Limited according to the specifications given by the Geological Surveys Branch and will be used for recording field data. The Field Data Collector provides an economical means of collecting information needed for geoscience field surveys. It partly automates the data-collection procedure by eliminating pencil and paper and replacing them by an electronic data entry terminal. In addition, a built-in microprocessor aids the operator in the collection procedure by guiding him/her through the entries of the data sets, avoiding omission of important information and reducing operator errors. The data sets are automatically date/time-stamped.

The Data Collector Terminal is small in size, hand-held, and powered by rechargeable batteries for several continuous full-shift operations (up to 30 hours). The data memory and the clock/calendar will work even under adverse climatic conditions over a wide temperature range and do not have external cables or connectors that could corrode and cause unreliable operation. The terminal can be placed in its Interface Cradle where recharging takes place and where the transfer of field data to a host computer is performed. Separate date/time-stamped data sets can be constructed for up to 45 field sites. The data sets can be transferred into a host computer for subsequent processing by suitable software packages, such as spreadsheet programs, database programs or GIS systems.

Strangely preserved flutes and grooves from the fluvial Port Hood Formation, (Carboniferous) of western Cape Breton Island, Nova Scotia

D.G. Keighley and R.K. Pickerill
Department of Geology, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick E3B 5A3, Canada

A widely accepted view in sedimentology is that flutes and grooves are sole marks, typically preserved on the undersides of sandstone beds, and formed by corrosion or fluid stressing at the sediment/water interface by fluvial, tidal, or

turbiditic currents. Accordingly, such structures have come to be accepted as excellent criteria for indicating "way-up" and "palaeocurrent direction" in ancient sandstones.

Structures within some of the fluvial sandstones of the Port Hood Formation of western Cape Breton Island appear to challenge this notion. Inverted grooves and spindle-shaped flutes occur on the top of sandstone beds, whereas populations of twisted and parabolic flutes occur on vertical and inclined margins of mudstone-sandstone interbeds in highly variable orientations, and independent of current direction.

An alternative explanation is required for the origin of these and other structures within the Port Hood Formation. A physical diagenetic origin, namely the remobilization of shallow subsurface, unconsolidated muds, possibly the result of tectonism, is one such candidate. Whatever the actual cause of these structures, additional care must in future be taken when discussing the sedimentological implications of flute and groove structures. Specifically, flutes and grooves should no longer be considered as having an exclusive affinity to sole marks.

Geological, geochemical, and fluid inclusion studies of the Gays River Pb-Zn deposit, southern Nova Scotia: a carbonate-hosted replacement deposit of Carboniferous age

D.J. Kontak
Nova Scotia Department of Natural Resources, P.O. Box 698, Halifax, Nova Scotia B3J 2T9, Canada

The Gays River Pb-Zn deposit (reserves 2.4 million tonnes 6.3% Pb, 8.7% Zn) is one of several significant Pb-Zn deposits hosted by Carboniferous rocks of Atlantic Canada. Mineralization is hosted by a dolomitized, Windsor Group (Viséan) carbonate-reef complex developed upon a basement high composed of Cambro-Ordovician metaturbiditic sedimentary rocks of the Meguma Group. The local mine stratigraphy (bottom to top) includes: (1) mixed psammites and pelites of the Meguma Group overlain unconformably by (2) a basal breccia unit consisting of Meguma Group clasts cemented by dolomitized limestone, (3) a complex package consisting of dolomitized carbonate lithologies (i.e., carbonate build-up), (4) evaporite (gypsum, anhydrite), and (5) a mixture of variably consolidated, Cretaceous-aged sedimentary debris (the "trench sediments"). Mineralization consists of both massive and disseminated ore, with the former by far the most important volumetrically and it is localized to the front of the reef rather than the saddle. The massive ore consists almost exclusively of fine-grained, Fe-poor sphalerite and Ag-poor galena and is formed from constant volume replacement of the dolostone; its thickness varies from several centimetres up to a few metres. In the central and western part of the deposit the massive ore generally has trench material as the hanging wall, while evaporite forms the hanging wall in the eastern part of the deposit. Important features of the ore include: (1) a primary control reflecting the locus of the precursor dolostone it replaced, (2) a limited vertical extent (ca. 86% of ore contained in 60 m vertical interval), and (3) ore textures suggestive of supersaturation and constant volume replacement origin. The disseminated ore, occurring both as a partial replacement and infilling of primary porosity, forms a broad halo of variable thickness beneath the apron of massive ore. Distribution of the breccia units suggests that it does not have a primary influence on the mineralization.

New S isotopic analysis, while confirming results of previous work, also indicates that there is a slight depletion in ^{34}S for galena mineralization in the breccia unit versus massive replacement ore ($\partial^{34}S_{gal}$-9.5 versus 12.5). REE analyses of dolostone, massive and disseminated ore and sparry calcite indicate several reservoirs for REE and that massive ore has inherited the REE signature of the dolostone. Fluid inclusion studies indicate salinities of <25 wt. % equivalent NaCl with a large apparent range in T_H (60° to >250°C). Preliminary interpretation of the data suggests that mineralization precipitated from saline brines of ca. 150° to 160°C and that the high T_H values possibly reflect (1) dissolved carbonic species in the fluid and/or (2) post-entrapment modification.

Geological studies south of the Brunswick Mines area (21 P/5 west), Bathurst Camp, northern New Brunswick

J.P. Langton
New Brunswick Department of Natural Resources and Energy, P.O. Box 50, Bathurst, New Brunswick E2A 3Z1, Canada

A 1:10 000 scale mapping project is being conducted between the Brunswick No. 6 and Heath Steele mines to delineate, in detail, the surface distribution of the massive-sulphide-bearing "Brunswick Horizon". This horizon typically occurs at or near the contact between the Middle Ordovician Nepisiguit Falls and Flat Landing Brook formations. The Nepisiguit Falls Formation consists mainly of interlayered, fine- to coarse-grained, quartz and quartz-feldspar crystal-rich rocks and fine-grained sedimentary rocks. These are divided into quartz-augen schist (QAS), quartz-feldspar-augen schist (QFAS), chlorite schist (CS), and iron formation/massive sulphides (the "Brunswick Horizon"). Most of the Nepisiguit Falls Formation rocks have been classified as tuffites, tuffs, lava flows, and/or porphyries.

The Flat Landing Brook Formation overlies the Nepisiguit Falls Formation and comprises mainly aphyric to feldspar-phyric, massive and fragmental, rhyolite and hyaloclastites. Many of these rocks exhibit false pyroclastic textures and were previously interpreted as tuffs and pyroclastic deposits. Volcaniclastic and volcanic-derived sedimentary rocks, stratigraphically equivalent to the rhyolites, are locally present and may overlie the massive sulphide deposits (e.g., Brunswick No. 12).

The area has been affected by at least five phases of deformation, but it is mainly the F2 and F4 folds that govern the macroscopic distribution of the rocks. Southwestward-directed thrusting, associated with the first phase of deformation (D1), has produced a repetition of the stratigraphy in the map area. The structure and stratigraphy of the area have been evaluated within the framework of the recently reinterpreted regional tectonostratigraphy. Lithogeochemical results indicate a potential for distinguishing between the Nepisiguit Falls and Flat Landing Brook formations based on heavy rare-earth-element concentrations.

Re-examination of the origin of quartz-augen schist in light of recent investigations at the Brunswick No. 12 sulphide deposit, Bathurst base-metal camp, Bathurst, New Brunswick

D.R. Lentz
Geological Survey of Canada, P.O. Box 50, Bathurst, New Brunswick E2A 3Z1, Canada
W.D. Goodfellow
Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada
and
S.J. Juras
Westmine Resources Limited, Myra Falls, P.O. Box 8000, Campbell River, British Columbia V9W 5E2, Canada

It has long been established that there is a common association between the occurrence of quartz porphyroidal rocks and massive sulphide deposits in felsic volcanic sequences. However, there has been some controversy over the origin of the quartz augen and their metallogenic significance, based primarily on textural evidence from numerous deposits including those in the Bathurst base-metal Camp. The quartz augen have been interpreted either as relic phenocrysts in deformed and metamorphosed felsic pyroclastic rocks or as porphyroblasts formed during the greenschist-grade regional metamorphic event that was associated with intense regional deformation.

For the most part, the felsic pyroclastic rocks occurring stratigraphically beneath the "Brunswick horizon" massive sulphides and laterally-equivalent Algoma-type iron formation were originally quartz- and feldspar-rich crystal tuffs. There is overwhelming evidence for a volcanic origin of quartz including vitreous (black) quartz, betaform quartz (dipyramidal, β quartz/high quartz), quartz crystal shards, and embayed quartz. However, the occurrence of quartz-only crystal tuffs is problematic because feldspar generally precedes quartz as a liquidus phase and should therefore be present in porphyritic volcanic rocks. The absence of feldspar in the fine- to coarse-grained quartz-augen schists (QAS) may be attributed to subaerial feldspar weathering, which is supported by sedimentological features and the regional extent of the QAS in the Bathurst Camp. Within the vicinity of the Brunswick No. 6 and 12 deposits however, the similarity in textures, immobile-element contents, and compositional homogeneity between QFAS and the QAS units does not support extensive feldspar weathering. Alternatively, protolysis and hydrolysis submarine hydrothermal alteration reactions associated with exhalative ore-forming processes, proposed originally in 1974, could account for the breakdown of alkali feldspar phenocrysts.

The contact between QAS and quartz-feldspar augen schists (QFAS) may be quite sharp (<20 cm) to gradational (>5 m). In general, the size of the quartz augen in QAS is commonly 1 to 2 mm smaller than the quartz augen in QFAS whereas feldspar in the latter are slightly larger than quartz. Numerous phenocrysts have variably developed fine-grained mica-quartz beards that have mineralogical and textural attributes similar to the those in pull apart structures. The S_1 and S_2 fabrics are usually more pronounced in the QAS by virtue of the higher mica content and absence of feldspars. The strong fabric development may, in part, be responsible for the apparent finer grain size in the QAS due to cataclastic fragmentation of the phenocrysts. Coarse-grained turbid alkali feldspar and quartz phenocrysts hosted in a very fine-grained matrix of sericite, chlorite (brown birefringence), albite, and opaques represent the least-altered, crystal-rich tuffs (QFAS). The weakly to moderately altered rocks consist of cryptic pseudomorphic replacements of quartz, albite, and lesser proportions of mica after alkali feldspar. The transition zone between the QFAS and QAS is identified macroscopically by micaceous and siliceous veinlets within the pseudomorphically replaced alkali feldspar phenocrysts. Within the QAS, the alkali feldspar phenocrysts are totally replaced by quartz, sericite, and chlorite and resemble milky quartz augen in hand specimen. Therefore, the confusion resulting from the occurrence of augen-shaped seriate aggregates of quartz and mica with coarse-grained, subrounded to angular vitreous quartz is a result of submarine hydrothermal alteration of alkali feldspar and is not due to the porphyroblastic growth of quartz. The occurrence of milky quartz-augen pseudomorphs with vitreous volcanic quartz may be used as evidence of submarine hydrothermal alteration and could explain the association of QAS with felsic volcanic-hosted massive sulphide deposits.

The geometrical relationship between the stretching lineation and the movement direction of shear zones

S. Lin and P.F. Williams
Department of Geology, University of New Brunswick, Fredericton, New Brunswick E3B 5H1, Canada

The internal structure of shear zones generally has monoclinic symmetry. The symmetry plane is perpendicular to the intersection of the shape fabric (S-foliation) and the shear zone boundary and contains the stretching lineation, the shear direction, and the poles to the S-foliation. It is the orthogonal projection of the stretching lineation on the shear zone boundary, not the stretching lineation itself, that is parallel to the shear direction. Unless the movement is truly strike-slip and the shear zone is vertical, the plunge of the shear direction is not equal to that of the stretching lineation. Qualitatively the point is obvious; what is not so obvious is that the magnitude of the potential error is likely to be significant, as is clear from a quantitative study.

A consistently shallowly plunging stretching lineation on a steeply dipping foliation in a shear zone is commonly interpreted as indicating strike-slip motion with a minor vertical component. This study shows that this may not necessarily be true. For example, the stretching lineation formed in a true strike-slip shear zone dipping 60° would pitch 16° (plunge 14°) on S-dipping 64°, if the angle between S and C is 30°. Movement on such a shear zone could be hundreds of kilometres. However, if the stretching lineation were correlated with the movement direction, there would be ca. 2.6 km dip slip for every 10 km strike-slip, and if there is no metamorphic change across the fault, we would conclude, perhaps erroneously, that the movement could be no more than 10 to 20 km. Faults with such geometry are known in the Canadian Appalachians.

Steeply plunging stretching lineations on steeply dipping foliations in shear zones are usually interpreted as indicating dominant dip-slip movement with only a minor horizontal component. However, this also may not necessarily be true. For example, sinistral reverse movement along a shear zone dipping 45° with movement direction pitching 45° (plunging 30°) would form a stretching lineation pitching 58° (plunging 52°) on a foliation dipping 69°, if the angle between S and C is 30°. Shear zones with such a geometry may be common in positive flower structures.

The stretching lineation and the S-foliation can be used to determine the shear direction if either the attitude or the strike of the shear zone is known. The true shear direction is parallel to the intersection of the symmetry plane and the shear zone boundary. The former is defined by the stretching lineation and the poles to the S-foliation. The latter, if it cannot be measured directly in the field, is parallel to the plane defined by the shear-zone strike and the pole to the symmetry plane.

ECSOOT Lithoprobe Line: some insights from offshore gravity and magnetic surveys

B.D. Loncarevic
Atlantic Geoscience Centre, Geological Survey of Canada, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2, Canada

The objective of the Lithoprobe deep seismic lines is to describe the crustal geology as a three-dimensional extension of surface bedrock geology. This connection is difficult because it is generally not known how the complexities of surface bedrock geology propagate in depth. The task becomes even more difficult in the offshore since the bedrock geology information is often minimal or non-existent. It is, therefore, important to use the geological information from the adjacent land mass and to project and extend trends to the offshore.

An important aid in projecting the geological trends from land to offshore are the maps of gravity and magnetic anomalies. This becomes particularly useful in the areas which are well mapped and where susceptibility and density contrasts between different rock types produce significant and easily recognizable anomalies.

Reconnaissance gravity and magnetic surveys have been completed over all of the Labrador Shelf. The survey line density varies between 5 and 20 km and thus the data will provide information on general trends only. The one exception is the area of Saglek Bank (between latitudes 58° and 59° north) where in 1976 a more detailed survey was conducted with line spacing of less than 2 km. These data have been combined with the new compilation of the East Coast Aeromagnetic data and the resulting maps will be discussed in the context of the offshore extension of land geology.

New insights into the generation, emplacement, and magmatic evolution of the South Mountain Batholith, Nova Scotia

M.A. MacDonald, M.C. Corey, L.J. Ham, R.J. Horne, and A.K. Chatterjee
Nova Scotia Department of Natural Resources, P.O. Box 698, Halifax, Nova Scotia B3J 2T9, Canada

The South Mountain Batholith of southwestern Nova Scotia is a composite, peraluminous batholith ranging in composition from biotite granodiorite to muscovite ± topaz leucogranite. Recent geological mapping has provided new insights into the evolution of the batholith. Granitic rocks have been assigned to thirteen discrete plutons that can be grouped into early (Phase 1) plutons comprising mostly granodiorite and monzogranite and late (Phase 2) plutons comprising mostly leucomonzogranite and leucogranite. Despite a systematic sequence of emplacement for the rocks of these plutons, an evaluation of published geochronological data indicates that the entire batholith was emplaced and crystallized during a very short time interval (<5 million years) at ca. 370 Ma. Various structural features, including the shape and distribution of plutons and the orientation of primary features (e.g., megacryst alignment, joints, veins), indicate that the batholith was subject to regional stresses associated with the Acadian Orogeny during, and following, its emplacement and crystallization.

The various rock types within the plutons have broadly similar compositions; however, detailed petrographic and geochemical studies indicate unique features that possibly reflect compositional variations within the protolith. Similarly, the style of mineralization within the sundry plutons is interpreted to reflect a combination of protolith composition and differences in the physio-chemical conditions that prevailed during crystallization of individual plutons.

A review of recent petrogenetic studies of granulite gneiss and mafic intrusions in the eastern Meguma Terrane provides a mechanism for generation of the large volume of granitic magma required for the South Mountain Batholith. This mechanism involves the melting of upper crustal rocks, possibly of the Avalon Terrane, which were subducted to lower crustal P-T conditions beneath the Meguma Terrane during continent/continent collision related to the Acadian Orogeny. The presence of mantle-derived mafic intrusions suggests that underplating by mantle magma may have contributed to crustal melting.

The Maritime Appalachian Transect (MAT): a new proposal to Lithoprobe

F. Marillier
Atlantic Geoscience Centre, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2, Canada
M. Malo
Institut National de la Recherche Scientifique, INRS-Géoressources, 270 rue Einstein, Case Postale 7500, Sainte-Foy, Quebec G1V 4C7, Canada
and
The MAT Group

A new Lithoprobe transect is proposed that will cross the Gaspé Peninsula, New Brunswick and Nova Scotia. The main theme of the transect is to unravel the three-dimensional geometry of the northern Appalachian Orogen. The transect will fill a gap between existing deep seismic lines. It lies between the Quebec-Maine transect where thin-skinned tectonics dominate to the Lithoprobe-East lines in the Gulf of St. Lawrence and in Newfoundland where steeply dipping boundaries cut across the crust. As a part of consistent data set, this new profile will address the generic problem of reentrant-promontory pairs in orogens. Other main themes include: (1) the development of successor basins within orogens (e.g., the Gaspé Synclinorium and the Maritimes Basin); (2) the relationship between surface geology (terranes) and the deeper parts of the crust; and (3) mantle tectonic and sub-Moho reflectors. The considerable economic potential in the rocks at middle to upper crustal levels will be investigated by high resolution seismic profiling and controlled source electromagnetic studies, in cooperation with industry in selected areas. The broad range of scientific problems and the diversity of Earth Sciences disciplines involved in the MAT proposal suggest that it will reap a rich harvest of scientific results.

Endogranitic Sn potential beneath the Nigadoo River base-metal vein/lode deposit, northern New Brunswick

S.R. McCutcheon
New Brunswick Department of Natural Resources, Geological Surveys Branch, P.O. Box 50, Bathurst, New Brunswick E2A 3Z1, Canada
D.R. Lentz
Geological Survey of Canada, P.O. Box 50, Bathurst, New Brunswick E2A 3Z1, Canada
and
W.W. Gardiner
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

The abandoned Nigadoo River Mine is located about 15 km northwest of Bathurst in the Nigadoo River Synclinorium, part of the Tobique-Chaleur tectonostratigraphic zone. Initially discovered in 1953, development at the Nigadoo deposit continued until 1958. The northwesterly trending Main and Anthonian vein-systems (A and C zones, respectively) produced approximately 1.9 million tonnes grading 2.2% Pb, 2.1% Zn, 0.2% Cu, and 90 g/t Ag, mostly from the

1075 m long, 640 m deep, and 1 m wide A-Zone. The deposit is centred upon the Nigadoo Porphyry and crosscuts both the porphyry and enclosing country rocks, which consist of northeast-trending, steeply dipping, greenish grey calcareous slates, siltstones, and limestones of the Late Silurian LaPlante Formation. In general, the Nigadoo Porphyry is a steep-walled, quartz-orthoclase porphyritic plug that has been sericitized, chloritized, and locally silicified by vein-forming hydrothermal fluids.

The Nigadoo Porphyry was considered to be synorogenic, but recent mapping and radiometric dating indicate that it is post-tectonic and probably Late Devonian in age like other Sn-W-Mo-bearing granites in central and southern New Brunswick. Quartz-feldspar porphyry, which is texturally identical to the Nigadoo Porphyry, is a late phase in the nearby Antinouri Lake Granite (371 ± 4 Ma; U-Pb zircon). Zn-Pb-Cu-Ag vein mineralization is, in part, hosted in texturally similar porphyry at the old Keymet Mine, located about 10 km north of the Nigadoo Mine.

Previously published literature suggested three stages of vein formation: (1) early pyrite-pyrrhotite-sphalerite-arsenopyrite veins; (2) the main stage sulphide veins; and (3) late-stage carbonate veins. In general, the main stage sulphides are coarse-grained and consist of monoclinic pyrrhotite, hexagonal pyrrhotite, pyrite (marcasite), Fe-rich sphalerite (≈ 22 mol. % FeS), galena, chalcopyrite, arsenopyrite, cassiterite, stannite, argentiferous tetrahedrite, and native bismuth. In addition, there are several complex Ag-Pb-Bi-Sb sulphosalts. Needle-cassiterite occurs within the pyrrhotite (hex)-arsenopyrite-rich parts of the lode, that predominate below the 270 m level. Textural evidence indicates complex sulphide replacements within the lode, as well as late-stage shearing of the sulphides. The sulphide assemblage reflects formation from a low-temperature (200°-300°C) and low-pressure [<50 MPa (500 bars)] hydrothermal fluid with low $f(S_2)$, low $f(O_2)$, and low pH. This type of hydrothermal fluid is commonly responsible for the formation of tin-sulphide lode deposits worldwide. Furthermore, the narrow range of $\partial^{34}S$ isotopic values of 1.4 ± 1.0‰ (n=11; published data) obtained on various sulphides is consistent with a magmatic origin for the mineralizing fluid. Closed-system sulphur isotopic fractionation of pyrite and pyrrhotite from an H_2S-dominated, magmatically-derived hydrothermal fluid is consistent with the isotopic compositions found in the veins.

Unfortunately, Sn was not routinely assayed during the mining operation. However, reported Sn contents of the first Zn, Pb, and Cu concentrates were 0.02%, 0.1%, and 0.2%, respectively. It was also reported that the highest In and Bi contents were coincident with the porphyry-hosted portion of the vein/lode. If the Nigadoo lodes are analogous to the Mount Pleasant base-metal-tin lodes (0.25 million tonnes grading 2.3% Zn, 0.36% Pb, 0.3% Cu, and 0.6% Sn), then there should be endogranitic Sn at depth as there is at Mount Pleasant (2.14 million tonnes grading 0.81% Zn, 0.45% Sn, 0.06% W, and 0.03% Mo). However, an endogranitic tin zone at Nigadoo could be considerably larger than the one at Mount Pleasant if the size of the base-metal lodes is any indication.

Southern New Brunswick compilation and correlation project by the New Brunswick Department of Natural Resources and Energy

M.J. McLeod, A.A. Ruitenberg, and S.C. Johnson
Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 1519, Sussex, New Brunswick E0E 1P0, Canada

The compilation and correlation project of southern New Brunswick geology, which is jointly funded by the New Brunswick Department of Natural Resources and Energy and the Cooperative Agreement on Mineral Development, is about two-thirds complete. To date, preliminary maps at a scale of 1:50 000 and 1:250 000 have been compiled and field checked for most of NTS map sheets 21 G and parts of 21 H and 21 B.

Field work, aided by U-Pb dates has resulted in major revisions in stratigraphy, correlations and metallogenic implications of some areas. The most significant revisions include: (1) delineation of the extensive base-metal- and gold-rich, Lower Ordovician Annidale belt along strike to the northeast of the St. Croix Terrane; (2) definition and correlation of the Silurian and gold-bearing Ordovician units in the St. Croix Terrane northwest of the Saint George Batholith; (3) refinement of stratigraphy and correlations in the Mascarene belt; and (4) expansion of Cambrian (to possibly Late Precambrian) designations to many of the stratified rocks in the Long Reach area on both sides of the Saint John River. The latter are correlated with similar base-metal-bearing rocks to the northeast and southwest along the entire southern margin of the Mascarene belt.

The final product of this project will be publication of coloured maps at a scale of 1:250 000 with accompanying descriptive reports, geological compilation maps at a scale of 1:50 000 and several papers dealing with the U-Pb dating program and with specific aspects of southern New Brunswick geology.

Evolution and extinction patterns in Late Ordovician-Early Silurian graptolites as revealed by the study of uncompressed specimens from Arctic Canada

M.J. Melchin
Department of Geology, St. Francis Xavier University, Antigonish, Nova Scotia B2G 1C0, Canada

The Late Ordovician to Early Silurian was a time of mass extinction and subsequent radiation of the planktonic graptolite faunas. Recent improvements in our understanding of graptolite morphology and phylogeny from the study of uncompressed specimens has resulted in a better appreciation of the magnitude and suddenness of these events. The Ashgill extinction event resulted in the termination of three of the four extant families and all but one genus and it culminated at the end of the *pacificus* Zone. Only *Normalograptus* survived the extinction and gave rise to the subsequent radiation.

The initial stages of the radiation were manifested mostly at the species level. Species of one proximal development pattern completely dominated the post-extinction *extraordinarius* Zone with the number of species in this group jumping from four or five in the latest *pacificus* Zone to over twenty in the *extraordinarius* Zone. The subsequent zone, however, witnesses the development of several new genera as well as new proximal development patterns. All of the major stocks of Silurian and Devonian graptoloids, with the exception of the retiolitids and the cyrtograptids, had become established within two graptolite zones after the extinction, a time period of probably less than 1 million years.

Evidence from sections in Arctic Canada and elsewhere suggests that the main extinction event coincides with a time of sea-level fall as well as changes in ocean chemistry, oxygenation, circulation patterns, and possibly temperature brought about by the Ashgill glaciation centred on North Africa.

Horton basin inversion event in the Moncton Subbasin, New Brunswick

W.A. Nickerson
Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X5, Canada

Released industry seismic data in the Moncton Subbasin imaged sedimentary rocks of the Horton Group in half-grabens with northeast-trending, northwest-dipping listric basin-bounding faults. These faults have been reactivated, inverting the Horton basin and partially extruding the basin fill before the Windsor Group was deposited in Viséan time.

Seismic cross-sections and mapped fault patterns show that the structural expression of this inversion event changes systematically along the basin's southeastern boundary with the Caledonia mountains. Analysis of the cross-section and published geological map data suggest that a combination of compressional and dextral strike-slip deformation has taken place.

Lacustrine stromatolites at the base of the Late Carboniferous Merigomish Formation, Pictou County, Nova Scotia

S. Palmer
Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada
J.W.F. Waldron
Geology Department, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada
and
W.G. Parkins
Department of Geological Sciences, Brock University, St. Catherine's, Ontario L2S 3A1, Canada

A distinctive unit of Late Carboniferous stromatolitic limestone occurs in outcrop and boreholes close to the north edge of the Stellarton graben, Pictou County, Nova Scotia. The unit occurs immediately above alluvial fan conglomerates of the Cumberland Group and is overlain by a thick succession of fluvial (meandering, anastomosing, and braided) sandstones and shales assigned to the Merigomish Formation of the Pictou Group. This carbonate unit is 7 to 15 cm thick and consists of mixed carbonate-siliciclastic sediments, stromatolites, and fossiliferous sandstones.

Vertical sequences through the carbonate unit show coarsening-upward cycles suggesting a prograding shoreline environment. Lithologies directly above boreholes P-57 and P-58 and those described at Smalls Brook are consistent with a shoreline environment.

Petrographic analysis of the stromatolites shows three distinct fabrics: radial fibrous, sparry calcite, and micritic. The radial fibrous calcite, which forms the majority of most samples, is unusual in marine stromatolites, but has been described from freshwater examples elsewhere. Paleontological data have been collected from the solution of stromatolitic samples yielding approximately 600 fragments of bone, teeth, and fish scales, and a species of bivalve. These indicate a freshwater environment. Gastropods from sandstone samples in core are also distinctively nonmarine.

The carbonate unit at the base of the Merigomish Formation is contemporary with lacustrine sedimentation in the Stellarton graben to the south. Tectonic control of lacustrine sedimentation is presumed to have been related to the development of the Cobequid-Hollow fault system, but additional data on the distribution of the stromatolites would be required to constrain a paleogeographic reconstruction.

Applications of regolith mapping and sampling in the California Lake area, northern New Brunswick

Michael A. Parkhill
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 50, Bathurst, New Brunswick E2A 3Z1, Canada

Regolith mapping (1:50 000 scale), involving sampling of C-horizon basal till, 100 pebbles from till, as well as B-horizon soil at 266 sites on a 2 km grid, was completed this year in the California Lake map area (N.T.S. 21 O/8). An additional 37 sites were sampled on a 500 m grid in the vicinity of the Halfmile Lake mineral deposit. Striae, grooves, roche moutonnée, granite boulder erratics, and till fabrics indicate eastward ice movement followed by northeastward- and southeastward-flowing ice. Ice-flow chronology and geochemistry are used to assess the glacial dispersal of geochemical anomalies. Pebble analysis supplies information on the composition of the various till units in the area and gives an indication of the underlying bedrock type in areas of sparse outcrop.

A locally derived, thin layer of Late Wisconsinan basal till (<2 m) covers most of the area and is divided into three units based on texture, composition, topography, underlying bedrock, and the presence or absence of overlying colluvium. Till is sandy over granite bedrock where a layer of preglacial weathered bedrock (grus) commonly occurs. Deeply weathered bedrock also occurs over other rock types but is generally restricted to the highest elevations in the western part of the area. Till thickens to the east where the topography is lowest and gently rolling.

Until recently, mineral explorationists were the primary users of surficial geology. Increasing demands from various user groups in New Brunswick has further outlined the importance of regolith mapping. The grus, ablation till, glaciofluvial and postglacial alluvial deposits are potential sources of aggregate. Till mapping has applications to acid mine drainage; geotechnical analysis of 60 till samples by Noranda Technology and till mapping, have outlined potential sources of clay-rich till near the Heath Steele Mine to cover tailings ponds and waste piles. Systematic mapping of surficial geology to delineate suitable till (high clay/low pebble content), provides essential geoscience information that future mining operations can use in Environmental Impact Assessments and mine reclamation plans. Forest site classification information, soil-profile descriptions, and pebble analysis obtained in this study are used to plan reforestation projects. Bedrock and regolith comprise the parent material of forest soils. Suitable tree species can be selected to match different regolith (till, soil, etc.) units. Regolith mapping also has applications in land-use planning, regional landfill siting, water resource management, environmental projects, and in the location of construction materials.

Significance of trace fossils from the Tancook Member of the Goldenville Formation; Meguma Group, Mahone Bay area, Nova Scotia

R.K. Pickerill
Department of Geology, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick E3B 5A3, Canada
and
J.W.F. Waldron
Geology Department, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada

The Meguma Group of southern mainland Nova Scotia consists of a thick unit of dominantly sandstone turbidites (Goldenville Formation). The Goldenville-Halifax transition is well exposed on Big and Little Tancook islands in Mahone Bay, where sandy and muddy facies alternate in the uppermost part of the Goldenville Formation, the Tancook Member. The Tancook Member is overlain in turn by laminated manganiferous argillites (Mosher's Island Member of the Halifax Formation), and by black, pyrite-rich slates and turbiditic siltstones (Cunard Member). This succession records the progressive development of anoxic conditions in the Meguma Basin, probably related to relative sea-level rise.

The Tancook Member contains a relatively diverse ichnofauna for a deep-water Cambrian sequence comprising the ichnogenera *Helminthoidichnites*, *Helminthopsis*, *Palaeophycus*, *Paleodictyon*, *Rhizocorallium*, *Rusophycus*, *Skolithos*, and abundant *Teichichnus*. Of these, *Rhizocorallium*, *Rusophycus*, *Skolithos*, and *Teichichnus* are elsewhere more typical of shallow-water neritic sequences. Their occurrence in the Tancook Member presumably reflects either colonization by opportunists in a relatively deep-water setting or, alternatively, doomed pioneers periodically introduced by sediment gravity flows. *Helminthoidichnites*, *Helminthopsis*, and *Palaeophycus* are simple horizontal burrowing ichnotoxa that elsewhere are facies-crossing forms. To our knowledge the presence of *Paleodictyon* represents its only occurrence within a deep-sea Cambrian setting, other examples having all previously been made from neritic sequences.

The use of regional stream sediment data in assessing drinking water quality: an example from southwest New Brunswick

A.G. Pronk
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

A recent problem with drinking water quality from private wells in southwest New Brunswick has focused attention on the natural presence of trace elements in our groundwater resources. High arsenic and antimony levels in drinking water in the Lake George area are attributed to mining activity by area residents and the media. Mining activity in the area dates back more than a century and more recently, the mine operated from the mid-1970's to 1990. The Lake George mine was established along the southeastern edge of the Pokiok Batholith to exploit the high levels of antimony and associated arsenic occurring naturally in the bedrock. High levels of these elements in the bedrock produce high natural levels in groundwater. Leakage from settling and tailings ponds may, however, have increased levels of these elements in the groundwater.

A regional stream-sediment survey revealed an anomalous trend along the southeastern margin of the Pokiok Batholith that may indicate high levels of arsenic, mercury, and antimony in groundwater. People searching for drinking water sources in this area should be made aware of this situation. To understand the relationship between trace elements and their presence in drinking water, it will be necessary to understand the lithological and structural control of the mineralization.

Geological mapping program on St Pierre and Miquelon Islands

D. Rabu
Nova Scotia Department of Natural Resources, P.O. Box 698, Halifax, Nova Scotia B3J 2T9, Canada
and
J.L. Rabottin
49 rue de l'abbé P. Gervain, 97500 St Pierre et Miquelon

St Pierre and Miquelon islands lie 50 km south of Newfoundland. The bedrock geology was mapped by Aubert de la Rüe in 1951 and the Quaternary evolution has been studied by Tucker and McCann in 1980. The Bureau de Recherches Géologiques et Minières French Geological Survey is undertaking a new program of 1:50 000-scale geological mapping (1991-1992).

Preliminary results are as follow: volcanic rocks exposed on St Pierre and the central part of Miquelon consist of subaerial rhyolitic-dacitic lava flows, pyroclastic rocks (agglomerate, tuff) and minor pillow mafic flows. These volcanic rocks are unconformably overlain by red polymictic conglomerate of latest Precambrian age. Latest Precambrian-Cambrian rocks are mainly exposed on Langlade (southern part of Miquelon) and are similar to the Burin Peninsula sequences. On the northeast Langlade coast, red arkosic sandstone and shale overlie rhyolitic lava flows and green vesicular basalt and may all be Devonian in age. Glacial features, such as striae and grooves, show that at least two major glacial events occurred on the archipelago: (1) northwest-southeast-directed flow, is found everywhere in the area and is probably early Wisconsin in age; and (2) northeast-southwest-directed flow, is only well displayed on the southern coast of St Pierre Island and is middle Wisconsin in age. Fossilized wood remains, below peat deposits around Miquelon, display a wide range of radiometric data between 5220 ± 90 BP and 2410 ± 70 BP.

Kinematic analysis of Late Paleozoic deformation in the western Cumberland Basin

B.C. Reed
Department of Geological Sciences, Ohio University, Athens, Ohio 45701, U.S.A.
J.H. Calder
Nova Scotia Department of Natural Resources, P.O. Box 1087, Halifax, Nova Scotia B3J 2X1, Canada
J.B. Murphy
Department of Geology, St. Francis Xavier University, Antigonish, Nova Scotia B2G 1C0, Canada
and
R.D. Nance
Department of Geological Sciences, Ohio University, Athens, Ohio 45701, U.S.A.

The Cumberland Basin is a large (3600 km^2) east-west-trending synclinorium located in northwestern Nova Scotia. Sediments at the centre of the basin are at least 7 km thick, suggesting anomalously rapid deposition in comparison with other Devono-Carboniferous basins in the Canadian Appalachians. The basin is bounded to the south by the

Cobequid Highlands, to the northwest by the Caledonian Highlands of southern New Brunswick, and to the east by the Scotsburn Anticline.

Upper Devonian to Lower Permian sedimentary rocks of mostly continental origin fill the basin and consist of conglomerates, sandstones, shales, and local but important deposits of coal and evaporites. These sedimentary rocks were deformed by faults and folds prior to the deposition of the Late Westphalian to Stephanian Pictou Group that unconformably overlies the Late Carboniferous Cumberland, Mabou, and Windsor groups in the northern Cumberland Basin.

Major east-west-trending faults including the subparallel Athol, Sand Cove, and Sand River faults that can be traced across the Cumberland Basin from Springhill to Chignecto Bay. To the east, the faults become splayed and join smaller north-south faults or die out near Springfield. The westward trace of these fault zones beyond the shoreline of Chignecto Bay is uncertain. Northwest-trending fault splays are exposed along the shore, but these either die out or are truncated by the sinistral northeast-trending Harvey-Hopewell Fault in the Caledonian Highlands. Inland exposure of these faults is poor, but analysis of structures elsewhere within the basin, such as those displayed by the Springhill coal seams, can be used to provide a kinematic synthesis of the evolution of the Cumberland Basin.

The Athol, Sand Cove, and Sand River fault zones outcrop along a 5 km section of the coast of Chignecto Bay from Sand River to Clam Cove. These faults deform the Late Carboniferous Ragged Reef Formation of the Cumberland Group which comprises massive, coarse conglomerates interbedded with finer-grained lithic arenites and thin beds of siltstone and shale that locally contain coalified fossil tree remains. Overall displacement across the fault zone is uncertain. Offset along individual normal and reverse faults is usually a matter of only a few metres, although the combined offset across the fault zone may be substantial.

A possible origin of the 1989-1990 Laurentian Channel earthquakes

A. Ruffman
Geomarine Associates Limited, P.O. Box 41, Station "M", Halifax, Nova Scotia B3J 2L4, Canada

Prior to February 2, 1989, the earthquake epicentre map of eastern Canada showed no earthquakes in most of the Laurentian Channel in the area between the Scotian Shelf and St. Pierre Bank. The only earthquakes shown were those near the mouth of the Channel, which were included in the Laurentian Slope Seismic Source Zone (LSP) of the 1985 National Building Code of Canada (NBCC).

Only one December 12, 1983 event of magnitude 3.0 was not included in the LSP for the 1985 NBCC. The LSP includes the major magnitude 7.2 event of November 18, 1929 and the numerous aftershocks that followed. Quite expectedly, beginning on February 2, 1989 with a magnitude 4.2 event, a striking series of 27 small, magnitude 2.1 to 4.2 earthquakes have lit up on apparent linear zone outside the LSP in the axis of the Laurentian Channel over a 1.3-year period. The new series of twenty-seven 1989-1990 events form quite an intriguing, apparently linear, zone 40 km long and perhaps longer if taken with the few older events along the channel to the southeast. The apparent linear zone is subparallel to the axis and to the margins of the Laurentian Channel.

The area is known to contain numerous salt diapirs in Carboniferous sedimentary rocks. It is suggested that the cause of the new earthquake swarm may be the reactivation of salt diapirism possibly of a single diapir. While these events have not been felt onshore, it is clear that a magnitude 4.2 felt event, which did occur onshore, followed by 26 smaller (aftershock?) events in rapid succession, would deserve immediate concern. It is recommended that this new area of seismic activity be included in the LSP or in the earlier suggested Laurentian Channel Experimental seismic source zone (LSX) for the proposed 1995 NBCC seismic hazard maps. An intensive sub-bottom investigation and recompilation of data for the area is recommended to possibly better define the seismic zone and to perhaps add some data to the present arbitrarily assigned 18 km hypocentre depth.

Gravity in central Nova Scotia south from the Liscomb Complex

P.J.C. Ryall and E. Pearson
Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada

Over 600 gravity measurements have been made in central Nova Scotia south from the West River St. Mary's Fault to the coast between longitudes 62°30'W and 63°W. This area encompasses the Liscomb Complex, the Beaver Dam granite, and the eastern half of the Musquodoboit Batholith. Along line (roads and trails) stations are typically 1 km apart, but the lines themselves are often several kilometres apart. The increased data density allows resolution of features not seen in earlier gravity surveys of the area.

Two general comments apply: (1) Bouguer gravity lows coincide with mapped granite outcrop, and (2) elongate Bouguer gravity highs coincide with the Halifax slates. Starting from the north, the Liscomb Complex is represented by an extensive 5 mGal low joining the Moose Lake and Long John Lake monzogranites.

There is no gravity expression of the Ten Mile Lake or Bog Island Lake gabbros/diatremes. To a large extent, gravity contours are perpendicular to mapped geological contacts. The Beaver Dam granite also causes a 5 mGal low separate from that due to the Musquodoboit Batholith. The gravity anomaly of the latter is in agreement with previous results although more detail is apparent. Preliminary modelling suggests that the contact between the granite and the Meguma is dipping moderately (-45°) for the first 2 or 3 km.

The Appalachian structural front, Port au Port Peninsula, western Newfoundland: balanced cross sections and implications for Humber Zone tectonics

G.S. Stockmal
Geological Survey of Canada, Institute of Sedimentary and Petroleum Geology, 3303-33rd Street Northwest, Calgary, Alberta T2L 2A7, Canada
and
J.W.F. Waldron
Department of Geology, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada

The traditional view that the carbonate platform of the western Newfoundland Humber Zone is autochthonous to parautochthonous has been challenged by Stockmal and Waldron (1991, Geology, 18, pp. 765-768) and Waldron and Stockmal (in press 1991, Canadian Journal of Earth Science, 28) on the basis of new geological mapping on the Port au Port Peninsula and interpretation of nearby offshore industry seismic reflection data. A series of balanced cross sections, constructed across the peninsula, demonstrate that a great variety of seemingly unrelated structural features on the peninsula and in adjacent areas can be explained as a consequence of progressive triangle zone (tectonic wedge) development where both the carbonate platform and the underlying basement and rift-related rocks are transported tens of kilometres to the northwest during the Acadian (Siluro-Devonian) Orogeny.

Our preferred interpretation involves: (1) normal-sense reactivation of an Iapetan(?) rift-stage basement-cutting normal fault (southeast-dipping) and associated antithetic faults during progressive encroachment of the Humber Arm Allochthon (the obducted accretionary wedge) during the Taconian (Middle Ordovician) Orogeny, with concomitant in-filling of this half-graben; (2) preservation of the half-graben "foreland" fill as the Humber Arm Allochthon structurally overrode this isolated basin; (3) thrust-sense reactivation of the southeast-dipping normal fault during the Acadian Orogeny, initiating a tectonic wedge or triangle zone structure, within which the carbonate platform and its underlying basement were structurally duplicated and transported to the northwest; (4) relatively late (post-Pridolian), out-of-sequence stepping of the triangle zone upper detachment, resulting in imbrication of the transported platform sequence and complete structural inversion of the half-graben "foreland" fill; and (5) minor dismemberment by strike-slip and inferred oblique-slip Carboniferous faults associated with regional transpression-transtension.

Total shortening across the Triangle zone associated with Step (4) is approximately 9.5 km. However, shortening associated with Step (3) must be at least 25-30 km because the autochthonous footwall of the Iapetan(?) normal fault must lie near Stephenville or farther east. The position of interpreted autochthonous platform and basement in Lithoprobe East Vibroseis lines 12 and 11 bears directly on the magnitude of transport of Humber Zone rocks during the Acadian Orogeny.

Preliminary report on the structural and metamorphic history of the Port aux Basques Complex in southwestern Newfoundland

C.R. van Staal
Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada
J.L. Burgess, M. Brown
Department of Geology, University of Maryland at College Park, Maryland 27042, U.S.A.
and
J.A. Winchester
Department of Geology, University of Keele, Keele, Staffordshire, England ST5 5BG

The polyphase deformed gneisses and schists of the Port aux Basques Complex in southwestern Newfoundland are among the most enigmatic rocks in the northern Appalachians. Our mapping shows that the Complex can be divided into at least three distinct lithological units, separated by large ductile shear zones. From west to east these units are the Grand Bay, Channel Port aux Basques, and Otter Bay divisions. All three divisions are dominated by metasedimentary rocks. The Grand Bay and Channel Port aux Basques divisions also contain mafic volcanic and ultramafic rocks. The shear zones record a complex deformation history, including reverse, and sinistral and dextral strike-slip movements, related to two sets of folds (F_3 and F_4), which also affect the rocks outside the shear zones. D_3 and D_4 indicate, respectively, a sinistral and dextral transpressive deformation regime. The deformation associated with the shear zones post-

dates two earlier phases of recumbent or inclined folding (F_1 and F_2). D_1 and D_2 are accompanied by high-grade metamorphism resulting in multiple stages of porphyroblast growth and matrix recrystallization. The metamorphism which accompanied F_2 is of kyanite-sillimanite type and included development of migmatites by anatexis, is interpreted to be the result of crustal thickening during a Silurian continent-continent collision as manifested in an overall clockwise P-T-t path. In the Channel Port aux Basques Division of the Complex, phase petrology and geothermobarometry indicate temperatures in excess of 650°C and pressures of ca. 8 kbar. The relationships between F_1 and F_2 are at present not well understood, but F_1 was locally accompanied by a phase of sillimanite blastesis.

Deformation mechanism transitions in the Cobequid fault zone, Nova Scotia

J.C. White
Centre for Deformation Studies in the Earth Sciences, Department of Geology, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick E3B 5A3, Canada

As a lithosphere-scale displacement zone, the Cobequid fault zone provides an exceptional opportunity to examine mid- to upper crustal deformation processes. This is spectacularly demonstrated within the Grenville Bay segment where displacements are accommodated by discrete fractures, coherent semi-brittle processes, and penetrative ductile flow. Variations in the deformation processes can largely be interpreted as combinations of inherent strength anisotropy among difference protoliths and localized partitioning of stress and/or strain rate. The widest range of deformation modes is exhibited by fault zone rocks assigned to the Grenville River Formation. The background deformation is pervasively ductile, indicating the predominance of a seismic displacement at the currently exposed crustal level of the fault zone. However, along the tectonic contact between Grenville River sedimentary rocks and a competent rhyolite fault sliver, the expression of deformation changes zonally from extensive sheath fold formation to multiple foliation phyllites to phyllosilicate-rich coherent breccia and gouge as the rhyolite block is approached. This transition suggests a strain rate gradient culminating in transient seismic events adjacent to the rhyolite block. Critical observations include the ability of the fine-grained sedimentary rocks to accommodate large displacements (at high strain rates?), effectively by superplastic flow, and the localized partitioning of displacement into brittle and semi-brittle deformation within a predominantly ductile regime.

Bedrock geology of the Heath Steele-Halfmile Lake area, Bathurst Camp, northern New Brunswick

R.A. Wilson
New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada

The Heath Steele-Halfmile Lake area in the Bathurst mining camp hosts six known base-metal deposits as well as several other mineral occurrences. The area is underlain for the most part by volcanic and sedimentary rocks that are assigned to the Ordovician Tetagouche Group. The Tetagouche Group has been subdivided into several formations, most of which are recognized in the study area. These include the Patrick Brook, Nepisiquit Falls, Flat Landing Brook, Canoe Landing Lake, and Boucher Brook formations. The Patrick Brook Formation consists of quartzofeldspathic and lithic sandstones and wackes that host many of the sulphide deposits in the Bathurst Camp. The Nepisiquit Falls Formation is composed predominantly of quartz and feldspar-phyric flows and high-level sills (quartz-feldspar porphyries) that commonly show a spatial relationship to sulphide mineralization. The Flat Landing Brook Formation is made up of aphyric and feldspar-phyric rhyolite flows that typically feature relict perlitic or spherulitic textures, and local hyaloclastic and rare pyroclastic rocks. Mafic extrusive and intrusive rocks collectively known as the Otter Brook tholeiite are locally abundant within the Flat Landing Brook Formation. The Canoe Landing Lake Formation is represented in the study area by a small portion of a thrust sheet underlain by basaltic rocks referred to as the Nine Mile Brook tholeiite. The Boucher Brook Formation overlies the preceding formations and comprises mainly sedimentary rocks, including a thin basal unit of red to maroon, hematitic and manganiferous slate or chert, overlain by lithic and feldspathic wackes, greywackes, siltstones, and graphitic or manganiferous shales and slates. Intercalated locally with the sedimentary rocks are units of mafic volcanic rock collectively known as the Brunswick alkalic basalt.

Knoll Reef facies and diagenesis of the LaPlante Formation (Late Silurian), northern New Brunswick

Q. Zheng and J.P.A. Noble
Department of Geology, University of New Brunswick, Fredericton, New Brunswick E3B 5A3, Canada

The LaPlante Formation outcrops in a narrow belt from near Petit Rocher southwest to Upsalquitch Lake and consists of numerous scattered small carbonate build-ups and associated strata. Field and laboratory studies indicate that these small carbonate build-ups have the following common features: (1) in morphology, they occur as isolated mounds that range in thickness from 5 to 20 m thick and laterally from 20 to 100 m across; (2) there are three distinct units and five different lithologic facies related to each individual build-up. The core unit consists of a laminar and massive stromatoporoid facies representing the organic production and frame construction. The flank unit is composed of crinoidal packstone and talus breccia facies consisting of large lithoclasts and bioclasts derived from the core unit within a grey shale matrix. The cap unit commonly is a thin layer (0.5-2 m) of grey shale with some bioclasts, representing the final phase of organic accumulation; (3) in core units, the framework builders are mainly stromatoporoids, algae and tabulate corals, and growth cavities are common, especially in the laminar stromatoporoid facies. Core units commonly contain a relatively high content of lime mud and terrigenous clay and silt, suggesting a relatively low-energy environment; (4) from base to top, the abundance of massive stromatoporoids increases and that of laminar stromatoporoids decreases; and (5) no grainstone facies nor lagoonal deposits were found, suggesting lack of strong influence of waves and probably no wave-resistant barriers.

The above features suggest that the small scattered carbonate build-ups in the LaPlante Formation are not fringing reefs, like the reefs in the West Point Formation of Gaspé, but are stromatoporoid-dominated knoll reefs. They formed on the upper slope at the margin of the Bathurst Basin in a relatively low-energy environment.

The LaPlante reefs show five phases of calcite cements formed in different diagenetic environments from marine to shallow burial through meteoric phreatic phase to a final deeper burial phase. Dolomite occurs as an anhedral open-space-filling cement phase and scattered euhedral or saddle form cement phase in cavities and fractures. Anhedral dolomite cement post-dates the latest calcite phase and may be burial dolomite. At least four generations of fractures are recognized and are related to the carbonate cement phases. The several generations of fracturing were formed by early diagenetic processes, brecciation, and tectonic activity. The last diagenetic phase in cavity fillings is authigenic quartz with fine-to-coarse, anhedral-to-euhedral crystal forms. It post-dates all calcite and dolomite.