

MEETINGS

ATLANTIC GEOSCIENCE COLLOQUIUM ON CURRENT RESEARCH IN THE MARITIMES

On December 11th, 1976, the Atlantic Geoscience Society held a one-day meeting entitled: "Current research in the Maritimes", at Mount Allison University, Sackville, New Brunswick. The conference attracted geologists from Maine, New Brunswick, and Nova Scotia from academic, government and industrial circles and was attended by a total of 88. Forty papers were presented, and they covered an extremely wide variety of topics. Abstracts of these topics are presented below. In view of the overall success of the conference the Atlantic Geoscience Society expects to hold a similar meeting in 1978. The organizing committee (R.K. Pickerill, L. Ferguson and D.J.W. Piper) would like to thank attending members of the society for their help and co-operation and also the chairmen of the various sessions (N. Rast, M.J. Keen, D.J.W. Piper, G. Williams and G.E. Pajari Jr.) who ensured that the meeting ran smoothly and efficiently.

MODERN MARINE ENVIRONMENT

ASPECTS OF SEDIMENTATION IN NORTHUMBERLAND STRAIT

BRUCE R. MCMULLIN and H.W. VAN DE POLL, University of New Brunswick, Fredericton, New Brunswick

During the summer of 1975 an integrated sampling program of bottom fauna and sediments was completed in Northumberland Strait to determine the potential effect of sediment type, dispersal and accumulation on the distribution of bottom fauna. This contribution is confined to the sedimentary aspects of the program.

The rocky substrate of Northumberland Strait and surrounding areas is primarily made up of friable Permo-Carboniferous red and grey sandstone and siltstone that has contributed either directly or indirectly to the sedimentary cover of the Strait.

The latter can be subdivided on the bases of grain-size and sorting characteristics into three major units.

1. Glacial and glacially derived sediments.
2. Permo - Carboniferous derived sediments and,
3. A modern fine sand and silt blanket derived from both glacial and Permo - Carboniferous sources.

Areas of active sediment accumulation have been tentatively identified. Core intersections support the conclusions that the sub-surficial relict sediments in the Strait are covered by a veneer of surficial deposits with sorting and grain-size characteristics indicative of extensive reworking under recent hydrodynamic conditions. This observation is consistent with the effects of the present Holocene marine transgression.

TIDAL-INLET CONTROL ON DISTRIBUTION OF SANDY SEDIMENTS, MIRAMICHI ESTUARY, N.B.

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The Miramichi is a shallow, funnel-shaped estuary situated on the eastern New Brunswick shore of the Gulf of St. Lawrence. An extensive barrier-island system, which is cut by three inlets, extends across the mouth of the estuary. The continuous landward flux of coarse-grained detritus through these inlets has maintained generally shallow conditions in the inner bay and restricted channel development. Tidal deltas are defined by a channel-shoal pattern adjacent to the barrier island inlets, and by sand bodies which are diagnostic of tidal-current controlled depositional processes. Echo-sounding and side-scan sonar surveys across these shoals have indicated mechanisms for tidal-current control of the morphology of these sand bodies. A comparison of historical bathymetric charts indicates that the shallow, sand-dominated seaward portion of the estuary has resulted from the continuous accretion and coalescing of migrating unstable flood-tidal deltas. Thus the estuary has been subjected to continuous landward transfer of littoral sand through the inlets; transfer of material by aeolian or storm (overwash) processes has been minimal compared with transfer by tidal-currents.

SHALLOW COASTAL MARINE GEOLOGY IN BOUCTOUCHE, NEW BRUNSWICK

J. THIBAUT and H.W. VAN DE POLL, University of New Brunswick, Fredericton, New Brunswick

Bouctouche Bay in eastern New Brunswick consists of two distinct geomorphological units: (1) the inundated valley of the Bouctouche River forming a broad and shallow estuary, and (2) a coastal lagoon. The estuary-lagoon complex is separated from the Northumberland Strait by a long and narrow recurved spit which extends to the southeast and subparallel to the coast for over a distance of approximately 10 km.

Silt is being deposited in the estuary whereas fine to medium sand derived from the offshore and from coastal erosion of the friable sandstone accumulates to form the spit and the spit platform. The lagoonal sediments comprise a mixture of sand and silt derived from both the estuary and the spit platform.

The relationship between the hydrodynamic environment in the foreshore and estuary-lagoon complex, and the morphology and orientation of macro-sedimentary structures is being investigated.

DISTRIBUTARY MESOCHANNELS, MEGAFLUTES, AND MICRO-TOPOGRAPHY OF NAVY SUBMARINE FAN, CALIFORNIA, AND ITS RELEVANCE TO ANCIENT TURBIDITES

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Navy fan, a late Pleistocene - early Holocene turbidite sequence in about 1800 m water depth, 75 km southwest of San Diego, California, has a well-preserved growth pattern. Conventional geophysical surveys and coring show it to be a type example of modern deep-sea fan sedimentation. A recent deep-tow survey of the fan provided narrow-

beam echo-sounding profiles with a resolution to better than 2 m, 4-kHz seismic reflection profiles and 90 percent scan sonar coverage of 60 km² of the suprafan and adjacent areas. These data together with more than 1000 bottom photographs, reveal a radial pattern of shallow (10 m) distributary channels formed at the terminus of the prominent leveed valley of the upper fan. These channels lead to areas of hummocky relief, which decreases in amplitude downfan. Scours, resembling flute marks but tens to hundred of meters across, have formed in sandy sediments on the middle fan. These scours point in an up-fan direction, and commonly occur in groups in channels. Several examined on intersecting tracks are not slumps, but are depressions to 20 m deep in the fan surface. Acoustic reflectivity (4 kHz) of the surficial sediments and the sediment distribution data from cores show that surface sand is more common in the southern distributaries than in the northern ones, which suggests a migration of the locus of deposition within the mid-fan region.

CORRELATION AND SIGNIFICANCE OF FORAMINIFERAL ASSEMBLAGES FROM REPLICATE CORES, GEORGES BAY, NOVA SCOTIA

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P. MUDIE and D. PLANNE, Dalhousie University, Halifax Nova Scotia

Two 0.5-m long cores were collected by divers from a water depth of about 22 m in Georges Bay, Nova Scotia to study the continuity of observed fossil assemblage relationships over a distance of about 4 m. Spatial variation, even among comparatively abundant species such as *Eggerella advena* and *Elphidium incertum/clavatum* Gp, is substantial and tends to become more pronounced at core depths greater than 20 cm (the mean index of similarity over the first 20 cm is 0.94 compared with a value of 0.87 in the 22 to 60-cm interval). A comparison of fossil assemblages with a recent foraminiferal distribution model for this part of the bay suggests the occurrence of several, major offshore, sediment transport events over the past 300 years.

CORRELATION AND INTERPRETATION OF PALYNOLOGICAL ASSEMBLAGES IN REPLICATE CORES OF MARINE SEDIMENT FROM GEORGES BAY, NOVA SCOTIA

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C.T. SCHAFER, Atlantic Geoscience Centre, Geological Survey of Canada, Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

Two short, diver-retrieved cores from Georges Bay, 0.6 m long and spaced 4 m apart, were studied to determine if the pollen records in this marine bay could be used to correlate Recent terrestrial and marine paleoecological events. By applying a new palynomorph processing technique, both pollen and dinocyst evidence of environmental changes could be investigated. Arboreal pollen assemblages and weed pollen markers, including *Ambrosia*, *Rumex acetosella* and *Plantago lanceolata*, consistently

indicate a post-European depositional history for the upper 30 cm of sediment. In contrast, pollen, cyst and radiocarbon evidence suggests that the lower half of the cores record a history of redistributed marine sediment that was originally deposited during a hypsithermal climatic interval.

USING SALT MARSH DEPOSITS FOR DETERMINING HOLOCENE SEA-LEVEL CHANGES IN THE MARITIME PROVINCES

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A salt-marsh zonation for the maritimes has been established using marsh foraminifera as indicators. These zones can be determined and associated with known sea-level datums in subsurface sediments. Subsurface sediments have been obtained from three Nova Scotia marshes: Chezzetcook Inlet, Chebogue Harbour, and Wallace Basin. Datum levels have been located at different depths in each area and it is possible to determine relative sea-level changes between areas as well as rates of change within an area.

ZONATION IN SALT MARSHES AS DETERMINED USING MARSH FORAMINIFERA

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Detailed sampling of the salt marsh environment has revealed that elevational zones of salt marsh plants and foraminifera roughly correspond. These zones occur because of a complex interaction of environmental parameters including salinity, pH of the sediments, and tidal circulation. Data from both Nova Scotia and southern California indicate that definite zones can be related to certain datum levels so that if the zone is determined, sea level is known to less than one foot (depending on tidal range). This kind of information is useful when studying recent sea level changes.

THE USE OF BENTHONIC FORAMINIFERA AS POLLUTION INDICATORS IN FORT ALBERNI HARBOUR, BRITISH COLUMBIA

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Foraminiferal analysis of core samples taken in Port Alberni Harbour show that increased fibre content has detrimental effects on the benthos. Areas sampled within the fibre blanket are void or greatly reduced in foraminifera. Core analysis revealed that below the fibre blanket, foraminiferal assemblages are greater in abundance and diversity.

Foraminiferal assemblages are related to the macrobenthos. Where *Nonionella* sp (a hardy species of foraminifera) was not found in the surface sample, no other macrobenthos life was recognized.

REEF ECOLOGY AND SEDIMENTS, CASTLE HARBOR, BERMUDA

STEPHEN DRYER and ALAN LOGAN, University of New Brunswick, Saint John Campus, Saint John, New Brunswick

Quantitative studies were conducted on the corals of the fringing, knoll and pinnacle coral reefs of Castle Harbour, and their associated sediments of Castle Harbor, Bermuda. Only about 10% of the available reef substrate is covered with coral. Of this, nearly 80% is occupied by four species: *Madracis mirabilis* (33%), *Oculina diffus* (26%), *M. decactis* (12%) and *Isophyllia* sp. (8%).

Three morphologic-ecologic reef divisions, distinguished by shape, amount of coral cover, and corals present, are recognized: (1) the fringing reefs (2) the northwestern reefs, and (3) the southeastern reefs which are knoll and pinnacle reefs. Coral species are not evenly distributed vertically over the reefs, as recognized by Frazier. However, it is felt that the distribution of corals is controlled by the energy conditions, inclination of substrate and exposure to sedimentation. Thus five major habitats are recognized: (1) horizontal surfaces, (2) vertical surfaces, (3) bottom wall, (4) cavity and crevice, and (5) off-reef.

The sediments are mostly sandy muds or muddy sands with a gradual, but poorly defined, decrease in sediment size with increasing distance from the reefs. *Halimeda* spp. and molluscs make up one-half and one-third respectively, of the sediments.

The homogeneous nature of the cores suggests that, sedimentologically, Castle Harbor has been little altered by the dredging during the years 1941 to 1943. Large massive corals, such as *Diploria* sp. seem to have been most effected by this event, because energy requirements for self-cleaning indicates that survival decreases with increasing colony size.

PHANEROZOIC STRATIGRAPHY AND PALEONTOLOGY

NORTH ATLANTIC CENOZOIC DINOFLAGELLATES

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Cenozoic sediments from 11 Scotian Shelf and 14 Grand Banks wells are rich in dinoflagellates, over 200 taxa having been identified. Species diversity reaches a peak of 96 in the late Eocene, but decreases to less than 5 in the Plio-Pleistocene. Evolutionary lineages involving certain species aid biostratigraphic interpretation. The 12 defined assemblage zones, cosmopolitan in the Paleogene, become increasingly provincial in the Neogene. Correlation of the zones with European type sections indicates that part or all of the Paleocene is missing on the Grand Banks and that the Eocene is a condensed sequence, apart from that in the East Newfoundland Basin. Oligocene-Pleistocene sediments are thin or absent in most of the 25 wells, thickening only on the southwestern margin of the Grand Banks. Marine conditions prevailed throughout the Cenozoic, except in some areas during the Pleistocene. On the Labrador Shelf, the Cenozoic zonation is local, probably reflecting cooler water conditions than to the south.

The lateral distribution of species of *Areosphaeridium* and *Distatodinium* in the Scotian Shelf-Grand Banks wells shows significant patterns, interpreted as reflecting geographic and ecological control. The distribution of these species in offshore eastern Canada, southern England, and in JOIDES core holes, offshore Florida and offshore west Africa, demonstrates provinciality in the Paleogene. Variation in stratigraphic ranges of a further 4 species in the North Atlantic is attributed to water-temperature differences, dependent in part on oceanic currents.

ORGANIC MATTER TYPE AND THERMAL ALTERATION INDEX IN SCOTIAN SHELF, GRAND BANKS AND LABRADOR SHELF WELLS.

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Dispersed organic matter has been examined from Paleozoic to Quaternary sediments in 70 exploratory wells in offshore southeastern Canada. Four types of organic matter, here termed amorphogen, phyrogen, hylogen and melanogen are related to the hydrocarbon potential of the region. The color (Thermal Alteration Index) of the organic matter indicates generally low thermal alteration in the area. In most wells examined, the combination of organic matter type and thermal alteration index are unfavorable for hydrocarbon generation. Exceptions are on the Labrador Shelf where thick Tertiary strata contain predominantly amorphogen, and on the Scotian Shelf close to salt diapirs where higher temperatures are indicated. Organic matter type is also related to the depositional environments. Amorphogen is most abundant in marine sediments, hylogen in non-marine sediments, but phyrogen and melanogen may be common in either sedimentary type.

A BIOMETRICAL STUDY OF CARBONIFEROUS OSTRACODS

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The moulting of ostracods has caused great confusion in their classification because in many cases the various moult stages have been given different specific names. Their classification is further confused by the fact that in the mature moult stages the males and females are sometimes quite different in appearance and have in many cases also been assigned to different species (if not general).

Several "species" of *Bairdia* and several of *Paraparchites* were previously recorded in the Second Abden Shale in Fife, Scotland. These are interpreted (on the basis of extensive collections) to be merely growth stages of one species in each case.

Examination of all specimens in British museums which are assigned to these species further demonstrates the majority of the "species" concerned are themselves spurious and should be suppressed.

Good "clustering" of the instars in *Bairdia* and a lack of clustering in *Paraparchites* are inter-

preted as being due to their growth in stable offshore conditions and highly variable nearshore conditions respectively. It is felt that the degree of clustering might therefore be a useful paleoecological criterion for nearness to shore.

THE LOWER CARBONIFEROUS STRATIGRAPHY OF THE MUSQUODOBOIT VALLEY CENTRAL MAINLAND NOVA SCOTIA

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The Windsor Group in the Musquodoboit Valley consists of 460 m (1500 feet) of marine carbonate, anhydrite and clastics (shale, siltstone and conglomeratic sandstone) which lie with angular unconformity upon the folded slates and metagreywackes of the Meguma Group (Ordovician) and are unconformably overlain by unconsolidated Cretaceous fire clays and Pleistocene till.

A fossiliferous dolostone, the Gays River Formation (new name), is found at the base of the succession and may be correlative with the Macumber Limestone. The Gays River Formation displays two principal facies; a "Bank Facies", up to 60 m thick, associated with positive basement features and laterally continuous with an "Interbank Facies" generally less than 2 m thick. The basal Windsor carbonate, which is elsewhere only sparsely fossiliferous, is found in the Musquodoboit Valley to possess an abundant fauna and flora.

The Gays River Formation is overlain by a 300-m succession of anhydrite and mixed terrigenous-carbonate sediments belonging to the Gleason Brook and Meaghers Grant Formations (new names) respectively. The Meaghers Grant Formation is interpreted to be the nearshore equivalent of the Gleason Brook Formation with which it interfingers, indicating a paleoshoreline to the south of the Musquodoboit Valley.

The units described above are designed the Lower Beds and are disconformably overlain by 150 m of interbedded marine carbonates and siltstones, informally termed the Upper Beds.

A mound-shaped carbonate member occurs at the base of the Upper Beds and is composed of abundant brachiopod shells and *Batostomellid* bryozoan fragments. This member, which interfingers with a thin dark crinoidal carbonate, is faunally and lithologically similar to the Miller or Maxner Limestones (B Subzone) of the type area. These mound-shaped bodies appear to be broadly similar to the Waulsortian Banks of Eire and the bryozoan mounds in the Mississippian of the United States.

A limestone unit bearing the *Gigantoproductus* faunal assemblage is well represented and is informally named the Musquodoboit Limestone. Previous workers have placed it in the E and F subzones of the Upper Windsor, but this study favours a possible stratigraphic equivalence to the limestones of the C subzone.

STRATIGRAPHY AND PALEOECOLOGY OF THE LITTLE POPELOGAN BROOK AREA, UPSALQUITCH FORKS, NORTHERN NEW BRUNSWICK

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A detailed study of the Silurian rocks of the Little Popelogan Brook area has defined and described a succession of stratigraphic units and biofacies.

These stratigraphic units include: the Matapedia Limestone of carbonate turbidite deposits; the Lower Siltstone Unit of cyclic deposits of turbidites and non-turbidites; the Upper Siltstone Unit of shallow marine clastics; the Grit Unit of transitional deposits from nearshore to continental; the Conglomerate Unit of fluvial debris flow deposits and Bryant Formation of volcanic flows. They range in age from Upper Ordovician to Wenlock or younger.

The *Atrypa-Eoplectodonta* biofacies in the Lower Siltstone and Upper Siltstone Unit and the *Phaulactis-Paleocyclus* biofacies in the Grit Unit suggest a regressive phase.

The sedimentologic and paleoecologic evidence thus indicates a continuing regressive trend from an originally deep basin to continental conditions.

SILURIAN STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS IN NORTHERN NEW BRUNSWICK AND ADJACENT AREAS

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On the basis of detailed sedimentologic and paleontologic studies in northern New Brunswick and southern Gaspé the stratigraphic succession and principle facies relations of the Silurian have been established. The main tectono-sedimentary elements were the Tetagouche Mountains alluvial fan in the Tetagouche River area, the Matapedia trough turbidites to the west, and turbidites of the fault-rounded Bathurst basin to the east and the shallow marine limestones and clastics of the broad Chaleur Bay shelf to the north. A general transgression southward took place during the Llandovery and Wenlock local uplift, and regression occurred along major faults at various times; this activity was associated with a linear belt of volcanism immediately west of the Tetagouche Mountains during middle Wenlock times.

TIDAL POOL ROCKY BOTTOM COMMUNITIES IN THE TRENTON LIMESTONE OF THE QUEBEC CITY AREA

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Rocky habitats are usually zones of erosion rather than sedimentation and are therefore rarely preserved in the geologic record. Northeast of Quebec City an outlier of autochthonous Middle Ordovician Trenton Limestone sits almost horizontally and with pronounced unconformity on the underlying Precambrian Grenville Gneiss. This

unconformity records such an example of a fossilized rocky habitat. It is particularly well illustrated in the Montmorency River section where, following the initial Trenton transgression, algal-dominated (*Solenopora*) communities developed on the irregular and boulder-strewn Precambrian topographic highs in tidal pools and weathered and eroded joint systems. These topographic highs probably represented small islands developed adjacent to a receding rocky coastline. Between the islands buff-weathering glauconitic sandstones were deposited. Subsequent coastal recession and associated transgression were accompanied by the cessation of glauconitic sandstone deposition and the establishment, more or less throughout, of *Solenopora*-dominated communities.

PROGRESS IN PALEOZOIC STRATIGRAPHY OF NOVA SCOTIA

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Nova Scotia

Early Paleozoics. After my regional study of the sedimentology of the Meguma, my students and I have been making very detailed columnar sections of the best, continuous exposures of the Group. These sections have been made both across and along strata. The Meguma consists of a number of coalescing deep-sea fans with intervening shaly units both between fan distributaries and also up on the continental slope.

Time control is vital for paleogeographic reconstruction so we are continuing our attempt at zonation by digesting slate for acritarchs and chitonozoa. Fear of large-scaled rotation of vectoral properties has launched a number of studies by honours students of strain-analysis in the Meguma terrain. Other students are attempting to map the "paleogeology" and tectonic activity of the Browns Mountain Group by studying the provenance and dispersal of Carboniferous molasse.

Middle Paleozoics. Tom Lane is completing his study on the White Rock Formation, has defined seven lithosomes, established lithic as well as time control, recognized widespread glacio-marine diamicrites, and related the succession to glacio-eustatic changes in a near-shore environment. Lynden Jensen is completing his study on the Lower Devonian Torbrook Formation, has identified twelve main environments, and proposes an involved model of nearshore sedimentology.

Late Paleozoics. For the first time, I have detailed, three-dimensional control over a single carbonate sheet not affected by tectonics. Barry Hatt and a number of honours students have worked with me in logging in close detail a beginning of the 250,000 feet of core at Gays River. Imperial Oil Company has been most co-operative.

Plans. Until we can zone the Early and Middle Paleozoics, I shall concentrate on the mud mound at Gays River. On sabbatical next year, I shall visit the Irish equivalents, and also continue my chase of the Meguma's source in Morocco, Iberia, and even Columbia!

SEDIMENTOLOGY OF THE HALIFAX FORMATION, SOUTH SHORE, NOVA SCOTIA

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The Halifax Formation at Blue Rocks, the Ovens and Rose Point, Lunenburg County, Nova Scotia, is well exposed and little metamorphosed. Shales with thin (1 to 10 mm) siltstone laminae are the most abundant lithology. The siltstones may be internally parallel or cross-laminated or occur as single, thin laminae. They are commonly lenticular and may display irregular loading into the shale. They are laterally extensive and have been traced for over 50 m. Thick (3 m) sandstones occur as massive to graded beds often with some of the Bouma A to E divisions present, and with sharp, scoured or flute coast bases. These beds wedge out over 50 to 100 m, or occasionally occur as lenticular bodies over about 10 m with rip-up shale clasts at their lower margins. Thin (2 to 20 cm) sandstones usually show parallel or cross-lamination, and have sharp, flat or sometimes load cast bases. They have been traced laterally for over 150 m.

These lithologies occur in repeated fining upward sequences, each showing a decrease in the thickness and frequency of sand beds over 10 to 50 cm of section. Occasional slump horizons (extending over 5 to 50 m) may indicate the proximity of a channel or lobe margin. The whole sequence is interpreted as part of a deep-sea fan complex, probably on the lower suprafan.

Erosional features (1 to 50 cm in magnitude) are commoner at the tops than at the bases of sandstone and siltstone beds. They occur most frequently where the upper part of the bed is rippled, the depth of the erosion tending to increase with the thickness of the sandstone. This may be interpreted as auto-erosion within one turbidity current flow. Other erosional features may be the result of scouring by contour currents.

IGNEOUS AND METAMOPHIC ROCKS

STUDIES OF GRANITIC ROCKS IN SOUTHWESTERN NEW BRUNSWICK

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Since 1969 a number of research programs designed to study the granitic rocks in southwestern New Brunswick has been carried out by faculty and students of the Geology Department, University of New Brunswick. These programs have included field study, petrography, whole-rock major and trace element analyses, and Rb/Sr radiometric dating (through the co-operation of Dr. R.F. Cormier, St. Francis Xavier University). The data accumulated from these programs indicate the emplacement of highly differentiated granitic magmas into two levels of the crust from Silurian to latest-Devonian - early Carboniferous time. The data are now being assembled for interpretation of their implications for understanding of the generation and emplacement of granitic magmas.

*CONTRASTS IN THE YOUNGER AND OLDER GRANITES IN
CENTRAL NEW BRUNSWICK*

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Granitic batholiths, stocks and bosses occur in a northeast-southwest zone extending from the International Border near Woodstock, New Brunswick to Chaleur Bay. The granites traverse rocks ranging in age from Lower Ordovician and older to Middle Silurian, and yield isotopic dates which range from 497 to 339 my. The majority of the plutons intrude the highly deformed and metamorphosed rocks that constitute the core and flanks of the Miramichi Anticlinorium.

The Younger Granites are predominantly quartz monzonites associated with varying amounts of granite and, to a lesser extent, granodiorite. They intrude rocks as young as Middle Silurian post-tectonically and discordantly, are virtually unaltered and have relatively narrow contact aureoles. The contact metamorphism is mostly developed in the epidote-albite hornfels facies but locally reaches the hornblende hornfels facies. The Younger Granites are thought to represent epizonal and, in some locations, sub-volcanic intrusions, which have been recomposed during the Carboniferous period.

Collectively, the Older Granites are much more heterogeneous than the Younger Granites. Certain granite types are associated with certain parts of the structural and stratigraphic sequence. Compositionally the Older Granites range from granodiorite to quartz monzonite. They intrude psammitic and semi-pelitic schists and migmatite gneisses to Lower Ordovician or older age but smaller, localized bodies to transect Middle Ordovician strata. Younger rocks have not been observed to be affected. The Older Granites are concordant, syntectonic intrusions with dynamothermal aureoles. The relative distribution of the granites and the types of aureoles displayed are apparently controlled by how far the plutons rose into the supracrustal sequence above the migmatite front or Unterbau.

*SIGNIFICANCE OF GRAIN SIZES IN A TRIASSIC THOLEIITE
SILL, GRAND MANAN ISLAND, NEW BRUNSWICK*

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The length and width of rectangular plagioclase grains were measured in thin sections selected at intervals from a 150-m thick horizontal diabase sill. The variation of the measured grain sizes is a function of the three-dimensional size of the plagioclase crystal as well as the physical position and orientation of the crystal intersected by the thin section.

A predicted frequency of two-dimensional grain sizes can be generated by computation from randomly orientated orthogonal crystals of a specified size. This computation is simplified if only the size frequency of two-dimensional rectangular grains is required. This simplification arises from the

fact that orthogonal crystals sectioned parallel to the axes that are perpendicular to the crystal faces only result in rectangular two-dimensional grains irrespective of the degree of rotation.

The measured grain-size frequency curves were matched with curves obtained from computed crystal sizes. By this process the dimensions of the plagioclase crystals in the specimens, as well as the relative volumes of each of the crystal sizes constituting the specimen, could be obtained.

The direct results showed, therefore, that each of the specimens contained a seriate population of crystal sizes. Relating the relative volumes of each of the crystal sizes to a cooling history for the sill obtained from heat conduction models, and considering that the smallest crystals crystallized last, it can be shown that all levels of the sill have solidified under conditions of increasing nucleation rate, i.e. progressive supercooling.

ALTERED WALL ROCKS AS A GUIDE TO MINERALIZATION

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The wall rock alteration attending epigenetic mineralization is outlined in rocks which range in age from Precambrian to lower Palaeozoic. The wall rocks include a variety of metamorphic and igneous rocks that can be grouped into three types: (1) those containing moderately abundant K-feldspar, (2) those containing abundant Fe-bearing minerals, and (3) those containing abundant Mg-bearing minerals. The first group includes biotite-muscovite granite, granodiorite, microcline-quartz-plagioclase-biotite gneiss, and biotite-quartz-plagioclase and related gneisses; the second group includes quartz diorite, amphibolite, quartz-biotite-garnet gneiss and schist; and the third group includes magnesian skarns.

In general, the altered wall rocks are similar throughout the region in that new mineral assemblages were derived from the pre-existing mineral assemblages, but in detail the degree of alteration, the width of the altered zones, and the type of alteration varies because of differences in lithology and structure of the host rocks and the differences in the intensity of the mineralizing solution. The width of the altered rock zones that bound the mineralized veins ranges from a few inches up to a few hundreds of feet. In Cape Breton Island, the epigenetic mineralization of various types is associated with one or the other type of alteration. These include feldspathization, tourmalinization, skarnification, sericitization, chloritization, silicification, pyritization, serpentization and steatization.

Similar, repetitive mineralogical-textural changes take place during wall-rock alteration with respect to type of mineralization and types of host rocks.

The mineralizing solutions that altered the rocks, as inferred from the mineralogical changes in the host wall rocks, were relatively dilute, slightly acid, and initially carried K and subsequently CO₂ and S ions or complexes. In high temperature

alteration B, F and Cl were very important.

Altered wall rocks are infallible guides to mineralization because the alteration and mineralizing processes were nearly contemporaneous. However, narrow zones of alteration are of limited help in searching for mineralization because finding the altered rock is about as difficult as finding the mineralization.

PROGRESSIVE COMPOSITIONAL VARIATION AND PARAGENESIS OF METAMORPHIC OLIVINES

R. DAMIAN NANCE, St. Francis Xavier University, Antigonish, Nova Scotia.

Meta-dunites from the mafic-ultramafic klippen of the Livadi Complex in northeastern Greece show a progressive compositional variation in their constituent olivines. The percentage of forsterite which remains homogeneous on a mesoscopic scale, systematically decreases with increasing structural height and, over a vertical thickness of 250 m, exhibits the range Fo97 - Fo89.

Petrographic and geochemical data are consistent with the derivation of these olivines through the metamorphic dehydration of a serpentine produced by the complete, isochemical hydration of a primary dunite of essentially uniform composition. An origin for the observed compositional trend through mechanisms involving magmatic differentiation and the degree of serpentinization is consequently precluded.

However, the composition of metamorphic olivine will ultimately depend on the partitioning of Fe between serpentine and magnetite which is itself dependent upon the effective oxygen fugacity of serpentinization. A model involving a progressive decrease in the effective FO_2 of serpentinization with increasing structural height is consistent with the modal distribution of magnetite and the anomalous Ni-variation trend of the olivines, and may indicate a decrease in temperature in this direction during serpentinization accompanying tectonic transport.

CURRENT PROJECTS IN Rb/Sr GEOCHRONOLOGY AT ST. FRANCIS XAVIER UNIVERSITY

R.F. CORMIER and JOHN A.R. STIRLING, St. Francis Xavier University, Antigonish, Nova Scotia

Rb/Sr ages are being measured in granitic rocks from the Cobequid Mountains, the Antigonish Highlands, the South Mountain batholith, and Fourchu Group volcanics in Cape Breton.

Two undeformed granites and two cataclastic granites in the Cobequids are being investigated and the preliminary results indicate an Acadian age. Samples have been collected from a gneissic granite and these will be processed this winter. The Fourchu Group volcanics were sampled in 1975, and again last summer. None of the samples contains suitable Rb/Sr ratios to be dated. Several plutons were sampled in the Antigonish Highlands and they will be processed this winter. Mineral ages are being determined for the South Mountain

batholith and these results will soon be published.

In southern New Brunswick, work is continuing on the Tower Hill stock; a megacrystic granite and other granitic rocks from the western end of St. George pluton will also be analysed.

The following isochron ages have been completed:

		$(^{87}\text{Sr}/^{86}\text{Sr})$
*Bocabec Complex	394 ± 20 m.y.	0.7065
Beech Hill Stock	345 ± 15 m.y.	0.7186
Eastern End of the St. George Pluton	335 ± 12 m.y.	0.724
Harvey and Mt. Pleasant Volcanics	324 ± 10 m.y.	0.7144
Older Deformed Granite in Northern New Brunswick	489 ± 14 m.y.	0.7030
Rb ⁸⁷ Decay Constant	$1.39 \times 10^{-11} \text{ yr}^{-1}$	

* Previously published in Can. J. Earth Sci., V. 11, 1309-1313 (1974).

PARTICLE TRACK STUDIES - URANIUM IN THE PORPHYRY ORE ENVIRONMENT

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Nuclear track techniques of mapping variations in the distribution and concentration of uranium in oceanic rocks have proved extremely sensitive in using particle tracks as indicators not only of primary magmatic variation but also of secondary hydrothermal and halmyrolitic alteration.

Current research involves the application of similar techniques of uranium analyses to hydrothermal "porphyry" environments. Preliminary studies on the distribution of the element in the El Salvador porphyry copper deposit in Chile indicate that the distribution of uranium may be related to zonal patterns of hydrothermal alteration.

Rocks collected from various known porphyry ore deposits will be studied to establish uranium concentrations within zones of hydrothermally altered rocks in the deposits. This will provide information on the behaviour of uranium hydrothermal ore systems and may aid exploration for copper, molybdenum or even uranium porphyry ore deposits.

This research is being supported by the Canadian Department of Energy, Mines and Resources and Dalhousie University.

STRUCTURE

STRUCTURAL MAPPING IN THE COBEQUID MOUNTAINS

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Structural mapping in the Cobequid Mountains in the last several field seasons has shown that several lithotectonic units exist with a distinctive

structural history and lithology. The most intensely deformed lithotectonic unit is exposed along the southern margin, next to the Cobequid fault; several generations of folding have affected these rocks. The age of these rocks is unknown; however the times of deformation appear to be Devonian and Carboniferous.

The remainder of the stratified rocks in the Cobequid Mountains are divisible into three lithotectonic units. Rocks in these units are Silurian; Middle Devonian; and Middle Carboniferous. The time of deformation appears to be Middle Carboniferous.

VARIATION IN STRUCTURAL HISTORY - WINDSOR GROUP OF THE EASTERN MINAS SUB-BASIN

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Detailed studies of the Windsor Group in the Shubenacadie-Stewiacke structural basin and in the Musquodoboit River Valley have shown that these rocks are typically little deformed except adjacent to major faults.

In the northwestern part of the Shubenacadie-Stewiacke basin, large scale recumbent folds which affect both the lower and upper Windsor, are well documented. These structures are known to involve the units above the thick lower sulphate, and appear to have fold limbs several miles in length. The data available indicate that this deformation may be attributable to a single large-scale fold which may have originated as a nappe.

In the northeastern Minas Sub-basin, structural complexity is much more typical. A large asymmetric syncline has been mapped in the Green Creek area, in which Upper Windsor members are involved. In the Walton River area, a single carbonate unit has been noted 12 times in a 300-m diamond drill hole, repeated through both faulting and tight folding.

Salt tectonics cannot entirely explain the observed deformation, which appears from preliminary studies, to be in part regionally systematic. It appears that differing tectonic settings best explain the observed variation in structural history. Regional lithostratigraphic variation supports this hypothesis.

TECTONIC SUBDIVISION OF SOUTHERN NOVA SCOTIA

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The rocks of southern Nova Scotia can be divided into three tectonic provinces: the Sonosco Pre-Cratonic Province, the Nova Scotia Epi-Cratonic Province, and the Blomidon Epi-Cratonic Province. They represent successive stages in cratonization.

The Sonosco Pre-Cratonic Province is interpreted as part of an orthotectonic orogen. It ranges in age from (?) Cambrian to Devonian. Its nature changed from an Atlantic-type continental margin during the Cambro-Ordovician to a Pacific-type continental margin in the Silurian culminating

in continental collision during the Devonian.

The Nova Scotia Epi-Cratonic Province is bounded by the Acadian Orogeny and the Maritime (Hercynian) Disturbance. The rocks, predominantly non-marine clastics with some marine intercalations and rare sills were deposited in and around the complex Fundy rift system and were affected by Germano-type structures. These structures were generated during lateral movements produced by the relative rotation of the North America and Gondwana cratons.

The Blomidon Epi-Cratonic Province is represented by cratonic cover rocks of Triassic and Cretaceous age. They were deposited on stable continental margins and in rift valleys accompanied by tholeiitic volcanism. The rift structures are interpreted as an aulacogene produced during the formation of the Atlantic Ocean.

IDENTIFICATION AND CORRELATION OF FAULT BLOCKS OF CAMPOBELLO ISLAND

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Current mapping of Campobello Island, located in the southwesternmost Passamaquoddy Bay area of New Brunswick, reveals three lithologically and structurally distinct fault blocks. The blocks are identified as: Lower Silurian Quoddy Formation sediments and volcanics, possible Mid-Upper Silurian sediments and volcanics, and Precambrian Coldbrook Group volcanics. In the presentation, these blocks are correlated with similar rocks to the northeast (southwestern New Brunswick) and to the southwest (Southern Maine). Faults delineating the boundaries of these blocks are correlated with the Back Bay, Letang, and Bellisle faults of New Brunswick and the Lubec and coastal faults of Maine.

Structural differences between the two Silurian sections are attributed to their proximity to the Precambrian basement.

GEOPHYSICS

DETECTION OF HOLOCENE SECULAR VARIATION IN THE GEOMAGNETIC FIELD USING MARINE SEDIMENT CORES FROM GEORGES BAY

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Nova Scotia and
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Paleomagnetic measurements have been made on two sets of duplicate cores collected in Georges Bay, Nova Scotia. The water depth at both locations was about 21 m and the duplicates were sampled about 2-m from each other. Three of the cores were totally oriented and one was vertically oriented.

One of the duplicate cores from the Pomquet Head area appeared to exhibit four secular variation cycles in declination. Assuming that the average cycle lasts about 2500 years, the age of the core at a depth of 80 cm is about 8500±2500 years. The

three other cores did not exhibit a similar pattern of declination. Two of these were found to be unsuitable for paleomagnetic measurements because of their texture and bioturbated(?) character. The third core was probably disturbed during sample recovery.

Inclination as a function of depth does not exhibit a cyclical pattern in any of the cores. However, all cores show a reproducible pattern of shallowing inclination with increasing depth and a 5-fold decrease in magnetic intensity over the top 10 cm.

Marine sediments from the Georges Bay areas sampled to date are not ideal material for establishing a magnetic stratigraphy reference section for eastern Canada. However, given a well defined reference section, they are potentially datable by paleomagnetic techniques.

THE ORIGIN OF THE NINETYEAST RIDGE AND THE NORTHWARD MOTION OF INDIA, BASED ON DSDP PALEOLATITUDES

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Paleomagnetic data are presented from the sediments and basalts at DSDP sites 213, 214, 216 and 217 on, or near the Ninetyeast Ridge in the eastern Indian Ocean. The paleolatitudes confirm that the ridge is attached to the Indian plate and that both have moved rapidly northwards since the Late Cretaceous. The Indian plate moved northwards with respect to the south pole at an average rate of 14.9 ± 4.5 cm/yr from 70 mybp until about 40 mybp when it slowed to its present rate of $5.2 \pm .8$ cm/yr.

Basal paleolatitudes on the Ninetyeast Ridge indicate that its volcanic source was approximately fixed in latitude near 50° S, supporting the concept that the ridge is the trace of the Kerguelen hotspot on the northward-moving Indian plate. The existence of a "mirror ridge" on the Antarctic plate and the very shallow depths of basement formation on the ridge suggest that the Indian-Antarctic spreading center must have remained near the hotspot from 80 to 40 mybp in spite of one-limb spreading rates of up to 12 cm/yr. This is unexpected in view of the apparently small amount of motion of the Antarctic plate during this time. It is suggested that Antarctica was held nearly fixed by the geometry of other plate motions and, therefore, the Kerguelen hotspot caused asymmetric accretion of new plate material at the southwestern end of the Ninetyeast Ridge. Evidence of such asymmetry has been reported in the form of an 11° southerly migration, or jump, of that spreading centre.

The Ninetyeast Ridge paleolatitudes are consistent with the Deccan Traps paleomagnetic poles. However, a comparison of the Australian paleomagnetic poles and these data shows a major inconsistency between 50 and 40 mybp. Although the reason for this inconsistency is not known, the error may be in the present estimates of the relative motions between India and Antarctica, and

between Australia and Antarctica as well as the paleomagnetic data itself. The two sets compare favorably in rate but the DSDP data imply that India was 13° farther south than the Australian poles indicate.

GRAVITY AND THE SUBSURFACE OF THE SOUTH MOUNTAIN GRANITIC BATHOLITH, NOVA SCOTIA

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We study again the three-dimensional shape of the complex of granitic bodies which underlies much of mainland Nova Scotia. These bodies are now known, from the work of C. MacKenzie, D.B. Clarke and others, to be a composite of various granitic rocks, which range from tonalites, relatively SiO_2 -poor, in western Nova Scotia to adamellites and SiO_2 -rich differentiates in other parts of the South Mountain batholith and the eastern, isolated plutons. We show that the most intense gravity low is associated with the major adamellite complex of New Ross, and that many of the changes in the Bouguer gravity anomaly field can be ascribed to variations in density between the granitic bodies, and not only to the contrast between the granites and the surrounding meta-sediments.

These intra-batholith variations in density lead to changes in gravity which place constraints upon the possible shapes of the adamellite bodies, for example, at depth. The eastern plutons, isolated from the main batholith in outcrop, may in fact be connected at depths of up to a few kilometres to the main batholith, and the meta-sediments of the Meguma become from this point of view mere roof shingles upon a large granitic complex.

There is little expression in the gravity field in western Nova Scotia of the granitic bodies; this will arise whether or not these bodies are extensive, because these bodies have higher densities than the eastern granites, and therefore little or no density contrast with the meta-sediments.

With these reservations, the batholith appears to be shaped rather like a flattened tear-drop, similar to the shape proposed by G.D. Farland, but with its central part extending to 20 km (not 29 km), and its sidelobes to 10 km, not three. Mineralization is relatively extensive within the New Ross adamellite complex, and gravity might possibly be a guide to mineralization in other adamellite bodies where surface exposures are poor.

LOCATING FOSSIL EARTHQUAKES IN SPACE AND TIME

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Earthquakes are useful tools in interpreting the dynamics of the earth's crust of today. Earthquakes are manifestations of brittle failure within the earth's crust. Study of brittle failure in the laboratory and the field over the last 50 years has shown the importance of pore fluids in the formation and orientation of cracks during failure. Pore-fluid theory has proved useful in interpreting earthquakes and their precursors.

If pore fluids can fill cracks resulting from an earthquake or its precursor and if that fluid solidifies or precipitates a filling, those cracks may be preserved and their orientations will reflect the stress field which caused the failure.

Certain practises (such as dating potassium-bearing minerals; sulphide, oxide, silicate and fluid inclusion studies; paleomagnetic analysis and careful field measurements of the fillings) can allow a history of stress-strain conditions to be estimated. This approach is being attempted with basic dykes and quartz-carbonate-sulphide veins in Nova Scotia.

ECONOMIC GEOLOGY

GEOLOGICAL APPRAISAL OF SUBMARINE COAL RESOURCES IN SYDNEY FIELD OF NOVA SCOTIA

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In the Sydney coalfield nearly all the remaining coal resources (calculated at 1.3 billion tons to 5 miles from shore) occur under the Atlantic Ocean. For a quantitative and detailed geological appraisal of these resources, expensive offshore drilling will be necessary. However, in addition, much can be learned about the seam development from comparisons of seam sections in adjacent worked areas. Correlation of stone partings and splint bands provide data on the possible direction of fluvial sedimentation that interfered with coal deposition. The general direction of seam deterioration by splitting can thus be indicated. This is illustrated with the Harbour and Phalen seams, which have been the main producers of the field.

When in the offshore area, rotary well samples are available also for coal evaluation, then the difficulty of recognizing truly representative seam samples is presented. Due to caving there usually is much mixing of coal fragments from one seam to another. However, the degree of caving can be judged from rank variations (in relation to Hilt's Law) of individual coal particles, as determined by vitrinite reflectance measurements. Highly mixed cuttings can thus be discarded and only the least contaminated ones used for further analytical studies. This procedural method is illustrated with a well drilled in the offshore portion of the Sydney coalfield, of which the cuttings have been examined with regard to true seam representation, rank, petrography, pyrite distribution and coking characteristics.

STRUCTURAL MODEL FOR THE SADDLE REEF AND ASSOCIATED GOLD VEINS IN THE MEGUMA GROUP, NOVA SCOTIA

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Auriferous quartz veins occupy zones of dilation. Fold-generated dilation zones are systematically distributed and are dependent upon the folding mechanism. Comparison of natural and theoretical

folds indicates that different mechanisms operated in the Halifax and Goldenville Formations.

In the slates of the Halifax Formation, the folds are of similar type and internal strain is most intense in the limbs. This internal strain is probably accommodated with little or no dilation.

In the meta-sandstones and slates of the Goldenville Formation, a combined flexural and tangential longitudinal strain mechanism modified by pure strain, produced the folds. Tension fissures produced by this mechanism are: (a) saddle reef veins in slate horizons, (b) veins normal to bedding in meta-sandstone layers in the fold hinges, (c) veins along faults in the cores of tight fold hinges, and (d) zones of en echelon veins in slate horizons in the limbs of folds. Since veins in fold hinges (a, b and c above) account for most of the gold production in the Meguma Group, other factors controlling the distribution and size of the veins are summarized as follows:

1. The size of the saddle reef veins is controlled by the curvature of the fold hinge. Thus a Curvature Index greater than 600 degrees indicates a promising prospect, e.g.,

$$\text{Curvature Index} = \frac{\theta}{h - 1/2 W} \quad \text{where}$$

θ = the change in attitude of the folded surface measured at two points close as possible on either side of the axial trace of the fold

h = the distance between the two measurements measured perpendicular to the axial trace

W = wavelength of the fold.

In general, the Curvature Index increases with depth in anticlines, and decreases in synclines. Therefore, in the largest first-order anticlines the Curvature Index reaches suitable values at depths of about 1.5 miles beneath the Halifax-Goldenville boundary. Smaller folds, for example, fourth-order Oldham anticline, are also good prospects and are not restricted by depth.

2. Domes are associated with many gold districts.

3. Conical folds are associated with most gold districts.

4. An angle of less than 35° between the fold limbs is a favourable prospect.

The association of several of the above factors increases the potential of an area.

*STRATIGRAPHY AND FACIES LIMITS OF SYNSEDIMENTARY
COPPER-SILVER OCCURRENCES IN SOUTHEASTERN NEW BRUNSWICK*

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Fredericton, New Brunswick

Copper-silver, locally with minor lead, and copper-silver-mercury-vanadium occurrences in Carboniferous strata of southeastern New Brunswick form part of a mineralized belt that extends from Cape Enrage in New Brunswick to Amet Sound, Nova Scotia.

The stratigraphic limits and vertical facies characteristics of the mineralized interval suggest that the conditions that have led to a change in the depositional environment from bahada-playa to fluvial has also played an important part in metallogenesis.

Two major types of mineral associations can be identified. Of these, oxide native-alloy minerals are confined to arkosic redbeds in which organic material appears absent whereas sulphide minerals, usually but not exclusively in association with comminuted plant remains, are confined to grey fluvial strata.

Tentative results from the present investigation indicate that marine regression sequences in combination with a palaeoclimatic change from relatively arid to more humid conditions may be of metallogenic significance, and should not be over-looked in the economic evaluation of sedimentary basins.

*GEOLOGIC INVESTIGATIONS, NEW BRUNSWICK DEPARTMENT
OF NATURAL RESOURCES*

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Department of Natural Resources, Mineral
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The Mineral Resources Branch of the New Brunswick Department of Natural Resources is mainly concerned with providing basic geologic data for mineral exploration and development, and land-use planning.

A large portion of the Precambrian, Cambro-Ordovician, and Silurian volcanic and sedimentary rocks in northern and southern New Brunswick have been mapped in detail (scale one inch equals one quarter mile) in recent years with financial assistance of the Canada Department of Regional Economic Expansion. Geophysical studies are conducted in conjunction with geological investigations. Stream-sediment geochemical surveys have been carried out throughout most of the province.

Computer-oriented systems were developed to facilitate collection, storage and retrieval of geological, geophysical and geochemical data. Synthesis of this data is used to provide models for mineral exploration, and as a basis for long term planning.

In addition to regional surveys, commodity-oriented investigations, mainly concerned with industrial, energy and granular resources are also in progress. It is anticipated that these investigations will be expanded.

*THE APPALACHIAN/CALEDONIAN OROGEN PROJECT OF THE
I.G.C.P. - A GATHERING OF PALEOZOIC GEOLOGISTS*

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Nova Scotia

This project is one of 150⁺ sponsored by UNESCO and the IUGS under the International Geological Correlation Program to promote international communication and assistance in the earth sciences. The Caledonian Orogen project (CO) began in 1975 under Brian Sturt of Norway to attack the now-disrupted segments of the Caledonide-Appalachian-Mauritanide orogen. Through the 7 year-life of the project, geologists will study by international teams the Late Precambrian through Devonian rock of these segments. Each of 18 participating countries have organized themselves under the Canadian plan into seven working groups. In Canada, these are headed by George Pajari (Plutonism), Steve Papezik (Volcanism), Duncan Keppie (Deformation), Walter Trzcienski (Metamorphism) John Riva (Faunal Provinces jointly with the United States group), Hank Williams (Western Margin and Basement/Cover Relations), and Paul Schenk (Eastern Margin and Stratigraphy/Sedimentology). Write to these people. Thus far in Canada we have for the first time organized integrated multi-disciplinary studies on our segment. We have led seven fairly large-scale field trips. Some of us have participated in excursions to Sweden, Norway, and next year to France, Iberia, and Morocco. The international group has met at Oslo, Bergen, and this fall in Nova Scotia after which we ran field trips on the plutonics, eastern margin, deformation, and western margin. Each country has also prepared short regional syntheses, "slice of time" maps for international compilation on the Ashgillian Stage, and diachronous deformation down the orogen. The purpose of the project is to formulate concerted, multispecialist projects on the Paleozoics of Atlantic Canada and Quebec, and also to promote international communication and exchange.

*GEOLOGICAL DATA MANAGEMENT: WHAT IT MEANS TO THE
WORKING GEOLOGIST*

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Oceanography, Dartmouth, Nova Scotia.

The presentation describes progress in the establishment of curation and data management facilities at the Atlantic Geoscience Centre, Dartmouth, Nova Scotia, and shows how even the small effort so far expended has helped geologists use their time more effectively.

The overall envisaged structure of the geological data system is presented and those modules already operational are described and their effects on the working geologist noted with a few case histories. The possible effects of future developments are also noted in summation.