GEOLOGICAL SURVEY OF CANADA

OPEN FILE 3118

Canada-Nova Scotia Cooperation Agreement on Mineral Development (1992-1995), Federal Exploration Stimulation Program: project summaries and cumulative bibliographies

compiled and edited by
D.G. Richardson

1996

Natural Resources Canada Ressources naturelles Canada

Canada

COOPERATION

COOPERATION
AGREEMENT ON
MINERAL DEVELOPMENT

ENTENTE DE
COOPÉRATION SUR
L'EXPLOITATION MINÉRALE

Contribution to Canada-Nova Scotia Cooperation Agreement on Mineral Development (1992-1995) a subsidiary agreement under the Economic and Regional Development Agreement.

Contribution à l'Entente de coopération Canada-Nouvelle-Écosse sur l'exploitation minérale (1992-1995), entente auxiliaire négociée en vertu de l'Entente Canada/Nouvelle-Écosse de développement économique et régional.

Canada

Nova Scotia
Province of
Nova Scotia

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Contents

INTRODUCTION

This report summarizes the results of projects carried out by the Geological Survey of Canada (GSC) under the Federal Exploration Stimulation Program of the 1992-1995, Canada-Nova Scotia Cooperation Agreement on Mineral Development [CNSCAMD]. The agreement was one of several subsidiary agreements developed under the general umbrella of the 1984-1994, Canada-Nova Scotia Economic and Regional Development Agreement.

The purpose of the Exploration Stimulation Program component of the CNSCAMD was to coordinate the efforts of Canada and Nova Scotia to enhance the activities of the private sector by producing the new geoscientific data required to permit discovery of new mineral resources. Funding in excess of $3.7 million was provided for the Program, cost shared between Canada and Nova Scotia approximately in the proportions of 70% and 30%, respectively. The term of the Program extended from April 1, 1992 to March 31, 1996. The GSC was provided with funding of approximately $2.7 million by the Atlantic Canada Opportunities Agency (ACOA) in order to implement the Federal component of the Exploration Stimulation Program. Actual Federal Exploration Stimulation Program project expenditures are provided in Appendix A.

Project summaries document work that was completed by university-based geologists, consultants and contractors, as well as by geoscientists from the GSC, many of whom collaborated closely with staff of mineral exploration companies and the Minerals and Energy Branch of the Nova Scotia Department of Natural Resources (NSDNR). Individual projects report on a wide range of activities related to mineral deposit geology, including: regional geology; structural geology; glacial geology; mineral deposit modelling; geochemistry; airborne geophysics; seismic studies; GIS computer applications; and near shore aggregate investigations. Each project summary is accompanied by the name of the responsible GSC project leader, a location map, and a cumulative bibliography of resulting publications, abstracts, work being prepared for publication, and manuscripts that are currently being reviewed. Project bibliographies document outputs produced up to June 1996.

Although it is too early to measure all of the impacts generated by the Federal Exploration Stimulation Program, the results summarized herein indicate that the Program has helped strengthen the mineral-resource base of the Province, and thus fulfilled a primary objective of the CNSCAMD. A major contributing factor to the success of the Program was the federal-provincial framework of cooperation in which program development occurred. The general thrust of the Program was determined jointly by federal and provincial coordinators to reflect provincial priorities and the interests of the mineral exploration industry. Within this framework, individual project proposals were developed jointly through working groups composed of interested scientists to provide a "best fit" program incorporating the needs of various clients and the available expertise. This approach to program planning generated relevant, applied projects that have resulted in increased provincial exloration activity and helped better target private-sector exploration and development programs. Notable accomplishments include:

- the discovery and definition of extensive deposits of Cretaceous filler-grade kaolin in the Musquodoboit Valley, Shubenacadie area of Hants and Halifax Counties, that have applications in the paper industry and possibly in the manufacture of other higher value products.
- significant revisions to the regional and structural geology of the Carboniferous basins of both mainland Nova Scotia and Cape Breton Island, that have: 1) widespread application in oil and coal geology; 2) increased knowledge of contained evaporite deposits with potential for underground storage utilization and production of salt and potash; 3) facilitated a new understanding of processes leading to the formation of carbonate-hosted Zn-Pb deposits and sandstone-hosted copper deposits; and, 4) provided new perspectives on the possible occurrence of paleo-placer gold deposits.

Many of the collaborative federal-provincial geoscience investigations initiatied under the CNSCAMD are on going and continue to be funded by the GSC's 1993-98 Magdalen Basin National Geoscience Mapping Program (NATMAP).

Appreciation is expressed to the many project leaders who contributed project summary information, and to R. Lacroix of the GSC's Cartography Unit, who assisted in the production of the project location maps. Terry Daniels (NRCan) and Pat Phelan (NSDNR), CNSCAMD Management Committee co-chairs, and Clyde Beals, who represented ACOA on Management Committee, are thanked for promoting the value of geoscience in government boardrooms and assured the funding that made this work possible. Program development benefitted greatly from the collaboration provided by Dan Murray and Bob Boehner (both of NSDNR), Don Pollock (mineral exploration industry consultant), and Jack Caldwell (Acadia University).

A.L. Sangster, GSC
CNSCAMD Federal Exploration Stimulation Program Co-Chair

D.G. Richardson, GSC
Federal-Provincial/Territorial Liaison Office

CANADA-NOVA SCOTIA COOPERATION AGREEMENT ON MINERAL DEVELOPMENT [CNSCAMD], FEDERAL EXPLORATION STIMULATION PROGRAM: PROJECT SUMMARIES AND CUMULATIVE BIBLIOGRAPHIES

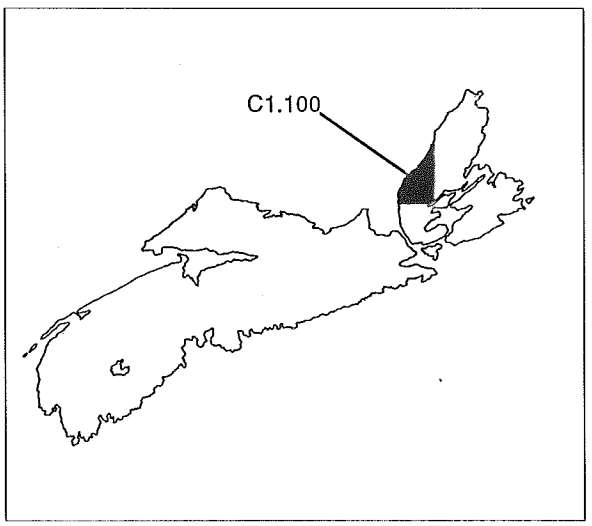
C1.1 GEOLOGY AND MINERAL DEPOSITS OF CARBONIFEROUS ROCKS SUBPROGRAM

C1.10 *Bedrock/Quaternary/Geochemical/ Geophysical Mapping*

C1.100 Geological mapping of Carboniferous rocks of western Cape Breton Island (P.S. Giles, GSC-Atlantic)

Objectives:
To map in detail appropriate for publication at 1:50 000 scale, Late Devonian to Carboniferous rocks of western Cape Breton Island in the area covered by parts of 11F/13, 11K/3, 4, 6, 10 and 11. This area stretches from the vicinity of Port Hood in the southwest to the vicinity of Cheticamp in the northeast. Much of the area was last examined in detail in the late 1930's and 1940's, and was identified as an area in need of updated geological understanding. Geological mapping was undertaken in order to better document the stratigraphy and structural history of the Carboniferous succession, as an aid to resource appraisal.

Results:
Mapping has been completed, and three digital colour maps have been completed for GSC Open File release in 1996. The stratigraphic subdivisions mapped in the area have been correlated with contiguous areas of eastern Nova Scotia, and summary stratigraphic work is currently in progress. Although no new mineral showings of great significance were identified during the course of the mapping, small showings of barite/fluorite with minor associated base metals were commonly found located along the perimeter of pre-Carboniferous highs. Mineralization is mostly vein-related, and occurs at the Horton-Windsor contact. One new showing of copper mineralization was noted in Fisset Brook Formation basalts east of Margaree Harbour.



The project has provided significant insight in the understanding of regional-scale deformation by bedding-parallel fault systems. The latter affect the Horton and Windsor Groups, as well as the lower Mabou Group. Significant stratigraphic omission occurs across at least one of these major structures, and may result in the local absence of virtually the entire Windsor Group succession in parts of the map-area. This has significant impact on the potential distribution of gypsum and salt deposits, as well as possible base-metal host rocks traditionally noted in rocks of this group.

Potential hydrocarbon source rocks in the Westphalian A shales of the upper Port Hood Formation are being studied in detail. Existing data indicate that these shales are in a marginal stage of maturity, but with increasing burial, as for example in offshore areas to the northwest, they represent a significant potential source for hydrocarbons. This work is in progress as part of an M.Sc. thesis at Dalhousie University (T.L. Crawford).

Impacts:
Arco International Oil and Gas has demonstrated interest in the Carboniferous succession of the western Maritimes Basin as a possible source of hydrocarbon resources, and have contributed approximately $20 000 to the project in direct support of source-rock appraisal of the upper part of the Port Hood Formation. These funds were used to support T.L. Crawford's post-graduate work. Discussions are on-going with Hunt Oil and with Intergaz Incorporated regarding the petroleum and natural gas potential gas potential of the Carboniferous rocks of the western Maritimes Basin. This interest has in part, been

stimulated by the MDA mapping completed in western Cape Breton and is now continuing under the GSC's Magdalen Basin NATMAP Project.

Outputs:

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1995a: A study of carbonate rocks from the Late Visean to Namurian Mabou Group, Cape Breton Island, Nova Scotia; Atlantic Geology, vol. 31, no. 1, p. 40.

1995b: A study of carbonate rocks from the Late Visean to Namurian Mabou Group, Cape Breton Island, Nova Scotia; B.Sc. (Honours) thesis, Dalhousie University.

Crawford, T.L.

In prep: Stratigraphy, sedimentology and source-rock potential of the Colindale Member of the upper Namurian-Westphalian Port Hood Formation, western Cape Breton Island, Nova Scotia; M.Sc. Thesis, Dalhousie University.

1995a: Carbonates and associated sedimentary rocks of the Upper Viséan to Namurian Mabou Group, Cape Breton Island, Nova Scotia: Evidence for lacustrine deposition; Atlantic Geology; v. 31, no. 3, p. 167-182.

1995b: Sedimentology and source-rock potential of the Colindale Member of the Prot Hood Formation (Westphalian A), Western Cape Breton Island; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities; Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 45.

Giles, P.S.

1996: Namurian and Early Westphalian stratigraphy of western and southwestern Cape Breton Island; in Program and Abstracts, Atlantic Geoscience Society Colloquium and Annual General Meeting, Bathurst New Brunswick, p.13-14.

Giles, P.S. and Allen T.L.

1995: Geology of Late Devonian and Carboniferous rocks of the Cheticamp map-area (NTS 11K/11 and 11K/10), Western Cape Breton Island, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities; Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 46.

Giles, P.S., Crawford, T.L. and Hein, F.J.

In prep.: Bedrock geology of the Cheticamp area (NTS 11K/11 and part of 11K/10), western Cape Breton Island, Nova Scotia; Geological Survey of Canada, Open File, 1:50 000 scale, with marginal notes.

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1996b: Bedrock geology of Port Hood-Lake Ainslie (11K/04, 11K/03, 11F/13), Cape Breton Island, Nova Scotia; Geological Survey of Canada, Open File 3253, 1:50 000 map with marginal notes.

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Hein, F.J.

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Hein, F.J. and Arnott, A.M.

1995: Petrography of coarse clastic facies, Fisset Brook Formation and Horton Group (Upper Devonian-Lower Carboniferous), Lake Ainslie and Margaree map areas, Cape Breton Island, Nova Scotia; in Current Research 1995-E; Geological Survey of Canada, p. 293-300.

Lynch, G. and Giles, P.S.

1996: The Ainslie Detachment: A regional flat-lying extensional fault in the Carboniferous evaporitic Maritimes Basin of Nova Scotia, Canada; Canadian Journal of Earth Sciences, v. 33, no. 2, p. 169-181.

C1.101 Characterization of major fault systems in western Cape Breton Island

Subproject 1: Major fault systems in western Cape Breton Island (G. Lynch, GSC-Quebec)

Objectives:

To identify, characterize, and classify the major fault systems of western Cape Breton Island in order to

provide a structural framework in which to guide exploration. Fundamental project objectives include: the production of updated 1:50 000 scale maps that highlight observed structures and associated mineralization; and establishing the distinctions and relationships between faults associated with Acadian compression, and faults responsible for post-Acadian basin-forming extensional collapse of the orogen.

Results:

A better understanding of major fault systems now contributes directly to an improved comprehension of shear zone hosted mineralization, allowing for more effective exploration tactics to be adopted. The maps produced and the structures outlined expand and better define exploration corridors along strike from known occurrences and to depth, and should provide an immediate exploration tool. Three previously unrecognized faults of regional extent and of major tectonic significance have been established, including: 1) the Cabot metamorphic nappe which dominates the Cape Breton Highlands and is bounded by the folded Highlands Shear Zone, juxtaposing amphibolite and greenschist crustal levels; 2) the late Devonian low-angle Margaree extensional shear zone, which provides an essential key to the understanding of how the Maritimes Basin was initiated, and of unroofing mechanisms for high grade metamorphic rocks; and 3) the Ainslie Detachment at the top of the Viséan Macumber limestone, which is a regional scale glide surface for allochthonous salt, producing tectonic breccia which hosts Pb-Zn occurrences, and resulting in offshore diapir buildup. The project has also provided insight into the alteration zones at the Coxheath porphyry Cu-Mo-Au deposit, and has defined metamorphic conditions for base metal VMS occurrences in the Chéticamp area.

Impacts:

Recognition of the fact that deformation style for salt detachment along the Ainslie Detachment is analogous to numerous oil producing diapir fields, will likely draw the attention of hydrocarbon exploration companies. Project results will be incorporated into the GSC's multidisciplinary Magdalen Basin NATMAP ARCINFO GIS comprehensive database (1:250 000 scale) that covers all of northern Nova Scotia. Regional maps of western Cape Breton Island that characterize and identify major Acadian and post-Acadian fault systems are fundamental in order to obtain a better geological comprehension of this region, and would have a direct bearing on mineral exploration due to the strong control exhibited by faulting on mineral resource distribution.

Outputs:

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1995a: Salt diapirism in relation to fault displacement transfer from a basement normal fault to an extensional detachment in the Carboniferous Maritimes basin, Nova Scotia, Canada; in Geological Society of America, Abstracts with Program, v. 27, no. 6, p. A-385.

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1992c: Extensional collapse of the Appalachian orogen: evidence from the Cape Breton Highlands; in Geological Association of Canada/Mineralogical Association of Canada, Abstracts Volume, v. 17, p. A69.

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Lynch, G. and Chatterjee, A.K.

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1996: Metamorphic characterization of two-step compressional and extensional denudation for high grade rocks, in the Appalachian Orogen of Cape Breton Island, Canada; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, p. A-60.

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1996: The Ainslie Detachment: a regional flat-lying extensional fault in the Carboniferous evaporitic Maritimes Basin of Nova Scotia, Canada; Canadian Journal of Earth Sciences, v. 33, p. 169-181.

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1993d: The Ainslie Detachment-field and geophysical evidence of Carboniferous low-angle extensional faulting in Nova Scotia; in Geological Survey of Canada, Forum 1993, Program with Abstracts, p. 15.

Lynch, G., Giles, P., and Houlahan, T.

1995: New 1:250 000 map of Cape Breton Island and tectonic revision, Magdalen Basin NATMAP project; in Geological Survey of Canada, Forum 1995, Abstracts, p. 35.

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1996a: Bedrock geology, Baddeck, Cape Breton Island, Nova Scotia (NTS 11K/2); Geological Survey of Canada, Open File 2488, 1 colour map (1:50 000 scale).

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1995: Bedrock geology, St Anns (NTS 11K/7); Geological Survey of Canada, Open File 3057, one map (1:50 000 scale).

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Ortega, J. And Lynch, G.

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Savard, M.M., Lynch, G. and Fallara, F.

In press: Burial diagenesis model for the Macumber Formation on Cape Breton Island - implications for the tectonic evolution of the Windsor Group;. Atlantic Geology, v. 32, no. 3.

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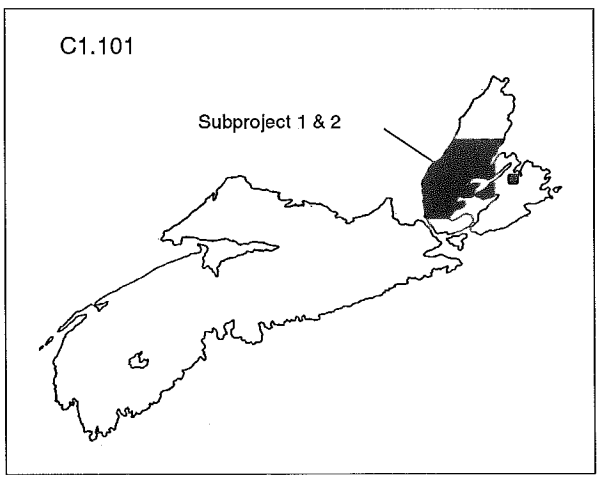


Subproject 2: Geothermometry of northwestern Cape Breton Island (K.L. Currie, Continental Geoscience Division-GSC)

Objectives:

To quantify metamorphic conditions in the western Cape Breton Highlands, and to determine their relation to tectonic and igneous events.

Results:

Upper amphibolite-grade (715°C, 8.2 kbar) rocks (Cabot nappe) tectonically overlie supracrustal rocks (Jumping Brook suite) displaying inverted isotherms reaching 660° C, 6.2 kbars at the bounding fault (Highland Shear Zone). Ar-Ar isotope data indicate that the hot Cabot nappe was emplaced over cool rocks at about 400 Ma, but that peak metamorphism in the nappe was slightly older (410-420 Ma). These data clearly show that strata and metamorphism in the Cabot nappe and Jumping Brook suite are not correlative, as previously supposed. Late greenschist-grade (415°C, 2.3 kbars) shear zones, which cut both the nappe and the Jumping Brook suite, but are truncated by the Late Devonian Fisset Brook Formation, indicate at least 6 km of cover had been removed from the assembled complex prior to deposition of the Fisset Brook Formation. All exposed parts of the complex had reached conditions of <400°C, <2.5 kbars by 370 Ma. At least a further 6 km of cover was removed by motion on the latest Devonian low-angle, extensional Margaree Shear Zone. One dimensional thermal modelling suggests the Cabot nappe was emplaced as a sheet ~16 km thick, and underwent almost immediate tectonic denudation in two stages separated by igneous activity at ~370 Ma. These data are compatible with a tectonic model involving late Silurian collision with a promontory of Laurentia (Lin et al., Geology v. 22, p. 897-900, 1994). With the additional supposition of delamination following crustal thickening and gravitational collapse, the model is capable of explaining the evolution of the area from Ordovician subduction-related events to formation of the Maritime Basin.

Impact:

Project provides the geoscientific community with new data and geological interpretations regarding the metamorphic and structural history of western Cape Breton Island.

Outputs:

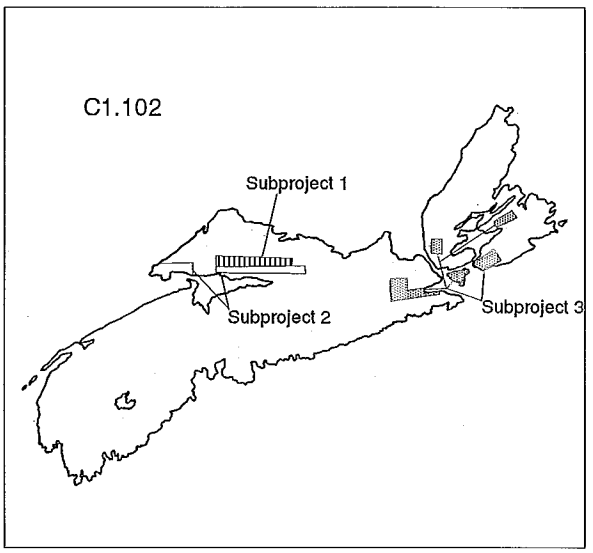
Currie, K.L. and Lynch, G.

In prep.: High-grade metamorphism during tectonic transport in the western Cape Breton Highlands, Nova Scotia; Journal of Metamorphic Petrology.

1996: Geodynamic modelling of post-tectonic denudation of high-grade metamorphic rocks in the Appalachian orogen of Cape Breton Island, Canada; in Penrose Conference on Post-Tectonic Processes, Program with Abstracts (in press).

Lynch, G. and Currie, K.L.
1996: Metamorphic characterization of two-step compressional and extensional denudation for high grade rocks in the Appalachian orogen of Cape Breton Island; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, p. A-60.

C1.102 Resource potential of latest Devonian-earliest Carboniferous rocks, southern Magdalen Basin (P.S. Giles, GSC-Atlantic)



Subproject 1: Stratigraphy, tectonic significance and resource potential of post-Acadian pre-Horton rocks of Nova Scotia (D.J.W. Piper, GSC-Atlantic)

Objectives:
To document and explain the distribution, stratigraphic age, deformation and basinal evolution of the sedimentary and associated igneous rocks of the earliest stages of the Magdalen Basin evolution (pre-Horton and local Horton equivalents of uncertain affinity).

Results:
The earliest basin sedimentation and volcanism in the eastern Cobequid Highlands comprises thick volcanic rocks (Fountain Lake Group) and mid-Devonian clastic sediments. The main phase of gabbro and granite pluton emplacement is latest Devonian in age (six U/Pb zircon ages from 361-365 Ma). This igneous activity is approximately synchronous with the lower part of the Horton Group. Magnetic data show three domains of pluton emplacement, including:

1) west of Parrsboro, predominantly granitic magmas emplaced along major east-west faults;

2) between Parrsboro and Portapique, pluton emplacement is more widespread and shows E-W trends. In this domain, pluton margins show northward thrusting, and Neoproterozoic-Silurian country rock host gabbro and rhyolite sheets along analogous thrust faults;

3) east of Portapique, magnetic data suggest that WNW-striking lineaments predominate. These lineaments post-date the main phase of pluton emplacement, which was associated with the rise of magma along the Rockland Brook faults and widespread northward thrusting. Small fault-bounded basins associated with this thrusting contain lacustrine, fluvial and alluvial fan sediments of the Nuttby Formation, locally containing Tournaisian spores (alynomorphs). Some sediments include plutonic clasts and are cut by marginal granite phases, suggesting that uplift accompanying pluton emplacement was rapid.

South of the Rockland Brook fault, Horton equivalent sedimentary rocks include the Rapid Brook Formation, Grenville River Formation, rocks formerly assigned to the Precambrian and Siluro-Devonian near Five Islands, and the Nuttby Formation. Facies include lacustrine shales and marginal lacustrine sandstones, fluvial sandstones and shales and alluvial fan conglomerates and are similar to Horton Group facies on the south side of the Minas Basin and in the St. Mary's graben. The Rockland Brook fault forms the northern margin of this depositional basin.

North of the Rockland Brook fault, sedimentary rocks equivalent to the Horton Group are interbedded with volcanic successions of the Fountain Lake Group, which, in the eastern Cobequid Highlands, are many kilometres thick. Sparse palynomorph data indicate a Tournaisian

age that is consistent with the available radiometric ages on the volcanic rocks. Sediment facies include fault scarp conglomerates associated with wrench and probably thrust faulting, lacustrine shales and siltstones, and fluvial to alluvial fan conglomerates. In the northeastern Cobequid Highlands, thick sandstones and mudstones that were deposited in a northward-flowing meandering fluvial system overlie the youngest volcanic rocks. These are in turn overlain by coarse alluvial fan - braided river conglomerates and coarse sandstone of Falls Formation that, based on seismic reflection profiles, pre-date the Windsor Group.

Impacts:

Geochronology and palynology have helped clarify stratigraphy and resolve uncertain relationships between units, which should provide constraints on tectonic models and assist in the assessment of the areas mineral potential.

Outputs:

Pe-Piper, G. and Piper, D.J.W.

1995: Late Devonian-Early Carboniferous evolution of the Cobequid Highlands; Atlantic Geology, v. 31, no. 1, p. 57.

Piper, D.J.W.

1996: Horton Group sedimentary rocks adjacent to the Cobequid Highlands, Nova Scotia; in Current Research 1996-D; Geological Survey of Canada, p. 55-60.

1995: Horton Group-equivalent sedimentation in the Cobequid Highlands; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 39.

1994: Devono-Carboniferous Basinal sediments and volcanic rocks north of the Main Plutonic Belt, Cobequid Highlands, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 39.

Piper, D.J.W., Durling, P. and Pe-Piper, G.

1996: Field evidence for the extent and style of overthrusting along the northeastern margin of the Cobequid Highlands, Nova Scotia; in Current Research 1996-D; Geological Survey of Canada, p. 41-46.

Piper, D.J.W., Pe-Piper, G. and Pass, D.J.

In press: The stratigraphy and geochemistry of late Devonian to early Carboniferous volcanic rocks of the northern Chignecto peninsula, Cobequid Highlands, Nova Scotia; Atlantic Geology.

Subproject 2: 1:10 000 and 1:25 000 mapping of Carboniferous plutonic and volcanic rocks of the Cobequid Highlands of northern Nova Scotia (G. Pe-Piper, St. Mary's University)

Objectives:

To synthesize the geology, geochemistry and mineral potential of Carboniferous igneous rocks of the central and western Cobequid Highlands through detailed mapping at 1:10 000 scale and of the eastern Highlands at 1:25 000 scale, in order to establish the character and timing of Carboniferous igneous and hydrothermal events and thus to place these rocks in a regional tectonic framework.

Results:

The widespread diorite/gabbro and smaller granite plutons of the Cobequid Highlands appear to be of latest Devonian to earliest Carboniferous age. Two plutons (Cape Chignecto, Pleasant Hills) have yielded U/Pb zircon dates of 360 Ma), corresponding to the Devonian-Carboniferous boundary. The Wyvern diorite has yielded a K/Ar hornblende date of 357 Ma, while the Cape Chignecto Pluton yielded an age of 329±11 Ma. Exposure is limited in the eastern Cobequids and the extent of plutonic rocks is unclear. Large areas have been mapped as Fountain Lake Group volcanics and Salmon River pluton granite. The central Cobequid Highlands are dominated by the Folly Lake-Wyvern diorite pluton; which is associated with granite (Pleasant Hills, Hart Lake-Byers Lake, Gilbert Hills) and other minor diorite plutons. The Folly Lake diorite and the Hart Lake-Byers Lake granite appear essentially synchronous and show lobate contacts and subtle intermingling. In the western Cobequid Highlands, the plutons are predominantly of granite with minor marginal gabbros. The Cape Chignecto pluton is cut by gabbro-diorite. Mafic dykes are common in all the plutons of the western Cobequid Highlands. The Cape Chignecto and North River plutons are at a slightly deeper structural

level than the West Moose River pluton and the plutons of the central Cobequid Highlands. Nowhere in the central and western Cobequid Highlands do plutons cut the Fountain Lake Group volcanic rocks, and in the western and central Cobequid Highlands the Fountain Group appears to be broadly synchronous with intrusion of the plutons; however, contacts mapped in the Cape Chignecto and Folly Lake plutons are demonstrably thrust faults. Diabase and minor microgranite sheets (dykes), of uncertain age, are widespread in the plutons and adjacent country rock, particularly in those plutons of the western Cobequid Highlands that may have been emplaced at a deeper structural level.

Gabbro-diorite outcrops throughout the western Cobequid Highlands show a spatial association of mafic magmas with the major faults in the area (i.e., CFZ (Cobequid Fault Zone), the Kirkhill and the Rockland Brook faults). This suggests that these faults were probably pathways for mafic magmas. The distribution of altered rocks suggests that the faults may also have functioned as conduits for later hydrothermal alteration. Observed strain aureoles in country rocks, north of the main contact of the plutons suggests that magma emplacement was forceful, with northwestward ductile movements that probably extended up to 10 km north of the CFZ. The less-deformed later coarse granite phases record development of a magma chamber without significant ductile tectonic strain, and emplacement occurred after most of the NW-directed deformation was complete.

Impacts:

Project investigations have been successful in defining the tectonic intrusion style of western Cobequid plutons (i.e., synmagmatic thrusting followed by extensional collapse); and the sequential geochemical evolution of plutons within this tectonic framework.

Outputs:

Doig, R., Murphy, J.B., Pe-Piper, G. and Piper, D.J.W.

In press: U-Pb geochronology of Late Paleozoic plutons, Cobequid Highlands, Nova Scotia, Canada: Evidence for Late Devonian emplacement adjacent to the Meguma-Avalon terrane boundary in the Canadian Appalachians; Geological Journal.

Koukouvelas, I. and Pe-Piper, G.

1996: The Hart Lake-Byers Lake-Folly Lake pluton, Cobequid Highlands, Nova Scotia: Deformation history inferred from mafic enclaves; in Current Research 1996-D; Geological Survey of Canada, p. 35-40.

1995: The role of granites in the evolution of the Folly Lake diorite, Cobequid Highlands, Nova Scotia; in Current Research 1995-D; Geological Survey of Canada, p. 33-38.

Koukouvelas, I., Pe-Piper, G. and Piper, D.J.W.

In review: Pluton emplacement by wall-rock thrusting, hanging-wall translation and extensional collapse: latest Devonian plutons of the Cobequid fault zone, Nova Scotia, Canada; Geological Magazine.

Pe-Piper, G.

1996: The Carboniferous plutons and associated igneous rocks of the western Cobequid Highlands, Nova Scotia; Geological Survey of Canada, Open File 3252, 89 p., 6 colour maps (1:10 000 scale).

Pe-Piper, G., Koukouvelas, I. and Piper, D.J.W.

1996: Geochemical and structural evolution of a shear zone granite with dyke-to-pluton emplacement: The Pleasant Hills Pluton, Canadian Appalachians; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, A-73.

1995: Geochemical and structural evolution of the Pleasant Hills Pluton, Cobequid Highlands; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 71.

1994: Emplacement of the Pleasant Hills, Folly Lake and Hart Lake-Byers Lake plutons and the role of the Rockland Brook Fault, Cobequid Highlands, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2 , p. 73.

Pe-Piper, G. and Piper, D.J.W.

1995: Late Devonian-Early Carboniferous evolution of the Cobequid Highlands; Atlantic Geology, vol. 31, no. 1, p. 57.

Pe-Piper, G., Piper, D.J.W., and Koukouvelas, I.

In press: The Precambrian plutons of the Cobequid Highlands, Nova Scotia; Geological Society of America Special Publication.

1995: The Folly Lake and the Hart Lake-Byers Lake plutons, Cobequid Highlands, Nova Scotia: Some comments on their deformational and magmatic history; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 70.

1995: Field evidence for the character of the Precambrian rocks south of the Rockland Brook fault, Bass River block, Cobequid Highlands, Nova Scotia; in Current Research 1995-D; Geological Survey of Canada, p. 27-31.

1994: Geology of the Neoproterozoic Bass River Block, Cobequid Highlands; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 72.

Pe-Piper, G., Piper, D.J.W., Parlee, K. and Turner, D.S.
1994: Geology of the headwaters of the River Philip, Cobequid Highlands; Geological Survey of Canada Open File 2887, 34 p., one (1:10 000 scale map sheet).

Pe-Piper, G., Zeeman, M. and Piper, D.J.W.
1996: Magmatic significance of the relationships between the mafic and felsic phases of the Folly Lake Pluton, Cobequid Highlands, Nova Scotia; in Current Research 1996-D; Geological Survey of Canada, p. 27-33.

Subproject 3: Plutonic and volcanic rocks of Guysborough County and southern Cape Breton (S.M. Barr, Acadia University)

Objectives:
To map the field relationships of Devono-Carboniferous plutonic and volcanic rocks in the Guysborough area and in southern Cape Breton Island, in order to determine their petrochemistry, and thus interpret their tectonic setting, petrogenesis and mineralization potential. In areas where previous studies have been done, data will be compiled and integrated with new data into a comprehensive database.

Results:
On-going studies of Devonian to Carboniferous volcanic and associated sedimentary and gabbroic rocks in the Guysborough area of northern mainland Nova Scotia and in central and southern Cape Breton Island have resulted in a more accurate interpretation of their distribution, age, and regional tectonic significance.

In Guysborough County, basalt and minor rhyolite of the Sunnyville Formation are overlain conformably (?) by red conglomerate and sandstone of the Glenkeen Formation, and quartz wacke and siltstone members of the Clam Harbour River Formation. A mid-Devonian age for these units is indicated by a U-Pb (zircon) date of 389 ± 2 Ma from rhyolite in the Sunnyville Formation, which contrasts to the previously assumed Devonian-Carboniferous age.

Mapping in the Gillanders Mountain and Lake Ainslie areas of Cape Breton Island has shown that the stratigraphy in the Fisset Brook Formation in both areas includes a distinctive brown polymictic conglomerate at the base overlain by basalt and rhyolite flows. The age of the Fisset Brook Formation has generally been considered to be Devonian to Carboniferous. However, a U-Pb date of 373 ± 4 Ma was obtained from rhyolite near the top of the formation, showing that the formation (at least in the Gillanders Mountain - Lake Ainslie area) is of mid- to Late Devonian age. In contrast to these Devonian volcanic rocks, the St. Peters Canal gabbro has yielded an Early Carboniferous U-Pb (zircon and baddeleyite) age of 339 ± 2 Ma. This work resolves long-standing uncertainty about the age of the St. Peters gabbros, previous interpretations of which ranged from Precambrian to Mesozoic. Similar gabbros in the Creignish Hills and Guysborough areas may also be of Carboniferous age. All of these igneous units have petrological features consistent with origin in a within-plate continental extensional setting.

Re-mapping of the McAdam Lake Formation in the Boisdale Peninsula of Cape Breton Island, shows that, contrary to previous reports, the formation lacks volcanic rocks, but has been intruded by rare fine-grained hornblende-bearing lamproite (spessartite) dykes and sills of uncertain age.

Impacts:
The diversity of ages, levels of exposure, tectonic settings, and rock types in Cape Breton Island make the area an excellent target for exploration.

Outputs:
Arnott, A.
1994: Devono-Carboniferous volcanic rocks in the Gillanders Mountain area, Cape Breton Island; B.Sc. thesis, Acadia University.

Barr, S.M., Arnott, A.M., Cormier, C.F.M. and MacDougall, G.A.
1993: Devo-Carboniferous volcanic and plutonic rocks of Guysborough County and central Cape Breton Island; in Nova Scotia Department of Natural Resources, Program and Summaries, Seventeenth Annual Review of Activities, Minerals and Energy Branches; D.R. MacDonald (ed.), Report 93-2, p. 41.

Barr, S.M., Cormier, C.F.M., White, C.E. and Dunning, G.R.
1995: Devonian-Carboniferous volcanic and gabbroic rocks in Guysborough County and Cape Breton Island, Nova Scotia; Atlantic Geology, vol. 31, no. 1, p 40.

Barr, S.M., Grammatikopoulos, A.L., and Dunning, G.R.
1994: Early Carboniferous gabbro and basalt in the St. Peters area, southern Cape Breton Island, Nova Scotia; Atlantic Geology, v. 30, p. 247-258.

Barr, S.M., Macdonald, A.S., Arnott, A.M. and Dunning, G.R.
1995: Field relations, structure, and geochemistry of the Fisset Brook Formation in the Lake Ainslie-Gillanders Mountain area, central Cape Breton Island, Nova Scotia; Atlantic Geology, v. 31, no. 3, p. 127-139.

Barr, S.M. and White, C.E.
1995: Devonian to Carboniferous stratigraphy in the Guysborough-Mulgrave-L'Ardoise area, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 57.

Barr, S.M., White, C.E., Cormier, C.F.M. and Dunning, G.R.
1994: Devonian-Carboniferous igneous and sedimentary rocks in southern Cape Breton Island and Guysborough County, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 62.

Barr, S.M., White, C.E., MacDonald, A.S.
1996: Geological maps of Late Precambrian and Cambrian rocks, southeastern Cape Breton Island, Nova Scotia (parts of NTS 11F/9, 10, 11, 15, 16; 11G/13; 11J/4; 11K/1); Geological Survey of Canada, Open File 2732, 6 map sheets (1:40 000 scale).

Barr, S.M., White, C.E. and Webster, T.
1996: Devonian and Carboniferous stratigraphy in the Guysborough-Loch Lomond area, Nova Scotia; in Program and Abstracts, Atlantic Geoscience Society Colloquium and Annual General Meeting, Bathurst New Brunswick, p. 8-9.

Cormier, C.F.M.
1994: Field relations, petrology, and age of volcanic and associated sedimentary and gabbroic in the Guysborough area, Nova Scotia; M.Sc. thesis, Acadia University.

Cormier, C.F.M., Barr, S.M. and Dunning, G.R.
1995: Geological setting and petrochemistry of early Middle Devonian volcanic and gabbroic rocks in the Guysborough area, Nova Scotia; Atlantic Geology, v. 31, no. 3, p. 153-166.

Macdonald, A.S., Barr, S.M., Arnott, A.M. and Dunning, G.R.
1995: The Fisset Brook Formation in the Lake Ainslie - Gillanders Mountain area, central Cape Breton Island, Nova Scotia: Age, geochemistry, structure and mineralization; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 59.

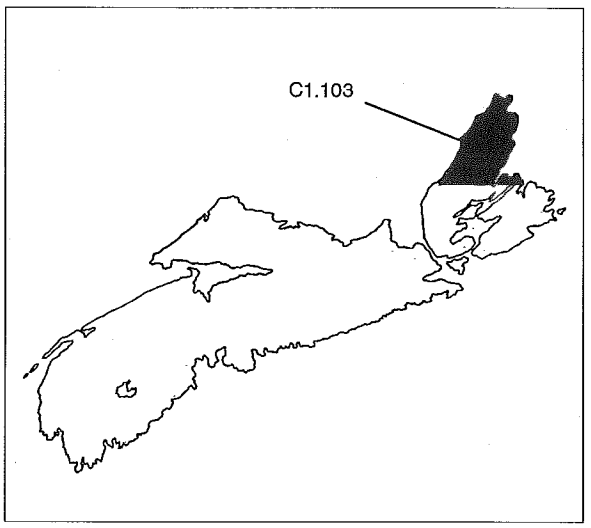
MacDougall, G.
1994: Field relations, petrology, and age of volcanic rocks around the southwestern margin of the Creignish Hills, western Cape Breton Island; B.Sc. thesis, Acadia University.

C1.103 Integrated spatial database for Cape Breton Island (G.P. Watson, Mineral Resources Division-GSC)

Objectives:
To acquire available satellite and airborne digital imagery (i.e., LANDSAT TM, SPOT, ERS-1 radar, etc.); airborne geophysical surveys (i.e., radiometric, magnetic/gradiometer) and digital topographic information for areas of Cape Breton Island under investigation by other Nova Scotia MDA mapping projects. To compile and integrate this information into a georeferenced database using SPANS GIS and EASI/PACE IAS workstation at GSC-Atlantic, and to provide datasets in formats compatible with mapping software to be used in the field.

Results:
The database has been designed to accommodate display, query, and manipulation using low cost, commercially available desktop mapping software (i.e., Image Processing and Analysis, Digital Cartographic (AutoCAD) and Geographic Information Systems [GIS]). The final digital product prototype, being produced on CD-ROM, contains all the unique data types as separate layers in two commonly used GIS formats-ArcInfo and SPANS. Users of these systems will be able to port the data gathered under this project directly for their own spatial analysis. Furthermore, the prototype has been developed with a built-in tutorial based on MS WINDOWS help files. This tutorial is intended to allow

users without either GIS background or software to explore the database and emulate functions and features available in most commercial GIS and viewing packages.



Impacts:
A fully digital integrated systematic geoscience database, comprised of various earth resource and remotely sensed data layers, will assist MDA and industry mapping projects in Cape Breton Island.

Outputs:

Watson, G.P.

In review: Integrated spatial database for Cape Breton Island; Geological Survey of Canada, Open File, 1 CD-ROM.

1995: Radar coverage of Cape Breton from aircraft to satellite: Comparing the differences; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 44.

Watson, G.P., Jones, W.P. and Mackenzie, L.M.

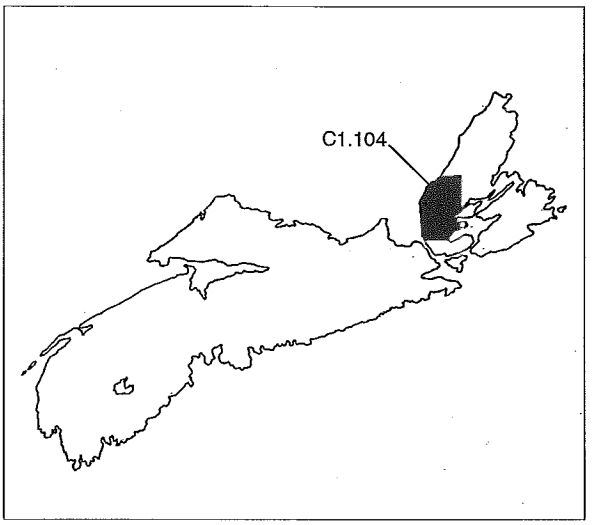
1994: Integrated Spatial Database for Cape Breton Island; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 30.

C1.104 Late Carboniferous, western Cape Breton Island (P.S. Giles, GSC-Atlantic)

Objectives:
To complete laboratory and field investigations in western Cape Breton Island (NTS 11K/3 - Lake Ainslie and 11K/4 - Port Hood) in order to:

1) evaluate the control of salt movements upon the sedimentary architecture of the Inverness Formation (Westphalian C-D); and,

2) define the stratigraphy and sedimentology of the host rocks and coal measures comprising the Late Carboniferous coal-bearing strata of the Inverness Formation (i.e., investigate well exposed sections at Inverness, Mabou Mines, Henry and Port Hood Islands and Margaree Island).



Results:
The Late Carboniferous section at Mabou Mines contains thick (>125 m) fine grained intervals that include coals and canneloid shales and were deposited in mires, lakes, and on poorly drained floodplains. Coal analysis indicates that the precursor peat accumulated under conditions of high ground-water levels consistent with an upper delta plain to alluvial plain setting. Thick (about 50-100 m) sandstone intervals with strongly erosional bases and multiple storeys alternate with the coal-bearing intervals and are interpreted as braided-fluvial deposits. Such a succession of thick coal-bearing and braided-fluvial intervals reflects recurrent, radical changes in depositional conditions, possibly related to activity on the adjacent Hollow fault Zone.

Re-examination of geophysical data from the Gulf of St. George and the west coast of Cape Breton has revealed the presence of spectacular salt structures, ranging from embryonic salt pillows to salt walls and diapirs. These

salt structures can be traced from seismic sections to onshore outcrops. Salt diapirs and their associated deformation of Carboniferous strata are exposed in coastal outcrops and can be traced inland from drill cores and as karst topography.

Impacts:
Project findings have important implications for the economic resource assessment of Cape Breton coal reserves. Seismic interpretation, combined with palynological age dating indicates that all coal seams within the Inverness Formation lie within a single Westphalian D 'zone', and not, as previous thought, in two different coal 'zones' (i.e., the Mabou Mines coal measures [Westphalian C] and the younger Inverness coal measures [Westphalian D]).

The geometry and deformation of syn-halokinetic sediments suggests that salt withdrawal and subsequent diapirism was initiated during the early Westphalian (Port Hood Formation equivalent) and continued until the halokinesis had a fundamental effect upon the development of the sedimentary architecture of Carboniferous sediments within the Gulf of St. George and the west coast of Cape Breton.

Outputs:

Brown, J.P.
1995a: Halokinetic controls on the sedimentary architecture of the Inverness Formation, western Cape Breton Island, Nova Scotia; in Current Research 1995-D; Geological Survey of Canada, p. 39-43.

1995b: Geophysical and outcrop evidence for extensive Carboniferous salt tectonics, Gulf of St. George, Nova Scotia; Atlantic Geology, v. 31, no. 1, p. 42.

1995c: Halokinetic controls on the sedimentary architecture of Carboniferous braided fluvial systems, western Cape Breton, Nova Scotia; in Victoria'95, Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Final Program and Abstracts, v. 20, p. A-10.

Brown, J.P., Davison, I. Alsop, I. And Gibling, M.R.
1996: Deformation related to Carboniferous salt tectonics, western Cape Breton, Nova Scotia; in Program and Abstracts, Atlantic Geoscience Society Colloquium and Annual General Meeting, Bathurst New Brunswick, p.10.

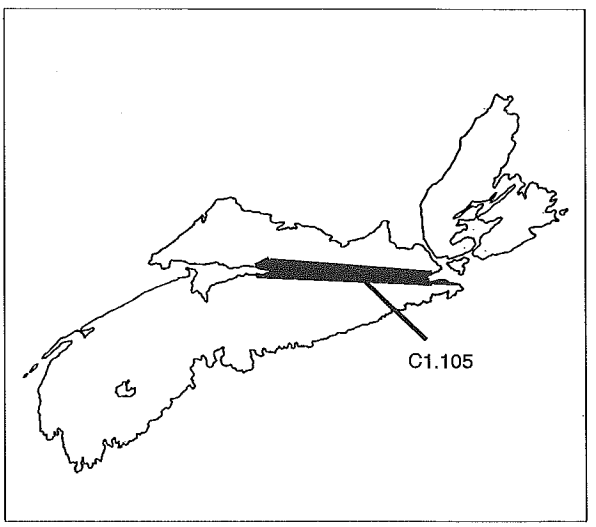
Brown, J.P., Gibling, M.R., Dolby, G. and Wightman, W.G.
In prep: High-resolution stratigraphic correlation of Upper Carboniferous coal seams, western Cape Breton Island, Nova Scotia; Canadian Journal of Earth Sciences.

Gibling, M.R., Marchioni, D.L. and Kalkreuth, W.D.
1994: Detrital and organic facies of Upper Carboniferous strata at Mabou Mines, western Cape Breton Island, Nova Scotia; in Current Research 1994-D; Geological Survey of Canada, p. 51-56.

1993: Sedimentology and coal petrology of Late Carboniferous strata at Mabou Mines, western Cape Breton Island; in Program and Summaries, 17th Annual Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 93-3, p 49.

C1.105 Geological evolution and mineral potential of the St. Mary's Basin (J.B. Murphy, St. Francis Xavier University and F.W. Chandler, Continental Geoscience Division-GSC)

Objectives:
To map the bedrock geology of the St. Mary's sedimentary basin at a scale suitable for publication at 1:50,000, in order to determine the geological history and mineral potential of this area and thus identify criteria that may aid mineral exploration. The study area encompasses parts of NTS mapsheets 11E/6, 7 8 and 11F/5, between latitudes 45°24' and 45°15'N and longitudes 61°30' and 63°15W, and extends east-west (i.e. parallel to the Cobequid-Chedabucto Fault) and is on average 15 km wide and about 150 km in length.



Results:

The St. Mary's Basin, is underlain by Latest Devonian-Early Carboniferous (Tournaisean) intra-continental fluviatile to lacustrine basin-fill sequence of clastic

sedimentary rocks that is assigned to the Horton Group. The basin occupies the boundary between the Meguma and Avalon Composite terranes. The contact with the Avalon Terrane is tectonic, but along the southern flank of the basin, Horton Group rocks unconformably overlie the Meguma Terrane, implying that a portion of the basin is underlain by Meguma basement. Facies relationships indicate deposition along the southern flank of the basin was influenced by coeval faulting. In the southwestern portion of the basin, the rocks are overlain, presumably unconformably, by the Windsor Group. Most Horton Group units defined in the eastern portion of the basin can be mapped westwards where they form part of a thick sequence that generally strikes northeast to east northeast, faces southeast, coarsens upward, thickens towards the southeastern margin of the basin and contains clasts of Meguma derivation. However, in the northwest portion of the basin, the clastic rocks have a mixed Avalonian-Meguma provenance confirming the status of the Horton Group as a post-Acadian overstep sequence.

The character of the basin-fill rocks does not vary with proximity to the Chedabucto fault suggesting that this fault does not constitute the original margin of the basin, and that an unknown portion of the basin has been tectonically removed and may be found north of the fault. Although it can be demonstrated that at least some of the basin-fill rocks overlie a basement composed of Meguma Terrane rocks, the existence of Avalonian basement rocks cannot be confirmed. Strike-slip motion along the Cobequid-Chedabucto fault system has resulted in heterogeneous deformation characterized by a variety of dextral kinematic indicators. In the western basin, the zone of intense deformation transects the basin in an northeast-southwest direction, where it produces a relatively intense, narrow (ca. 2 km) zone characterized by small-scale and regional tight to isoclinal folds, with locally developed mylonitic fabrics. In the eastern basin, deformation is relatively mild. Regional factors suggest that this deformation reflects Late Paleozoic dextral relative motion between Avalonian and Meguma terranes, and between Laurentia and Gondwana.

The predominance of clasts of the Meguma Group lithologies in the basin-fill rocks suggests that these units may have paleoplacer gold potential. The distribution of these units has been mapped westwards where the additional presence of volcanic clasts, particularly in red clastic rocks along the northern margin of the basin suggests that some lithologies may have a mixed Meguma-Avalon provenance. The doubly-plunging fold structures in which dark organic shales are overlain by coarse sandstones may be a favourable trap for natural gas deposits.

Impacts:

As a direct result of this project, a substantial portion of this area has been staked by Caledonia Mining Incorporated, a Toronto based exploration company that specializes in paleoplacer exploration. Company interest resulted in NSERC funding, which facilitated study of the relationship between tectonics, sedimentology and mineral potential of the basin (i.e., funding to support sedimentological work by Research Associate Randy Rice, and geophysical investigations by graduate students). The knowledge gained in this area is critical to the understanding of the geology and mineral potential of the westernmost portion of the basin.

Outputs:

Murphy, J.B., Rice, R.J. and Stevens, J.

1995: Geology of the western St. Marys Basin: Preliminary results; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 66.

Murphy, J.B., Rice, R.J., Stokes, T.R. and Keppie, D.F.

In press: St. Mary's Basin, central mainland Nova Scotia: Late Paleozoic basin formation and deformation along the Avalon-Meguma terrane boundary; Canadian Appalachians; in Current Perspectives in the Appalachian-Caledonian Orogen, J.P. Hibbard, C.R. van Staal and P.A. Cawood (ed.); Geological Association of Canada Special Paper 41.

1995a: Geology of the central part of St. Mary's Basin, Nova Scotia; in Current Research 1995-D; Geological Survey of Canada, p. 11-18.

1995b: Geology of the St. Mary's Basin, Nova Scotia; Atlantic Geology, v. 31, no. 1, p.54-55.

Murphy, J.B., Rice, R.J., Stokes, T.R. and Webster, T.

In prep: Geology of the Late Paleozoic St. Mary's Basin, central mainland Nova Scotia; Geological Survey of Canada, Bulletin.

Murphy, J.B. and Stokes, T.R.

1994: Late Paleozoic geology of the eastern St. Mary's Basin, Nova Scotia: Strike-slip tectonics along a terrane boundary during the formation of Pangea; in Waterloo'94, Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 19, p. A81.

Murphy, J.B., Webster, T. and Rice, R.J.
1996: Late Paleozoic St. Mary's Basin, Nova Scotia: Post-collisional development and evolution in the Appalachian; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, p. A-68.

1996: Tectonic evolution of the Late Paleozoic St. Mary's Basin, Nova Scotia; in Program and Abstracts, Atlantic Geoscience Society Colloquium and Annual General Meeting, Bathurst New Brunswick, p.23-24.

Rice, R.J., Murphy, J.B. and Stokes, T.R.
1995: The St. Mary's Basin, central mainland Nova Scotia: Late Paleozoic basin formation and deformation along the Avalon-Meguma terrane boundary, Canadian Appalachians; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Final Program and Abstracts, v. 20, p. A-118.

Webster, T. and Murphy, J.B.
1996: Remote sensing and GIS for terrane boundary assessment; in Program and Abstracts, Atlantic Geoscience Society Colloquium and Annual General Meeting, Bathurst New Brunswick, p.33.

C1.106 Regional evolution and metallogeny of the Cumberland Basin [Stellarton Gap]

Subproject 1: Geological mapping and metallogeny of the Stellarton Gap (F.W. Chandler, Continental Geoscience Division-GSC)

Objectives:
To complete regional geological mapping of the Cumberland Basin by mapping its east end (the Stellarton Gap) and to prepare digital coloured 1:50 000 scale geological maps, a comprehensive final report, and journal papers. These products will contribute to the understanding of the geology and metallogeny of the study area.

Results:
1) Regional stratigraphy of the Namurian is generally similar throughout southeast New Brunswick to Cape Breton Island. Fine-grained coastal redbeds with local sabkha evaporites pass up into fluviolacustrine clastics with evidence of abundant vegetation and increasingly wetter climate.

2) A major detachment fault appears to have removed the middle of the Windsor Group in Stellarton Gap. Comparison of the lithology of the Upper Windsor Group rocks in the study area with other areas indicates significant (120 km) dextral movement on large scale strike slip faults

3) Studies suggest that the Late Devonian-Late Carboniferous climate was generally tropical semi-arid. Evidence of seasonality (monsoons) has not yet been found in pre-Namurian rocks, that is, Alleghenian coalescence of Pangea may have been important in promoting seasonality during the Namurian and later Carboniferous. The paleoclimate of the Windsor Group was probably no drier than semi-arid. The wettest climate during the Carboniferous was during the Early Westphalian, which was not "everwet", but more likely strongly seasonal, with a pronounced wet season. Thus, coals of the time formed in monsoonal climate and required high water table.

4) Interpretation of paleosols must take into account catenary relationships (i.e., discovery of soils of both semi-arid and swamp environment in same formation indicates soil type is in some measure controlled by local water table).

Impacts:
Recognition of an Early Westphalian wet climate phase explains the formation, and predicts the presence of widespread organic and pyrite-rich sandstones. These sediments are a natural trap for base metal mineralization. Examination of a number of mineral occurrences indicates that the underlying units are important in determining ore deposit type.

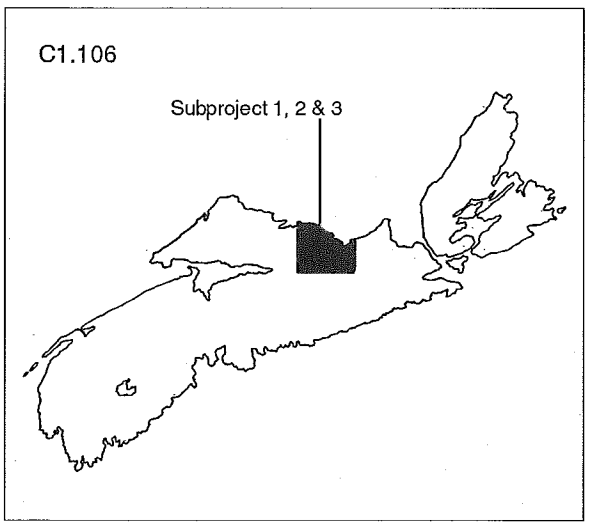
Outputs:
Archer, A.W., Chandler, F.W., Fralick, P.W. and Naylor, R.D.
In review: Fluvial style, tectonics, and glacioeustasy in a monsoonal climate: A Late Westphalian example from Nova Scotia, Canada; Sedimentology.

Chandler, F.W.
1995: Geological mapping in the Stellarton Gap (NTS 11E/7, 9, 10, 15): A status report; Atlantic Geology, vol. 31, no. 1, p. 43.

1994: Highlights of geological mapping in the Stellarton Gap (NTS 11E/7, 9, 10, 15), with comments on Carboniferous paleoclimate and its economic significance; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 37.

Chandler, F.W., Waldron, J.W.F., Giles, P.S. and Gall,
1996: Geological map of the Stellarton Gap (NTS 11E/7, 9, 10, 15); Geological Survey of Canada, Open File , one colour 1:50 000 scale map (in review).

Chandler, F.W., Waldron, J.W.F., Palmer, S., Giles, P.S., Gall, Q., Howells, K. and Durling, P.
1995: Geological map of the Stellarton Gap (NTS 11E/07, 09, 10 and 15); in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 41.



Subproject 2: Sedimentary and structural evolution of the Stellarton Basin and underlying Namurian rocks (J.W.F. Waldron, St. Mary's University)

Objectives:
To carry out sedimentological and metallogenic studies and detailed mapping of the Stellarton Coal basin and investigate the relationship between structural development and evolution of sedimentary fill in order to produce up-to-date maps of the Stellarton Gap and to develop predictive structural-sedimentological models for coal formation.

Results:
The Stellarton basin is a pull-apart basin located at a releasing bend on the Cobequid-Hollow fault system in Nova Scotia. The basin fill accumulated during Westphalian time. At the base, redbeds occupy fault bounded basins at the western and eastern extremities of the area. The overlying Stellarton Formation includes shale, sandstone, minor conglomerate, coal, and oil shale. Within the basin, map-scale extensional normal and oblique faults strike northwest-southeast and are listric in profile. Motion on these faults has produced map-scale 'rollover' fault-bend folds. At the northeast margin of the basin, older rocks are uplifted along reverse faults and folds to form a positive flower structure. Outcrop-scale structures within the basin show a history of extension followed by shortening. Early normal faults, formed while sediment was not fully lithified, are overprinted by thrust faults and asymmetric folds indicating eastward transport of stratigraphically higher units. In summary, the structure of the Stellarton basin is consistent with an overall history of dextral strike slip motion. Deposition probably occurred in a transtensional environment associated with a releasing bend in the Cobequid-Hollow fault system; subsequent transpression along the northwest margin was probably associated with a change in movement direction or fault geometry.

Impacts:
The western Stellarton basin in the vicinity of the Wimpey pit is currently under environmental review for open-pit mining. Structural results will likely be of assistance in planning any future developments in this region, and have application in the planning for eventual site reclamation. Because the area has potential for coalbed methane, as evidenced by limited exploration work carried out by industry this summer, the structural condition of the seams is critical in evaluation of coalbed methane recovery.

Outputs:
Gilles, K.S., Naylor, R.D., Waldron, J.W.F., Archer, A.W. and Belt, E.S.
1995: Geological research to assist open pit coal mining in the Stellarton Basin; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 19.

Howells, K., and Waldron, J.W.F.
1995: Gravity measurements in Pictou County, Nova Scotia; Atlantic Geology, vol. 31, no. 1, p. 48.

Naylor, R.D., Waldron, J.W.F., Palmer, S.E., Skilliter, D.M. and Johnston, S.K.
1995: The other side of the Mountain: Late Carboniferous strata immediately south of the Cobequid Fault; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy; D.R. MacDonald and K.A. Mills (ed.), Branch Report 95-2, p. 22.

Waldron, J.W.F.
1996: Differential subsidence and tectonic control of sedimentation in the Stellarton Basin, Pictou coalfield, Nova Scotia; in Current Research 1996-E; Geological Survey of Canada, p. 261-268.

Waldron, J.W.F., Chandler, F.W. and Gillis, K.S.
1996: Geological map of the Stellarton Coal Basin, Pictou County, Nova Scotia; Geological Survey of Canada, Open File, two sheets at 1:25 000 scale (in prep.).

Waldron, J.W.F., Gillis, K.S., Naylor, R.D. and Chandler, F.W.
1995: Structural investigations in the Stellarton pull-apart basin, Nova Scotia; in Current Research 1995-D; Geological Survey of Canada, p. 19-25.

Waldron, J.W.F. and Howells, K.
1995: Deposition and deformation of the Stellarton Formation, Nova Scotia: Strike-slip motion at the Southern Margin of the Magdalen Basin; in Atlantic Geoscience Society Colloquium and Annual General Meeting, February 3-4, 1995, Antigonish, Nova Scotia; Program and Abstracts, p. 28-29.

Subproject 3: Paleomagnetic study of the New Glasgow Formation of the Cumberland Basin in Nova Scotia (K. Buchan, Continental Geoscience Division-GSC)

Objectives:

1) To use paleomagnetism as a stratigraphic tool in dating the redbeds of the Cumberland Basin.

2) To contribute to metallogenic modelling of the redbed copper occurrences present in the Westphalian sandstones of the Cumberland Basin by dating their reddening (i.e., dating the passage of oxidizing cupriferous fluids).

Results:

1) Conglomerate test in New Glasgow Formation: Redbed clasts from conglomerates at two sites in the New Glasgow Formation carry stable but random magnetization directions. This demonstrates their ability to retain a remanence from the time of conglomerate formation. At one site, there is evidence of a partial overprint which post-dates deposition of the conglomerate.

2) Partial magnetic overprinting has been documented at several redbed sites in the New Glasgow Formation. This is evident from: 1) the superposition of both normal and reversed magnetization in some samples; and, 2) the presence of two distinct reversed components within individual samples. The component with the lowest blocking temperatures typically has a reversed direction of magnetization. This may suggest that overprinting occurred during the Kiaman (late Carboniferous-Permian) Reversed Superchron. These preliminary data indicate that paleomagnetism may prove useful in constraining the time of reddening of the New Glasgow Formation sedimentary rocks in the Cumberland Basin.

3) Some New Glasgow redbed sampling sites show evidence for a normally magnetized high blocking temperature component. If this component is primary it would indicate that these redbeds were deposited before the start of the Kiaman Reversed Superchron, and may serve as a tool for estimating the base of the Superchron, a potentially important time stratigraphic marker.

Impacts:

Newly discovered evidence for dual polarity remanences will serve as a major time stratigraphic marker in placing units above the early Westphalian A, which marks commencement of the Kiamen Reversed Superchron.

Outputs:

Buchans, K.L. and Chandler, F.W.
1996: Stratigraphic and metallogenic implications of paelomagnetic studies in the Carboniferous Cumberland Basin, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Twentieth Annual Review of Activities, Minerals and Energy Branch Report (In prep.).

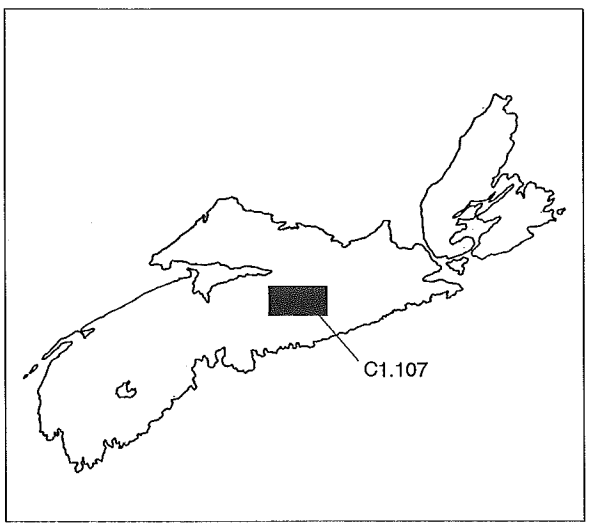
C1.107 Till lithology, geochemistry and provenance, Shubenacadie Basin (R.N.W. DiLabio, Terrain Sciences Division-GSC)

Objectives:

In cooperation with R.R. Stea and P.W. Finck (both of the NSDNR), who are investigating the Quaternary and Cretaceous fill in the Shubenacadie Basin, this project will determine till clast lithology and geochemistry over the basin. Detailed study of till near known mineral occurrences will be performed, to demonstrate the response of those occurrences in till, for comparison with results from analysis of other sample types (e.g., vegetation). The main sampling program, completed by contract (D.R. Duncan and Associates) during fiscal 1994-95, consisted of till sampling at a density of about 1 site per 4 km^2. The 1995 follow-up sampling program

(completed by Maritime Ground water Incorporated) consisted of sampling at 500 m spacings in order to provide data on areas of exploration interest.

Results:
Areas of anomalous trace element levels in till have been identified in the Shubenacadie and Walton areas. Elevated levels of Zn, Pb, Cu, and Ba in till between Walton and the Avon River reflect the presence of Walton-type mineralization near the Windsor-Horton contact. Copper levels are also elevated over Pictou Group bedrock. At five sites between Walton and Noel Shore, gold levels in the till are elevated. Three of the sites are near the contact between the Horton Group and the Fundy Group (Wolfville Formation). Thick, partly exotic till characterized by low trace element levels around Shubenacadie masks the signature of underlying bedrock; however, a few high levels of Ba were detected in till overlying Pictou Group rocks in the Stewiacke valley and on Windsor Group rocks in the Musquodoboit valley. Over the Meguma Group (Halifax Formation), glacial drift tends to be thin and locally derived. Till derived from the Meguma Group can be enriched in Br, Au, Zn, As, Pb, Ni, Co, Mn, Cu, Fe, Mo and Ag. Late glacial northward dispersal of Meguma Group debris complicates drift prospecting along the flanks of Meguma - cored uplands. In the southeast corner of NTS 11E/3, near Newcomb Corner, Ag, Mo, Co, Cu, Ni, As, and Au levels are elevated in an area underlain by the Halifax Formation. In the area between Gays River and Newcomb Corner, there are elevated levels of Zn, Pb, and Ba in till at a few sites on basal Windsor Group rocks.



Impacts:
Till clast lithology was successful in delineating an area containing exotic till around Shubenacadie. This area coincides with the region with the highest potential for Cretaceous industrial mineral deposits, as determined by seismic work done in GSC MDA project C1.110, and by NSDNR drilling.

Outputs:
McClenaghan, M.B., DiLabio, R.N.W. and Stea, R.R.
In prep: Till geochemistry and clast lithology, Shubenacadie and Walton areas, Nova Scotia; Geological Survey of Canada, Open File.

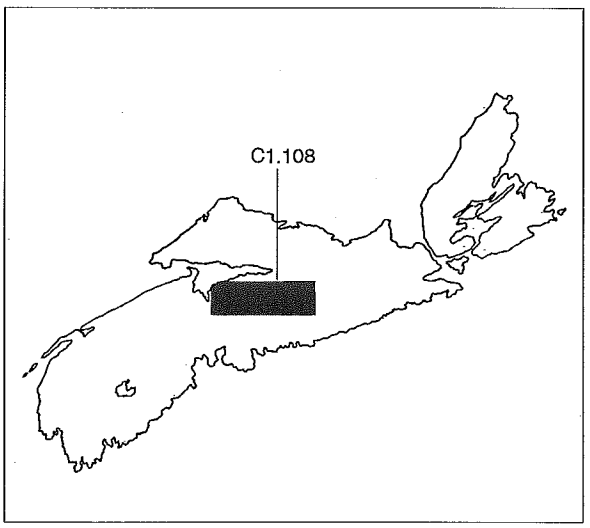
DiLabio, R.N.W., McClenaghan, M.B. and Stea, R.R.
1995: Till geochemistry in the Shubenacadie Basin and the Walton Belt; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 38.

C1.108 Biogeochemical/Hydrogeochemical Investigations (C.E. Dunn and G.E.M. Hall, Mineral Resources Division-GSC)

Objectives:
To undertake geochemical surveys (i.e., collection of stream waters, and several tissue types [outer bark and or twigs] from spruce and balsam fir) at sample densities of approximately 1 site per 6 km^2 in southwestern Cape Breton Island, and in central Nova Scotia. Sample collection and computer analysis of results, directed by C. Dunn and G. Hall (both of the GSC) were completed by contract. Samples were prepared for analysis in the field (millipore filtration of waters), at the GSC in Ottawa, and in commercial laboratories. Major , minor and trace elements were analyzed using appropriate chemical methods. Detailed and/or follow-up surveys were undertaken in areas of particular interest.

Results:
Vegetation survey results defined several sites that yielded relatively high concentrations of Au (up to 160 ppb in twig ash compared to background levels of < 10 ppb Au). This zone lies near the crest of the Shubenacadie Anticline and actually resulted in the Province issuing a land closure to exploration over a small area near the south end of Grand Lake Shubenacadie. This area was investigated in more detail in 1995 (GSC and NSDNR), and follow-up survey results yielded lower concentrations of gold than the

previous year, but confirmed that there are sites in the vicinity between Golden Lake and Sandy Lake, in which twigs of red spruce and balsam fir locally have relative enrichment of gold, silver, and arsenic. Concentrations reached maxima of 35 ppb Au in balsam fir twigs, and 47 ppb Au and 5 ppm Ag in red spruce twigs. The underlying poorly exposed bedrock of the Meguma Group is dominated by greywacke of the Goldenville Formation. The sites of Au enrichment in the trees lie along strike southwest from the gold-bearing Oldham Anticline, and the Shubenacadie Anticline. Water samples collected around the Shubenacadie Grand Lake area and analyzed for Au contained Au below the detection limit of 0.2 ppt (ng g-1).



Impacts:

Results from these surveys have stirred considerable interest among companies and prospectors. Several prospectors have adopted the biogeochemical methods developed at the GSC and are claiming satisfaction with the techniques and some exploration successes. Results from the hydrogeochemical surveys have provided fundamental new information on the application of the method to regional exploration. Several presentations on parts of the data sets have ben made at national and international meetings.

Outputs:

Dunn, C.E.

1994: Chapter 20: Biogeochemical prospecting for metals; in "Biological Systems in Mineral Exploration and Processing"; R.R. Brooks, C.E. Dunn and G.E.M. Hall (ed.), Ellis Harwood, U.K., 538p.

Dunn, C.E., Adcock, S.W. and Spirito, W.A.

1994a: Reconnaissance biogeochemical survey, southwestern Nova Scotia: Part 2, Balsam Fir Twigs. GSC Open File 2757, 200 pp.

1994b: Reconnaissance biogeochemical survey, southeastern Cape Breton Island, Nova Scotia: Part 2, Balsam Fir Twigs. GSC Open File 2758, 200 pp.

Dunn, C.E. and Balma, R.G.

1994: Biogeochemical exploration in central Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 41.

1995: Biogeochemical studies in Nova Scotia, 1995; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 36.

Dunn, C.E., Balma, R.G. and Spirito, W.A.

1996: Reconnaissance biogeochemical survey of central Nova Scotia, Part 1 - Balsam Fir Twigs, (parts of NTS 11D, E, 21A, H); Geological Survey of Canada, Open File 3221, 173 p., + 50 maps, + 1 colour map at 1:130 000 scale, 1 diskette of ASCII formatted data.

In prep: Reconnaissance biogeochemical survey of southwestern Cape Breton Island (NTS 11F/11, 14 and parts of sheet 11F/10 and 15); Geological Survey of Canada, Open File.

In prep: Reconnaissance biogeochemical survey in the Shubenacadie Grand Lake area, Nova Scotia; Geological Survey of Canada, Open File.

Hall, G.E.M. and Pelchat, P.

1995: Hydrogeochemical survey in southwest Cape Breton, 1995; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 50.

Hall, G.E.M., Pelchat, P. and Balma, R.G.

1994: Hydrogeochemical exploration in central Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 40.

In prep: Hydrogeochemical investigations in Southwest Cape Breton, Nova Scotia; Geological Survey of Canada, Open File.

In prep: Hydrogeochemical investigations in the Shubenacadie Grand Lake area, Nova Scotia; Geological Survey of Canada, Open File.

C1.109 Seismic reflection, Carboniferous Basins (F. Marillier, GSC-Atlantic)

Subproject 1: Seismic Reflection, Cumberland Basin

Objectives:

To compile and interpret industry seismic reflection data for the Cumberland Basin of northern Nova Scotia; and to relate seismic data to recent NSDNR stratigraphic and structural mapping in order to provide a three dimensional understanding of the deep structures of the basin and link major rock units and structures between the Cumberland Basin and the adjacent parts of the Gulf of St. Lawrence.

Results:

The Cumberland Basin can be divided into four structural domains, including: 1) the Athol Syncline; 2) the Tatamagouche Syncline; 3) the Hastings Uplift, a large basement high; and, 4) a highly disrupted area intruded by salt of widespread distribution, separating the previous three areas. All four domains are clearly evident in the base Boss Point map. Domain 4 appears to be an area of localized basin inversion. Of the several identified seismic horizons, two have been mapped regionally across the basin near the base of both the Windsor Group and Boss Point Formation (Cumberland Group). The base of the Windsor Group horizon, which has tentatively been correlated with a series of reflections typical of evaporite strata, can be correlated regionally, and appears to have a fairly uniform depth throughout the study area (attaining depths of 4 km). The distribution of Fountain Lake Group rocks has also been mapped, and the stratigraphic subdivision of the group has been refined. Seismic data also established the age of the Falls Formation as pre-Windsor Group.

Impact:

The project has provided a regional synthesis of the deep structures present in the Cumberland Basin which was not previously available. This is expected to have an impact on the exploration of hydrocarbon resources in the Cumberland Basin (e.g., coalbed methane).

Outputs:

Durling, P.

1996: A seismic reflection study of the Fountain Lake Group in the Scotsburn anticline area, northern Nova Scotia; in Current Research 1996-D; Geological Survey of Canada, p. 47-53.

Durling, P. and Marillier, F.

1995: Stratigraphy and structural elements of the Cumberland Basin from seismic reflection data; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 40.

Marillier, F. And Durling, P.

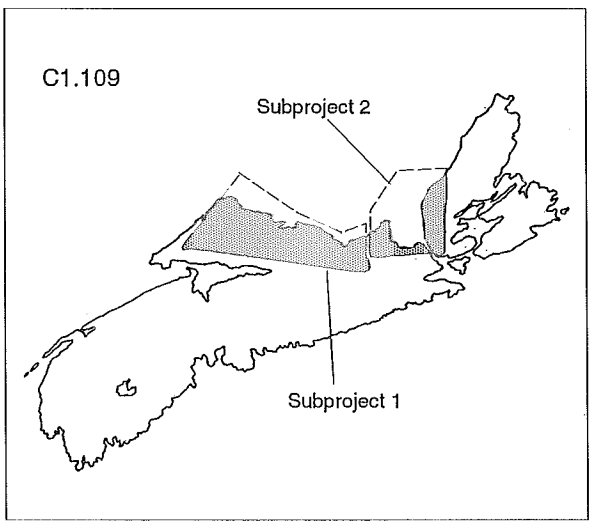
1995a: Preliminary results from reprocessing of seismic reflection data in the Cumberland Basin, Nova Scotia; in Current Research 1995-D; Geological Survey of Canada, p. 45-52.

1995b: Re-processing of seismic reflection data in the Cumberland Basin; Atlantic Geology, vol. 31, no. 1, p. 54.

1994: Reprocessing of seismic reflection data in the Cumberland Basin, Nova Scotia: Preliminary results; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 38.

Piper, D.J.W., Durling, P. and Pe-Piper, G.

1996: Field evidence for the extent and style of overthrusting along the northeastern margin of the Cobequid Highlands, Nova Scotia; in Current Research 1996-D; Geological Survey of Canada, p. 41-46.



Subproject 2: Seismic Reflection, St. Georges Bay Basin

Objectives:

1) To compile and interpret industry seismic reflection data in the St. Georges Bay area of northern Nova Scotia, and concurrently interpret onshore industry seismic data available for the Antigonish Basin and the Port Hood-Cheticamp areas of Cape Breton Island.

2) To compare results with interpreted seismic data in the for the adjacent Magdalen Basin in order to assess the stratigraphic and sedimentological significance of major fault system(s) separating St. Georges Bay from the larger Magdalen Basin to the north.

3) To relate seismic reflection data to major Carboniferous rocks units and major structures mapped in the onshore areas peripheral to St. Georges Bay.

Results:

Four horizons were mapped in the St. Georges Bay area on the basis of reflection strength and continuity. The deepest reflection was interpreted as an event near the base of the Windsor Group. Time structure contours on this horizon reached up to 2800 ms (5600 m) and form a roughly circular pattern in the north-central part of the Bay. Away from this area, the basin becomes much shallower (0-500 ms). Several basement-related faults affect this horizon, showing geometries that suggest reverse or thrust displacements. The next shallower horizon mapped was interpreted as the highest Windsor Group strata. The reflections show good continuity between salt structures but the reflection character deteriorates adjacent to salt structures and in areas with thin strata. The time structure maps shows that this horizon has been folded into open synclines between salt structures. The two shallowest horizons mapped are probably reflections from coal strata and are only recognized in the northeastern part of the Bay. The time structure contour maps from these horizons are simple in comparison to the top and base of Windsor Group maps, and show that the strata have been folded into broad, open synclines that are separated by northeast-striking faults.

The St. Georges Bay area appears to have all the ingredients necessary for hydrocarbons: organic-rich source rocks, porous reservoir rocks, potential shale and evaporite cap rocks, and mild deformation suitable for the formation of structural and stratigraphic straps. Organic-rich source rocks exist in the Horton Group at Big Marsh, and in the Windsor Group at MacIsaac Point. Oil shales and organic rich shales, similar to those at Big Marsh, have acted as regional petroleum source rocks in the Maritimes Basin. Recently, a 500 m thick, black shale package of Westphalian A age near St. Rose-Chimney Corner was identified as potential source rock. Similar rocks of the same age extend beneath St. Georges Bay. Migration pathways may include northeast-striking faults, north- to northwest-striking faults, and low angle thrust faults. The major structural elements in St. Georges Bay are salt-cored features. Salt-cored structures result from the flowage of thick Windsor Group evaporite rocks. An onshore borehole drilled near Antigonish flowed natural gas from salt and anhydrite within the Windsor Group. Reservoir development could occur on the crest ans flanks of these structures. Porous Windsor Group limestones, or potentially clastic rocks, could form reservoirs capped by evaporites, which act as an excellent cap rock. The Cumberland Group, with its course sandstone content could also form potential reservoirs (e.g., anticlines, lenses, pinchouts, algal mounds, or less likely, pinnacle reefs) capped by shale or mudrock.

Impacts:

The project has facilitated an understanding of the physical and related deformation of the Windsor Group which is fundamental in assessing the region's potential for oil and gas.

Outputs:

Durling, P. and Harvey, P.J.

1995: Results of seismic mapping in the St.. Georges Bay area: Implications for stratigraphy, structure, salt tectonism and petroleum potential; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p.42.

Durling, P., Howells, K. And Harvey, P.

1995: The near-surface geology of St.. Georges Bay, Nova Scotia: Implications for the Hollow Fault; Canadian Journal of Earth Sciences, vol. 32, p. 603-613.

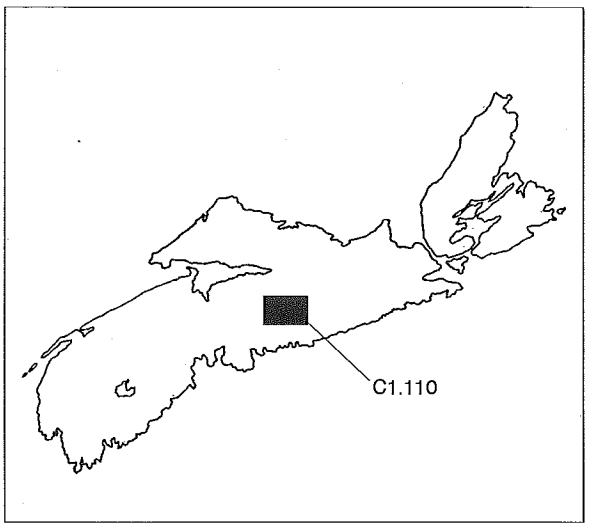
1994: Seismic and gravity studies in the St.. Georges Bay area; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 36.

Harvey, P, Howells, K., and Durling, P.
1995: Preliminary Geophysical Interpretations of the Antigonish-Mabou Subbasin; Atlantic Geology, v. 31, no. 1, p. 47.

Durling, P., Harvey, P., and Howells, K.
1995: Geophysical evidence for thrust faulting in the Carboniferous Antigonish-Mabou Subbasin, Nova Scotia; Atlantic Geology, v. 31, no. 3, p. 183-196.

C1.110 Shallow seismic and borehole geophysical surveys in the Shubenacadie Basin (S.E. Pullan, Terrain Sciences Division-GSC)

Objectives:
To use high resolution shallow seismic and borehole geophysical methods to assist in delineating the overburden stratigraphy in key areas of the Shubenacadie Basin, in support of NSDNR studies of Quaternary and Cretaceous lithologies in Carboniferous and Triassic basins of Nova Scotia.



Results:
The project has resulted in a total of: 65 shallow seismic test sites across the Shubenacadie, Musquodoboit and Stewiacke valleys; 10 line-km of 12-fold CDP (Common Depth Point) shallow seismic reflection profiles in the Shubenacadie and Musquodoboit valleys; and borehole logs (natural gamma, conductivity, magnetic susceptibility, and P-wave velocity) for one borehole located on a seismic line in Shubenacadie. In 1994 and 1995, NSDNR drilled over 20 boreholes in the survey area.

Initial seismic test results suggested that there were areas in the Shubenacadie basin where bedrock was at depths greater than 100 m below surface. This was subsequently confirmed by NSDNR drilling. The test sites were used to determine the optimum locations for follow up seismic profiling in the Shubenacadie valley (1994) and the Musquodoboit valley (1995). These sections have clearly delineated subsurface Quaternary and Cretaceous infilling of deep bedrock valleys.

Geophysical logs have only been obtained in one borehole to date, but they suggest that borehole logs would be excellent lithological tools. In particular, the magnetic susceptibility log clearly shows the Quaternary/Cretaceous boundary as an abrupt decrease in magnetic susceptibility values. This may imply that the contact could be accurately determined from such logs without the requirement for collecting core.

Impacts:
Prior to the initiation of this project, small isolated occurrences of economically valuable silica sand and kaolin clays were known to occur in the Shubenacadie and Musquodoboit basins. This project used drilling and shallow seismic reflection surveys to delineate the three-dimensional distribution of Cretaceous and Quaternary unconsolidated sediments in the study area. The known extent of Cretaceous outliers in the Shubenacadie and Musquodoboit valleys has been expanded from an area of < 1 km^2 to > 57 km^2. Revised mapping based on drilling and seismic results indicate the potential for large tonnage kaolin and silica sand deposits within these valleys. Presentation of preliminary results of the work at the Nova Scotia Open House in November 1995 resulted in staking of over 5000 acres (200,000 claims) in the Musquodoboit valley.

Preliminary tests of clays recovered from drilling indicate that brightness and whiteness values meet the requirements for standard filler kaolin products. Presently, the majority of North American industrial demand for kaolin is met by U.S. domestic production. In December 1995, Stora Forest Industries Ltd. announced plans to expand their paper mill operations at Point Tupper, Nova Scotia, to produce supercalendered paper, which will require approximately 112,000 tonnes of kaolin annually. As a result of this CNSMDA cooperative project between the GSC and NSDNR, a potential source of this kaolin is now known to exist in Nova Scotia.

Drilling and seismic results to date suggest a geological model for the deposits of Cretaceous sediments that implies the potential for additional Cretaceous sediments in other faulted or sheltered basin and/or depression in Nova Scotia. Further exploration will benefit considerably from the development and testing of geophysical techniques and depositional models that has been conducted under this program. Future Nova Scotia kaolin producers may be competitive suppliers of clay to paper companies in New Brunswick, Newfoundland, and New England, and local supplies may attract other producers of value-added paper products to the region.

Outputs:

Finck, P.W., Stea, R.R. and Pullen, S.

In press: Cretaceous deposits of high purity kaolin and silica sand in Nova Scotia; in Proceedings, Conference of the Society of Mining and Metallurgy, Phoenix, Arizona, March 1996.

1995a: Discovery of an Early Cretaceous paleovalley in the Shubenacadie Basin area, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 5.

1995b: New discoveries of Cretaceous sediments near Shubenacadie, Nova Scotia; in Nova Scotia Department Natural Resources, Minerals and Energy Branch, Report of Activities 1994, Report 95-1, p. 139-158.

Pullen, S., Finck, P.W. and Stea, R.R.

In prep: Shallow seismic and borehole geophysical surveys in the Shubenacadie Basin, Nova Scotia, Canada; Journal of Environmental and Engineering Geophysics.

In prep: Test spread data and results of geophysical investigations in the Shubenacadie Basin, Nova Scotia; Geological Survey of Canada, Open File.

In prep: Shallow seismic reflection data from the Shubenacadie Basin, Nova Scotia; Geological Survey of Canada, Open File.

Stea, R.R., Finck, P.W. and Pullen, S.E.

1996: New evidence for extensive Cretaceous Basins in Nova Scotia; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, p. A-89.

Stea, R.R., Finck, P.W., Pullan, S.E., and Corey, M.C.

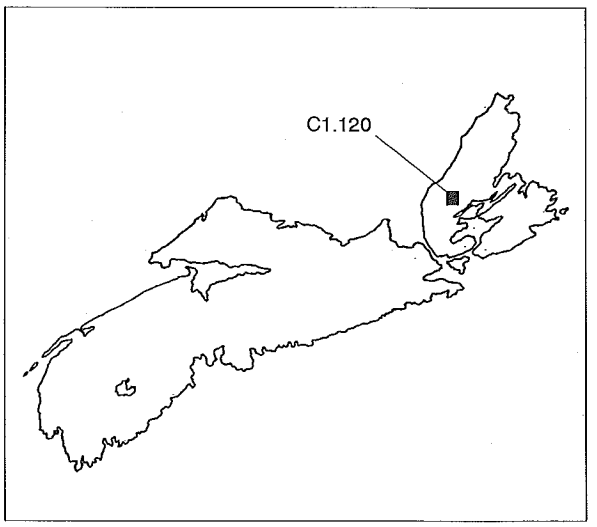
1996: Cretaceous deposits of kaolin clay and silica sand in the Shubenacadie and Musquodoboit valleys, Nova Scotia, Canada; Nova Scotia Department Natural Resources, Minerals and Energy Branch, Open File Report 96-003, 58 pp plus appendices.

C1.12 *Mineral Deposits Studies*

C1.120 Barite-fluorite vein deposits, Lake Ainslie, Cape Breton Island (A.L. Sangster, Mineral Resources Division-GSC)

Objectives:

To complete field and laboratory studies on the barite-fluorite mineralization located east of Lake Ainslie, Cape Breton Island. Project investigations focussed on documenting vein geometry and distribution, and on determination of the timing and conditions of mineralization in order to formulate a unifying genetic model for these occurrences which will assist future exploration initiatives.



Results:

The series of barite-fluorite veins located east of Lake Ainslie are hosted in the Scotsville and Trout Brook fault-block inliers. The blocks are comprised of a pre-Devonian basement of psammitic gneisses, diorite and granite, with a nonconformable cover of conglomerate, sandstone, basalt and rhyolite that has been assigned to the Late Devonian Fisset Brook Formation. Clastic and carbonate rocks of the Carboniferous Horton and Windsor groups are folded and faulted against the blocks. In the Lake Ainslie area, rocks of the Fisset Brook

Formation (along with underlying metamorphic and plutonic rocks) are restricted to a north-south array of rhombic fault blocks. Barite-fluorite vein mineralization, which is hosted mainly by the Fissett Brook Formation, but also locally by semipelitic gneiss and diorite, is controlled by this rhombic fault pattern. ENE-striking sets of veins (near East Lake Ainslie) are affected by dextral oblique-slip movements, and a N to NNW vein set (near Scotsville) is affected by dip-slip movement. Dynamic analysis of minor fault surfaces associated with the veins indicates that compressive stress, accompanying both sets of movements, was oriented NW-SE. The rhombic blocks are interpreted to have formed as push-ups within a regional, NE dextral strike-slip regime of post Viséan age. Initial fluid inclusion studies (by D. Kontak, NSDNR) on fluorite from the veins suggests that deposition was from saline fluids (14-18 wt% equiv. NaCl) at relatively low temperatures (Th = 60-130°C). Such fluids may represent basinal brines expelled from the Mabou sub-basin during transpressional deformation and channelled into active, brittle fault systems near the basin margin, particularly where they cut thick, competent units such as rhyolite of the Fisset Brook Formation and the adjacent crystalline basement.

Impacts:

The project has successfully characterized the barite-fluorite mineralization at Lake Ainslie (i.e., geochemistry, isotopic signatures and, fluid inclusion data), and a structural model for vein emplacement has been formulated.

Outputs:

Barr, S,M., Macdonald, A.S. and Dunning, G.R.

1995: Field relations, structure, and geochemistry of the Fisset Brook Formation in the Lake Ainslie-Gillanders Mountain area, central Cape Breton Island, Nova Scotia; Atlantic Geology, v. 31, no. 3, p. 127-139.

Kontak, D.J. and Macdonald, A.S.

1995: Initial results of a fluid inclusion study of fluorite from the Lake Ainslie barite-fluorite deposits, Inverness County, Nova Scotia; in Nova Scotia Department of Natural Resources, Report of Activities 1994, Mineral and Energy Branch, Report 95-1, p. 99-106.

Macdonald, A.S.

1994: Structural environment of the Lake Ainslie barite-fluorite veins, Cape Breton Island; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 61.

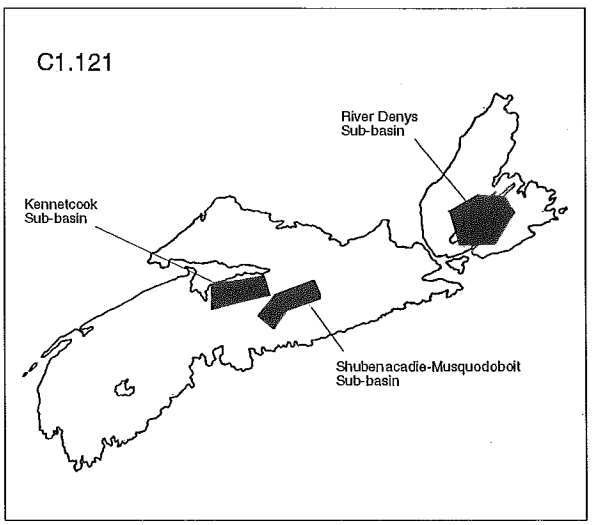
Macdonald, A.S., Barr, S.M., Arnott, A.M. and Dunning, G.R.

1995: The Fisset Brook Formation in the Lake Ainslie-Gillanders Mountain area, Central Cape Breton Island, Nova Scotia: Age, Geochemistry, structure and mineralization; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 59.

C1.121 Fluid migration and mineralization in the Lower Windsor Group (D.F. Sangster, Mineral Resources Division-GSC)

Objectives:

To determine the source, path, and timing of fluids within and between three sub-basins in the Nova Scotian Lower Carboniferous (i.e., Kennetcook, Shubenacadie-Musquodoboit, and River Denys) and the relationship of these fluids to base metal mineralization. The project, a multi-disciplinary, multi-institutional undertaking, builds upon a previous MDA project that resulted in a detailed description of the geology, stratigraphy, mineralogy, and ore textures of basal Windsor deposits in New Brunswick, Nova Scotia, and Newfoundland.



Results:

The project examined three sub-basins (Kennetcook, Shubenacadie-Musquodoboit, and River Denys), each of which contains at least one well-studied base metal deposit-Walton, Gays River, and Jubilee, respectively.

Research into host rocks and mineralization focused on carbonate petrogenesis, diagenetic tracers (such as isotope geochemistry, organic matter, and clay minerals), mineralogy and paragenesis, timing of mineralization, Pb-isotopes, and fluid inclusion systematics. Information and data collected as a result of this research were used to compare diagenetic and hydrothermal events associated with mineralization in the three sub-basins.

Very early in the project, it was recognized that more than one type of carbonate breccia occurred in the Macumber Formation but neither the distinguishing characteristics, nor the origins of any of these was known. The distinction was important because breccias are associated with many deposits in the basal Windsor. Project investigations recognized three main types of breccia, including: i) a synsedimentary slump breccia, which locally is an important ore control (Walton); ii) an ore-hosting tectonic breccia (Jubilee); and, iii) a chaotic carbonate breccia with a red silt matrix, interpreted to be a very late, post-ore near-surface collapse breccia. This breccia is a destructive one, having removed a significant, but unknown, quantity of ore at the Walton, Gays River, and Smithfield deposits.

Dolomite, present only at the Gays River deposit, has been shown to be pre-ore and not related in any way to the ore-forming event. Its absence in the other two sub-basins emphasizes that dolomite should be used with caution as a prospecting aid in searching for other basal Windsor deposits.

A conscious decision at the outset of the project was that, to the extent possible, the same parameters would be measured in all three sub-basins and their respective mineral deposits in order to permit comparison of final results. For example, although ore-related carbonates in the Gays River and Jubilee deposits share a similar range in O-isotopic compositions, the starting compositions for Sr-isotopes are distinctly different, Gays River being the much more radiogenic of the two. The conclusion here is that fluids responsible for the two deposits were in contact with distinctly different source rocks. $d^{13}C$ values for ore-related carbonate gangue at Jubilee are characteristically very light compared with those for Gays River. Similar ^{13}C-depleted values were also found at the Walton deposit. In both instances, hydrocarbons are abundant in ore-stage fluid inclusions and are interpreted to have participated in the ore-forming event, most probably by catalyzing sulphate reduction in a closed system. In contrast, at Gays River, there is little evidence, either isotopically or in fluid inclusions, of hydrocarbons being present in the ore fluids.

The relationships between the characteristics of organic matter (OM), clay mineral assemblages (CMA), and mineral deposits suggest that these parameters can be used as new guides for base-metal exploration. Research in the Gays River area identified four clay mineral assemblages, including: i) a zone in which smectite is most abundant at the edge of the orebody; ii) a small kaolinite zone within the ore body; iii) a corrensite zone, also within the orebody; and iv) a well-crystallized illite and chlorite assemblage most abundant well outside the ore zone and which probably represents an unaltered detrital assemblage. The deposit is also surrounded by a positive thermal anomaly. Reflectance values (R_o) decrease abruptly within the deposit and this feature is attributed to chemical alteration of the organic material. Research has also revealed that the nature of specific clay mineral assemblages is controlled by key parameters of the fluid, especially major cation activities, temperature, and pH as well as the rock-fluid ratio. All these factors combine to induce dissolution or alteration of chlorite in the vicinity of ore and formation of neomorphic kaolinite and smectite. This low-temperature alteration of organic material and clay minerals is showing considerable promise as a prospecting aid for MVT deposits which have traditionally been regarded as having no visible associated wall-rock alteration.

Because "fluid migration" was the main subject of the project, much attention was paid to fluid inclusion studies. At Jubilee, for example, the earliest fluid, in fact pre-ore, was one of high salinity and low temperature. This has been interpreted to represent the ambient, pore-filling fluid in the host rocks prior to mineralization. The ore-forming fluid, in contrast, was a high-temperature, high-salinity fluid which, as soon as it entered the host rocks, began to mix with, and be cooled by, the ambient fluid. At some point during this mixing process, a third fluid, relatively cool and non-saline, entered the system. This third fluid interrupted the original mixing trend and eventually shut down the ore-forming system through massive dilution and cooling. Another very important result of the Jubilee fluid inclusion research was documentation of the presence of liquid petroleum throughout all phases of the mineralizing event.

Gays River thermometric data, the result of detailed fluid inclusion studies, are: i) first melting occurs at -55°C indicating the presence of calcium chloride in addition to

sodium chloride; ii) most salinities fall in the range 20-28 wt.% equivalent sodium chloride; and iii) homogenization temperatures range from 70°-260°C. These data may be interpreted either as mixing of a hot ore fluid with a cool ambient fluid or simply cooling of a single ore fluid. Collectively the data indicate pressures during mineralization of about 400 bars.

At Walton, a wide variety of barite types have been recognized: i) massive, constant-volume replacement of sideritized Macumber; ii) fine-grained aphanitic to coarse bladed; iii) white to transparent coarse bladed crystals in massive sulphide ore; and iv) late-stage euhedral cementing sulphide breccia and which may be coated with a soft, black bituminous material. All Walton barites contained excellent fluid inclusions with: i) a wide range of salinities from 0-28 wt. % sodium chloride equivalent and first melt temperatures suggesting the presence of cations other than sodium.; ii) homogenization temperatures ranging from 100°-300°C. The data also revealed a minor amount of mixing with a low-salinity fluid, of unknown source, at about 200°C. As at Gays River, the data collectively indicate ambient pressures during mineralization were about 400 bars (= about 1500 metres lithostatic burial).

Walton fluid inclusions also revealed the ubiquitous presence of liquid petroleum and homogenization data for these range from 70°-300°C, suggesting a mineralizing event which cooled very rapidly following mineral deposition. Liquid petroleum occurs in petroleum-only or in water-petroleum inclusions indicating co-existence of petroleum and mineralizing fluid. More than 99.9% of the hydrocarbon occurs as liquid petroleum rather than a solid hydrocarbon such as bitumen, which, given the high temperatures of this deposit, indicate a short-lived mineralizing system, probably in the order of a few hundred thousand years.
Geological studies at Walton showed that the deposit, a 5 million tonne barite body with a half-million tonne Pb-Zn-Cu-Ag zone within it, is a massive replacement of at least half of a 10 million tonne siderite body which itself replaced the original Macumber limestone breccia. The project has defined two previously-unrecognized ore types at Walton - a semi-concordant Ba-Pb body and a discordant Cu-Ag body.

The Pb-isotope data reveal that deposits in each sub-basin are isotopically distinct from those in the other sub-basins. The basin-specific nature of these data suggest very strongly that lead was derived from very local sources which were apparently specific to each individual deposit. Common to all deposits is the fact that Horton Group clastics either directly underlie the deposits or are immediately laterally adjacent to the footwall. However, Horton clastics were derived largely, if not entirely, from local basement surrounding each sub-basin and the composition of these clastics is therefore mainly a function of these sources.

While ore fluids in basal Windsor mineralization were significantly hotter than most MVT deposits, there is evidence they were cooled relatively rapidly, probably by mixing with a cooler ambient fluid. Fluids may have been heated to these unusually high temperatures by a combination of incipient rifting, leading to thinning of the crust, augmented by the widespread presence of older high heat-producing granitic intrusions in the Windsor basement. Source of the ore fluids is still unclear although circumstantial evidence, not presented here today, suggests a northerly source for deposits in the Kennetcook and Shubenacadie-Musquodoboit sub-basins, perhaps in response to uplift of the Cobequid Mountains. Fluid flow in River Denys sub-basin may have been affected, if not controlled, by the Ainslie Detachment.

Impacts:
Because project results are only now being prepared for publication, visible and recognizable impacts of this project on the mineral exploration industry are precluded at this time. However, the fact that a fully documented and integrated geological-based model for basal Windsor mineralization will be appearing in a prestigious international journal will serve to attract both domestic and international attention to the exploration potential of Nova Scotia. Furthermore, the project has served to bring together, for the first time, investigators in several eastern Canadian institutions in the successful formulation and completion of a complex research project.

Outputs:
Bertrand, R., Chagnon, A., Héroux, Y. and Savard, M.M.
In review: Hydrothermal alteration of clay minerals and organic matter near the Jubilee carbonate-hosted deposit, Cape Breton Island, Canada; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

Burtt, M.D.
1995: Geology of the B-baseline zone, Walton Ba-Cu-Pb-Zn-Ag deposit, Nova Scotia; unpublished. MSc thesis, University of Ottawa, Ottawa, Canada, 116p. plus appendices.

Chi, G-X., Kontak, D.J. and Williams-Jones, A.E.
In review: Fluid composition and thermal regime during base-metal mineralization of the Lower Windsor Group, Nova Scotia; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology..

Chi, G-X. and Savard, M.M.
In review: Basinal fluid flow models related to Pb-Zn mineralization in the southern margin of the Maritimes Basin; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

1995a: Fluid evolution and mixing in the Gays River carbonate-hosted Zn-Pb deposit and its surrounding barren areas, Nova Scotia; Atlantic Geology, v. 31, no. 3, p. 141-152.

1995b: A preliminary microthermometric study of the Sugar Camp, Yankee Line and MacPhailis Brook Pb-Zn showings, Cape Breton Island, Nova Scotia; in Current Research 1995-D; Geological Survey of Canada, p. 53-58

1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Fluid inclusions in the Jubilee Zn-Pb deposit; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 54.

Chi, G., Savard, M.M., and Héroux, Y.
1995: Constraints from fluid inclusion data on the origin of the Jubilee Zn-Pb deposit, Nova Scotia; Canadian Mineralogist, v.33, p. 709-721.

Chi, G., Savard, M.M., St-Antoine, P. and Héroux, Y.
1995: Basinal fluid flow mechanisms related to carbonate-hosted Zn-Pb mineralization in the Maritimes Basin, Nova Scotia, Canada: An Overview; in Abstracts with Program, Geological Society of America 1995 Annual Meeting, v. 27, no.6, p. A-378.

Fallara, F.
1996: Evolution structurale, pétrographie et géochimie des carbonates, et modèle métollégénique de l'indice de Pb-Zn de Jubilee Ile du Cap Breton Nouvelle-Ecosse; Mémoire de Mâtrise, INRS, 71 pages, 6 annexes, 1 carte.

Fallara, F., Savard, M.M., Lynch, G., and Paradis, S.
1994: Preliminary geological and geochemical results characterizing the mineralization processes in the Jubilee Pb-Zn deposit, Cape Breton Island, Nova Scotia; in Current Research 1994-D, Geological Survey of Canada, p. 63-71.

Fallara, F., Savard, M.M. and Paradis, S.
In review: A structural, petrographic, and geochemical study of the Jubilee Zn-Pb deposit, Nova Scotia: A new metallogenic model deposit; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

Héroux, Y., Chagnon, A., Sainte-Antoine, P. and Savard, M.M.
1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Organic matter and clay assemblages from the Gays River, Jubilee and Walton deposit; in Nova Scotia Department of Natural resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 55.

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1996: Organic matter and clay anomalies associated with base-metal sulfide deposits: three case studies; Organic Geology Research (in press).

St-Antoine, P., Héroux, Y., Savard, M.M. and Chagnon, A.
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Kontak, D.J.
In review: A study of fluid inclusions in sulfide and non-sulfide mineral phases from a carbonate-hosted Zn-Pb deposit, Gays River, Nova Scotia; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

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Kontak, D.J. and Sangster, D.F.
In review: Aqueous and liquid petroleum inclusions in barite from the Walton deposit, Nova Scotia, Canada: A Carboniferous, carbonate-hosted Ba-Zn-Pb-Cu-Ag deposit; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

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Lavoie, D. and Sami, T.
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1995: Multiple breccia events in the lower part of the Carboniferous Windsor Group, Nova Scotia; Atlantic Geology, v. 31, no.3, p. 197-207.

Lavoie, D., Sangster, D.F., Savard, M.M. and Fallara, F..
In review: Breccias in the Lower part of the Windsor Group and their relation to mineralization; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

Lavoie, D., Savard, M.M. and Sangster, D.F.
1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: The Pb-Zn - rich, Lower Carboniferous (Viséan) Basal Windsor carbonate; in Nova Scotia Department of Natural resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches, D.R. MacDonald (ed.), Report 94-2, p. 47.

Lynch, G., Keller, J.V.A. and Giles, P.S.
In review: Stratigraphy of the Maritimes Basin, and influence of the Ainslie Detachment on mineralization in the Windsor Group of northern Nova Scotia, Canada; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

Sangster, D.F.
1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Background; in Nova Scotia Department of Natural resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches, D.R. MacDonald (ed.), Report 94-2, p. 46.

Sangster, D.F., Burtt, M.D. and Kontak, D.J.
In review: Geology and genesis of the B-baseline zone, Walton Cu-Pb-Zn-Ag-Ba deposit, Nova Scotia, Canada; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

Sangster, D.F. and Kontak, D.J.
1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Timing of mineralization; in Nova Scotia Department of Natural resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches, D.R. MacDonald (ed.), Report 94-2, p. 56.

Sangster, D.F. and Savard, M.M.
In prep: Introduction: Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

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Sangster, D.F., Savard, M.M. and Burtt, M.D.
In review: Isotope geochemistry of carbonate host rocks, Walton area; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Isotope geochemistry of the Macumber Formation and altered equivalents, Walton deposit area, Kennetcook Sub-basin; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 49.

Sangster, D.F., Savard, M.M. and Kontak, D.J.
In prep.: An integrated model for mineralization of the Lower Windsor carbonates of Nova Scotia; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

In review: Pb and Sr isotopes of ore-stage minerals in Pb-Zn deposits of the Lower Windsor Group, Nova Scotia; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

Savard, M.M.
1996: Pre-ore burial dolomitization adjacent to the carbonate-hosted Gays River Zn-Pb deposit, Nova Scotia; Canadian Journal of Earth Sciences, v. 33, no. 2., p. 303-315.

1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Paragenetic sequences and genetic comparison of carbonate-hosted base metal deposits; in Nova Scotia Department of Natural resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 48.

Savard, M.M. and Chi, G.
In review: Cation study of fluid inclusion decrepitates from the Jubilee and Gays River Zn-Pb deposits - Characterization of ore-forming brines; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

Savard, M.M., Chi, G-X., Kontak, D.J. and Fallara, F.
1995a: The Gays River and Jubilee Zinc-Lead deposits of the Carboniferous Basal Windsor Group, Eastern Canada: Carbonates, porosity, fluids and temperature; Irish Association for Economic Geology, Annual Review 1995, p. 73-74.

1995b: Temperature, chemistry, water-rock interaction and mineralization processes around the Gays River and Jubilee Zn-Pb deposits, Basal Windsor group, Nova Scotia; Atlantic Geology, vol. 31, no. 1, p 59-60.

1995c: Ore-forming fluids in carbonate-hosted Pb-Zn deposits of the Carboniferous basal Windsor Group, Nova Scotia, Canada: temperature, chemistry and water-rock interaction; Society of Economic Geologists, 75th anniversary - International Field Conference - Carbonate-hosted lead-zinc deposits, June 3 to 6, Missouri USA, Extended abstract volume, p.267-269.

Savard, M.M. and Fallara, F.
1994: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Isotope geochemistry and characterization of mineralizing fluids from the Macumber formation in the Jubilee deposit, Rivers Denys Sub-basin; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald, Report 94-2, p. 51.

Savard, M.M., Héroux, Y. and Chagnon, A.
1994: Carbonate cements, organic matter and clay minerals around the Gays River Pb-Zn deposit - an integrated regional study; SEPM Research International Conference, Lake Ozark, Missouri; Program, abstracts and field guide, J.M. Gregg, I.P. Montanez and K.L. Shelton (ed.), p. 78.

Savard, M.M. and Kontak, D.J.
In review: $\delta^{13}C$-$\delta^{18}O$-$^{87}Sr/^{86}Sr$ covariations in ore-stage calcites at and around the Gays River Pb-Zn deposit - Evidence for fluid mixing; in Zinc-Lead mineralization and basinal brine movement, Lower Windsor Group (Viséan), Nova Scotia, Canada, D.F. Sangster and M.M. Savard (ed.); Economic Geology.

1994a: Regional versus deposit-scale geochemical attributes of a mineralizing system (MVT) in the Viséan Gays River Formation, southern Nova Scotia; in Waterloo'94, Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 19, p.A99

1994b: Fluid migration and mineralization in the Lower Windsor Group, Nova Scotia: Isotope geochemistry and characterization of mineralizing fluids in the Gays River Formation, gays River Deposit and Shubenacadie-Musquodoboit Sub-basin; in Nova Scotia Department of Natural resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 50.

Savard, M.M., Lynch, G. and Fallara, F.
In press: Burial diagenesis model for the Macumber Formation on Cape Breton Island - Implications for the tectonic evolution of the region; Atlantic Geology, v. 32, no.1.

1994: Stable isotope study of the Ainslie detachment, Cape Breton island-Characterizing ore fluids that affected the Pb-Zn Jubilee deposit; in Waterloo'94, Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 19, p. A99.

St-Antoine, P., Chagnon, A., Savard, M.M.
1993: Etude de la minéralogie des argiles dans l'encaissant carbonaté du gîte de Gays River, Nouvelle-Ecosse; dans Recherche en Cours, Commission Géologique du Canada, Partie E; Etude 93-1E, p.361-368.

St-Antoine, P., Chagnon, A., Savard, M.M., and Héroux, Y.
1995: Influence of Pb-Zn mineralization on Clays Fraction of the Gays River Formation, Nova Scotia, Canada; Society of Economic Geologists, 75th Anniversary - International Field Conference, Carbonate-hosted lead-zinc deposits, June 3 to 6, Missouri USA, Extended abstract volume, p. 302-304.

St.-Antoine, P., Héroux, Y., Savard, M.M. and Chagnon, A.
1994: Organic matter and clay mineral: elaboration of a metallogenic model for Gays River MVT deposit and role as a prospection tool; in Waterloo'94, Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 19, p. A106.

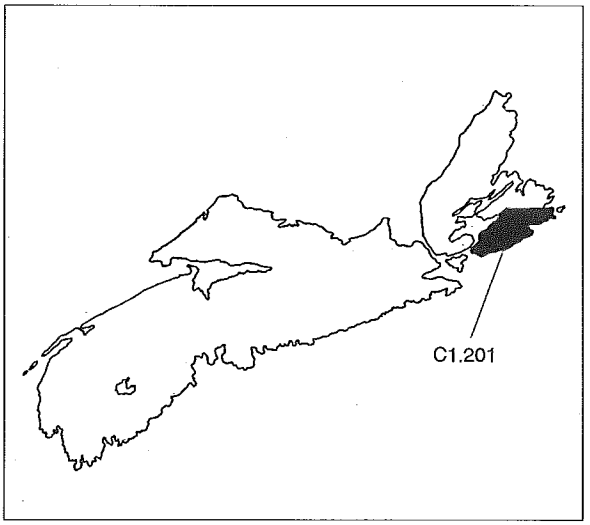
C1.2 CAPE BRETON ISLAND SUBPROGRAM

C1.200 Stratigraphy, physical and chemical volcanology and ore petrography - Stirling Belt (A.L. Sangster, Mineral Resources Division-GSC)

The project was cancelled at the beginning of fiscal 1994-95.

C1.201 Metamorphism in Late Precambrian volcanic and sedimentary rocks-southeastern Cape Breton Island (J.B. Whalen, Continental Geoscience Division-GSC)

Objectives:
To determine the relative effects and P-T conditions of regional dynamothermal metamorphism, burial metamorphism, shear-zone-related dynamic metamorphism, and hydrothermal/skarn overprinting in the Late Precambrian volcanic-sedimentary belts of southeastern Cape Breton Island. Although this information is deemed essential to the understanding of tectonothermal evolution of the area, and indirectly, mineralizing processes, such a study has previously never been initiated anywhere in the Avalon terrane of the Appalachian orogen.



Results:
From a suite of more than 2000 samples, only 1% of these samples were of suitable composition and contain invariant or univariant mineral assemblages that provided information on the conditions of metamorphism. These were predominantly prehnite-, prehnite-actinolite, actinolite-bearing, and rare pumpellyite-bearing assemblages which indicate that metamorphism occurred at high geothermal gradients (50°C/km or 200°C < T < 350°C for P < 3 kbar), with fluids relatively poor in CO_2. Pressure-temperature calculations indicate temperatures of 300–325°C (P = 2-3 kbar) for the lowest grades and 360-380°C (P = 2—3 kbar) for higher grade rocks.

Greenschist facies assemblages dominate in rocks of the Stirling belt, whereas in the East Bay Hills belt, greenschist facies rocks are restricted to narrow zones around plutons. In the Coastal belt, the Fourchu Group is predominantly at greenschist facies in wide zones around plutons (mainly of Devonian age), either outcropping at the surface or inferred to be present at shallow depth. In contrast, rocks of the Main-à-Dieu Group are mostly at prehnite-pumpellyite facies, with the exception of narrow bands of greenschist facies rocks close to the Baleine Gabbro and in the Devonian Blue Mountain contact metamorphic aureole

Impacts:
Mineral exploration in Late Precambrian volcanic-sedimentary sequences in southeastern Cape Breton Island has been hampered by a lack of understanding of the nature of the deposits, in part because of localized contact metamorphic and hydrothermal overprints, and associated mineralization. In addition to quantifying variations in temperature and pressure conditions and type of metamorphism throughout the area, project investigations suggest that there is no evidence for the traditionally assumed Late Precambrian "Avalonian orogeny" in southeastern Cape Breton Island.

Outputs:
Barr, S.M., Raeside, R.P., Miller, B.V. and White, C.E.
1995a: Terrane evolution and accretion in Cape Breton Island, Nova Scotia; in Current Perspectives in the Appalachian-Caledonian Orogen, J.P. Hibbard, C.R. van Staal and P.A. Cawood (ed.); Geological Association of Canada Special Paper 41 (in press).

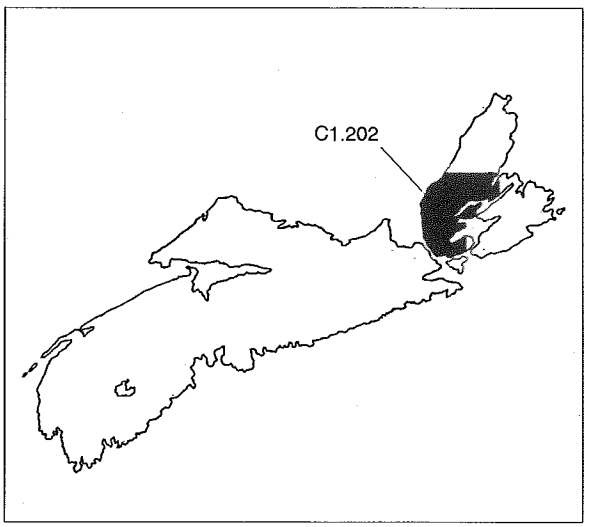
1995b: Terranes and metallogeny, Cape Breton Island, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 56.

McMullin, D.W.A., Barr, S.M. and Raeside, R.P.
1994: Metamorphism of Late Precambrian volcanic-sedimentary rocks of southeastern Cape Breton Island, Nova Scotia: Preliminary results; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 60.

C1.202 Aeromagnetic/gradiometer/VLF-EM surveys - western Cape Breton Island (F. Kiss, Continental Geoscience Division-GSC)

Objectives:
To carry out contract detailed high resolution magnetic total field/gradiometer/VLF-EM surveys in the proposed survey area (NTS 11F/11, 14; 11K/2, 3, 15); to publish: contour maps at 1:25,000 scale, colour interval maps at 1:50,000 scale and VLF-EM profiles at 1:50,000 scale. To incorporate the resulting data set into the GSC and NSDNR databases, and to collaborate with workers within GSC, NSDNR and Nova Scotia universities to effectively use project data in conjunction with other data sets to improve geological mapping, thus increasing the probability of discovering economic mineral deposits.

Results:
In the survey area, the magnetic anomaly patterns can be correlated with the mapped geology and used to extend the magnetic units under sedimentary cover or under thick overburden cover to refine geological boundaries.



The magnetic vertical gradiometer results are particularly effective for the later purpose. At the western flank of the Creignish Hills in NTS 11F/14, the gradiometer data define an unmapped northeasterly-trending linear magnetic feature 2 km west of the intrusive contact on existing detailed geological maps. The VLF-EM responses are quite useful for outlining major conductive fractures and fault systems. A comparison of the results of the VLF-Em and magnetic vertical gradient data provides direct evidence of a series of sub-parallel faults striking northeast.

Impacts:
Resulting geophysical maps have improved the geoscientific database and have direct application to geological mapping (e.g., definition of contacts between basic and felsic volcanics and between volcanic and sedimentary rock units) and resource assessment.

Outputs:

Dumont, R., Kiss, F., Stone, P.E., Anderson, K., Teskey, D.J., Gibb, R.A. and Palacky, G.

1995: Aeromagnetic survey program of the Geological Survey of Canada, 1994-95; in Current Research 1995-D; Geological Survey of Canada, p.101-104.

Geological Survey of Canada

1995a: Release of high resolution aeromagnetic vertical gradient, total field and VLF-EM survey of the Western Cape Breton Area, Nova Scotia; Geological Survey of Canada, Open File 2932, 28 sheets (1:25 000 scale)(14 aeromagnetic total field contour maps with flight path on topographic base; 14 aeromagnetic vertical gradient contour maps with flight path on topographic base).

1995b: High resolution aeromagnetic total field and vertical gradiometer surveys of the western Cape Breton area in Nova Scotia (NTS 11F/13, 14; 11K/2, 3, 4); Geological Survey of Canada; Aeromagnetic residual total field maps (1:50 000 scale): C21543G to C21546G; Vertical gradient maps (1:50 000 scale) C41543G to C41546G.

Kiss, F., Dumont, R., Stone, P.E. and Tod, J.

1995: Aeromagnetic Total field/Vertical gradient/VLF-EM survey in western Cape Breton Island, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, 19th Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p. 47.

Kiss, F., Teskey, D.J., Dumont, R., Stone, P.E., Anderson, K. and Gibb, R.A.

1994: Aeromagnetic Total Field/Vertical Gradient/VLF-EM survey in western Cape Breton island; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald, Report 94-2, p. 32.

C1.203 Mapping of the Appalachian Central Mobile Belt in the Cape Breton Highlands (S. Lin, Continental Geoscience Division-GSC)

Objectives:
Using detailed geological mapping and isotopic age dating techniques, the primary project objective is to elucidate the regional correlation of units in the Aspy terrane of the Cape Breton Highlands, with an emphasis on identifying potential correlatives of the mineral-rich Appalachian Central Mobile Belt in the Aspy terrane.

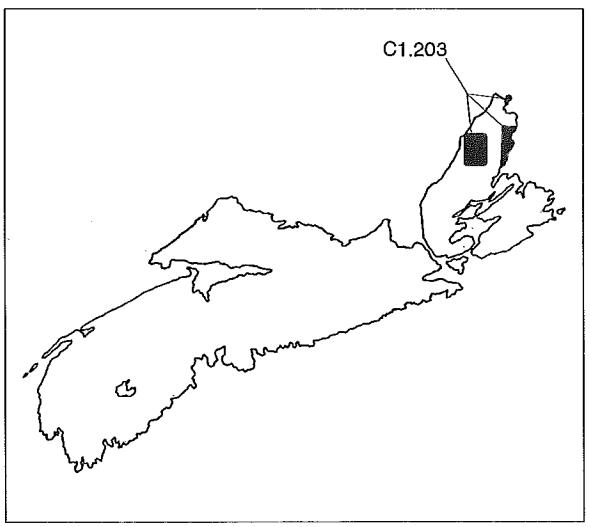
Results:

1) Detailed mapping results in a clear unit-by-unit correlation between St.. Paul Island and the Cape North-Money Point area, northern Cape Breton Highlands. The western part of the map area consists dominantly of granitic and dioritic dykes and some metasedimentary rocks. U-Pb zircon dating of a dioritic dyke yields an early Silurian age. This part of the study area is a probable correlative of the Grand Bay Complex in southwestern Newfoundland. The eastern part of the map area consists of metavolcanic and metasedimentary rocks. Conclusive structural evidence for west-over-east thrusting was documented for the first time in this area, which is important for better understanding of the geological evolution of this part of the Canadian Appalachians.

the geological evolution of this part of the Canadian Appalachians.

2) A sulphide-hosting felsic dyke (or sill) in the Jumping Brook Metamorphic Suite in the Faribault Brook are of western Cape Breton Island, yields a U-Pb zircon age of ca. 432 Ma. The Rocky Brook conglomerate in the area was found not to be an integral part of the Jumping Brook Metamorphic Suite. This observation necessitates re-evaluation and re-interpretation of the internal stratigraphic sequence of the suite. Dating of the suite itself is currently ongoing and results are expected by the end of March 1996.

3) Detrital zircon geochronology of a conglomerate in the Aspy terrane of eastern Cape Breton Highlands indicates that the detrital sources of the conglomerate contains rocks similar in age to those of both the Bras d'Or and Mira terranes. This not only supports a depositional relationship between the Aspy and Bras d'Or terranes, but also indicates that the Bras d'Or and the Mira terranes had been connected by the time of deposition of the conglomerate. One dated detrital zircon yields an age of ca. 462 Ma. The age is typical of Middle Ordovician rocks of the Dunnage Zone of the Appalachian Central Mobile Belt, and represents the first such age in Cape Breton Highlands.



Impacts:
The results of geochronologic and mapping investigations are significant in the evaluation of the mineral potential of this part of Cape Breton Island.

Outputs:

Chen, Y.-D., Lin, S. and van Staal, C.R.
1995: Detrital zircon geochronology of a conglomerate in the northeastern Cape Breton Highlands: Implications for the relationships between terranes in Cape Breton Island of the Canadian Appalachians; Canadian Journal of Earth Sciences, v. 32, no. 1, p. 216-233.

Lin, S.
1994: Geology of St.. Paul Island and the Cape North-Money Point area (NTS 11N/01), Nova Scotia, and evidence for West-over East thrusting; in Nova Scotia Department of Natural resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 31.

1995: Structural evolution and tectonic significance of the Eastern Highlands shear zone in Cape Breton Island, the Canadian Appalachians; Canadian Journal of Earth Sciences, vol. 32, p. 545-554.

In prep.: Geology of the Cape North map sheet (NTS 11N/01); Geological Survey of Canada, Open File, coloured map at 1:50 000 scale.

In prep.: Geology of the Ingonish map sheet (NTS 11K/09); Geological Survey of Canada, Open File, coloured map at 1:50 000 scale.

Lin, S., Barr, S.M., Chen, Y.-D. and van Staal, C.R.
1995: Confirmation of Late Precambrian metavolcanic and plutonic rocks in the Mabou Highlands, Cape Breton Island, Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, 19th Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p.58.

Lin, S., Chen, Y.D. and Davis, D.
In prep.: Geochronology and its implications for timing of mineralization in the Jumping Brook Metamorphic Suite, western Cape Breton Highlands (journal manuscript).

Lin, S., Jiang, D. and Williams, P.F.
In prep.: A new transpressional shear zone model based on a shear zone in the Eastern Cape Breton Highlands (journal manuscript).

Lin, S., van Staal, C.R. and Barr, S.M.
1994: The stratigraphic and tectonic significance of the Rocky Brook conglomerate in the western cape Breton Highlands, Nova Scotia: A re-evaluation; in Current Research 1994-E; Geological Survey of Canada, p. 205-210.

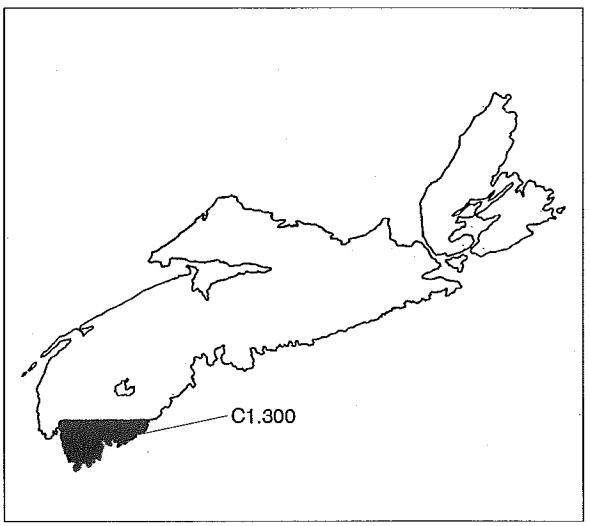
Lin, S., van Staal, C.R. and Dubé, B.
1994: Effects of promontory-promontory collision in the Canadian Appalachians; in 1994 Abstracts with Programs, Geological Society of America 29th Annual Northeastern Section Meeting, v. 26, no. 3, p. 32.

C1.3 MEGUMA SUBPROGRAM

C1.300 Emplacement of Meguma granites and beryl potential of southern Nova Scotia Granites (K.L. Currie, Continental Geoscience Division-GSC)

Objectives:

To determine the factors controlling beryl mineralization in southern Nova Scotia plutons, and assess the probability of finding larger deposits; and to map and explain the nature of the contact metamorphic aureole of the South Mountain batholith.



Results:

1) Field, chemical and isotopic data indicate that southern Nova Scotia plutons crystallized from magma containing both mantle and crustal components. Although evolved portions of the plutons compositionally resemble plutons parental to rare-metal pegmatite fields, pegmatites are rare around these plutons. Beryl-bearing pegmatites, which are restricted to distinctive muscovite and/or garnet-bearing varieties, crystallised at ~620 C, 4 kbars under water saturated conditions. They occur only where host rocks were not subjected to previous sillimanite-grade metamorphism. Pegmatites of any kind are scarce in host rocks of high metamorphic grade. Absence of a pegmatite field can be ascribed to some combination of insufficient amounts of F, Cl and B, and dehydration and plasticity of metamorphic host rocks. Significant loss of pegmatites to erosion is considered unlikely. These factors suggest that the potential for commercially exploitable beryl mineralisation is low.

2) Of twelve traverses from pluton into country rocks, 10 display hornfelsing with increase in grade toward the contact, 1 displays decrease in grade toward the contact, and 1 displays no change. The normal progression is appearance of cordierite spots 1.5-3 km from the contact, appearance of biotite and disappearance of chlorite, appearance of andalusite (0.3-1.7 km from the contact), appearance of fibrolite and prismatic sillimanite (up to 20 m from the contact). Screens within the pluton contain corundum and spinel indicative of desilication. Along the northern edge of the batholith, effects of contact metamorphism are weak or absent. This phenomenon is ascribed to fluid flow toward the pluton, preventing outward advection of heat. Detailed petrographic examination of contact metamorphic assemblages indicates that equilibrium was attained, and assemblages have been generally well preserved, despite variable hydrothermal alteration. P-T analysis by the multi-equilibrium method suggests peak temperatures near 600 C, with pressures ranging from ~2.5 kbars on the north and western margins to about 4 kbars on the eastern margin.

Impacts:

Project investigations suggest that the potential for discovery of commercially exploitable beryl mineralisation in southern Meguma granites is low.

Outputs:

Currie, K.L. and Whalen, J.B.
1996: Origin and development of beryl-bearing pegmatites in southern Nova Scotia; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, A-20.

1995: A further note on the occurrence of beryl in southern Nova Scotia plutons; in Current Research 1995-D; Geological Survey of Canada, p. 59-64

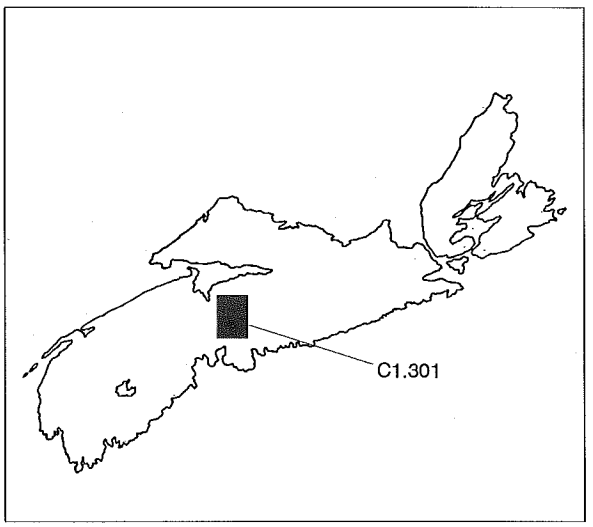
1994: A note on the occurrence of beryl in the Port Mouton pluton, southern Nova Scotia; in Current Research 1994-D; Geological Survey of Canada, p. 73-77

Currie, K.L., Whalen, J.B. and Longstaffe, F.J.
1996: Petrological data for southern Nova Scotia plutons relevant to beryl mineralization; in Current Research 1996-D; Geological Survey of Canada, p. 1-10.

Mahoney, K.L. and Raeside,R.P.
1996: The contact aureole of the South Mountain batholith; unpublished report completing contract 010SS. 23226-3-0180, 103p.

C1.301 Meguma high-resolution seismics (K.C. Coflin, GSC-Atlantic)

Objectives:
To complete deposit scale multi-channel high resolution seismics in the Meguma gold district in order to test its application to detailed structural imaging for the identification of minor folds, and crossing planar structures relevant to the focussing of mineralizing fluids. Data acquisition, to be done by contract, will include rock-property determinations in order to permit enhanced seismic interpretation (modelling) and to provide input to concurrent regional magnetic and gravity investigations.



Results:
The interpretation of project data collected from a known gold-bearing structure in Meguma sediments west of Halifax, indicates that it is possible to image dipping strata within the Meguma Group. The geological condition that produce the reflections is the interlayering of shales (or slates) with quartzite within the Goldenville Formation. The data also indicate the existence of very bright reflections below 1 km depth. Three separate bands of energy, with a small south east dip, are clearly discernable along the 5 km seismic profile.

Imapcts:
Project investigations confirm the idea that multi-channel reflection seismics can be used to augment conventional exploration methods for Meguma gold vein mineralization.

Outputs:
Coflin, K.C., Salisbury, M.H. and Giles, P.S.
1995: High resolution seismic reflection image of parasitic folding in Meguma metasediments: Nova Scotia; in Geological Survey of Canada forum 1995, Abstracts, p. 35.

Coflin, K.C., Salisbury, M. and Horne, R.
1995: High resolution multi-channel reflection imaging of gold-bearing structure in the Meguma of Nova Scotia; in Victoria'95, Geological Association of Canada/Mineralogical Association of Canada, Final Program and Abstracts, vol. 20, p. A-18.

C1.302 Meguma Group magnetics (B. Loncarevic, GSC-Atlantic)

Objectives:
Using existing high-quality magnetic data, the overall project objective is to subdivide the Meguma Group on the basis of variations in magnetic response, in order to improve the stratigraphic and structural understanding of the Meguma Group, which can then possibly facilitate a rigorous assessment of the primary stratigraphic control over gold mineralization. By applying available mathematical functions to the existing, under-appreciated magnetic database, it should be possible to portray/identify magnetic units with contrasting magnetic character that can then be compared with known/geologically determined rock units.

Results:
1) Many magnetic anomalies within the Halifax Formation have been resolved into groups of separate features and they also appear more continuous due to adjustment of the griding procedure for each map.

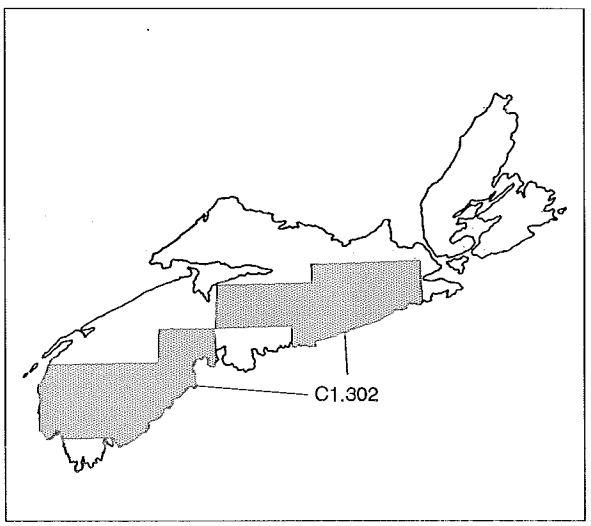
2) Advancements in creating the shaded relief layer greatly enhance the low-amplitude anomalies characteristic of the Goldenville Formation.

greatly enhance the low-amplitude anomalies characteristic of the Goldenville Formation.

3) Systematic anomaly patterns have been examined as part of the characterization of the aeromagnetic signatures of the Meguma Group. These patterns have been assessed in terms of known and predicted stratigraphic features, in particular those resulting from the erosion of non-cylindrical folds, which characterize the Meguma Group.

4) Correlation of aeromagnetic signatures with stratigraphy was addressed in the Beaverbank area. Susceptibility measurements were taken along two detailed stratigraphic sections and correspond with second derivative aeromagnetic maps. Results show the stratigraphic resolution of enhanced aeromagnetic maps to be on the order of tens of metres, and ground susceptibility measurements are correlatable with stratigraphic units less than 1 metre in width.

5) A detailed model was created from the total field data from the Boot Jack Bog area. The model consisted of theoretical magnetic units defined by existing geology and drill core susceptibility measurements. Because the resultant calculated profile matched the measured profile almost perfectly, several minor folds were interpreted and four magnetostratigraphic units were defined. This technique should prove valuable to exploration in identifying minor folds or tracing metalliferous horizons.



6) Acquisition and processing of digital topography to produce a shaded relief grid of glacial features that was superimposed on the enhanced aeromagnetic grid showed that no significant attenuation of magnetic response was noted in till-covered areas. Therefore, while there does not appear to be any magnetic signature associated with glacial features themselves; the technique appears to have application for modelling till thickness.

Imapcts:

The resulting magnetic interpretation should provide guidance to the field geologist in determining mappable units in the Meguma Group, which to date has proven very difficult to subdivide. Successful completion of the project should also result in the developing of local expertise within the private sector to undertake this type of detailed magnetic study.

Outputs:

King, M.S.

1995a: Interpretation of magnetic data from the Meguma Group of Nova Scotia: Magnetic mineralogy; in Nova Scotia Department of Natural Resources, Minerals and Energy Branch Report of Activities 1994, Report 95-1, p. 63-72.

1995b: Assessment of aeromagnetic studies in Nova Scotia; in Nova Scotia Department of Natural Resources, Program and Summaries, Nineteenth Annual Review of Activities, Minerals and Energy Branch; D.R. MacDonald and K.A. Mills (ed.), Report 95-2, p.14.

1994a: Magnetic mineralogy and susceptibility of the north-central Meguma Group: Implications for the interpretation of aeromagnetic total field, first derivative and second derivative; Nova Scotia Department of Natural Resources, Open File Report 94-004.

1994b: Magnetic signature of the Goldenville-Halifax transition zone, North Beaverbank; Nova Scotia Department of Natural Resources; Mines and Energy Branches, Open File Report 94-015, 13p.

1994c: Quantitative analysis of aeromagnetic data from the Goldenville Formation, Boot Jack Bog, Guysborough County; in Nova Scotia Department of Natural resources, Minerals and Energy Branch Report of Activities, Report 94-1, p. 141-145.

King, M.S. and Loncarevic, B.D.
1994: Aeromagnetic enhancement and interpretation: Central Meguma Project; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and Energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 20.

C1.303 Gamma ray follow-up, southwest Nova Scotia (K.L. Ford, Mineral Resources Division-GSC)

Objectives:

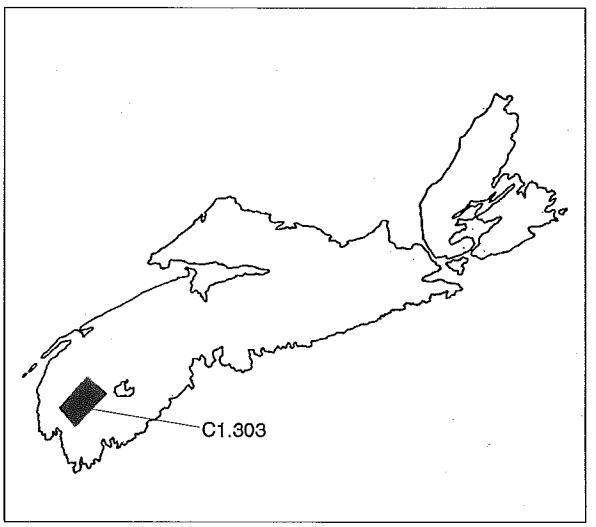
The objective of this project were to evaluate the geological and exploration significance of the airborne gamma ray spectrometric patterns in the Flintstone Rock / West Roseway Lake / Hannah Lake area of NTS 21A/4 in southwestern Nova Scotia. These patterns resemble those associated with granophile-element mineralization elsewhere in the Meguma Zone, including the East Kemptville Tin Deposit. This project ties in closely with M.C. Corey's (NSDNR) investigation of the mineral potential of the Tobeatic Shear Zone. The objectives have been met with the compilation and combination of available satellite imagery (LANDSAT TM and ERS-1) and available airborne geophysical data (regional and detailed gamma ray spectrometry, total field magnetics and vertical magnetic gradient). Field studies have included in-situ gamma ray spectrometry of representative boulders and overburden, along with till mapping and sampling for pebble counting and analysis of the heavy mineral concentrates and -230 mesh fractions. In addition eight, shallow (30-40 metres) NQ diamond drill holes were drilled by the NSDNR along Highway 203 to provide bedrock control. Borehole geophysical logging of these holes were completed by P.G. Killeen (GSC) under CNSMDA project C1.304.

Results:

Ground follow-up investigations have established that correlations between the Airborne Gamma Ray Spectrometric (AGRS) patterns, the in-situ gamma ray spectrometry, till clast lithologies and drill core lithologies suggest that the bedrock source for the West Roseway Lake anomaly is relatively local. According to R.M. Graves (D.R. Duncan & Associates Limited), renewal distances for till lithologies in the Little Tobeatic Lake area, east of the study area, and south of the Granite/Meguma Group contact, are on the order of 2-4 km. In the study area, renewal distances vary from 0 km along parts of the northern contact to between 0.5 and 2 km in and around the Dog Lake and Flintstone Rock/West Roseway Lake areas.

Lithologies responsible for the West Roseway Lake anomaly are composed primarily of a medium to coarse grained, blue-grey, equigranular to weakly megacrystic, biotite-muscovite leucomonzogranite with minor quantities of blue-grey, fine to medium grained, porphyritic leucomonzogranite. These radioelement variations correspond to subtle lithological and often cryptic compositional zonation within the Davis Lake leucomonzogranite.

In addition to variations in granitic lithologies and compositional bedrock sources, some of the radioelement patterns over the granitic intrusions were shown to reflect variations in till lithologies with several of the low eU/eTh ratio anomalies relating to Meguma derived tills.



Impacts:

Correlations between the West Roseway Lake anomaly and similar AGRS patterns associated with the East Kemptville Tin Deposit and other granophile-element mineralization in the Meguma Zone illustrate the valuable application that the AGRS surveys have for exploration for this style of mineralization. In addition to being able to define areas of pervasively altered granitic rocks or cryptic compositional zonation, the AGRS surveys can also assist in the delineation of different till lithologies.

Outputs:

Ford, K.L., Graves, R.M., Corey, M.C., Killeen, P.G. and Pflug, K.A..
1997: Mapping and exploration significance of the East Kemptville high eU/eTh ratio anomaly, southwest Nova Scotia; Geological Survey of Canada, Current Research (in prep.).

Ford, K.L., Graves, R.M., Corey, M.C., Graham, D.F., Grant, J.A., Killeen, P.G., Pflug, K.A. and Holman, P.W.B.
1994: Geological and geophysical investigations of the East Kemptville U/Th ratio anomaly; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 42.

Ford, K.L., Graham, D.F. and Corey, M.C.
1996: Integration of LANDSAT TM with Airborne Geophysical Data, East Kemptville/Little Tobeatic Lake Area, southwest Nova Scotia; Geological Survey of Canada Open File 3204, (in press).

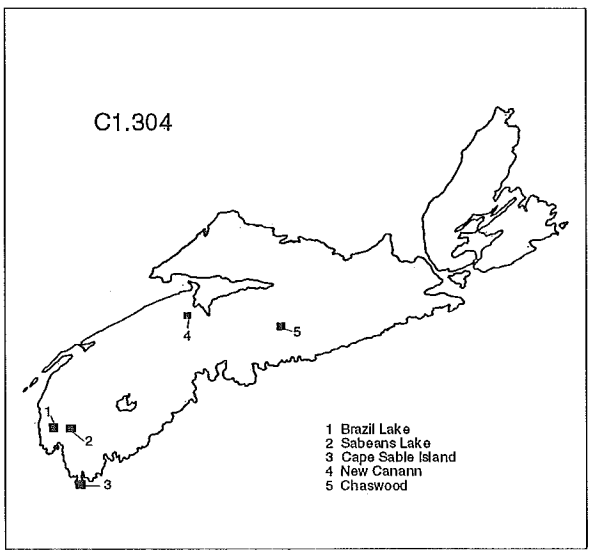
Hetu, R.J., Ford, K.L. and Holman, P.B.
1996: Airborne gamma-ray spectrometry compilation, cape Breton Island, Nova Scotia; Potassium map; Geological Survey of Canada, Open File 3215a, 1 colour map, 1:250 000 scale.

C1.304 Borehole Geophysics (P.G. Killeen, Mineral Resources Division-GSC)

Objectives:

Using the GSC's Research logging system, to:

1) provide geophysical downhole signatures related to lithological changes in the stratigraphic section including the New Canaan, Kentville, and White Rock formations; and
2) provide geophysical data related to layering or zonation in pegmatites and to the distribution of Be and Li mineralization.



Results:

Field work during the 1995 field season included plans for multiparameter borehole geophysical studies in holes in three inter-related areas (Tobeatic Lake, Sabeans Lake and Steves road area). Because holes drilled in the vicinity of the Steves Road occurrence (in support of R. Ryan's (NSDNR) central Meguma mapping project) were blocked, project collaborators agreed to substitute holes in potentially economic cretaceous kaolin clay deposits (i.e., the Chaswood holes). Salient results include:

1) Tobeatic Lake area: A new hole northeast of Sabeans Lake was drilled to a depth of 140 m and geophysically logged in late December, 1995. The hole, which was planned to be drilled and logged in the Peter Lake area, southeast of Sabeans Lake, was cancelled. The geophysical logs are in support of M. Corey's project on economic potential of shear-related polymetallic mineralization (South Mountain Batholith project). The unique GSC logging system measurements included induced polarization, electrical resistivity, self potential, magnetic susceptibility, natural gamma ray spectrometry (K, U, Th), density, spectral gamma gamma, temperature and temperature gradient. Geological and geophysical logs have been compiled together and are now undergoing interpretation.

2) Based on results of core analysis in the Sabeans Lake area in 1994 (K. Ford's GSC MDA project C1.303), some additional gamma-ray spectral logging was carried out in holes which were logged in a preliminary manner during the previous field season. The gamma-ray spectrometric logging was done to confirm comparative results from field and laboratory measurements and to sort out apparent discrepancies between them, regarding the radioelement ratios, in particular U/Th. Analysis and interpretation of the December 1995, field data are in progress and will be correlated with lithogeochemical data obtained by K.L. Ford on drill core.

3) Geophysical logs were recorded in a plastic-pipe cased hole in Cretaceous sediments near Chaswood in support of kaolin clay deposit investigations being conducted by NSDNR. The geophysical logs, also recorded in late December 1995, included magnetic susceptibility, natural gamma ray spectrometry, density, spectral gamma gamma, temperature and temperature gradient. The plastic pipe precluded any electrical logging. Data processing is in progress. Preliminary results indicate that certain clays may

have characteristic geophysical signatures which could prove useful in deposit evaluation. The white clays for example, appear to have the highest combined density, radioactivity, and magnetic susceptibility values.

Impacts:
The development of applied borehole logging techniques and the interpretation of geophysical borehole data derived from various mineral deposit environments in Nova Scotia will result in recommendations useful to the mineral exploration community.

Outputs:

Elliott B.E., Bernius G.R. and Killeen P.G.
In prep.: Borehole Geophysical Logs from the South Mountain Batholith, Nova Scotia: The Deep Digby borehole, and the Wedgeport Granite; Geological Survey of Canada, Open File.

Ford, K.L., Graves, R.M., Corey, M.C., Graham, D.F., Grant, J.A., Killeen, P.G., Pflug, K.A. and Holman, P.W.B.
1994: Geological and geophysical investigations of the East Kemptville U/Th ratio anomaly; in Nova Scotia Department of Natural Resources, Program and Summaries, Eighteenth Annual Open House and Review of Activities, Mines and energy Branches; D.R. MacDonald (ed.), Report 94-2, p. 42.

Ford, K.L., Graves, R.M., Corey, M.C., Killeen, P.G. and Pflug, K.A..
1997.: Mapping and exploration significance of the East Kemptville high eU/eTh ratio anomaly, southwest Nova Scotia; Geological Survey of Canada, Current Research (in prep.).

Killeen P.G., Bernius G.R. and Elliott B.E.
In prep.: Borehole Geophysical Logs from the East Kemptville and Dominique Tin Deposits, Nova Scotia; Geological Survey of Canada, Open File.

Killeen P.G. and Elliott B.E.
In prep.: Geological Applications of Borehole Geophysical Logs in Nova Scotia: New Canaan, Cape Sable Island, Brazil Lake and Chaswood Areas; Geological Survey of Canada, Open File.

Killeen P.G., Elliott B.E. and Aoki C.
In prep.: Borehole Geophysical Logs in Meguma Gold Occurrences: Beaver Dam, Moose River and Lake Charlotte areas, Nova Scotia; Geological Survey of Canada, Open File.

Killeen P.G., Elliott B.E., Pflug K.A., Mwenifumbo C.J., and Bernius G.R.
In prep.: Applications of Borehole Geophysics to Mineral Exploration and Development Problems in Nova Scotia; Geological Survey of Canada, Bulletin.

Mwenifumbo C.J., Cinq-Mars A. and Elliott B.E.
In prep.: Borehole Geophysical Logs from the Yava Sandstone Lead Deposit, Nova Scotia; Geological Survey of Canada, Open File.

Mwenifumbo, C.J., Killeen, P.G. and Elliot, B.E.
1993: Classic examples from the Geological Survey of Canada data files illustrating the utility of borehole geophysics; in Proceedings of the Fifth International Symposium on Geophysics for Minerals, Geotechnical, and Environmental Applications, Minerals and Geotechnical Logging Society, Section K, 15p.

Pflug K.A., Killeen P.G. and Elliott B.E.
In prep.: Borehole Geophysical Investigation of the Sabeans Lake U/Th Ratio Anomaly, Nova Scotia; Geological Survey of Canada, Open File.

C1.4 OFFSHORE SUBPROGRAM

C1.400 Offshore aggregates (G.B. Fader, GSC-Atlantic)

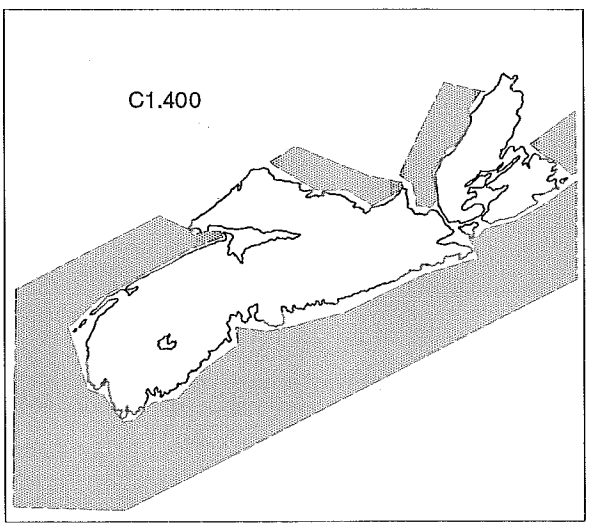
Objectives:
To assess the aggregate potential of both the nearshore (less than 25 km from land) and selected offshore bank areas of the Scotian Shelf, Bay of Fundy and Gulf of Maine surrounding the Province of Nova Scotia (water depths less than 100 m). Areas of the shelf where fishing was important, such as Georges Bank, and where special conditions existed, such as Sable Island Bank, were avoided in the study.

Results:
Western Cape Breton Island:
Analysis of the samples collected suggest that most of the material is not suitable for aggregate applications because of the presence of excessive quantities of fines. However, areas of gravel ripples, well-sorted deposits of granitic gravel, offer some promise for the area.

Eastern Scotian Shelf & Bay of Fundy:
Results of the analysis of the material collected from the CSS Hudson survey have greater potential than the Western Cape Breton Island area. Results indicate that substantial quantities of quality coarse sand and gravel occur in the inner Bay of Fundy, on Middle Bank and Banquereau on the Scotian Shelf. In general, gravel deposits were rare and local in the nearshore. The Scots Bay Sand Wave Field and isolated sand waves on the floor of the Bay of Fundy also contain large volumes of exploitable material. In the Bay of Fundy seabed mining

may also be beneficial to the preservation of fishable marine habitat. Large quantities of sand were identified from Middle Bank and Banquereau that exhibit suitable characteristics for applications in asphaltic concrete, concrete and other specialized applications. Areas of ripples in gravel and coarse sand represent the easiest-to-locate deposits and likely hold the most promise for future development. A deposit on the north of Middle Bank could hold as much as 700 million cubic metres of exploitable aggregate. In addition, a large deposit of silica sand with a purity of 99% was identified on Banquereau, Eastern Shoal. This material was tested for its suitability in the production of glass and the test results indicate that the quartz-rich Banquereau samples represent a potential raw material source. Industry has expressed an interest in this discovery.

The report of the analysis of the CSS. Hudson samples is a comprehensive document that includes evaluations of encrusting Lithothamnium, grain surface features and test results from concrete cylinders batched using Scotian Shelf aggregates. The materials comply to varying degrees with typical industry specifications; however, samples collected from an interpreted low sea level stand delta in Chedabucto Bay did not meet industry specifications. A report on the macrobenthic organisms sampled from the CSS Hudson survey was completed by Arenicola Marine Consulting and released on GSC Open File. One hundred and forty species were found during the survey. The fauna was more variable on the gravelly sediments than the sandy seabeds. Biodiversity was low on Banquereau. A report on the foraminiferal content of collected cores has been released as GSC Open File 3258.



Impacts:

The discovery of suitable materials on the seabed, and silica sand, will stimulate both local and offshore industry to consider further evaluation and may result in further pressure on both federal and Provincial Governments to establish a framework for marine mining off Nova Scotia.

Outputs:

Fadar, G.B.J. and Miller, R.O.

1994: A preliminary assessment of the aggregate potential of the Scotian shelf and adjacent areas; Proceedings, Coastal zone Canada'94, Volume 1, p. 230-263.

Fader, G.B.J., Miller, R.O. and Shaw, J.

1995: Macrobenthic organisms on the Scotian Shelf CSS Hudson mission 94-032 mineral aggregate survey, November 15-25, 1994; Geological Survey of Canada Open File 3088, 25p.

Maritime Testing Limited (1985)

1995a: Aggregate testing of marine sand and gravel samples from offshore Cape Breton Island; Geological Survey of Canada Open File 3087, 107 p.

1995b: Testing of marine seabed samples from the eastern Scotian Shelf for aggregate characterisitics; Geological Survey of Canada, Open File 3177, 250p. (includes 76 colour pages, 3 fold-outs).

Miller, A.A.L.

1996: Foraminiferal distribution on selected bank areas of the Scotian Shelf and Holocene history of the inner Chedabucto Bay: Foraminiferal evidence; as a contribution to assessment of the marine aggregate potential of the Scotian Shelf; Geological Survey of Canada, Open File 3258, 57p.

Miller, R.O.

1996: Environmental seabed conditions of the Lunenburg Marine Park, Nova Scotia; Geological Survey of Canada, Open File 3257, 1 poster.

Shaw, J

1995: The aggregate potential of the Scotian Shelf; in Underwater Mining Institute, Twenty-Sixth Annual Meeting of the Underwater Mining Institute, St. John's Newfoundland, October 29 -31, 1995 (oral presentation).

Shaw, J., Forbes, D.L., Ceman, J.A., Asprey, K.A., Beaver, D.E., Wile, B., Frobel, D. and Jodrey, F.

1996: Cruise Report 94-138: Marine geological surveys in Chedabucto and St.. George's Bays, Nova Scotia, and Bay of Islands, Newfoundland; Geological Survey of Canada, Open File 3230, 187p.

Stea, R.R., Scott, D.B. and Fadar, G.B.J
1995: Deglaciation of the inner Scotian Shelf, Nova Scotia: Correlation of land-sea events; Atlantic Geology, vol. 31, no. 1, p. 60-61.

C1.5 COORDINATION SUBPROGRAM

C1.500 Coordination, administration and publication (A.L. Sangster, Mineral Resources Division-GSC)

Objectives:

To coordinate the federal Geoscience Program to ensure optimum selection, design and implementation of projects in a cooperative and collaborative milieu through discussion with federal, provincial, industry, and university staff, scientists and officials. The coordinator will represent GSC on the Geoscience Subcommittee, and work closely with Nova Scotia Department of Natural Resources staff and the industry review committee. Funding for the coordination project will also be used to expedite the publication of outstanding products/outputs resulting from the two previous CNSMDAs (i.e., 1984-1989 & 1990-1992).

Results and Impacts:

Successful completion of the federal CNSMDA Geoscience Program has helped improve the geoscience database of the province and in conjunction with the NSDNR, assisted in identifying areas with high mineral potential (e.g. Early Cretaceous clay & silica sand in the Shubenacadie-Musquodoboit area). The results of several projects were prepared for inclusion in the Special Atlantic Canada volume of the Canadian Journal of Earth Sciences, which was published in April 1996. Coordination funds were used, and will, during fiscal 1996-97, continue to be used to support the publication of outstanding CNSMDA products and outputs.

Outputs:

Barr, S.M., White, C.E. and Macdonald, A.S.
1996: Geology, southeastern Cape Breton Island, Nova Scotia (NTS 11F/9, 10, 15, 16 and parts of 11F/6, 7, 11; 11G/13, 11J/4, 11K/1,2); Geological Survey of Canada, Map 1853A (1:100 000 scale).

McClenaghan, M.B. and DiLabio, R.N.W.
1996: Ice-flow history and glacial dispersal patterns, southeastern Cape Breton Island, Nova Scotia: Implications for mineral exploration; Canadian Journal of Earth Sciences, v. 33, no. 2, p. 351-362.

Sangster, A.L. (ed.)
1996: Geological Studies in Atlantic Canada; Special Issue of the Canadian Journal of Earth Sciences, v. 33, no. 2, 258 p.

APPENDIX A: FINANCIAL SUMMARY

		EXPENDITURES
C1.1	**GEOLOGY AND MINERAL DEPOSITS OF CARBONIFEROUS ROCKS SUBPROGRAM**	
C1.100	Geological mapping of Carboniferous rocks of western Cape Breton Island	$ 187,384
C1.101	Characterization of major fault systems in western Cape Breton Island	$ 142,499
C1.102	Resource potential of latest Devonian-earliest Carboniferous rocks, southern Magdalen Basin	$ 202,016
C1.103	Integrated spatial database for Cape Breton Island	$ 67,673
C1.104	Late Carboniferous, western Cape Breton Island	$ 43,315
C1.105	Geological evolution and mineral potential of the St. Mary's Basin	$ 184,001
C1.106	Regional evolution and metallogeny of the Cumberland Basin [Stellarton Gap]	$ 78,153
C1.107	Till lithology, geochemistry and provenance, Shubenacadie Basin	$ 97,924
C1.108	Biogeochemical/Hydrogeochemical Investigations	$ 240,687
C1.109	Seismic reflection, Carboniferous basins	$ 217,662
C1.110	Shallow seismic and borehole geophysical surveys in the Shubenacadie Basin	$ 51,404
C1.120	Barite-fluorite vein deposits, Lake Ainslie, Cape Breton Island	$ 18,720
C1.121	Fluid migration and mineralization in the Lower Windsor Group	$ 146,908
C1.2	**CAPE BRETON ISLAND SUBPROGRAM**	
C1.200	Stratigraphy, physical and chemical volcanology and ore petrography - Stirling Belt	$ -
C1.201	Metamorphism in Late Precambrian volcanic and sedimentary rocks-southeastern Cape Breton Island.	$ 15,600
C1.202	Aeromagnetic/gradiometer/VLF-EM surveys-western Cape Breton Island	$ 328,000
C1.203	Mapping of the Appalachian Central Mobile Belt in the Cape Breton Highlands	$ 45,780
C1.3	**MEGUMA SUBPROGRAM**	
C1.300	Emplacement of Meguma granites and beryl potential of southern Nova Scotia granites	$ 35,998
C1.301	Meguma high-resolution seismics	$ 33,489
C1.302	Meguma Group magnetics	$ 50,530
C1.303	Gamma ray follow-up, southwest Nova Scotia	$ 49,449
C1.304	Borehole geophysics	$ 19,210
C1.4	**OFFSHORE SUBPROGRAM**	
C1.400	Offshore aggregates	$ 214,726
C1.5	**COORDINATION SUBPROGRAM**	
C1.500	Coordination, administration and publication	$ 221,587
TOTAL		$ 2,692,715