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GEOLOGICAL SURVEY OF CANADA

OPEN FILE 3375

PROJECT SUMMARIES

Part A. Canada-Newfoundland Cooperation Agreement on Mineral Development, 1990-1994

Part B. Canada-Newfoundland Agreement on Mineral Development, 1994-1995

compiled by

Agreements Management Committee

also released as

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Canada

FOREWORD

This report summarizes the results of two Canada-Newfoundland Mineral Development Agreements. The first, the Canada-Newfoundland Cooperation Agreement on Mineral Development, covered the period 1990-1995, and was one of a number of federal-provincial agreements carried out under the general umbrella of the Canada-Newfoundland Economic and Regional Development Agreement (ERDA). The agreement was funded by the Atlantic Canada Opportunities Agency (ACOA), and managed by that agency, and the federal and provincial Departments of Natural Resources. The second agreement spanned the period 1994-1996 and was funded and managed by the federal and provincial Departments of Natural Resources.

These two Agreements are the last in a series of federal-provincial cooperative agreements aimed at strengthening the mineral industry in Newfoundland and Labrador. This series began in 1971 and proceeded without significant interruption until 1996. The agreements as a whole were an outstanding success. They were a major factor in the building of the modern Geological Survey of Newfoundland and Labrador; in the provision of a geological knowledge base for the province; in the establishment of a new and vibrant prospecting and junior mining community; in the discovery of many significant mineral deposits and occurrences; and in providing technical and financial assistance to a number of existing mining operations.

The successes outlined in this report indicate that the final two agreements provide a fitting conclusion to 25 years of formal cooperation between federal and provincial agencies and the mineral industry to strengthen the contribution of minerals to the economy of the province. The knowledge base and the cooperative atmosphere established under the agreements will continue to assist development in the future, as the province reaps the benefits of the "Agreements" years.

We express our appreciation to all those who have assisted in any way to make these Agreements the success they were. In particular, we thank the representatives of the mineral industry, who assisted with the planning of the programs, and the many project leaders, both provincial and federal, who were responsible for their successful implementation.

T. Daniels
Co-Chairman
Canada

B. Greene
Co-Chairman
Newfoundland

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PART A. CANADA-NEWFOUNDLAND COOPERATION AGREEMENT ON MINERAL DEVELOPMENT, 1990-1995

PROVINCIAL PROJECTS

1. GEOSCIENCE

1.1 GEOLOGICAL MAPPING

N.1.1.1 Cambro-Ordovician Carbonates (I. Knight)

Objectives. The principle goals of the project were to define the stratigraphy and structure of a poorly understood belt of Lower Paleozoic shelf carbonates and siliciclastic rocks in the Pasadena (12H/4) and Corner Brook Lake (12A/13) map area. Base metal and dimension stone potential was also evaluated in the area. Coordinated biostratigraphic studies of fossil faunas in the areas was conducted by D. Boyce.

Methods. The project began with detailed lithostratigraphic, biostratigraphic and sedimentalogical sectioning of the Cambro-Ordovician shelf sequence in the Pasadena (12H/4) in 1990 and 1991. This was followed in 1991, 1993 and 1994 by 1:50,000 scale geological mapping of the Pasadena map area and part of the Corner Brook Lake map areas and detailed 1:12,500 mapping of specific areas of economic dimension stone potential.

Field mapping was by a 2-man field party in 1991 and 1994, and a 5-man team in 1993. Access to the area was by road, foot and boat.

Results. Litho- and bio stratigraphic studies indicates that the Lower Paleozoic shelf succession in the area originally lay on a distal part of the ancient shelf. Cambrian sediments were part of a prograding, eastward deepening ramp and only by Lower Ordovician was a true platform present. The St. George Unconformity separates passive margin sequences from a Middle Ordovician foreland basin sequence.

Detailed 1:50,000 scale geological mapping showed that the area is a polydeformed foreland fold and thrust belt. Early west-verging thrusts and accompanying folds were later deformed by east-verging and south-verging folds. A number of shear zones occur locally. The structurally overlying Humber Arm Old Man Pond Allochthon was deformed with the shelf. It formed the roof to the thrust stack. All structural contacts are brittle. The deformation is believed to be Salinian and Acadian, i.e. Silurian-Devonian. Some post-tectonic mafic dykes intrude the succession. The area was also affected by numerous later (?Carboniferous) strike-slip, cross faults. Carboniferous karstification including paleocave formation occurred extensively in the area. Peculiar vascular roots were discovered at one locality.

Minor base metal mineralization is mostly confined to Cambrian carbonates. The map areas host several varieties of white, pink, grey and red marbles including stylolitic, brecciated, veined and conglomeratic varieties.

Outputs.

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1995: Preliminary 1:50,000 mapping of Lower Paleozoic parautochthonous sedimentary rocks of the Corner Brook area. *In* Current Research (1995) Newfoundland Department of Natural Resources, Geologicial Survey, Report 95-1, pages 257-265.

1994: Geology of Cambrian-Ordovician Platformal rocks of the Pasadena map area (NTS 12H/4). *In* Current Research (1994), Newfoundland Department of Mines and Energy, Geological Survey, Report 94-1, pages 175-186.

1992: Geology of marmorized lower Paleozoic platformal carbonate rocks, "Pye's Ridge", Deer Lake. *In* Current Research, Newfoundland Department of Mines and Energy, Report 92-1, pages 141-158.

1991: Geology of the Cambro-Ordovician Rocks in the Port Saunders, Castors River, St. John Island and Torrent River Map Sheets. Newfoundland Department of Mines and Energy, Report 91-4, 147p.

Knight, I. and Boyce, W.D.

1991: Deformed Lower Paleozoic platformal carbonates, Goose Arm Old Man's Pond. *In* Current Research, Newfoundland Department of Mines and Energy, Report 91-1, pages 141-154.

Knight, I. James, N.P. and Lane T.E.

1991: The Ordovician St. George Unconformity, Northern Appalachians: The relationship of plate convergence at the St. Lawrence Promontory to the Sauk-Tippecanoe sequence boundary. Geological Society of America Bulletin, V.103, pages 1200-1225.

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Boyce, W.D., Knight, I., and Ash, J.S.
1992: The Weasel Group, Goose Arm Area, Western Newfoundland; lithostratigraphy, biostratigraphy, correlation and implications. *In* Current Research, Newfoundland Department of Mines and Energy, Report 92-1, pages 69-84.

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1992, Late Precambrian volcaniclastic deposits of the Avalonian Eastport basin (Newfoundland Appalachians): Pettrofacies, detritial clinopyroxene geochemistry and paleotectonic implications. Precambrian Research, vol. 59, pages 243-262.

Stenzel, S.R., Knight, I., and James, N.P.
1990: Carbonate platform to foreland basin; revised stratigraphy of the Table Head Group (Middle Ordovician), Western Newfoundland: Canadian Journal of Earth Sciences, V.27, pages 14-26.

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1995: Upper Precambrian - Lower Cambrian clastic sedimentary and volcanic rocks (Humber Zone). *In* Chapter 3 of Geology of the Appalachian/Caledonian Orogen in Canada and Greenland, Harold Williams (Ed.); Geological Survey of Canada, Geology of Canada, no. 6 (also Geological Society of America, The Geology of North America, v. F-1), pages 61-67.

Wright, D.W. and Knight, I.
1995: A revised chronostratigraphy for the lower Durness Group. Scottish Journal of Geology, vol. 31, no 1, pages 11-22.

Published Maps

1:50,000

Map 9520 - Cambrian-Ordovician shelf and co-eval offshelf rocks of the Pinchgut Lake Group in parts of the Corner Brook (12A13), Little Grand Lake (12A/12), Georges Lake (12B/16) and Harry's River (12B/9)
Map 93163 - Pasadena map area (12H/4)
Maps in Report 91-4: Geology of the Port Saunders etc.

1:1,000,000 coloured map

Map 90-01 - Geology of the Island of Newfoundland - compiled by Colman-Sadd, S., Hayes J. P., and Knight, I.

Contributions to

1995: Geological road map of Newfoundland. Geological Association of Canada.

Studies and Presentations made during secondment to Centre for Earth Resources Research, Memorial University and Petroleum Resource Development Division, Department of Energy, Government of Newfoundland and Labrador during 1991, 1992, 1993 and 1994.

Knight I.
1995: Western Newfoundland, Canada: a Lower Paleozoic basin with hydrocarbon potential. C.S.P.G. luncheon talk, Calgary, March, 1995
1994: Stratigraphic logs of carbonate rocks of western Newfoundland. Based on mineral exploration drill hole logs. Newfoundland Department of Mines and Energy, Petroleum Resource Development Division Open File release PRD-1, 90 pages.

Knight, I. and Cawood, P.A.
1991: Paleozoic geology of Western Newfoundland: an exploration of a deformed Cambro-Ordovician passive margin and foreland basin, and Carboniferous successor basin. Centre for Earth Resources Research short course and field guide, 403 pages.

Baker, D. and Knight, I.
1993: The Catoche Dolomite project, Anticosti Basin, eastern Canada, final report. Confidential report for BHP Petroleum, Canada and Labrador Mining and Exploration Ltd., Centre for Earth Resources Research, St John's Newfoundland, 174 pages.

Presentations, invited and, at conferences

Knight I.
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Knight I and Hawkins D.
1994: Western Newfoundland, a Lower Paleozoic basin with hydrocarbon potential. Abstract,. Annual meeting, CEPG/CSPG conference, Calgary, May 1994.
1993: Western Newfoundland, a Lower Paleozoic basin with hydrocarbon potential. Abstract, Annual meeting of Eastern Chapter of AAPG, Williamsburg, Virginia

Fowler, M. G., Hamblin A. P., Hawkins D. and Knight, I, and Stasiuk, L.D.
1995: Petroleum geochemistry and hydrocarbon potential of Cambrian and Ordovician rocks of western Newfoundland. Bulletin of Canadian Petroleum Geology, vol. 43, no 2, pages 187-213.

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Poster displays

1994: Hydrocarbon potential of western Newfoundland. Annual meeting, AAPG, June, 1994, Denver, USA.
1994: Hydrocarbon potential of western Newfoundland. Annual meeting, CEPG/CSPG, May, 1994, Calgary, Alberta.
1993: Hydrocarbon potential of western Newfoundland. Annual meeting, Eastern chapter of AAPG, September, 1993, Williamsburg, Virginia, USA.
1992: Hydrocarbon potential of western Newfoundland. Annual meeting, CSPG/AAPG, June, 1992, Calgary, Alberta.

N.1.1.2 Paleontological Support (W. D. Boyce)

Objectives. This project supplied a broad range of paleontological services (*i.e.*, fossil collection, identification, curation, reconstruction, description, dating and correlation, biofacies analysis, etc.) to all provincial geological projects, as well as external client groups.

Methods. Work was conducted by D. Boyce and J. Stephen Ash. In southeastern Labrador, co-operative biostratigraphic investigations were carried out with C. F. Gower and I. Knight (Newfoundland Department of Natural Resources, Geological Survey).

In western Newfoundland, detailed biostratigraphic sampling (for macrofossils and microfossils) complemented detailed lithostratigraphic investigations conducted simultaneously by I. Knight (Newfoundland Department of Natural Resources, Geological Survey). Co-operative biostratigraphic investigations were also carried out with C. R. Barnes (University of Victoria), J. W. Botsford (Newfoundland and Labrador Science and Technology Advisory Council), F. H. C. O'Brien and S. H. Williams (Memorial University of Newfoundland), and S. Stouge (Geological Survey of Denmark).

In central Newfoundland, co-operative investigations were carried out with S. P. Colman-Sadd, W. L. Dickson, J. P. Hayes and B. H. O'Brien (Newfoundland Department of Natural Resources, Geological Survey), S. K. Donovan (The University of the West Indies), D. T. W. Evans (Newfoundland Department of Natural Resources, Mineral Deposits), D. A. T. Harper (University of Galway)and S. H. Williams (Memorial University of Newfoundland).

In eastern Newfoundland, co-operative biostratigraphic investigations were carried out with J. P. Hayes and S. J. O'Brien (Newfoundland Department of Natural Resources, Geological Survey).

Results. The following are highlights of the paleontological-support project:

1) Previously unknown Middle Cambrian to Early Ordovician trilobite faunas were discovered in the Goose Arm--Hughes Brook area, Lomond (NTS 12H/5) and Pasadena (NTS 12H/4) map sheets. The position of the Cambrian--Ordovician boundary was identified for the first time in the para/autochthonous carbonate sequence of western Newfoundland.

2) Previously unrecorded late Middle Cambrian to earliest Ordovician trilobite faunas were discovered in the Cooks Brook Formation (Northern Head Group) of the Humber Arm Allochthon of the Bay of Islands, western Newfoundland.

3) Previously unknown Middle to Late Cambrian trilobite faunas were discovered in the Weasel Group, exposed in the Weasel Slice of the Humber Arm Allochthon on the boundary of the Lomond (NTS 12H/5) and Pasadena (NTS 12H/4) map sheets, western Newfoundland.

4) A previously unrecorded Late Ordovician, Ashgill (Rawtheyan) cyclopygid trilobite fauna was recovered from previously undated turbidite deposits on Upper Black Island, Point Leamington (NTS 2E/6) map sheet, central Newfoundland.

5) A previously unknown Late Arenig graptolite and (cyclopygid) trilobite fauna was described from the top of the Coy Pond Complex of south-central Newfoundland. The fossils provided an upper age limit for the ophiolite complex.

6) A trilobite collected from the uppermost Riches Island Formation (Baie D'Espoir Group)in the St. Alban's map area (NTS 1M/13) enabled a Late Arenig age to be assigned to the unit; it had earlier been assigned a less constrained Late Arenig to Early Caradoc age.

7) Many new fossil localities of Late Ordovician and Early Silurian age were documented in the Botwood (NTS 2E/3) and Point Leamington (2E/6) areas.

8) A previously unknown bivalve fauna was discovered in the Indian Islands Group exposed on Careless Brook in the Gander map area (NTS 2D/15). The fauna correlates with that of the Pridoli (latest Silurian) to Gedinnian (earliest Devonian) Stonehouse Formation of Nova Scotia. This indicates that Paleozoic marine sedimentation

in central Newfoundland continued much later than was previously suspected.

9) A previously unknown crinoid fauna of probable Silurian age was collected from an exposure along the Baie d'Espoir Highway.

10) A previously unknown bivalve fauna was collected from the Wigwam Formation (Botwood Group) near Lewisporte in the Botwood (NTS 2E/3) map area. The fauna indicates a possible Late Silurian (Ludlow) to Early Devonian (Gedinnian) age.

11) It has been proposed that the base of the second series of the Ordovician be defined in the Cow Head Group of western Newfoundland.

12) A major taxonomic revision of four Middle Cambrian trilobite superfamilies has been proposed, using Computer Aided Restoration-Reconstruction Of Trilobites (CARROT).

Outputs.

Boyce, W.D.
1993: Bivalve biostratigraphy of the Arisaig Group, Nova Scotia.
1994: Trilobite biofacies and biostratigraphy of the St. George and Table Head groups, western Newfoundland.
1995a: Ordovician trilobite biostratigraphy of the autochthon / parautochthon, western Newfoundland.
1995b: Trilobite biostratigraphy and biofacies of the autochthon / parautochthon, western Newfoundland - World Wide Web demonstration

Boyce, W. D. and Ash, J. S.
1992: Paleontological investigations in Newfoundland, 1992.

Boyce, W.D. , Ash, J.S., Knight, I. and Botsford, J. W.
1991: Paleontological investigations in Newfoundland, 1991.

Boyce, W. D., Ash, J. S., Knight, I., O'Brien, B. H., Hayes, J. P. and Mandville, L. W. J.
1990: Paleontological investigations in Newfoundland.

OTHER DISPLAYS

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1991a: Newfoundland fossils. Science Day, Bishop Feild School, St. John's (Thursday 25, April, 1991)
1991b: Newfoundland fossils. 1991 Science Is Fun Festival. Newfoundland Fresh Water Resources Centre/Pippy Park Fluvarium, St. John's. (Saturday, May 25, 1991)
1991c: Newfoundland fossils. Radisson Plaza Hotel, St. John's, Mining Week 1991 (Mining, Minerals and You). (November 8, 1991).
1992: Newfoundland fossils. SET SQUARE. Marine Intitute, St. John's. (May, 1992)
1993: Newfoundland fossils. SET SQUARE. Marine Intitute, St. John's. (Saturday, May 1, 1993)

Boyce, W.D. , Botsford, J.W. and Ash, J.S.
1994 to present: Prehistoric freshwater fish. Newfoundland Fresh Water Resource Centre/Pippy Park Fluvarium, St. John's.

WINTER SEMINARS

Boyce, W. D., Ash, J. S., Botsford, J. W. and Knight, I.
1992: Feeling a little boulder in western Newfoundland: Trilobite hunting in the carbonate conglomerates of the Cooks Brook, Reluctant Head and Weasel Formations. (April 16, 1992)

Boyce, W. D., Ash, J. S., Dickson, W. L. and O'Brien, B.H.
1993: Ordovician-Silurian "mantle" activity and basin development, Newfoundland Appalachians. (February 5, 1993)

Boyce, W. D. and Ash, J. S.
1994: Supect trains of Norris Arm. (February 11, 1994)

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1994: Palaeobiogeography and faunal dynamics in the Lower to Middle Ordovician of western Newfoundland of the Iapetus Ocean region. *In* New perspectives in the Appalachian - Caledonian Orogen: a conference in honour of Dr. Harold Williams. Geological Association of Canada, NUNA Conference, Program and Abstracts, pages26-27.

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Williams, S.H., Harper, D.A.T., Neuman, R.B., Boyce, W.D. and Niocaill, C.M.
1994: Faunal provincialism and paleogeography of Iapetus - an update for the 90's. *In* New perspectives in the Appalachian - Caledonian Orogen: a conference in honour of Dr. Harold Williams. Geological Association of Canada, NUNA Conference, Program and Abstracts, page 30.

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1995: Ordovician trilobite biostratigraphy of the autochthon / parautochthon, western Newfoundland. Newfoundland Department of Natural Resources, Geological Survey Branch, Report of Activities 1995, page 43.

Boyce, W. D. and Ash, J. S.
1992: Paleontological investigations in Newfoundland, 1992. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report of Activities 1992, pages 5-7.
1993: Paleontological investigations in Newfoundland, 1993. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report of Activities 1993, pages 104-105.

Boyce, W.D. , Ash, J.S., Knight, I. and Botsford, J. W.
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Boyce, W. D., Ash, J. S., Knight, I., O'Brien, B. H., Hayes, J. P. and Mandville, L. W. J.
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1991: A new fossil locality in the Bay Of Exploits, central Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 91-1, pages 79-81.

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1992: Preliminary trilobite biostratigraphy of the Cooks Brook formation (Northern Head group), Humber Arm Allochthon, Bay of Islands, western Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 55- 68.

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1992: The Weasel group, Goose Arm area, western Newfoundland: lithostratigraphy, biostratigraphy, correlation and implications. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 69-83.

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1993: Sedimentology, paleontology, provenance and revised stratigraphic status of polymictic, deep-sea conglomerates in the area of Point Leamington, Notre Dame Bay. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, pages 195-207.

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refined understanding of the closure of the Iapetus Ocean. Canadian Journal of Earth Sciences, Volume 29, pages 2046-2057.

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1994a: A proposed global stratotype for the second series of the Ordovician System: Cow Head Peninsula, western Newfoundland. Ordovician News, Number 11, pages 25-31.

1994b: A proposed global stratotype for the second series of the Ordovician System: Cow Head Peninsula, western Newfoundland. Bulletin of Canadian Petroleum Geology, Volume 42, pages 219-231.

Williams, S.H., Harper, D.A.T., Neuman, R.B., Boyce, W.D. and Niocall, C.M.

In press: Lower Paleozoic fossils from Newfoundland and their importance in understanding the history of the Iapetus Ocean. *In* New Perspectives in the Appalachian-Caledonian Orogen. Geological Association of Canada, NUNA Publication 4.

MISCELLANEOUS

Boyce, W. D.

1991: A short guide to trilobites. Prepared for the 1991 Science Is Fun Festival (Newfoundland Fresh Water Resource Centre / Pippy Park Fluvarium), May 25, 1991. 4 pages.

1993: Kelligrew's Quarries, Red Bridge Road. Fieldtrip stop for 1993 Atlantic Universities Geological Conference (A.U.G.C.), Memorial University, St. John's, 1 page.

1994: Fossils in Newfoundland. Prepared for Mining Week 1994 ("From the Ground Up"), 4 pages.

1995: Kelligrew's Quarries, Red Bridge Road, Conception Bay South, Avalon Peninsula, Newfoundland. Fieldtrip guide, 1 page (July 18, 1995)

OTHER TALKS

Boyce, W. D.

1992: Using the (Atari) ST to reconstruct fossils. Seminar presented at ACE '92: The Atari Canadian Exposition, Toronto, Ontario. (April 4, 1992)

Fieldtrips

Boyce and Ash led a Grade 4 class from Holyrood on a fieldtrip to the Kelligrews quarries in May, 1991.

Lectures.

Boyce gave lectures on fossils/trilobites at:

1) Sir Wilfred Grenfell College, ElderHostel class, July, 1991;

2) Newfoundland Museum, Sunday, November 10, 1991 (Mining Week 1991); and

3) Memorial University of Newfoundland, Earth Sciences class, Friday, February 8, 1992.

Note: Many other school presentations were made, and fieldtrips led, but I never made a comprehensive list.

N.1.1.3 Granites - North-Central Newfoundland (W.L. Dickson)

Objectives. The purpose of the project was to survey the 2D/11W (Eastern Pond), 2D/14 (Mount Peyton) and the southern portion of the 2E/3 (Botwood) map areas in north-central Newfoundland. Mapping in the Botwood (2E/3) map area was carried out in conjunction with B.H. O'Brien and S.P. Colman-Sadd who were responsible for surveying the northern portion of the map area.

Methods. A 1:50,000-scale mapping and regional lithogeochemical survey was carried out in the survey area by a 2-person geoscientific crew. Paleontological support was provided by W.D. Boyce and J.S. Ash as required. Fieldwork was carried out by boat, truck, on foot and helicopter. The extensive networks of forest access roads were covered mainly by all-terrain vehicle.

Field observations were initially recorded in notebooks and on aerial photographs and subsequently the data were compiled in a digital database and map line-work was also digitized. Data from O'Brien and Colman-Sadd were also included in the database. From this work coloured digital geological maps for 2D/14 and 2E/3 were produced along with the usual hand drawn geology maps. The database used was FIELDLOG and AUTOCAD was used for map production.

The 2D/11W map area was surveyed during 1991, 2D/14 during 1992, and 2E/3 (southern portion) during 1993. The work on the 2D/11W map area complemented mapping of the 2D/11E map area by R.F. Blackwood (1981). R. Eckstrand and E. Cogolu of the G.S.C subsequently carried out detailed mapping of a small part of the 2D/11W map area during 1992 and 1993. J.P. Hayes remapped parts of 2D/11E and 2D/10 during 1992 in areas where bedrock had been exposed by forest access roads. This data was also compiled into a digital database.

Geochemical analyses were carried out at the Department of Natural Resources laboratory and under contract with a commercial laboratory. All geochemical data have been stored in digital format in the computer program SPSS-PC. Thin sections were made under contract with the Department of Earth Sciences, Memorial University. Radiometric dating was also done under contract with the Department of Earth Sciences and the Department of Geological Sciences, University of Maine. Some fossil identifications were carried out under contract.

Results. Mapping of the 2D/11W, 2D/14 and 2E/3 map areas has resulted in the redefinition of many geological contacts and the reassignment of many rock units. The internal divisions of many units have been for the first time. It is clear, for example, that many sedimentary rocks are not part of the terrestrial Silurian Botwood Group but are part of an earlier sequence of rocks produced in a marine deep-sea environment. Structural complexities include extensive thrusting and shearing. The basal thrusts along the Great Bend Ophiolite complex was reported for the first time. Numerous new fossil localities were discovered. The sites were examined by Boyce and Ash, and S.H. Williams. The results indicate the presence of new young stratigraphic units and allowed the assignment of precise stratigraphic positions to others. Internal variations within the Mount Peyton Intrusive Complex were defined and distinctive new units identified. These include extensive areas of layered mafic and ultramafic rocks and plugs of granite within the gabbro. Dating of the gabbro and layered rocks indicates that they have similar Early Silurian ages. Dating of the granite gave ambiguous results. The 1-km-wide, high-grade contact metamorphic aureole of the complex was also mapped out for the first time. It was also noted that the aureole is absent along much of the eastern side of the Mount Peyton Intrusive Complex indicating that a major fault is present. Several new mineral occurrences were discovered and these could lead to further exploration activity. Known mineral occurrences were also examined and assayed for various elements including gold. Areas of gabbro suitable for building stone were also noted and described. Descriptions of each map area have been published in the annual reports for Current Research.

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N.1.1.4 Newfoundland Geochronology (S. P. Colman-Sadd)

Objectives. This project was designed to assist mapping projects by determining the age of important rock units in the different field areas of insular Newfoundland.

Methods. Two geochronological methods were used for dating rocks from insular Newfoundland. Most samples were dated using the U-Pb method, through a contract with Memorial University of Newfoundland, where the laboratory run by Dr. G. Dunning is at the forefront of technology in this field. A small amount of funding was used for Ar-Ar dating, which was done by Dr. D. Lux of the University of Maine.

Results. U-Pb dates have been reported to the Department of Natural Resources by Memorial University in three annual reports. The annual production was:

1991-92: 28 analyses providing 7 dates.

1992-93: 23 analyses providing 5 dates

1993-94: 32 analyses providing 7 dates

One Ar-Ar date was successfully completed and results were reported to the Department of Natural Resources by Dr. Lux of the University of Maine.

The principal results that have emanated from the U-Pb program are as follows:

1. Dating of a number of important granitic and gabbroic intrusions in central and eastern Newfoundland has defined an intrusive history during the Appalachian orogenic cycle ranging from the Middle Ordovician (Snowshoe Pond Granite) to the Devonian (Petits and St. Lawrence granites). The ages of these intrusions also place valuable constraints on the history of surrounding stratified units.

2. Volcanic rocks and granites from the Avalonian cycle have been dated; together with geochronology from other sources, these results have served to define a detailed geological history for Avalonian rocks, consisting of four igneous/tectonic events during the Precambrian. This new information has been of critical importance to the mineral exploration industry in the Hermitage-Fortune Bay area.

3. The controversy over the age and affiliation of the supposed stitching pluton of the Straddling Granite in south-central Newfoundland has been resolved. The granite has been conclusively shown to consist of two separate intrusions, one Precambrian, the other Devonian, and to provide no constraints on terrane accretion.

4. Together with dating from other sources, this project has determined the geological history of rocks in the Bay du Nord Group that host the Strickland massive sulphide prospect; this work has aided current mineral exploration in the area.

5. The project has provided information that allows events in the pre-Caradoc history of the Notre Dame Bay area to be distinguished for the first time. This is especially important because massive sulphide prospects are associated with certain rocks of this age and it is now possible, by a combination of geochronology, geochemistry and stratigraphy, to identify and map out the most prospective units.

Ar-Ar dating has determined that amphibolite, forming a possible dynamothermal aureole at the base of the Great Bend Complex (ophiolite), is Middle Ordovician, providing a new constraint on the thrusting of the Dunnage Zone over the Gander Zone and on mineralising events in the ophiolitic rocks.

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N.1.1.5 Eastern Grenville (C.F. Gower)

Objectives. The objectives of this project were to carry out 1:100 000-scale reconnaissance geological mapping and mineral potential assessment of NTS areas 13A/NW, 13A/SW and 12P/NE, all in the Grenville Province in southeast Labrador and including parts of the Mealy Mountains and Pinware terranes.

Methods. All areas were systematically mapped using helicopter-positioned ground traverses, helicopter landings on isolated outcrops, and boat-supported traverses along the coast.

Mapping was carried out during 10-12-week field seasons in 1991, 1992 and 1993. Mapping in 1991 was under the field direction of T. van Nostrand with a two-week visit by C.F. Gower at the end of the season. Field work in 1992 and 1993 was under the direction of C.F. Gower and carried out mostly by C.F. Gower and T. van Nostrand. The field investigations were supported by U-Pb geochronological studies carried out by H. Wasteneys, S. Kamo and D. Moser, under the general direction of T. Krogh at the Royal Ontario Museum. Complementary Sm-Nd isotopic investigations have been completed by S. Daly (University College, Dublin).

Results. Field work in 1991 (van Nostrand, 1992) extended knowledge of bedrock underlying the southeast part of the Mealy Mountains terrane. In addition to mapping extensions of previously known Labradorian high-grade pelitic gneisses and calc-alkaline granitoid rocks, part of a previously unknown anorthosite-mangerite-charnockite-granite (AMCG) suite was mapped (the Upper Paradise River pluton). This body underlies at least 2000 km^2 and its western boundary still remains undefined. Subsequent U-Pb geochronological studies have yielded a 1500 Ma age, which means that this is the only AMCG suite of this age known in North America.

In 1992 field investigations (i) defined the southeastern limit of the Upper Paradise River pluton, (ii) mapped large areas of alkali-rich granitoid gneisses, (iii) discovered a 110 by 12 km layered mafic body (Kyfanan Lake intrusion), (iv) discovered several aegerine-bearing alkali-feldspar syenites and one nepheline occurrence, (v) outlined several post-Grenvillian granites (Gower et al., 1993). The Kyfanan Lake intrusion and other mafic intrusions in the Pinware terrane are now largely covered in mineral claims following the Voisey Bay Ni-Cu-Co discovery and publication of a report noting a correlation between Ni, Co, V and Ag lake-sediment anomalies and ultramafic rocks within the Kyfanan Lake intrusion (Gower et al., 1995).

Mapping in 1993 outlined the distribution of similar rocks farther to the southeast (Gower et al., 1994). Of particular note was the discovery of sizeable areas underlain by supracrustal rocks believed to be of felsic volcanic origin. These host minor Cu and Mo mineralization and correlate with U, Cu, Mo, Ag and Pb lake-sediment anomalies (Gower et al., 1995), the most significant of which have now all been staked. Nepheline syenite was discovered 10 km north of Red Bay; it is also being investigated for its economic potential.

Outputs.

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1993: A trip through Proterozoic time in eastern Labrador. Newfoundland Department of Mines and Energy, Geological Survey Branch, Colloquium Series 1993, Department of Earth Sciences, Memorial University, St. John's, Newfoundland. January 15th, 1993.

1993: The Grenville Province in eastern Labrador: a 14-year onshore mapping transect completed and offshore seismic studies initiated. Eastern Canadian Shield Onshore-Offshore Transect (ECSOOT), Transect Meeting, Montreal, December 10-11th, 1993.

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1995: U-Pb geochronological constraints on Labradorian events in the eastern Grenville Province of Labrador. GAC/MAC Annual Meeting, Victoria. Program with Abstracts, Volume 20, page A51.

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Makkovikian-Ketilidian mobile belt. Precambrian Crustal Evolution in the North Atlantic Regions, Joint Meeting of Project 275 The Deep Geology of the Baltic/Fennoscandian Shield and Project 371 Structure and Correlation of the Precambrian in NE Europe and the North Atlantic Realm. Nottingham, England , 13-17 September, 1994.

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N.1.1.6 Labrador Geochronology (R. Wardle)

Objectives. To provide support in the form of U-Pb dating of critical rock units to Labrador bedrock mapping projects. Information from this project has been used in conjunction with data from the mapping projects to aid in the identification of mineral exploration opportunities in Labrador.

Methods. The work was conducted under contract at the geochronological laboratories of the Royal Ontario Museum (Dr. T. Krogh) and Memorial University (Dr. G. Dunning). Work was divided equally between the organisations. Samples were generally submitted following field work and were processed and dated by March 31 of the following year. Results were reported in annual contract reports that are on public file with the Department of Natural Resources. Results have been further interpreted and published by incorporation into Geological Survey reports and external publications co-authored with the geochronologists.

Results. Number of samples dated:

1992 - 18 (inc. 7 non-MDA funded samples)
1993 - 17
1994 - 12
TOTAL - 47

The numbers vary according to the funding available in that year and in 1992 also include some work that was done using additional A-base funds. Some free work that was performed over and above the contract requirements to satisfy problems of interpretation.

The work included samples from the southwestern Churchill Province, the Nain Plutonic Suite and its host rocks, and the eastern and western Grenville Province. Highlights include:

- delineation of the chronology of the Nain Plutonic suite and its Archean host gneisses. The NPS results will be particularly valuable in the wake of the Voisey Bay discovery .

- establishment of a tectonic framework for the evolution of the southeastern Grenville Province.

- recognition of a distinctive belt of 1.4 - 1. 5 Ga rocks in the Pinware Terrane of SE Labrador. These were previously unrecognised and have a good potential for Ni-Cu-V and Cu-Mo-U-Ag mineralization.

- deliniation of the metamorphic and structural history of the southwestern Churchill Province and the recognition that most of this area comprises reworked Archean rocks

- recognition of two ages of volcanism in the Flowers River Caldera and the implication that only one age may be associated with Y-REE enrichment and possible mineralization

Outputs. Output from this project consisted largely of annual reports from the two contract agencies; the Jack Satterly Geochronological Laboratory of the Royal Ontario Museum and the Geochronological Laboratory at the Department of Earth Sciences, Memorial University. These unpublished reports, which are listed below, are available as public documents in the geofiles of the Newfoundland Department of Natural resources. Many of the individual ages have been used or further described in both Geological Survey and journal publications.

Connelly, J.N.
1992: U-Pb Geochronological Research Agreement: Final Report for the Newfoundland Department of Mines and Energy, Labrador Mapping Section. Newfoundland Department of Mines and Energy, Geological Survey Branch, File LAB 945, 72p.

Krogh, T.E.
1992: Report on 1992 Geochronological Contract Work, Labrador. Unpublished report to Newfoundland Department of Mines and Energy. Newfoundland Department of Mines and Energy, Geological Survey Branch, File LAB 944, 69p.

Krogh, T.E.
1993: Report on Labrador Geochronology, 1992-93. Newfoundland Department of Mines and Energy, Geological Survey Branch, File LAB 0977, 75p.

Connelly, J.N.
1993: U-Pb Geochronological Research Agreement: Final Report for the Newfoundland Department of Mines and Energy, Labrador Mapping Section. Newfoundland Department of Mines and Energy, Geological Survey Branch, File LAB 0978, 86p.

Wasteneys, H.
1994: U-Pb Geochronology of samples from the Pinware Terrane, Eastern Churchill and Flowers River Complex, Labrador. Newfoundland Department of Mines and Energy, Geological Survey Branch, File LAB 1031, 16p.

Connelly, J.N.
1994: U-Pb Geochronological Research Contract Agreement: Final Report for the Newfoundland Department of Mines and Energy, Geological Survey Branch. Newfoundland Department of Mines and Energy, Geological Survey Branch, File LAB 1020, 67p.

Wasteneys, H.A.
1995: U-Pb geochronology of supracrustal rocks in the Pinware Terrane (VO92-105c) and of the Gilbert Bay Dikes (MN86-188); final contract report for the Newfoundland Department of Natural Resources. Unpublished report to the Newfoundland Department of Natural Resources, File LAB 1087, 6p.

N.1.1.7 Report on Granitoids (A. Kerr)

Objectives. This represents a continuation of the Granitoid Database Project described in Project NC.1.1.3, and involves further sampling and analytical work to complete coverage of the island, and preparation of a final memoir and related maps. In recognition of growing interest in dimension stone in Newfoundland, this has also involved some applied studies in two areas of potential, and some thematic work aimed at understanding colour development processes as an aid to dimension stone exploration.

Results. Completion of a final memoir has been delayed due to demands from the dimension stone aspect of the project, and Kerr's involvement in a new mapping project in the Buchans-Robert's Arm area. Applied studies in the Topsails and Hodges Hill areas have led to a better understanding of the roles of hydrothermal and surficial alteration processes in colour and texture development, and have identified and described potential quarry sites, some with major potential. Investment in exploration, and interest in further dimension stone development, resulted from this work.

Outputs. The results of the dimension stone work have been described in two current research articles. The final report on the granitoid database project is currently in progress, but its completion will not be possible until after Kerr's new mapping project in the Buchans - Robert's Arm area is finished.

NC.1.1.1 Gander Zone (P. O'Neill)

Objectives. The purpose of the project was to complete regional 1:50,000-scale geological mapping of Gander Zone rocks in the area west of Glovertown.

Methods. Field work was done over a four month period during 1991 by a two-man field party. Access to the area was by highway, woods roads and ponds. Mapping was done by systematic foot traversing at 1 km spacing.

[Note that some aspects of the dimension stone studies conducted in 1994/5 received funding from A-base sources rather than from the MDA]

Results. Northwest of Gambo Pond, the Gander Group is metamorphosed at greenschist facies, except where static metamorphism at cordierite and andalusite grade have overprinted the regional metamorphism around the post-tectonic Gander Lake Granite. The Gander Group rocks have been intensely deformed in a southern extension of the Wing Pond shear zone.

Southeast of Gambo Pond, the Gander Group is metamorphosed at sillimanite grade and intruded by a varied suite of granitoid rocks. There is also a belt of paragneiss and orthogneiss (Hare Bay Gneiss) adjacent to the Dover Fault, which marks the Gander-Avalon zone boundary. In this area, deformation has affected most rocks, including the granitoid intrusions; the main exception is the post-tectonic, megacrystic Maccles Lake Granite.

Outputs.

O'Neill, P.P.
1991: Poster display. Newfoundland Department of Mines and Energy, Geological Survey Branch, Annual Review of Activities and Open House.
1992: Geology of the northwestern part of the Glovertown map area (NTS 2D/9) and the northeastern part of the Dead Wolf Pond map area (NTS 2D/10). *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pp. 195-202.

O'Brien, S.J., O'Neill, P.P., and Holdsworth,R.E.
1991: Glovertown (2D/9, east half), Newfoundland. Newfoundland Department of Mines and Energy, Geological Survey Branch, Map 91-169.

Blackwood, R.F., Green, L., and O'Neill, P.P.
1991: Dead Wolf Pond (2D/10), Newfoundland. Newfoundland Department of Mines and Energy, Geological Survey Branch, Map 91-165.

NC.1.1.2 Notre Dame Bay (B.H. O'Brien)

Objectives. Selected rock units were focused upon and surveyed in detail in certain areas of central Notre Dame Bay. One aim of this work was to provide a regionally consistent geological database since this much-explored and well-studied region had previously been systematically mapped at only 1:250 000 scale. A second objective was to address some reported problems in the tectonic evolution of the mineral-rich Central Volcanic Belt by examining it on Newfoundland's north coast, where this tract is well-exposed in cross section.

Methods. During this 1:50 000 scale mapping project, field-based structural investigations (B. O'Brien) were augmented by sedimentological (T. Dec), stratigraphical (R. Hughes, S. Colman-Sadd), lithogeochemical (S. Swinden), geochronological (G. Dunning, D. Lux) and paleontological (D. Boyce, H. Williams, F. O'Brien, S. Molyneux) studies carried out in the area surveyed (most of 2E/3,6 and parts of 2E/2,4,5,7,11). All of the geological mapping (two-person team) and most of the supporting studies (NGS staff and contract researchers) were done over four fieldseasons between 1990 and 1993. Considerable field time was spent integrating data collected by the multidisciplinary team and interfacing with W.L. Dickson (NGS) and K. Currie, H. Williams and M. Piasecki (GSC) working in overlapping areas or adjacent map sheets.

Results. Examination of the map areas has yielded new geological information about the Ordovician, Silurian and Devonian history of central Notre Dame Bay. The establishment of the chronostratigraphy of the Exploits Group, the chemostratigraphic correlation between Wild Bight and Exploits groups, the lithostratigraphic revision of the Cottrells Cove Group, the age of synmagmatic shearing and tectonic linkage in the South Lake Igneous Complex, and the various types and ages of melange adjacent to the Red Indian Line are all significant in understanding the early-mid Ordovician evolution of the region. The complexity of the pretectonic Silurian record is demonstrated by biostratigraphic evidence of condensation and local facies development in the disparate constituents of the marine Badger Group, the recognition of a petrochemically bipartite suite of sheeted gabbros with unique distribution and emplacement, the lithostratigraphic subdivision, geochemical fingerprint and new age of terrestrial strata in the type Botwood Group, and the correct identification and regional separation of the Badger and Botwood groups from each other and their Ordovician substrates. New insights into the Siluro-Devonian history of central Notre Dame Bay are given by the mechanics and the relative and absolute ages of reverse-fault imbrication of the Badger Group, basin inversion of the Botwood Group, localized high-temperature shearing and dynamothermal metamorphism along the margin of the Long Island Granodiorite and the Dunnage Melange, and high-grade contact metamorphism (granofels) associated with the margin of the post-tectonic Mount Peyton Diorite.

Base metal mineralization is related to a petrochemically distinct, Arenig-aged, arc-rifting event in the Exploits and Wild Bight groups. Precious metal mineralization is commonly associated with brittle-ductile shears near the faulted Silurian boundary between Badger and Botwood groups or in adjacent Ordovician inliers.

Outputs.

Reports

Boyce, W.D., Ash, J.S. and O'Brien, B.H.
1991: A new fossil locality in the Bay of Exploits, central Newfoundland. *In* Current Research.

Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 91-1, pages 79-81.

Boyce, W.D., Ash, J.S., Knight, I., O'Brien, B.H., Hayes, J.P. and Mandville L.W.J.

1990: Paleontological investigations in Newfoundland. *In* Review of Activities. Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 21-23.

Hughes, R.A. and O'Brien, B.H.

1994: Syndepositional transport on a deep-mantle slope and soft-sediment reworking of detritus from an exhumed Iapetan arc: evidence from the upper New Bay Formation of the Exploits Group. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 94-1, pages 135-145.

O'Brien, B.H.

1990: Regional geology of the New Bay area (parts of 2E/6 and 2E/11), Notre Dame Bay, Newfoundland. *In* Report of Activities. Newfounland Department of Mines and Energy, Geological Survey Branch, pages 42-44.

1991: On some relationships between Early and Late Ordovician rocks of the Exploits Subzone in central Notre Dame Bay (NTS 2E/5,6), Newfoundland. *In* Report of Activities. Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 22-26.

1991: Geological development of the Exploits and Notre Dame subzones in the New Bay area (parts of NTS 2E/6 and 2E/11), Notre Dame Bay, Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 91-1, pages 155-166.

1992: Internal and external relationships of the South Lake Igneous Complex, north-central Newfoundland (NTS 2E/5,6): Ordovician and later tectonism in the Exploits Subzone? *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 159-169.

1993: Geology of the Botwood region (NTS 2E/3,6) north-central Newfoundland. *In* Report of Activities. Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 124-126.

1993: A mapper's guide to Notre Dame Bay's folded thrust faults: evolution and regional development. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, pages 279-291.

1995: The early Ordovician Tea Arm magmatic arc - VMS potential of the lower Exploits Group. *In* Report of Activities. Newfoundland Department of Natural Resources, Geological Survey, pages 64-65.

O'Brien, B.H., Dec, T. and Swinden, H.S.

1994: Origin and accretion of Ordovician rocks near the Red Indian Line on the Fortune Harbour Peninsula. *In* Report of Activities. Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 73-76.

O'Brien, B.H. and O'Brien, S.J.

1990: Reinvestigation and reinterpretation of the Silurian La Poile Group of southwest Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 90-1, pages 305-316.

O'Brien, S.J. and O'Brien, B.H.

1991: Geology of the Bay du Nord Group between East Bay and the La Poile River (NTS 11O/16), western Hermitage Flexure, Newfoundland. *In* Report of Activities. Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 27-29.

Williams, S.H. and O'Brien, B.H.

1994: Graptolite biostratigraphy within a fault-imbricated black shale and chert sequence: implications for a triangle zone in the Shoal Arm Formation of the Exploits Subzone. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 94-1, pages 201-209.

Williams, S.H., O'Brien, B.H., Colman-Sadd, S.P. and O'Brien, F.H.C.

1992: Dunnage Zone graptolites: an extension of the age range and distribution of certain Ordovician formations of the Exploits Subzone. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 203-209.

Maps

O'Brien, B.H.

1990: Geology of the New Bay area (parts of 2E/6 and 2E/11), Notre Dame Bay, Newfoundland. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map 90-124.

1991: Geology of the Red Indian Line Structural Zone: Winter Tickle-Hornet Island (parts of 2E/6,7), north-central Newfoundland. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map 91-167.

1992: Geology of the Western Arm Brook-Leading Tickles area (parts of 2E/5,6,11), Notre Dame Bay, Newfoundland. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map 91-171.

1992: Geology of the region around Lewisporte (parts of 2E/2,3,6,7), north-central Newfoundland. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map 90-025.

1993: Geology of the region around Botwood (parts of 2E/2,4,6), north-central Newfoundland. Scale 1:50 000. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map 93-168.

Dickson, W.L., Colman-Sadd, S.P. and O'Brien, B.H.
1995: Geology of the Botwood map area (NTS 2E/3), central Newfoundland. Scale 1:50 000. Newfoundland Department of Natural Resources, Geological Survey, Open File Map 94-245.

Field Guidebooks

O'Brien, B.H.
1992: Field Excursion A-7 (Day 3). *In* Lithoprobe East in Newfoundland (the Burgeo Transect): a cross-section through the southwest Newfoundland Appalachians. *Compilers* S.P. Colman-Sadd and others. 1992 Annual GAC-MAC Fieldtrip Guidebook (Wolfville, Nova Scotia).
1993: Day 2 Excursion to the Fortune Harbour Peninsula (Notre Dame Bay). *In* 1993 GAC-NF Fieldtrip Guidebook. *Compilers* T. Dec and others. GAC Newfoundland Section (St. John's, Newfoundland).
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NC.1.1.3 Granitoid Database (A. Kerr)

Objectives. This project was initiated to compile existing petrological and geochemical data from granitoid intrusive rocks across insular Newfoundland, to acquire new data from many poorly-known areas, and release a digital geochemical database. Interpretation of the integrated database is intended to aid in regional geological problems, interpretation of seismic reflection data, and in assessing the metallic and industrial mineral potential of specific granitoid associations.

Methods. This was not a systematic mapping project, but involved systematic sampling and examination of many different granites in coastal areas and other access corridors such as road networks and river systems. In addition to new sampling, archived samples were reanalyzed to bring analytical data to a consistent standard. An assessment of data precision and accuracy over time was also conducted (work

by J. Hayes). In addition to field and elemental geochemical studies, SM-Nd and Rb-Sr isotopic work was conducted with B.J. Fryer and G.A. Jenner of Memorial University, and via student projects. U-Pb zircon dating was also conducted by R. Tucker (Royal Ontario Museum) and G. Dunning (MUN).

Results. A digital database containing over 4500 analyses with locational and field data was submitted at the end of the contract period. This was accompanied by a lengthy contract report that presented the results of field work and preliminary interpretations of the geochemical data. The digital database was subsequently released as an open file in MS-DOS format, and is available to explorationists. The results confirm some earlier suppositions about the mineralization potential of specific associations and also point to other potential target areas and groupings. In addition, extensive sample suites were collected for use in assessment of dimension-stone potential.

Outputs. In addition to the contract reports and open-file database release, several articles have been published from the project. These include three current research articles, one of which is directly concerned with the mineral potential of Devonian granites, and two research papers in Canadian Journal of Earth Sciences, which detail the results of geochronological work, and the implications of Sm-Nd isotopic studies for our understanding of the deep-crustal structure of southeastern Newfoundland. A review paper on granites in Newfoundland was invited for a forthcoming GSA special paper, and was submitted in February 1995.

Refereed Journal/Special Paper Publications

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Kerr, A.
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Poster Presentations

Poster Displays at CIMM/NDME meetings in 1991, 1992, 1993 and 1994.

NC.1.1.4 Superior Province Project (D.T. James)

Objectives. Prime objectives of the project were the regional mapping and economic evaluation of the Archean Ashuanipi Complex, part of the Superior Province, in NTS map areas 23G (map sheets 2, 3, 7, 10, 11, 13, 14, 15) and 23B/14.

Prior to this study, this part of the Ashuanipi Complex had only been covered by small-scale, reconnaissance mapping, and the geology was not known in enough detail to meet current exploration needs. In view of the results from regional geochemical surveys, which suggest that the Ashuanipi Complex has potential for gold mineralization, and the discovery of gold in the Ashuanipi Complex northwest of Schefferville, Québec, it became necessary to upgrade the geological data base for this area. This study also makes a contribution to the overall understanding of structural, metamorphic and intrusive relations in this part of the Ashuanipi Complex.

Methods. The study area was mapped at a scale of 1:100,000. Approximately 85% of the area was mapped during a 3-month field season in 1991. Mapping involved helicopter- and boat-supported ground traverses and helicopter landings on isolated outcrops. Mapping of the southern part of the study area, including parts of NTS map areas 23 G/2, G/3 and 23 B/14, was completed in two weeks of June in 1992; mapping was conducted entirely by making helicopter landings on isolated outcrops.

Results. In the study area, the Ashuanipi Complex consists principally of metasedimentary migmatite, orthogneisses, plutons of orthopyroxene-bearing monzogranite to granodiorite that are termed diatexite, and a composite granite pluton. Field relations demonstrate that the sedimentary precursors of the metasedimentary migmatite were intruded by plutons and related dykes of tonalite, quartz diorite and gabbro, and small plutons and dykes of granite to granodiorite, prior to a regional tectonothermal event involving deformation, granulite-facies metamorphism and intrusion of the diatexite plutons. Late syn-metamorphic superposed folds, which postdate the diatexite plutons, have produced a regional-scale structural pattern of culminations and depressions. The culminations are cored by the diatexite and the depressions by the metasedimentary rocks and orthogneisses.

A composite pluton consisting of biotite + muscovite granite and biotite granite, is inferred to be the youngest of the Archean units. The various phases that make up this pluton are variably foliated and recrystallized, and their intrusion is considered to be mainly posttectonic with respect to the high-grade metamorphism and deformation.

Regional lake-sediment geochemical studies, and the occurrence of gold in the Ashuanipi Complex northwest of Schefferville, Québec, suggest that the high-grade supracrustal rocks have some potential for gold mineralization. Assay results from gossanous rocks in the study area have not yielded significant gold values.

Outputs.

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Superior Province, western Labrador. *In* Report of Activities 1992, Geological Survey Branch, Newfoundland Department of Mines and Energy, pages 117-119.

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NC.1.1.4 Eastern Churchill Province Project (D.T. James and G.A.G. Nunn)

Objectives. Prime objectives of the project were the regional mapping and economic evaluation of Archean and Paleoproterozoic high-grade metamorphic and plutonic rocks in the eastern Churchill Province in NTS areas 23I and in parts of 13L/NW. This study also makes a contribution to the understanding of Archean, Paleoproterozoic and Mesoproterozoic tectonothermal and magmatic events in the western part of the eastern Churchill Province.

Methods. The NTS 23I study area was systematically mapped at 1:100,000 scale. Mapping was accomplished using a combination of helicopter-supported ground traverses, helicopter landings on isolated outcrops and boat-supported examination of the superb exposures around the Smallwood Reservoir. Mapping occurred in two, three-month field seasons in 1992 and 1993, and involved two traversing teams in each field season. The field studies are complemented by

U - Pb geochronological studies with J. Connelly and G. Dunning (Memorial University) and H. Wasteneys (Royal Ontario Museum), and by isotopic studies with A. Kerr (Newfoundland Geological Survey). In addition to the systematic, regional-scale mapping, the southern part of the NTS 23I study area was mapped in detail by Nunn with the aim of deciphering Paleoproterozoic (>1800 Ma) and Labradorian intrusive and tectonic relationships.

Mapping of the NTS 13L/NW study area at 1:100,000 scale was carried out by Nunn in July and August of 1993. Mapping was accomplished mainly using helicopter landings on isolated outcrops and by making short, helicopter-supported ground traverses.

The bedrock mapping in the eastern Churchill Province is supplemented by detailed gravity surveys made by Gerry Kilfoil (Newfoundland Geological Survey) in the 1993 field season. In total, approximately 650 km of new gravity data were acquired in three transects. One of the transects crosses the NTS 23I study area, extending from the Superior Province to the eastern margin of the Michikamau Intrusion (in NTS area 13L).

Results. In the NTS 23I study area, the eastern Churchill Province consists of three Paleoproterozoic tectonostratigraphic domains (McKenzie River, Crossroads and Orma), which are separated from each other and a low-grade fold-and-thrust belt (New Québec Orogen) by dextral transpressive high-strain zones. The Crossroads and Orma domains are thought to be derived from Archean high-grade granite - greenstone terrane crust, whereas the McKenzie River domain is inferred to have been part of an Archean plutonic terrane mainly consisting of high-grade tonalite gneiss. The three domains were assembled during dextral oblique convergence of the Rae and Superior cratons, and was complete by ca. 1.80 Ga. Field and geochronological data demonstrate that in the McKenzie River and Crossroads domains assembly was attendant with medium-grade metamorphism and the formation of north-trending structures and regionally persistent high-strain zones. The Crossroads domain also contains a significant amount of 1.83 - 1.80 Ga granitic plutons, including the southern end of the 500-km-long De Pas batholith. In contrast, the Orma domain appears to have mainly escaped Paleoproterozoic metamorphism and deformation.

The southern part of the NTS 13L/NW study area consists of Orma domain rocks including orthogneiss and minor amounts of metasedimentary and metavolcanic gneisses. A southeasterly trending line of leucogabbroic rocks defines the northern limit of the Orma domain. North of the boundary is a granulite-facies domain composed of interlayered granitoid and metabasic rocks.

The NTS 23I and 13L/NW study areas contain rocks belonging to the Mesoproterozoic Michikamau and Harp Lake intrusions. Border phases of these anorthosite - leucotroctolite complexes have base-metal and PGE potential. There is some potential for gold and base-metal deposits in the Archean, high-grade metasedimentary rocks (wacke and chert - magnetite iron formation) and metavolcanic rocks in the Crossroads and Orma domains.

1.2 METALLIC MINERAL DEPOSIT STUDIES

N.1.2.1 Diamond Assessment, Labrador (B. Ryan and J. McConnell)

Objectives. Kimberlite and related rocks are hosts to diamonds. These rocks contain a distinctive suite of minerals that are dispersed by erosion into sediments, and may then be transported significant distances from source by fluvial systems. The minerals constitute an "indicator" suite that can be used to pinpoint possible diamondiferous rocks in a given area. A survey of sediment from glaciofluvial environments between Makkovik and Saglek Fiord in Labrador was carried out in 1994 in order to ascertain if kimberlitic intrusions may be present in areas from which these sediments were derived. Such areas could be targets for diamond exploration companies. In addition to collecting sediment for kimberlite indicator minerals, a cursory examination of lamprophyric dykes near Makkovik was undertaken.

Project Methods. The full-time project personnel included a project geologist (B. Ryan), a geochemist (J. McConnell) and a boatman/assistant (R. Webb).

Initial field work was carried out in the Aillik Bay area near Makkovik. This entailed an examination of lamprophyre dykes and collection of a sample suite from them. Many of these rock samples have been submitted to the Earth Science Department of Memorial University for thin section preparation, and some samples will be subjected to whole-rock geochemical analyses. Two dykes have been submitted to GEOTOP in Montreal for age determinations.

Sediment samples were collected by boat from beaches and from near-shore sites. A helicopter was utilized for 45 hours to collect samples at inland sites within the project area. The majority of the surficial sampling sites were designated prior to and during the field season based on examination of maps showing the distribution of glacial sediments. Sites were chosen preferentially from areas of reworked glaciofluvial and glaciomarine deposits; in areas lacking such sediment, reworked ablation drift and eskers were sampled. Sixty-four bulk samples of river, stream and beach sediment were collected, wet-sieved on site to <4 mm and stored in heavy

plastic sample bags. At most sites, a small sample for geochemistry and a random collection of 20 pebbles were also obtained. The 64 sediment bulk samples that were collected have undergone post-season processing at the Department of Natural Resources Laboratory in St John's where they have been dried in ovens and further sieved through a 1 mm mesh screen. The coarse fraction from this sieving has been saved for reference purposes, and the fine fraction has been submitted to a commercial processor for heavy mineral separation.

Results. There are no results to report at this time (March, 1995) because the sediment samples are currently undergoing additional analytical screening at a commercial laboratory. The non-magnetic heavy mineral fraction will be scrutinised for possible kimberlite indicator minerals including pyrope garnets, chrome diopside, picroilmenite and chromite. The outcome of the various field and analytical studies will be published within a year.

Outputs.

PUBLICATIONS

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NC.1.2.1 Rare Metal Metallogeny (R. Miller)

In Labrador, high-level peralkaline intrusions, including both granites and syenites, and associated peralkaline volcanic rocks contain significant amounts of rare metals (e.g. Zr, Y, Nb, Be, REE). Rare-metal mineralization is found in the Strange Lake peralkaline granite, the Flowers River Igneous Suite and the Red Wine igneous suite; all of these suites are Mesoproterozoic.

Strange Lake peralkaline granite (Zr-Y-Nb-Be-REE)

This multiphase arfvedsonite-aegirine peralkaline granite forms a circular ring complex, approximately 7 km in diameter, that straddles the contact between a quartz monzonite pluton and Rae Province gneisses on the Labrador-Quebec border (Miller 1985, 1986). Late phases of the complex, consisting of small intrusions and pegmatite-aplite lenses, are highly enriched in a group of exotic rare-metal bearing minerals including gittinsite, armstrongite, pyrochlore, gagarinite and gadolinite (Miller 1990). Earlier phases contain lesser, but still significant, amounts of rare-metals and related exotic minerals. The age of the complex is 1240 Ma (Miller, Heaman and Birkett, in prep.).

High-grade mineralization occurs in pegmatite-aplite lenses and veins, and disseminated in medium-grained granite located in and near the roof zone of a small intrusion (< 2 km2) in the central portion of the complex (Miller 1986, 1988). On-going studies indicate that this mineralization is magmatic. Magmatic processes con-centrated rare-metals and other incompatible elements in residual magmas found in the roof zone of the crystallizing magma chamber.

Published reserve figures indicate that the Strange Lake deposit (Iron Ore Company) contains 52 million tonnes of 2.93% Zr, 0.31% Y2O3, 0.38% Nb2O5, 0.08% BeO and 0.54% REE (Venkatswaren 1983). A high-grade zone within the deposit contains about 2 million tonnes (exact value unpublished) grading 3.25% ZrO2, 0.66% Y2O3, 0.56% Nb2O5, 0.12% BeO and 1.30% REE.

Flowers River Igneous Suite (Y-Zr)

This suite consists of the Flowers River granitic suite and the Nuiklavik volcanic suite (Hill 1982; Miller 1992). These rocks form a rudimentary ring complex consisting of arcuate plutons (Hill 1991) that occupies an area approximately 70 x 50 km south of Nain. It forms part of the Nain plutonic suite, and intrudes older members of this suite and gneisses of the Nain and Churchill Provinces.

All granites in the suite are A-type and include arfvedsonite peralkaline granite and fayalite-clinopyroxene transitional granite. Chill zones, porphyritic rocks, aplite-pegmatite dykes and cogenetic volcanic rocks indicate that this is a high-level suite. Some intrusive phases are 1288 Ma (Emslie, personal communication, 1992), but others may be as young as 1271 Ma (Hill 1991).

The Nuiklavik volcanic suite occurs in the Flowers River cauldron complex, which is located in the southeastern part of the Nain plutonic suite. These volcanic rocks consist of a series of aphyric to feldspar-quartz phyric trachytic, comenditic and pantelleritic ash-flow tuffs (Miller 1992, 1993). Stratigraphic, ring dyke, aeromagnetic and structural data indicate that the cauldron complex consists of one early caldera, approximately 10 km in diameter, and at least 7 late calderas, 2 to 5 km in diameter; in addition, the smaller, nested, calderas occur within the older caldera. Ring dykes in the cauldron complex consists of hypabyssal equivalents of the volcanic and granitic suites. Peralkaline and transitional granite bodies intrude the lower part of the stratigraphy, dated at 1292 Ma (Krogh 1993), but do not intrude the upper part of the stratigraphy, dated at 1289 Ma (Wastenays 1994).

Rare-metal mineralization within the Flowers River Igneous Suite occurs mainly in the volcanic rocks and associated hypabyssal rocks of the Flowers River cauldron complex. Highly anomalous Zr (> 8000 ppm) and Y (500 - 1900 ppm) occurs in the upper part of the Nuiklavik volcanic rocks in small-volume pantelleritic aphyric to sparsely phyric ash-flow tuffs and lithic ash-flow tuffs (Miller 1993). This mineralization is stratabound, disseminated and occurs in minor accessory minerals including gel-zircon, zircon and chevkinite. Although hydrothermal alteration is widespread, it is post-mineralization, produces alkali-depletion by breakdown of feldspars and does not affect the immobile rare metals (Miller 1994). Geochemical data indicate that the rare-metal mineralization is magmatic.

Fluorite mineralization (Hill 1981) occurs in non-peralkaline volcanic rocks and related dykes that are preserved in the Flowers River cauldron complex beneath the peralkaline volcanic suite. This mineralization is very minor (< 1% F in thin veinlets) and does not occur in peralkaline ash-flow tuffs (commonly < 0.2% F). Hill (1982) also reports minor zinc mineralization in the volcanic suite and Mo in the granitic suite.

Red Wine Igneous Suite (Nb-Be±Y±Zr)

The Red Wine Igneous Suite consists of silica oversaturated and undersaturated peralkaline intrusions of the Red Wine intrusive suite and the trachytic to comenditic and pantelleritic volcanic rocks of the Letitia Lake Group. These rocks occur in a belt, which is approximately 60 km long by 6 km wide, centred on Letitia Lake in the Central Mineral Belt of Labrador. They are in fault contact with older intrusions of the Trans-Labrador Batholith, to the south and east, and are unconformably overlain by the Seal Lake Group to the north and west. This region occurs just south of the northern boundary of the Grenville Province.

The Letitia Lake Group consists of three members (Hill and Thomas 1983; Miller 1987): a lower member, containing quartz-feldspar ash-flow tuffs and dykes; a middle member, containing comenditic ash-flow tuffs and flows, and; an upper member containing comenditic to pantelleritic ash-flow tuffs (silica oversaturated) and trachytic flows (silica oversaturated to undersaturated). Marten (1975) and Thomas (1981) suggest that the upper member of the group is a regolithic unit consisting of weathered equivalents of the lower units; however, detailed geochemical and field data indicate that most of the upper unit represents in-situ subaerial peralkaline volcanic rocks. Hematite veinlets and zones of alteration, found in the upper units of the group, may alternately be due to hydrothermal activity (Wilton, in press) or be related to fenitization associated with the peralkaline suite (e.g. fenites reported by Curtis and Currie 1981). The Letitia Lake Group occurs mostly in the northern portion of the belt. The age of a quartz-feldspar porphyry in the lower member is 1327 Ma (Fryer in Hill and Thomas 1983).

The Red Wine intrusive suite contains a series of peralkaline silica undersaturated to oversaturated high-level plutons: 1) two undersaturated plutons, the Red Wine South and Red Wine North alkaline complexes, consist of agpaitic nepheline syenites, malignites and related mafic rocks (Curtis and Currie 1981); 2) three peralkaline quartz syenite intrusions, the Two Tom Lake, Mann #1 and Mann #2 - Ten Mile Lake intrusions (Miller 1987), and; 3) three peralkaline granite complexes, the Arc Lake granite-syenite complex, the Partridge River peralkaline granite and the Shallow Lake peralkaline granite (Thomas 1981; Miller 1987). The undersaturated plutons and the granitic plutons occur in the southern and central portions of the belt, whereas the quartz syenites occur in the northern part. The presence of porphyritic and fine grained phases, and cogenetic volcanic equivalents suggest that these are high-level intrusions. Both the Mann #1 and Two Tom Lake quartz syenite intrusions contain features suggestive of cauldron complexes (Miller 1988). The age of the Arc Lake ganite-syenite complex is 1337 Ma (Gandhi et al. 1988).

Rare-metal mineralization is widespread in the Letitia Lake area. The most significant mineralization occurs in the Mann #1 deposit, which contains reserves of 1.8 million tonnes of 0.35 - 0.40% BeO and 0.24% Nb_2O_5 (Dujardin 1961); however, significant Nb-Be mineralization also occurs in the Two Tom Lake and the Mann #2 showings (Miller 1988). This mineralization occurs in stratabound volcanic rocks and cross-cutting dykes. The Ten Mile Lake syenite exhibits anomalous Y (Miller 1988) and the Red Wine intrusions exhibit anomalous Zr (Curtis and Currie 1981). Miller attributes rare-metal mineralization in the Letitia Lake area to magmatic processes. The Letitia Lake Group also contains sulphide mineralization, both in epigenetic, pyritiferous quartz vein systems and in syngenetic, disseminated, pyrite-minor chalcopyrite occurrences (Wilton, in press). Wilton suggests that the hematite veins located in

the Letitia Lake Group may represent the upper parts of an Olympic Dam (Cu-U-Au-REE) style mineralizing system.

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1991: Nuiklavik (Flowers River) Volcanic Suite
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1993: Rare Metals in Labrador
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NC.1.2.2 Gold Metallogeny, Eastern Dunnage Zone (D.T.W. Evans)

Objectives. Epigenetic gold occurrences within the eastern and central portions of the Dunnage Zone comprise a geographically widespread class of mineralization, the significance of which has only recently been recognized. To document the style and setting of this mineralization and develop regional metallogenic models that would benefit mineral exploration, a metallogenic study was undertaken.

Methods. Field studies were initiated in 1989 and consisted of detailed deposit-level mapping, sampling and diamond-drill core logging and minor regional mapping. Field work during the 1989-1990 seasons concentrated on the northeastern Dunnage Zone in the Notre Dame Bay and Glenwood areas. The 1991-1992 field work concentrated on the central and southern Dunnage Zone. A short field season in 1993 concentrated on visiting a number of the previously examined occurrences. Office activities included the interpretation of field data, compilation of assessment reports and report writing.

In 1991, a detailed deposit level study of the Duder Lake gold prospects was initiated as part of a M.Sc. study by R. Churchill. In 1993, a similar study dealing with the Beaver Brook antimony deposit was initiated as part of a M.Sc. study by P. Tallman.

Results. The regional gold metallogenic study produced a number of significant results which may impact on mineral exploration in the area. These results include: 1) recognition that the epigenetic gold occurrences are structurally controlled and spatially associated with regionally extensive structures; 2) recognition of both epithermal and mesothermal styles of mineralization; 3) the documentation of all known epigenetic gold occurrences in the eastern and central Dunnage Zone; 4) the development of a classification scheme for gold mineralization; and 5) the development of a regional gold mineralization model based on occurrence characteristics and isotopic signatures.

The gold occurrences studied are structurally controlled and can be subdivided into mesothermal and epithermal styles. The two styles share common characteristics including form of mineralization, alteration and geological setting. The epithermal occurrences exhibit argillic alteration, intense hydrothermal brecciation and low gold values. In some instances there appears to be an overlap between epithermal and mesothermal styles of gold mineralization. The mesothermal gold occurrences cluster along regionally extensive structural discontinuities which may have acted as hydrothermal fluid conduits. The mesothermal mineralization can be further subdivided into auriferous quartz vein, altered wallrock (+/- quartz veins) and disseminated gold subclasses.

The isotopic data and the sulphide mineralogy of the quartz veins define an apparent provinciality for the gold occurrences. The thick sedimentary sequences of the eastern Dunnage Zone host arsenopyrite- and/or stibnite-rich quartz veins that exhibit $\delta^{18}O$ quartz and $\delta^{34}S$ pyrite values of >15 and <1.2 per mil, respectively. Volcanic or intrusive rock dominated sequences, such as the Victoria Lake area, host pyrite-rich quartz veins that exhibit $\delta^{18}O$ quartz and $\delta^{34}S$ pyrite values of <12.7 and >4.3 per mil, respectively. The $\delta^{13}C$ values for carbonate from many of mineralized quartz

veins have low values which suggest an organic carbon (sedimentary) component.

The geologic setting of the mesothermal gold occurrences, the brittle nature of the deformation associated with them, together with the large degree of variability in gangue mineral isotopic compositions due to the apparent mixing of deep crustal and meteoric fluids suggests that the mesothermal gold occurrences formed at fairly shallow depths, possibly transitional between typical mesothermal and epithermal settings. The deeper crustal fluids may have originated from metamorphosed Exploits subzone sequences which are allochthonous upon rocks of the Gander Zone, or from the underlying metasedimentary rocks of the Gander Zone.

Outputs.

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NC.1.2.3 Volcanic Rock Geochemical Database (C.M. Saunders)

Objectives. The aim of this project was to compile existing geochemical data for volcanic and subvolcanic rocks in Newfoundland and Labrador and release these data in a form accessible to the general public. This entailed development of a database structure suitable for lithogeochemical data.

Methods. Data were compiled using R:base 4.0 a relational database, and were either typed in directly or imported from existing files. Descriptive data for each sample included major unit (group or complex), minor unit (formation), subunit (member), location (NTS map and UTM coordinates), rock type and age. For the geochemical data the analytical method, analytical laboratory, and year of analysis were denoted.

Results. In May 1994, Version 1.0 was released on floppy disk with accompanying user manual and browse and retrieve application. This first release contained data from over 2000 rock samples from over 30 different sources, including theses and published and unpublished Newfoundland Department of Natural Resources collections. A user can query the database by unit, NTS map, rock type or other criteria. Elements can be selected and listed in preferred order. Data may be output to screen, file or printer in several predetermined formats. The application will run on most up-to-date IBM compatible computers and provides access to much data that has previously not been readily available to the general public.

Outputs.

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[1] A preliminary 88 page copy of the user manual, plus database and application on three diskettes was submitted as final contract output in February, 1994.

1.3 GEOCHEMISTRY

NC.1.3.1 Analysis of archived samples, Newfoundland (P.H. Davenport)

Objectives. To increase the usefulness of the regional geochemical database by extending the range of elements available.

Methods. Samples had been analysed previously for 12 elements by a combination of atomic absorption spectrophotometry (AAS), potentiometric and gravimetric techniques. Following orientation work in 1986 and 1987, it was shown that the archived samples would provide useful data for gold exploration when analysed directly for gold and pathfinder elements by instrumental neutron activation analysis (INAA). Samples were packaged into special vials, quality control samples (control reference and duplicates) inserted in the Geochemical Laboratory of the Geological Survey, St. John's, and shipped to Becquerel Laboratories Inc., Mississauga, Ontario, for analysis for Au, As, Ba, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Mo, Na, Ni, Rb, Sb, Sc, Sm, Ta, Tb, Th, U, Yb and Zn.

Results. This work was started in 1987, and under this project analysis of the final 3471 samples was completed. Open files of the results as digitally produced colour element distribution maps with accompanying notes and data listings were released for NTS areas 2C + 2F, 12B + 12G, 12I + 12G, and 12P + 2M.

Outputs.

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ORAL AND POSTER PRESENTATIONS

Davenport, P.H., Nolan L.W. and Honarvar, P.

1994. Digital Geochemical Atlas of Newfoundland. Poster presented at the the GSC Minerals Colloquium, January, Ottawa, and GAC/MAC Annual Meeting, Waterloo, May.

NC.1.3.2 Geochemical Field Surveys (J.W. McConnell)

Objectives. The primary objectives were to promote base-metal, gold and diamond exploration in northern Labrador. The principal work for surficial surveys for diamonds (kimberlites) was done during 1994 with Bruce Ryan and is described elsewhere (N.1.2.1). Secondary objectives included mapping the dispersion of contaminants in water from the Rambler Mines area and assessing the effectiveness of overbank sediment and water geochemical techniques as exploration methods on the Baie Verte Peninsula.

Methods (Labrador). Areas of the Nain Province were selected on the basis of regional lake and stream geochemistry for detailed stream sediment/water geochemical surveys and prospecting for copper, nickel and gold mineralization. During two six-week field seasons in 1991 and 1992, a five-person crew with helicopter support conducted stream surveys from a number of fly-camp locations in the Nain Province. The sediment, water and rock samples were analysed in the Department's laboratory and the results presented as open files and poster displays.

Results (Labrador). Several geochemical anomalies were identified and new Cu-Ni-Co mineralization discovered in schists and mafic rocks. Following the release of the data in early 1993, Archean Resources staked the base-metal discoveries and some of the stream-sediment anomalies. During the course of their own follow-up work on these and other targets, they discovered the Voisey Bay Ni-Cu deposit.

Methods (Newfoundland). A two person crew spent a few weeks in the spring and late summer of 1993 sampling stream and overbank sediment and water on the Bay Verte Peninsula. Samples were analysed in the Department's laboratory.

Results (Newfoundland). The geochemical data identified several sources of contamination on the former Rambler Mines property. Three streams, one river and a diversion ditch have copper contents in their water that are far in excess of levels that are lethal to aquatic life. From a mineral exploration vantage, other results demonstrated that stream water and overbank geochemistry are both viable methods of mineral exploration in this area.

Outputs.

PUBLICATIONS

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McConnell, J.W.

1991: Stream sediment and water follow-up surveys in the Torngat Region of Labrador. *In* Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 60-61.

Finch, C., Hall, G. and McConnell, J.W.

1992: The development and application of geo-chemical analyses of water. *In* Current Research, Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 297-307.

McConnell, J.W.

1992: Conventional and overbank stream-sediment surveys on the Baie Verte and Springdale Peninsulas. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Nfld 2191.

McConnell, J.W.
1992: Detailed stream sediment and water surveys in northern Labrador. *In* Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 58-59.

McConnell, J.W. and Honarvar, P.
1993: First year results of detailed stream-sediment and water geochemical surveys in northern Labrador. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Lab/0969.

McConnell, J.W.
1993: Aspects of stream sediment and water surveys in northern Labrador. *In* Current Research, Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, pages 451-462.

McConnell, J.W.
1993: Sampling of stream water and active and overbank stream sediment for exploration and environmental monitoring. *In* Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 27-28.

McConnell, J.W., Finch, C., Hall, G.E.M. and Davenport, P.H.
1993: Geochemical mapping employing active and overbank stream-sediment, lake sediment, and lake water in two areas of Newfoundland. *In* Journal of Geochemical Exploration, 49, pages 123-143.

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1993: Seasonal variation in surface-water geochemistry. *In* Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 3-5.

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1993: A PC-based approach to the integration of regional geoscience data sets. *In* Conference Program and Extended Abstracts. Integrated Methods in Exploration and Discovery, Denver, Colorado. Society of Economic Geologists, Littleton, Co., pages AB55-56.

McConnell, J.W.
1994: Detailed survey of stream-sediment and water geochemistry, northern Labrador. *In* Current Research, Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 94-1, pages 313-326.

McConnell, J.W. and Honarvar, P.
1994: Results of a detailed survey of stream-sediment and stream-water geochemical survey in northern Labrador. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File LAB/1016, 47 pages and 33 colour maps.

Hall, G.E.M. and McConnell, J.W.
1994: Hydrogeochemical surveys in Newfoundland - Geological mapping with REEs in lake waters. *In* Explore, Association of Exploration Geochemists, Number 83, pages 1-10. (April, 1994)

Ryan, B. and McConnell, J.W.
1994: Reconnaissance survey for kimberlites and lamproites in northern Labrador. *In* Report of Activities, Newfoundland Department of Natural Resources, Geological Survey Branch, pages 10-12.

Davenport, P.H., Finch, C., McConnell, J.W., Kingston, J.C. and Collins, G.
1994: Causes of variation in surface-water geochemistry in southeastern Newfoundland. *In* Report of Activities, Newfoundland Department of Natural Resources, Geological Survey Branch, pages 3-4.

McConnell, J.W.
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1995: The search for kimberlite and lamproite intrusions in eastern Labrador: Initial report of a bedrock and surficial-sediment sampling survey. *In* Current Research, Newfoundland Department Natural Resources, Geological Survey Branch, Report 95-1, pages 47-54.

Gower, C.F., McConnell, J.W. and van Nostrand, T.
1995: New mineral-exploration targets in the Pinware Terrane, Grenville Province, southeast Labrador. *In* Current Research, Newfoundland Department of Natural Resources, Geological Survey Branch, Report 95-1, pages 15-24.

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1995: Development and application of a sensitive and rapid analytical method to determine the rare earth elements in surface waters. *In* Chemical Geology, Vol. 120, Nos. 1-2, pages 91-109.

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1996: A description of soil- and stream-geochemical surveys of the Florence Lake greenstone belt, eastern Labrador. *In* Current Research, Newfoundland Department of Natural Resources, Geological Survey Branch, Report 96-1.

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1996: The search for kimberlite and lamproite intrusion in north-eastern Labrador: results of a surficial sediment survey and bedrock orientation study. *In* Current Research, Newfoundland Department of Natural Resources, Geological Survey Branch, Report 96-1.

Poster Displays

McConnell, J.W. and Honarvar, P.H.
1993: Results of stream sediment and stream-water geochemistry in northern Labrador. Poster display at the Geological Survey Branch's Open House, St. John's, Nfld, November, 1993.

Gower, C.F., van Nostrand, T. and McConnell, J.W.
1994: New mineral exploration targets in the Pinware Terrane, Grenville Province, southeast Labrador. Poster display at the CIM Annual General Meeting, Toronto, May, 1994.

McConnell, J.W.
1994: Stream water geochemistry - implications for mineral exploration and environmental monitoring. Poster display at the Geological Survey Branch's Open House, St. John's, November, 1994.

Gower, C.F. and McConnell, J.W.
1994: New mineral exploration targets in the Pinware Terrane, Grenville Province, eastern Labrador. Poster display at the Geological Survey Branch's Open House, St. John's, November, 1994.

Ryan A.B. and McConnell, J.W.
1994: Diamond potential of Labrador: survey for kimberlite and lamproite indicator minerals in eastern Labrador. Poster display at the Geological Survey Branch's Open House, St. John's, November, 1994

McConnell, J.W., House, S. and Vaughan, M.
1995: Soil and stream geochemistry over Florence Lake greenstone belt. Poster display at the Geological Survey Branch's Open House, St. John's, November, 1995.

Verbal Presentations

McConnell, J.W.
1993: The geology and natural history of the Torngat Mountains. Slide show and talk given to the Natural History Society of Newfoundland and Labrador, St. John's, November, 1993.

McConnell, J.W.
1993: Geochemical exploration in northern Labrador. Illustrated talk given at the Winter Seminar Series of the Geological Survey Branch, St. John's, March 19, 1993.

McConnell, J.W. and Honarvar, P.
1994: Bergs, bears and bays - stream geochemistry from Okak to Cape Chidley. Illustrated talk given at the Winter Seminar Series of the Geological Survey Branch, St. John's, March, 1994.

McConnell, J.W.
1995: Stream water geochemistry: seasonal and mining influences in the former Rambler Mines area. Illustrated talk given at the Winter Seminar Series of the Geological Survey Branch, St. John's, March, 1995.

McConnell, J.W. and Davenport, P.H.
1995: The role of geochemical surveys in mineral exploration in Labrador. Talk given to Annual Meeting of CIM, St. John's, November, 1995.

McConnell, J.W. and Davenport, P.H.
1996: Geochemical exploration in Labrador for Voisey Bay-type deposits. Invited talk to be given to the University of Toronto, Student Chapter, Society of Economic Geologists. A one day symposium "Exploration for Voisey Bay-type Cu-Ni-Co magmatic sulphide deposits". January 26, 1996, Toronto.

NC.1.3.3 Analysis of archived NGR samples, Labrador (P.H. Davenport)

Objectives. To increase the usefulness of the NGR database by extending the range of elements available.

Methods. Samples had been analysed previously for about 35 elements by a combination of atomic absorption spectrophotometry (AAS), instrumental neutron activation analysis (INAA), potentiometric and gravimetric techniques. Following INAA analysis, the irradiation vials were shipped to St. John's and analysed further by inductively coupled plasma emission spectrometry (ICP-ES) following an HF, $HClO_4$, HCl digestion. Of the 30 elements (Al, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Dy, Fe, Ga, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Sc, Ti, V, Y, Zn and Zr), 13 elements had not been previously determined, and data for 3 more were of significantly higher quality. The overlap in element suites for 14 elements provides a very effective and objective check on data quality.

Results. A total of 2740 samples were analyzed, comprising stream sediment samples from NTS sheets 14L, 14M, 24I and 24P, and lake sediment samples from 14C, 14E, 14F, 14L and 24I. The project is continuing under provincial funding, and when completed the data will be released on open file.

1.4 GEOPHYSICS

N.1.4.1 Colour Map Production from Digital Databases (G. Kilfoil)

Objectives. This project was designed to enhance the output capabilities of the Geological Survey through the purchase of a colour raster plotter capable of E-size maps and implementation of driving software.

Methods. An HP-7600 series (Model 355) colour, electrostatic plotter was purchased during the first year of the Project. A colour plotting software package, CPLOT, was then purchased to function within the HP-UX operating

system on the Department's mini-computer. This software provides the link between plots generated by GEOSOFT's PC-based software and the HP raster plot language (RTL) required by the plotter. The CPLOT package was tested and modified to comply with the Department's hardware installation.

The suite of programs used to generate quality colour maps has been continually upgraded by addition of ancillary programs designed to enhance raster output quality and to streamline map production. Noteworthy, among these are:

- the ability to combine several smaller raster plots into a single plotter file, thereby reducing operating costs and plotting time;
- a routine to simultaneously include several PCX-format graphic images directly into raster plots. Example PCX files might be descriptive text output from a word processor, index maps, graphic pie charts, emblems or other art-work output from a scanner or generated by graphic programs such as CorelDraw.

Recently, a utility has been added to convert RTL format plotter files to an industry standard image format. A recently purchased graphic conversion utility, Image Alchemy, allows interchange of files in this format to virtually any of the more commonly used graphic formats.

Approximately nine man-months of the Project Geophysicist's time were required to install, trouble-shoot, streamline and instruct on the use of the colour map production software. A considerably greater amount of time has been expended by Project Geologists in generating colour maps on the electrostatic plotter.

Results. Data from geophysical surveys and geochemical analyses are now routinely presented as enhanced colour images that had been previously either unavailable or generated in a piecemeal and time-consuming fashion. When properly produced, colour images can often demonstrate the often subtle spatial relations that exist between these data, bedrock and surficial geological maps, and zones of mineralization.

Colour maps have been generated as part of recent Open File releases by the Department. In addition, numerous custom colour products were generated from the Department's databases upon the request of researchers in government, universities and the mineral exploration industry.

The project turned out to be timely with respect to the recent identification of copper, nickel and cobalt mineralization near Voisey Bay, Labrador. Since the initial discovery in November, 1994, a large number of colour, shaded-relief maps have been produced by the plotter for purposes of mineral claim-staking in nearly all regions of Labrador.

NC.1.4.1 Geophysical Data Compilation (G. Kilfoil)

Objectives. The objectives of the project were to catalogue and document the quality of all geophysical data collected within the Province, to extract pertinent geophysical information from mineral assessment files into the Geological Survey's digital databases, to optimize the usefulness of existing digital geophysical data to the geoscientific and mineral exploration communities, and thereby to broaden and increase accessibility to this information base.

Methods. To aid in data quality evaluation and project planning, a digital index of airborne geophysical surveys was developed by linking bibliographic information about individual surveys (extracted from GEOSCAN) to the survey extents digitized from location maps and sketches. As constructed under ArcView™ for a desktop PC, the digital index provides a means to display the extents of surveys in combination with virtually any other spatially referenced data type and to query the index information that is tightly linked to each survey polygon. The airborne geophysical survey indexes also provide indirect links to positional information and colour images prepared from digital datasets.

Methods of recapture of analog geophysical information (profiles, postings, plots, contour maps) submitted with mineral assessment reports as digital datasets were evaluated. Computer programs were written to efficiently and accurately input data in profile and contour format, and to scale output using georeferencing. The digital index of airborne surveys was queried to select data for digitizing on the basis of data quality, perceived mineral potential, areal extent and in coordination with mapping efforts of other project leaders. Extracted information was processed and prepared for release as digital Open Files using data formats coordinated with the digital data archivist.

Refinements have been made to the methods of filtering, gridding and presentation of government-sponsored surveys, i.e. the complete aeromagnetic coverage for the province; high-resolution, aeromagnetic/ gradiometric data from surveys in central Newfoundland; and available gamma-ray spectrometric and VLF-EM survey data. The interpolated and filtered results have been released in piecemeal fashion as digital files in portions suitable for manipulation on desktop PC's. Computer programs, designed to display the data on a VGA monitor and to join adjacent grid files seamlessly, have accompanied all data releases. The majority of the efforts of a Project Geophysicist and a Geologist I have been devoted to this project.

Regulations in the Mineral Act pertaining to submission of information for mineral assessment were reviewed and recommendations were put forth to amend the Act to require such information to be included in standard digital formats and on standard media. Data release formats and pricing policy have also been discussed at length with the objective of improving digital data exchange.

Project Results. Separate digital indexes of airborne geophysical surveys have been generated for Newfoundland and for Labrador regions. These have been accessed extensively for project planning purposes by the Project Geophysicist and, on a daily basis, to determine the existence of geophysical coverage in particular areas by other project leaders and mineral explorationists. Development of similar indexes for ground geophysical surveys, geochemical surveys and geological map digitizing have also commenced.

Magnetic and electromagnetic data were digitized from three large surveys in Labrador and from ten surveys in Newfoundland. As well, original flight archive data were obtained from the sponsoring agency for two other surveys. Data from several of these surveys have been prepared for release as digital Open File reports. These data have also been used to generate detailed geophysical plots as colour shaded-relief maps and ArcView™ images upon request or demand.

The province-wide aeromagnetic dataset has been combined with digital topographic information and marginal notes to generate an Open File series of 1:250 000 scale colour, shaded-relief aeromagnetic maps for Newfoundland. Although not formally released, similar maps have been generated for many regions of Labrador, as well as from portions of the magnetic gradiometer and gamma-ray survey datasets. Recently, colour, shaded relief images generated at approximate 1:250 000 scale from these data have also been made available to explorationists. Demand for organized geophysical data for mapping and mineral exploration purposes has grown much stronger over the duration of the project, and notably intense with a demand for colour shaded-relief magnetic maps for Labrador as a result of the November, 1994 discovery of significant mineralization near Voisey Bay.

Progress and overall results from the project have been reported in the Geological Survey's annual publications and presented at local, national and international technical conferences. The project has been well received by technical advisory committees and numerous copies of maps have been generated from digital geophysical databases to satisfy a demand from mineral explorationists.

1.5 QUATERNARY MAPPING

N.1.5.1 Thesis Support (D. Liverman)

Objectives. To carry out several surficial geology and geochemistry projects in Newfoundland through providing support for three M.Sc. theses. Two of these projects aimed to provide basic surficial mapping and glacial dispersal information for two NTS sheets, Carmanville (2E/8) and Botwood (2E/3). The third project investigated the geochemistry of lake sediments in the St. John's area.

Methods. Surficial mapping projects were conducted by standard methods, involving aerial photograph interpretation, ground checking, section description, clast fabric analysis, and grain size analysis.

Results. Quaternary Geology of the Botwood area- Till is the dominant surficial sediment in this area, and was likely deposited by either easterly or north easterly ice flow. Glaciofluvial sediments are important in the area, forming an important source of aggregate. Peat is also a major surficial unit, and is being commercially expoited near Bishop's Falls.

Quaternary Geology of the Carmanville area:- Ice flow in the Carmanville area has been documented through mapping, and consists of three phases, sucessively eastward, northeastward, and northwestward. Geomorphology and clast fabric are dominated by the notheasterly ice flow. Much of the area was submerged following deglaciation, with a marine limit of at least 52 m asl. Reworking of till, and deposition of glaciomarine sediments may make drift prospecting methods difficult to apply in these areas.

Lake sediment geochemistry, St. John's - The record of chemical, physical and biological change over the past 2000 - 3000 years is well preserved in sediment cores from lakes in the St. John's area. Most attention has been focused on Quidi Vidi Lake. Particularly prominent are changes since about 1770 AD, when clearing of the forest and the onset of farming are recorded by compositional changes in the sediments, and increases in sedimentation rates. Much more intense disturbance of the catchment coincident with sub-division development between 1950 and 1970 led to even more dramatic changes in sediment type and 20 fold increases in sedimentation rate. Superimposed on these changes in bulk sediment composition were increases in heavy-metal loadings. Levels of Hg, Sb, As and Au peak at about 1880, and levels of Pb, Zn and Co are also many times their local background at the base of the core. By 1950, Pb had become the dominant heavy-metal pollutant, with loadings peaking in 1970. These features are attributed in the first case to fall-out

from coal combustion, and in the second to the use of leaded gasoline. Heavy-metal loadings and sedimentation rates have declined rapidly since1970.

NC.1.5.1 Quaternary Mapping, Western Labrador (D. Liverman)

Objectives. Surficial mapping of the Labrador Trough, with the main objectives of identifying surficial sediment distribution and grain size, location of ice flow indicators, examination of sediment dispersion and geochemistry, and definition of Quaternary history. The specific area studied consisted of four 1:50,000 map sheets that compose the northeast quarter of the 23J NTS area.

Methods. The project was active over three years. The first year a two person field party concentrated on mapping over 23J/15 and 23J/9, using the extensive road network associated with iron ore exploration for access with limited helicopter support. The second year a five person field party conducted mapping and extensive regional sampling over 23J/16 and 23J/8, as well as deatiled sampling over a known mineral occurrence. This required extensive helicopter support, and water access. The third year consisted of analysis, interpretation of laboratory results, preparation of open files, and writng of a final report, using the laboratory facilities of the Survey, extensive computer support and assistance in preparation of digital maps, and student hiring for 4 months. External analyses were contracted to Bequerel Ltd.

Results. The surficial geology of the northeast part of the Schefferville 1:250,000 NTS sheet (23J) is mapped and described. Ice flow history was deduced using the results of striation mapping, geomorphology, indicator erratics, and clast fabric of glacigenic diamictons. The earliest ice flow identified in the area resulted in dispersal west from the Trough and the Martin Lake area from an ice centre was located around the eastern margin of the Trough at this time. A later shift westward of the ice centre, and the development of an ice divide north of Attikamagen Lake resulted in southeastward flow over most of the area, with northwestward flow found in the northeast only. In the final stages of glaciation, dispersal shifted further to the west of the Labrador Trough, resulting in a pronounced northeast ice flow over the northern part of the area. As the ice sheet finally stagnated, major sub-glacial meltwater flow took place, and this was controlled by a combination of topography at the base of the ice, combined with the hydraulic gradient within the ice. The preserved landscape show a pronounced zonation, possibly due to this meltwater event. Drumlinoid landforms are in low lying areas in the north of the study area, flanked by bare bedrock ridges with sub-glacial meltwater channels. Very little sediment is preserved in these areas, apart from in topographic lows protected from southeast flow. South of this zone an area of thicker drift cover, with fewer drumlinoid landforms occurs, and south and east of this, a zone of ribbed and rogen moraine with eskers is found. Larger areas of ribbed moraine with large eskers are found south of the study area.

The matrix geochemistry of diamictons in the eastern half of the study area was intensively examined. This showed that till geochemistry is a successful method for identifying mineral occurrences in this part of the Labrador Trough. Glacial dispersal in the Martin Lake area appears to be mainly to the east and northeast, and transport distances are short (100-500 m). A series of anomalous values east and south of known showings in the Martin Lake area appears to indicate an undiscovered area of mineralization, geochemically distinct from known showings. Sediment dispersal in the east and southeast of the study area is controlled by a late northeast to east-northeast flow. The west of the Labrador Trough in this area is dominated by south to southeastward dispersal. The boundaries between these broad areas are poorly defined, due to lack of exposure, and further work, particularly clast fabric studies needs to be done to define them.

Outputs.

Liverman, D.G.E.

1992: Quaternary Geology of the Schefferville area, western Labrador. Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland, p 72-74.

1992: Quaternary Geology of the Schefferville area, western Labrador. Poster presented at Geological Survey open house.

Liverman, D.G.E. and Vatcher, H.

1992: Quaternary Geology of the Schefferville area, western Labrador. In Current Research, Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland, Report 92-1, pages 27-37.

Liverman, D.G.E.

1993: Quaternary Geology of the Schefferville area, western Labrador. Presntation in Geological Survey seminar series.

1993: Ice-flow mapping in Newfoundland and Labrador; the relationship between striations, geomorphology and the depositional record. CANQUA'93, Applied Quaternary Research, Program with abstracts and field guide. p A30.

1993: Ice-flow mapping in Newfoundland and Labrador; the relationship between striations, geomorphology and the depositional record. Poster presented at CANQUA'93

1993: Ice-flow mapping in Newfoundland and Labrador; the relationship between striations, geomorphology and the depositional record. Geological

Association of Canada annual meeting, Edmonton, Alberta. Programme with abstracts.

1993: Ice-flow mapping in Newfoundland and Labrador; the relationship between striations, geomorphology and the depositional record. Poster presented at Geological Association of Canada annual meeting, Edmonton, Alberta.

Liverman, D.G.E. and Vatcher, H.

1993: Surficial geology of the Cavers and Hollinger Lake areas (NTS 23J/9 and 16). Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland, p 71-72.

1993: Surficial geology of the Cavers and Hollinger Lake areas (NTS 23J/9 and 16). Poster presented at Geological Survey open house.

1993: Surficial geology of the Cavers and Hollinger Lake areas (NTS 23J/9 and 16), Labrador. *In* Current Research, Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland, Report 93-1, pages 127-138.

Liverman, D.G.E., Vatcher, H. and Boger, R.A.

1993: Landform classification, surficial geology, and ice flow indicators, Stakit Lake, Labrador (NTS 23J/8). Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map # 93-96, scale 1:50,000. Open File 023J/09/0300

1993: Landform classification, surficial geology, and ice flow indicators, Cavers Lake, Labrador (NTS 23J/9). Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map # 93-95, scale 1:50,000. Open File 023J/09/0299

1993: Landform classification, surficial geology, and ice flow indicators, Knob Lake, Labrador (NTS 23J/15). Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map # 93-97, scale 1:50,000. Open File 023J/09/0301

1993: Landform classification, surficial geology, and ice flow indicators, Hollinger Lake, Labrador (NTS 23J/16). Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Map # 93-98, scale 1:50,000. Open File 023J/09/0302

Liverman, D.G.E., Boger, R.A. Honarvar, P. and Vatcher, H.

1993: Till geochemistry, Cavers Lake and Hollinger Lake areas (NTS 23J/9 and 16), western Labrador. Newfoundland Department of Mines and Energy, Geological Survey Branch Open File 23J/0303 (13 maps and text).

Liverman, D.G.E.

1994: Surficial Geology and Geochemistry in the Dyke Lake-Schefferville area of western Labrador. Final report (unpublished), 41 pages plus appendices.

NC.1.5.2 Placer potential/till geochemistry, NE Newfoundland (S. Scott)

Objectives. To evaluate the potential for gold placer formation in glaciofluvial sediments; and to examine dispersal of gold in surficial sediments in NE Newfoundland.

Methods. The project was active over two years. The first year consisted of detailed mapping and sampling of glaciofIvial sediments in the Birchy Bay area of NE Newfoundland. Bulk samples (34-150 kg) were taken and concentrated in the field using a combination of sieving and a spiral separator. Concentrates were analysed by fire assay, and neutron activation analysis. The chemistry and morphology of individual gold grains were examined with an electron microprobe.

The second year concentrated on surficial mapping and geochemistry of the source areas for the gold found in the glaciofluvial sediments. Matrix samples were obtained from till over much of the 2E/7 (Comfort Cove-Newstead) and 2E/2 (Gander River) NTS map areas, and these were combined with samples obtained under a previous mapping programme for geochemical analysis.

Results. The sampling methodology used in assessing gold values was found to be effective, and results were reproducible in duplicate sampling. Gold was found to be common in glaciofluvial sediments in the Birchy Bay area, but concentrations are relatively low. Gold was found at highest levels in coarser grained massive gravels, and from lags at the base of palaeochannels. Such deposits are unlikely to be economic, apart from as a by-product to gravel extraction and washing.

Till geochemistry, Comfort Cove-Newstead and Gander River areas - At least four ice-flow events affected the study area during the Late Wisconsinan. The first was a regional east to southeastward flow from a source west of Mount Peyton. This was followed by a regional north to northeastward flow and two local flows; a northeastward flow in the west and a northwestward flow in the east.

Diamictons (generally till) are common throughout the region. Generally they have a sandy matrix, contain 25 - 70 percent clasts of pebble to cobble size, and range from internally massive to stratified with sand or silt lenses. These diamictons were deposited by basal meltout or glacigenic debris flows.

Clast fabrics and lithological studies suggest several sediment dispersal orientations. These include east-southeast dispersal in the south and southcentral region; a north and northeast trend in the south, southcentral and northern regions; and northwest dispersal just southeast of Birchy Bay.

A till-geochemical study demonstrates that gold values are higher over the Botwood and Davidsville Groups and that evidence for a southeast dispersal is found in several element plots for the region. The gold element plot shows known gold occurrences and three areas not associated with any of the known occurrences. The arsenic and antimony plots confirm these anomalies. These three previously unknown highs are potential exploration targets.

Sand and gravel deposits at Birchy Bay form the upper part of two delta complexes, the distal bottomsets of one of these delta complexes and a kame deposit. Geochemical analyses indicates gold is present in these sediments but not in quantities sufficient to sustain mining. Detailed study and measurement of these gravels indicate that material was fluvially transported to the northwest. This suggests a source to the south or southeast.

Gold grains within the sand and gravel at Birchy Bay have morphologies indicating transport distances of two to 30 km. The pitted nature of the grains, and their similar morphology suggest the same transport history for most. Geochemically, three distinct types of gold are recognized.

Analysis of gold from Big Pond shows that it has a geochemical signature similar to that of several gold grains in the sand and gravel deposits, thus it is a possible source. Other grains located in the gravel pits and in the till have very high fineness suggesting that much of the gold is a result of oxidation.

Outputs.

Scott, S.

1992: Placer gold in glaciofluvial deposits, Comfort Cove map area (2E/07). Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland, p 109-110

1992: Placer gold in glaciofluvial deposits, Comfort Cove map area (2E/07). Poster presented at Geological Survey open house.

1992: Placer gold in glaciofluvial deposits, Comfort Cove map area (2E/07). In Current Research, Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland, Report 92-1, pages 387-400.

1993: Placer gold in glaciofluvial deposits, Comfort Cove map area (2E/07). Presntation in Geological Survey seminar series

1993: Placer gold in glaciofluvial deposits, Birchy Bay (2E/07). Department of Mines and Energy, Geological Survey of Newfoundland, open file release.

1993: Surficial Geologyand drift exploration of Comfort Cove - Newstead and Gander River map areas (NTS 2E/7 and 2E/2). Report of Activities, Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland

1993: Surficial Geology and drift exploration of Comfort Cove - Newstead and Gander River map areas (NTS 2E/7 and 2E/2). Poster presented at Geological Survey open house.

1994: Surficial Geologyand drift exploration of Comfort Cove - Newstead and Gander River map areas (NTS 2E/7 and 2E/2) (pages 29-42). Report 94-1.

1994: Surficial Geology and landform classification of the Comfort Cove - Newstead and Gander River map areas (NTS 2E/2 and 2E/7), Scale 1:50,000. Department of Mines and Energy. Open File maps.

1994: MDA final report.

1.8 SUPPORT SERVICES

N.1.8.1 - N.1.8.5 Support Services

Five projects were sponsored under the subprogram as follows: N.1.8.1 Analytical Support (P.Davenport); N.1.8.2 Computer Support (H. Missan); N.1.8.3 Cartographic Support (K.Byrne); N.1.8.4 Mineral Exploration Consulting Services (N. Mercer); N.1.8.5 Administration Support (W. Ryder). These projects provided support services to the geoscientific research projects and information projects as required.

NC.1.8.1 SUPPORT SERVICES

One project was sponsored under the subprogram: NC.1.8.1 Financial Control (W. Ryder). It provided budgeting, accounting, financial monitoring and reporting services for all Agreement projects.

2. MINING AND MINERALS TECHNOLOGY

2.3 PRODUCTIVITY IMPROVEMENT

N.2.3.1 Definition Drilling at Baie Verte Mines (F. Morrissey)

Objectives. The drilling program was designed to enhance the potential for underground mining of the asbestos resource. The project was initiated as a result of rising asbestos prices and recommendations for further drilling of the deposit outlined in a 1989 feasibility study. By having the information available at such time when asbestos prices are increasing may result in revitalization of this property.

Methods. The public tendering process was used to contract the drilling and to transport the boxed core to Baie Verte where it was logged and stored. Holes were drilled to intersect "key areas" of "probable ore" to determine if they occurred at depth as interpreted. A total of 12,578 feet of NQ-size core was drilled in 15 holes, and the core logged for fibre content, geology, and geotechnical characteristics. The information was evaluated and combined in a drill-hole database.

Results. As a result of the drilling project, the proven reserves of asbestos were increased from 8.11 million tonnes of 4.21% visual clean fibre to 8.66 million tonnes of 4.89% visual clean fibre. The drilling information also became a major component in two subsequent Canada-Newfoundland MDA studies; "Revision of Preliminary Underground Design and Feasibility Study - Baie Verte Asbestos Mine" (Project N.2.3.6) and "Evaluation of the Fibre Group Distribution of the Underground Asbestos Deposit at Baie Verte Mines" (Project N.2.3.10).

Outputs. A report entitled "Definition Drilling at Baie Verte Mines (January 1993)" was prepared by the Engineering Section.

N.2.3.2 Sodium Silicate as a Filtration Rate Modifier: Teranov Mining Corporation (F. Morrissey)

Objectives. The purpose of the project was to determine the best method of lowering the asbestos fibre-filtration rate from approximately 300 seconds to less than 200 seconds, in the Teranov operation. This would have increased the marketability of the Teranov product as many asbestos cement producers are unable to use the Teranov fibre due to filtration problems. The production methods of the end users were unable to handle the highly opened fibre and consequently they accepted only product with filtration rates below 200 seconds. Sodium silicate had been shown to be an effective filter aid on fibrous materials in other mining operations. Application methods were critical as complete surface coating was desired without the addition of significant moisture to the final product. The test work attempted to establish a relationship between addition rates of sodium silicate and filtration rates of final fibre product.

Methods. Testing was done at a metallurgical laboratory in British Columbia. The two methods tested were a spray application of sodium silicate to dry fibre and an addition of sodium silicate to a fibre slurry. The spray application method involved spraying sodium silicate through an atomizing nozzle after the drying process and before packaging. This was the method most commonly used at other operations. The second method involved metering specific addition rates of sodium silicate into the stock tank immediately preceding the filter. Laboratory work indicated that the sodium silicate effectively coats asbestos fibre in a stirred tank and remains with the fibre through filtering, drying, and fibre opening processes.

Results. Results indicated that sodium silicate was effective as a filtration aid on the Teranov fibre. Both application methods indicated that addition rates in excess of 16.5 lb/tonne would be effective in improving filtration rates to below 200 seconds. However, there were concerns with both methods, as tests indicated an increase in moisture content of the fibre. It was recommended in the testing report that the application of sodium silicate to a fibre slurry be plant tested first.

Outputs. A number of reports on sodium silicate testing on Teranov fibre samples were completed. They are as follows:

1. "Testing of Sodium Silicate as a Filtration Aid for the Final Product (June 1992)" by Rachel Kunz of the Princeton Mining Corporation, Vancouver, B.C.

2. "Sodium Silicate Application Testing (July 1992)" by William Callan of Thetford Mines, Quebec.

3. "Sodium Silicate Testing (April 1993)" by Terry Fredin, Chief Metallurgist with the Princeton Mining Corporation, Vancouver, B.C.

N.2.3.3 Pine Cove Assessment Drilling, Nova Gold Resources Inc. (F. Morrissey)

Objectives. The project entailed an infill-drilling program designed to place "probable" ore into a "proven"

category, and to increase the potential of the property to become a producing mine. More specifically, the drilling would provide additional core for metallurgical testing, better information for mine planning, and enhance the feasibility study by having much of the orebody drilled on a 25 metre grid.

Methods. A total of 2,390 metres were drilled in 32 holes. Core logging and sample assaying was completed, together with a metallurgical study.

Results. The confidence level of the ore reserves was increased by confirming the continuity of the mineralization. Also, the potential for additional near surface mineralization laterally along strike from the known deposit was established. A revision of the mineable diluted reserves, as calculated by NovaGold, showed an increase in the tonnage and grade.

Outputs. An assessment report entitled "Geology and Diamond Drilling on the Pine Cove Property, Baie Verte Area, Newfoundland (October 1992)" was completed by D.R. Duncan & Associates Ltd. of Elmsdale, Nova Scotia for NovaGold Resources.

N.2.3.4 Metallurgical Testing: Rendell-Jackman Property Major General Resources Ltd. (F. Morrissey)

Objectives. A program of metallurgical testing was considered a crucial step in advancing the Rendell-Jackman project to a feasibility study stage. Due to the nature of the gold being very fine-grained, it was important to determine the type of product which could be recovered on site (90% of individual grains are <10 microns in diameter). The results of this test work would not only determine an appropriate recovery method, it would also determine any variability of recovery rates at low, medium, and high gold grades within the Main Zone. The test work would also determine the characteristics of a final product and whether the gold ore was refractory.

Methods. Metallurgical test work on ore-intercept samples from the Hammerdown gold deposit included cyanidation, flotation, and gravity separation testing to investigate the recovery of gold. To understand the nature of gold mineralization, a number of drill core specimens of gold ore were submitted for mineragraphic examination. Ore microscope examinations were carried out on polished sections from the drill-core samples.

Results. The samples were found to contain free gold (17%) and gold-bearing sulphides easily recoverable by gravity separation. Subsequent flotation yielded a combined concentrate of 183 g/t Au at 14% weight recovery, representing 82% of the gold. Cyanidation tests achieved recoveries in the 95% range. Test results suggested that many options were available for processing this ore, dependent upon local environmental regulations, smelter availability, as well as equipment needs and limitations. Options included; direct cyanidation (with or without gravity separation), flotation followed by cyanidation of the concentrate (with or without gravity separation), or flotation followed by smelting of the concentrate. Results from the testing of ore-zone interval samples from a 1993 drilling program were in agreement with initial assay test results and showed high gold recoveries with cyanidation.

Microscopic examinations revealed that the gold mineralization was of erratic distribution, with particle sizes ranging from <1 micrometre to a maximum of 25 micrometres in diameter. The majority of the gold occurrences were associated spatially with pyrite. Photomicrographs of polished sections provided visual support of the mode of gold occurrence and suggested that excellent recovery of gold by direct cyanidation should be achieved.

Outputs. A progress report entitled "A Laboratory Investigation of the Recovery of Gold from the Rendell-Jackman Samples" contains two parts. These are a gold recovery test work report (January 1994) and a mineralogical report (May 1994) completed by Lakefield Research, Lakefield, Ontario.

N.2.3.5 Recovery and Treatment of a Copper or Bulk Sulphide Flotation Concentrate from the Hope Brook Ore: Royal Oak Mines Inc., Newfoundland Division. (F. Morrissey)

Objectives. Royal Oak Mines proposed to investigate the metallurgical and economic feasibility of modifying the Hope Brook milling flowsheet to extract the copper sulphide minerals prior to cyanide leaching and economically reduce the consumption of sodium cyanide in extracting gold from the Hope Brook ore.

Methods. Mineralogical evaluation of the leach-plant tailings showed that lost and unliberated gold was very fine, typically 3 to 5 microns. Most of the gold lost to tailings occurred as inclusions in pyrite (60%). A smaller amount (30%) reported as tellurides and chalcopyrite, with the remainder in gangue (10%), primarily quartz and rutile. Flotation test work conducted early in 1993 suggested that a marketable grade of gold-bearing copper concentrate could be produced from the SO_2 reactor product, which was the mill tailings. Preliminary economic evaluation demonstrated a favourable return could be expected, and a fast track research, plant design and construction program was initiated in March of 1993.

Results. Copper concentrate has been produced at Hope Brook since late May of 1993. The copper flotation plant was producing 14 tons of concentrate per day, grading 19% copper and 1 oz/t of gold. It is a profitable operation which has become a vital component of milling strategy at Hope Brook. Gold recovery has increased by 4%, from 83% to 87% overall. The capital cost for the plant was recovered within 9 months of the plant start up. The Hope Brook mine presently produces a non-toxic effluent, containing 20% less sulphur in the solid tailings.

Outputs. A number of studies were completed for this project. They are:

1. "Process Mineralogical Examination, Hope Brook Mine (October 1993)" by Lakefield Research, Lakefield, Ontario.

2. "Evaluation of the Characteristics of Gold in the Rougher Flotation Feed to the Cu-Circuit of Royal Oak Mines (December 1993)" by the Mineral Sciences Laboratories of CANMET, Ottawa.

3. "Evaluation of the Characteristics of Gold in the Copper Circuit of Royal Oak Mines (February 1994)" by the Mineral Sciences Laboratories of CANMET, Ottawa.

4. "The Hope Brook Mine Copper Flotation Plant (March 1994)" by Royal Oak Mines.

5. "Production of a Copper Flotation Concentrate at Hope Brook - Metallurgical and Economic Feasibility (March 1994)" by Royal Oak Mines .

N.2.3.6 Revision of Preliminary Underground Design and Feasibility Study - Baie Verte Asbestos Mine. (F. Morrissey)

Objectives. In 1989 a Preliminary Underground Design and Feasibility Study was completed at Baie Verte Mines (Canada-Newfoundland MDA, Project N.3.2.5). A major recommendation in the report was the need for further drilling of the underground portion of the orebody. In 1992 a drilling program (Canada-Newfoundland MDA, Project N.2.3.1) was carried out based on these recommendations. It was therefore proposed that an update of the initial feasibility study be completed taking into account current market and site conditions, and results from the 1992 drilling project. This program was intended to enhance the potential for underground mining of the asbestos resource, by having updated information available during times of asbestos price increases.

Methods. Kilborn Engineering was chosen to complete the study and was sent an information package containing maps and updated drilling information. Representatives of the company travelled to Baie Verte to inspect and evaluate buildings and equipment at the mine site. Drill core from the 1992 drilling project in the asbestos orebody was visually inspected. A final report was prepared and submitted.

Results. Underground reserves were recalculated, using the additional 1992 drilling. The undiluted mineable reserves were stated at 8.66 million tonnes of 4.89% fibre. The report concluded that the establishment of an underground mining operation utilizing the dry mill in its present condition was not viable at the current asbestos prices. Kilborn believed that a significant price increase would be required to reactivate the former operation.

Outputs. A final report entitled "Addendum to Preliminary Underground Design and Feasibility Study: Baie Verte Mines Inc. (March 1993)" was prepared by Kilborn and Associates Limited of Brossard, Quebec. The findings of the report were presented by Kilborn at a mining conference in Baie Verte in June of 1993.

N.2.3.7 Pre-screening Reclaimed Tailings at Teranov Mining Corporation (F. Morrissey)

Objectives. The test program was conducted to evaluate the effect of pre-screening the tailings feed to the existing reclaim plant. This would determine if the removal of coarse material from the classifier feed would facilitate increasing the reclaim throughput rate with acceptable fibre loss from the classifiers. The classifiers in the reclaim circuit remove coarse, barren rock. The optimum size feed to this unit is half an inch. Before screens were installed the typical size distribution of this material showed a +5/8 inch size fraction of 25%. A bulldozer and a loader had been used to feed unscreened tailings material to a hopper, which in turn fed a conveyor belt to a spiral classifier. Also contained in the unscreened tailings were quantities of scrap metal and wood which resulted in damage to equipment, down time, and processing problems.

Methods. Test work was carried out for a one month period. The equipment to pre-screen the reclaimed tailings processed in the wet asbestos processing plant was installed and a full scale plant test was completed. The installation included a feed hopper, two belt conveyors, a 5' X 12' vibrating screen, wash sprays, and a variety of chutes and steelwork.

Results. During the first two weeks of operation with a screen in place, fibre losses were high in the screen oversize and resulted in lower yields. A problem of poor washing of

the screen oversize was corrected using a booster pump to feed additional spray nozzles. Initial results were encouraging. Plant feed rate increased by 29% or 43 tonnes per hour when using the screen. It was concluded that pre-screening the material reclaimed from the tailings pile was an effective means of increasing the tonnage to be treated. The elimination of scrap metal and wood also reduced classifier wear.

Outputs. A report entitled "Pre-screening Reclaimed Tailings at Teranov Mining Corporation (April 1994)" was prepared by Teranov Mining Corporation.

N.2.3.8 Mineral Processing Test Work on the Buchans Brook Delta Tailings Deposit - Newfoundland Mining and Exploration Ltd. (F. Morrissey)

Objectives. The objective of the Project was to determine the potential for the economic recovery of base metals, precious metals, and barite from the Buchans Brook Delta tailings deposit by performing various mineralogical and metallurgical testwork on representative bulk samples. The indicated recoverable resource in the deposit was 1.9 million tonnes at 2.12% zinc, 0.59% lead, 0.36% copper, 37.0 g/t silver, 0.86 g/t gold, and 39.8% barite. A potential local market existed for barite drill-mud if offshore oil production and exploration proceeded. A second potential market existed for barite as a heavy media for stabilization of offshore oil structures. Also, high-purity barite had metallurgical (ie. paint manufacturing) and pharmaceutical uses.

Methods. Approximately 18 kilograms of tailings, half from the East and half from the West Lobe of the delta, was delivered to the Minerals Engineering Centre of the Technical University of Nova Scotia in Halifax for testing. The testing program included size analysis and heavy liquid separations, gravity tests, bottle cyanidation, and flotation tests. The head samples were analyzed for major oxides and trace elements.

Results. Due to sample size submitted, only preliminary tests were carried out - no optimization was possible. The evaluation indicated no apparent problems in producing a copper, lead, and zinc concentrate from the bulk sulphide concentrate. The best method to recover metals in the ore appeared to be flotation, but further work was required to optimize the flotation parameters to improve the grades and recoveries.

Outputs. A report entitled "Mineral Processing Test Work on the Buchans Brook Delta Tailings Deposit (March 1994)" was prepared by the Minerals Engineering Centre of the Technical University of Nova Scotia.

N.2.3.9 Infill Drilling Program on the Hammerdown Gold Deposit - Major General Resources Ltd. (F. Morrissey)

Objectives. An infill-drilling program was proposed to increase the level of confidence of the ore reserves at the Hammerdown gold deposit and retrieve core samples for metallurgical testing. Results of this program were combined with previous drilling results in order to update ore reserves. The geological reserves would be reclassified to "Probable". The provision of substantial drill core of the gold mineralization allowed for continued metallurgical test work. Additional gold assay results allowed a true cutting factor to be determined. The confirmation and improvement of the indicated reserves would lead to financial and engineering studies, the next stage of development.

Methods. A total 11 holes totalling 2,269 metres of NQ and HQ core were drilled on approximately 25 metre sections. The area of influence for any one drill hole was reduced from between 40 and 50 metres to between 25 and 30 metres.

Results. The drilling program was successful in advancing the project towards the development stage. It established the continuity of the main zone as well as several hangingwall and footwall veins. These latter veins contributed to the overall tonnage of the deposit. Individual gold assays up to 185 g/t over 0.75 metres were reported. Similar high grade assays were also returned from several of the hanging and footwall veins. Metallurgical testing on the HQ-core was completed.

Outputs. A report entitled "Hammerdown Infill Drilling Program, Rendell-Jackman Property, Springdale, Newfoundland (February 1994)" was prepared by Major General Resources Ltd.

N.2.3.10 Evaluation of the Fibre Group Distribution of the Underground Asbestos Deposit at Baie Verte Mines. (F. Morrissey)

Objectives. The study was initiated in order to resolve variations in the fibre group distributions as stated in two separate reports dealing with the underground asbestos deposit. The fibre group distribution outlined in a 1989 report was 70% group 4, 17% group 5, and 13% group 6, and in a 1993 study was estimated at 28.8% group 4, 48.7% group 5, and 22.5% group 6. The higher dollar value of group 4 fibre suggests that its group distribution would have a direct effect on the economic evaluation of any proposed underground-mining operation of this deposit. A second component of this project was to determine the implications to underground

mining if the two open pits were to be used as waste-dumping sites.

Methods. The fibre group distribution of the underground asbestos deposit was determined by evaluating all available technical data. This included past production records, mine studies, pilot mill reports, drill-log information, mine maps, government reports, and verbal communication with several past mine employees. The percentage production of group 4 fibre depends on a number of factors including fibre length and % fibre in the ore, mining methods, efficiency in blending short and long fibre ore, plus the availability of each on a consistent basis.

An assessment of pit-dumping on future underground mining was completed by a mining engineer.

Results. The estimate of the fibre distribution in the underground ore blocks was calculated at 53% group 4, 35% group 5, and 12% group 6. Fibre distribution in the 1989 report was based mainly on a 1967 report outlining results from drill core being run through a pilot line. A detailed look at the Fibre Strength Unit results in the 1967 report indicated that the estimate of 70% for group 4 may have been too high. If fibre were sold on a strength unit basis then the estimate would have been reduced to 53%. The estimation in the 1993 report was based on historical distribution data for the periods 1977 to 1981 and 1983 to 1990, but apparently not for 1963 to 1976. Too much weight was placed on the 1983-90 period fibre recoveries. By not significantly considering the 1964-81 period of production, it appears that the estimate may have been overly conservative.

It had been determined that the only economic underground mining method suitable for the asbestos deposit was block caving. Due to this, both the North and West pits would have to be de-watered before underground mining could proceed and remain so during the period of underground mining. Mining activity and a West pit waste-dumping project would not be concurrently compatible. If underground mining preceded a waste-dumping project, possible pit access restrictions would be imposed on the dumping project that could render it uneconomic. If underground mining were carried out after the West pit was filled through dumping, there would be some potential of ore and fibre contamination from tailings compaction and fine waste materials.

Outputs. A report entitled "Expected Fibre Graded Distribution of Underground Ore Reserves and Implications to Mining When the Open Pits are used as Dumping Sites at the Baie Verte Asbestos Mine (March 1994)" was prepared by Ralph Stewart, consulting geologist in Oshawa, Ontario.

N.2.3.11 A Technical and Economic Evaluation of Replacing Cement with Flocculant to Reduce Cement Consumption while Increasing Gold Recovery on the Pine Cove Ore - Pine Cove Resources Inc. (F. Morrissey)

Objectives. The project was designed to determine the technical and economic viability of adding flocculants to a vat-leaching process to produce smaller agglomerates, reduce cement consumption, and increase gold recovery. Prior metallurgical test work on Pine Cove ore determined that 11.6 kg/tonne of cement was required to make a strong and permeable agglomerate. A test program carried out on a similar deposit with comparable ore characteristics, concluded that flocculant had a beneficial effect on agglomeration and gold recovery, as well as producing smaller agglomerates.

Methods. A combined bulk sample was collected from various ore zones and two bore holes. This one-tonne sample was shipped to the Mineral Engineering Centre of the Technical University of Nova Scotia in Halifax to be used in the pilot-plant testing of three reagents.

Results. All three reagents showed excellent column tests. Recoveries using flocculants increased by approximately five percent to ninety percent. The agglomerating agents produced smaller pellets, faster gold extraction, and increased recoveries compared to using cement only. The test work suggested a net increase in operating costs if flocculant was used, but it would be offset by a potential increase in revenue.

Outputs. A report entitled "A Technical and Economic Evaluation of Replacing Cement with Flocculant to Reduce Cement Consumption While Increasing Gold Recovery on the Pine Cove Ore (March 1994)" was prepared by Pine Cove Resources Inc. Of Baie Verte. It contains a report from the Mineral Engineering Centre of the Technical University of Nova Scotia entitled "Effect of Agglomeration Agents on Leaching Process for Recovery of Gold from the Pine Cove Ore".

N.2.3.12 Assessment of Dolomite Potential at Lower Cove, Nfld. - Newfoundland Resources and Mining Co. Ltd. (F. Morrissey)

Objectives. The aim of the project was to enhance Newfoundland's potential to supply dolomite to Canadian markets and provide an opportunity to enter the international marketplace. A dolomite market had been identified and therefor the quality and quantity of dolomite from the Lower Cove quarry needed to be defined. Successful results would

broaden the product line available at Newfoundland Resources and Mining by including dolomite. The Lower Cove dolomite resource had substantial reserves very close to tide-water and had existing crushing, screening, and shipping facilities.

Methods. Work on the project began with a drilling program in a high purity dolomite area. Thirteen vertical BQ diamond drill-holes totalling 465 metres were completed. All drill holes except one encountered high purity dolomite. The drill core was split and half underwent chemical whole rock analyses for SiO_2, MgO, Na_2O, K_2O, Fe_2O_3, MnO, TiO_2, P_2O_5, ZnO, S, and LOI. Results placed the dolomite within the required limits for a High Purity Dolomite Product. A reference collection was assembled for independent testing by perspective global clients.

Results. Proven dolomite reserves were calculated at 52 million tonnes of 19.3% MgO content. The deposit outcropped over a surface area of 300 metres by 1,200 metres and dipped approximately 10 degrees to the north; an ideal ore body to quarry with potential to expand reserves. The final report concluded that the deposit had potential for economically exploitable proven reserves and development as a mineral resource for use in the chemical, metallurgical, steel, and aggregate industries. The dolomite met specifications making it suitable for use in the glassmaking and chemical industry.

Presently, the dolomite deposit is being mined, with 130,000 tonnes quarried in the first year of operations. Of that amount, 70,000 tonnes was processed and shipped as trial loads to Trinidad and Mexico. For the second year of operations, trial-load shipments totalling approximately 250,000 tonnes are planned. Some of this amount may be shipped to Wabush, Labrador for use in the iron ore process.

Outputs. A report entitled "High Purity dolomite of the Port Au Port Peninsula at Lower Cove, Newfoundland (March 1994)" was completed by Stride Consulting of Kippens, Newfoundland.

N.2.3.13 Ground Control Instrumentation Program - Royal Oak Mines Inc. (F. Morrissey)

Objectives. The mining method used at Hope Brook Mine was "modified open stoping with cablebolting". The principal justification for the ground control instrumentation installation, monitoring, and data analysis was to ascertain the integrity of the pillars and hangingwall above the 4900 level where cablebolting was being used as support. Large scale failure of either would have presented a dilution problem, turning economic ore into uneconomic ore. The economic viability of the mine was dependent on the successful implementation of the cablebolting program. The analysis of the accumulated data was to be used to make decisions on the timing of the pillar recovery and further mining in depth. A reduction in mine costs with a reduction in the amount of cablebolting would be realized if the instrumentation proved that the pillars and hangingwall were acceptably stable. After successful pillar recovery, the possibility of utilizing a different mining method could be advantageous with controlled hangingwall failure permitted.

Methods. The stability of the 4950 sill pillar was evaluated using ground monitoring instrumentation. This instrumentation included extensometers and vibrating wire stressmeters. The meters were read on a regular basis, normally every day, and emphasis was placed on having readings taken before and after a stope blast. Numerical modelling based on the received data was conducted to predict stress redistribution as mining proceeded based on the stope sequencing. Additional instrumentation was installed as mining progressed. Mining strategy changes were based on data obtained from this instrumentation.

Results. The use of extensometers and stressmeters gave confidence to the staff and employees of the mine when microseismic activity was present in a heading. The failure criteria for extensometers was 0.2% strain. The numerical modelling did not yield additional knowledge about the stability of the stopes. The stressmeter did not produce any failure guidelines that can be used to predict failures or imminent danger. Further evaluation is required. Cablebolting was not successful in giving additional stope stability.

Outputs. A report entitled "Pillar and Hangingwall Ground Control Instrumentation Program at Hope Brook Mine (December 1994)" was prepared by Royal Oak Mines.

N.2.3.14 Mining and Milling Studies - Feasibility Study for a Docking, Conveying, and Loading Facility at Fischells Brook. (F. Morrissey)

Objectives. A feasibility study for a docking, conveying, and loading facility to serve the Fischells Brook gypsum deposit was required in conjunction with a "Call for Proposals" on Exempt Mineral Land containing the gypsum resource. This study would supply a construction cost estimate, a major component in evaluating the potential of developing the "Fischells" gypsum deposit.

Methods. Requests for proposals were sent to five engineering firms in Atlantic Canada and all responded with proposals outlining methodology and cost estimates for the study. After thorough evaluation of the proposals, Newfoundland Design Associates Limited of St. John's was chosen to complete the study based on their lowest submitted bid.

Results. After an initial investigation and a site visit to Fischells Brook, it was discovered by the consultant that the area lacked detailed hydrographic mapping. The village of Fischells was determined to be the most appropriate location for the facility because of the availability of foreshore land and proximity to the proposed mineral development. It was determined that most suitable dock structure should consist of precast concrete caissons. The facility (1230 metres total length) would consist of a rock-filled causeway, a series of concrete caissons, with a superstructure stretching from the causeway to breasting and mooring dolphins. This would support vehicle access and a conveyor system. The final report estimates a construction cost of 30 million dollars, within +/- 20%.

Outputs. A report was received from Newfoundland Design Associates Limited of St. John's entitled "Docking, Conveying & Loading Facility, Fischells, St. George's Bay, Newfoundland / Pre-feasibility Report, Estimate of Probable Construction Costs (May 1995)".

2.4 MINE DATABASE SYSTEM

N.2.4.1 Mine Database System (F. Morrissey)

Objectives. The purpose of the mine database was to aid in the resource assessment process. Information generated from the assessment of exploration drilling to further defined mineralized and mineable zones. This data was to be used in promoting further exploration and development of deposits and assisting in feasibility studies. Drilling information from mining properties was in assisting companies not having computerized orebody evaluation systems, to more effectively understand their deposits, and develop or modify mining plans. The project resulted in greater effectiveness in assessing, promoting, developing, and managing the mineral resources of this province. It was also intended to make available a new technology and management tool to mine operators in the province.

Methods. Establishment of a mine data base system involved the collection and interpretation of basic drilling information from producing mining properties and advanced exploration programs in order to evaluate mineral resources. After the data was entered into a computer database, grades and tonnages were estimated and plan and section maps were produced. This information was then made readily available by having it stored in a reproducible digitized format.

Results. Mineral deposits evaluated under this project underwent tonnage and grade estimations, and creation of colour-coded plan and section maps showing geological and mineralization information. Geological interpretation and mineralized zone delineation were carried using these maps. Updates of some deposits occurred as drill information became available. The properties reviewed included Hope Brook (Au), Pine Cove (Au), Nugget Pond (Au), Rendell-Jackman properties (Au), Stog'er Tight (Au), Fischells Brook (gypsum), Baie Verte Mine (asbestos), Cape Ray (Au), Deer Cove (Au), Duck Pond (Cu, Pb, Zn, Ag), Rambler-Ming (Cu, Au), and St. Lawrence (fluorspar). Planning of several MDA-funded infill-drilling projects was assisted by having maps on file for those deposits. Properties recently becoming active that will be investigated are Voisey Bay (Cu, Ni, Co), and the Beaver Brook (antimony) deposit.

The three reports on potential mining properties were prepared to encourage development of the sites. This included geology, reserve and grade estimations, technical drawings, summaries of major property assessments, and mineral potential. Mining properties for which "Call for Proposals" were prepared included the Ming Mine (Rambler) area, the St. Lawrence Fluorspar mine area, and the Fischells Brook gypsum deposit. The first two areas of Exempt Mineral Land are now undergoing development planning by mining companies as a result of the "Call for Proposals".

3. ECONOMIC DEVELOPMENT

3.1 FEASIBILITY STUDIES

N.3.1.1 Pyrophyllite - Ceramic Tile Prefeasibility Study (B. Hynes)

Objective. The main objective of this study was to evaluate the technical, financial and commercial requirements for further processing of our pyrophyllite resources and ceramic tile manufacturing. The secondary objective was to review the feasibility of conducting only a grinding operation in Newfoundland should the manufacture of tile appear unfeasible.

Method. The information for this study was gathered in five ways: literature searches; interviews with people knowledgeable in the ceramic industry and tile manufacturing; interviews with raw material suppliers and transportation companies; correspondence with US and Canadian commerce/trade officials; and, visits and interviews with Italian equipment manufacturers.

Results. A report has been received that provides an overview of the world market for tile and presents the pros and cons of the development of a processing facility in the province. The report does conclude that the manufacture of ceramic tile in Newfoundland can be economic. The viability would depend first and foremost on the choice of product produced.

N.3.1.2 Pyrophyllite Absorbency (B. Hynes)

Objective. The objectives of this project were (1) to do further testing of pyrophyllite to detail its absorbency qualities in a commercial environment; (2) to obtain input from consumers, especially in terms of suitability, handling concerns, packaging requirements, volumes, etc; and (3) to undertake commercial level production on a test basis to verify the cost and technical feasibility of the operation, and to identify any production or related technical difficulties which may arise.

Method. This project was done in two phases. Phase one was to test absorbency qualities of pyrophyllite. Test samples were provided to commercial establishments for use as an absorbent. Phase two of this project was to explore other market areas where pyrophyllite could be used.

Results. While preliminary test results indicated that pyrophyllite did have encouraging oil absorbing properties, detailed testing led to the conclusion that while high grade pyrophyllite does have absorbing properties, it is inferior to other materials currently on the market.

While these results were disappointing the proponent was excited in finding several other uses for the product which are meeting with success in the market place. Larger stone (2") has applications for use as a mulch and as a decorative stone for gardens and cemeteries while the smaller stone that was originally intended for use as an oil absorbent was found to be an excellent material when compacted for walkways and trails.

In addition, other uses of pyrophyllite have been identified. These include the use of fine material for line drawings on soccer, baseball and softball fields and as decorative "plaque" or "marker". In this case large rocks would be inscribed with house numbers or family names.

3.3 PROMOTIONS

N.3.3.1 Dimension Stone Industry Seminar (B. Hynes)

Objectives. The purpose was to provide an educational forum for potential producers, the investment community, local architects and federal and provincial decision makers to learn about the dimension stone industry. The event was also organized to facilitate discussions between these groups and bring to their attention the extremely fine quality and variety of the province's reserves of stone.

Methods. During the one and one-half day seminar held in St. John's, experts from Canada, the United States and Italy provided an overview of the dimension stone industry and d etailed key aspects such as markets, equipment and production. An examination of the province's resources was also presented. Audio-visual aids were used in many presentations. A number of displays allowed participants to see samples from Newfoundland and Labrador's dimension stone deposits and to gain an insight into the type of extraction and processing equipment used. A professional video taping of the seminar was made for subsequent distribution.

Results. The seminar was well attended - approximately 160 people registered. It provided an excellent medium for the exchange of information, and contributed to the successful development of the province's dimension stone industry. The commercial displays facilitated contact between equipment suppliers and entrepreneurs/developers. The seminar's success has been demonstrated by another province's request for copies of the video tapes and information on how to set up a similar forum.

N.3.3.2 Newfoundland Peat Opportunities – An International Conference (B. Hynes)

Objective. The purpose of the conference was to provide an overview of the provincial and world market opportunities for peat and bring to international attention the extent and quality of Newfoundland peat.

Method. World experts delivered papers and audio-visual presentations at the four-day conference held in Corner Brook. Topics included market potential, new product development potential, emerging technologies and environmental considerations. Various displays offered a medium for additional discussion.

Results. The conference was extremely successful and attracted interest from Ireland, Finland, England, Norway, Indonesia, the United States and other parts of Canada. Approximately 150 attended, over 60% being non-governmental people. A copy of the conference proceedings has been published.

N.3.3.3 Mineral Industry Brochure (B. Hynes)

Objective. The objective of this project was to contract a company with the appropriate expertise to design and print

Survey scale bars, decals and lapel pins; Gold-panning tank for science fairs; Ads in newspapers; Mineral-information folder; CNCAMD Newsletter; CNCAMD Notification Cards announcing display booths; Mining and Minerals Video Library for interested-party loans.

Other Activities: School lectures; Assisted prospectors with their Rock Room displays; Purchased and distributed minerals-related educational posters; Contributed to "Rich Mineral Resources" brochure; Newspaper articles on Agreement Projects; Mining Week and Atlantic Canada Rock Room committees.

FEDERAL PROJECTS

1. GEOSCIENCE

C1.11 BASE METALS AND PRECIOUS METALS SUBPROGRAM

C1.111 Geology, Notre Dame Subzone (J.B. Whalen)

Objectives. To carry out geological mapping plus geochemical and isotopic (Nd, Pb and O) studies of Ordovician to Silurian plutonic rocks of the Notre Dame Subzone with the objective of obtaining a better understanding of their protoliths, tectonic setting of formation and mineralization potential. Like Dunnage Zone volcanic rocks, these plutonic rocks should provide key information on the evolution of the Appalachian orogen. Also, the mineral potential of various dismembered ophiolitic and volcanic sequences and of major tectonic breaks in this area had not previously received much attention.

Method. Geological mapping and map production were carried out using digital compilation and publication techniques. Isotopic tracer analyses for O and Pb were obtained by university contracts. High quality trace element plus Nd isotopic tracer analyses were carried out by a GSC term employee (C. Collins) in the laboratories of the Department of Earth Sciences, Memorial University of Newfoundland. The project involved cooperative research work with Prof. G. Jenner, MUN (geochemistry) and Otto van Breeman, GSC (U-Pb dating).

Results. Colour, 1:50 000 scale, open file geological maps of NTS sheets 12A/11,12 document a diversity of dismembered and deformed Ordovician plutonic suites which are generally fault bounded; both deformed and massive Late Ordovician to Early Silurian plutonic suites are present. Reconnaissance geology and geochemical sampling were carried out over the remainder of the Notre Dame subzone.

A previously recognized, but undocumented, ophiolite complex, located northeast of Star Lake in NTS 12A/11, was mapped, dated by U-Pb techniques as ca. 484 Ma, and geochemically plus isotopically characterized.

New U-Pb ages indicate that Notre Dame arc plutonism ranges in age from 484 to 464 Ma and, like contemporaneous volcanic sequences in the Dunnage Zone, includes juxtaposed oceanic non-arc, and arc type assemblages. Many of the arc-type rocks display geochemical characteristics indicative of input from slab-derived melts. This supports current models of ophiolite generation by attenuation and back-arc spreading within the Notre Dame arc, followed by basin closure and ophiolite obduction. Nd isotopic signatures indicative of major input to these plutons from Paleoproterozoic or older sources, dictate that this was a continental rather than an oceanic arc.

Late Ordovician to Early Silurian magmatism includes bimodal basaltic-rhyolitic volcanism and peraluminous to peralkaline felsic plutonism. Nd and O isotopic data indicate that this magmatism was mainly derived from mantle-like protoliths (i.e., it received little or no contributions from the old crustal source(s) which were involved in the Early to Middle Ordovician plutonism). This is compatible with a tectonic model involving pre-Late Ordovician arc-collision-related detachment or delamination of the lower crustal source of the earlier magmatism. The younger, juvenile magmatism is interpreted as a product of this delamination event.

Although usually unexposed, the many postulated major faults and shear zones which separate Notre Dame arc plutonic assemblages in NTS 12A/11,12 merit exploration for shear-zone-related Au mineralization.

Outputs.

PUBLICATIONS

Piasecki, M.A.J.

1992: Tectonics across the Gander-Dunnage boundary in Northeastern Newfoundland; in Current Research, Part E; Geological Survey of Canada, Paper 92-1E, p. 259-268.

1993: Tectonics along the Dog Bay Line - a Silurian terrane boundary in northeastern Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 93-1E, p. 291-298.

Whalen, J.B., Currie, K.L. and Piasecki, M.A.J.

1993: A re-examination of relations between Dunnage subzones in southwest Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 93-1D, p. 65-72.

Whalen, J.B. Jenner, G.A., Longstaffe, F.J., Robert, F., Gariepy, C. and Hegner, E.

In review: Geochemical and isotopic (Nd, O, Pb and Sr) constraints on A-type granite petrogenesis based on the Topsails igneous suite, western Newfoundland; Contributions to Mineralogy and Petrology.

1995b: Implications of granitoid geochemical and isotopic (Nd, O, Pb) data from the Cambro-Ordovician Notre Dame arc for the evolution of the Central Mobile Belt, Newfoundland Appalachians; in Magmatism in the Appalachian Orogen, A.K. Sinha, J.B. Whalen and J. Hogan (eds.), Geological Society of America Memoir.

OPEN FILES

Whalen, J.B.

1994a: Geology of the Star Lake Sheet, Newfoundland (NTS 12A/11); Geological Survey of Canada, Open File 2735, 1 colour map (1:50 000 scale).

1994b: Geology of the Little Grand Lake Sheet, Newfoundland (NTS 12A/12); Geological Survey of Canada, Open File 2736, 1 colour map (1:50 000 Scale).

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Whalen, J.B.

1993: Granitoid rocks, Notre Dame and Dashwoods subzones; in Report of Activities 1993, Newfoundland Department of Mines and Energy, p. 133.

1996: Contrasting orogenic and anorogenic granitoid magmatic events in the Notre Dame Subzone, Central Mobile Belt, Newfoundland; Geological Survey of Canada, Minerals Colloquium, January 22-24, 1996, Ottawa, Ontario (poster presentation).

Whalen, J.B., Currie, K.L. and Piasecki, M.A.J.

1993: A re-examination of relations between Dunnage subzones in southwest Newfoundland; in Current Research 1993, Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, p. 486.

Whalen, J.B. and Jenner, G.

1992: Granitoid rocks, Notre Dame Subzone; in Report of Activities 1992, Newfoundland Department of Mines and Energy, p. 44.

C1.112 Geology, Corner Brook Lake Area (K.L. Currie)

Objectives. The objective of this project was to produce a 1:50,000 scale geological map of NTS 12A/13, a key region straddling the boundary of the Dunnage and Humber zones. Geological investigations were focussed on documenting the age and style of deformation and metamorphism, presence of Precambrian basement, and tectonic history. The project also included an investigation of the geological setting of potentially economic mineral occurrences on Glover Island (Glover Group).

Methods. Peter Cawood, Memorial University of Newfoundland (MUN) was contracted to complete the project under the scientific authority of K.L. Currie. P. Cawood recruited Jeroen van Goel [MUN post-doctoral fellow] to assist him in his investigations. Two junior assistants were hired from Memorial University for two of the three summers of field work. Field work was carried out by a combination of truck-based and helicopter-based mapping, using field equipment supplied by the Geological Survey. Office and laboratory work was carried out at Memorial University, and involved a number of experts, particularly Greg Dunning.

Results. The Glover Island region straddles the boundary between the Humber and Dunnage zones. The Keystone shear zone, developed within the basal mafic greenschist and ultramafic lithologies of the Grand Lake Complex, marks the boundary of the Humber and Dunnage Zones. The Kettle Pond shear zone separates the ophiolitic rocks of the Grand Lake complex from the volcanic and high level intrusive rocks of the Glover Formation on Glover Island, and also marks a site of quartz-sericite alteration and mineralization. Precambrian rocks (1.5 Ga) of the internides of the Humber Zone project from the south into the map area, but Silurian metamorphism produced a convergence in structure and appearance with younger quartzofeldspathic gneisses. Mafic igneous rocks (555 Ma -Lady Slipper pluton) also occur, a spectacular new result which forces rethinking of the definition of the Avalon Zone on the opposite side of the island. Structurally the region is dominated by Silurian basement-involved westward thrusting accompanied by metamorphism of kyanite-staurolite grade. No "Taconic" structure or metamorphism was recognized.

Economic/Project Impacts. The economic value of this quartz-sericite alteration and mineralization was immediately recognized by industry, and in part led to the development of the Glover Group volcanic geological mapping project under the 1994-95 Canada-Newfoundland Agreement on Mineral Development.

Outputs.

PUBLICATIONS

Cawood, P.A. and van Gool, J.A.M.

1992: Stratigraphic, structural, and metamorphic relations along the eastern margin of the Humber Zone, Corner Brook Lake map area, western Newfoundland; in Current Research, Part E; Geological Survey of Canada, Paper 92-1E, p. 239-248.

1993: Stratigraphic and structural relations within the western Dunnage Zone, Glover Island region, western Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 93-1D, p. 29-37.

Cawood, P.A., van Gool, J.A.M. and Dunning, G.R.

1996: Geological development of eastern Humber and western Dunnage zones: Corner Brook-Glover Island Region, Newfoundland; Canadian Journal of Earth Sciences, v. 33, p. 182-198.

In Press: Geology of the Corner Brook - Glover Island Region, Newfoundland; Geological Survey of Canada, Bulletin 427, to be accompanied by map 1893A.

OPEN FILES

Cawood, P.A. and van Gool, J.A.M.
1994: Geology, Corner Brook Lake region, Newfoundland (NTS 12A/13); Geological Survey of Canada Open File 2830, 1 map, 2 sheets (1:50 000 scale)

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Cawood, P.A. and van Gool, J.A.M.
1993: Stratigraphic and structural relations within the western Dunnage Zone, Glover Island region, western Newfoundland; in Current Research (1993), Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, p. 479.

C1.113 Geology, Southernmost Long Range (C.R. van Staal and S. Lin)

Objectives. Project objectives were to upgrade the existing geological mapping for the four 1:50 000 NTS sheets (11O/10, 11, 14 and 15); characterize tectonostratigraphic affinities of the rocks; and investigate the geological evolution of this part of the Newfoundland Appalachians.

Method. Geological mapping of NTS 11O/10, 11 and parts of 11O/14, 15 and 16, was completed at 1:10 000 to 1:25 000 scale, and emphasis was placed on understanding the geometry and the relationship between structure, magmatism and metamorphism. Detailed geological investigations concentrated on areas where critical relationships were best preserved and outcrop was abundant. Inland mapping, done by both helicopter supported flycamping and strategic traverses, and coastline mapping was done by C.R. van Staal, S. Lin, graduate students and senior assistants. New geological maps at 1:25 000 scale have been produced for NTS 11O/10 and 11, and new mapping of NTS 11O/14, 15 and 16 are being compiled and will be published during fiscal 1995-96, at 1:150 000 or 1:250 000 scale.

Metamorphic investigations focussed on: definition of the detailed geometry of the various isograds present (e.g., kyanite to sillimanite); study of microstructures; and, definition of P-T-t paths through microprobe study of critical mineral assemblages. Microprobe work was contracted to M. Brown and J. Burgess (both of the University of Maryland, U.S.A.). A study of the absolute age of deformation, metamorphism and magmatism is currently being completed by G. Dunning and P. Valverde (both of the Memorial University of Newfoundland). The nature and geochemistry of the supracrustal and infracrustal rocks, using whole rock and trace element data, was investigated by J. Winchester and D. Schofield (both of the University of Keele, United Kingdom).

Results. Mapping has determined that the southwestern portion of Newfoundland has a complicated geometry that contains a much larger variety of lithologies than originally thought. Significant new results for the various zones/ subzones are detailed below:

Dashwood/Notre Dame subzone:

Early Ordovician tonalites, granodiorites and granites (490-470 Ma) intrude the remnants of the Long Range ophiolite complexes. Polydeformed Ordovician magmatic rocks appear to be syntectonic with Early to Middle Ordovician deformation and are of amphibolite facies metamorphism. These rocks are in turn cut by relatively undeformed Late Ordovician/Early Silurian granitoid bodies.

Exploits/Gander zones:

Identification of three lithologically distinct terranes, from west to east, these include the:

1) Grand Bay complex, which consists mainly of pelitic rocks of Dunnage affinity interlayered with amphibolites, ultramafics, coticules, and gedrite-bearing rocks, and is host to massive sulphide deposits and shear zone related mineralization;

2) Port aux Basques complex, which consists of interstratified psammites, semipelitic and pelitic paragneisses and schists, of Gander affinity, interlayered with gneissic granite and abundant amphibolite sheets. The age of the sedimentary rocks appear to be Early Ordovician, or older; and,

3) Harbour Le Cou/Bay du Nord groups of the Dunnage Zone, which consists of psammites and pelites containing coticules. The occurrence of rare tholeiitic pillow basalts at the contract between the psammite and pelite sequences suggests that the pelites are Middle Ordovician in age while the psammites are Early Ordovician.

The Port aux Basques and Grand Bay complexes have been intruded by bimodal orthogneisses of Early to Middle Ordovician age and the Late Ordovician Port aux Basques granite. Both sets of igneous rocks are completely absent in the Harbour Le Cou Group, suggesting that the latter was juxtaposed with the Port aux Basques complex between the Late Ordovician and the Late Silurian. Late Ordovician to Late Silurian age metamorphism is characterized by High Pressure-High Temperature (10 kb - 700°C) conditions.

Economic/Project Impact. Recognition of rocks of Dunnage affinity among the Port aux Basques gneisses and

mineralization along the major shear zones has led to significant mineral exploration activity in this part of southwestern Newfoundland.

Outputs.

PUBLICATIONS

Benn, K., Genkin, M., van Staal, C.R. and Lin, S.
1993: Structure and anisotropy of magnetic susceptibility of the Rose Blanche Granite, southwestern Newfoundland: kinematics and relative timing of emplacement; in Current Research, Part D; Geological Survey of Canada, Paper 93-1D, p. 73-82.

Burgess, J.L., Brown, M. and van Staal, C.R.
1992: Preliminary report on the metamorphic geology of the Port aux Basques Complex, southwestern Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 92-1D, p. 145-143.
1993: Pressure-temperature conditions and a P-T path for the Port aux Basques area, southwest Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 93-1D, p. 47-55.

Burgess, J.L., Brown, M., Dallmeyer, R.D. and van Staal, C.R.
1995: Progressive metamorphism, thermochronology and P-T-t deformation history of the Port aux Basques Gneisses, southwest Newfoundland, Canada; Journal of Metamorphic Geology, v. 13, p. 751-776.

Lin, S., van Staal, C.R. and Dubé, B.
1994: Promontory-promontory collision in the Canadian Appalachians; Geology, v. 22, p. 897-900.

Lin, S., van Staal, C.R. and Lee, C.
1993: The Harbour Le Cou Group and its correlation with the Bay du Nord Group, southwestern Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 93-1D, p. 57-64.

Schofield, D.I., Winchester, J.A. and van Staal, C.R.
1993: The Isle aux Morts metabasalt, southwest Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 93-1D, p. 39-46.

van Staal, C.R., Winchester, J.A., Brown, M. and Burgess, J.L.
1992: A reconnaissance geotraverse through southwestern Newfoundland; in Current Research, Part D; Geological Survey of Canada, Paper 92-1D, p. 133-143.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Benn, K., Genkin, M., van Staal, C.R. and Lin, S.
1993: Structure and anisotropy of magnetic susceptibility of the Rose Blanche Granite, southwestern Newfoundland: kinematics and relative timing of emplacement; in Current Research (1993), Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, p. 477.

Burgess, J.L., Brown, M. and van Staal, C.R.
1992a: Preliminary report on the metamorphic geology of the Port aux Basques Complex, southwestern Newfoundland; in Current Research (1992), Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, p. 458.
1992b: The pressure-temperature-deformation history of the Port aux Basques Complex around Port aux Basques, Newfoundland Canada; in Geological Society of America, Annual Meeting, Abstracts with Programs, v. 24, no. 7, p. A305.
1992c: Metamorphism and deformation of the Port Aux Basques complex, southwest Newfoundland, Canada; in Geological Association of Canada/Mineralogical Association of Canada, Abstracts Volume, v. 17, p. A13.
1993a: Pressure-temperature conditions and a P-T path for the Port aux Basques area, southwest Newfoundland; in Current Research (1993), Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, p. 478.
1993b: Amphibolite facies metamorphism, melting and the pressure-temperature-deformation history of the Port Aux Basques complex, southwest Newfoundland; in Geological Association of Canada/Mineralogical Association of Canada, Program and Abstracts, p. A-14.

Burgess, J.L., Dallmeyer, R.D., Brown, M., Krogstad, E.J. and Tomascak, P.
1993: Geochronologic constraints on the tectono-metamorphic evolution of the Port Aux Basques gneisses, Newfoundland; in Geological Society of America, Abstracts with Programs, v. 25, no. 6, p. A484-485.

Genkin, M.B., Benn, K. and van Staal, C.R.
1993: Structure, microstructure and AMS of the Rose Blanche granites, southwestern Newfoundland; in Geological Association of Canada/Mineralogical Association of Canada, Program and Abstracts, v. 18, p. A-34.

Hall, L.A.F., van Staal, C.R. and Williams, H.
1994: Ordovician structural evolution of SW Newfoundland; in Geological Association of Canada/Mineralogical Association of Canada, Annual Meeting, Program with Abstracts, v. 19, p. A46.

Lin, S. and van Staal, C.R.
1993: Polyphase deformation in Southwest Newfoundland; in Geological Association of Canada/ Mineralogical Association of Canada, Program and Abstracts, p. A-59.

Lin, S., van Staal, C.R. and Dubé, B.
1994: Promontory-promontory collision and tear faulting in the Canadian Appalachians; in Geological Association of Canada/Mineralogical Association of Canada, Annual Meeting, Program with Abstracts, v. 19, p. A66.

Lin, S., van Staal, C.R. and Lee, C.
1993: The Harbour Le Cou Group and its correlation

with the Bay du Nord Group, southwestern Newfoundland; in Current Research (1993), Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, p. 482.

Schofield, D.I., Winchester, J.A. and van Staal, C.R.
1993: The Isle aux Morts metabasalt, southwest Newfoundland; in Current Research (1993), Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, p. 483.

van Staal, C.R. and Lin, S.
1993: Geology of the Port aux Basques area, Newfoundland; in Forum 1993, Geological Survey of Canada, Program with Abstracts, p. 9.

van Staal, C.R., Burgess, J., Hall, L., Lee, C., Lin, S. and Schofield, D.
1992: Geology of the Port aux Basques - Rose Blanche area (NTS 11O/10 & 11O/11); in Report of Activities 1992, Newfoundland Department of Mines and Energy, p. 41-43.

van Staal, C.R., Winchester, J.A., Brown, M. and Burgess, J.L.
1992: A reconnaissance geotraverse through southwestern Newfoundland; in Current Research (1992), Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, p. 467.

C1.115 Interpretation of Airborne Gamma Ray Spectrometric Surveys (K.L. Ford and F. Santaguida)

Objectives. The project was designed to:

1) collect new, digital, high resolution, 500m line spaced Airborne Gamma Ray Spectrometric (AGRS), total field magnetic and VLF-EM data in selected areas to augment existing regional, 1000m line spaced multi-parameter geophysical coverage; and,

2) demonstrate the geological and potential exploration significance of airborne gamma ray spectrometric patterns as they pertain to Volcanic-Hosted Massive Sulphide (VHMS) mineralization.

Method. In the fall of 1991, a detailed (500m line spaced) AGRS survey was flown by the Geological Survey of Canada in the Tulks volcanic belt. The surveyed area, which hosts several VHMS deposits, had not been covered by any existing regional (1000 m line spaced) survey. Survey results were published in June, 1992 as GSC Open File 2481.

Subsequent ground follow-up investigation of both 1000 m and 500 m AGRS survey anomalies were completed during the 1992 and 1993 field seasons, and were concentrated in the northern part of the Roberts Arm Group, the Cutwell Group on Long Island and the Tulks volcanic belt of the Victoria Lake Group. These investigations involved in-situ gamma ray spectrometry measurements and bedrock sampling in selected areas for later analytical and petrographic studies.

Results. AGRS surveys in the western Notre Dame Bay area and Tulks volcanic belt detected areas of anomalous potassium concentration associated with large felsic volcanic sequences. Ground investigations have shown that some of these anomalies correspond to potassium enrichment associated with massive and stringer sulphide mineralization (e.g., Spencer's Dock and Bumble Bee Bight on Pilley's Island in the Roberts Arm Group; Aspen Cove [Shamrock Occurrence] and Southern Head on Long Island in the Cutwell Group; Tulks Hill, Tulks East, Jacks Pond, Daniels Pond and Hoffs Pond in the Tulks volcanic belt). In many instances, single, AGRS potassium anomalies were actually found to result from several separate sources on the ground. An example of this occurs at Bumble Bee Bight on Pilley's Island where elevated potassium levels are associated with hydrothermally altered dacitic flows and pyroclastics in several smaller zones including: 1) several narrow, lenticular zones in the hanging wall of the 3B deposit; 2) the Mansfield showing; and 3) zones of apparently unmineralized alteration and in pervasively altered pillow basalt. These zones of local alteration are separated by less altered and unaltered dacitic flows and pyroclastic deposits. The zones of potassic alteration are associated with potassium feldspar recrystallization that are peripheral/distal to sericitization and massive sulphide mineralization. Samples displaying the highest potassium enrichment typically contain low abundances of sericite and a high abundance of potassium feldspar and generally have primary volcanic textures preserved. There also exists a high degree of correlation between K concentrations measured by in-situ gamma ray spectrometry and alkali alteration index $[\{(K_2O+MgO)/(K_2O+MgO+Na_2O+CaO)\}X100]$ calculated from major element analysis. Although this type of potassic alteration is not obvious in surface exposures, it can be identified by detailed ground gamma ray spectrometry supported by cost effective routine petrographic work and selective chemical analysis on a limited number of samples. The lack of potassium enrichment within the barren pyritic gossans hosted by pillowed basalts on Sunday Cove Island enables in-situ gamma ray spectrometry to be used to distinguish it from a similar looking, but mineralized, gossans at Bumble Bee Bight that contain sericite alteration. Project investigations from the Tulks belt suggest that where sufficient pre-alteration thorium variation exists identification of different protoliths is possible using ground gamma ray spectrometry.

Economic/Project Impacts. Regional and deposit scale in-situ gamma ray spectrometry confirms the radioelement variations indicated by the AGRS surveys and clearly demonstrates the application of these surveys to regional exploration for VHMS style mineralization in this part of Newfoundland. Project investigations also directly contributed to significant mineral exploration activity during the course of the 1990-1994 Canada-Newfoundland MDA.

Outputs.

OPEN FILES

Ford, K.L. and Holman, P.B.
1992: Airborne geophysical survey of the Tulks volcanic belt, Red Indian Lake area, Newfoundland; Geological Survey of Canada, Open File 2481, 1:100 000 scale (8 gamma ray spectrometric, 3 magnetic, 2 VLF profile maps, 1 geology, 1 flight path, and stacked profiles).

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Ford, K.L.
1992a: Gamma-ray spectrometry as an indicator of VMS mineralization in the Roberts Arm and Tulks Volcanic belts, Newfoundland; in Report of Activities 1992, Newfoundland Department of Mines and Energy, p. 52.
1992b: Gamma ray spectrometry as an indicator of VMS mineralization in the Robert's Arm and Tulks volcanic belts, Newfoundland; in Forum 1993, Geological Survey of Canada, Program with Abstracts, p. 22.
1993: Application of gamma-ray spectrometry to the exploration for VMS deposits in the Robert's Arm Group and Tulk's Volcanic Belt, central Newfoundland; in Report of Activities 1993, Newfoundland Department of Mines and Energy, p. 12-13.

Ford, K.L., Charbonneau, B.W. and Shives, R.B.K.
1993: Application of Gamma Ray Spectrometry to Precious and Base Metal Exploration; in 40th Annual Meeting of the Newfoundland Branch, Canadian Institute of Mining, Metallurgy & Petroleum, Program (with Abstracts), p. 9.

Ford, K.L. and Shives, R.B.K.
1994: Gamma ray spectrometry: Application to the search for VMS deposits; in Geological Survey of Canada, Minerals Colloquium, Program with Abstracts, p. 16.

C1.116 Multiple Data Set Interpretation (G.P. Watson)

Objectives. The primary project objective was to develop methodology and expertise to facilitate the multi-disciplinary analysis of geologic terrains for resource assessment or exploration applications. The approach provided a means of compiling and coordinating spatial geoscience data and also of modelling regional metallotects. For the Baie Verte area, well-defined genetic models exist for the main deposit types (i.e. massive sulphide, ophiolite-hosted, epigenetic vein and disseminated Au). These models provide criteria for assessing the potential for mineralization in the surrounding region using both data dependent and expert dependent analysis approaches in the GIS. Regional maps of relative favourability can be produced for each of the main deposit types which can be used to target future exploration activity. A second objective was to assess the utility of combining high resolution SPOT satellite data with SAR, LANDSAT and geophysical data in enhanced imagery for regional structural interpretation in the Baie Verte area and portions of Cape Ray-Hope Brook areas in southern Newfoundland.

Methods.

1) Compilation and Integration

Initial project efforts focused on the compilation of geoscience data sets from Baie Verte Peninsula (NTS 12H/7,8,9,12,16, 2E/5,13) for integration within the Geographic Information System (GIS). Data sets acquired included: 1) 1988 GSC airborne radiometric, magnetometer and VLF data; 2) GSC regional geochemical data; 3) generalized bedrock geology digitized from provincial 1:1 000 000 scale maps; 4) LANDSAT TM image, which was georeferenced and corrected using the EASI/PACE image analysis system at GSC Ottawa; 5) mineral occurrence data from the GSC's CANMINDEX files and the Newfoundland Department of Natural Resources' provincial mineral deposits database (MODS); and 6) miscellaneous additional data, for example provincial regional geochemical surveys (lake waters and sediments, stream sediments, both as point files and gridded data) and regridded geophysical data. An arrangement was made through the Canada Centre for Remote Sensing (CCRS) store-front office at the GSC to acquire and correct Synthetic Aperture Radar (SAR) imagery from surveys flown in 1988 by CCRS. In addition, high resolution panchromatic SPOT satellite data for test areas in the Baie Verte and Cape Ray regions were acquired to evaluate application to regional structural analysis. Image analysis software (EASI/PACE from PCI Inc.) was also acquired late in fiscal 1991-92 to facilitate image processing. Much of the compilation work was initially done in cooperation with members of the GSC's Mathematical Applications Group at Ottawa. Subsequent digitizing and image analysis tasks were contracted to SYNMAP Information Technologies, of Halifax.

2) Analysis and Modelling

The compiled digital data from Baie Verte was initially incorporated in SPANS GIS and was later converted into ARCINFO format. This geoscience database was used to conduct a comparison of mineral potential modelling techniques (i.e. weights of evidence, decision-trees, logistic regression, Dempster-Schafer).

Digital maps were produced that combine topographic relief with geological and geophysical survey data from portions of southwestern Newfoundland including the Cape Ray Fault Zone and coastal sections. The main source of relief information used was panchromatic SPOT satellite imagery with a ground resolution of 10 m. Geophysical data consisted of information from regional airborne radiometric, magnetic

and electromagnetic surveys flown in 1984 for the GSC. Geologic mapping data was generalized from field mapping studies completed by Dubé and Lauzière and others from the Quebec Geoscience Centre (Newfoundland MDA project C1.124). Several procedures were used to highlight and enhance linear patterns (assumed to reflect underlying bedrock structure) within the satellite imagery, including spatial filtering, and shaded relief techniques. The information derived from these methods was plotted at a 1:125 000 scale and visual interpretation for structural features was done. Several types of digital image products were made, for example, an IHS (Intensity-Hue-Saturation) display was created using intensity from the airborne radiometrics or magnetics, hue (colour) from the SPOT data, and saturation from an artificial channel set to a constant. Vector outlines of geologic features identified from field mapping were overlain on these various products to compare with interpretations on remotely sensed data.

Results. Once various datasets have been converted to digital format and integrated, spatial data processing and analysis technologies can be used to increase the information extraction capabilities for the geoscientist. A final digital product prototype for the Baie Verte area is being produced on CD-ROM for use by both public and private sector geologists. The prototype 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 export the data gathered under this project directly for their own spatial analysis. The prototype has been developed with a built-in tutorial based on MS WINDOWS help files, which 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. As a further aid, the public domain GIS viewing package ARCVIEW Version 1.0 will be included on the CD-ROM.

Enhanced digital imagery maps that combine topographic relief with geoscience survey data have been found to be superior to traditional cartographic representations, because on the same map sheet, the geoscientist is provided with a visual expression of topographic relief control/expression of subsurface geological features that are easily correlated to spatially distributed geological and geophysical features.

Outputs.

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C1.12 MINERAL DEPOSITS ENVIRONMENTS

C1.121 Geology, Mineralogy and Geochemistry of Massive Sulphide Deposits, Newfoundland and Labrador
(F. Santaguida and M.D. Hannington)

Objectives. The overall objective of this project was to utilize new analytical techniques and knowledge regarding modern seafloor massive sulphides in the study of several known Volcaonogenic Massive Sulphide (VMS) deposits and prospects in Newfoundland and Labrador. Both detailed/mine scale and reconnaissance/regional scale investigations were completed.

Methods and Results.

Pilley's Island.

Mine scale studies were concentrated on the Cu-Zn-Pb massive sulphides at Pilley's Island and included support from E.C. Jowett and I.L. Gibson, both of the University of Waterloo. In addition to detailed mapping, existing drill core was re-logged at 1:200 scale and sampled for lithogeochemistry.

Investigations indicate that:

1) The volcanic stratigraphy has been slightly modified from previous interpretations in order to correlate the massive sulphide horizons in the Old Mine area to the massive sulphides in the nearby 3B Zone.

2) The felsic volcanics which host the massive sulphide horizons on Pilley's Island are continuous between both areas of mineralization and suggest contemporaneous sulphide deposition. A lower dacitic flow unit is overlain by pyroclastics which contain most of the mineralization

as massive, disseminated and transported sulphides subsequently capped by an upper dacitic flow unit.

3) Hydrothermal alteration envelopes the sulphide horizons dominated by quartz-sericite assemblages and occur as discordant zones with chlorite and/or K feldspar within the felsic and mafic volcanics in the area. Mass balance of major and trace elements concentrations of the altered wall rocks show variable enrichment of Si, Fe, Mg, K, V, and Ba and depletion of Ca and Na in the mineralized dacite pyroclastics. Rock volume changes in the felsic volcanics reflect enhanced hydrothermal fluid flow within the pyroclastics compared to the felsic flow units. Mineral chemistry analysis of alteration minerals indicate progressive Fe-enrichment over Mg in chlorite toward the massive sulphide zones, but sericite compositions remain relatively consistent.

4) Sulphide textures reflect both surface and sub-seafloor mineralization and corresponding hydrothermal- felsic volcanic activity.

5) Sulphur isotopes of Pilley's Island sulphides are comparable to other Newfoundland VMS deposits and occur within a range of −2 to +7 ‰. Sulphur isotopes are not variable with mineralogy but an enriched signature in later sulphide phases suggest an influence of seawater in the latter stages of hydrothermal activity.

6) The nature of volcanism and geochemisty of the hydrothermal alteration reflect a relatively shallow water environment for sulphide mineralization at Pilley's Island, similar to that interpreted at the Buchans VMS orebodies, and imply these deposits are an important exploration target in Central Newfoundland.

Central Newfoundland- Notre Dame Bay Area.

Regional scale studies of VMS deposits in Central Newfoundland focussed on the mineralogy, Au-Ag content, and alteration assemblages associated with base metal sulphides. Representative sulphide mineral assemblages from 19 sulphide deposits and showings, including Pilley's Island, were examined and analyzed for Au and Ag as well as other trace elements and metals using INAA and ICP techniques.

Nine deposits and showings were found to contain free gold as native grains or as tellurides. Most notably, the Betts Cove deposit returned values up to 30 g/tonne Au and the Point Leamington prospect contains up to 15 g/tonne with an overall average through the massive sulphides of >1 g/tonne. Gold concentrations were found to correlate with particular metal-sulphide assemblages having similar geological settings. Similar Au-metal correlations have been made for modern seafloor massive sulphides. These correlations and the local preservation of primary sulphide depositional textures supports the notion that Au in Central Newfoundland VMS deposits, although likely reconcentrated, is primary and not tectonic.

Other regional mineralogical studies in Central Newfoundland focused on anomalous potassic alteration zones proximal to VMS deposits identified using airborne gamma ray spectrometry (Canada-Newfoundland MDA project C1.115). Airborne potassium anomalies were found to correspond to up to 11 weight % K_2O in whole rock analyses in both felsic and mafic volcanic rocks. In these volcanic rocks, K-feldspar was observed as small microlites that replace the vitric groundmass. This alteration precludes quartz-sericite and associated sulphide mineralization, but appears to be spatially correlatable to Zn-Pb mineralization. Although K-feldspar alteration occurs sporadically in most felsic centres in Central Newfoundland, it appears to be concentrated in centres which host significant sulphide mineralization. This alteration is likely the result of the interaction of volcanic rocks and seawater-dominated fluids at relatively low temperatures, and its presence distal to the zone of main alteration and sulphide mineralization provides a larger exploration target easily identifiable by geophysical techniques.

Regional mineralogical studies of epidote-quartz alteration developed throughout Central Newfoundland were initiated in order to determine if compositional variations in epidote chemistry are related to sulphide mineralization. Several depositional environments are represented in Central Newfoundland ranging from volcanogenic to epithermal-style alteration. Most volcanogenic epidote alteration appears to be related to seawater-basalt interaction at low to moderate temperatures (i.e. <250 °C), while epidote contained in epithermal-style alteration, such as that found at the Lake Bond prospect, occurs as a gangue mineral with pyrite and sphalerite. Although mineral chemistry investigations are on-going, preliminary results of INAA and ICP-MS data from epidote mineral separates suggest variations in trace elements such as Sr and Rb exist and may reflect the nature of hydrothermal fluids (i.e. influence of seawater). The study is important to understand the processes of hydrothermal fluid-basalt reactions as potential metal-releasing mechanisms in the formation/deposition of massive sulphides.

Labrador Trough.

In conjunction with H.S. Swinden, Newfoundland Geological Survey Branch, regional investigations of several base metal sulphide showings in western Labrador were done to establish genetic models to further guide mineral exploration in the area. The geological settings of the various showings were documented using reconnaissance mapping of outcrops, geochemical analysis of sulphides and host argillaceous rocks, and petrographic studies.

In most areas, sulphide mineralization consists of pyrrhotite with minor chalcopyrite and trace sphalerite and galena superimposed on pyritic argillaceous sediments. Gabbro intrusive rocks are not related to sulphide accumulations, although they may have been emplaced coincident with argillite deposition. Concentrations of Au are typically below 1 g/tonne, but may be correlated to anomalous Cu. In one area (Montgomery Lake Prospect), argillites are intensely altered to a quartz-sericite-carbonate-fuchsite assemblage with widespread stringer and disseminated pyrite and chalcopyrite. Indications of widespread hydrothermal activity suggest that the exploration potential of the Montgomery Lake area is good. Deposit models for all of the sulphide showings studied in the area are believed to be analogous to the general class of fine-grained, clastic sediment associated, rift-related, exhalative copper deposits referred to as "Besshi-type" (i.e., Japan VMS district).

Economic/Project Impacts.

1) Favourable hydrothermal conditions occur in the Roberts Arm Group for Cu-Zn-Pb mineralization at Pilley's Island similar to the Buchans VMS orebodies. Identification of potassium anomalies in volcanic rocks that are spatially related to VMS mineralization at Pilley's Island and elsewhere in the Roberts Arm Group suggests that the base metal potential of the area is good. The widespread occurrence of anomalous Au throughout Central Newfoundland in VMS deposits further enhances the economic potential of the area.

2) The geochemistry of epidote alteration, which is persistent in central Newfoundland, has potential to be used as a diagnostic criteria for establishing the presence/absence of high temperature hydrothermal fluids and VMS mineralization.

3) The high Au values obtained at Betts Cove, which correlate with sphalerite-pyrite massive sulphides, suggests that this area should be further investigated to determine the extent of Zn-Au mineralization.

4) Copper mineralization contained in both disseminated and conformable massive bands of pyrrhotite, like that found in the Martin Lake and Howse Lake areas, are believed to belong to the general class of exhalative copper deposits known as "Besshi-type", and the exploration potential for this deposit type, in this portion of the Labrador Trough, is believed to be good. Occurrences immediately east and southeast of Howse Lake, which consist of minor disseminated pyrite and very minor chalcopyrite in a quartzitic sandstone have no lateral extent and appear to have no economic significance.

5) The presence of mesothermal style alteration and mineralization related to major faults in the Howse Zone of Labrador (i.e, Montgomery Lake Prospect) suggests that mesothermal gold occurrences may be present in western Labrador.

Outputs.

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C1.122 Sulphide Mineralization in Cambro-Ordovician Sediments (A.L. Sangster)

Subproject I: Gold Geochemistry of Caradocian Black Shale/Chert (A.L. Sangster)

Objectives. This primary objective of this subproject was to investigated the potential for an association between gold concentration and organic sedimentary rocks in some parts of the Caradocian cherts/shales in central Newfoundland. This project was initiated in response to increasing international exploration interest in the relationship of gold to organic sedimentary rocks (e.g., documentation of Russian and Chinese deposits that commonly display an association of gold with organic materials).

Methods. Pulps of Caradocian chert/shale samples, originally collected and analyzed by P. Dean and J. Meyers (both of Newfoundland Department of Mines and Energy), in the early 1980s, were retrieved form archives and selected samples were sent for INAA analyses (Au+33 element package) by Becquerel Laboratories, Mississauga, Ontario. In addition to these archived samples, a section of the Lawrence Harbour Formation near Loon Bay (i.e., from Campbellton to Loon Bay), which contains a transition from Mn-rich low-organic metasedimentary rocks to Mn-poor, high organic sulphidic rocks, was examined and sampled.

Results. Although no ore grade, or near ore grade, gold analyses were encountered in the reanalysis program, some black shale samples contained anomalous Au contents (ranging between 10 and 60 ppb relative to normal backgrounds near 1 ppb). Associated elements, such as As and Sb were also commonly anomalous in those samples displaying elevated gold contents. The best exposed, and most notable section is that located along highway 340, about 1 km east of the head of Loon Bay (NTS 2E/7). Here, the stratigraphic section passes from Mn-rich metasedimentary rocks upwards into pyrite-rich organic-rich argillites. The organic-rich rocks are enriched in V-Mo-U, which is typical of sediment deposited under anoxic conditions. Transition lithologies containing both organic material and Mn are rich in the sulphide pyrrhotite rather than pyrite, and it is here that the anomalous gold contents are found. The occurrence of the auriferous pyrrhotite-rich rocks, may be of either exhalative or of sedimentary origin in a rather specialized marine chemical

environment. Discrimination diagrams used to distinguish between exhalative and pelagic origins give equivocal results.

Economic/Project Impact. The similarity in trace chemistry between the Loon Bay Au-Sb-As assemblage and the mineralogy of gold occurrences in rocks along the GRUB line appears to suggest that rocks similar to those found at Loon bay may be a suitable protolith for metamorphogenic mineralizing fluids.

Subproject II: Characterization of the Nugget Pond Gold Deposit, Baie Verte, Newfoundland

(A. Sangster, J. Lavigne and S. Douma)

Objectives. The primary objective of this subproject was to characterize the geological setting, alteration and sulphur isotopic geochemistry of the Nugget Pond gold deposit. The subproject was funded by the GSC's Industrial Partners Program, (joint funding provided by GSC and Bitech Corporation) and the Canada-Newfoundland CAMD.

Methods. The Nugget Pond study was based on the relogging of approximately 75 of the 106 holes drilled during Bitech's 1989 deposit delineation program. Follow-up investigations included: thin and polished section petrography, including SEM examination; microprobe analysis of stilpnomelane, biotite and chlorite; alteration studies; and sulphide separation and sulphur isotope analyses. Instrumentation used at the GSC included a Cambridge S200 scanning electron microscope for mineralogical characterization with analyses carried out on a Cameca SX50 microprobe. Sulphur isotope analyses were carried out in the Ottawa-Carleton Geoscience Centre Stable Isotope Facility. One U/Pb age determination was carried out by the geochronology Section of the GSC.

Results. The Nugget Pond gold deposit is a stratiform body of disseminated, megacrystic, auriferous pyrite in magnetite-pyrite/pyrrhotite-rich horizons at the contact between lower red and upper green shaley turbidite units within the Betts Cove ophiolite. The gold occurs as inclusions and fracture fillings in pyrite, and disseminated in altered host rock. Associated opaque minerals include traces of chalcopyrite, galena, native silver, silver telluride as well as pre-existing pyrite and magnetite associated with the host rocks. The alteration is dominated by medium to coarse grained stilpnomelane which occurs as massive to disseminated, sheaves and star bursts, which overprint the regional chlorite-albite alteration assemblage. The alteration zone and gold deposit show a close spatial association with pyritic and auriferous quartz-feldspar-carbonate veins that appear to crosscut stratigraphy and occur both above and below the mineralized horizon.

Sulphur isotopic analyses of various sulphide phases associated with the deposit clearly demonstrate that the ore phase pyrite is distinct from other pyrites. Ore phase pyrite, and pyrite in the quartz-feldspar-carbonate veins have a relatively constant composition near +4 per mil. Pyrite associated with epidocite in the footwall pillowed basalt, thought by some to be ore-related fumarolic subvolcanic alteration, is appreciably more heavy (near + 20 per mil). The heavy isotopic character indicates an association with seawater sulphate, and that the epidocites and contained pyrite are genetically related to metasomatism by seawater immediately following extrusion and not to gold ore deposition. Similarly, the regional sulphide-rich horizon that contains the Nugget Pond deposit, which was previously considered to be an exhalite, contains sulphides of biogenic origin that display light isotopic compositions near -20 per mil. Because the ore phase pyrite (+ 4 per mil) is clearly seen overgrowing the biogenic sulphide, the Nugget Pond gold mineralization is not thought to be related to exhalative processes. Rather, the Nugget Pond deposit is interpreted to be a disseminated stratiform replacement deposit with mineralization resulting from fluids associated with the emplacement/intrusion of the auriferous quartz-feldspar-carbonate pegmatitic veins. A preliminary U/Pb age determination on one monazite suggests an age for the veins and associated deposit of about 374 Ma.

Economic/Project Impacts.

1) Recognition of the association of ore with iron formations, and identification of the possible importance of the association of pegmatitic quartz-feldspar-carbonate veins to ore formation provides a first level criteria for further mineral exploration.

2) Characterization of the nature of the alteration in the vicinity of the deposit, and identification of similar alteration in a drill hole about 1 km SW of the deposit (i.e., including the presence of stilpnomelane) has identified a new drill target.

3) The analysis of sulphur isotope compositions was useful in differentiating ore-related (i.e., auriferous) sulphide from sulphides associated with barren mineralizing systems. Results suggest that application of this analytical technique on a more regional scale could be used to distinguish sulphide in auriferous ore bearing systems in the Betts Cove Ophiolite from barren sulphide systems.

Outputs.

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C1.123 Metallogeny of Codroy Group (D.F. Sangster)

Objectives. The objectives of this project were to:

1) examine, characterize, and classify the known base metal occurrences in basal Windsor and equivalent strata;

2) integrate the information to elucidate the regional and temporal geological pattern; identify favourable areas that could potentially host undiscovered deposits; and,

3) stimulate private sector mineral exploration.

This project was actually a subcomponent of an integrated, tri-provincial (Newfoundland, New Brunswick, Nova Scotia) study of the basal Windsor that was also funded by the 1990-1995 Canada-New Brunswick, and the 1990-1992 Canada-Nova Scotia CAMDs.

Methods. Project work was done under contract with Cuesta Research Limited. The first contract, initiated in 1990-91, consisted of two and one half years of data-gathering (i.e. compilation of information from government and corporate files, publications and university theses; and field examination of deposits and core collections). The second contract, initiated in 1993-94, consisted of a one year manuscript-generating phase.

Results.

1) Regional assessments of the character and distribution of Zn, Pb, Cu, Ba, Fe, Mn, and Sr mineralization within Maritime Basin, basal Windsor (Codroy) Group carbonates, of Atlantic Canada, show that the major deposits typically have sphalerite, galena, barite and/or celestite associated with sparry calcite.

2) Mineral deposits are hosted by laminated carbonates of the Macumber and Ship Cove formations; bioclastic carbonate reefs of the Gays River Formation; and bioclastic and biohermal carbonates associated with karst-valleys of the Big Cove Formation.

3) Copper showings are hosted within both the basal Windsor Group carbonate and rocks just below the carbonate, at both Windsor/Horton and Windsor/Lower Paleozoic contacts.

4) The degree of base-metal mineralization within the basal Windsor (Codroy) Group rocks in the Maritimes Basin is related to a number of principal factors, including: the original porosity and permeability of the host sedimentary rocks; the occurrence of subbasin-bounding faults, disconformities and unconformities; the proximity of laterally continuous subsurface aquifers beneath thick caps; and, the presence of hydrocarbons beneath a cap (commonly sulphate) rock at the time of mineralization.

5) Common features of the deposits, include:
   i) ore and gangue mineralization within breccia and fracture porosity;
   ii) best grade of mineralization between massive carbonate and massive sulphate;
   iii) deep, post-ore karst between ore and massive sulphate;
   iv) mineralization by basinal brines;
   v) fracturing and brecciation and subsequently mineralized; and,
   vi) presence of liquid hydrocarbons at the time of mineralization.

6) Significant showings and deposits are classified into the following type examples:
   i) Deer Lake uranium and copper, within lacustrine clastics and carbonates, unconformably overlying karsted carbonate basement;
   ii) MacRae celestite, hosted within caliche carbonates of alluvial fanglomerate successions in fault or nonconformable overstep relationship with basement;
   iii) Gays River sphalerite-galena-pyrite within reefal or biohermal carbonate banks that grew on basement highs or irregularities;

iv) Jubilee galena-pyrite-sphalerite, within brecciated or fractured laminated carbonate that accumulated at the base of synsedimentary faults; and,

v) Walton siderite-barite-silver in laminated and porous brecciated carbonate units within a structurally complex zone..

Outputs.

OPEN FILES

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C1.124 Metallogeny of Gold in Major Fault Zones (B. Dubé)

Objectives. The overall project objective was to gain a better understanding of the relationship between gold mineralization at Cape Ray, Springdale and Baie Verte Peninsulas, Hope Brook, and spatially related major fault zones. The study focussed on documenting: the control(s) of the ore geometry; spatial distribution and timing of gold mineralization; and, structural history of the faults.

Methods. B. Dubé, K. Lauzière and numerous GSC summer assistants completed detailed structural and metallogenic field and laboratory studies on selected (i.e., economically significant) gold deposits/occurrences. The work was done in collaboration with: G. Dunning (Memorial University of Newfoundland) and C.R. Roddick (GSC)-geochronology of key units; M. Belanger-M.Sc. thesis documenting the Dorset gold occurrence; D. Gaboury-M.Sc. thesis documenting the Hammer Down gold deposit; the Newfoundland Geological Survey Branch and K.H. Poulsen and F. Robert (both of the GSC). Logistical support, and access to confidential information was supplied by many companies including: Noranda, BP-Selco, Royal Oak Mines, Dolphin's Explorations, Corona, Major General Resources, Bitech, Fortunes Bay Resources and Placer Dome.

Results.

1) In several deposits the main control on gold mineralization is structural: 1) breccia veins in the hanging wall, and at a high angle to main faults (e.g., Deer Cove); and, 2) laminated fault fill veins hosted by brittle-ductile shear zones mainly related to the anisotropy induced by competent felsic dykes (e.g., Hammer Down, Dorset).

2) In other deposits, the chemical influence of the host rocks is also a key element in gold deposition. Gold mineralization at Stog'er Tight is hosted by altered gabbroic sills, where both the layer anisotropy and the iron-rich content of the hosting gabbro favour the stratabound geometry of the ore zone. At the Cape Ray Gold deposit, graphitic schists played a key role in gold precipitation. Here the brittle character of the graphite schist favoured fluid circulation, while the carbon reacted with the H_2O to produce CO_2 and methane. The corresponding production of methane led to a reduction in oxygen fugacity, the destabilization of gold-complexes, and the subsequent precipitation of gold. Iron-rich sediments are also thought to be responsible for precipitation of gold at the Isle aux Morts prospect (Cape Ray Fault).

3) Regionally, it has been established that mineralized gold zones are related to a major post Taconic phase of deformation, magmatism and metamorphism which corresponds to the Silurian Orogeny. In southwestern Newfoundland, it has been demonstrated that the Cape Ray fault zone, one of the most significant gold-bearing structures in the Appalachians, represents the suture zone between Gondwanan and Laurentian terranes. This collision, which occurred between 412 Ma and 386 Ma, resulted in complex thrusting motions, strike slip movement, subsequent metamorphism and magmatism and associated gold mineralization. Detailed regional and structural investigations have specifically defined which deformation phase the gold mineralization was related to and how ore zone geometry was later modified by superimposed deformation.

Economic/Project Impacts.

The project was successful in:

1) establishing a new classification of gold deposits applicable across the entire Appalachians (i.e., Disseminated Stratabound Sulphide Gold (DSSG) deposits in silicified rocks [e.g., Hope Brook]; DSSG deposits in sedimentary rocks [e.g., Nugget Pond]; Mesothermal quartz vein type [e.g., Cape Ray, Hammer Down, Deer Cove/Dorset];and Mesothermal altered wallrock deposits [e.g., Stog'er Tight]);

2) defining the geometry and control(s) of gold mineralization at the deposit and district scales, and helped design critical exploration criteria useful to the mining industry. For example, at the Hammer Down gold deposit, project investigations helped to clarify the geological and structural controls of mineralization, which in turn resulted helped to increase the geological reserves of the deposit; and,

3) recognizing the presence of a near surface epithermal hydrothermal system within the Cape Ray Fault, which

may strongly influence the future exploration strategy of companies working in the area.

Outputs.

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C1.125 Metallogeny of Baie Verte and Bay of Islands (J.W. Lydon)

Objectives. To compile and publish the data base acquired during metallogenic studies completed by the GSC in the Bay of Islands ophiolite complex and ophiolites of the Baie Verte Peninsula during the 1984-1989-Canada-Newfoundland Mineral Development Agreement.

Methods. J.G. Lavigne was contracted to: compile and list lithogeochemical data in a consistent format; and, produce digital simplified geological maps showing sample locations. J.W. Lydon was to produce text explaining the scientific

rationale for sampling in individual areas. It is expected that the several hundred pages of lists, maps and text will eventually be released on GSC Open File.

Results.

Each Open File report will likely consist of:

1) General introductory text outlining the purpose, scope and major results and/or conclusions of the work, with an accompanying index map of the area showing the simplified geology of the area and locations of local areas of work for which the data is presented;

2) Maps showing the geology, locations of mineral occurrences, and location (with identification numbers) of samples for which data is reported. Accompanying text will define the purpose, scope and limits of the study, and the major results and conclusions of the study, including references to published and unpublished manuscripts that are available. A series of tables showing sample identification number, sample lithology and chemical data (i.e., whole rock major elements; whole rock minor elements; and where appropriate, whole rock Pt, Pd, Au, mineral chemistry, isotope analyses and speciality analysis [e.g., radiometric dating]) are also included for the various study areas.

Occurrences mineral deposits, plutonic, volcanic and sedimentary sequences examined in the Bay of Islands area include the Lewis Hills (e.g. Springer's Hill, Bluff Head, Rope Cove Canyon), Blow me Down Mountain (York Harbour, North Arm Mountain (e.g., Gregory River, Mitchell Brook, Liverpool Brook) and Table Mountain (e.g., Winterhouse Brook) Massifs.

Occurrences/mineral deposits, plutonic, volcanic and sedimentary sequences examined in the Baie Verte Peninsula include the Betts Cove Ophiolite (e.g., Beaver Cove Pond-Tilt Cove deposit, West Pond-Radcliffe Pond, Kitty Pond-West Pond, Betts Cove mine site, Burton's Pond-Nipper's Harbour-Rogues Harbour), Ming's Bight Ophiolite (e.g., Deer Cove, Barry and Cunningham-Goldenville, Scrape Thrust-Ming's Bight Road), the Baie Verte Line (e.g., Flatwater Pond, Fleur de Lys-Mic Mac Pond) and selected felsic lithologies (e.g., Armchair Pond, Brent's Cove),

Economic/Project Impacts. Improved lithogeochemical data base of the gold, PGE, chromite and base metal mineralization and geological processes associated with the genesis of ophiolites in the Bay of Islands and Baie Verte Peninsula. These data will improve the effectiveness of mineral exploration in these areas, and the Open Files will provide these data in a form easily accessible to the exploration community.

Outputs.

OPEN FILES

Lydon, J.W. and Lavigne, J.G.

In prep.: Chemical data for chromite, gold and sulphide occurrences and their host rocks in the Bay of Islands ophiolite complex, Newfoundland; Geological Survey of Canada, Open File.

In prep.: Chemical data for gold and sulphide occurrences and their host rocks associated with ophiolites of the Baie Verte Peninsula, Newfoundland; Geological Survey of Canada, Open File.

C1.126 Platinum Group Elements (PGE) in Mafic-Ultramafic Intrusions (O.R. Eckstrand)

Objectives. The purpose of the project was to conduct a reconnaissance study of selected mafic and ultramafic intrusions in various parts and geological environments of Newfoundland, in order to assess their potential to contain Platinum-Group Element (PGE) and nickel deposits. Emphasis was placed on studying intrusions of non-ophiolitic association, because, on a world-wide basis, they have more favourable potential to host PGE-Ni mineralization.

Methods. The field work, done under contract by Ersen Cogulu during the 1991 to 1993 field seasons, consisted of three components:

1) Field examination of representative (and often the more accessible) portions of the intrusion or complex in order to determine the nature and distribution of its main facies (e.g., gabbro, troctolite, peridotite). Of primary importance was to determine the presence of igneous layering, which is a common characteristic of PGE-bearing intrusions.

2) Prospecting for sulphides minerals and subsequent geochemical analyses. Because sulphides are a direct indication of possible PGE or nickel potential, all sulphide-bearing samples were analyzed for PGE and other typically associated elements (Cu-Ni) by Acme Analytical Laboratories and the GSC's analytical laboratories.

3) Sampling typical facies of the intrusions and chemically analysing their major, minor and trace (including rare-earth elements) contents. These analyses, done at the GSC, enabled petrological classification of the intrusions, and provided a basis for a generalized assessment of their PGE and Ni potential.

Results. A total of ten intrusions and intrusive complexes were investigated. Of these three showed indications of some potential for deposits of PGE and nickel.

The most interesting of these is a portion of the Silurian Mt. Peyton complex which lies in the Exploits subzone of the Dunnage Zone. The complex is a large (> 60 km long), lenticular, post kinematic, calc-alkaline gabbro-granite mass that intrudes strongly deformed siliciclastic sedimentary formations of late Ordovician and Silurian age. Previously observed structure tentatively identified as magmatic layering in the southern portion of the complex was verified, and was demonstrated to be part of an early, homoclinally tilted, layered tholeiitic phase of the complex, subsequently named the Caribou Hill intrusion. This intrusion comprises gabbro, olivine gabbro, troctolite, anorthosite and clinopyroxenite, and is divided into a lower, cyclically layered olivine gabbro unit; a middle, schlieric troctolite unit; and an upper, more felsic gabbro unit. The feature of greatest interest is a swarm of about a dozen pegmatoidal clinopyroxenite-peridotite pipes that cross-cut the layering at about 75°. The pipes range in diameter from less than 10 m to greater than 300 metres, and are largely confined to the lower layered unit of the Caribou Hill intrusion. They bear a remarkable resemblance to pipes of similar compositions in the Bushveld complex of South Africa, two of which were mined for platinum. Although preliminary reconnaissance assays of the Caribou Hill pipes yielded no anomalous PGE values, the possibility of platiniferous zones within the pipes has not been eliminated. The lack of sulphides is not a discouraging sign in this case, as sulphides are not associated with the Bushveld platinum deposits.

The second intrusion of interest is the Devonian (?) Red Cross Lake intrusion, east of the northeast end of Victoria Lake. It intrudes folded Ordovician volcanic-sedimentary strata of the Exploits subzone to the northwest, and metasedimentary rocks of the Gander Zone to the southeast. The intrusion consists of well layered feldspathic peridotite and troctolite in a lower or southern unit, troctolite and pyroxenite in a middle unit, and gabbro in the upper or northern unit. Disseminated sulphides (up to a few percent of pyrrhotite, pentlandite and chalcopyrite) that occur in cyclically layered peridotite/troctolite of the lower unit are probably the source of a geochemical nickel anomaly that was detected previously, and may indicate the presence of ore-grade concentrations of nickel sulphides somewhere (possibly at the base ?) In the intrusion. PGE assays of the sulphide-bearing samples yield non-anomalous values, and give no direct indication of primarily PGE-type mineralization.

The third complex showing indications of possible mineral potential is the Tilting Harbour complex on Fogo Island in the Dunnage tectonic zone. This is a layered mafic/ultramafic body that intrudes Silurian metasedimentary rocks ans is enveloped in a Devonian granitic pluton. The body comprises a succession of layered gabbro, leucogabbro and pyroxenite, and another succession of weakly layered websterite and feldspathic websterite. The latter contains a zone, possibly as much as 20 metres thick, of sparsely disseminated, intercumulus sulphides (pyrrhotite, chalcopyrite, pyrite) that could indicate the existence of greater concentrations of nickel-copper sulphides elsewhere in the intrusion. Assays of the sulphide-bearing material produced no anomalous PGE values.

Other intrusions that were found to have previously unreported igneous layering included the Lance Cove sills, St. Mary's Bay; and the Wandsworth gabbro and Frenchman's Cove intrusions, Burin Peninsula. However, the lack of sulphides does not support any indication of associated magmatic (e.g., nickel or PGE-bearing) mineralization.

Economic/Project Impacts. Investigation of the Caribou Hill intrusion and documentation of the presence of Bushveld-type ultramafic pipes elicited some interest by the mineral exploration community.

Outputs.

ORAL AND POSTER PRESENTATIONS/
EXTENDED ABSTRACTS

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C1.127 Quaternary Geology and Till Geochemistry, Central Volcanic Belt (R.A. Klassen)

Objectives.

1) To map the surficial geology of central Newfoundland in the area of Buchans, and to determine the glacial origins and compositional properties of surficial deposits by

mapping ice flow indicators, and by lithological, mineralogical, and geochemical analyses of till.

2) Based on the compilation and analysis of Quaternary geology and till geochemical data, establish an effective protocol for using drift prospecting in mineral exploration in the part of Newfoundland.

Methods. During the summers of 1991 and 1992, R.A. Klassen, contract geologists, and summer assistants completed fieldwork in NTS map areas 12A/9, 15, 16, and 12H/1. Based out of rental accommodations at Millertown and Badger, and using truck and all-terrain vehicles, surficial deposits along logging and Provincial roads were mapped and till samples were collected in order to characterize drift composition. From field information and a review of aerial photographs, surficial units were defined and maps of Quaternary geology compiled at 1:50 000 scale. Ice flow history was characterized by measuring/mapping striations, in order to determine ice flow trends and relative ages, and indicator erratics were mapped to determine net distances and directions of glacial transport and to model glacial dispersal trains. Sections of surficial deposits were examined to determine Quaternary stratigraphy and vertical variations in drift composition: the most important sections occur in the margins of open pits at Buchans.

The clay-sized (<0.002 mm) and silt and clay-sized (<0.063 mm) fractions of more than 1000 till samples were separated and geochemically analyzed by CHEMEX using Inductively Coupled Plasma Emission Spectroscopy (ICP-AES) and by Neutron Activation Laboratories, using Inductive Neutron Activation (INA) methods. To characterize till provenance, pebbles (4-5.6 mm) and cobbles (4-10 cm) were analyzed for lithology, and heavy mineral separations were done on selected samples to characterize the distribution of sulphide minerals and their weathering. The pebble analysis and heavy mineral separations were done under contract to R. D. Thomas and to Consorminex Ltd.

Colour digital till geochemistry and GSC Open File maps were prepared by Northwood Geoscience, Ottawa.

Results. Careful mapping of striations has provided a basis for modelling ice flow history and glacial dispersal trains. Investigations have identified a sequence of distinct ice flow events, that include: 1) early regional southward flow from the Topsails Plateau; 2) regional northeastward flow across the Study Area that could be associated with an ice divide near Buchans and westward to southwestward flow from there; 3) southward and northward flow near Buchans originating with an ice divide in the topographic saddle between Buchans and Hinds Lake; and, 4) late glacial flow outwards along the axis of Red Indian Lake. The local effects of topography are clearly shown by ice flow 'wrapping' northward around the southeastern margin of the Topsails Plateau. Although models of glacial history defined by this work are generally applicable, at the detailed, exploration scale of investigation careful review of striations must be done to determine which record is predominant. In terms of glacial dispersal, the relative effects of the different ice flow events vary. Across the Lake Ambrose map area the effects of northeastward ice flow predominate, although widespread granitic erratics reflect earlier, southward ice flow. Near Buchans, the effects of southward ice flow are predominate in surficial deposits.

Stratigraphic studies in backhoe pits throughout the study area and in sections exposed along the margins of open pits at Buchans have revealed the close linkage between ice flow history and drift composition. At Buchans, two compositionally distinct glacial deposits and intervening glacial lake sediments are exposed. The older till, deposited by northeastward flowing ice, lies in contact with sulphide-bearing bedrock and is rich in volcanic debris. It is overlain by glacial lake sediments that include subaqueous debris flows, some of which are rich in mineralized debris. The glacial lake sediments, which have not been previously recognized as a Quaternary unit near Buchans, can be extensive and thick in the subsurface and can mask the compositional expression of underlying bedrock. The surficial cover in the Buchans area comprises glacial deposits derived from southward flowing ice and variably reworked as subaerial debris flows. The deposits incorporate underlying glacial lake sediments within the matrix and are rich in granitic debris. The granitic rock defines a glacial dispersal train extending > 5 km southward from Buchans toward Red Indian Lake. The compositional differences between tills are clearly reflected by their geochemical properties (i.e., the volcanic-rich till is enriched in Cu, Pb, Zn and Cr, among other elements, and contains the signature of volcanogenic massive sulphide mineralization). The stratigraphic sequence illustrates the varied provenance and sedimentological origins of surficial deposits. The glacial lake sediments indicate that Red Indian Lake contained residual blocks of glacier ice during deglaciation that impeded drainage. Comparable sequences of glacial lake sediments could be extensive and thick in valleys elsewhere in central Newfoundland.

In the study area, maps of till geochemistry broadly reflect the composition of underlying bedrock, an interpretation supported by their comparison with bedrock and till lithology maps. The effects of glacial transport on till geochemistry, although notable in some areas, especially near Buchans, are for the most generally minimal. Salient features provided by till geochemistry include the following:

1) Because till geochemistry maps reflect large-scale (km to tens of km) compositional variation within and among bedrock units, and can be used to infer compositional

differences within and between bedrock units, they are a useful guide to exploration. For example, within the Lake Ambrose map area, till derived from volcanic and sedimentary bedrock of the Victoria Lake Group is enriched in most trace metal elements, notably so for arsenic, compared with till elsewhere in the study area. Within a northeast trending belt across the central part of that area, till is further enriched in Ag (silver), Bi (bismuth), Mo (molybdenum), and Ni (nickel), among other elements. The belt is coincident with bedrock of the Victoria Lake Group and is centered either on or along the southwestward extension of a major, northeast trending fold axis. On either side of that belt till geochemistry also reflects compositional differences between volcanic rocks of the Tally Pond and Tulks Hill. Till overlying Tulks Hill volcanic rock is generally lower in K, Fe, and Ti, and is higher in As and Ba. For the Victoria Lake Group, the geochemical differences can serve to focus exploration effort in terms of metallogenic models, and of bedrock structure and environment of formation.

2) Gold concentrations, although variable, are generally >4 ppb south of Red Indian Lake, and Exploits River samples containing >20 ppb occur throughout the map area, including two sites near Buchans Junction, two sites near the southern margin of mafic to intermediate rock near the eastern margin of Dawes Pond map area, and one site west of Buchans townsite. Within areas of sedimentary rock in the eastern Badger map area, south of Exploits river, till generally contains >8 ppb gold. The greatest concentration is 76 ppm.

3) Near Buchans, a southwest-trending glacial dispersal train is evident in maps of lead geochemistry. It is interpreted as the net result of southwestward glacial transport from subcropping sulphide mineralization, and of redeposition of that mineralized debris in subaqueous debris flows within glacial lakes, and in subaerial flows following deglaciation. At, and northeast of Buchans, the compositional expression of bedrock is masked by glacial lake deposits, which are thick and extensive in the subsurface.

4) The elevated concentrations of arsenic that characterize till in the southern part of the study area could be of potential environmental concern.

Economic/Project Impacts. Maps of drift composition, and models of ice flow and Quaternary stratigraphy provided by the MDA work comprise a geological framework for mineral exploration in the Buchans area. The complex patterns of ice flow that characterize the area have long been known and have made drift prospecting difficult. Thick sequences of Quaternary sediments, especially near Buchans, have been a further hindrance to exploration. Because the complex character of ice flow and of glacial and paraglaical sedimentation near Buchans may be typical of other large interior basins, the work likely has wider application for central Newfoundland. Project geochemical results have been used by the mineral exploration community to identify and stake prospective areas.

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C1.128 Biogeochemistry (C.E. Dunn)

Objectives. A biogeochemical survey was conducted over an area of 200 km^2 that included the Baie Verte peninsula. The main objective was to determine the concentrations of metals in common tree species near zones of known mineralization and in 'background' areas, and thereby assess the applicability of biogeochemical methods to exploration, particularly for gold, in forested areas of Newfoundland.

Methods. A brief orientation survey was conducted to determine a common species of tree that was able to absorb metals of significance to mineral exploration, and store them in easily accessible parts of the tree. Black spruce was selected as the principal sample medium because, locally, twigs (latest 10 years of growth) and outer bark (loose scales) are highly enriched in metals.

Twig and bark samples were collected from 145 sites within an area of 200 km^2 from the northern tip of the Baie Verte peninsula southward to just south of the Brass Buckle Au deposit. Significant mineral deposits (notably Rambler, Ming and Pine Cove) were within the survey area. Sample collection was undertaken in conjunction with G.E.M. Hall's hydrogeochemical survey (Newfoundland MDA project C1.129), and with the assistance Peter Dimmell (consultant).

Samples were shipped to Ottawa for preparation prior to analysis of ash samples at commercial laboratories. Analytical data for 48 elements were digitally compiled, evaluated and plotted on digitized base maps as percentile values, using ArcInfo software.

Results. The twigs and bark provided similar results, but with some subtle differences for a few elements because of the ability of spruce to fix elements in different tissue types. Plots of the data set for each tree tissue type show a strong response (Ag, As, Au, Bi, Cu, Fe, Pb, Sb, Se, Zn) in the vicinity of the abandoned Rambler Mine and neighbouring deposits. Chromium and Ni are not concentrated around these deposits, but are present in high concentrations in samples collected over the mafic to ultramafic rocks of the Point Rousse Complex.

Tailings from the Rambler and Ming deposits appear to have contributed to the tree chemistry by a) absorption through root systems; and b) air-borne dust. Subsequent dissection of trees in the vicinity of Rambler demonstrated that some metals have been absorbed through root systems, but there is an overprint of airborne contamination. Trees adjacent to oxidizing tailings also contain metals absorbed in solution. However, by excluding samples from the contaminated areas it becomes possible to outline other areas of metal enrichment that may be worthy of closer investigation.

Samples of the common seaweed (*Fucus*) were collected along the shores of the Baie Verte peninsula. Analyses show strong enrichment of copper in samples receiving the influence of drainage along South Brook. This implies that analysis of seaweed may have applications in assessing the mineral potential of the land surrounding rugged fjorded coastlines of Canada (i.e., an enrichment of metals in the seaweed would indicate near-shore zones of metal enrichment).

Economic/Project Impacts. Biogeochemistry appears to be a viable mineral exploration methodology in this part of Newfoundland which can be applied in forested terrain even during winter months.

Outputs.

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C1.129 Hydrogeochemistry: Surface Waters for Geochemical Exploration (G.E.M. Hall)

Objectives. Two hydrogeochemical (Lake and stream water) surveys were carried out in Newfoundland to evaluate the potential of using newly developed analytical methods based mainly on inductively coupled plasma mass spectrometry (ICP-MS) for geochemical exploration. Elements of particular interest included the rare-earths (REE), Au and associated pathfinders (e.g., As, Sb, Se, Te, Bi), and base metals (e.g., Cu, Ni, Pb, Zn).

Methods. With the assistance of John McConnell and Chris Finch (both of the NDNR), the lake survey was carried out in the summer of 1991 in southern Newfoundland, north of Fortune Bay and east of Baie d'Espoir. A total of 136 lake water samples, including 11 field (site) duplicates, were collected in one day using a float-equipped helicopter. Samples were collected about 20 cm below the surface after initial rinsing of the bottle with the lake water. Within 24 hours following collection, samples were filtered through a 0.45 µm filter paper into a 250 ml bottle, using Millipore glass apparatus, and acidified with 1 ml of 16 M HNO_3 (Ultrex). About 50 elements, including the REEs, were determined in these waters by the GSC Analytical Method Development Section in Ottawa. Data were compared with analyses conducted at NDNR (mainly ICP-ES) and at Memorial University (direct ICP-MS, without preconcentration).

The 1992 Baie Verte Peninsula hydrogeochemical survey included the collection and multi-element analysis of 150 stream water samples and controls within an area of approximately 200 km^2 that extended from the northern tip of the peninsula to just south of the Brass Buckle Gold occurrence. Because this survey was done concurrently with C.E. Dunn's biogeochemical survey (Newfoundland MDA project C1.128), biogeochemical and hydrogeochemical samples were taken at similar sites; Peter Dimmell (consultant) assisted in both collections. This study focused on areas of known and potential mineralization, including: the ophiolitic Pacquet Harbour Group (Consolidated Rambler massive sulphide deposit [Cu-Zn-Au-Ag]; and the Point Rousse Complex (Goldenville gold-sulphide-bearing quartz veins; Penny Cove chalcopyrite-pyrite-sphalerite vein mineralization; and, Green Cove and Mud Pond volcanogenic sulphide mineralization). Samples were also taken at Deer Cove and Pine Cove. At each site, two bottles of water were collected: a 250 ml volume for trace elements which was filtered (0.45 µm) and acidified (to 0.4% in nitric acid) within 12 hours following collection; and a 125 ml volume for determination of pH, conductivity, organic carbon and the anions F, Cl, Br, SO_4, PO_4, NO_3. At selected sites, a third bottle of 1 litre volume was taken for gold determination; this sample was not stabilised to keep gold in solution as the method employed for analysis incorporated a step to leach that portion of metal adsorbed onto the container walls. All analyses were done by the GSC in Ottawa.

Results.

Baie d'Espoir lake survey

Even at low ppt levels, REEs patterns in water successfully delineated the two contrasting geological terranes found in the Baie d'Espoir area which are separated by the northeast trending Hermitage Bay Fault (i.e. Hadrynian Avalon Zone volcanic, sedimentary and intrusive assemblage to the southeast, and the Gander and Dunnage Zones clastic-sedimentary and volcanic assemblage to the northwest). In fact, waters provided more information on bedrock geological features than did the corresponding sediments. The results of this survey suggest: a) contamination is not introduced from sampling bottles (Nalgene™, LPE) or during the filtering and acidification process, even at low ng l^{-1} (ppt) levels; b) there is a high degree of correlation in element distribution patterns between lake waters and their corresponding centre-lake sediments for Yb and Tb; c) the chondrite-normalized plots for water and sediment are similar in shape and show consistent patterns *within* geological units but are distinct *between* such units; and d) the analysis of REE concentrations in surface water has potential applications for geochemical mapping.

Baie Verte stream water survey

This survey was hampered by the fact that for some drainages, the *natural* hydrogeochemical signatures were overprinted by contamination from leaching of abandoned low grade tailings at Rambler, Ming, Ming West and Deer Cove. The influence of the Rambler (Cu-Zn-Au-Ag ore) and Ming tailings were found to persist over a long distance (i.e., from Rambler Pond northwest via South Brook to its outflow into Baie Verte). Very high levels of Cu, Zn, Co, Ni, Cd, Mn, Fe and Al together with elevated levels of the REEs, Y and In were evident in the streams at these sites. Interpretation of the Baie Verte results could only be carried out by eliminating the contaminated sites from the elemental maps and then evaluating element distributions within each major lithology. With the contaminated sites removed, it was found that the upper percentiles of the data reflected the location of all known occurrences and highlighted areas for further investigation within the Pacquet Harbour and Point Rousse Groups. Stream water signatures of Cu, Ni, As, Bi and Au in particular reflect both known (e.g., Brass Buckle, Pine Cove and Deer Cove) and potential (e.g., Devil's Cove at the northern extremity of the study area, and in the southwest, at the contact between the Burlington granodiorite and the

Pacquet Harbour) areas of mineralisation, as previously indicated by bedrock features, till surveys and on-site investigations. Streams draining the serpentinised ultramafic unit in the northern part of the Point Rousse Complex were clearly anomalous in: As at 1-3.4 ppb compared to a background of < 0.2 ppb; Sb at concentrations up to 1100 ppt compared to a background of 15-25 ppt; Se at 200-600 ppt compared to 60-120 ppt; and Ni at 4-13 ppb in contrast to a background of 0.5-2 ppb. Although elaborate and costly sampling techniques designed to minimize contamination from other sources were not employed for this survey, care was taken (e.g. multiple rinsings) in sample processing (0.45 µm filtration and acidification) and analysis to negate errors due to cross-contamination. Results for deionised water blanks and sample duplicates indicate that the methodologies employed successfully minimized contamination and provides confidence in detected elemental concentrations.

Economic/Project Impacts.

1) Analysis of stream and lake waters for constituents at ppt and ppb concentration levels appears to offer a cost-effective geochemical exploration methodology that requires only minutes at each site for collection and filtration and relatively straightforward analytical procedures. Ultra-clean, expensive protocols in the field and in the laboratory are *not mandatory* for accurate and precise results.

2) Bedrock geological features can be outlined by water trace element chemistry, as shown particularly well by the REEs.

3) These surveys led directly to the development of recommended procedures for hydrogeochemical exploration programs.

4) These surveys pioneered the application of low level ICP-MS analysis in hydrogeochemistry.

5) The Baie Verte water analyses led to an environmental study of the contamination around Rambler, and ultimately resulted in a clean-up of the tailings impoundments.

Outputs.

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C1.21 LABRADOR BASE METAL AND PRECIOUS METALS SUBPROGRAM

C1.211 Geology, Northern Torngat Mountains (M.J. Van Kranendonk)

Objectives. The original project objective was to document the geology and structural development of the Archean to Paleoproterozoic Burwell domain, of the northern Torngat Mountains, and to produce a 1:50,000 scale map of this area. However, because of the involvement of the Newfoundland Geological Survey Branch, the project was expanded to include mapping of the entire northern Labrador peninsula north of 59°15'N and examination of the structural relationships around the triangular region formed by the "big bend" in the Abloviak shear zone and the Komaktorvik zone. Final results were to be published at 1:50,000 (NTS 24P/7, 8, 9, 10, 11,15, 16 and 1:100,000 (NTS 25A, 24P and 14M) scales.

Methods. This three year collaborative mapping project, was jointly undertaken by the GSC (M.J. Van Kranendonk), the Newfoundland Geological Survey Branch (R.J. Wardle and B. Ryan) and several university research groups (i.e., D. Bridgwater, Geological Museum, Copenhagen - Pb-Pb isotopes on Archean rocks; F.C. Mengel, Danish Lithosphere Centre-geothermobarometry; L.M. Campbell, University of Colorado - Sm-Nd isotopes on Archean and Proterozoic rocks; T. Rivers and R. Patey, Memorial University of Newfoundland-geothermobarometry and metamorphic/ structural studies; D.J. Scott, GEOTOP, Université du Québec à Montreal - U-Pb geochronology; J. Connelly, University of Texas - U-Pb and Sm-Nd geochronology; and L. Godin, Université du Québec à Montreal - structural studies). Initial field work in 1991 was directed at mapping of areas accessible from the coast. Field work in 1992 benefited from full-time helicopter support and focussed on extending the mapping to the south. The final summer of field work, which also employed helicopter-supported traverses, focussed on the most southern part of the map area (Rae Province, interior Burwell domain, and Four Peaks domain) and on Killinek Island. The three seasons of mapping were accomplished from base camps on the northern Labrador Peninsula. Helicopter and aviation fuel were shipped to the site the year before mapping commenced in 1991. Twin Otter aircraft were chartered from the nearest communities to: bring equipment and crew to the field area; resupply camps during the mapping season, and, to leave the field area. The services of local boat operators were also employed whenever possible. All logistical costs were equally shared by the GSC and the NGSB and the cost of the Polar Continental Shelf project helicopter was also funded by various University research projects. FIELDLOG, a field-based computer mapping system, was used by the GSC

The project has resulted in the publication of seven, 1:50,000 scale colour GSC Open File maps, and a 1:100,000 scale colour compilation Open File map of the entire peninsula north of 59°15'N. Annual progress reports were written for both the GSC and NGSB "Current Research" series, and annual contributions were also made to the Lithoprobe ECSOOT volumes. Oral and poster presentations were made at: the various annual Open Houses hosted by the GSC and NGSB; Lithoprobe workshops; Joint Annual Meeting of the GAC-MAC; and, at a recent IGCP project meeting in Nottingham, England, on the "Precambrian evolution of the North Atlantic Regions".

Results. The study area forms part of the Paleoproterozoic Torngat Orogen and consists of three principal tectonic divisions. In the east are Archean gneisses of the Four Peaks domain, which escaped penetrative Paleoproterozoic deformation and is correlative with the Nain Province; in the centre is the Komaktorvik shear zone, and in the west are the Paleoproterozoic plutonic and metasedimentary rocks of the Burwell domain. The Burwell domain is bounded to the south and southwest from reworked Archean gneisses of the Rae Province and deformed Paleoproterozoic supracrustal rocks of the Lake Harbour Group by the Abloviak shear zone. The eastern margin of the Rae craton within the Torngat Orogen is marked by a 10-40 km wide unit of garnet-feldspar-quartz-sillimanite-graphite paragneiss and diatexite known as the Tasiuyak gneiss complex. In the Burwell domain, the Tasiuyak gneiss grades northward into paragneiss with calc-silicate horizons that contain tectonically-bounded slices of Archean orthogneisses of unknown precursor (Nain, Rae, other?).

The Four Peaks domain, which consists predominantly of buff-coloured, granulite-facies Archean gneisses of overall tonalitic composition, occupies the easternmost part of the map area from Cape Kakkiviak to Home Island. These rocks extend into the north-south trending Komaktorvik shear zone, where they become variably sheared and where they are intruded by Paleoproterozoic plutonic and metasedimentary rocks that extend west to form the Burwell domain. The Four Peaks domain is intruded by Paleoproterozoic (pre-1.91 Ga) Avayalik dykes.

The Komaktorvik shear zone refers to the broad zone of ductile shearing that separates the Burwell domain from the Four Peaks domain and also locally overprints the boundaries of these domains. The eastern part of the Komaktorvik shear zone consists of Archean gneisses, the Hutton anorthositic suite, and Proterozoic dykes and tonalite intrusions, all variably straightened and mylonitized by Paleoproterozoic deformation. The western part of the shear zone is located within the various Paleoproterozoic plutonic and metasedimentary rocks that extend westward into the Burwell domain.

The Burwell domain consists predominantly of Paleoproterozoic plutonic rocks interspersed with belts of metasedimentary gneiss. The plutonic rocks of the domain consist of two major components; an eastern belt of grey diorite, quartz diorite, tonalite and granite, and their derived gneisses; and a western association of buff, charnockitic rocks ranging from granite to monzonite and quartz diorite in composition (i.e., Killinek charnockitic suite). Burwell domain plutonic rocks have calc-alkaline chemistry, indicative of a magmatic arc origin. U-Pb dating indicates a range of 1.91 to 1.86 Ga., and preliminary Nd-Sm isotopic results indicate that these rocks have interacted, in part, with Archean basement. In the southern part of the Burwell domain, the presence of slivers of layered amphibolite having MORB-like composition are interpreted to represent slices of oceanic crust (i.e., possibly the relics of a back-arc basin).

Metasedimentary rocks of the Burwell domain are represented by several belts of rusty-weathering, garnet-biotite pelitic and psammitic gneiss, generally strongly migmatized and dispersed throughout the domain.

The structural pattern of the map area is dominated by a major swing in strike from east-west in the interior of the Burwell domain, into the north-south trends that define the sinistral Komaktorvik shear zone. This is proposed to have resulted from oblique, sinistral Burwell-Archean Nain convergence and was accompanied by east-side-up uplift, resulting in exposure of the lower crustal levels of the Nain Province in the form of the granulite-facies gneisses of the Four Peaks domain. A late, west-side-up phase of contractional shear that followed this deformation may have been associated with uplift of Burwell domain. An age range of 1.79 to 1.71 Ga has been established for amphibolite-facies deformation in the Komaktorvik shear zone. This is younger than the 1.845 to 1.825 Ga Abloviak shear zone, which forms the Burwell (Nain)-Rae province suture to the southwest and suggests that the Komaktorvik shear zone evolved as the result of continued Archean Nain-Burwell interaction following Burwell (Nain)-Rae collision.

Although still very debatable, the tectonic evolution of the northern Torngat Orogen appears to be related to, in sequence: late Archean-Paleoproterozoic rifting of the Nain margin (depending on age and origin, possible emplacement of Hutton anorthosite complex?); deposition of platformal and extensive turbiditic metasediments on the Rae margin (Tasiuyak and Burwell gneisses), coeval with, or postdated by, accretion; arc magmatism (e.g. Killinek charnockitic suite) on both the Nain and Rae margins, with the possible development of a back-arc basin in the former (1.91-1.89 Ga.); and Nain-Rae collision at ca. 1.86 Ga (development of Abloviak shear zone). Subsequent deformation and cooling continued through several pulses, from ca. 1.843-1.710 Ga. (Komaktorvik shear zone). According to this model, the Tasiuyak gneiss complex and Burwell domain rocks represent the remnants of an arc terrane trapped between the two colliding Archean (Rae and Nain) cratons.

Economic/Project Impacts. The project has resulted in:

1) A better knowledge of the distribution of rock types throughout the northern Labrador peninsula;

2) The recognition of a Paleoproterozoic magmatic arc suite built on Nain Province margin;

3) A more thorough understanding of the structural and tectonic evolution of the Paleoproterozoic Torngat Orogen;

4) The identification of a suite of posttectonic, ultrapotassic (lamprophyre clan) dykes, which probably represent an extension of the kimberlite/lamprophyre suite of the Saglek area into northernmost Labrador, and that may have diamond potential;

5) Identification of rusty-weathering gossans with massive pyrite and local chalcopyrite in: anorthositic rocks along the Labrador Sea coast; in or adjacent to, granulite-facies metasedimentary rocks situated in the western part of the map area; and charnockitic rocks of the interior Burwell domain. Assay results of sampled gossan zones yielded uneconomic concentrations of sulphides, precious metals and PGE's.

6) Identification of numerous pyrite-pyrrhotite enriched zones contained in the Tasiuyak domain gneisses, which may possibly be derived from metal-rich black shale units in the gneiss protolith, and could have some SEDEX potential. The ultramafic slices, found along the boundary of this unit, and also pyritiferous layers within meta-gabbro-ultramafic horizons of the meta-anorthosite suite, may also be worth investigating for Ni-Cu mineralization.

Outputs.

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C1.212 Lithogeochemistry and Geochronology of the Mugford Group (M.A. Hamilton and R.F. Emslie)

Objectives.

1) To systematically map, prepare stratigraphic sections, describe the physical volcanology, sample and analyse volcanic and sedimentary rocks of the Mugford Group.

2) Obtain high-quality major and trace element geochemical analyses, and isotopic analyses (U-Pb, Sm-Nd, Rb-Sr and Pb-Pb) on selected samples in order to determine the tectonic setting, age and economic potential Mugford Group units.

3) Compare Mugford Group rocks with possible correlative mineralized units of the Ramah Group (e.g., Pb-Zn Mississippi Valley Type (MVT)-style mineralization in the Reddick Bight Formation).

Methods. During the 1992 and 1993 field seasons, M.A. Hamilton (GSC Post Doctoral Fellow) with the assistance of a student and R.F. Emslie (GSC) used base and fly camps, foot and boat traverses, and occasional helicopter support to complete geological mapping and sampling of the Mugford Group along coastal Labrador. Camp equipment and other logistical support was provided by the GSC. Sample preparation and major and trace element analysis (XRF, ICP) were done in the analytical labs of the GSC in Ottawa. Examination of thin sections, prepared by an external contractor, and electron microprobe mineral chemical analyses were completed by M.A. Hamilton. All isotopic analyses (tracer Sr, Nd and Pb; geochronological U-Pb) were completed by M.A. Hamilton in the GSC's Geochronology Laboratory. Final project map compilation was done with the assistance of the GSC's cartographic section.

Results.

1) The Mugford Group is one of three principal sequences of essentially undeformed Paleoproterozoic supracrustal rocks that have been deposited on the Archean Nain craton in northern Labrador, and is unique in exposing a relatively high proportion of mafic volcanic extrusives.

2) Analysis of fractions of rare, euhedral zircons in tuffaceous rocks of the Shark Gut formation (middle of Mugford Group stratigraphy) yields an age of 1969±4 Ma, which is interpreted as the age of extrusion of the Mugford Group basic lavas. This is supported by an internal Sm-Nd mineral-whole rock age of 1902±54 Ma for a 30+m thick gabbroic sill that intrudes basal shales of the group, which must be a minimum age for sedimentation.

3) Extensive petrologic and chemical analysis of Mugford Group volcanics illustrate that the lavas have a relatively restricted compositional range. However, there are early flows in the main units (Calm Cove and overlying Finger Hill formations) which are transitional to weakly alkalic in composition, and in each case, these are followed by progressively more tholeiitic, subalkaline basalts. The rocks in general share many physical and chemical properties of continental rift or plateau basalts (e.g. Coppermine, Keweenawan, early Iapetus rift) as well as those from rifted continental margins (i.e., they are relatively evolved (Mg# 65-40) basalts and have elevated concentrations of incompatible trace elements and the REE ([La/Yb]N = 2-12, La 30-200 xCH). The overall incompatible trace element concentrations and Nd isotopic compositions show no evidence for a MORB-like source reservoir for the Mugford Group volcanics. Calculated initial ϵ_{Nd} (at 1.97 Ga) range from +1.5 to -5.5, which, combined with low Zr/Nb, La/Nb and Y/Nb ratios, suggests limited continental lithospheric influence and a potential role of plume activity during the initiation of rifting accompanying Mugford Group volcanism.

4) The Mugford Group hosts several types of sulphide occurrences, including: minor massive pyrite-pyrrhotite lenses interbedded with cherts and siltstones; pyritiferous black shales; pyrite mineralizations near the base of many gabbroic sills which intrude sediments, and numerous fragmental sulphide showings (py, po, sp, ga), present in a basal debris flow. Chalcopyrite and pyrite disseminations and blebs occur throughout many of the volcanics, agglomerates and volcanic breccias.

Economic/Project Impacts. The mafic volcanic sequences, combined with a roughly 150m thick lower sedimentary sequence, suggests that the Mugford Group has considerable

sequence, suggests that the Mugford Group has considerable metallogenic (SEDEX/MVT base metal) potential. Observed similarities between basal Mugford and mineralized Ramah Group stratigraphies implies the former has a similar potential for SEDEX and MVT sulphide occurrences. Many petrological and geochemical similarities exist between Mugford Group volcanics and basalts of the Noril'sk region, Siberia. Analyses are currently in progress to determine the potential of Mugford Group rocks and associated subvolcanic gabbroic and ultramafic sills for their PGE, Ni and Cu sulphide potential.

Outputs.

PUBLICATIONS

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C1.214 Metallogenic Map, Central Labrador Mineral Belt (S.S. Gandhi)

Objectives. To compile metallogenic map(s), at 1:250 000 scale, of the Central Labrador Mineral Belt (i.e., those parts of NTS 13E, F, G, H, I, J, K, L, M, N and O that are contained between latitude 53°45' N-55°30' and longitude 56°30'W-63°00'W).

Methods. The compilation and plotting of geological, mineral occurrence, geochronological and structural data was done by various GSC employees under the direct supervision of S.S. Gandhi. The final compilation will consist of three sheets: one east of longitude 60°00'W; one west of longitude 60°00'W, and a third containing the legend and insert maps. Preliminary uncoloured version of the map and legend are expected to be released on GSC open file at the end of March 1997.

Results. The resulting project maps will provide users with an up-to-date, comprehensive, geological and metallogenic synthesis of the Central Labrador Mineral Belt.

Economic/Project Impacts. Open File release of the compendium map sheets of the Central Labrador Mineral Belt should prove useful to government sponsored mineral resource assessments, private sector mineral exploration and academic geoscience research.

Outputs.

OPEN FILES

Gandhi, S.S., Dumpfey, D. and Williamson, B.L.

In Prep: Preliminary metallogenic map of Central Labrador Mineral Belt; Geological Survey of Canada, Open File Report, two 1:250 000 scale map sheets and 1 sheet of inset maps and accompanying legend.

C1.215 Regional Geochemistry, Labrador (P.W.B. Friske)

Objectives.

1) To complete high density, in-fill lake sediment and water survey in selected areas of central Labrador.

2) To initiate an extensive reanalysis program of previously collected archived lake and stream sediment samples.

3) To produce for GSC Open File release, a series of 1:1 000 000 scale geochemical compilation maps (geochemical atlas).

Methods.

Florence Lake Detailed Lake Sediment and Water Survey

Under the direction of P.W.B. Friske and C.C. Durham (both of the GSC), and in collaboration with J. McConnell of the Newfoundland Geological Survey, a high-density, helicopter-supported lake sediment survey was completed during the period June 26 to July 7, 1992 in the vicinity of Florence Lake, Labrador (i.e., NTS 13K/6, 13K/7, 13K/10, and 13K/15). Four hundred and four lake sediment samples

over a 3 600 km² area. Data was published in GSC Open File 2650, which was released on June 29, 1993. This open file included text, data listings with statistics, 43 element distribution maps, and a sample location map.

In order to examine element distribution and sediment composition and structure at, and just below, the sediment-water interface, lake sediment core samples were collected at seven sites. 'Wet' geochemical analyses were completed by Berringer Laboratories Limited (Alberta), for 109 samples prepared from cuts along the core lengths (including duplicates and control references). Associated waters were analyzed for 33 elements at the GSC's analytical laboratories in Ottawa.

Reanalysis Program

Lake sediments and waters have been collected by the Geological Survey of Canada (GSC) in Labrador under various geochemical initiatives since 1976. Following completion of the 1986 stream sediment survey, completed under the 1984-89 Canada-Newfoundland Mineral Development Agreement, the entire region of Labrador had been covered by drainage geochemical reconnaissance surveys at a sampling density of one sample per 13 km². Dried sediments remaining after initial analyses were stored at archive facilities.

Under the direction of P.W. Friske, and in consultation with Dr. Peter Davenport, Newfoundland Geological Survey Branch, the dried archived sediments from approximately 21 450 lake sediment sites and 1 650 stream sediment sites, were submitted to Becquerel Laboratories Incorporated, Mississauga, Ontario, for the reanalysis of 34 elements using Instrumental Neutron Activation Analysis (INAA). Analytical results from INNA analysis, together with previous analytical results, were released in a series of 18 open files, the last of which were published on March 24, 1994. These Open Files typically consisted of: a 1:250 000 scale sample location map accompanied by text that details the sampling and analytical methods; analytical results; and relevant statistics. Maps and text, which were printed by Ashley Reproductions, Ottawa, were also made available in digital form.

Labrador Geochemical Atlas Series

Digital geochemical data for all of Labrador for copper, nickel, and mercury are being compiled by GSC staff, and a number of preliminary maps have been produced. This initiative will be concluded under the succeeding 1994-1995 Canada-Newfoundland Agreement on Mineral Development.

Results.

Florence Lake Detailed Lake Sediment and Water Survey

Results of this study indicate that there is a significant correlation in the distribution of a number of elements in lake sediment and water. Of the 15 elements considered U, Ni, Ce, La, Sm, Tb, Cu, and Mn exhibit some degree of association. Zn, Cd, Pb, F, V, Fe, and Co do no appear to have a sympathetic relationship based on the available data. Plots of the sediment and water data indicate that, for those elements which do not correlate, the distribution of the sediment data is closely related to chemical composition of the underlying bedrock, whereas the water data show no obvious association. The lack of correlation for some elements may be related to relatively high within-site variability. This is particularly the case for the water data, where collection procedures need to be re-evaluated in order to identify, and if possible reduce, the source(s) of variability. The correlation in the distribution of sediment and water data suggests that the existing extensive National Geochemical Reconnaissance sediment database may be useful for identifying areas in which naturally elevated concentrations of elements occur in surface waters.

Reanalysis Program

With the exception of reconnaissance scale bedrock geology, project geochemical data often represent the only existing source of geoscientific information in the public domain for much of Labrador. Reanalysis data provides the mining community with a valuable source of data for exploration purposes as evidenced by the increase in sales of geochemical open files following the recent discovery of significant nickel-copper-cobalt sulphide mineralization in mafic rocks along the western edge of the Nain Plutonic Suite at Voisey Bay, southwest of Nain.

Economic/Project Impacts.

The project has resulted in high quality geochemical data which supports both mineral resource assessment initiatives and exploration activity, geological mapping, and provides fundamental baseline date for environmental and public health studies.

Outputs.

PUBLICATIONS

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reconnaissance data, Province of Newfoundland (Labrador) (NTS 22P, 23A and 23B); Geological Survey of Canada, Open File 2689, 170 p., 1 map.

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C1.216 Labrador Geoscience Data Integration and Interpretation (R.A. Klassen)

Objectives. To compare geochemical data derived from regional surveys of till and lake sediments, and to evaluate their significance in terms of bedrock geology, glacial history, and mineral exploration using GIS analysis.

Methods. The study is based on multi-element geochemical surveys of lake sediment and till samples from an area covering much of central Labrador, including the Central Mineral Belt and the Labrador Trough. In addition, the data include: surficial geology, bedrock geology, based on a recent compilation, till pebble lithology, and glacial direction. The data have been combined into a 'multi-layer' GIS database for analysis (ArcInfo). Because the two media types were collected at different geographic locations and at different sample densities, geochemical variations in lake sediments were approximated by a contoured surface. From that surface, at each till collection site an 'estimated' lake sediment value was determined for geochemical comparison.

Results. Geochemically, the two media types illustrate similar regional patterns, although there can be notable local exceptions. Where the geochemical patterns are similar, the geochemistry of both surficial material types reflect bedrock composition, modified to varying degrees by the effects of glacial history and transport. There are systematic regional differences, however, in the relative enrichment of trace elements between sample media. The differences could reflect regional differences in geology, climate, vegetation, and lake productivity, among other factors. For example, the degree of trace metal enrichment in lake sediments is greater in the Labrador Trough (more than four-fold) than over the over the Harp Lake Highlands (one to two fold). They indicate that factors other than geology could be significant to the interpretation of lake sediment geochemistry surveys.

Economic/Project Impacts. Because there have been significant delays in compilation of datasets and results are preliminary, impacts of this project are limited. It has, however, the potential to define: 1) computer-based methods for the review of regional geological and geochemical datasets; 2) a basis for evaluating and comparing two distinct types of regional geochemical surveys and their signicance to mineral exploration.

Outputs.

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C1.31 NEARSHORE PLACER SUBPROGRAM

C1.311 Placer Mineral Potential off Northeast Newfoundland (D.L. Forbes and J. Shaw)

Objectives. To map the distribution of surficial sediments and the abundance of placer minerals (particularly gold) off the northeast coast of Newfoundland and develop local deposit models.

Method. Project goals were achieved primarily through the use of ships based at the Atlantic Geoscience Centre to collect reflection seismic and sidescan sonar data, cores, sea-bed photographs, and grab samples. The offshore surveys included:

1990: Cruise 90-013 (C.S.S. Hudson) - White Bay, Baie Verte, Halls Bay.
Cruise 90-035 (C.S.S. Navicula) - Coastal waters, Baie Verte-Hamilton Sound.

1991: Cruise 91-031 (C.S.S. Navicula) - Coastal waters, White Bay-Twillingate.
Cruise 91-026 (C.S.S. Dawson) - Baie Verte to Cape Freels.

1992: Cruise 92-301 (C.S.S. Parizeau)-Fogo-La Scie
Various small boat surveys (the Nicholas, the Paul and inflatable Zodiac) -Baie Verte-Hamilton Sd.

Some project work (e.g., sample analyses) was done under contract/in collaboration with C-CORE (Centre for Cold Ocean Resources Engineering, Memorial University of Newfoundland) and M-Tech Incorporated. As the project progressed, cruise reports and contract reports on assays and

placer potential were released on GSC Open File, and presentations were made at conferences, including the Newfoundland Department of Natural Resources Open House. A GSC Bulletin is being prepared that includes a 1:250 000-scale map of off shore surficial sediments.

Results. The project has successfully identified five zones of surficial sediments and processes present off northeast Newfoundland, these include:

1) Deep offshore basins that contain thick postglacial mud overlying glacial marine gravelly sandy mud.

2) Basin transition zone in which the sea bed has been eroded by currents, so that glacial marine sediments are exposed in places. This zone has slight potential for hosting enhanced levels of (non-exploitable) fine particulate gold.

3) Iceberg impacted zone: above 200 m depth, the keels of icebergs impact the sea bed, which enhances the potential for concentration of (non-economic) fine particulate gold.

4) Wave dominated zone: above 60 m depth, sea-bed sediments are mobile due to waves, currents, and iceberg impact, which are frequent in this zone. The main sediment sources are glacial deposits. This zone could potentially host gold placers, however, little gold has been found in grab samples.

5) Intertidal - supratidal zone: although this zone could potentially host placer gold, little gold has been found.

The wide, shallow inner shelf between Hamilton Sound and Cape Freels has extensive deposits of highly mobile sand and gravel, together with numerous beaches and coastal dunes. Gold placers could have formed in this setting, but unfortunately there are no sources of gold in the local bedrock or glacial sediments, hence gold is absent in offshore samples. Elsewhere there are gold occurrences onshore, but the lack of high levels of gold in glacial sediments, the narrowness of the wave and current-dominated zone, and the general absence of beach deposits makes the existence of economic gold placers unlikely. However, anomalous levels of gold, including visible particles, were found in localized, small, discontinuous shallow pockets of coarse postglacial sand proximal to local till sources, at Deer Cove in Baie Verte.

Economic/Project Impacts. This study provides the first comprehensive understanding of surficial sediments and processes on the inner shelf between White Bay and Cape Freels, an area that encompasses some of the largest coastal embayments on the island (e.g. Bay of Exploits, Halls Bay). In addition to assessing the potential for placer gold in the coastal zone, project results provide the first overview of seabed characteristics over a wide area of the northeast Newfoundland inner shelf. This provides not only essential complementary data on Quaternary events in relation to onshore information, but also a necessary framework for further mineral and aggregate exploration, resource management (e.g., exploitation of fish resources) and environmental assessment on the inner shelf (e.g., identification of suitable areas for marine and provincial parks).

Outputs.

PUBLICATIONS

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1991: Progress in marine-placer surveys off northeast Newfoundland; in Report of Activities 1991, Newfoundland Department of Mines and Energy, p. 102.

C1.411 Coordination (A.L. Sangster)

Objectives. To facilitate the production/publication/ dissemination of federal (and/or) appropriate provincial Exploration Stimulation Program outputs that have been completed after the official termination dates of any of the Canada-Newfoundland Economic Regional Development Agreements (e.g., 1984-89 Mineral Development Agreement; 1990-1994 Cooperation Agreement on Mineral Development).

Economic/Project Impacts. This project ensures that all federal Geoscience Program Newfoundland MDA project investigations are thorough and complete, and that relevant results are made available to identified user groups in an expeditious fashion.

Outputs.

PUBLICATIONS

Currie, K.L. and van Berkel, J.T.
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2. MINING AND MINERALS TECHNOLOGY

C2.1.1 Development of 3D Finite Element Algorithm for Blast Modelling

Objectives. Advances in the development of mathematical models to describe fragmentation processes led BP Selco to investigate this technique as a blast design tool to improve production and safety at their Hope Brook gold mine. A computer program, designed to account for factors known to affect breakage, fragmentation and damage, was to be developed and verified with field data from the Hope Brook Mine.

Methods. Based on a cost-shared agreement, a federal contract was awarded to BP Selco. An engineering firm that specializes in finite element modelling was to be sub-contracted to assist in software development.

Results. BP Selco suspended operation of the Hope Brook gold mine in May 1991 and was not able to fulfil its contractual commitment. The contract was therefore cancelled. A plan for executing the project had been developed, computer hardware had been purchased and a literature survey had been undertaken prior to contract termination. The subsequent new operator of the mine, Royal Oak Mines, was not interested in pursuing this work.

C2.1.6 Development of a Blasthole Drill Positioning System

Objectives. As part of their continuing efforts to increase drill productivity, IOCC, together with Custom Industrial Automation, proposed to develop, demonstrate and evaluate support software and an operating interface to position blasthole drills. While component technologies were available to perform different aspects of the positioning function, there was no system on the market that could integrate them into an effective drill positioning system. An evaluation of available positioning technology (GPS, microwave and laser autotracker) as applicable to IOCC's requirements was also conducted.

Methods. Based on a cost-shared agreement, a federal contract was awarded to IOCC. IOCC sub-contracted Custom Industrial Automation of Toronto to develop an interface that would convert position information from a mobile receiver on the drill mast into a graphical operator display which would present the pre-planned drill pattern and real-time drill position. This system was then demonstrated in the field using a microwave range-range positioning system that consisted of three beacons overlooking the test drill pattern.

Results. This project, using the off-the-shelf microwave-based positioning technology and a custom designed user interface, successfully demonstrated the accuracy and practicality of a remote-based drill positioning system. Hole positions as surveyed by IOCC after drilling compared well to the drilled positions as computed by the microwave system, with an average difference of 24 cm between the survey and the system.

The direct impact of this project is that IOCC budgeted over $200,000 in 1994 for the development of a complete automatic drill positioning system. Coupled with drill positioning will be the development of an automatic shovel positioning and locating system. Successful implementation of these systems will eliminate the need for staking and surveying every blasthole, improve blasting results and provide more direct control over the grade of ore delivered to the mill. All of these benefits will reduce the unit cost of mining a ton of iron ore and improve IOCC's competitiveness.

C2.1.7 Development of Shovel/Drill Monitoring Systems

Objectives. As part of IOCC's efforts to reduce the cost of production, they have undertaken, with Aquila Mining Systems, the development of a drill monitoring system that will improve blasting efficiency while maximizing production rates. Also being developed is a shovel monitoring system that will be capable of assessing muckpile diggability, blast effectiveness and shovel operating practices as well as be able to generate basic shovel production statistics. Each system will also be able to monitor, record and analyze data for predictive maintenance purposes.

Methods. Based on a cost-shared agreement, a federal contract was awarded to IOCC. Aquila Mining Systems was sub-contracted to develop the necessary software/hardware and commission it on IOCC's #33 Drill (Bucyrus-Erie 49RH) and #53 Shovel (Bucyrus-Erie 295BII). Operating and trouble-shooting manuals were to be developed to accompany each system.

Results. The drill monitor is used routinely by drill operators as it provides a real-time display of a variety of drill operating variables plus basic production statistics. IOCC is using the fracture detection information, as identified by the designed and trained neural network component of the system, to examine explosive selection and charge placement in the borehole. IOCC has also used the system to conduct a comprehensive analysis of bit performance and wear.

The shovel monitoring system was designed as a passive system with no operator interface or communication. It

continuously records relevant operating parameters and characterizes muckpile diggability for each dig cycle and then downloads this information to IOCC's DISPATCH system. IOCC is using the diggability data, together with information from the drill monitoring system, to improve blast design. The dig cycle data will be used to help IOCC improve shovel operators' skills.

The comprehensive instrumentation assembled for the shovel by Aquila has made it possible to monitor a number of operating variables the mine had not had ready access to in the past. The availability of this data motivated mine maintenance to explore expanding the shovel monitor's capability towards a comprehensive maintenance monitoring and trouble shooting facility. In March 1995, Aquila was awarded a $243,000 contract by IOCC to develop a trouble shooting graphical user interface (GUI) and data buffering capability for the shovel and to expand the shovel monitoring capability to include a calculation of dipper load weights for production control.

Since 1990, IOCC has spent more than 40 million dollars replacing older shovels and drills with new, more productive units. The development of these advanced monitoring systems will insure the continued health, reliability and productivity of this new equipment and contribute to IOCC's ability to compete in the marketplace.

C2.2.1 Improved Iron Recovery in Spiral Plant

Objectives. A new design of wash water distributor was proposed to effect better spiral performance. These distributors were expected to reduce the variance of wash-water flowrates across a spiral bank, enabling greater control of metallurgical performance than the old wash water header system. The objective of the project is to evaluate the new wash water distributors via in-plant trials.

Methods. Based on a cost shared agreement, a federal contract was awarded to Wabush Mines. The project was carried out in the plant with in-house technical and operational staff. No sub-contracting was necessary. The wash water distributors were installed on specific mill lines and tested over a several month period.

Results. A comparative test program was carried out using Mill Line #3 as the standard of comparison. There were two phases of testing. First, Mill Lines #3 and #4 were operated under identical conditions to determine whether the new distributors would produce a spiral concentrate of superior quality. This was achieved. The second phase focused on more detailed testing of Mill Line #4. Based on the success of this project, Wabush recommended that the new distributors be installed on all remaining mill lines. This has since been done. The net improvement in iron recovery attributed to the application of these distributors is approximately 1.9%.

C2.2.2 Bentonite Substitution, Phase I: Pot-Grate Testwork with a Selected Organic Binder

Objectives. Bentonite addition to the pelletizing mix has an adverse effect on the technology and economy of iron ore pellet production. Earlier testing has shown that an organic binder (Peridur) has promise as a substitute binding agent. The substitution of Peridur for bentonite is estimated to reduce the gangue content of the pellets by 0.5%, thereby improving pellet quality. The objective of the project is to carry out further testing to optimize the application of Peridur.

Methods. Based on a cost shared agreement, a federal contract was awarded to IOCC. CRM was sub-contracted to carry out the additional pot grate experiments using various concentrations and mixtures of binding agents. Optimum process conditions were to be developed prior to undertaking larger scaled in-plant test trials and economic evaluations, both of which are outside the scope of this project.

Results. The laboratory testwork showed that Peridur with a small addition of bentonite can be used to successfully control the balling process. The influence of a small amount of bentonite is especially helpful at higher filtercake moistures. Pot-grate tests showed that pellet reducibility can be achieved while maintaining the other important pellet quality variables. Pellet silica is reduced by 0.5% which provides an additional benefit to the customers. Pellet swelling is a problem for acid pellets but not with fluxed pellets.

The results of this project are sufficiently encouraging to proceed with a commercial trial on one balling module in the pellet plant. As well, a detailed technical and economic assessment would need to be completed.

C2.2.4 Improved Iron Recovery while Meeting Varied Customer Quality Demands

Objectives. Iron recovery has been declining because of improved product quality demands by customers and changes in crude ore characteristics. Optimization of spiral performance and examination of alternative process flowsheets were seen as areas needing investigating. In-plant testing utilizing IOCC's pilot plant facilities is required for this exercise. The objective, therefore, of the project is to carry out in-plant pilot testing to identify where process improvements could be made using existing process equipments.

Methods. Based on a cost shared agreement, a federal contract was awarded to IOCC. The pilot test program was

carried out in-house with technical and operating staff provided by IOCC. An independent contractor (D. Doyle and Associates) was hired to facilitate the test program.

Results. Several pilot runs were completed under different flowsheet configurations at a throughput of approximately 20 tph. The basic conclusion drawn from the test program is that to improve iron recovery, the magnetite and hematite fractions require initial magnetic separation followed by separate concentration circuits for recovery of these two minerals. Iron recoveries of 78% were achieved at silica levels of less than 3%. The cost and complexity of the flowsheets studied, however, have raised some concern over their practical application in the mill. It was recommended that testing of other gravity concentration methods are needed which has formed, in part, the substance of a future MDA project (C2.2.8).

C2.2.5 Application of Expert Systems to High Tension Circuit

Objectives. The high tension circuit at Wabush is used to separate hematite from silica. Ore characteristics which affect the separation include specific gravity, size, shape, surface condition and liberation and purity of the minerals. The circuit is manually controlled and this presents difficulties in maintaining product quality during fluctuations in feed characteristics. The objective of the project is to introduce circuit automation through the application of an expert system.

Methods. Based on a cost shared agreement, a federal contract was awarded to Wabush Mines. Comdale Technologies Inc. was sub-contracted to develop and apply the expert system. Two phases were identified: Phase I (Development of the software and knowledge base) and Phase II (In-plant testing and final system application).

Results. A real-time expert system was successfully developed and installed and is now controlling the high tension circuit. The system is expected to provide a more consistent iron concentrate product and has provided the basis for future expandability. Plans are underway by Wabush to build on the system via the installation and prototyping of additional field sensors.

C2.2.6 Process Development for the Production of Manganese Concentrates

Objectives. The average manganese (Mn) content of the orebody at Wabush is 2%. The market for high manganese iron concentrates/pellets is dwindling. Selective mining is currently practised to enable control of the grade of manganese being fed to the plant. Such practises are costly and highly inefficient. This project will investigate removal of manganese from the ore using rare earth magnetic separators. The aim is to produce a saleable grade manganese concentrate product while concurrently lowering the Mn content of the iron concentrate.

Methods. A federal contract was awarded to Wabush Mines. Wabush sub-contracted their corporate research facility in Hibbing, Minnesota (Cleveland Cliffs) to carry out some of the laboratory scale process testing. A pilot size rare earth magnetic separator was leased from a supplier and was in-plant tested to remove/reject manganese.

Results. The test program showed that Mn rich tailings (3 - 14% Mn) from the rare earth separator circuit can be treated by a number of steps, including high tension separation, rare earth separation, reduction roasting, grinding and magnetic separation to produce a 60% Mn concentrate. Roasting is necessary to convert the iron present as goethite to magnetite. The developed flowsheet would recover 80-90% of the Mn from the tailings feed and result in a gain in iron recovery of 1.2 percentage points over existing plant performance.

The project was very successful in that an economic process was developed to produce approximately 70,000 tpy of saleable manganese concentrate. As a consequence, an increase in iron production of approximately 300,000 tpy is possible. Wabush is considering commercial installation of this manganese recovery process.

C2.2.7 Testing of Finer Mill Sizing for Improved Spiral Circuit Iron Recovery

Objectives. Preliminary testing showed that finer grinding could improve spiral circuit iron recovery using 4 mm trommel panels and 1.5 mm sizing screens. These changes were made to the mill resulting in an increase in iron recovery. Further reduction to 1.0 mm screens was proposed to recover even more iron units. The objective of the project is to in-plant test finer screen media to determine whether a further improvement in iron recovery is possible.

Methods. Based on a cost shared agreement, a federal contract was awarded to Wabush Mines. The project was carried out by in-house technical and operating staff. Screens were purchased and installed in the spiral mill circuit for actual in-plant evaluation.

Results. The finer media screens were installed in 50% of the test mill line and ran over a four month period. The screens performed well and several grade and recovery curves were generated. The results were inconclusive in terms of whether any improvement in recovery was obtained. Wabush concluded that the partial installation (50% of the mill line) may be responsible for such insignificant results.

Consequently, Wabush proceeded to outfit the entire mill line with these screens to determine whether any improvement can be realized.

C2.2.8 Iron Weight Yield Improvement

Objectives. Iron recovery has been declining in recent years because of the milling of finer grain ores and market demands for concentrates having a lower silica content. The future of the operation is seen to be dependant on reducing unit operating costs by recovering more of the iron. IOCC have supported many studies in the past to address the whole problem of low iron recovery (e.g., Project C2.2.4). This project is viewed as the final research stage before implementation of significant changes to the mill process. In particular, the objective of the project is to identify processes that will increase fine iron recovery.

Methods. Based on a cost-shared agreement, a federal contract was awarded to IOCC. Numerous sub-contractors were hired over the course of the project (3 years) to bring specific expertise to bear in the carrying out of the various project elements. Four phases were identified: Phase I, Assessment of Gravity Concentrators; Phase II, Assessment of Spirals and Flotation; Phase III, Mineralogical Evaluation; and Phase IV, Review of On-Stream Analyzers.

Results. The results of the project have given IOCC direction on improving their mill to effect better iron recoveries. A decision was made to replace the existing Humphrey spirals with Reichart spirals, a change which is expected to improve mill throughput, product variability and iron recovery by 5%. Flotation test work proved successful but was not seen as a feasible option because of the environmental effects. Several centrifugal and jigging concentrators were tested, and the Kelsey jig performed the best in terms of recovering a high grade low silica product. IOCC is proposing to purchase several Kelsey units over the next couple of years. The mineralogical work at Memorial University has been useful in determining various ore types and areas where recovery improvements can be made. The evaluation of on-stream analyzers has provided key information needed to proceed with further automation of the mill process. Final conclusions and recommendations are being drafted by IOCC.

C2.2.9 Iron Concentrate Recovery Improvements

Objectives. Iron recovery remains a priority. Wabush has invested a great deal of time and money into improving the recovery of saleable iron units. This project, in part, is a follow up of past MDA work and has the objective to investigate various techniques and technological advances to overcome iron recovery constraints.

Methods. Based on a cost-shared agreement, a federal contract was awarded to Wabush Mines. The project was divided into four phases: Phase I - Improvements to existing spiral circuits, Phase II - Flotation, Phase III - Centrifugal separation and Phase IV - Process control improvements. Various contractors were hired over the course of the three-year project and a variety of process units for in-plant testing were leased.

Results. Phase I demonstrated that mothballed spiral circuits could be used to respiral rougher tailings to increase iron recovery approximately 1.4%. Under Phases II and III, flotation and the Kelsey jig were compared. The jig was deemed to be better because could remove iron from tailings at concentrate grade with no environmental impact. Treatment of flotation reagents poses an environmental problem. Iron recovery improvement of 9.8% is possible with the jig and Wabush is planning to purchase a unit in 1996. Phase IV reviewed the existing process control system and determined the best route for expansion. This phase recommended the installation of a Distributed Control System for future expansion.

C2.2.10 Improvement in LTD Property of Fluxed Pellets

Objectives. Current trending suggests that market demand for fluxed pellets are on the rise in North America. Low temperature disintegration (LTD) is an important metallurgical property in marketing fluxed pellets. Changes in iron blast furnace practises have demanded feed pellets having improved LTD properties. The objective of the project is to investigate process options to improve the LTD quality of IOCC's fluxed pellets.

Methods. Based on a cost shared agreement, a federal contract was awarded to Iron Ore Company of Canada. CRM (Centre des Recherches Miniere) and CANMET were sub-contracted to carry out pot-grate experiments using different binding agents and pellet mineralogy, respectively. The laboratory test conditions were plant tested to confirm the laboratory findings.

Results. The project was successful in identifying process conditions that improved LTD. A range of results were achieved using the different binding agents (colemanite and Greek bentonite) and fluxes from various sources. Process conditions such as finer grind, higher firing temperatures and higher magnetite equivalent were determined to have positive influences on LTD values. Some of the project findings which have had a positive effect on LTD have already been incorporated into plant practise with positive results.

C2.2.11 Development of a Direct Reduction Pellet Product

Objectives. The fastest growing markets for iron ore is in the form of low silica pellets for direct reduction in electric furnaces. Reduction in silica is key to IOCC producing a direct reduction pellet product. Flotation is an established method to reduce silica at acceptable iron recoveries to meet DR grade specifications. The objective of the project is to investigate the application of flotation on pellet plant feed to meet a target of 1.5% silica.

Methods. Based on a cost-shared agreement, a federal contract was awarded to the Iron Ore Company of Canada. Lakefield and CANMET were sub-contracted to carry out laboratory and in-plant flotation (using both conventional and column cells) and amine destruction testing, respectively. CRM was contracted to carry out pot-grate experiments on the flotation concentrate. Operating costs for flotation were estimated.

Results. The in-plant tests confirmed the laboratory work at Lakefield with similar reagent consumption rates. Concentrate with less than 1% silica can be produced at iron recoveries of 98%. Columns produced similar metallurgical results as conventional cells. It was estimated that the operating cost of a 500 t/day flotation plant would be $0.87 per tonne for reagents and labour. CRM concluded that DR pellets meeting international quality standards can be easily produced from the flotation concentrate. Based on the success of this work, IOCC is continuing its examination of the commercial application of flotation in Labrador City.

C2.2.12 Reduction of Iron Pellets on a Straight Grate Indurating Machine

Objectives. In 1991, some preliminary testing was completed at McMaster University which showed that it was possible to reduce green or partially indurated pellets to a high degree of metallization in a short period. This direct reduced iron (DRI) would provide IOCC with the opportunity to market a higher priced product which is gaining a wider market as new steel making processes are being commercialized. Further testing is necessary to establish suitable operating conditions, and an estimation of the process requirements such as gas and heat and of the process economics. The objective of the project is to address these requirements.

Methods. Based on a cost shared agreement, a federal contract was awarded to IOCC. McMaster and Menex Inc. were sub-contracted to carry out the laboratory test program and a pre-feasibility of co-generation, respectively. Davy International was hired to estimate the capital and operating costs.

Results. The laboratory results confirmed the thermodynamics and reaction kinetics. A product with a high degree of reduction and of acceptable metallurgical quality (97%) can be produced in a modified straight grate furnace. Coal was a preferred carbon source compared to coke. The major obstacle to overcome is the large volume of hot off-gases that result from the process. For the economics of the project to be attractive, the energy contained in these gases need to be utilized. Co-generation was considered. For 500 megawatts of electrical energy production, the capital cost would be in the order of $150-$200 million. Davy estimated that to convert one furnace to produce DRI, the capital and operating cost would be $60 million US and $70 - $80 US per tonne, respectively.

Other process options need to be studied before the full economic potential of producing DRI can be determined.

C2.2.13 2B Belt Wash Manganese Correlation

Objectives. The lag time between shovel set-ups in an out-of-grade combination and detection of this situation is about six hours. The objective of the project is to determine whether there is a correlation between the manganese content of the ore storage tripper belt wash material and the ore delivered to ore storage. Considerable savings would result from early detection and response to shovel set-ups if the belt wash manganese assay could be correlated for this purpose.

Methods. A federal contract was awarded to Wabush Mines. A pipe sampler was purchased to facilitate the sampling process. The test program involved reducing one mill line to empty and then refilling to capacity while automatically cutting periodic samples from the 2B belt wash water using the pipe sampler. The collected samples were then assayed.

Results. The pipe sampler manganese assay was compared to predicted mine composites, as well as to mill hourly spiral concentrate data. The final stage compared the pipe sample manganese to the spiral circuit tails and concentrate on one mill line. Although some correlation between the manganese content of the residual fines washed from the 2B crude ore feed belt and the grade of the final spiral iron concentrate, the correlation is not accurate enough to be used confidently for ore grading control purposes. However, the project has provided a greater appreciation of the variation of manganese within the ore body, the heterogeneity of ore movement through the milling process and the variation in manganese distribution by size fraction.

C2.3.4 Metallurgical Evaluation of Using In-door Vat Leaching on Pine Cove

Objectives. In-door vat leaching for the recovery of precious metals has been developed by NovaGold Resources.

NovaGold operated a mine in New Brunswick based on this processing technology with success. This project will evaluate the feasibility of applying this technology to the Pine Cove gold deposit located near the town of Baie Verte.

Methods. Based on a cost shared agreement, a federal contract was awarded to Pine Cove Resources. TUNS (Technical University of Nova Scotia) was sub-contracted to carry out the test program which consisted of laboratory scale experiments to investigate process parameters such as ore feed sizing, agglomeration and leaching conditions. Column leaching was used to extract the gold from the agglomerated ore.

Results. The test program demonstrated that in-door vat leaching can be economically applied to the Pine Cove gold deposit. In the bottle rolls and column tests, gold recoveries in excess of 85% were achieved within a leaching time of 24 hours using cyanide as the leaching reagent. Prior to leaching the ore had to be ground to -100 mesh and agglomerated with cyanide solution and cement in a balling mill. Approximately 11.24 kg/t of cement is necessary to effect proper pellet strength at a moisture content of around 25% and a curing time of 10 -20 hours. Proper agglomeration is critical to achieving high gold recoveries over a short time frame.

Based on the favourable results returned by this project, Pine Cove Resources has decided to proceed with a feasibility study to commercialize the Pine Cove property. The feasibility has been completed which has deemed the project/mine to be economic. The company is currently in negotiations with potential investors regarding financing of the commercial project.

3. ECONOMIC DEVELOPMENT

C.3.1.1 Limestone/Dolomite Study

Objectives. To identify markets and specifications for dolomite, along with production and delivery costs. To relate known provincial limestone and dolomite resources with these identified markets and determine the opportunities for further development of the limestone and dolomite industry in Newfoundland.

Methods. A contract was awarded to Atlantic Consulting Economists Limited (Atlantecon) to carry out the project according to the terms of reference. Sub-consultants for the study included: O.W. Roskill Industrial Consultants, of London, England; Jacques Whitford Consulting Engineers and Scientists, Dartmouth, N.S.; and, J. Tuach Geological Consultants, Inc.

Results. The report deals principally with crushed stone for construction and includes a pre-feasibility study for large export quarries at Port au Port sites. Main market focus in on the eastern United States. Extensive trade statistics are given. The report compiles information for review by potential developers and it was produced to encourage interest in the investment of this aspect of the mineral industry in the Province.

World trade figures did not reveal major opportunities for the export of limestone and dolomite from Newfoundland. In Europe, considerable quantities of limestone for aggregates are imported overland by Germany, the Netherlands and Switzerland, and it may be that there are opportunities to supply the first two countries by sea. However, eastbound ocean freight rates are less advantageous than westbound rates and there is strong competition from the very large quarries in the United Kingdom, which are pursuing these markets.

The United States offers opportunities for the sale of aggregates, since the U.S. market is expected to expand as the economy comes out of recession. There are markets on the east coast which are in a position of diminishing reserves and others where the truck, rail, or barging distances from the domestic sources to big coastal cities make seaborne aggregate potentially competitive. The potential opportunities, and the degree of competition, are very specifically determined by local factors, and each needs detailed examination on its merits.

The Canadian market to target would essentially be west of the Maritimes, though probably Quebec rather than in to the Great Lakes, where shipment must be in the Seaway and prices on the U.S. side tend to be very low because of the presence of some very large, low-cost producers. The Caribbean market is a feasible target for part of a Newfoundland producers output. The total market seems to be in the order of 2-3 million tonnes per year, but a large part is presumably satisfied by a major producer in the Bahamas.

C.3.1.2 Peat Market Study

Objectives. To identify markets and specifications for peat, along with production and delivery costs. To relate known provincial peat resources with these identified markets and determine the opportunities for further development of the industry in Newfoundland.

Methods. A contract was awarded to Acres International Limited of St. John's, Newfoundland, who worked in

association with Northland Associates Limited to carry out the project according to the terms of reference.

Results. The report provides a review of uses for peat, world horticultural peat markets, and Newfoundland's competitive position. The conclusions and recommendations section of the report provides ideas under the utilization categories of energy, horticultural peat, and high value-added products. It was recommended that government undertake additional research on the development of a peat inventory, weather research as it relates to peat drying, and block-cutting technology.

C.3.1.3 IRMIS Demonstration

Objectives. The purpose of the project was to provide a demonstration of the capabilities of the INFOCUS software so the package and the concept could be assessed by the Newfoundland Department of Natural Resources.

Methods. The cost of a consultant's trip to St. John's in November, 1991, was underwritten. The consultant answered technical questions about the INFOCUS software and discussed with government officials the sort of applications that were feasible for the software.

Results. The project was predicated on the assumption that exploration and development would be encouraged by making the data maintained by the then Department of Mines and Energy more accessible to private companies. The project assisted departmental officials in their continuing assessment of "desk -top GIS" packages, and no further action specific to this project was planned or implemented beyond the funding of the briefing trip.

C.3.1.4 27th Industrial Minerals Information Exchange (Banff, Alberta)

Ojectives. Attendance at these forums raised the profile of Atlantic Canada in the Industrial Minerals market and facilitated the making of new marketing contacts.

Methods. Under this authorization and parallel ones in the other Atlantic Mineral Development Agreement holding provinces, the 27th Forum on the Geology of Industrial Minerals, held May 5-10, 1991, in Banff Alberta, was attended by a delegation consisting of three provincial representatives, one each from N.S, N.B., and Nfld., and one representative from the Atlantic Regional Office of Energy, Mines and Resources Canada.

Results. As a result of this trip, the conference organizers have accepted a bid to host the conference in Halifax, Nova Scotia in May, 1994. Reports by Conference participants were submitted to Management Committee for their guidance in assessing future initiatives put to the Agreement.

C.3.1.5 28th Industrial Minerals Forum (West Virginia, U.S.A.)

Objectives. As with the 27th Industrial Minerals Forum, this project raised the profile of Atlantic Canada in the Industrial Minerals market and facilitated the making of new marketing contacts.

Methods. Under this authorization and parallel ones in the other Atlantic Mineral Development Agreement holding provinces, the 28th Forum on the Geology of Industrial Minerals, held in May, 1992, in West Virginia, was attended by a delegation consisting of three provincial representatives, one each from N.S, N.B., and Nfld., and one representative from the Atlantic Regional Office of Energy, Mines and Resources Canada.

Results. See C.3.1.4.

C.3.1.6 Mini-Mill Steel Industry Conference

Objectives. To obtain information on the future of the steel industry as it will affect the communities in Labrador dependent on iron ore sales.

Methods. A conference on this topic was attended March 1-3, 1992, by a senior Newfoundland Department of Mines and Energy employee and a representative from Labrador.

Results. Information was acquired which was of assistance in planning future educational/informational activities on the iron ore industry in Labrador. A participant's report was made available on the conference.

C.3.1.7 CERR Economic Studies Program

Objectives. The objective was to develop a practical program which will provide participants with a comprehensive understanding of current analytical techniques and economic evaluation tools used in the mining and mineral industry. The Centre for Earth Resources Research has a mandate to promote knowledge and indeed excellence in the area of earth resources, research and development. The Centre has designated the areas of mineral and petroleum economics as areas of high priority. The program of study will take the form of an intensive two-week program to be presented at the Centre. The target clientele will be people involved in the mining industry, both private and public sector. The program of study will be designed and promoted so as to attract not only people involved directly in mining through employment with a mining company or a governmental department or agency with responsibilities for mining, but also to attract people involved in financing, servicing and monitoring the industry, e.g. the banking

industry, the investment industry, environmental industries and representatives of Departments of Finance, Development, Environment, Justice (Fed. & Prov.), etc. Previous experience with this type of program has demonstrated the value of a broad technical approach to training. The interaction between regulators, industry and suppliers of goods and services in this environment has proven quite beneficial to all sides.

Methods. Negotiations with CERR/MUN (the Center for Earth Resources Research/ Memorial University of Newfoundland) were completed and a contract was signed in the last quarter of 1992-93.

The material was keyed to the client group noted above. The program also involved the preparation of teaching aids such as computer based case studies and problem solving techniques.

Results. The content of a two-week course on the economic impact of mineral industry developments has been prepared by CERR.

The project was completed on March 31, 1995. Earlier in the fiscal year, it had been agreed to by all parties involved in directing the work that the local market for such a course had been weakened by economic problems and government restraint with regard to potential civil service attendees, and thus completion of the work would be accepted to be the completion of the course materials.

C.3.1.8 Labrador West Economic Diversification Study

Objectives. In February, 1992, representatives from the Department of Mines and Energy, Department of Natural Resources Canada, Town Councils of Labrador West, IOCC and Wabush discussed and agreed to the need for a detailed study of the Labrador West mineral sector. The Labrador West area is almost totally dependent on the exploitation of the iron ore resources of the area. This study is seen as a way to increase local participation in the industry by servicing the existing industry; assessing the potential for further processing, refinement or expansion of the products presently produced; and to assist and promote the potential for other developments in the mineral sector.

Methods. A contract was awarded to Hatch Associates Limited to carry out the project according to the terms of reference.

Results. A status reporting session held in Toronto June 17 and 18, 1993, had determined that there was serious potential in, and further work was warranted on: the production of direct reduction iron by the Midrex Fastmet process; silicon metal production; the local production of grinding media; and, the production of manganese concentrate. During the second day's briefings, seven Wabush and Labrador City municipal officials and businessmen were present as well as representatives of Midrex, IOCC and the commercial banking firm of Gundy and Associates, Limited.

A final report on this project was completed on February 18, 1994, and over fifty copies of this report were requested by participants at the Labrador West Iron Ore Conference "Prospects For The Future", held November 6-8, 1994 in Labrador. The author of the report, Dr. Gordon Laurie, also gave an overview of the work at this conference. In fiscal year 1994-95, as a follow-up activity on this project, Synmap Limited were contracted to determine locations of diamond potential in Labrador.

C.3.1.9 Completion of Existing Initiatives

Objectives. This was a clean-up initiative to support various provincial projects that were underfunded due to budget constraints. Each of the tasks undertaken will ensure that the projects are brought to a logical conclusion to maximize the benefits from money already expended by the Agreement.

Methods. As each initiative was defined it was incorporated into a requisition and the work was contracted for as per the standard requirement for federal contracts.

Results. Contracts were issued as follows: (1) James Weick was retained to work with a provincial geologist to: sort samples according to the year collected; select samples representative of rock types found in each area; plot the location of samples on geological maps; and, store the selected samples in trays in secure storage in the drill core library at Torbay. (2) Robinson Blackmore were issued a contract to print and bind a volume entitled "Geology and Mineral Deposits of the Lushs Bight Group".

C.3.1.10 Update on Fluorspar

Objectives. During 1994 a consensus was reached by the Economic Development Sub-Committee Co-chairmen that only one of the targeted industrial minerals warranted further examination in this fiscal year and that mineral was fluorspar.

Methods. The foremost authority on fluorspar is B.L. Hodge and Partners of the U.K. The Company principal, Brian Hodge, had been to the Newfoundland fluorspar deposit as recently as December, 1993, and he had been an advisor to the Newfoundland government on market opportunities for that deposit since 1977. His Company agreed to prepare a report identifying market potential for the St. Lawrence

fluorspar deposits and developing a marketing strategy for the resource for a fixed fee. The intent of this strategy was to renew the interest of investors and developers in the resource.

Results. The project was completed in the fall of 1994 and potential developers are still assessing the economic viability of reactivating the deposit.

C.3.1.11 Demonstration of Dimension Stone

Objectives. The dimension stone sector in Newfoundland and Labrador has made great gains in the past few years in identifying deposits and bringing several deposits into commercial development. It was the intension of the Economic Development Sub-Committee to work with the Newfoundland and Labrador Dimension Stone Producers Association (DSPA) and the Federal-Provincial Dimension Stone Industry Development Committee, to identify how best to display the potential output of the various quarries in Newfoundland and Labrador. The objectives defined in greater detail as the project was developed were: (1) to transport and process material from selected marble deposits for use as a decorative stone; (2) to undertake commercial level production on a test basis to verify the cost and technical feasibility of these operations, and to identify any production or related technical difficulties which may arise at that stage; (3) to obtain input relating to suitability, handling concerns, packaging requirements, volumes, etc.; and, (4) to have material displayed in a major ski resort/ tourist development.

Methods. A contract was issued to the Marble Mountain Development Corporation to execute an unsolicited proposal which fit the intention of the project authorization. Project officers visited the project architect, Nova Tile, Nelson Monuments, the Lodge under construction at Marble Mountain, and the extraction sites for the marble blocks.

Results. The demonstration project produced quantities of dimension stone which were used in a major ski resort/tourist development and as sample display material.

This project assisted in demonstrating the technical and commercial feasibility of the marble industry for Newfoundland and Labrador. The installation in the resort and the samples improved product viability. The proponent will meet all environmental regulations and conditions. Finally, the results of this processing and usage will be detailed in a report which was presented at the completion of the project.

C.3.1.12 Participation in the 30th Industrial Minerals Forum

No funding accessed for this purpose.

C.3.1.13 Chamber of Minerals Industries

Objectives. The purpose of this project was to assist in the establishment of a Chamber of Mineral Industries in Newfoundland and to follow-up on earlier studies which had substantiated the value and need for such a special interest body.

Methods. Contract was let to Peter Dimmell, Geologist, to work on the development of the Chamber.

Results. A Newfoundland and Labrador Chamber of Mineral Resources was established and Peter Dimmell, P.Geo., was appointed the Executive Director. During the period of the contract, Board of Directors meeting were held, and local, national, and international promotional and educational efforts in support of the mineral industries of the Province were undertaken in an effort to demonstrate the value of the Chamber and to secure its' future.

IV. MINERAL INDUSTRY ASSISTANCE PROGRAM

4.1 INFRASTRUCTURE

C4.1.1 Newfoundland Resources and Mining Access Road-Lower Cove

Objectives. The Newfoundland Resources and Mining Company operates a large limestone aggregate quarry at Lower Cove on the Port au Port Peninsula. The Port au Port Peninsula is host to many different beds and grades of carbonates and the purpose of this project was to assist the company in gaining access to a bed of high quality calcium carbonate a few kilometers in-land from the aggregate quarry. The company hopes to be able to market the high quality calcium carbonate into the flue gas desulphurization market.

Methods. Access was provided through construction of a properly ditched and graded haul road. The work was carried out under the supervision of the applicant.

Results. The company now has ready access to this deposit of high purity limestone and has shipped out some trial shipments for marketing purposes.

Economic/Project Impacts. No sales of material have resulted from the project at this point in time so there are no significant economic impacts to date.

C4.1.2 Newfoundland Slate Inc. Access Road to Quarry

Objectives. Newfoundland Slate Inc. operates a slate quarry at Nut Cove across from Random Island. The company has constructed a new building to house a modern slate processing plant and developed the quarry to allow the use of modern quarrying equipment. It needed a good access road to allow passage of heavy equipment for efficient transportation of the slate from the quarry to the plant. This project facilitated the construction of the access road.

Methods. Access was provided through construction of properly ditched and graded haul road. The work was carried out under the supervision of the applicant.

Results. The quarry and plant are now accessible via a road suitable for large haulage trucks

Economic/Project Impacts. The plant and quarry are now in operation, providing 60 full-time jobs

C4.1.3 NovaGold Resources Inc. Pine Cove-Power Line

Objectives. The Pine Cove gold deposit was discovered several years ago. It was examined (and drilled) by several large companies who all walked away from it on the basis of the deposit being too small to support a conventional mill. NovaGold proposed to put the deposit into production using the technology (agglomerated vat leach) it used to produce at Murray Brook in New Brunswick. The purpose of this MIAP project was to assist with the construction of the needed power line to make the project more viable.

Methods. The power line was to be a standard design, installed by Newfoundland Power.

Results. The applicant was unable to acquire the major financing required to put the deposit into production so the power line never went ahead.

Economic/Project Impacts. The project was approved but never completed.

C4.1.4 Teranov Mining Corporation, Pressure Packer Upgrade

Objectives. Teranov Mining is producing marketable asbestos fibre from the tailings pile at the old asbestos mine in Baie Verte. The operation has been having technical difficulties, partly due to worn out pressure packers in the mill. The objective of this project was to make the operation more viable by overhauling and upgrading the pressure packers.

Methods. The pressure packers were overhauled using standard parts and techniques, under the supervision of the applicant.

Results. The result of the project was that the packers worked much more efficiently with reduced down time.

Economic/Project Impacts. The plant employs 80 people when operating.

C4.1.5 Teranov Mining Corporation, Tailings Line Upgrade

Objectives. Teranov Mining is producing marketable asbestos fibre from the tailings pile at the old asbestos mine in Baie Verte. After re-processing, the tailings are being dumped via pipe line into the old north pit. The operation has been having technical difficulties, partly due to an inadequate tailings line. The objective of this project was to install a new tailings line to reduce down time in the plant caused by problems with tailings disposal.

Methods. The tailings line was constructed of standard materials using routine techniques.

Results. The new line works well and has reduced the down time of the plant.

Economic/Project Impacts. The plant employs 80 people when operating.

C4.1.6 Greater Lamaline Area Development, Road to Thermal Peat Resource

Objectives. The residents of the Greater Lamaline area rely on peat from local bogs for much of their home heating needs. There was a need to extend the existing access road further into the bog to keep up with production.

Methods. The road was constructed using standard road construction equipment and techniques.

Results. The community now has continued access to this important local resource.

Economic/Project Impacts. With access ot the locally produced peat, the need for importing alternate fuels is diminished. Also four local, seasonal jobs are protected.

C4.1.7 Armstrong World Industries Canada, Access Road to Pyrophyllite

Objectives. Armstrong World Industries opperater a pyrophyllite mine at Manuels, Nfld. If the pit is developed to its full potential, it will cut across an existing public road that

is used by local residents to access woodlands. The objective of the project was to build a new stretch of road to bypass the pit's furthest point of possible development. In particular, the applicant needed assistance with that portion that crossed Johny's Pond.

Methods. The road was constructed with standard road building techniques and equipment under the supervision of the applicant.

Results. The result is that the roadway has been constructed across Johny's Pond, and only a small amount of work is needed to completely bypass the pit.

Economic/Project Impacts. The project has extended the life of the mining operation and the ten associated jobs by several years.

C4.1.8 Royal Oak Mines Inc., Gravel Airstrip

Objectives. When Royal Oak took over the Hope Brook mine, one of the assumptions they made was that they could improve efficiency by ferrying work crews in and out by aircraft rather than by boat. To facilitate this, a new gravel airstrip needed to be constructed with suitable navitgation equipment installed.

Methods. The airstrip was built to normal standards using conventional equipment. State of the art navigational aids were installed to facilitate landing in adverse conditions.

Results. The airstrip is fully operational and crew changes now occur on schedule with resulting improvements in morale and efficiency.

Economic/Project Impacts. This project is just one factor in the economic viability of the Hope Brook mine and the creation of 230 jobs.

C4.1.9 Royal Oak Mines Inc., Construction of Bulk Storage

Objectives. When Royal Oak took over the Hope Brook mine, one of the assumptions they made was that they could improve efficiency by reducing the length and number of trips that their supply boat had to make from Port aux Basques. This project enabled the construction of bulk storage facilities and the improvement of docking facilities to allow this assumption to hold true.

Methods. Docking facilities were improved at Rose Blanche so that the ship did not have to return all of the way to Port aux Basques on each run. A storage shed was constructed at the mine site to hold copper concentrate so that the ship's schedule was not predicated on the copper concentrate production.

Results. The length and number of trips made each month by the supply boat has been greatly reduced along with the associated costs.

Economic/Project Impacts. This project is just one factor in the economic viability of the Hope Brook mine and the creation of 230 jobs.

C4.1.10 Newfoundland Resources and Mining Co., Lower Cove Power Line

Objectives. The Newfoundland Resources and Mining Co. recently constructed an access road to a high quality calcium carbonate deposit near their aggregate quarry. They wished to construct a power line to the site which would enable the use of an electircally powered crusher.

Methods. The power line was to be strictly conventional in design and construction.

Results. The applicant decided not to proceed with the project due to a lack of signed contracts for the product.

Economic/Project Impacts. The project was approved but never completed.

C4.1.11 LIDC, Bus Boat for Quarry

Objectives. The LIDC operates a dimension stone quarry on Paul Island in Ten Mile Bay, near Nain. They needed a boat suitable for hauling men and equipment to and from the quarry to make the operation more efficient.

Methods. The applicant located and purchased a suitable boat with financial assistance under this project.

Results. The operation now is properly equipped for efficient transportation of men and equipment.

Economic/Project Impacts. This project is just one factor in the economic viability of the Paul Island quarry and the creation of 25 jobs.

C4.1.12 Newfoundland Slate, Generators

Objectives. Newfoundland Slate Inc. operates a slate quarry at Nut Cove across from Random Island. The company has constructed a new building to house a modern

slate processing plant and developed the quarry to allow the use of modern quarrying equipment. It needed three phase power to operate the plant equipment. This project facilitated the purchase and installation of diesel generators to provide the needed power.

Methods. Suitable generators were purchased "off the shelf" and installed in a properly designed and constructed building adjacent to the main plant.

Results. The complany now has suitable, cost effective power to operate the plant.

Economic/Project Impacts. The plant and quarry are now in operation, providing 80 full-time jobs

C4.1.13 Classic Stone Inc. (Granite), Road Upgrade to Quarry

Objectives. Classic Stone Inc. wished to sample the red granite from a sight known as the "runway quarry". The road needed to be upgraded and extended in order to get suitable equipment into the site.

Methods. The actual road construction was contracted to a local construction firm who used standard equipment and techniques.

Results. The quarry site is now readily accessable. This road may also provide future access to other granites in the southern portion of the Topsails.

Economic/Project Impacts. This project was one factor in the start-up of the North Atlantic Stone plant in Buchans. The plant employs 23 people who create monuments and stone furniture for export and import substitution.

C4.1.14 Mount Peyton Granite Co., Road Upgrade to Quarry

Objectives. Mount Peyton Granite Co. (since aborbed by Classic Stone Inc.) needed to upgrade the access road to Borney Lake to test the "Black Granite" found there.

Methods. The road construction techniques were quite routine and involved the replacement of a culvert where the road crossed a salmon stream.

Results. The company now has access to this deposit. The deposit is now the source of one of the main commodities being marketed by the North Atlantic Stone Co.

Economic/Project Impacts. This project was one factor in the start-up of the North Atlantic Stone plant in Buchans. The plant employs 23 people who create monuments and stone furniture for export and import substitution.

C4.1.15 Armstrong World Industries Canada, Access Road to Pyrophyllite Phase II

Objectives. Armstrong World Industries opperater a pyrophyllite mine at Manuels, Nfld. If the pit is developed to its full potential, it will cut across an existing public road that is used by local residents to access woodlands. The objective of the project was to build a new stretch of road to bypass the pit's furthest point of possible development. In particular, the applicant requested assistance with that portion of road after Johny's Pond.

Methods. The road was to be extended using conventional equipment and techniques.

Results. This project was approved as a contingency project. It is valid work that needs to be done, but was considered by the MIAP subcommittee to be of a lower priority than other projects (in part because the company had already received some assistance for road constructon) and was never implemented.

Economic/Project Impacts. The project was approved but never completed.

4.2 FEASIBILITY / DEMONSTRATION

C4.2.1 Placer Chromite Bulk Sample, Port au Port Bay

Objectives. It has been known for many years that chromium rich placer deposits exist on the floor of Port au Port Bay. The objective of this project was to sample and map these deposits to test them for commercial viability.

Methods. The applicant leased soft sediment drilling/ sampling equipment from the U.S. and carried out an orderly sampling program. The necessary boats were leased for the project from local fishermen.

Results. The program confirmed the areal extent of the placer deposits, but showed that there is insufficient grade and volume to support commercial production at current prices.

Economic/Project Impacts. No long-term economic benefit will accrue from this project unless the price of chromium increases substantially in the future.

C4.2.2 Hollinger North Shore Exploration, Manganese Feasibility Study

Objectives. The applicant wished to complete a feasibility study examining the economic viability of the James Mine.

Methods. The feasibility study was to be completed by a combination of in-house personnel and outside consultants using standard industry practices.

Results. The applicant submitted final products. The products were rejected by NRCan due to significant inadequacies. The company declined the opportunity to address NRCan's concerns and the project was cancelled.

Economic/Project Impacts. No known economic benefits have accrued to date from this project.

C4.2.3 Hollinger North Shore Exploration, Iron Feasibility Study

Objectives. The applicant wished to complete a feasibility study examining the economic viability of the Ruth Lake Mine.

Methods. The feasibility study was to be completed by a combination of in-house personnel and outside consultants using standard industry practices.

Results. The applicant submitted final products. The products were rejected by NRCan due to significant inadequacies. The company declined the opportunity to address NRCan's concerns and the project was cancelled.

Economic/Project Impacts. No known economic benefits have accrued to date from this project.

C.4.2.4 Mart Mining and Exploration Ltd., Graphite - Bench-scale Beneficiation Study

Objectives. The applicant has acquired the mineral rights to a graphite deposit in Labrador. The objective of this project was to confirm the beneficiation procedures that would be required to produce marketable products from the deposit.

Methods. The applicant proposed to use the services of CANMET, TUNS, Graphicor Resources inc. or Asbury Graphite Mills Inc. to conduct bench scale metallurgical studies to confirm benficiation characteristics and blending parameters needed to produce a marketable concentrate.

Results. The company was unable to raise its required funding for the project and it did not proceed.

Economic/Project Impacts. No economic benefits have accrued at this point.

C4.2.5 Auracal Resources Inc., Calcium Carbonate Feasibility

Objectives. Auracal Resources owns the mineral rights to a high quality calcium carbonate deposit near Roddickton on the Great Northern Peninsula. The objective of this project was to test the marketability of this material by shipping a suitable sample to an end-user in Chicago for beneficiation and marketing tests.

Methods. The material was shipped by boat to Chicago and run through a battery of industry standard procedures to determine its suitability.

Results. The material was determined to be of good quality, but not economic to produce commercially at this time. The high cost of transportation is one of the major factors working against the deposit.

Economic/Project Impacts. No economic benefits have accrued to date.

C.4.2.6 Tiara Marble Corp., Block and Tile Samples

Objectives. Tiara Marble owns the marble deposit known as Pye's Ridge, located near Deer Lake. The objective of the project was to extract and ship several sample blocks of marble from this deposit to established marble fabrication plants. These sample blocks were cut and polished into finished one square foot tiles for testing and marketing purposes.

Methods. Where possible, blocks were extracted from fresh outcrop using minimal amounts of explosives. Where this was not feasible, competent boulders were used.

Results. The material behaved well on the production scale equipment and polished into a good final product.

Economic/Project Impacts. This particular deposit has not yet gone into production and so no long term economic benefits have been realized to date.

C.4.2.7 Classic Stone Inc. (Granite), Block and Tile Samples

Objectives. Classic Stone Inc. holds the quarry rights to a number of granite deposits in Newfoundland. The objective of the project was to extract and ship several sample blocks of granite from these deposits to established granite fabrication plants. These sample blocks were cut and polished into finished one square foot tiles for testing and marketing purposes.

Methods. Where possible, blocks were extracted from fresh outcrop using minimal amounts of explosives. Where this was not feasible, competent boulders were used.

Results. The material behaved well on the production scale equipment and polished into a good final product.

Economic/Project Impacts. This project was one factor in the start-up of the North Atlantic Stone plant in Buchans. The plant employs 23 people who create monuments and stone furniture for export and import substitution.

C.4.2.8 J.Tuach, Sandstone Sample - Retaining Wall

Objectives. John Tuach discovered a deposit of competent sandstone near Deer Lake, that has potential to produce marketable flagstone products for landscaping. The purpose of this project was to open up a suitable quarry face for production purposes and to build a demonstration project to show the beauty and utility of the product.

Methods. The applicant has kept the project small to avoid over-capitalising. The rock was loosened by blasting and then moved with a small front end loader.

The demonstration project that was finally constructed was a small patio and with a table and benches at a gas station at the foot of Marble Mountain.

Results. The project was a complete success, with the applicant now having reasonable access to the material and local landscaping firms and customers being able to see the potential of the material.

Economic/Project Impacts. The applicant is now producing from the quarry on a reasonably regular basis, creating up to six seasonal jobs.

C.4.2.9 Appalachian Granite, Quarry Trial

Objectives. The Appalachian Granite Co. holds the quarry rights to a number of granite deposits in Newfoundland. The objective of the project was to extract and ship sample blocks of granite from one of these deposits to established granite fabrication plants.

These sample blocks were cut and polished into finished one square foot tiles for testing and marketing purposes.

Methods. Where possible, blocks were extracted from fresh outcrop using minimal amounts of explosives. Where this was not feasible, competent boulders were used.

Results. The material behaved well on the production scale equipment and polished into a good final product.

Economic/Project Impacts. The applicant decided against establishing a stone quarry at this time and no long term economic benefit has been realized from this project as of yet.

C4.2.10 Classic Stone Inc. (Granite), Quarry Trial

Objectives. Classic Stone Inc. holds the quarry rights to a number of granite deposits in Newfoundland. The objective of the project was to extract several sample blocks of granite from the runway quarry deposit to test the material for suitaility in monument construction.

Methods. Blocks were extracted from fresh outcrop using standard dimension stone quarrying procedurs. The sample blocks were cut and polished into finished products for demonstration and marketing. Samples were also submitted to standard ASTM tests.

Results. The material behaved well on the production scale equipment, polishing into an excellent final product. The ASTM tests also showed that material to be of excellent quality.

Economic/Project Impacts. This project was one factor in the start-up of the North Atlantic Stone plant in Buchans. The plant employs 23 people who create monuments and stone furniture for export and import substitution.

C4.2.11 Monument and Granite Works, Quarry Trial

Objectives. Monument and Granite Works holds the quarry rights to a red granite deposits near Grand Falls in Newfoundland. The objective of the project was to extract several sample blocks of granite from this deposit to test the material for suitaility in monument construction.

Methods. Monument and Granite Works entered into a joint venture arrangement with Classic Stone Inc., whereby Classic Stone was contracted to do the actual quarrying of the material using standard dimension stone quarrying techniques. The sample blocks were cut and polished into finished products for demonstration and marketing. Samples were also submitted to standard ASTM tests.

Results. The material behaved well on the production scale equipment, polishing into an excellent final product. The ASTM tests also showed that material to be of excellent quality.

Economic/Project Impacts. This project was one factor in the start-up of the North Atlantic Stone plant in Buchans. The plant employs 23 people who create monuments and stone furniture for export and import substitution.

C4.2.12 Major General Resources (Gold), Rendell-Jackman Feasibility Study

Objectives. Major General Resources has acquired the mineral rights to the Rendell-Jackman gold deposit near Springdale. The purpose of this project was to do a preliminary feasibility study on the deposit to determine if the potential for production warranted further work.

Methods. The study was carried out uing a combination of in-house staff and outside consultants using standard industry practices.

Results. The results of the study were favourable and the company has proceeded to the next stage of developing mine plans and more detailed feasibility calculations.

Economic/Project Impacts. No long term benefits have been realized as of yet, but we are optimistic that this deposit will go into production in the immediate future and this project will have been one of the factors that made that possible.

5. PUBLIC INFORMATION

C.5.1. - C.5.10 Special Publications and Promotions* (R. Sparkes)

Objectives. Promote the province's mineral resources and their potential to the mining and exploration industries, and inform the general public, educators and students about the value of mining and the role of geoscience in society.

Methods. A variety of promotional activitites was used in attaining the project's objectives. These were: geoscientific and technical displays at local, national and international meetings dealing with mining and mineral exploration; brochures; newsletters; articles, supplements and advertisements in local, national and international publications; resource materials for schools and the public, including posters, slide sets, rock and mineral sets and videos; Mining Week activities including displays at local malls; displays at science fairs; support for Science and Technology Week; presentations to schools and junior colleges.

Results. Increased awareness of the province's mineral potential, the role of mining in the provincial and national economy, and the cooperative efforts of the federal and provincial governments to stimulate mineral development.

Outputs. Technical Displays: 36 international, national and local mining, exploration and geoscientific meetings.

General Displays: 30 public venues and special-interest meetings, such as science fairs.

Technical Publications and Material: Approximately 36 display panels on province's mineral potential and geology; "Dimension Stone" brochure; "MIAP" brochure; "Granular Aggregate" brochure; Prospectors' "Properties Available for Option" booklets; Ads and supplements in trade journals; Geological Survey brochure.

General-Promotion Publications and Materials: Travellers' Guide to the Geology - Newfoundland and Labrador (geological maps and stop descriptions); Mining Week Tabloids (funding, articles and ideas); Annual Media Kits; Five large rocks-and-minerals-in-society display panels; Rock and Mineral Kits plus guidebooks (36 specimens in wooden boxes); "Aspects of Mining" slide sets; "Geological Features" side sets; "Out of the Earth" poster (products from mining); Mining Week place mats and stickers; Geological Survey scale bars, decals and lapel pins; Gold-panning tank for science fairs; Ads in newspapers; Mineral-information folder; CNCAMD Newsletter; CNCAMD Notification Cards announcing display booths; Mining and Minerals Video Library for interested-party loans.

Other Activities: School lectures; Assisted prospectors with their Rock Room displays; Purchased and distributed minerals-related educational posters; Contributed to "Rich Mineral Resources" brochure; Newspaper articles on Agreement Projects; Mining Week and Atlantic Canada Rock Room committees.

* The provincial and federal Public Information Programs were jointly planned, executed and reported on.

PART B. CANADA-NEWFOUNDLAND AGREEMENT ON MINERAL DEVELOPMENT, 1994-1996

PROVINCIAL PROJECTS

1. GEOSCIENCE

A. Buchans - Robert's Arm

NC.1.A.1 Data Compilation / Data Management Buchan's - Robert's Arm (L. Nolan)

Objectives. The Data Compilation / Data Management component of the Buchans-Robert's Arm multidisciplinary project is designed to collect and compile, in an organized and integrated format, all relevant information for the study area. This involves extensive file research of existing data and then the collection of new data to fill gaps based upon analysis of where the existing data is out of date or is incomplete. The digital data compilations can be used in the detailed geological mapping and can be integrated with the new work into a digital format that can be incorporated in a Geographic Information System (GIS). The objectives are:

1) To compile a digital index of all geoscience data within the project area in GIS format, and to construct a digital database of all data deemed relevant and of good quality.

2) To design and maintain a GIS database for the project that will contain both existing data and new data that will be generated by field work under this program.

3) To ensure that the project database is readily accessible through desktop mapping systems and databases, and computer-generated colour maps for both project geoscientists and mineral industry clients.

Methods. The first phase of the digital compilation for the Buchans-Robert's-Arm project area focused on the windowing of regional data sets to provide a backdrop of the entire project area (1:50 000 NTS map sheets 2E/5, 2E/12, 12H/1, 12H/8, 12A/15 and 12A/16). The second phase has been to compile existing detailed information into digital form and to input new information gathered under the project. A review of relevant assessment reports has been carried out and a digital index of the contents of these files has been created.

A topographic base map was created by combining waterbodies, streams and roads from existing digital topographic NTS 1:50 000 data from Surveys and Mapping Branch, Newfoundland Department of Natural Resources. A composite geology map has been prepared for the project area from existing maps digitised at a scale of 1:50 000 and linked with legend attribute tables using the GIS software. Existing surficial geology maps have been digitised and till geochemical data from new field surveys and existing GSC surveys have been compiled to provide coverage for most of the study area. New and existing geophysical data have been compiled and data from the industry assessment reports has been captured and incorporated into the digital index for the area.

The digital index of geofile information has been compiled after a comprehensive review of government, industry and university data using GEOSCAN as a search tool. The data base contains a defined set of fields which are used to describe the assessment reports. Subsequently the geologist, geophysist or geochemist can look up the report and determine if there is any information that is relevant to thier field of interest.

The GIS database will be used to produce maps and reports for the project using CARIS Geographic Information System software. The data will also be made available in a desktop computer mapping format to ensure that all information collected by the projects is accessible to interested parties.

Outputs.

A digital index of all geoscience information within the project area has been formatted for use with ArcViewTM (A PC-based shareware viewing software). Several draft versions have been produced on CD-ROM and sent out for comments and review.

Nolan, L., Honarvar, P., Kilfoil, G., Hogan, A., King, D. and Ash, S.

1994: Buchans-Robert's Arm / Hopedale Multidisciplinary Projects, Newfoundland Geological Survey, Review of Activities. (Poster)

1995: Buchans-Robert's Arm, Newfoundland Geological Survey, Review of Activities. (Poster)

Honarvar, P., Hogan, A., Kilfoil, G., King, D., Nolan,L., Ash, S., Leawood, T., Hayes, P., Davenport, P.

1995: Digital Geoscience Data Compilations for the Buchans-Robert's Arm and Hopedale Multidisciplinary Projects, In Report of Activities, Newfoundland Department of Natural Resources, Newfoundland Geological Survey, pages 75-78.

NC.1.A.2 (cancelled)

NC.1.A.3 Quaternary Mapping and Till Geochemistry, Robert's Arm Belt (D. Liverman)

Objectives. 1:50,000 surficial mapping of the Buchans-Robert's Arm Belt was conducted with the main objectives of identifying surficial sediment distribution and grain size, mapping of ice flow indicators, examination of sediment dispersion, geochemical mapping using till and definition of Quaternary history. Mapping will concentrated on 2E/5, and 2E/12 in support of bedrock and mineral deposit studies in the same area, with sampling to supplement existing mapping on 12H/1 and 12H/8. Further geochemical sampling took place to fill gaps from previous surveys in the Buchans area.

Methods. All roads and tracks were traversed by truck or all-terrain vehicle, samples obtained and ice flow indicators on bedrock were located and recorded. This was supplemented by helicopter sampling in remote areas. 4 person field parties were used for the helicopter work, otherwise 2 person crews were employed. Natural sections, road cuts, gravel pits, exploration trenches and other exposures were examined and described when encountered. Sediment sampling was mostly from hand-dug pits 0.3-1.3 m deep, where possible from the C-soil horizon of soils developed on glacigenic diamictons (tills). Where this was not obtainable, BC or B horizons were sampled. In some areas, till was absent, and marine diamictons, marine gravels, or residual soils were sampled to investigate the potential of using these media in drift exploration.

Results. The surficial geology and geomorphology of the area is variable, with a strong contrast between coastal areas and inland. In the coastal margin topography is rugged, with mostly exposed or vegetated bedrock knobs interspersed with areas of bog and fen. Till is rare, restricted to small patches of till veneer. Close to sea level, thick fossiliferous glaciomarine diamicton is sporadically found. Marine limit is marked at the western and eastern extremes of the study area by deltas at South Brook at 75 m asl and in the Bay of Exploits at up to 58 m asl.

Inland from the coast, the surficial geology consists of a variable cover of till, mostly as veneers or blankets, with large areas of hummocks. Over most of the area striations record a single dominant north to northeast ice flow is recorded with some local variations are attributed to late deglacial topographic drawdown.

Approximately 600 samples of surficial sediment were taken with the sucessful objective of achieiving a complete regional coverage over the Buchans-Roberts Arm belt. Preliminary examination of geochemistry shows a number of high copper values, and also some significant antimony results.

Outputs.

Liverman, D.G.E., Taylor, D., and Benson, L.

1994: Quaternary mapping and surficial geochemistry, Robert's Arm, Little Bay Island and Springdale areas (NTS 2E/5, 2E/12 and 12H/8). Open House Poster, November, 1994.

1994: Quaternary mapping and surficial geochemistry, Robert's Arm, Little Bay Island and Springdale areas (NTS 2E/5, 2E/12 and 12H/8). Newfoundland Department of Natural Resources, Geological Survey, Report of Activities, p 18-20.

Liverman, D.G.E., Taylor, D., Maunder, J. and Benson, L.

1995: Quaternary mapping, Robert's Arm, Little Bay Island and Springdale areas (NTS 2E/5, 2E/12 and 12H/8). In Current Research, Newfoundland Department of Natural Resources, Geological Survey, Report 95-1, pages 113-125.

Liverman, D.G.E., Honarvar, P., Hayes, J. , Ash, S. and Colman-Sadd, S.

1995: Till Geochemistry, Robert's Arm, Little Bay Island, and Springdale areas (NTS 2E/ 5, 2E/12 and 12H/8). Open file NFLD/2513 (11 maps and text).

Liverman, D.G.E., Honarvar, P., Taylor, D., and McCrindle, P.

1995: Till Geochemistry, Robert's Arm, Little Bay Island, and Springdale areas (NTS 2E/ 5, 2E/12 and 12H/8). Newfoundland Department of Natural Resources, Geological Survey, Report of Activities.

1995: Till Geochemistry, Robert's Arm, Little Bay Island, and Springdale areas (NTS 2E/ 5, 2E/12 and 12H/8),Open House Poster, October, 1995.

NC.1.A.4 Mineral Deposit Studies (D. Evans)

Introduction. A metallogenic study of mineralization within the Robert's Arm, Cutwell and Catchers Pond groups was initiated as part of the Buchans - Robert's Arm Multi-disciplinary Project. These groups have high potential for economic base metal and gold mineralization. To aid mineral exploration a project was initiated to document the known

mineral occurrences and develop metallogenic models which would aid exploration companies. This project involved visiting each occurrence and conducting, where necessary, detailed grid and trench mapping, diamond drill core logging and collecting samples for laboratory analyses.

Work Summary, April - Sept. 1995

Work during the period of this report involved: 1) preparation for field work (examining assessment reports etc.), and 2) a 3 month field season. The field work had two main components: 1) a detailed examination of the mineral occurrences within the Roberts Arm Group, which included Handcamp, Loon Pond, Rust Pond -Ghost Pond, Sunday Cove Tickle, Chignic, West Cleary, Crescent Lake Mine, Roberts Arm Pond and the Flat Rock Tickle area; and 2) a detailed examination of significant mineral occurrences in the adjoining calc-alkaline sequences, this included the Shamrock and Oil Islands prospects in the Cutwell Group and the Lochinvar deposit in the Catchers Pond Group. The Lochinvar deposit forms part of an M.Sc. study by T. Froude at Memorial University.

Results. The mineral deposits within the calc-alkaline sequences of the northern Notre Dame Subzone can be classified as either volcanogenic massive sulphide related or epigenetic, structurally controlled, locally vein-hosted, mineralization. The volcanogenic massive sulphide mineralization varies from structurally modified massive and stringer sulphides to typical pyritic stockwork style mineralization. The epigenetic mineralization occurs either as structurally-controlled base metal/auriferous quartz veins or as disseminated mineralization.

Outputs.

Evans, D.T.W.

1995: Metallogeny of the Calc-alkaline Sequences Notre Dame Subzone. Poster, Newfoundland Department of Natural Resources, Mines Branch, 19th Annual Open House and Review of Activities.

1996: Metallogenic study of the calc-alkaline sequences, north-central Newfoundland: Preliminary Results. *In* Current Research. Newfoundland Department of Natural Resources, Geological Survey, Report 96-1.

Froude, T., Evans, D.T.W., and Wilton, D.H.C.

1995: The Lochinvar Volcanogenic Massive Sulphide Deposit. Poster, Newfoundland Department of Natural Resources, Mines Branch, 19th Annual Open House and Review of Activities.

Froude, T., Evans, D.T.W., Mullen, D, and Wilton, D.H.C.

1996: The Lochinvar volcanigenic massive sulphide deposit, Catchers Pond Group, central Newfoundland. *In* Current Research. Newfoundland Department of Natural Resources, Geological Survey, Report 96-1.

Planned Reports

Evans, D.T.W. and Froude, T.

1996: Metallogenic study of the calc-alkaline sequences, north-central Newfoundland: Perliminary Results. Newfoundland Department of Mines and Energy, Geological Survey, Report of Activities.

Plans for 1995-96

Compilation of field data and preparation of a final project report.

NC.1.A.5 Bedrock Mapping (A. Kerr)

Objectives. To provide regional geological information valuable in exploration for volcanogenic massive sulphide (VMS) deposits. Project plans emphasized detailed mapping and examination of key relation ships in volcanic sequences of the Buchans and Roberts Arm groups, to establish details of stratigraphy, petrochemistry and structure.

Methods. Field work was conducted in the northern Roberts Arm group from mid-June to Late October, by a 4-person crew consisting of the project geologist, a senior assistant and two junior assistants. The work emphasized detailed coastal mapping, mapping of logging road networks and cross-country traversing. Systematic lithogeochemical sampling was also an important aspect of the work, and over 400 samples of mafic and felsic volcanic rocks were acquired for internal (NDNR) and external (Memorial University) analyses. Samples were also collected for U-Pb geochronology at Memorial University.

Results. Mapping showed that previous 1:50,000 mapping by the Geological Survey of Canada is very accurate in terms of unit distributions. However, examination of key relationships and regional data synthesis suggests a new interpretation of stratigraphy and structure. Several major thrust-bounded "terranes" are now defined, and their structural polarity appears to be northwest-directed opposite to most previous ideas. Felsic volcanic rocks associated with VMS mineralization at Pilley's Island are petrologically distinct from their counterparts elsewhere in the Roberts Arm group, and lie in a discrete, laterally discontinuous, terrane. Recognition of these patterns provides useful criteria for mineral exploration in parts of the Roberts Arm group where ore-bearing rocks may lie in the subsurface beneath higher thrust slices, or may be structurally repeated by thrusting.

Outputs.

Kerr, A.

1995: Bedrock geology of calc-alkaline volcanic rocks, Roberts Arm group. Poster Display at APEGN-CIMM meeting, St. John's, 1995.

1995: Island-arc volcanic rocks of the Ordovician Robert's Arm Group, Notre Dame Bay: preliminary report on 1995 field work. Newfoundland Department of Natural Resources, Geological Survey, Report of Activities for 1995, p. 51-53.
1996: New perspectives on the stratigraphy, volcanology and structure of island-arc volcanic rocks in the Ordovician Roberts Arm group, Notre Dame Bay. Article to appear in Geological Survey Current Research series, March 1996.

B. Hopedale

NC.1.B.1 Data Compilation / Data Management Hopedale (L. Nolan)

Objectives. The Data Compilation / Data Management component of the Hopedale multi-disciplinary project is designed to collect and compile, in an organized and integrated format, all relevant information for the study area. This involves extensive file research of existing data and then the collection of new data to fill gaps based upon analysis of where the existing data is out of date or is incomplete. The digital data compilations can be used in the detailed geological mapping and can be integrated with the new work into a digital format that can be incorporated in a Geographic Information System (GIS).

1) To compile a digital index of all geoscience data within the project area in GIS format, and to construct a digital database of all data deemed relevant and of good quality.

2) To design and maintain a GIS database for the project that will contain both existing data and new data that will be generated by field work under this program.

3) To ensure that the project database is readily accessible through desktop mapping systems and databases, and computer-generated colour maps for both project geoscientists and mineral industry clients.

Methods. The first phase of the digital compilation for the Hopedale project area focused on the windowing of regional data sets to provide a backdrop of the entire project area (1:50 000 NTS map sheets 13N/01, 13N/02, 13N/03, 13K/14, 13K/15 and 13K/10). The second phase has been to compile existing detailed information into digital form and to input new information gathered under the project. A review of relevant assessment reports has been carried out and a digital index of the contents of these files has been created.

A topographic base map was created by combining waterbodies, streams and roads from existing digital topographic NTS 1:50 000 data from Surveys and Mapping Branch, Newfoundland Department of Natural Resources. A bedrock geology map has been prepared for the project area from 1995 field work at a scale of 1:25 000 using GIS software and new surficial geology maps have been digitised from 1994 and 1995 field work at a scale of 1:50 000. Geophysical data from the Geological Survey of Canada's regional aeromagnetic survey has been windowed and several higher resolution surveys have been compiled from the industry assessment reports and incorporated into the digital index for the area.

The digital index of geofile information has been compiled after a comprehensive review of government, industry and university data using GEOSCAN as a search tool. The data base contains a defined set of fields which are used to describe the assessment reports. Subsequently the geologist, geophysist or geochemist can look up the report and determine if there is any information that is relevant to thier field of interest.

The GIS database will be used to produce maps and reports for the project using CARIS Geographic Information System software. The data will also be made available in a desktop computer mapping format to ensure that all information collected by the projects is accessible to interested parties.

Outputs. A digital index of all geoscience information within the project area has been formatted for use with ArcViewTM (A PC-based shareware viewing software).

Nolan, L., Honarvar, P., Kilfoil, G., Hogan, A., King, D. and Ash, S.
1994: Buchans-Robert's Arm / Hopedale Multidisciplinary Projects, Newfoundland Geological Survey, Review of Activities. (Poster)
Kilfoil, G., Honarvar, P., Nolan, L., Hogan, A., King, D. and Leawood, T.
1995: Hopedale Multidisciplinary Project, Newfoundland Geological Survey, Review of Activities. (Poster)
Honarvar, P., Hogan, A., Kilfoil, G., King, D., Nolan, L., Ash, S., Leawood, T., Hayes, P., Davenport, P.
1995: Digital Geoscience Data Compilations for the Buchans-Robert's Arm and Hopedale Multidisciplinary Projects, In Report of Activities, Newfoundland Department of Natural Resources, Newfoundland Geological Survey, pages 75-78.

N.1.B.2 Bedrock Mapping (D. James)

Objectives. The Hopedale Block, southern Nain Province, is an Archean granite - greenstone terrane in eastern Labrador. It includes several northeast-striking volcanic belts

that are intruded and encompassed by Archean granitoid plutons and orthogneiss units ofseveral ages. One of the volcanic belts, the Florence Lake greenstone belt (FLGB), was the focus of study in 1995.

Detailed geological, geophysical and prospecting studies suggest the FLGB has potential for komatiite-associated nickel sulphide mineralization, volcanogenic massive sulphide (VMS) deposits and mesothermal gold. In view of the mineral potential and the need for an updated bedrock geology map, parts of the FLGB were mapped at 1:25 000 scale in 1995. The bedrock mapping is in collaboration with more detailed mapping and sampling of known and newly discovered sulphide mineralization (R. Miller), a soil and stream-sediment geochemical sampling program (J. McConnell), and surficial geology studies (M. Batterson). The data collected in these studies will be combined with non-confidential mineral-industry data currently held in the Newfoundlnd Department of Natural Resources assessment files. The digital compilation work is being conducted by L. Nolan, G. Kilfoil and T. Leawood.

Methods. The bedrock mapping project involved systematic, 1:25 000-scale mapping of the FLGB in parts of NTS map areas 13K(NE) and 13N(SE). Mapping was conducted by three traversing teams (7-person fieldcrew), and was mainly boat supported. A minor amount of the work was helicopter supported. Approximately 400-person days were spent in the field.

Field logistics were shared with Geochemistry (McConnell) and Surficial Mapping (Batterson) projects. The Newfoundland Geological Survey Field Office in Goose Bay provided logistical support.

Results. The FLGB consists of greenschist- to amphibolite- facies mafic and ultramafic rocks, and lesser amounts of felsic and intermediate volcanics and volcaniclastic sedimentary rocks. The ultramafic rocks commonly occur as composite units that areinterlayered with felsic and mafic volcanic rocks and volcaniclastic sediments. The composite nature of these units and their stratigraphic continuity demonstrate that they are extrusive in origin. A genetic relationship between ultramafic and felsic volcanism is suggested by the close spatial relationship between the two rock types. The ultramafic rocks have potential to host komatiite-associated nickel sulphide deposits. Felsic volcanic rocks in the southwestern part of the FLGB have potential for VMS mineralization.

The bedrock geology map produced in 1995 represents a significant improvement over existing 1:50 000-scale maps of the FLGB, and should serve as a useful exploration tool. All ground in the FLGB is currently held.

Outputs.

James, D.T. and Miller, R.R.

1995: Exploration targets for Ni and VMS deposits in theArchean Florence Lake greenstone belt of eastern Labrador. Labrador Workshop (October 25), Newfoundland Geological Survey, Review of Activities 1995 (oral presentation).

James, D.T., Miller, R.R., Patey, R.P., and Thibodeau, S.

1995: The Archean Florence Lake greenstone belt: some preliminary observations on the geology and mineral potential. *In* Report of Activities, Newfoundland Department of Natural Resources, Geological Survey, pages 31-37.

1995: The Archean Florence Lake greenstone belt: some preliminary observations on the geology and mineral potential. Newfoundland Geological Survey, Review of Activities 1995 (poster).

James, D.T., Miller, R.R., Patey, R.P., Thibodeau, S. And Kilfoil, G.J.

1996: Geology and mineral potential of the Archean Florence Lake greenstone belt, Hopedale Block (Nain Province), eastern Labrador. *In* Current Research, Newfoundland Geological Survey, Department of Natural Resources, Report 96-1.

N.1.B.3 Quaternary Mapping, Kanairiktok River Area (M. Batterson)

Objectives. As part of the multidisciplinary project in the Kanairiktok River area, this project will provide a Quaternary geology framework for the evaluation of regional and detailed geochemical and geophysical data, as well as describing the glacial history of the region. The project will include mapping the distribution of Quaternary sediments and landforms, and mapping ice flow directional indicators to provide a summary of ice flow events. This investigation will contribute to our knowledge of the glacial history of the area. It will be a direct benefit to mineral exploration activities, especially in drift covered areas, by providing data on dispersal distances and directions, as well as suitable sediment sampling media for drift exploration programs.

Methods. A preliminary aerial photograph interpretation of the surficial geology was completed in the spring for the five 1:50,000 map sheets included in the study area. A three week field component was conducted in the area between late June and early July, from the base camp at Florence Lake. This component, using less than 15 hours helicopter time, involved ground verification of the air photograph interpretation, and mapping of ice flow indicators. Following the field work, the original aerial photograph interpretation was amended, and transferred to topographic base maps in preparation for digitizing. This latter component of the project

is ongoing. A Report of Activities, in support of the upcoming Open House has been completed.

Results. Ice flow across the area is simple, with a unidirectional trend towards the coast at about 035° to 075°. This suggests that any dispersal trains should be linear towards the northeast.

- The highland areas commonly have a thin and discontinuous till cover. This sediment is suitable for drift exploration, because it appears to be mainly local in origin.

- Areas less suited for conventional drift exploration techniques are those with sediments not deposited directly by glaciers. These include the well-sorted sand, gravel and muds found in the major valleys, of glaciofluvial and glaciomarine origin. In these areas, fluvial transport models should be employed. Geochemistry data generated through this approach should be interpreted separately from any till geochemistry program. There are numerous sand dunes in the major valleys. These should be avoided in drift exploration programs.

- Marine limit in the study area is about 125 m asl, defined by several deltas, higher than previously thought. Therefore, any mineralized erratics found on the surface below 125 m asl may have been emplaced by marine processes (e.g., icebergs). Similarly geochemical or geophysical anomalies may be related to sediments deposited within a marine environment. Sediments encountered in this area are well sorted sands and bedded silts and clays, locally containing marine shells. Drift exploration programs in these areas should be undertaken with caution.

Outputs

Batterson, M.J.

1995: Quaternary Geology of parts of the Central and Southern Hopedale Block, Labrador. Newfoundland Department of Natural Resources, Geological Survey, Report of Activities.

1995: Quaternary Geology of parts of the Central and Southern Hopedale Block, Labrador. Newfoundland Department of Natural Resources, Geological Survey, Poster Display, Open House.

N.1.B.4 Geochemistry (J.W. McConnell)

Objectives. The geochemical surveys project is a component of the larger Hopedale Project - a multidisciplinary program involving bedrock mapping, mineral deposit studies and surficial geology studies in addition to geochemistry. The Hopedale Project is designed to assess the mineral potential of portions of the Hopedale Block, eastern Labrador, with emphasis on the greenstone areas, notably the Florence Lake and Hunt River belts. Elsewhere in Canada, such belts are known to host a variety of gold and base metal deposits. The primary objectives of the geochemical surveys component are to provide the mineral industry with geochemical data, including maps and interpretation, to aid them in the selection of areas warranting follow-up activity.

Methods. Prior to the field season, the regional lake sediment geochemistry, quaternary geology and all industry reports of the areas underlain by the Florence Lake greenstone belt were reviewed and assessed. Areas that appeared most prospective were selected for soil and/or stream sediment/water surveys. Some preference was given to those that had received little exploration attention previously.

Approximately 680 soil, 170 stream-water (± stream sediment) and 28 rock samples were collected. Glacial flow from the southwest is likely to have developed geochemical dispersion trains trending northeasterly from any mineralized zones. Where possible, soil sampling was conducted along lines oriented at approximately right angles to glacial flow to maximize the likelihood of intersecting any dispersion trains. In several areas where the volcanic belts are very narrow and oriented nearly parallel to ice flow, this sampling strategy was impossible and sampling was conducted along the belt-axis or along what was regarded as the down-ice margin. Generally, soil samples were collected from the B-horizon at 200 m intervals along lines spaced 1 km apart. Additional, high-density sampling was done over the Baikie Showing, one of the few locations of known nickel mineralization, to provide orientation data. Stream waters were collected in purified, 250 mL nalgene bottles particularly in areas unsuitable for soil sampling due to lack of till cover or extreme topographic relief. In some cases stream sediment was sampled at the same site. Samples of typical bedrock as well as outcrops of sulphide mineralization discovered during the field work were also sampled.

Soil and sediment samples were air-dried in the field, further dried in the laboratory and sieved to < 180 µm in preparation for analysis. Water samples were analyzed for conductivity in the field lab, filtered to remove < 0.45 µm suspended material, acidified and returned to St. John's for detailed analysis. Soil and sediment samples are being analyzed presently for a large suite of elements including gold and base metals. Similarly, waters are being analyzed for a smaller suite that will include base metals.

The geochemistry sub-project worked closely both in the field and in the office with the other project geologists

involved with the overall Hopedale Project, notably Martin Batterson (Quaternary geology), Don James (bedrock mapping) and Randy Miller (Mineral Deposits). During the seven-week field season, a four-person crew with some helicopter and fixed-wing support conducted stream surveys from a number of fly-camp locations in the Nain Province.

Results. The geochemical results of the survey will not be available until early in 1996. During the course of the surficial sampling, several new occurrences of sulphide mineralization were discovered and sampled. Non of these outcrops appeared to be of significant extent or grade.

Outputs.

McConnell, J.W.

1995: Soil and stream geochemical surveys of the Florence Lake greenstone belt, Labrador. *In* Report of Activities, Newfoundland Department of Natural Resources, Geological Survey, pages 80-82.

1996: A description of soil and stream geochemical surveys of the Florence Lake greenstone belt, eastern Labrador. *In* Current Research, Newfoundland Department of Natural Resources, Geological Survey.

McConnell, J.W., House, S. and Vaughan, M.

1995: Soil and stream geochemistry over the Florence Lake greenstone belt. Poster Display at the Geological Survey's Open House.

N.1.B.5 Hopedale Project (G.Kilfoil)

Objectives. The objectives of the geophysical component of this project were to compile all existing geophysical data for the Hopedale Block, and particularly for the area encompassing the Florence Lake greenstone belt (FLGB). This information can be used to help refine the geological interpretation of the area and is to be integrated into the final digital data compilation.

The project will evaluate the quality and geological significance of geophysical data contained in mineral assessment reports (geofiles) within the Geological Survey and produce a synoptic digital index of those data. Tasks included under the project are: completion of digital indexes, and where appropriate, digital capture, processing, and linking with the Survey's GIS.

Methods. A compiled digital index of airborne geophysical surveys conducted within the province provided a focal point for this sub-project. This existing index was reviewed and updated. A similar index to reference geophysical surveys conducted on the ground was extracted as a subset from the digital index of all assessment reports pertaining to the project area. These geophysical indexes were used to identify assessment files containing pertinent geophysical data and to plan their recapture as digital databases. Digital indexes will be included with the final data compilation to provide a means to reference and navigate the data layers.

Prior to the start of the project, geophysical data were digitized from plots within an assessment file, LAB(704), submitted for the airborne survey flown in 1982 over the FLGB by BP Resources and Billiton Canada Ltd. Maps were produced at 1:25 000 scale from these data and at 1:250 000 scale from the G.S.C. aeromagnetic dataset for the province to assist with the geological interpretation of the project area. Data from these sources were also used to generate point, vector and image coverages in ArcView™ format. These data layers will form the geophysical component of the final data compilation.

All other existing geophysical information from within the study area was reviewed and specific portions to be digitized or scanned were identified.

Geophysical and other digital geoscientific information were provided to a cooperative project designed to identify linears and areas having a high potential for diamond mineralization based upon Landsat, ERS-1 SAR data and scanned/georeferenced aerial photography. Outputs from this project were submitted in ArcView™ format and therefore may be readily incorporated within the final data compilation.

Results. Maps produced from digital geophysical data, particularly that from the 1982 BP-Billiton airborne survey of the FLGB, were used to identify conductive linears corresponding to faults and to infer the positions of geological contacts in areas of limited bedrock exposure. As well, maps of the total field VLF-EM data show an enhanced signal situated over the lowlands of the Kanairiktok River and over the larger lakes at lower elevations. Areas of enhanced and variable VLF-EM response fall within the limit of marine incursion during the last post-glacial period. Therefore, this pattern has been attributed to the presence/absence of conductive marine clays within the surficial deposits in this region.

Outputs.

Colour, shaded-relief maps have been generated at 1:250 000 scale from the levelled aeromagnetic dataset flown by the G.S.C. to give the regional magnetic setting for the project. Data from the BP-Billiton airborne magnetic, VLF-EM and active EM survey were compiled onto 1:25 000 scale maps to assist geological mapping of the area.

Colour, shaded-relief images, EM anomaly locations and other reference information have been generated, in ArcView™-readable format, from these non-

confidential airborne surveys (see above) for inclusion with the digital data compilation. Data submitted digitally from an airborne survey flown over the southern Florence Lake greenstone belt by BP Resources Ltd. have been processed and prepared as data coverages in similar fashion. These can be added to the data compilation when these data gain non-confidential status in May of 1996. Digital indexes of airborne and ground-based geophysical surveys, compiled for the project area, will be used to help organize and reference the final data compilation on CD.

Compiled data from non-confidential airborne geophysical surveys, the satellite imagery, the airphoto mosaic and the digital indexes were presented, using ArcView™, as part of two PC-based poster displays at the Review of Activities, 1995, of the Newfoundland Geological Survey.

N.1.B.6 Mineral Deposit Studies (R. Miller)

Objectives. The purpose of this project is to evaluate the potential for magmatic Ni-Cu deposits and volcanogenic massive sulfide deposits in the Archean volcanic rocks of the Hopedale block. The target volcanic rocks studied in 1996 consisted of the Florence Lake Greenstone Belt and spatially related slivers of volcanic rocks.

Methods. The project's field objectives were achieved by a two-person crew during a 9 week mapping and sampling program, which was supplied from the Newfoundland Department of Natural Resources Goose Bay Office. It consisted of mapping the volcanic stratigraphy of portions of the Florence Lake Greenstone belt (1:10,000 and 1:20,000 scale), focusing on ultramafic rocks and the location and evaluation of sulfide-bearing showings.

Office-based studies by the project geologist include petrographic and geochemical identification of samples, chemostratigraphic mapping of the greenstone belt and geochemical evaluation of showings. These studies are supported by thin sections provided by the Memorial University of Newfoundland petrographic lab and geochemical data provided by the Newfoundland Department of Natural Resources geochemical lab.

Results. The ultramafic rocks of the Florence Lake Greenstone belt occur as volcanic flows and rare subvolcanic sills. These host rocks and the contemporaneous Ni-Cu-Fe sulphides exhibit many of the features of Kambalda-type Ni-Cu deposits. The Florence Lake ultramafic rocks mostly represent poorly differentiated thin flows located between lava channels and at distal locations in the lava field. Kambalda-type deposits commonly occur within or peripheral to lava channels. One major lava channel is tentatively identified in the Florence Lake greenstone belt; in addition, several smaller channels may also occur. None of these occurrences exhibit significant Ni-Cu mineralization, however, Ni-Cu sulphide-bearing mineralization occurs in several relatively thin ultramafic units. This indicates potential for larger deposits and the need for further exploration.

In the Kambalda model for ultramafic volcanic hosted Ni-Cu deposits, sulphur required for magmatic sulphide formation originates in sulphidic sediments underlying the ultramafic flows. Similar sulphidic sediments, commonly associated with felsic volcanic rocks, occur in the Florence Lake belt. The juxtaposition of these sediments and ultramafic rocks in the Baikie sub-belt correlates well with the occurrence of several ultramafic rock-hosted Ni-Cu showings. In addition, some of the felsic rock-hosted sulfidic sediments also host Cu-Zn sulphides indicating that these rocks may host volcanogenic sulphide deposits. The large number of these showings indicates a good potential for Cu-Zn mineralization that requires further exploration work.

Outputs.

James, D.T. and Miller, R.R.
1996: The Archean Florence Lake greenstone belt, southern Nain Province, Labrador: stratigraphy, structure and mineral potential. Poster, Geological Survey of Canada, Colloquium 1996.

James, D.T., Miller, R.R., Patey, R.P., and Thibodeau, S.
1995: The Archean Florence Lake greenstone belt: some preliminary observations on the geology and mineral potential. Poster, Newfoundland Department of Natural Resources, Geological Survey, Open House.
1995: The Archean Florence Lake greenstone belt: some preliminary observations on the geology and mineral potential. In Report of Activities, Newfoundland Department of Natural Resources, Geological Survey, pages 31-37.
1996: Geology and mineral potential of the Archean Florence Lake greenstone belt, Hopedale Block (NainProvince), eastern Labrador. In Report of Activities, Newfoundland Department of Natural Resources, Geological Survey, Report 96-1.

Miller, R.R.
1995: Ultramafic rocks and Ni - Cu mineralization in the Florence Lake - Ugjoktok Bay area, Labrador. Poster, Newfoundland Department of Natural Resources, Geological Survey, Open House.
1995: Ultramafic rocks and Ni - Cu mineralization in the Florence Lake - Ugjoktok Bay area, Labrador. In Report of Activities, Newfoundland Department of Natural Resources, Geological Survey, pages 18-19.
1996: Ultramafic rocks and Ni - Cu mineralization in the Florence Lake - Ugjoktok Bay area, Labrador. In Current Research, Newfoundland Department of Natural Resources, Geological Survey, Report 96-1.

2. MINERAL TECHNOLOGY

N.B.2.4.1 Mine Database System (F. Morrissey)

Objectives. The purpose of the mine data base was to aid in the resource assessment process. Information generated from the assessment of exploration drilling to further define mineralized and mineable zones. This data was to be used in promoting further exploration and development of deposits and assisting in feasibility studies. Drilling information from mining properties was in assisting companies not having computerized orebody evaluation systems, to more effectively understand their deposits, and develop or modify mining plans. The project resulted in greater effectiveness in assessing, promoting, developing, and managing the mineral resources of this province. It was also intended to make available a new technology and management tool to mine operators in the province.

Methods. Establishment of a mine database system involved the collection and interpretation of basic drilling information from producing mining properties and advanced exploration programs in order to evaluate mineral resources. After the data was entered into a computer database, grades and tonnages were estimated and plan and section maps were produced. This information was then made readily available by having it stored in a reproducible digitized format.

Results. Mineral deposits evaluated under this project underwent tonnage and grade estimations, and creation of colour-coded plan and section maps showing geological and mineralization information. Geological interpretation and mineralized zone delineation were carried using these maps. Updates of some deposits occurred as drill information became available. The properties reviewed included Hope Brook (Au), Pine Cove (Au), Nugget Pond (Au), Rendell-Jackman properties (Au), Stog'er Tight (Au), Fischells Brook (gypsum), Baie Verte Mine (asbestos), Cape Ray (Au), Deer Cove (Au), Duck Pond (Cu, Pb, Zn, Ag), Rambler-Ming (Cu, Au), and St. Lawrence (fluorspar). Planning of several MDA-funded infill-drilling projects was assisted by having maps on file for those deposits. Properties recently becoming active that are presently being investigated are Voisey Bay (Cu, Ni, Co), and the Veaver Book (Sb) deposit.

Mining properties and exempt mineral lands for which "Call for proposals" were prepared included the MingMine (Rambler) area, the St. Lawrence Fluorspar mine area, and the Fischells Brook gypsum deposit. Reports on these properties were prepared to encourage development of the deposits. They included geology, reserve and grade estimations, technical drawings, summaries of major property assessments, and mineral potential. Underground mining is presently taking place on the Ming Mine Property, and the St. Lawrence property is presently undergoing development planning by as mining company. Third property, Fischells, will be advertised for availability during the fourth quarter of the fiscal year 95-96.

Outputs.

A display and talk were presented at the Canadian Institute of Mining and Metallurgy meeting in St. John's in November of 1993 on "Computer-Aided Mineral Deposit Evaluation" related to this project. Talks on the same was also given at the Department of Mines & Energy winter seminar series in January of 1994, and at a Computerized-Mining Conference in Halifax, Nova Scotia in November of 1994.

-- A display of the St. Lawrence "Call for Prosposals" was shown at the CIMM conference in St. John's in November of 1995.

3. ECONOMIC EVALUATION AND PROSPECTOR TRAINING

N.B.3.3.3. Mineral Industry Brochure (G. Luther)

4. MINERAL INDUSTRY ASSISTANCE PROGRAM

N.B.4.1.1 MIAP COORDINATOR (M.J. Collins)

Objectives. The purpose of the Mineral Industry Assistance Program (MIAP) was to provide direct financial assistance to individuals and companies involved in the development of the mineral resources of Newfoundland and Labrador. MIAP provided this assistance by:

1a) Providing part of the risk capital required by prospectors to finance mineral prospecting. This funding was provided through the Prospectors Assistance Program (PAP). PAP contributed up to 100 percent of the eligible costs of the approved project to $5000 per project. Additional assistance of $2500 for projects involving credible, newly discovered prospects was also available.

1b) The educational component of PAP covered all student-related costs of providing a comprehensive training course in basic prospecting skills. The course was delivered annually in late spring through the provincial community-college system. Twenty students completed the course in June 1995.

2) Providing financial assistance to individuals and companies to develop economically viable mineral resources. This funding was provided through the Feasibility/Demonstration Program (FDP) and the Mining Infrastructure Program (MIP). FDP provided grants to eligible companies or individuals to cover up to 50 percent or $50 000, whichever is less, of eligible costs of market studies, feasibility studies and demonstration projects related to new or proposed mineral developments. The MIP provided grants to eligible companies or individuals, to cover up to 50 percent or $100 000, whichever is less, of eligible costs of infrastructure for mineral development.

The role of the Program Co-ordinator was to daily manage, supervise and monitor the program and all its sponsored projects in such a way that the aims and objectives of MIAP and optimum utilization of MIAP funds were achieved.

Methods. The program Co-ordinator in cooperation with the Mining Sector of Natural Resources Canada established the program guidelines, implemented, advertised and promoted the program, screened applicants, chaired the selection committees and recommended projects to the CN-AMD Management Committee. The Co-ordinator also monitored the sponsored projects in the field and recommended final payments.

Results. The program was successfully implemented and the mineral industry was promoted. All elements of the program were over-subscribed and sponsored projects are, thus far, very successful. There has been positive feedback from the mineral resource industry especially concerning the increase in prospecting activity.

NB.4.1.2 PROSPECTING GRANTS (M.J. Collins)

Objectives. The Prospecting Grants Program was designed to increase the discovery of wealth generating mineral deposits and to promote the development of a local prospecting fraternity by providing funding assistance to carry out independent prospecting on Crown Lands and mineral claims registered to grantees.

Methods. Direct financial assistance was provided to eligible prospectors involved in independent mineral-exploration activity in Newfoundland and Labrador. Approved projects on Crown Land or the proponents' registered claims were supported by grants up to $5000 for eligible prospecting expenses. Additional assistance of $2500 for projects involving credible, newly discovered prospects was also available. Usually 20% of the grant was awarded upon approval of the project, the remainder was paid upon satisfactory completion of the program and submission of a prospecting report including documented expenses. Prospectors' reports are confidential for three years unless their release is specifically requested by the prospector.

Prospectors were visited in the field by the Coordinator and were encouraged to conduct background research on their areas and many sought advice from and discussed their projects with the geological staff of the Geological Survey Branch of the Newfoundland Department of Natural Resources.

Results. Thirty seven projects involving various prospecting targets were funded under the Agreement. To date four of the completed projects resulted in the discovery of significant prospects which led to option agreements with mineral exploration companies. These prospecting successes will stimulate private-sector mineral exploration expenditures.

Approximately 250 claims were staked over several of the geological environments of the province. Prospecting targets included base metals, gold, gemstones, marble, slate and other dimension and ornamental stone.

The mineral exploration industry has recognized the efficacy and benefits of this program and are currently involved in several PAP generated projects. Any mineral prospect that develops to production will have a positive "real wealth" affect on the Newfoundland economy.

5. PUBLIC INFORMATION

N.5.1 Special Publications and Promotions* (B.F. Kean)

Objectives. Promote the province's mineral resources and their potential to the mining and exploration industries, and inform the general public, educators and students about the value of mining and the role of geoscience in society.

Methods. A variety of promotional activitites was used in attaining the project's objectives. These were: geoscientific and technical displays at local, national and international meetings dealing with mining and mineral exploration; brochures; newsletters; articles, supplements and advertisements in local, national and international publications; resource materials for schools and the public, including posters, slide sets, rock and mineral sets and videos; Mining Week activities including displays at local malls; displays at science fairs; support for Science and Technology Week; presentations to schools and junior colleges.

Results. Increased awareness of the province's mineral potential, the role of mining in the provincial and national economy, and the cooperative efforts of the federal and provincial governments to stimulate mineral development.

Outputs. Technical Displays: 8 international, national and local mining, exploration and geoscientific meetings.

General Displays: 5 public venues and special-interest meetings, such as science fairs.

Technical Publications and Material: Approximately 10 display panels on province's mineral potential and geology; Prospectors' "Properties Available for Option" booklets; Ads and supplements in trade journals; Geological Survey brochure, MINFO, RICH MINERAL RESOURCES.

General-Promotion Publications and Materials: 1995 Media Kits; Rock and Mineral Kits plus guidebooks (36 specimens in wooden boxes); Ads in newspapers; Mineral-information folder; OUT OF THE EARTH POSTER.

Other Activities: School lectures; Assisted prospectors with their Rock Room displays; Distributed minerals-related educational posters, mining booklet, coloring books; Mining Week and Atlantic Canada Rock Room committees.

* The provincial and federal Public Information Programs were jointly planned, executed and reported on.

FEDERAL PROJECTS

1. GEOSCIENCE

C1.1 BAIE VERTE-CAPE RAY SUBPROGRAM

C1.11 Mapping of Betts Cove Ophiolitic Complex (J. Bédard)

Objectives. In order to provide exploration companies with modern, up-to-date, exploration data (i.e., geological maps), this project was initiated to: 1) produce a 1:20 000 scale digital map of the Betts Cove ophiolite complex; 2) refine the volcanic and cumulate stratigraphy; and 3) resolve structural complexities that have been identified in the overlying Snooks Arm Group.

Methods. J. Bédard, K. Lauzière (both of the GSC), M. Tellier (M.Sc. Candidate at the Universite du Quebec), T. Dec (contractor) and A. Tremblay (Institut National de la Recherche Scientifique) completed fieldwork during the 1994 and 1995 field seasons. Specific work carried out by researchers included:

- reconnaissance geological mapping/sampling and analysis of subsequent geochemical and petrographic data (J. Bédard and K. Lauzière)
- definition of the stratigraphy and sedimentology of the Snooks Arm and Betts Cove Groups (T. Dec)
- petrography and geochemistry of plutonic units comprising the Betts Cove Ophiolitic Complex (M. Tellier)
- structural analysis (A. Tremblay)
- production of digital maps and integration of project results into a database (E. Boisvert, GSC)

Results. Serpentinite-talc schists line the margin of the ophiolite, with crosscutting talc-ankerite-sulphide-bearing shear zones. At Kitty Pond and Betts Cove, depositional cumulate cycles are dissected by pyroxenitic and gabbroic intrusions, and are topped by sheeted dykes and lavas. At Long Pond and Tilt Cove, most plutonic rocks are gabbro-pyroxenite-diabase igneous and tectonic breccias. The contact between the plutonic and volcanic sequences are obscured by faulting, brecciation and sill injection. Some of these breccias may represent intra-oceanic fault talus deposits associated with seafloor extension. Cu-ore is found near the contacts of a sliver of the sheeted dykes at Tilt Cove, while the Betts Cove Cu-deposit is within a chloritic shear zone. The ore developed where high-level gabbroic intrusions provided a source of heat to drive hydrothermal convection and transport metals. These high-level gabbros may be related to the intrusive suite cutting the layered cumulates. The northwest-to-southwest trending shear and breccia zones are injected by dykes and as are the intra-oceanic fault breccia zones. The shear zones also offset the Betts Cove Lower Lavas (BCLL) and the Nugget Pond Sediments and Iron Formation (NPSI). Commonly, the BCLL under the NPSI are magnetic. The base of the NPSI grades laterally from a conglomerate with fragments of chert and basalt, locally veined and cemented by pure magnetite, to thin-bedded pebbly volcaniclastic sandstones, siltstones and ironstones, that are typically red-weathering, pyritiferous, and magnetic. Above these are green-weathering sandstone/siltstone turbidites. The discontinuous conglomerates and slump folds of the NPSI suggest that deposition was synchronous with faulting. Late gabbroic sills split the NPSI into thinner packages. The Betts Cove Upper Lavas (BCUL) are typically amygdaloidal, sparsely-phyric pillow lavas and massive flows. The overlying Snooks Arm Group is composed of alternating submarine sedimentary and basaltic formations. The basal-sediment-dominated formation of the Snooks Arm Group is composed of subaqueous volcaniclastic debris flows and volcaniclastic turbiditic interbeds that represent distal equivalents. Some of the graded rhyolitic tuffs may be subaqueously-deposited ashfalls. The upper sediment-dominated formation of the Snooks Arm Group is epiclastic, contains a large proportion of pelagic mudstones, and appears to represent reworking of older volcaniclastic deposits. Rocks of the Betts Cove and Snooks Arm sequence are folded into an open, shallowly northeast-plunging syncline. There is no evidence for large-scale structural repetition (thrusts) within the Snooks Arm Group. The Siluro-Devonian Cape St. John Group is composed of fluviatile sandstones and conglomerates, felsic tuffs and lavas, and mafic to intermediate sabaerial lavas. Discovery of an undeformed angular unconformity confirms that the Cape St. John lavas erupted through, and were deposited upon the ophiolitic rocks. More typically, the contact between the Cape St. John and the Snooks Arm Groups is sheared, with shallow to moderate northwest dips, and a down-dip stretching lineation. Kinematic indicators suggest normal movement. Late-stage quartz-feldspar-mica-porphyritic dykes occur throughout the Betts Cove sequence and probably represent feeders for felsic pyroclastic rocks of the Cape St. John Group. Locally, the quartz-porphyries have a brecciated appearance and may represent phreatomagmatic deposits.

Outputs.

OPEN FILES

Bédard, J., Lauzière, K., Sangster, A.L., Boisvert, E., Tellier, M., Tremblay, A. and Dec, T.

1996: Geological map of the Betts Cove ophiolitic massif and its cover rocks; Geological Survey of Canada, Open File 3271, one 1:20 000 scale colour map.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Bédard, J.H., Dec, T., Lauzière, K., Tremblay, A. and Tellier, M.

1994: Preliminary results of Betts Cove ophiolite mapping project; in Report of Activities 1994, Newfoundland Department of Natural Resources, p. 99-103.

Lauzière, K.; Bédard, J.H.; Dec, T.; Tremblay, A.; Tellier, M.

1995: Preliminary map of Betts Cove ophiolite; in Report of Activities 1995, Newfoundland Department of Natural Resources, p. 56-59.

C1.12 Mineral Deposit Studies - Betts Cove Ophiolite (A.L. Sangster)

Objectives. The objective of the project is to upgrade the knowledge of mineral occurrences in the Betts Cove Ophiolite, particularly the occurrence of gold in various sulphide and oxide iron formation facies along the "Nugget Pond Horizon" and elsewhere, and the association of gold with the ophiolitic base metal occurrences at Tilt Cove and Betts Cove.

Methods. The project was carried out by A.L. Sangster in conjunction with work carried out under project C1.11 by J. Bédard and C. Lauzière. Work included field mapping and sampling of mineral occurrences, lithochemical and petrographic analyses of mineralized and associated unmineralized lithologies. Petrographic studies, SEM investigations of the occurrence of gold and microprobe analyses are being carried out under contract by S. Douma.

Results. At the time of writing, only preliminary results based on field work and initial analytical results are available.

The Betts Cove ophiolite contains two broad classes of metallic mineral occurrences; 1) Cu-rich sulphide deposits, commonly regarded as "massive sulphides"; and 2) auriferous pyrite deposits contained within sedimentary rocks in and/or overlying the ophiolite suite of rocks and commonly associated with iron formation.

Massive sulphide deposits and occurrences

The largest massive sulphide is the past producing Tilt Cove deposit (about 9,000,000 tons of Cu-Zn ore). The deposit occurred as several lenses that occurred throughout much of the thickness of the basal mafic volcanic unit of the ophiolite which at Tilt Cove is dominantly hyaloclastite (dominantly pillow breccia and resedimented volcanic debris). Where seen, the sulphides consist of massive stringers and disseminated sulphides dominantly controlled by the hyaloclastite matrix. Both specular hematite and magnetite are important and locally dominant alteration phases. Gold contents of the ores range in the 100's to about 1000 ppb with higher values in hematite-rich copper ores. The dominance of hyaloclastite, abundance of oxide minerals, and gold rich character suggest deposition of the sulphides by sub-seafloor replacement of the volcanic rocks in a shallow water oxidizing environment.

Three smaller occurrences, Nudulama, Mount Misery and Betts Cove, all occur within the sheared contact zone between the sheeted dyke unit and overlying basalts. The Nudulama occurrence lies beneath finer grained "distal" portions of the Tilt Cove hyaloclastite. It is copper-rich, contains gersdorfite and cobaltite and local strongly anomalous gold in the 1000's of ppb. The mount misery occurrence consists of replacement and breccia fillings of iron sulphides and chalcopyrite in basalt. Copper and gold values were erratic, ranging from Cu= .5% to 4.5% and Au 100 to 2000 ppb. The Betts Cove massive sulphide, mined in the last century, is a Cu (0.2 to 6.5%)-Zn 0.1 to 16%) massive sulphide. Associated gold values are high, varying in the range 1.2 and 16 grams/tonne with the higher values in zinc-rich ore. These occurrences are believed to reflect sub-volcanic processes under a shallow water column with a minor component of exhalative sulphide.

Gold deposits and occurrences

The Nugget Pond Au deposit is the major occurrence of gold in the area. It is located in a thin, locally magnetite/pyrite-rich red/green argillite bed within ophiolitic basalts. The deposit is associated with a stockwork of quartz-feldspar-carbonate veins that has been dated at 374 +/- 8 Ma. The ores consist of spectacular megacrystic pyrite cubes (commonly 1 to 2 cm) in stilpnomelane-altered argillaceous metasedimentary rocks.

Euhedral pyrite and weak stilpnomelane alteration are common along the "Nugget Pond Horizon" east of the deposit but gold values are low.

The two other main gold occurrences in the Betts Cove ophiolite are in the east end near Tilt Cove. The Castle Rock occurrence contains high gold values to 46 gm/tonne in slivers of pyritic red argillite contained within talc-carbonate schist. The Long Pond East occurrence consists of weakly

auriferous pyritic green argillite with 2 grams of gold contained in pyritic talc-carbonate schist. Both occurrences are adjacent to magnetite-hematite iron formation. The talc carbonate schist associated with these occurrences is believe to be a product of Devonian tectonism and metasomatism of the basal ultramafic units of the ophiolite.

Outputs.

OPEN FILES

Bédard, J., Lauzière, K., Sangster, A.L., Boisvert, E., Tellier, M., Tremblay, A. and Dec, T.

1996: Geological map of the Betts Cove ophiolitic massif and its cover rocks; Geological Survey of Canada, Open File 3271, one 1:20 000 scale colour map.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Sangster, A.L.

1996: Gold metallogeny of the Betts Cove ophiolite; in Geological Association of Canada-Newfoundland Section 1996 Annual Meeting: from Cape Chidley to Cape Race: Exciting new developments in mineral and petroleum exploration, Program and Abstracts, p. 14.

Sangster, A.L. and Douma, S.

1996: Geology of iron-formation-hosted Au occurrences, Betts Cove Ophiolite, Newfoundland; Geological Survey of Canada, Mineral Deposits Colloquium, January 22-24, 1996, Ottawa, Ontario; and Annual General Meeting of the Prospectors and Developers Association of Canada, March 1996, Toronto, Ontario (poster presentation).

Sangster A.L., Lauziere, K. and Bedard, J.

1995a: Mineral deposit studies in the Betts Cove ophiolite; 19th Annual Review of Activities, Newfoundland Geological Surveys branch, Newfoundland Department of Natural Resources/CIM, Newfoundland Section Annual Meeting, October, 1995, St. John's, Newfoundland (poster presentation).

1995b: Mineral deposit studies in the Betts Cove Ophiolite; in Review of Activities 1995, Newfoundland Department of Natural Resources, p. 20-21.

Sangster, A.L., Lavigne, J.G., Douma, S. and Hamilton, W.

1994: Geology, alteration and stable-isotope geochemistry of the Nugget Pond gold deposit; in Review of Activities 1994, Newfoundland Department of Natural Resources, p. 34-37.

C1.13 Geological Mapping - Glover Group Volcanics (K.L. Currie)

Objectives.

1) To map and assess the stratigraphy, structure and mineral potential of the Glover Group/Formation in the Glover Island region, and between Grand Lake and Little Grand Lake.

2) To compile project results in the form of a digital coloured map and a publishable report.

Methods. The project was completed under contract by G.A. Jenner and Z.A. Szybinski (both of the Memorial University of Newfoundland [MUN]). Field work, completed during the summers of 1994 and 1995, consisted of a combination of ATV-, boat-, and helicopter-based geological and structural mapping, using field equipment supplied by the Geological Survey of Canada. Subsequent office and laboratory work was carried out at MUN. Although at the time of writing, the final report had not yet been submitted to the GSC, the project is on schedule and within budget.

Results. The Glover Group consists of the Kettle Pond and Tuckamore formations. On Glover Island, the Kettle Pond Formation structurally overlies the Grand Lake Complex (ultramafic rocks and mafic volcanic rocks). The structure of southern Glover Island is controlled by intricate fold interference patterns, resulting from the overprinting of D_2 related folds by D_3 folds. Field observations disagree with the findings of previous workers and indicate that the Kettle Pond and Tuckamore formations represent stratigraphic units rather than a large shear zone (i.e., P.A. Cawood and J. Van Gool's Kettle Pond Shear Zone). The Glover Group comprises a lower Kettle Pond Formation (predominantly felsic schists) and an upper Tuckamore Formation (schistose to strongly flattened, predominantly pillowed mafic flows and lesser tuffaceous rocks). Southeast of Grand Lake, the Glover Group forms a large NE-elongated, generally upright, F_2/F_3 dome-type antiform and synform. Mafic, pillowed and massive flows (Tuckamore Formation) form the core of the antiform, while the core of the synform is predominantly siliceous sedimentary rocks (Kettle Pond Formation). Sedimentary rocks and mafic rocks on the southeastern limb of the syncline are cut by mafic and felsic dykes and sills, and pillowed to massive mafic lavas are amphibolitized and strongly hornfelsed near the contact with the Topsail Complex. Preliminary geochemical data indicate that mafic rocks of the Tuckamore Formation are predominantly of non-arc, mid-ocean ridge (MORB) affinity, similar to rocks of the Grand Lake Complex. In contrast, felsic tuffaceous schists from Glover Island have arc-like chemistry.

Project /Economic Impact. Metallogenic studies on Glover Island are actively being pursued by Newfoundland Gold Bar Ltd. and D. Barbour, (Ph.D. candidate, MUN). The numerous VMS-type sulphide showings, most of which are associated with mafic volcanic rocks southeast of Glover Island, were examined and sampled, and preliminary results suggest that the area has considerable base-metal potential.

Project investigations have focussed on an area of particular interest to the exploration community and have helped clarify Glover Group structure and stratigraphy.

Outputs.

PUBLICATIONS

Jenner, G.A. and Szybinski, Z.A.
1995: Stratigraphy and structure of the Glover Group, Grand Lake-Little Grand Lake area, Newfoundland; Current Research 1995-E; Geological Survey of Canada, p. 245-251.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Jenner, G.A. and Szybinski, Z.A.
1994: Stratigraphy and structure of the Glover Group, Grand Lake-Little Grand Lake area, Newfoundland; 18th Annual review of Activities, Newfoundland Geological Survey Branch, Newfoundland Department of Natural Resources, St. John's, Newfoundland, October 1994.
1995: Stratigraphy and structure of the Glover Group, Grand Lake-Little Grand Lake area, Newfoundland; 19th Annual Review of Activities, Newfoundland Geological Survey Branch, Newfoundland Department of Natural Resources, St. John's, Newfoundland, October 1995.

C1.14 Hope Brook - Metallogenic Studies (B. Dubé)

Objectives. To determine the validity of the working hypothesis that the Hope Brook mine is an intrusive-related, pre-ductile deformation, acid-sulphate type gold deposit, which has implications for future gold exploration in the area and elsewhere in Newfoundland.

Methods. Detailed field and underground mapping and core logging of the lithologies and hydrothermal alteration in the Hope Brook mine area was conducted by B. Dubé, K. Lauzière and E. Boisvert (all of the GSC). The focus of this work was to define the: nature and geometry of the geological setting; primary chemical signature of the deposit; and, evolution of the alteration system. The large, existing, mine geochemical database was also used to produce lithological and geochemical sections, define metal zonation, and helped in the characterization of the different alteration units. The age dating of key units and stable isotopic studies were done in collaboration with G.R. Dunning and M. Wilson (both of MUN), respectively. The project benefited greatly from the logistical, technical and scientific support provided by Royal Oak Mines Limited, and their permission to examine confidential information. Much appreciated scientific support was also provided by H.S. Swinden, B. O'Brien and S. O'Brien, all from the Newfoundland Department of Natural Resources' Geological Survey.

Results. The Hope Brook gold mine, in southwestern Newfoundland, is an acid-sulphate gold deposit hosted by Late Precambrian rocks. Hostrocks include tuff/volcaniclastics interdigitated with Whittle Hill Sandstone, both of which have been intruded by quartz-feldspar porphyries (QFP). The structural hangingwall of the ore zone corresponds to a dike-sill complex composed mainly of QFP and mafic sills/dykes. Alteration is characterized by an advanced argillic alteration zone, containing alunite, and two stages of silicification. The first silicification stage: is barren of mineralization; of regional extent; is locally preserved in the deposit; and constitutes most of the silicified rocks to the west of the economic ore zones. The second stage of silicification: hosts the gold mineralization; is vuggy and grey to dark grey in colour; and, is characterized by several percent pyrite and chalcopyrite/bornite found as either disseminations, impregnations or veinlets. Observed structural relationships indicate that the deposit area is characterized by the development of a strong northeast-oriented ductile fabric with a locally preserved stretching lineation plunging at about 50° to the southwest that is related to Silurian reverse-sinistral motion along the Cinq Cerf Fault Zone. This, in turn, is overprinted by a dextral strike slip reactivation of the fault zone, and is contact metamorphosed by the Devonian Chetwynd granite. The nature and distribution of the lithotectonic and alteration units strongly suggest that the deposit is located within, and genetically related to, a subvolcanic intrusive complex containing both intrusive and extrusive lithologies.

Project/Economic Impact. The recognition of the two-phases of silicification has added greatly to the understanding of the deposit and provides guidelines for exploration of similar style mineralization. The metal zonation have been used by Royal Oak Mines Limited to define and test exploration targets and in reserves evaluation. On-going geochronological investigations, which should establish the definite age of the mineralization, will also have a significant impact on future exploration initiatives.

Outputs.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS/CONFIDENTIAL REPORTS

Boisvert, E., Dubé, B., Lauzière, K. and Bédard, J.H.
1995: Database structure for geological data: a digital initiative from the GSC in Newfoundland; Newfoundland Department of Natural Resources, 19th Annual review of Activities, Newfoundland Geological Survey

Branch, St. John's, Newfoundland, October 1995 (poster display).

Dubé, B.

1996: The Hope Brook gold mine: Example of an acid sulfate intrusion-related epithermal gold deposit in Newfoundland; The Trail of'96, 6th Annual CIM Geological Society Field Conference, September 10, 1996, Gander, Newfoundland (oral presentation).

Dubé, B. and Boisvert, E.

1995: Preliminary Report on the Hope Brook Deposit; Confidential report to Royal Oak Mines Limited, 10 p.

Dubé, B. and Dunning, G.R.

1995: Preliminary results on the geochronological work at Hope Brook; Confidential report to Royal Oak Mines Limited, 2p.

Dubé, B., Lauzière K. and Boisvert E.

1995a: Preliminary report on the geological setting of the acid-sulfate Hope Brook gold deposit, SW Newfoundland; in Report of Activities 1995, Newfoundland Department of Natural Resources, p 49-50.

1995b: Geological setting of the acid-sulfate Hope Brook gold deposit, SW Newfoundland: nature of the host rocks; Newfoundland Department of Natural Resources, 19th Annual review of Activities, Newfoundland Geological Survey Branch, St. John's, Newfoundland, October 1995 (poster display).

Dubé, B., Lauzière, K. and Robert, F.

1994a: Preliminary report on the alteration and deformation at the Hope Brook gold deposit; Report of Activities 1994, Newfoundland Department of Natural Resources, p 63-64.

1994b: Evidence of two phases of silicification at the Hope Brook Gold deposit, Newfoundland, and its implications; Newfoundland Department of Natural Resources, 18th Annual review of Activities, Newfoundland Geological Survey Branch, St. John's, Newfoundland, October 1994 (poster display).

1994c: Preliminary report in the Hope Brook Deposit; Confidential report to Royal Oak Mines Limited, 2p.

Dubé, B., Lauzière, K., Robert, F. and Poulsen, K.H.

1996: The Hope Brook gold deposit: an example of acid sulfate, intrusion-related gold deposit in Newfoundland; Geological Survey of Canada, Minerals Colloquium, January 22-24, 1996, Ottawa, Ontario (poster presentation).

C1.15 Structural Geology - Southernmost Long Range (C.R. van Staal and S. Lin)

Objectives. To investigate the: lithostratigraphy, structure, metamorphism, magmatic history, base and precious metal mineral potential, and tectonostratigraphic relationships of the gneisses and schist that are exposed in southwest Newfoundland (i.e., principally NTS 11O/10 and 11O/11sheets, and selected portions of NTS 11O/14 and 11O/15). The correlation of these rocks with those found in Cape Breton Island was also investigated.

Methods. This project represents an extension to C.R. van Staal and S. Lin's 1990-1994 Canada-Newfoundland Cooperation Agreement on Mineral Development (CAMDA) project, and was undertaken to ensure that the results of the 1:25 000 scale detailed remapping of NTS 11O/10 and 11 were prepared for GSC Open File release. Project funding was also provided to support new reconnaissance and detailed mapping of parts of NTS 11O/14, 15 and 16, by C.R. van Staal and assistants, during the 1994 field season.

During the course of this project, the results of the original multidisciplinary CAMDA project continued to be documented. This research included:

- documentation of the structure and geological history of the Cape Ray Igneous and Long Range Mafic and Ultramafic complexes (CRIC and LRMUC) were investigated in detail by L. Hall for a M.Sc. study at Memorial under the supervision of H. Williams and C. van Staal;
- geochemical and isotope tracer studies of the igneous rocks were carried out by J. Whalen at the GSC;
- a study of the petrology and origin of the mafic igneous rocks and psammites in the Port aux Basques gneisses (PABG) was carried by D. Schofield at Keele University, United Kingdom, through a contract to J. Winchester;
- detailing of the metamorphic petrology of the PABG was mainly done by J. Burgess as part of a M.Sc. project at the University of New Maryland, U.S.A., through a contract to M. Brown;
- establishing the emplacement history of the Rose Blanche pluton, carried out by M. Genkin and K. Benn at the University of Ottawa;
- documenting the uplift/cooling history of the PABG formed an integral part of this project and the necessary Ar^{39}/Ar^{40} studies were done in the laboratory of D. Dallmeyer at the University of Georgia
- a study of the bimodal orthogneisses in the PABG, with emphasis on internal relationships and age, formed a component of P. Valverde's Ph.D thesis at MUN; and
- U-Pb zircon and monazite age dating of all rock units carried out at Memorial University through a contract to G. Dunning.

Results. Further mapping and subsequent interpretation suggest the following:

1) The CRIC and Long Range Mafic and Ultramafic Complex LRMUC represent the remnants of a Lower to

Middle Ordovician magmatic arc and Upper Cambrian to Lowest Ordovician ophiolite, respectively. Contrary to earlier ideas, the mapping unequivocally showed that the CRIC intrudes the LRMUC after its obduction on rocks which have been correlated with the Fleur de Lys Supergroup (part of the North American margin). Obduction thus must predate the oldest rock in the CRIC (488 Ma). Xenocrystic zircon and Isotope tracer studies confirm that the CRIC was build on North American crust; hence subduction of Iapetus, at least during the Lower Ordovician - 488 Ma, must have been towards the west, not eastwards as is usually thought. Both the CRIC and LRMUC were intensely ductilely deformed and metamorphosed to amphibolite facies conditions during the Early to Middle Ordovician. This deformational event was finished by the end of the Ordovician and the high grade rocks were exhumed back to surface before the Silurian

2) The Port aux Basques Gneiss (PABG), contrary to previous work, contain several distinct lithological packages, separated by major shear zones. These lithological packages, each containing distinct lithological units, can be assigned to the Exploits Subzone and Gander Zone. The Exploits subzone rocks (Grand Bay Complex and Harbour Le Cou Group) are characterised by a relative abundance of coticule rocks in meta pelites, which are generally closely associated with coeval massive sulphide mineralization and gedrite alteration. Highly deformed suprasubduction zone mafic-ultramafic rocks occur in the Grand Bay Complex, and previously unknown tholeiitic meta pillow basalts were identified in the Harbour Le Cou Group. The presence of coticules, pillow basalts, ophiolitic rocks and massive sulphides suggest that these rocks are very likely Lower to Middle Ordovician in age. Such an interpretation is entirely consistent with Ordovician U-Pb zircon ages of the orthogneisses, which are probably consanguineous with the basalts.

3) Psammites and pelites near the town of Port aux Basques are quartz-rich and resemble lower grade rocks typical of the Gander Zone elsewhere in Newfoundland. Tholeiitic amphibolite dikes that have intruded these rocks have, on the basis of geochemistry, been interpreted as consanguineous with dated Lower to Middle Ordovician amphibolites in the orthogneisses. The Gander zone psammites are thus Lowest Ordovician or older in age.

4) Deformation of the PABG was intense and was accompanied by high pressure amphibolite facies conditions. The first two generations of structures are represented by recumbent sheathfolds and a very strong LS fabric, indicating a progressive deformation regime typical of ductile foldnappes and thrusting. The transport direction in the western part of NTS11O/11 was towards the west. The Upper Ordovician Port aux Basques, and Upper Silurian Rose Blanche granites, intruded during F_1 and F_2 respectively, demonstrating that this deformation was a long lasting event. The F_1 and F_2 structures were subsequently overprinted by inclined to upright, non-cylindrical F_3 folds, which have been interpreted to have formed during oblique convergence and wedging. Wedging drove the exhumation of the high-pressure rocks, which were near the surface by Middle Devonian time. Structures of the latter event are spectacularly preserved along the Cape Ray Fault zone.

Project/Economic Impacts. The recognition of Exploits subzone rocks in southwestern Newfoundland gneisses has led to a renewed surge in mineral exploration.

Outputs.

PUBLICATIONS

Lin, S., van Staal, C. R. and Dubé, B.
1994: Promontory-promontory collision in the Canadian Appalachians; Geology, vol. 22, p. 897-900.

Burgess, J. L., Brown, M., Dallmeyer, R. D. and van Staal, C. R.
1995: Microstructure, metamorphism, thermochronology and P-T-t deformation history of the Port aux Basques gneisses, south-west Newfoundland, Canada; Journal of Metamorphic Geology, vol. 13, p. 751-776.

Whalen, J. B., van Staal, C. R., Jenner, G. A. and Longstaff, F. J.
In Review: Tectonostratigraphic zone correlation after promontory-promontory collision: geochemical and isotopic insights from southwestern Newfoundland; Atlantic Geology.

OPEN FILES

van Staal, C. R., Hall, L., Schofield, D., and Valverde, P.
1996: Geology Port aux Basques, Newfoundland; Geological Survey of Canada, Open File 3165, Geological map with marginal notes, (1:25 000 scale).

van Staal, C. R., Lin, S., Valverde, P., Hall, L. and Genkin, M.
1996: Geology Rose Blanche, Newfoundland; Geological Survey of Canada, Open File 3219, Geological map with marginal notes, (1: 25 000 scale).

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Lin, S. and van Staal, C. R.
1994: Promontory-promontory collision in the Canadian

Appalachians; Canadian Tectonics Group 94, Program with Abstracts.

Lin, S, van Staal, C. R. and Dubé, B.
1994a: Effects of promontory-promontory collision in the Canadian Appalachians; Geological Society of America, 29th annual Northeastern Section, Program with Abstracts, p. 32
1994b: Northwest-vergent thrusting and tectonic wedging associated with Silurian promontory-promontory collision in the Canadian Appalachians; New Perspectives in the Appalachian-Caledonian Orogen, Geological Association of Canada, NUNA Conference, Program and Abstracts, p. 17-18; also reprinted in Atlantic Geology, vol. 30, p. 169-170

van Staal, C. R., Dunning, G., Valverde, P., Burgess, J. and Brown, M.
1994: Arenig and younger evolution of the Gander margin: A comparison of the New Brunswick and Newfoundland segments. Geological Association of Canada, NUNA conference: New perspectives in the Appalachian-Caledonian Orogen, Program and Abstracts, p. 28-29; also reprinted in Atlantic Geology, vol. 30, p. 178-179

Van Staal, C. R. and Whalen, J.
1995: The Appalachian Orogen - Record of Multiple Arc-Continent Collisions; EOS Transactions, American Geophysical Union 1995 Fall Meeting, abstract supplement, vol. 76, no. 46, p. F603.

C1.16 Mapping and Mineral Deposit Modelling - Pacquet Harbour Group (A.L. Sangster)

Objectives. The primary objectives of this project were: 1) compile existing geoscientific data on the Pacquet Harbour Group, south of the Rambler Brook fault; 2) geologically map the Pacquet Harbour Group, south of the Rambler Brook Fault, including the southern outlier, at 1:50 000 scale; 3) provide an outline and interpretation of the stratigraphy ans structural history of the southern Pacquet Harbour Group; 4) document the stratigraphic and structural setting of known gold and base metal occurrences in the southern Pacquet Harbour Group; and 5) provide guidelines for further exploration in the area and a stratigraphic/structural framework that can be applied to the more complex northern part of the Pacquet Harbour Group.

Methods. The project was contracted to G.A. Jenner and Z.A. Szybinski (both of Memorial University of Newfoundland [MUN]). Field investigations were completed during the 1994 and 1995 field seasons. During the 1994, field season, Z.A. Szybinski and S. House (MUN) completed an initial reconnaissance survey of the Pacquet Harbour Group in order to establish stratigraphic relationships within the group. This mapping focussed on outcrops in the vicinity of existing logging roads. During the 1995 field season, mapping involved systematic traversing of the entire map areas and emphasis was placed on unravelling the volcanic stratigraphy of the group by carefully recording facing direction in pillow lavas and associated tuffs in order to document the fold interference pattern recognized during 1994. Emphasis was also placed on examining the rhyolitic/dacitic intrusive phase, that locally is associated with a "rusty" iron oxide alteration and is known to host sulphide/gold mineralization. Kinematic indicators within the shear zone associated with the fault contact between the Pacquet Harbour Group and Silurian Cape St. John and Cape Brule groups were carefully recorded, and the possible disruption of the stratigraphic order by the numerous faults and associated splays were documented. The latter work forms the basis of a B.Sc. honours thesis being done by S. Piercey (MUN). Because the study area displays significant lithological, intrusive, and metamorphic heterogeneity, a significant number of samples were collected for whole rock geochemistry..

Results. The main block of the Pacquet Harbour Group on Baie Verte Peninsula is transected by the Rambler Brook Fault, which divides the block into two distinct structural domains. The domain north of the fault is strongly deformed (mylonites) and metamorphosed (amphibolite facies), and hosts at least four VMS deposits. South of the fault, deformation is mostly brittle, metamorphic grade is predominantly greenschist, and this domain hosts a number of sulphide/gold showing. Southeast of the Pacquet Harbour Group main block there is a smaller outlier of Pacquet Harbour Group rocks that contains several small gold showings. Both the main block and southeastern outlier are in intrusive contact with the Burlington Granodiorite. The contact aureole is locally greater than 500m wide and includes strongly amphibolitized and schistose mafic rocks. Consequently, both blocks display metamorphic zonation, with greenschist facies in the centres of the blocks, to amphibolite facies near their contacts with Burlington granodiorite.

Differences in metamorphic grade and strongly heterogenous brittle to plastic deformation pose a significant problem in establishing a definitive lithostratigraphic framework for the group. Field observations suggest that some lithostratigraphic units (e.g., pillow lavas, monomictic and polymictic tuff breccias), found north of the Rambler Brook Fault, specifically in the East Mine area, can also be recognized south of the fault.

The lithology of the central portion of the southeastern outlier differs markedly from that of the main block. The outlier contains several generations of subvolcanic rocks that exhibit complex intrusive relationships, including a

rhyolitic/dacitic intrusive phase somewhat similar to the rhyolitic dome associated with the Rambler deposit north of the Rambler Brook Fault. Volcanic and volcaniclastic rocks that underlie the margins of the southern outlier are, however, similar to lithological types recognized in the main block of the Pacquet Harbour Group.

At least two deformational events have resulted in a "dome and basin" fold interference pattern. This pattern is probably responsible for the presence of smaller areas of higher grade rocks away from contacts with the Burlington granodiorite.

Preliminary geochemical data suggest that the Pacquet Harbour Group consists of two main types of mafic volcanic and subvolcanic rocks, including: boninitic rocks, known to be associated with an early arc stage or back-arc opening; and those having MORB affinity. The relatively widespread felsic subvolcanic rocks located in the southeastern outlier, are of arc affinity. Based on field observation and chemistry, boninitic flows cut by rhyolitic sills of arc affinity, are intruded by diabase and diorite plugs of MORB affinity, which are in turn cut by boninitic dykes. The diabase dykes most likely formed feeders to MORB-type pillow lavas that are present in the southeastern outlier. It is not clear whether there were two stages of boninitic volcanism separated by a relatively prolonged phase of MORB-type magmatism, or if all volcanic phases were emplaced within a very short time span. Therefore, rocks of the Pacquet Harbour Group could represent a volcanic pile deposited within an arc/back-arc transition zone, or, alternatively, are indicative of a complex history involving early arc evolution (emplacement of boninites and felsic intrusive rocks) followed by emplacement of MORB-type subvolcanic and volcanic rocks, associated with the early stages of arc rifting and back-arc formation. It is expected that additional geochemistry will reveal the presence of more rock types within the Pacquet Harbour Group that will further help define the stratigraphy of the volcanic/subvolcanic pile.

Although no new mineral showings were discovered, the chemostratigraphic setting of existing volcanogenic mineralization were investigated. In the southeastern outlier, a wide east-west trending zone of hydrothermal(?) alteration, spatially associated with several gold/sulphide showings (i.e., Brass Buckle mineralization), was identified. According to previous work, the latter, coupled with the presence of boninitic rocks suggest the area could possibility be host to a large sulphide/gold deposit.

C1.2 BUCHANS-ROBERT'S ARM SUBPROGRAM

C1.21 Airborne Gamma Ray / Magnetics / VLF Survey (K.L. Ford)

Objectives. The project was designed to collect new, digital, high resolution, 350m line spaced multiparameter (gamma ray spectrometry, total field magnetic and VLF-EM) airborne geophysical data for parts of NTS 2E/04,/05,/12; 12H/01,/08 and 12A/16 in the Robert's Arm-Lake Bond area of central Newfoundland. These data will augment existing regional, 1000m line spaced multiparameter geophysical data and assist planned and future mapping activities, mineral deposit studies and exploration in the northern part of the Robert's Arm Group.

Methods. During the period of August 14-24, 1995, the Geological Survey of Canada Skyvan aircraft completed 2,000 line kilometres of an originally planned 6,400 line kilometres of flying in the Robert's Arm-Lake Bond area. As a result of major airframe problems, the remaining two thirds of the planned survey area (Gullbridge-Lake Bond) was not completed. Results from that part of the survey completed have undergone initial processing and compilation at the Geological Survey of Canada.

Results. Results for the 1995 flying are still being compiled, and a detailed comparison of these data with the 1988 regional, 1000m line spaced coverage and available geology is awaiting final compilation and map production. A preliminary interpretation (potassium only) shows that the 1995 data provides increased resolution of all anomalies and apparent stratigraphic trends shown in the 1988 regional data. Potassium concentrations appear slightly higher within the Crescent Terrane compared to the Mud Pond Boot Harbour Terrane, possibly reflecting an increased abundance of sedimentary units of the Crescent Lake Formation. Within the Mud Pond Boot Harbour Terrane, elevated potassium levels are restricted to the major felsic centres at Boot Harbour, Haywards Bight and Pilley's Island. Anomalous concentrations of potassium on Pilley's Island associated with potassic altered felsic volcanics, appear to form a continuous zone from Bumble Bee Bight to Spencers Dock. On Long Island (Cutwell Group), 1995 data has outlined additional potassium anomalies and better resolved those that were previously noted in the 1988 coverage. Anomalies within both

the Robert's Arm and Cutwell groups, will require additional "ground truthing" to determine if they are related to alteration, and possibly mineralization, or normal lithological variations. The 1995 survey results are being prepared for release during fiscal 1996-97, as a GSC Open File booklet containing appropriate colour maps and stacked profiles.

Outputs.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Santaguida, F., Ford, K.L. and Hannington, M.D.
1996: Identification of potassic alteration zones associated with massive sulphide mineralization in volcanic rocks, Central Newfoundland; in Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, p. A-82.

C1.22 Epidote Alteration Studies (F. Santaguida and M.D. Hannington)

Objectives. To determine the spatial and geochemical distribution of epidote alteration in the Roberts Arm Group volcanics in order to improve the understanding of fluid chemistry conditions (and/or) water-rock interactions related to base metal mineralization in various volcanic settings in Central Newfoundland. Detailed mineralogical and trace element geochemical studies will be conducted to constrain the physical processes which control the formation of epidote and other minerals during hydrothermal alteration. Both mineralized and unmineralized epidote-altered volcanics in the Roberts Arm Group will be examined.

Methods. Field work consisted of sampling surface exposures throughout central Newfoundland, particularly in the Baie Verte-Springfield area. Drill core, archived in the Department of Mines core library at Springdale was also sampled. Petrographic investigation and mineral chemistry study were completed at the Geological Survey of Canada's laboratories in Ottawa. The determination of epidote mineral chemistry of the different representative alteration styles was derived by a combination of microprobe analyses and trace element geochemistry of mineral separates All field and laboratory investigations were was conducted by Frank Santaguida (Ph.D. candidate, Carleton University), under the supervision of Mark Hannington (GSC).

Results. Epidote-quartz alteration facies are an important assemblage in several metal-bearing, hydrothermal environments such as epithermal deposits, volcanogenic massive sulphides and porphyry deposits. Because epidote mineral stability ranges over a wide spectrum of geochemical conditions, it can be utilized as an indicator for fluid compositions in ancient hydrothermal systems. Field descriptions and petrographic analyses have identified several styles of epidote-quartz alteration which have been subdivided into "volcanogenic" or "epithermal". Variations in epidote mineral chemistry consist of the substitution of Fe^{3+} (as well as traces of Mn, Ti, and Cr) for Al^{3+} in the octahedral atomic site. In most cases, chemical variation is greatest within a single sample illustrating the progressive growth of epidote during hydrothermal activity. In general, stringer and veinlet-style epidote ("epithermal") are Fe-rich compared to groundmass and matrix replacement styles ("volcanogenic"). Strontium values for epidote separates are variable (range of 200-1700 ppm), but the high values, typically within "volcanogenic epidote" suggest a substantial contribution by seawater to the mineral compositions. Epidote REE profiles illustrate the tendency for epidote to concentrate the LREE compared to the HREE. Positive Eu anomalies in all samples are obvious, and likely reflect the degree of plagioclase destruction. The major and trace element geochemistry may be explained in terms of temperature and fluid:rock ratios which are important in the economic evaluation of a hydrothermal system with regard to its base-metal potential.

Outputs.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Santaguida, F. and Hannington, M.D.
1996: Epidote mineral compositions as indicators for diverse hydrothermal settings in central Newfoundland; Geological Survey of Canada, Mineral Colloquium, January 22-24, 1996, Ottawa, Ontario (poster presentation).
1995: Styles of epidote-quartz alteration as indicators for variable hydrothermal systems in Central Newfoundland; 19th Annual review of Activites, Newfoundland Geological Survey Branch, Newfoundland Department of Natural Resources, St. John's, Newfoundland, October 1995.

Santaguida, F., Ford, K.L. and Hannington, M.D.
1996: Identification of potassic alteration zones associated with massive sulphide mineralization in volcanic rocks, Central Newfoundland; in Geological Association of Canada/Mineralogical Asssociation of Canada, Joint Annual Meeting, Program with Abstracts, v. 21, p. A-82.

C1.3 LABRADOR SUBPROGRAM

C1.31 Labrador Geochemical Atlas (P.W.B. Friske and M.W. McCurdy)

Objectives. The goal of this project was to publish a series of interpretative geochemical maps based on analytical

data from the National Geochemical Reconnaissance database. The geochemical maps, to be published at 1:1 000 000 scale, will consist of background geology and drainage overlain by proportional dot symbols representing relative elemental concentrations. Peripheral information will include descriptive notes, index maps, an element contour map, legends , and statistical notes and diagrams.

Methods. The first step in compiling the atlas was to input the vast amounts of geochemical data (i.e., original analytical data + reanalysis program data released as 21 GSC Open Files for over 20 000 lakes and 1 250 streams) resulting from the analysis of lake and stream sediments in Labrador) into a Relational Database Management System (RDMS). The task of database creation and management was completed by P.W.B. Friske and S.W. Adcock (both of the GSC) using Microsoft Access RDMS. A drainage base map was assembled from the 1:1 000 000 scale vector Digital Chart of the World (DCW) for Arc/Info, and bedrock geology was derived from R.J. Wardle's (Newfoundland Geological Survey) recent compilation of Labrador geology. R.J. Wardle's original geology base map was digitized by Northwood Geoscience, Ottawa, and subsequently corrected and converted to Arc/Info format by M.W. McCurdy (GSC). As mentioned above, relative elemental concentrations are to be represented as proportional-sized dots overlain on drainage and bedrock geology. The order in which Atlas map sheets will be released on Open File is: copper, nickel, fluoride in water, zinc, uranium, lead, and gold. Establishing the order of publication was done in consultation with J McConnell and P.H. Davenport (both of the Newfoundland Geological Survey [NGS]). The draft version of the 1:1 000 000 scale copper broadsheet open file, which was compiled by P.W. Friske, M. McCurdy, S.J. Day, and T. West (all of the GSC) has been submitted to the NGS for review.

Results/Economic Impact. The representation of relative concentrations of elements in drainage sediments with proportional-sized dots, overlain on a contemporary bedrock geology map, is deemed to be a very practical means of reviewing a large amount of data. The product, a visually pleasing and scientifically useful set of maps highlighting the relationship between elemental concentrations in drainage sediments and geology, illustrates those regions of Labrador that warrant further mineral exploration. The atlas should stimulate further research and exploration in the region.

Outputs

OPEN FILES

Friske, P.W.B., McCurdy, M.W. and Day, S.J.A.

1996a: National geochemical reconnaissance-Labrador compilation: Distribution of copper in 18 839 lake sediment samples and 1244 stream sediment samples; Geological Survey of Canada Open File 3260a, 1 colour map (1:1 000 000 scale).

1996b: National geochemical reconnaissance-Labrador compilation: Distribution of nickel in 18 839 lake sediment samples and 1244 stream sediment samples; Geological Survey of Canada Open File 3260b, 1 colour map (1:1 000 000 scale).

1996c: National geochemical reconnaissance-Labrador compilation: Distribution of zinc in 18 839 lake sediment samples and 1244 stream sediment samples; Geological Survey of Canada Open File 3260c, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of uranium in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260d, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of lead in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260e, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of gold in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260f, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of arsenic in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260g, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of iron in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260h, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of chromium in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260i, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of ytterbium in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260j, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of loss-on-ignition values in lake sediment samples and 1244 stream sediment samples; Geological Survey of Canada Open File 3260k, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of molybdenum in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260l, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of antimony in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260m, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of barium in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260n, 1 colour map (1:1 000 000 scale).

In Press: National geochemical reconnaissance-Labrador compilation: Distribution of fluoride in lake sediment samples and stream sediment samples; Geological Survey of Canada Open File 3260o, 1 colour map (1:1 000 000 scale).

C1.32 Quaternary Till Geochemistry - Re-analysis Program (R.A. Klassen)

Objectives. To further define and expand on the geochemical properties of till in Labrador, till samples collected as part of MDA field programs in the 1980's were geochemically reanalyzed.

Methods. For more than two thousand archived samples, the silt and clay-sized fraction (<0.063 mm) was sieved and geoochemically analysed by Inductively coupled plasma-atomic emission spectrometry (ICP-AES) and by Instrumental Neutron Activation Analysis methods. Through these analytical methods, the concentrations of more than thirty two elements have been determined, many of which are either not in the original Open File releases or were determined for only part of the sample collection (e. g. As, Au, REE, among others).

Results. The geochemical data illustrate compositional variations in till that, in turn, reflect large-scale compositional variations in bedrock. In the contexts of the Labrador Trough, the Ashuanipi Complex, the Central Mineral Belt, and the Flowers River Igneous Suite, for example, the data indicate differences among and within comparable lithologic units at scales of kilometres to tens of kilometres. The differences are defined either by 'anomalous' concentrations of one or more trace elements, or by element associations at concentrations not necessarily 'anomalous'. The geochemical patterns can reflect gross differences in bedrock mineralogy and mineralization types, as well as metamorphic effects, among other considerations. Thus, both areas of geochemical 'enrichment', which could be associated with a potential for economic mineralization, and 'background' areas alike can help to define a focus for exploration effort.

Project/Economic Impact. The geochemical data can be of use to mineral exploration in the following ways: 1) to identify areas of 'anomalous' till geochemistry, with implication for undiscovered mineralization, 2) to distinguish among comparable geological terrains favorable to exploration, either based on single element concentrations or trace element associations. Such distinction allows exploration effort to be focussed toward favorable areas, with more efficient use of resources, and 3) to identify previously unrecognized geochemical associations that could lead to reevaluation of geology and mineral potential. The geochemical data sets have also been used by mining companies to identify and stake areas for purposes of mineral exploration.

Outputs.

OPEN FILES

Klassen, R.A. and Knight, R.D.
1996: Till geochemistry of central Labrador; Geological Survey of Canada, Open File 3213, 250p., 1 diskette (DOS format in .csv, .xls or .dbf format).

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Klassen, R.A., Friske, P.W.B., Rencz, A.N. and Wardle, R.J.
1996: Interpretation of regional till and lake sediment geochemistry in terms of the glacial history and bedrock geology of central Labrador; Minerals Colloquium 1996, Geological Survey of Canada, Ottawa, January 22-24, 1996.

Klassen, R.A., Rencz, A.N., and Friske, P.W.B.
1995: A GIS analysis of bedrock geology, and regional till and lake-sediment geochemistry in Labrador: Implications for mineral exploration; Report of Activities 1995, Newfoundland Department of Natural Resources, Geological Survey, p 79.

C1.33 Geological Mapping - Mealy Mountain Anorthosite Complex (R.F. Emslie)

Objectives. To complete helicopter-supported mapping and sampling of parts of the Mealy Mountains anorthositic complex (NTS 13G/1 to 8) and compile available geochemical, isotopic, and mineral chemistry data. The field results will be incorporated into a digital (and/or) manual 1:250 000 scale map and an accompanying report.

Methods. Five weeks of field mapping and sampling were completed by R.F. Emslie along the southern flanks of the Mealy Mountains in collaboration with the field parties of C.F. Gower and G.A.G. Nunn (both of the Newfoundland Department of Natural Resources). Substantial gaps in the previous geological map coverage of the Mealy Mountains complex were filled and geological contacts altered accordingly. In order to complete U-Pb geochronology, samples were collected from pegmatitic pods in the anorthositic Etagaulet massif, along with a sample of the Mealy diabase dyke swarm.

Results. Project field work facilitates completion of a final map and report on the Mealy Mountains complex. This will provide a detailed petrological study of the oldest major igneous complex of this type in Canada. The complex intrudes Labradorian crust, and on-going laboratory results indicate that basic anorthositic and granitoid members of the complex were all derived from sources with extremely short crustal residence time relative to the Labradorian event. Unusually high temperature ternary feldspar compositions from the voluminous monzonitic rocks of the suite indicate a strong role for the close involvement of hot mafic magmas in their genesis. Assessment of the anorthositic and related rocks of the complex vis-a-vis the Nain Plutonic Suite with its associated Voisey's Bay Ni-Cu-Co deposit is now in progress. If technical support permits, a digitally-based open-file map will be completed and released prior to the 1996 field season.

Outputs.

PUBLICATIONS

Emslie, R.F.

1996: Troctolitic rocks of the Reid Brook intrusion, Nain Plutonic Suite, Voisey Bat area, Labrador; in Current Research 1996-C; Geological Survey of Canada, p. 183-196.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS

Emslie, R.F.

1995a: Anorthosite-mangerite-charnockite-granite (AMCG) Suites in the Nain, Churchill and Grenville Provinces of Labrador, Canada; Abstracts Volume, Symposium on Rapakivi Granites and Related Rocks, Belém, Brazil, August 2-5, 1995, p. 3.

1995b: Anorthosite-granitoid igneous complexes of Labrador: geology, petrology, and economic potential; Association of Professional Engineers and Geoscientists of Newfoundland/Canadian Institute of Mining, Metallurgy & Petroleum (Newfoundland Branch) Joint Technical Conference, October 1995, St. John's, Newfoundland (oral presentation).

Emslie, R.F. and Hegner, E.

1995: Granitoid rocks of the Mealy Mountains complex, Grenville Province, Labrador, Canada; Abstracts Volume, Symposium on Rapakivi Granites and Related Rocks, Belém, Brazil, August 2-5, 1995, p. 28-29.

C1.4 COORDINATION SUBPROGRAM

C1.41 Digital Initiatives (E. Boisvert)

Objectives. This project is designed to support projects C1.11 (Mapping of Betts Cove Ophiolitic Complex - J. Bédard) and C1.14 (Hope Brook - Metallogenic Studies - B. Dubé). The objective is to create a database structure that permits the broad range of geological data collected under projects C1.11 and C1.14 to be stored in a consistent, logical and expandable format. This database will subsequently facilitate publication of digital geological information. In conjunction with data derived from project C1.14, a three dimensional geochemical study of the Hope Brook deposit was also initiated using from Royal Oak mining database system. The latter study involves the creation of multiple cross-sections and plans of the deposit, in order to better understand the geochemical patterns around the deposit.

Methods. A large component of this project involved the gathering of information from various sources and digitized them into GIS, CAD and Data Base Management System (DBMS) softwares. This process included the digitalizing of air photos and maps, the manual entry of information from field books and down loading computer data obtained in the field. The sources of information (i.e., their precision) were carefully preserved in the database. All data will be released either on CD ROM or diskettes, depending of the size of the dataset in the various computer formats. Since the Geological Survey of Canada uses Arc/Info (ESRI) extensively, and because this GIS software is extremely popular, project data will be released in ESRI format. However, to accommodate less powerful computers, the dataset will also be made available in E00 format (Arc/Info exchange format). The latter format allows retrieval and browsing from a freeware version of ArcView (also from ESRI). Dataset will also be release in AutoCAD's (AutoDesk) DXF format. The DXF format is probably the most widely used graphic exchange format and can be imported into a range of softwares. Beside ESRI and E00 format, tabular data will also be released in a popular DBMS, such as DBase (Asthon) and MS Access (Microsoft corp.). ASC II text versions of the database will also be available, as data in this format is easily imported into any data management software.

Results. The two datasets for projects C1.11 and C1.14, which will contain topological (georeferenced) information and all geological and geochemical data, will be released in digital format. Accompanying text will describe the comprehensive geological data structure used for both projects. Results of the Hope Brook three-dimensional geochemical study will be reported on within project C1.14.

Outputs.

OPEN FILES

Bédard, J., Lauzière, K., Sangster, A.L., Boisvert, E., Tellier, M., Tremblay, A. and Dec, T.
1996: Geological map of the Betts Cove ophiolitic massif and its cover rocks; Geological Survey of Canada, Open File 3271, one 1:20 000 scale colour map.

ORAL AND POSTER PRESENTATIONS/ EXTENDED ABSTRACTS/CONFIDENTIAL REPORTS

Boisvert, E., Dubé, B., Bédard, J. and Lauzière, K.
1995: Geological Database Structure; Newfoundland Department of Natural Resources, 19th Annual Review of Activities, Newfoundland Geological Survey Branch, St. John's, Newfoundland, October 1995.

Dubé, B., and Boisvert, E.
1995: Preliminary Report on the Hope Brook Deposit; Confidential report to Royal Oak. 10 p.

Dubé, B., Lauzière K., and Boisvert E.
1995a: Preliminary report on the geological setting of the acid-sulfate Hope Brook gold deposit, SW Newfoundland; Report of Activities 1995, Newfoundland Department of Natural Resources, Geological Survey, p. 49-50.
1995b: Geological setting of he acid-sulfate Hope Brook gold deposit, SW Newfoundland: nature of the host rocks; Newfoundland Department of Natural Resources, 19th Annual Review of Activities, Newfoundland Geological Survey Branch, St. John's, Newfoundland, October 1995.

C1.42 Coordination and Administration (A.L. Sangster)

Objectives. To facilitate the production/publication/ dissemination of federal (and/or) appropriate provincial Exploration Stimulation Program outputs that have been completed after the official termination dates of any of the Canada-Newfoundland Economic Regional Development Agreements (e.g., 1984-89 Mineral Development Agreement; 1990-1994 Cooperation Agreement on Mineral Development).

Economic/Project Impacts. This project ensures that all federal Geoscience Program Newfoundland MDA project investigations are thorough and complete, and that relevant results are made available to identified user groups in an expeditious fashion.

Summaries for the federal contribution to Programs 2 to 5 were not available for inclusion in this Project Summaries report.

FINANCIAL SUMMARY

PART A. CANADA–NEWFOUNDLAND COOPERATION AGREEMENT ON MINERAL DEVELOPMENT, 1990-1995

PROVINCIALLY IMPLEMENTED PROJECTS (PART A)

PROGRAM I – GEOSCIENCE (2,131,300)

		Expenditures
NEWFOUNDLAND FUNDED AND DELIVERED		
N.1.1.1	Cambro–Ordovician Carbonates	93,700
N.1.1.2	Paleontological Support	130,800
N.1.1.3	Granites, North-Central Newfoundland	114,200
N.1.1.4	Newfoundland Geochronology	77,200
N.1.1.5	Eastern Grenville	597,100
N.1.1.6	Labrador Geochronology	119,500
N.1.1.7	Report on Granitoids	66,400
N.1.4.1	Colour Map Production from Digital Databases	74,300
N.1.5.1	Thesis Support	41,500
N.1.8.1	Analytical Support	254,000
N.1.8.2	Computer Support	199,000
N.1.8.3	Cartographic Support	125,000
N.1.8.4	Mineral Exploration Consulting Services	61,900
N.1.8.5	Administrative Support	137,900
N.1.2.1	Diamond Assessment, Labrador	-
N.1.2.2	Volcanic Metallogenic Database	38,800
	Total	**2,131,300**

FEDERALLY FUNDED, NEWFOUNDLAND DELIVERED (2,671,400)		
NC.1.1.1	Gander Zone	71,700
NC.1.1.2	Notre Dame Bay	111,100
NC.1.1.3	Granitoid Database	178,500
NC.1.1.4	Superior–Eastern Churchill Provinces Project	485,100
NC.1.2.1	Rare Metal Metallogeny	273,900
NC.1.2.2	Gold Metallogeny, Eastern Dunnage Zone	205,700
NC.1.2.3	Volcanic Rock Geochemical Database	145,700
NC.1.3.1	Analysis of Archived Samples, Newfoundland	135,000
NC.1.3.2	Geochemical Field Surveys	276,000
NC.1.3.3	Analysis of Archived NGR Samples, Labrador	30,400
NC.1.4.1	Geophysical Data Compilation	269,900
NC.1.5.1	Quaternary Mapping, Western Labrador	300,900
NC.1.5.2	Placer Potential/Till Geochemistry, Northeast Newfoundland	136,800
NC.1.8.1	Support Services	50,700
	Total	**2,671,400**

PROGRAM 2 – MINERALS TECHNOLOGY (901,000)

		Expenditures
NEWFOUNDLAND FUNDED AND DELIVERED		
N.2.3.1	Definition Drilling at Baie Verte Mines	127,300
N.2.3.2	Sodium Silicate as a Filtration Rate Modifier: Terranov Mining Corp., Baie Verte	6,800
N.2.3.3	Pine Cove Assessment Drilling, Nova Gold Resources Inc	50,000
N.2.3.4	Metallurgical Testing – Rendell Jackman Property, Major General Resources Ltd	11,900
N.2.3.5	Recovery and Treatment of a Copper or Bulk Sulphide Flotation Concentrate from the Hope Brook Ore: Royal Oak Mines Inc., Newfoundland Division	85,100
N.2.3.6	Revision of Preliminary Underground Design and Feasibility Study – Baie Verte Asbestos Mine	27,400
N.2.3.7	Pre-screening Reclaimed Tailings at Teranov Mining Corporation.	30,750
N.2.3.8	Mineral Processing Test Work on the Buchans Brook Delta Tailings Deposit – Newfoundland Mining and Exploration Ltd	3,500
N.2.3.9	Infill Drilling Program on the Hammerdown Gold Deposit – Major General Resources Ltd.	50,000
N.2.3.10	Evaluation of the Fibre Group Distribution of the Underground Asbestos Deposit at Baie Verte Mines	10,900
N.2.3.11	A Technical and Economic Evaluation of Replacing Cement with Flocculant to Reduce Cement Consumption while Increasing Gold Recovery on the Pine Cove Ore – Pine Cove Resources Inc	16,250
N.2.3.12	Assessment of Dolomite Potential at Lower Cove, Newfoundland – Newfoundland Resources and Mining Company Limited.	19,800
N.2.3.13	Ground Control Instrumentation Program, Royal Oak Mines Inc	34,500
N.2.3.14	Mining and Milling Studies – Feasibility Study for a Docking, Conveying, and Loading Facility at Fischells Brook	30,000
N.2.4.1	Mine Data Base System	385,000
	Total	**889,200**

PROGRAM 3 – ECONOMIC DEVELOPMENT (300,000)

NEWFOUNDLAND FUNDED AND DELIVERED		
N.3.1.1	Pyrophyllite – Ceramic Tile Prefeasibility Study	64,600
N.3.1.2	Demonstration Project – Pyrophyllite Absorbency	48,500
N.3.3.1	Dimension Stone Industry Seminar	5,000
N.3.3.2	Newfoundland Peat Opportunities – An International Conference	16,400
N.3.3.3	Mineral Industry Brochure	-
N.3.3.4	Peat Promotion – Mole Drainage	5,000
N.3.3.5	Newfoundland Mineral Industry Promotion	15,000
N.3.4.1	Chamber of Mineral Resources	20,900
N.3.4.2	Mining Tax Review	40,000
N.3.4.3	Energy Intensive Industries	70,000
N.3.5.1	Mineral Policy Updates – Consulting	12,000
	Total	**297,400**

PROGRAM 4 – MINERAL INDUSTRY ASSISTANCE (1,100,000)

		Expenditures
NEWFOUNDLAND FUNDED AND DELIVERED		
N.4.1.1	MIAP Coordinator	366,800
N.4.1.2	Prospectors Grants	540,000
N.4.1.3	Prospectors Training	193,500
	Total	**1,100,300**

PROGRAM 5 – PUBLIC INFORMATION (309,500)

NEWFOUNDLAND FUNDED AND DELIVERED		
N.5.1	Special Publications and Promotions	309,500
	Total	**309,500**
	GRAND TOTAL	**7,399,100**

FEDERALLY IMPLEMENTED PROJECTS (PART A)

PROGRAM 1 – GEOSCIENCE

		Expenditures
C.1.111	Geology, Notre Dame Subzone	194,771
C.1.112	Geology, Corner Brook Lake Area	200,768
C.1.113	Geology, Southernmost Long Range	329,822
C.1.115	Introduction of Airborne Gamma Ray Spectrometric Surveys	86,729
C.1.116	Multiple Data Set Interpretation	167,071
C.1.121	Gold Mineralogy and Geochemistry of Massive Sulphide Deposits, Newfoundland and Labrador	94,025
C.1.122	Sulphide Mineralization in Cambro–Ordovician Sediments	202,534
C.1.123	Metallogeny of Codroy Group	16,954
C.1.124	Metallogeny of Gold in Major Fault Zones	128,387
C.1.125	Metallogeny of Baie Verte and Bay of Islands	109,294
C.1.126	PGE in Mafic–Ultramafic Intrusions	84,387
C.1.127	Quaternary Geology and Till Geochemistry, Central Volcanic Belt	399,149
C.1.128	Biogeochemistry	23,532
C.1.129	Hydrogeochemistry: Surface Waters for Geochemical Exploration	28,318
C.1.211	Geology, Northern Torngat Mountains	346,945
C.1.212	Lithogeochemistry and Geochronology of the Mugford Group	149,445
C.1.213	Platinum Group Elements	2,719
C.1.214	Metallogenic Map, Central Labrador Mineral Belt	11,339
C.1.215	Regional Geochemistry, Labrador	429,139
C.1.216	Labrador Geoscience Data Integration and Interpretation	121,556
C.1.311	Placer Mineral Potential off Northeast Newfoundland	272,422
C.1.411	Co-ordination	175,772
C.1.412	Contract Geoscience	2,743,631
	Total (GSC)	**6,318,709**

PROGRAM 2 – MINING AND MINERALS TECHNOLOGY

C.2.0.1	Project Management	236,070
C.2.1.1	Development of 3D Finite Element Algorithm for Blast Modelling	21,270
C.2.1.6	Development of a Blasthole Drill Positioning System	17,680
C.2.1.7	Development of a Shovel/Drill Monitoring System	109,509
C.2.1.8	Use of Spent Fuel Oil in ANFO	-
C.2.2.1	Improved Iron Recovery in Spiral Plant	48,300
C.2.2.2	Benfonite Substitution Program	43,380
C.2.2.4	Improved Iron Recovery while Meeting Varied Customer Quality Demands	96,292
C.2.2.5	Application of Expert Systems to High Tension Circuit	96,768
C.2.2.6	Process Development for the Production of Manganese Concentrates	60,708
C.2.2.7	Iron Recovery – Scully Mill	25,975
C.2.2.8	Iron Weight Yield Improvement	574,158
C.2.2.9	Iron Concentrate Recovery Improvement	636,270

		Expenditures
C.2.2.10	Improvement of LTD of Fluxed Pellets	130,000
C.2.2.11	Development of DR Pellet Product	133,790
C.2.2.12	Reduction of Iron Pellets on a Straight Grab Induration Machine	52,000
C.2.2.13	2B Belt Wash Mn Correlation	9,165
C.2.3.4	Metallurgical Evaluation of Using Indoor Vat Leach – Pine Cove	42,045
C.2.3.5	Improvement in Gold Processing	-
	Total (CANMET)	**2,333,380**

PROGRAM 3 – DEVELOPMENT STUDIES

C.3.1.1	Limestone/Dolomite Study	51,612
C.3.1.2	Peat Market Study	49,825
C.3.1.3	IRMIS Demonstration	1,366
C.3.1.4	Industrial Minerals Information Exchange	2,162
C.3.1.5	Information Exchange 28th. Forum	9,331
C.3.1.6	7th International Mini-Mill Conference	7,344
C.3.1.7	Centre for Earth Resource Research Economic Studies Program	58,654
C.3.1.8	Labrador Weset Economic Diversification Study	136,109
C.3.1.9	Completion of Existing Initiatives Printing and Binding 5,000 Sample Review 12,500	21,934
C.3.1.10	Update on Fluorspar	20,000
C.3.1.11	Demonstration of Newfoundland Dimension Stone	29,446
C.3.1.12	30th. Industrial Minerals Information Exchange	-
C.3.1.13	Chamber of Mineral Industries	36,937
	Total	**424,720**

PROGRAM 4 – PUBLIC INFORMATION

C.5.1	Publications	192,606
C.5.2	Advertising	22,000
C.5.3	Videos	18,895
C.5.4	Exhibits	26,331
C.5.5	Newsletter	11,110
C.5.6	Special Events	29,209
C.5.7	Photography	10,557
C.5.8	Research and Writing	37,553
C.5.9	Project Manager	60,591
C.5.10	MIAP Brochure	34,753
	Total	**443,605**

		Expenditures
C.6.1	Administration	897,593
C.6.2	Environmental Screening	3,671
	Total	**901,264**
	Total (MPS)	**1,769,589**
	Total Parallel Program	**10,421,678**

PROGRAM 5 – CONTRIBUTION TO MIAP

C.4.1.1	Resource Access Road – Lower Cove	50,000
C.4.1.2	Newfoundland Slate Inc.	71,000
C.4.1.3	Nova Gold – Power Line	-
C.4.1.4	Teranov Mining (Pressure Packer)	45,093
C.4.1.5	Teranov Mining (Tailings Line)	33,300
C.4.1.6	Greater Lamaline Area Development	6,000
C.4.1.7	Armstrong World Industries Access Road	50,000
C.4.1.8	Royal Oak Mines Construction of Gravel Airstrips	100,000
C.4.1.9	Royal Oak Mines Construction of Bulk Storages	100,000
C.4.1.10	Newfoundland Resources and Mining Company Lower	-
C.4.1.11	LIDC Bus Boat for Quarry	17,500
C.4.1.12	Newfoundland Slate Inc. – Nut Cove	100,000
C.4.1.13	Classic Stone Inc. (Road Upgrade)	31,000
C.4.1.14	Mt. Peyton Granite – Road Upgrade	31,457
C.4.1.15	Armstrong World Industries Canada Ltd. – Access Road	-
C.4.2.1	Corona Corporation – Placer Chromite	50,000
C.4.2.2	Hollinger North Shore Exploration Inc.	-
C.4.2.3	Hollinger North Shore Exploration Inc.	-
C.4.2.4	Mart Mining	-
C.4.2.5	Auracal Resources Inc. Calcium Carbonate	50,000
C.4.2.6	Tiara Marble	50,000
C.4.2.7	Classic Stone	24,200
C.4.2.8	J. Tuach Sample – Retaining Wall	23,000
C.4.2.9	Appalachian Granite Quarry Trail	17,121
C.4.2.10	Classic Stone Inc. – Quarry Test – Buchans	20,416
	Classic Stone	50,000
C.4.2.11	Monument and Granite Works – Quarry Test	41,910
C.4.2.12	Major General Resources – Feasibility Study	-
	Total	**961,997**
	TOTAL ($11,855,000)	**11,383,675**

PART B. CANADA–NEWFOUNDLAND AGREEMENT ON MINERAL DEVELOPMENT, 1994-1996

PROVINCIALLY IMPLEMENTED PROJECTS (PART B)

PROGRAM 1 – GEOSCIENCE

		Expenditures
FEDERALLY FUNDED, NEWFOUNDLAND DELIVERED (400,000)		
NC.1.A.1	Digital Compilation/Data Management Buchan's–Robert's Arm	78,095
NC.1.A.2	Buchans Group Compilation	-
NC.1.A.3	Quaternary Mapping and Till Geochemistry, Robert's Arm Belt	29,368
NC.1.A.4	Mineral Deposit Studies	48,766
NC.1.A.5	Bedrock Mapping	65,369
	Total	**221,598**
NEWFOUNDLAND FUNDED AND DELIVERED (484,000)		
N.1.B.1	Data Compilation/Data Management, Hopedale	50,259
N.1.B.2	Bedrock Mapping	337,352
N.1.B.3	Quaternary Mapping, Kanaririktok River Area	-
N.1.B.4	Geochemistry	-
N.1.B.5	Hopedale Project	11,343
N.1.B.6	Mineral Deposit Studies	-
	Total	**398,954**

PROGRAM 2 – MINERAL TECHNOLOGY

NEWFOUNDLAND FUNDED AND DELIVERED (100,000)		
N.B.2.4.1	Mine Data Base System	101,715
	Total	**101,715**

PROGRAM 3 – ECONOMIC EVALUATION AND PROSPECTORS' TRAINING

NEWFOUNDLAND FUNDED AND DELIVERED (40,000)		
N.B.3.3.3	Mineral Industry Brochure	20,868
	Total	**20,868**

PROGRAM 4 – MIAP

N.B.4.1.1	MIAP Coordinator	44,671
N.B.4.1.2	Prospectors' Grants	36,500
	Total	**81,171**

PROGRAM 5 – PUBLIC INFORMATION

		Expenditures
NEWFOUNDLAND FUNDED AND DELIVERED (100.000)		
N.5.B.1	Special Publications and Promotions	71,117
	Total	**71,117**
	Grand Total	**895,423**

FEDERALLY IMPLEMENTED PROJECTS (PART B)

PROGRAM 1 – GEOSCIENCE

		Expenditures
C.1.11	Mapping of Betts Cove Ophiolitic Complex	73,139
C.1.12	Mineral Deposit Studies – Betts Cove Ophiolite	59,248
C.1.13	Geological Mapping – Glover Group Volcanics	74,988
C.1.14	Hope Brook – Metallogenic Studies	65,991
C.1.15	Structural Geology – Southernmost Long Range	10,000
C.1.16	Mapping and Mineral Deposit Modelling – Pacquet Harbour Group	22,240
C.1.21	Airborne Gamma Ray/Magnetic/VLF Survey	100,000
C.1.22	Epidote Alteration Studies	7,200
C.1.23	Contract Geoscience	400,520
C.1.31	Labrador Geochemical Atlas	35,597
C.1.32	Quaternary Till Geochemistry – Re-analysis Program	74,075
C.1.33	Geological Mapping – Mealy Mountains Anorthosite Complex	10,000
C.1.41	Digital Initiatives	43,500
C.1.42	Coordination and Administration	25,823
	Total (GSC)	**1,006,321**

PROGRAM 2 – MINERALS TECHNOLOGY

C.2.0.1	Project Management	47,585
	Project Management Extension	45,585
C.2.1.1	Evaluation of GPS for Real-Time Shovel Locating	88,820
C.2.1.2	Shovel Maintenance Monitoring	-
C.2.2.1	Manganese Rejection	62,400
C.2.2.2	Vat Leaching	11,336
C.2.2.3	Environmental Impact of Silica Flotation	44,274
C.2.2.4	Gold Recovery Improvements	-
C.2.2.5	Iron Recovery and Pellet Quality	-
	Total (CANMET)	**300,000**

PROGRAM 3 – ECONOMIC EVALUATION AND PROSPECTORS TRAINING

C.3.1	Prospectors Training Course	115,000
C.3.2	Demonstration on NF Dimension Stones	17,449
C.3.3	Peat Deposits	14,361
C.3.4	Chamber/Trade Mission	5,000

		Expenditures
C.3.5	Completion of Existing Initiatives	49,820
	– 94/95 Kimberlite Indicator 12,000	
	– 94/95 Geochronology 22,000	
	– 94/95 Sample Boxes 2,160	
	– 94/95 Publications 13,000	
	Total (Economic Evaluation and Prospectors Training)	**201,630**

PROGRAM 4 – MINERAL INDUSTRY ASSISTANCE PROGRAM

C.4.1.1	Nova Gold Resources Inc. Pine Cove – Power Line	-
C.4.1.2	Armstrong World Industries Can. Ltd. – Access Road	-
C.4.1.3	Ming Minerals Inc.	50,000
C.4.1.4	Aurora International Inc.	50,000
C.4.2.1	Classic Stone	50,000
C.4.2.2	J. Tuach Geological Consultants	25,000
C.4.2.3	Major General Resources Ltd.	54,038
C.4.2.4	Roycefield Resources Ltd.	50,000
C.4.2.5	Henry Jefford/Island Gams	-
	Total (MIAP)	**279,038**

PROGRAM 5 – PLANNING, IMPLEMENTATION, EVALUATION, AUDIT AND PUBLIC INFORMATION

C.5.1	Planning, Implementation, Evaluation, Audit and Public Information	250,000
	Total	**250,000**
	TOTAL	**2,036,989**