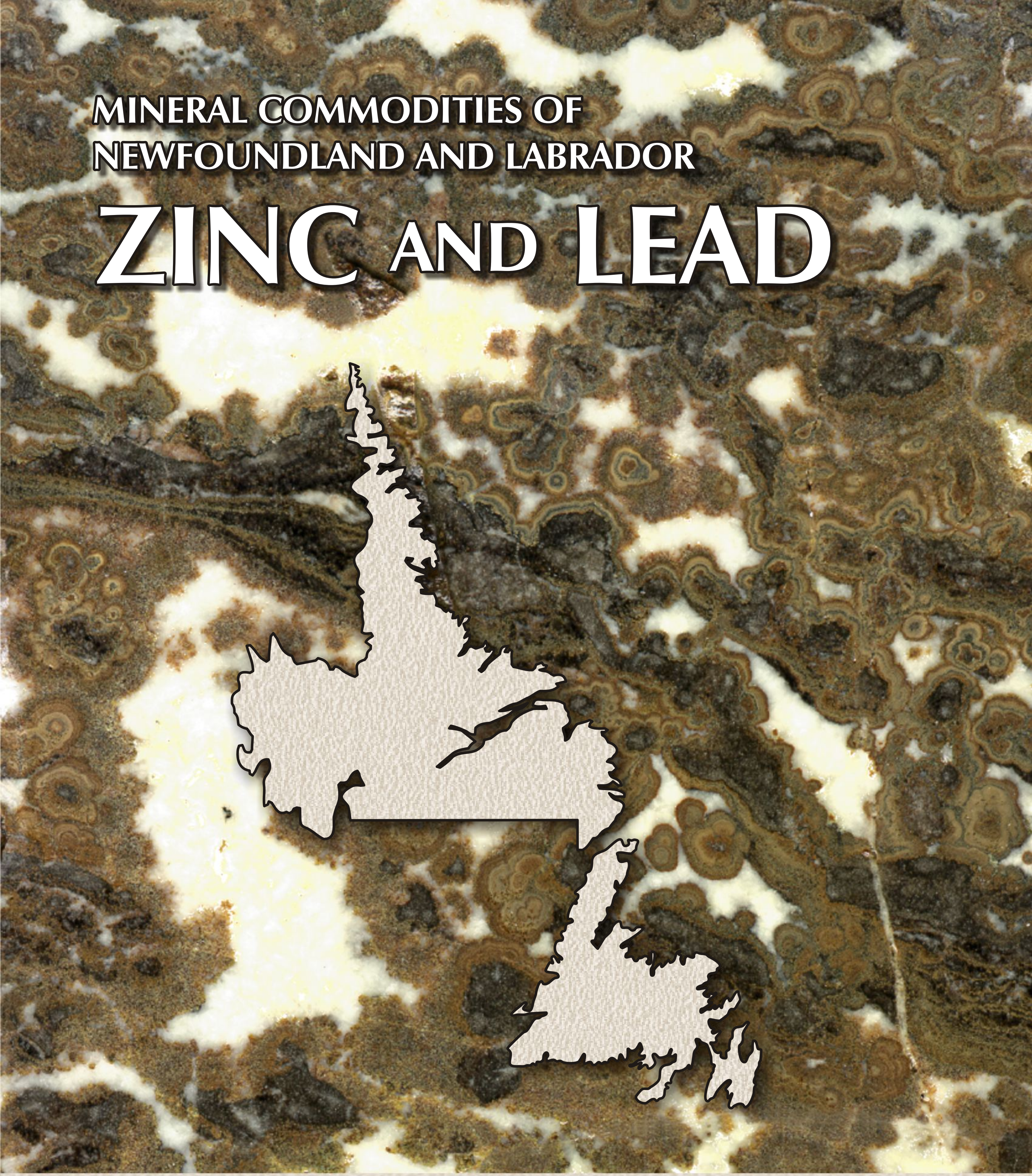
MINERAL COMMODITIES OF NEWFOUNDLAND AND LABRADOR

ZINC AND LEAD



Newfoundland Labrador
Natural Resources
Mines Branch

Geological Survey
Mineral Commodities Series
Number 1

Mineral Commodities of Newfoundland and Labrador

Zinc and Lead

Foreword

This is the first in a series of summary publications covering the principal mineral commodities of the Province. It's purpose is to act as a source of initial information for explorationists and to provide a bridge to the detailed repository of information that is contained in the maps and reports of the provincial and federal geological surveys, as well as in numerous exploration-assessment reports. The information contained in this series is accessible via the internet at the Geological Survey of Newfoundland and Labrador web site http://www.nr.gov.nl.ca/mines&en/geosurvey/

Publications in the Series

Zinc and Lead (Number 1, revised 2008); Nickel (Number 2, revised 2008);
Copper (Number 3, revised 2007); Gold (Number 4, revised 2008); Uranium in Labrador (Number 5, 2008)

Additional Sources of Information

Further information is available in the publications of the geological surveys of Newfoundland and Labrador and Canada. The Geological Survey of Newfoundland and Labrador also holds a considerable inventory of exploration-assessment files available for onsite inspection at its St. John's headquarters and for download via the Geological Survey of Newfoundland and Labrador web site http://www.nr.gov.nl.ca/mines&en/geosurvey/. Descriptions of individual mineral occurrences are available through the provincial Mineral Occurrence Database System (MODS), which is accessible from the Survey's web site. Up-to-date overviews of mining developments and exploration activity targeting copper are available on-line at http://www.nr.gov.nl.ca/mines&en/

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Compiled by R.J. Wardle, 2000
Reprinted with minor revisions, 2008

Front Cover: Colloform sphalerite ore, Daniel's Harbour mine.

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Introduction

Zinc was the most important non-ferrous metallic commodity produced in Newfoundland between 1928 and 1990. During this period, 2.3 million tonnes of the metal were produced with an *in situ* value of US$3.1 billion, using present day prices. Lead, apart from some early ventures, was generally produced only as a by-product of other mining operations for a total production of 1.22 million tonnes at a present day *in situ* value of US$556 million.

The two most important geological environments for zinc and lead mineralization in Newfoundland are the carbonate platform rocks of western Newfoundland, which host Mississippi Valley-type (MVT) deposits, and the volcanic terranes of central Newfoundland, which host numerous volcanogenic massive sulphide (VMS) deposits. Lead, and to a lesser extent zinc, also occur in a number of vein-hosted epigenetic occurrences that locally formed the basis for 19th century mining operations, but which are generally uneconomic in today's markets.

The first recorded production of lead in Newfoundland was from vein deposits at the La Manche Mine of Placentia Bay in 1855. Attempts were made to develop other mines between 1860 and 1885; however, these were all based on small epigenetic veins and none managed any sustained period of production or profitability.

Modern mining of zinc and lead began in 1928 with the development of the Buchans volcanic-hosted deposits located in central Newfoundland (Figure 1). Further discoveries followed, and the Buchans operations remained in production until their eventual depletion in 1984. In the meantime, exploration in the western Newfoundland carbonate platform had led to the discovery in 1963 of the Daniel's Harbour zinc deposit. This came into production in 1975 and closed in 1990, again following depletion of the ore reserves.

Zinc was the most important non-ferrous metallic commodity produced in Newfoundland during the period 1928 to 1990 when 2.3 million tonnes of the metal were produced.

Although there is currently no production of zinc or lead in the Province, there remains considerable potential for future discoveries.

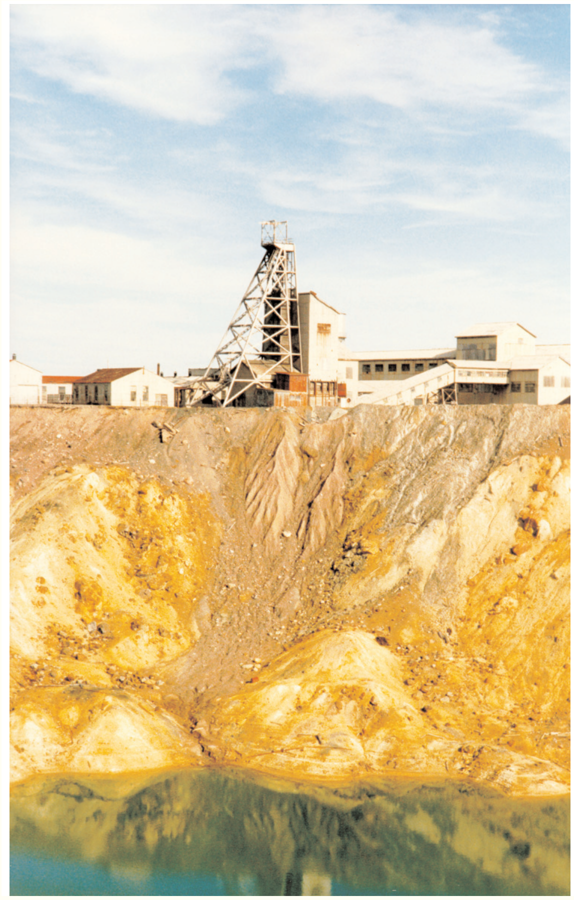

Figure 1. *The Lucky Strike Glory Hole – the first Buchans Mine.*

Carbonate-Hosted Mineralization Environments

The principal mineralization environments of this type are found in the carbonate rocks of the Humber Zone that form the western margin of the Newfoundland Appalachians. Three rock units host zinc–lead mineralization in the Humber Zone, the most important of which is the Cambro-Ordovician platformal carbonate sequence that stretches from the Port au Port Peninsula in the south to the top of the Great Northern Peninsula (Figure 2). The predominant mineralization consists of sphalerite–galena and pyrite filling secondary voids as a replacement of carbonate beds and as the matrix to collapse breccias.

Generally, this mineralization is considered to be of Mississippi Valley-type (MVT) and comparable to other deposits of this type found in the western platformal sequences of the Appalachian Orogen (e.g., the lead and zinc deposits of Tennessee). Mineralization is found throughout the sequence but predominantly within the Port au Port and St. George groups (Figure 3). Sphalerite is the dominant ore mineral and

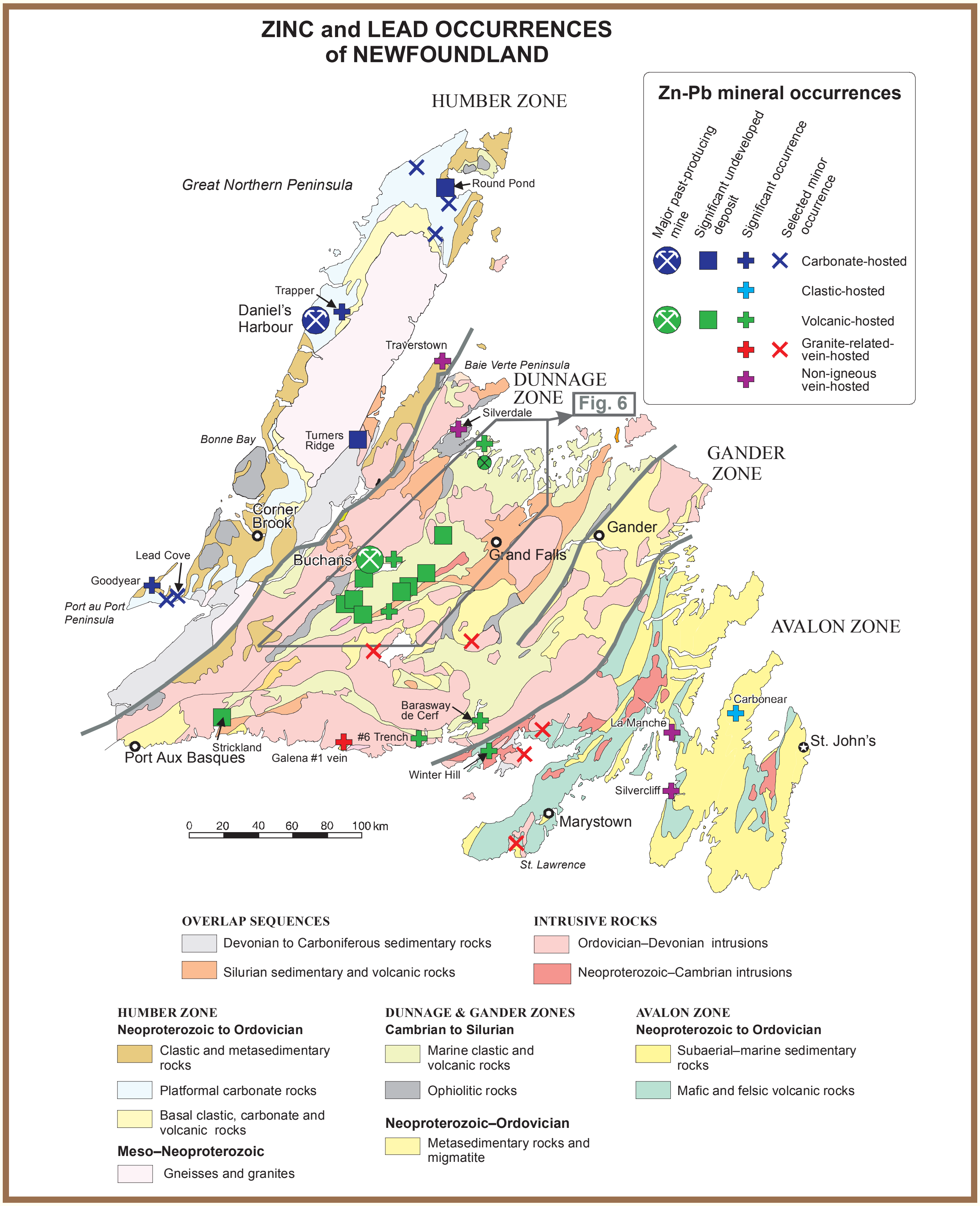

Figure 2. *Simplified geological map of Newfoundland showing location of major zinc and lead occurrences.*

was preceded by the development of a secondary porosity in association with formation of pseudobreccia. The latter is a replacement product in which “fragments” of earlier dolomitized limestone are left floating in a matrix of secondary sparry dolomite (Figure 4). Other true breccias in the vicinity of the deposits are related to solution collapse, probably in response to the local emergence of the platform and consequent karstification of the carbonate rocks below a regional unconformity.

platform. These include vein-hosted and void-fill sphalerite–galena occurrences in sparry and fine-grained dolomite of the Cambrian Port au Port Group on the tip of the Great Northern Peninsula, and near Corner Brook in the south. These are too numerous to be all shown on Figure 2 but are depicted schematically in Figure 3.

A different style of mineralization is found within the brecciated and reefoid Carboniferous rocks that

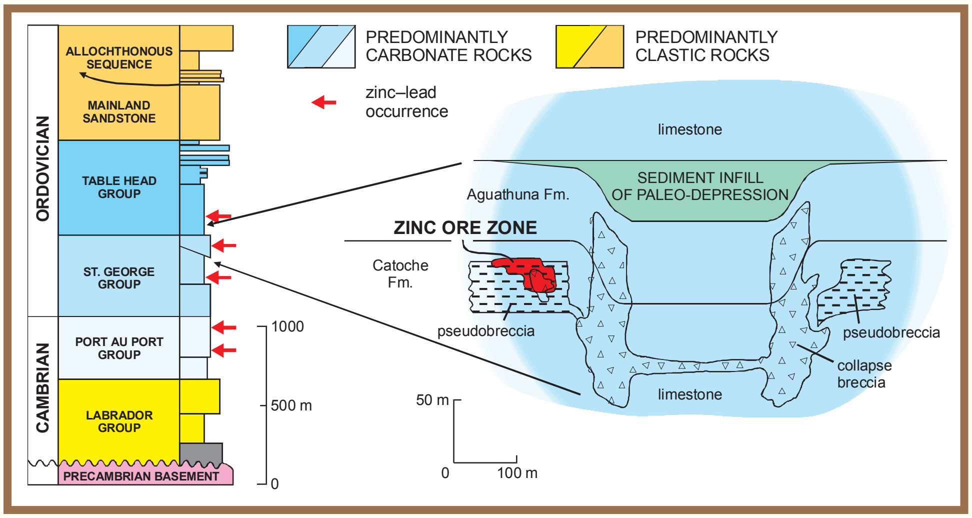

Figure 3. *Setting of Daniel’s Harbour-type zinc–lead mineralization in relation to paleodepressions and pseudobreccia. Column at left shows stratigraphic position of Daniel’s Harbour and other MVT zinc–lead occurrences (*after *Lane, 1984).*

The single major example of an MVT-type deposit was at Daniel's Harbour, where about 7 million tonnes of zinc ore, at an average grade of 7.8% zinc, were mined between 1975 and 1990. The deposit consisted of numerous ribbon-like orebodies hosted by pseudobreccia. The orebodies were localized on the margins of structural depressions, interpreted as solution collapse structures that formed during emergence, closely associated with contemporaneous faulting (Figure 3). Sphalerite was deposited together with hydrothermal dolomite after significant burial. Reactivated faults and veins served as conduits for warm, saline brines that carried the zinc. Numerous other zinc showings outcrop in the Daniel’s Harbour area, including the Trapper prospect, where mineralization has been encountered in a widely spaced drilling program. The only other significant deposit is at Round Pond, where 152 400 tonnes of 2.5% Zn have been identified in cherty dolomite breccias and pseudobreccia of the Boat Harbour Formation (St. George Group), locally in association with bitumen-rich zones and other zinc–lead occurrences.

Numerous other minor occurrences are found throughout the stratigraphic sequence of the carbonate

Figure 4. *Daniel’s Harbour ore. Early, grey, burrowed dolostone has been replaced by yellow sphalerite and white dolomite, locally enclosing suspended fragments of dolostone in pseudobreccia texture.*

overly the Cambro-Ordovician sequences on the Port au Port Peninsula. The basal Carboniferous rocks occupy north-trending paleokarst valleys and contain open-space fillings of galena and sphalerite associated with marcasite, calcite, and locally barite and strontianite/celestite gangue. The underlying Cambro-Ordovician carbonates also contain similar mineralization in veins and vugs that at least locally have a speleothem character and may thus be karst related. Therefore, the lead-rich mineralization in this area may be of predominantly Carboniferous or younger age. Examples of this style of mineralization are found at the Goodyear and Lead Cove prospects (Figure 2). The latter is noteworthy for an unsuccessful attempt, ca. 1874, to mine lead. Veins of similar style, and age of mineralization, are known in other areas of the Port au Port Peninsula and to the east.

The single, major carbonate-hosted deposit was at Daniel's Harbour where approximately 7 million tonnes of zinc ore, at an average grade of 7.8% zinc, were mined.

A third carbonate-hosted environment is found in the Silurian Sops Arm Group of western White Bay where brecciated dolomite at the base of the sequence is host to the Turners Ridge deposit (Figure 2), containing 200 000 tonnes of between 3 and 4% lead in the form of galena, and in association with sphalerite and pyrite mineralization. Brecciation is likely related to thrusting of this part of the Sops Arm Group over Carboniferous rocks of the Deer Lake Basin. As the galena and sphalerite postdate the brecciation, it is probable that the mineralization is Carboniferous and derived from fluids expelled from the Deer Lake Basin.

A Paleoproterozoic equivalent of MVT mineralization occurs in the Ramah Group of northern Labrador (Figure 5) where the Reddick Bight Formation dolomite is host to a number of small sphalerite–galena ± pyrite occurrences associated with secondary void-fill texture.

Volcanic-Hosted Mineralization Environments

For zinc and lead mineralization, this environment is largely restricted to the volcanic terranes of the Dunnage Zone in central Newfoundland (Figures 2 and 6) but is also known in the Neoproterozoic volcanic rocks of the western Avalon Zone (Figure 2). The Dunnage Zone represents a collage of Cambrian to Mid-Ordovician island-arc terranes, which were mostly constructed on a substrate of ophiolitic oceanic crust, and structurally juxtaposed during Late Ordovician to Early Silurian ocean closure. The junction between the western and eastern margins of this ocean is generally termed the Red Indian Line (Figure 6).

The arc terranes comprise variable proportions of mafic and felsic volcanic rocks in association with thick epiclastic sequences and have been grouped into back-arc, primitive-arc, mature-arc and continental-rift (back-arc?) associations. Zinc–lead mineralization is generally associated with the mature-arc and continental-rift associations, but also with mixed mafic/felsic sequences in the primitive-arc association. In contrast, the back-arc and mafic-dominated primitive-arc sequences tend to be copper dominated; however, deposits in these sequences commonly contain zinc and lead as secondary commodities, e.g., in the Betts Cove, Whalesback and Little Deer mines of Notre Dame Bay (*see the companion summary on Copper*). Mineral assemblages are typically polymetallic, ranging from Zn–Pb–Cu–Au–Ag to Zn–Pb–Ag, lead and zinc becoming increasingly dominant toward the south, possibly reflecting the greater influence of continental crust in that direction.

Mineralizing environments are generally those associated with the development of volcanogenic massive sulphide (VMS) deposits and include genetically related stringer-stockwork, massive sulphide, and debris-flow deposits.

The Dunnage Zone is conveniently divided into a number of belts, as shown on Figure 6. The Early Ordovician *Buchans–Roberts Arm belt* is characterized by bimodal calc-alkalic volcanic rocks of mature-arc character and is deformed into a series of generally southeast-verging duplexes and thrust stacks, locally associated with strong deformation. The most significant zinc–lead VMS occurrences are those at Buchans in the southwest and Pilley's Island in the northeast. The major source of production has been the Buchans deposits, where five major orebodies were mined between 1928 and 1984 for a total of 16.2 million tonnes at average grades of 14.51% zinc, 7.56% lead, 1.33% copper, 1.37 g/t gold and 126.0 g/t silver. In terms of the value of the metal produced, these rank as world-class deposits and underscore the

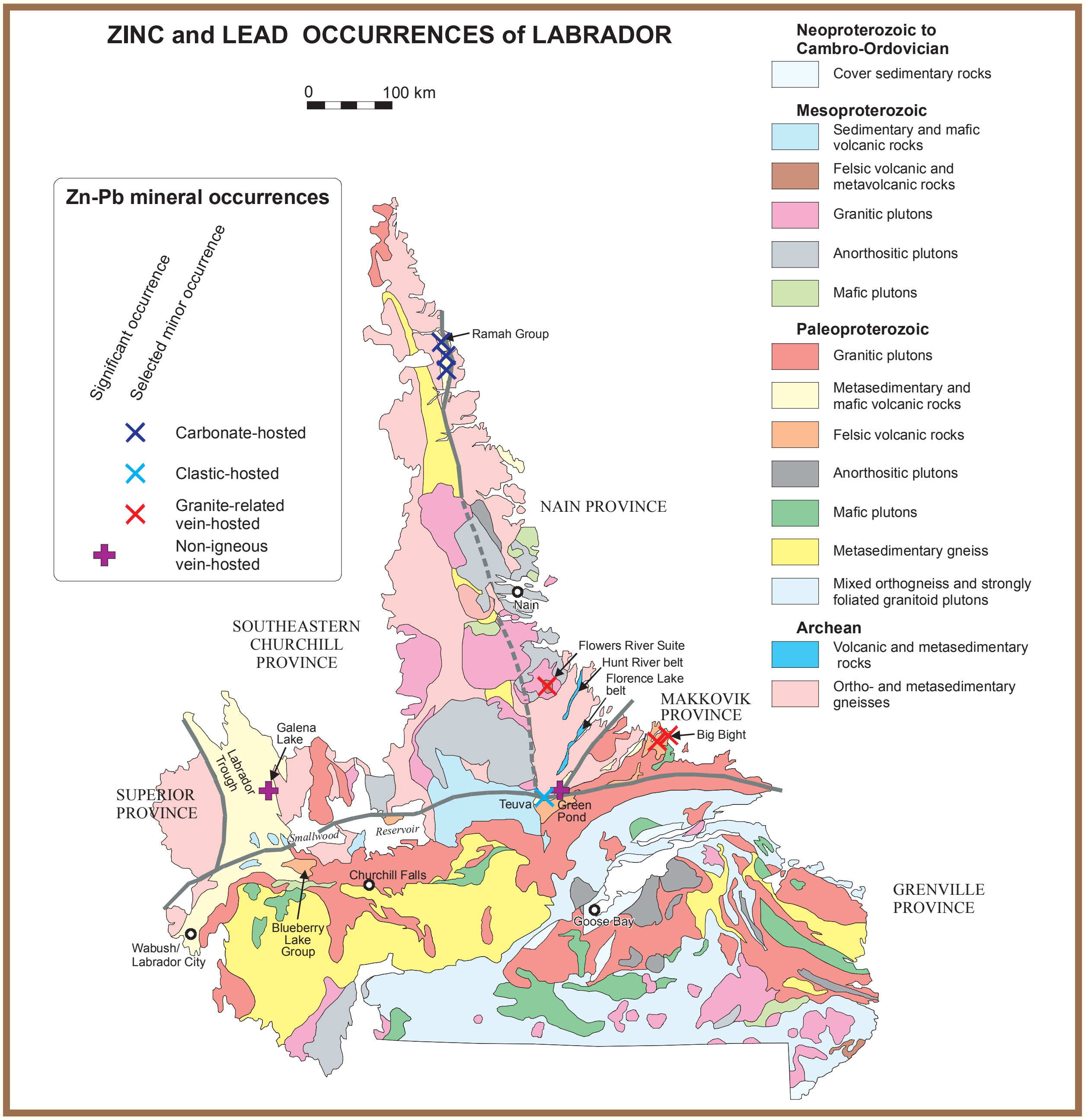

Figure 5. *Simplified geological map of Labrador showing location of significant zinc and lead occurrences.*

potential of the central Newfoundland volcanic terranes. Most of the mineralization is associated with felsic pyroclastic rocks and breccias, and conforms to the classic Kuroko model for VMS deposits. Three distinct ore types, termed “stockwork”, “in-situ” and “transported” have been mined at Buchans, the most important being the in situ and transported types. The transported ores are perhaps better developed than anywhere else in the world, and consist of tongue-like debris-flow breccia deposits (Figure 7).

The Pilley's Island deposit is a predominantly copper–pyrite deposit that was originally mined for its pyrite content. However, it contains localized zinc-rich zones, e.g., the Bull Road occurrence, which has yielded samples containing up to 45.9% Zn. Other significant zinc occurrences in the Buchans–Roberts Arm belt include the Lake Bond deposit (geological resource of up to 1 325 900 tonnes grading 2.6% Zn and 0.38% Cu), the Connell and Shamrock prospects, and the Skidder deposit, which contains 1 000 000 tonnes of 2% Zn and 2% Cu.

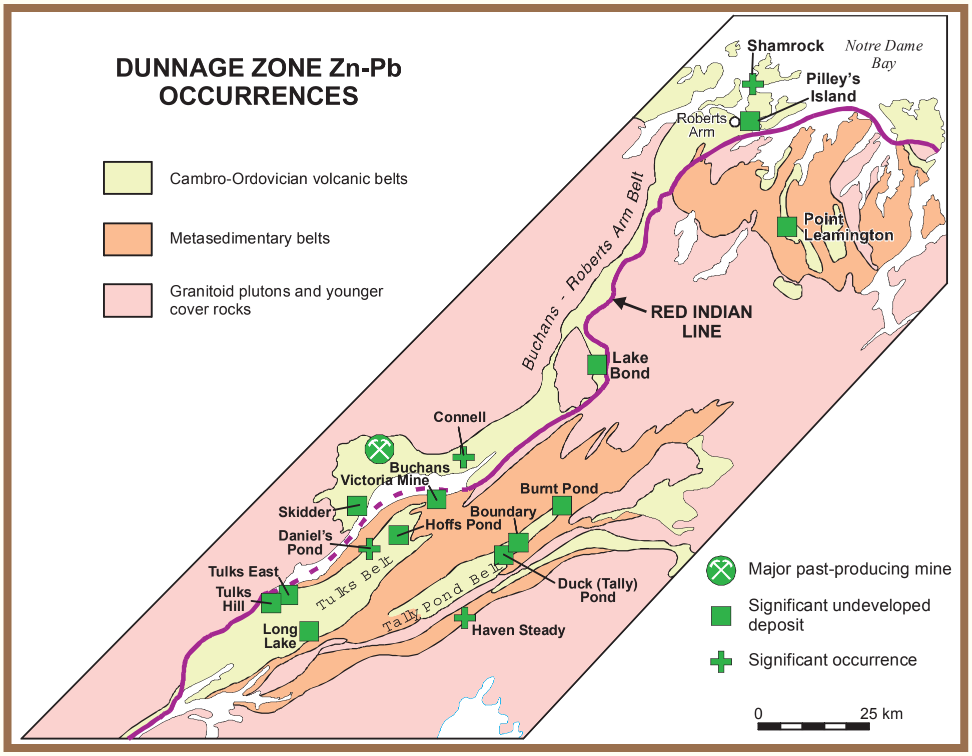

Figure 6. *Simplified map of the volcanic and metasedimentary belts of the Dunnage Zone, central Newfoundland. For location, see Figure 2.*

Figure 7. *Buchans transported-ore breccia. Note clasts of massive chalcopyrite yellow ore (Y) and sphalerite–galena black ore (B)*

The Early Ordovician *Tulks belt*, located in rocks of the Victoria Lake Group south of the Red Indian Line, consists of strongly deformed felsic and mafic volcanic rocks and is host to several significant deposits. The largest is the Tulks East deposit, which contains 5 000 000 tonnes of 1.5% Zn, 0.12% Pb, 0.24% Cu, 8.5 g/t Ag and trace Au in the A zone, in addition to 230 000 tonnes of higher grade combined metals in the B zone. The nearby Tulks Hill deposit contains an additional 720 000 tonnes of 5.6% Zn, 2% Pb, 1.3% Cu, 41 g/t Ag and 0.4 g/t Au. Other occurrences include the Hoffs Pond (1 233 000 tonnes of 6.91% Zn, 1.06% Cu, 0.71% Pb, 16.8 g/t Ag and 0.2 g/t Au) and Long Lake (560 000 tonnes 16.0% Zn, 2.2% Cu, 1.3% Pb, 38 g/t Ag and 0.9 g/t Au) deposits, and the Daniel's Pond prospect. The Victoria Mine deposit, although generally copper-rich, contains zinc–lead-rich zones (e.g., the Jig Zone).

The Cambrian *Tally Pond belt* comprises similar, but less penetratively deformed, rocks of the Victoria Lake Group. The principal deposit is Duck Pond (otherwise known as Tally Pond), which when combined with the nearby Boundary deposit contains a geological resource of 6 350 000 tonnes of 6.3% Zn, 3.29% Cu, 1.0% Pb, 63.5 g/t Ag and 0.82 g/t Au. Aur Resources Inc. put the Duck Pond Mine into production in January 2007 and the first shipment left the island in April 2007. The plan for the current reserves is to mine and mill 4.1 million tonnes of ore, at a rate of 1800 tonnes per day, over a projected mine life of 6.2 years. Based on the existing reserves, the annual production is expected to be 76 million pounds of zinc. Other significant occurrences include the Burnt Pond and Haven Steady prospects.

A significant occurrence lying to the northeast of these belts is the Point Leamington deposit (Figure 6). This is a large, low grade Cu–Zn massive sulphide deposit that contains an interesting Zn–Au-rich zone.

The major source of production from volcanic-hosted environments has been the Buchans deposits, where five major orebodies were mined between 1928 and 1984 for a total of 16.2 million tonnes at average grades of 14.51% zinc, 7.56% lead, 1.33% copper, 1.37 g/t gold and 126.0 g/t silver. In terms of the value of the metal produced, these rank as world-class deposits and underscore the potential of the central Newfoundland volcanic terranes.

In addition, there are a number of Zn–Pb-rich occurrences along the southern margin of the Dunnage Zone, the largest of which are the Strickland, Number 6 Trench and Barasway de Cerf prospects (Figure 2) characterized by sphalerite–galena–pyrite mineralization within Early Ordovician felsic volcanic rocks. The Strickland prospect is estimated to contain 260 000 tonnes at 5.6% combined Pb and Zn and 195 g/t Ag. A separate copper zone is also present.

The Neoproterozoic rocks of the western Avalon locally contain sphalerite–galena mineralization in felsic volcanic rocks, the principal occurrence being the Winter Hill prospect. Volcanic-hosted base-metal mineralization is otherwise atypical of the volcanic rocks of the Avalon Zone in Newfoundland.

Labrador is markedly deficient in VMS-style mineralization. However, there may be potential for this type of mineralization in the Archean Florence Lake and Hunt River greenstone belts of eastern Labrador, and in the Paleoproterozoic volcanic rocks of the Blueberry Lake Group of western Labrador (Figure 5).

Vein-Hosted Mineralization Environments

Early attempts to mine lead and zinc were directed at vein-hosted epigenetic deposits that can be divided into non-igneous and granite-associated types.

Non-igneous types include the Silvercliff and La Manche prospects, located in fault-confined galena–sphalerite veins in Neoproterozoic rocks of the Avalon Peninsula, as well as the Silverdale and Traverstown prospects of the Baie Verte Peninsula located within veins in Cambro-Ordovician rocks. All of these were the targets of unsuccessful mining attempts in the late 19th century. Zinc and lead also occur locally in association with gold-bearing veins of central Newfoundland and the Baie Verte Peninsula. In Labrador, non-igneous vein-hosted prospects are present within Paleoproterozoic shale–sandstone sequences of the Moran Lake Group of eastern Labrador (e.g., Green Pond prospect, Figure 5), and the Labrador Trough of western Labrador (e.g., Galena Lake prospect, Figure 5).

Granite-related veins are found in, or adjacent to, various Siluro-Devonian granites in southern New-foundland, e.g., the Galena Number 1 prospect located in a sulphide-bearing quartz vein within the Burgeo batholith, and various Pb–Zn–U and Pb–fluorite veins in the St. Lawrence peralkaline granite (Figure 2). One of the latter in the Lawn area was also the target of an early attempt, (ca. 1860), to mine argentiferous galena. In Labrador, the Flowers River Suite (Nain Province) hosts minor sphalerite–galena– pyrite mineralization in association with veinlets and alteration zones in peralkaline granite and volcanic rocks. Some high-level granites of the Makkovik Province, although best known for their molybdenum mineralization, are locally associated with marginal galena–sphalerite veins (e.g., Big Bight prospect) developed within volcanic country rocks (Figure 5).

Clastic Sediment-Hosted Mineralization Environments

Finally, there are a number of zinc and lead occurrences associated with sandstone–shale sequences. Neoproterozoic clastic rocks of the eastern Avalon Zone near Carbonear (Figure 2) host widespread low-grade Pb–Zn mineralization of SEDEX style associated with surface gossans. In Labrador (Figure 5), the Paleoproterozoic clastic rocks of the Moran Lake Group (Teuva occurrence, northern

Makkovik Province) also locally host small strata-bound zinc occurrences in association with pyritic gossans. The coeval shales of the western Labrador Trough contain elevated zinc levels in lake sediments but *in situ* mineralization has yet to be discovered.

Exploration Potential

The carbonate-hosted mineralization environments of western Newfoundland have seen relatively little exploration since the closure of the Daniel's Harbour mine, but it is anticipated that activity will resume as the price of zinc rebounds from the lows of the late 1990s. The most favourable area for exploration is probably north of Bonne Bay (Figure 2) where the requisite secondary dolomitization and pseudobreccia are most abundant.

The search for volcanic-hosted polymetallic deposits of the Buchans type has always been a mainstay of exploration in Newfoundland and will doubtless continue in all areas of the highly prospective Dunnage Zone. For a considerable time the most prospective parts of this area were held under long-term concession by a limited number of companies. However, these holdings have now been broken up into a number of smaller parcels resulting in a resurgence of junior company interest in the area.

The clastic-hosted, or SEDEX, environment is arguably the least-explored lead–zinc environment in the Province. Paleoproterozoic clastic sequences in Labrador, notably the Labrador Trough and the Ramah, Mugford and Moran Lake groups, may have significant grassroots potential in this respect.

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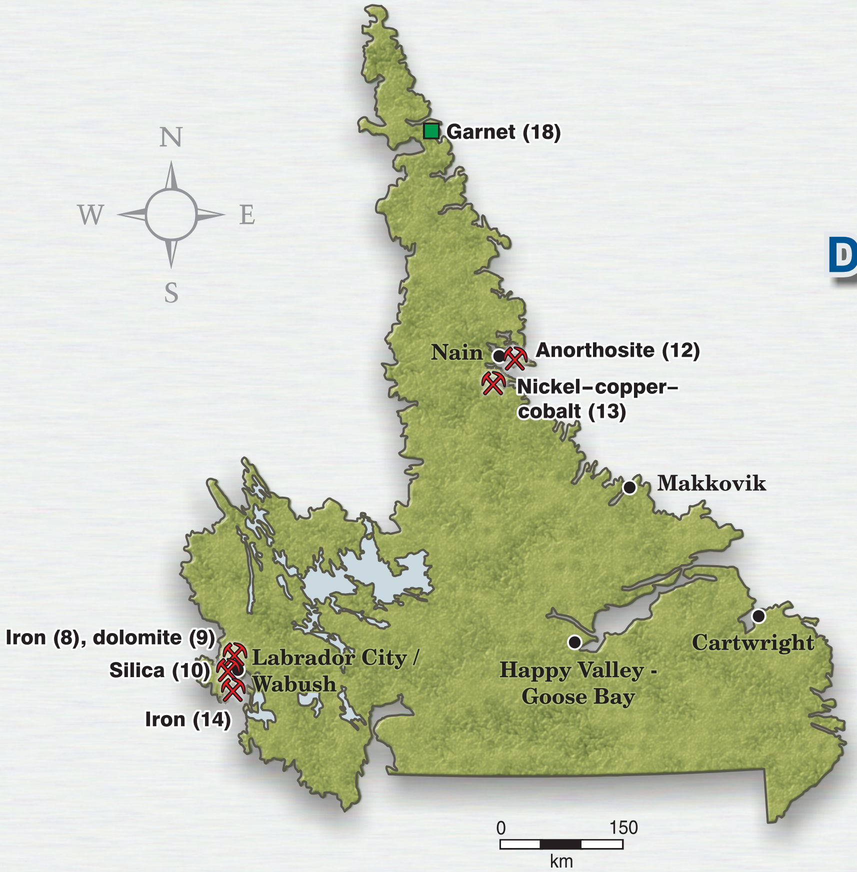
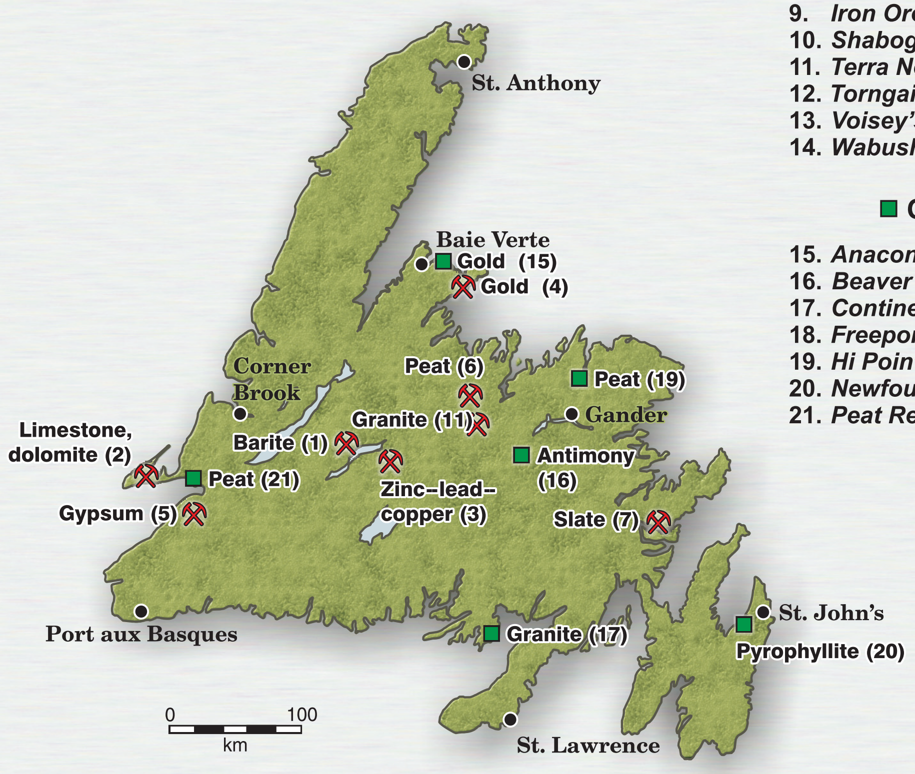
PRODUCING MINES AND DEVELOPING PROPERTIES

WINTER 2008



* Note scale differences of Labrador and Newfoundland maps



Commodities in production

1. *Atlantic Barite Ltd.,* Buchans
2. *Atlantic Minerals Ltd.,* Lower Cove
3. *Aur Resources Inc.,* Duck Pond
4. *Crew Gold Canada Ltd.,* Nugget Pond
5. *Galen Gypsum Mines Ltd.,* Coal Brook
6. *Hi Point Industries (1991) Ltd.,* Bishop's Falls
7. *Hurley Slateworks Company Inc.,* Burgoynes Cove
8. *Iron Ore Company of Canada,* Labrador City
9. *Iron Ore Company of Canada,* Labrador City
10. *Shabogamo Mining & Exploration Ltd.,* Labrador City
11. *Terra Nova Granite Inc.,* Jumpers Brook
12. *Torngait Ujaganniavingit Corp.,* Ten Mile Bay
13. *Voisey's Bay Nickel Company Ltd.,* Voisey's Bay
14. *Wabush Mines Ltd.,* Wabush

Commodities in development

15. *Anaconda Mining Inc.,* Pine Cove
16. *Beaver Brook Antimony Mine Inc.,* Beaver Brook
17. *Continental Stone Ltd.,* Belloram
18. *Freeport Resources,* Hutton Beaches
19. *Hi Point Industries (1991) Ltd.,* Gander Bay
20. *Newfoundland Pyrophyllite,* Manuels
21. *Peat Resources Ltd.,* Stephenville