# MINERAL COMMODITIES OF NEWFOUNDLAND AND LABRADOR

# IRON ORE

Newfoundland Labrador
Natural Resources

Geological Survey
Mineral Commodities Series
Number 7

## Mineral Commodities of Newfoundland and Labrador

# Iron Ore

**Foreword**

This is the seventh in a series of summary publications covering the principal mineral commodities of the province. Their 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 website: http://www.nr.gov.nl.ca/nr/mines/geoscience/

**Publications in the Series**

Zinc and Lead (Number 1, 2000, revised 2008)
Nickel (Number 2, 2000, revised 2005, 2008)
Copper (Number 3, 2000, revised 2005, 2007)
Gold (Number 4, 2005, reprinted 2008)
Uranium (Number 5, 2009)
Rare-earth Elements (Number 6, 2011)
Iron Ore (Number 7, 2012)

**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 website: http://www.nr.gov.nl.ca/nr/mines/geoscience/. Descriptions of individual mineral occurrences are available through the provincial Mineral Occurrence Database System (MODS), which is accessible from the Survey's website. Up-to-date overviews of mining developments and exploration activity targeting a range of commodities are available on-line at http://www.nr.gov. nl.ca/nr/mines/

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**NOTE**



**DISCLAIMER**



Compiled by J. Conliffe, A. Kerr and D. Hanchar, 2012

Front Cover: Folded banded taconite, Gabbro Lake, Labrador.

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## Introduction

Iron is the fourth most abundant element in the Earth's crust after oxygen, silicon and aluminium and is an essential commodity for modern industry. The province has a long history of iron-ore production, dating back (~1100 AD) to the Vikings at L'Anse aux Meadows, who smelted 'bog iron' to produce crude nails to repair their longships. Iron has been continuously mined, on a large scale, in this province since the late 19th century. The iron-ore deposit on Bell Island was mined from 1895 to 1966, and produced over 80 million tons of ore. In the last 50 years, virtually all of Canada's iron-ore production has been from western Labrador and northeastern Québec, within a geological region known as the Labrador Trough (Figures 1 and 2). The iron formations were first described in the journals of Father Babel, a Jesuit missionary who travelled in the region in the 1860s, and A.P. Low, of the Geological Survey of Canada, first reported the potential for large deposits in the 1890s, recognizing similarities to iron formations in the northern United States. However, it initially attracted little interest due to the remote location. In 1929, high-grade iron ore was first discovered near the Québec–Labrador border, but the full definition and eventual development of these resources would take over two decades. After World War II, increased demand for iron ore, and depletion of high-grade deposits in the Lake Superior region, created the impetus for opening up the new resources of Labrador, and adjacent Québec. In the 1950s, a railroad was pushed northward through the wilderness from Sept-Îles, Québec, and the town of Schefferville was established. Production of iron ore commenced in 1954 and continued until 1982, but substantial resources remained upon closure. Over the same period, large deposits of lower grade metamorphosed iron formations were defined, and these led to the foundation of Labrador City and Wabush in the 1960s. In total, iron-ore deposits in the Labrador sector of the Labrador Trough have produced in excess of 2 billion tonnes of iron ore.

*Iron has been continuously mined on a large scale in this province since the late 19th century.*

The iron-ore mines of western Labrador are currently the largest operations in the province, and account for more than half of the value of our mineral production. The two largest producers are in the Labrador City–Wabush area: the Carol Lake project operated by the Iron Ore Company of Canada (IOC; part of Rio Tinto Group) and the Scully Mine operated by Wabush Mines (part of Cliffs Natural Resources). Production of direct shipping ores (DSO) in the Schefferville area recently resumed at the James Mine of Labrador Iron Mines (LIM) and at the Timmins Mine of Tata Steel Minerals Canada/New Millennium Iron Corp. There are now several other advanced-stage exploration projects where resources are defined and some of the more remote parts of western Labrador are targets for early stage exploration programs.

## Geology of the Iron-Ore Deposits

Although iron is present in most common rock types, it is generally uneconomic, or in forms that are not readily processed. Iron-ore deposits generally have >25 wt % Fe, usually in the form of hematite ($Fe_2O_3$), magnetite ($Fe_3O_4$), goethite ($FeO(OH)$), limonite ($FeO(OH) \cdot nH_2O$) or siderite ($FeCO_3$). Iron-ore deposits are found in a wide range of igneous, sedimentary and metamorphic rocks. Examples of igneous iron ores include magnetite accumulations in mafic intrusions, as well as large deposits of probable magmatic–hydrothermal affinity, such as Kiruna in Sweden. However, most (>90%) of global iron-ore production, including that of the Labrador Trough, comes from iron-rich cherty sedimentary rocks and their metamorphic or supergene derivatives, grouped under the general term 'iron formations'.

Iron formations are stratigraphic units of bedded or laminated sedimentary rocks or layered metasedimentary rocks with >15% Fe. They can be subdivided into two main types, based on their tectonic settings, associated rocks, and depositional environment. Algoma-type iron formations are associated with submarine-emplaced volcanic rocks, especially in greenstone belts. Lake Superior-type iron formations formed on continental-margins, without direct relationships with volcanic rocks, and are typically much larger than Algoma-type iron formations. Lake Superior-type iron formations are most common in Precambrian sedimentary successions, with peaks in iron sedimentation between ~2.65 and 2.32 billion years ago (Ga) and again from ~1.90 to 1.85 Ga. The Lake Superior-type iron formations of the Labrador Trough formed at ~1.88 Ga, during this second major phase of iron deposition. Although their depositional mechanisms are still debated, recent studies have stressed the importance of mantle plume activity and rapid crustal growth, with large volumes of ferrous iron being released into the anoxic deep oceans during submarine volcanism. Iron was precipitated where such waters upwelled onto continental shelves and mixed with oxygenated waters in shallow-water depositional settings.

## Geology of the Labrador Trough

The Labrador Trough consists of Paleoproterozoic (2.17 to 1.87 Ga) sedimentary and volcanic rocks, which extend along the eastern margin of the Archean Superior

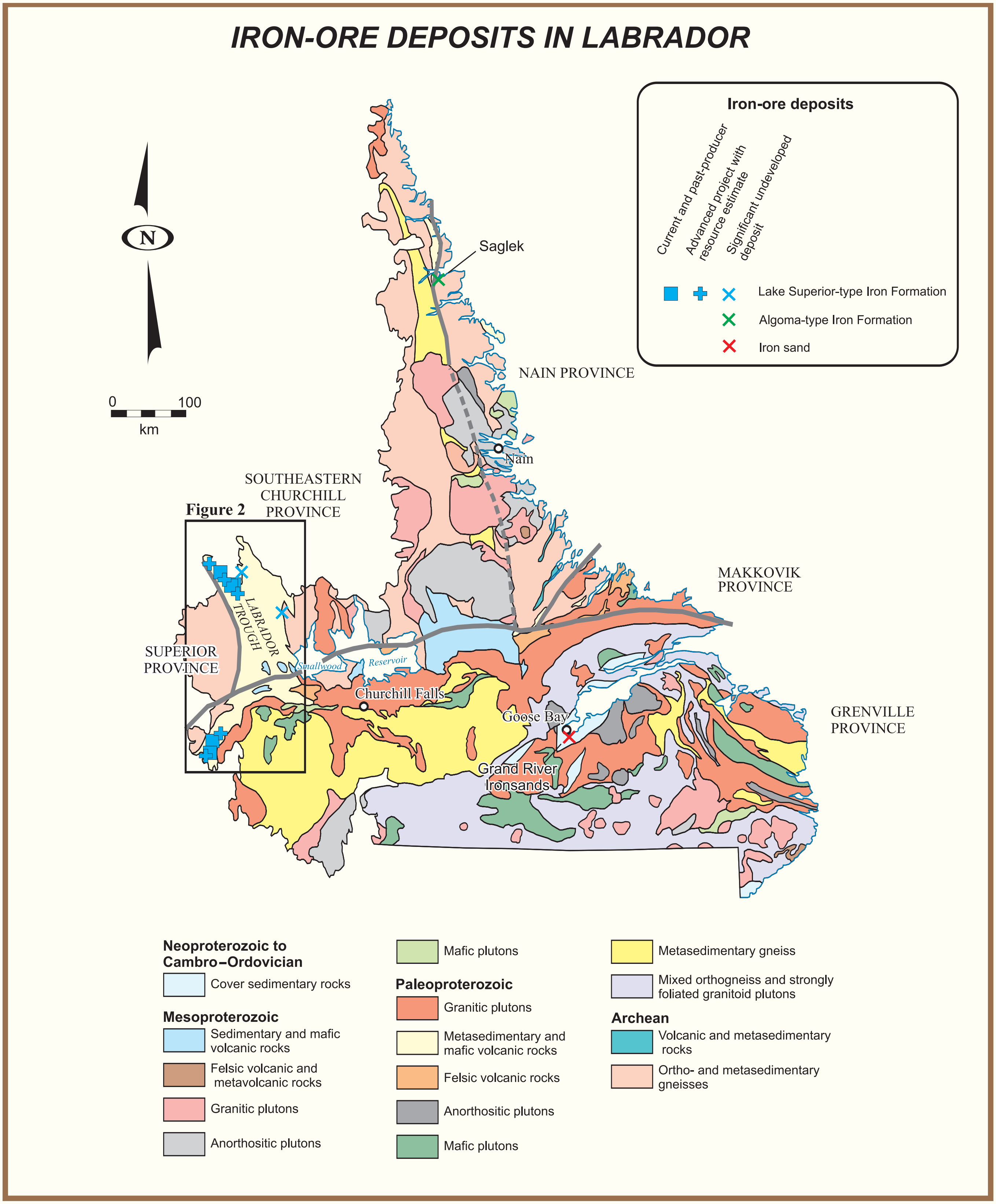


**Figure 1.** *Simplified geological map of Labrador, showing the locations of selected iron-ore deposits.*

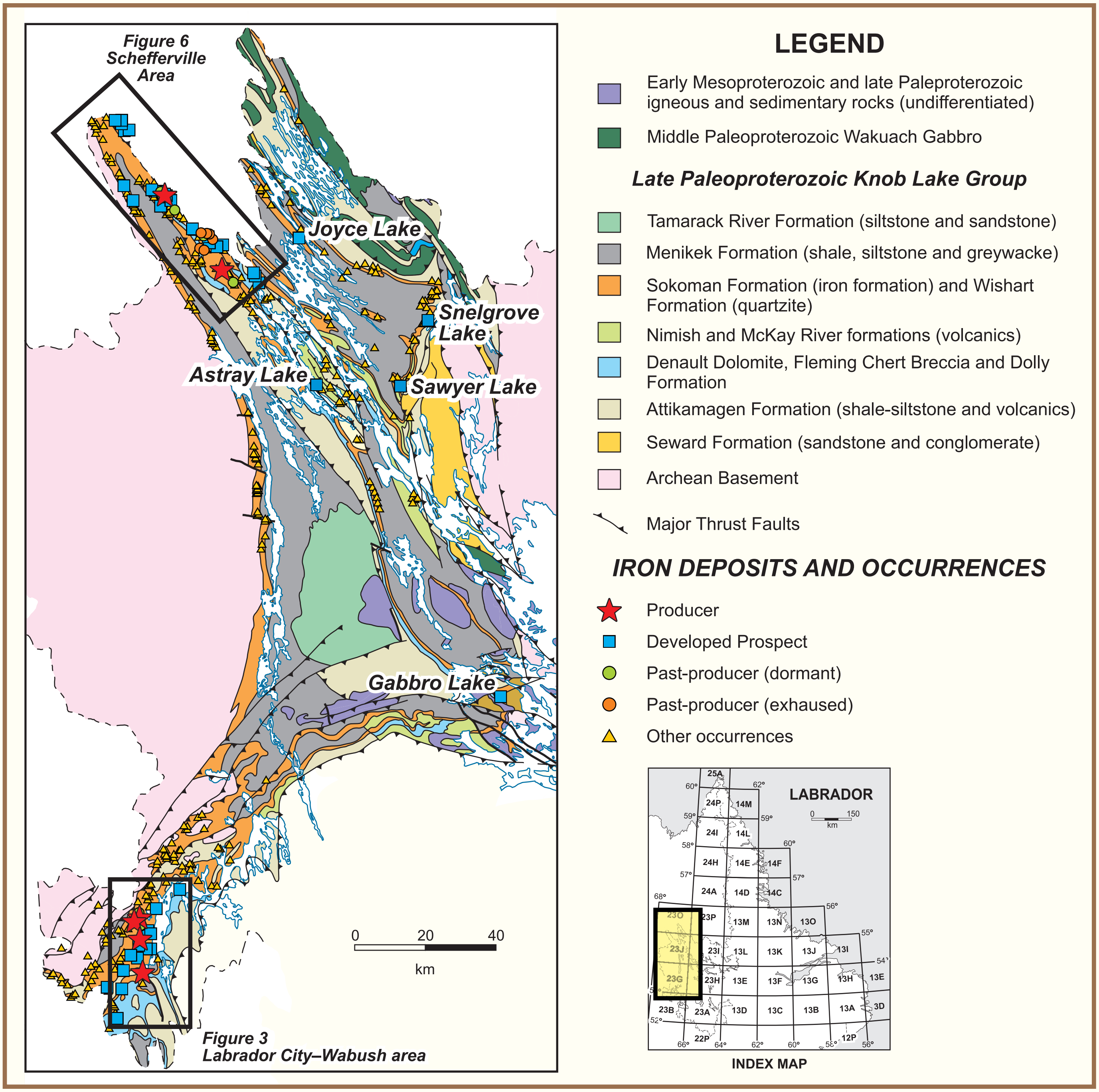


**Figure 2.** *Geological map of the Labrador Trough, showing the locations of major iron deposits and occurrences.*

Craton to Ungava Bay. It forms the western part of a larger orogenic belt called the New Québec Orogen. In southwestern Labrador, the Labrador Trough extends into the younger Grenville Province, where the sedimentary rocks were deformed and metamorphosed *ca.* 1.0 Ga. The western boundary of the Labrador Trough is the basal unconformity between Paleoproterozoic sedimentary rocks and the Archean basement. To the east, it is bounded by allochthonous deep-water sedimentary and volcanic rocks, possibly derived from an oceanic realm. The sedimentary sequence of the Labrador Trough, termed the Kaniapiskau Supergroup, is interpreted to include a lower rift-related sequence and an upper transgressive sequence that progresses from shelf sediments at the base through deep-water turbidites and into shallow marine and terrestrial rocks at the top.

Iron-ore deposits in the Labrador Trough are hosted in the Sokoman Formation, which sits toward the top of the shelf sequence, above a thick package of shale, dolostones, and siliciclastic rocks. The Sokoman Formation consists of a 30–170-m-thick sequence of cherty iron-rich sediments, and is continuous for 250 km from Labrador City to Schefferville; it also continues into Québec in both directions, and is one of the most extensive iron formations known on Earth. North of the Grenville Province, the stratigraphic sequence is largely intact, and the position and distribution of the Sokoman Formation are very predictable. Parts of this area experienced low-grade (greenschist facies) metamorphism and open to tight folding, but in the western foreland, the rocks are gently dipping and essentially undisturbed. In the southern part of the Labrador Trough, the rocks are highly metamorphosed and complexly folded, but the essential stratigraphy of the Kaniapiskau Supergroup remains discernable, albeit structurally disrupted. The productive unit in this area is locally known as the Wabush Iron Formation, but it is directly equivalent to the Sokoman Formation to the north.

The lower part of the Sokoman Formation consists largely of iron silicates and siderite, with some disseminated magnetite. This grades upward into a sequence of thick massive beds of grey to pinkish chert and iron-oxide-rich beds. These oxide-rich beds are the most important economically, with iron-rich layers and lenses commonly containing more than 50% hematite and magnetite. The upper part of the Sokoman Formation comprises beds of dull green to grey or black massive chert that contain ferruginous carbonates, but is relatively iron-poor. The Sokoman Formation is interbedded in places with mafic volcanic rocks of the Nimish Formation and is underlain by quartzites of the Wishart Formation (also important as economic sources of silica). The overlying rocks (Menihek Formation) consist largely of black shales and slates that record a sudden deepening of the basin.

*90% of global iron ore production, including that of the Labrador Trough, comes from iron-rich cherty sedimentary rocks and their metamorphic or supergene derivates.*

## Iron-Ore Associations in the Labrador Trough

All iron-ore deposits in the Labrador Trough formed as chemical sediments that were lithified and variably affected by alteration and metamorphism. This had important effects upon grade, mineralogy and grain size, which impacts the economic viability of iron-ore deposits. In addition, faulting and folding led to repetition of sequences in many areas, which greatly increases the surface extent and mineable thicknesses of the iron-ore deposits. Three main types of iron-ore deposits are as follows.

*Taconites* are found throughout the Labrador Trough. These are fine-grained, unmetamorphosed or weakly metamorphosed sedimentary iron formations (15 to 30% Fe), with magnetite as the dominant iron-ore mineral. None are presently mined in the Labrador Trough, although they are important sources for iron ore elsewhere (*e.g.*, Minnesota).

*Metataconites* are present in the southern part of the Labrador Trough, especially in the Labrador City–Wabush area. They have been moderately to strongly metamorphosed during the Grenville orogeny at *ca.* 1.0 Ga, and are coarse grained with specular hematite, granular magnetite and friable quartz. The grade of these iron-ore deposits is generally higher than unmetamorphosed taconites (up to 41% Fe). They are easily beneficiated into iron concentrates (approximately 65% Fe), which are ideal for pellet production.

*Direct Shipping Ores (DSO)* are secondary iron ores containing >50% Fe that formed from the enrichment of primary taconites. Such ores require minimal beneficiation and have very low mining costs. Two main types of DSO deposits have been described in the Labrador Trough. Soft, friable, fine-grained, variably porous deposits occur mostly in the Schefferville District and may be related to deep groundwater circulation and supergene enrichment associated with Mesozoic (Cretaceous) tropical climates. Specifically, silica and carbonate were leached from the ores, leaving a high residual iron content. Hard DSO deposits occur in several locations, including Sawyer Lake and Astray Lake, southeast of Schefferville (Figure 2). These are dominated by blue hematite and martite, and, typically, are denser than the soft, friable ores, with no evidence of an increase in porosity. The origin of these deposits is unknown, but they may be related to early hydrothermal processes. In addition, some DSO deposits have characteristics of both the soft and hard DSO deposits (*e.g.*, the Houston deposits close to Schefferville).

## Major Ore Deposits in Western Labrador

### Labrador City–Wabush Area

Several large metataconite deposits are located in the Labrador City–Wabush area and adjacent Québec, and have been mined continuously since the 1960s. These deposits are all thought to represent a single stratigraphic horizon, and the economic deposits are largely developed by hinge-thickening and fold repetition. The distribution of the major deposits in the Labrador City–Wabush area is shown in Figure 3 and reserve and resource estimates are listed in Table 1.

*Large metataconite deposits located in the Labrador City–Wabush area and adjacent Québec have been mined continuously since the 1960s.*

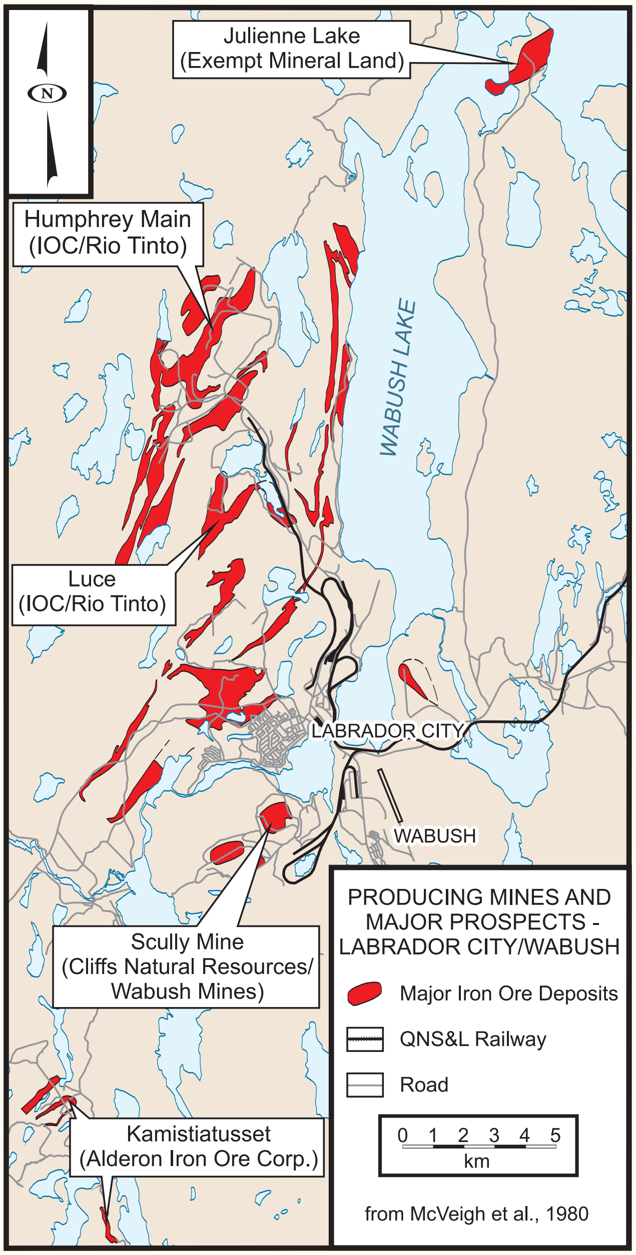


**Figure 3.** *Map showing distribution of metataconite deposits in the Labrador City–Wabush area (adapted from McVeigh* et al.*, 1980). IOC=Iron Ore Company of Canada.*

Current production comes from Carol Lake (Humphrey and Luce deposits) and the Scully Mine (Figure 3). There are also large operations at Mont-Wright and Bloom Lake in adjacent Québec. The latter deposit is located very close to the provincial border, and iron ore is actually loaded for shipment in Labrador.

IOC's Carol Lake project is the largest operation in the Labrador Trough, with an open-pit mine, concentrator and pellet plant in Labrador City. Annual capacity is presently 22 million tonnes (Mt), and an ongoing expansion program could eventually increase annual concentrate production to 50 Mt. In total, the Carol Lake deposits consist of 13 separate ore bodies, of which two are currently active (Humphrey Main and Luce; Figure 4). Individual deposits are associated with thickening of the magnetite–hematite schist on the closures of synforms and its repetition by complex isoclinal folds, which increase the aggregate thickness of deposits to approximately 400 m, in places. Production, to date, is more than 1300 Mt of iron ore, and reserves of crude ore on IOC lands are estimated at 1374 Mt at 38% Fe, within a total resource of 2463 Mt at 38% Fe (Table 1).

**Figure 4.** *Humphrey Main pit in the IOC's Carol Lake project.*

Cliffs Natural Resources' Scully Mine produced 4 Mt of iron concentrates in 2011, and its total reserves are estimated at 207.6 Mt of crude ore (69.2 Mt of equivalent pellets or concentrate). The deposit is structurally complex, with a broad syncline modified by multiple folding events and offset by several faults. The original metataconites have been partially leached of silica and carbonate, resulting in a soft, friable quartz-specular hematite ore with

**Table 1.** Iron resources in the Labrador Trough

| Deposit | Owner/Operator | Tonnage (millions of tonnes) | Grade (% Fe) |
|---|---|---|---|
| **Current Producers** | | | |
| Carol Lake | IOC - Rio Tinto Ltd. | 1374 (Reserves)[1]<br>2463 (Resources)[1] | 38<br>38.1 |
| Scully Mine | Wabush Mines - Cliffs Natural Resources | 207.6 (Reserves)[2] | 33 |
| Schefferville DSO | Labrador Iron Mines | 45 (Measured and Indicated)[3] | 56.5 |
| | New Millennium Iron Corp./ Tata Steel Minerals Canada | 64.1 (Proven and probable)[3] | 58.9 |
| **Projects with Resource Estimates** | | | |
| LabMag (Howells River) | New Millennium Iron Corp./ Tata Steel Minerals Canada | 3500 (Proven and probable)[3]<br>1000 (Measured and Indicated)[3] | 29.6<br>29.5 |
| Kamistiatusset (Kami) | Alderon Iron Ore Corp | 1100 (Measured and Indicated)[3]<br>227.4 (Inferred)[3] | 29.8<br>29.5 |
| Julienne Lake | Exempt Mineral Land | 867 (Measured and Indicated)[4] | 33.7 |
| **Deposit** | **Owner/Operator** | **Exploration Highlights** | |
| **Projects without Resource Estimates** | | | |
| Attikamagen | Century Iron Mines Corp./ Champion Minerals | 139.0m @ 52.8% Fe | |
| Block 103 | Cap-Ex Ventures | 64.0 to 216.4m @ 26.7% to 30.2% | |
| Gabbro Lake | Golden Dory Resources | 125.17m @ 28.28% Fe | |
| Snelgrove Lake | CIP Magnetite Ltd./ Altius Minerals Corp. | High grade grab samples up to 64% Fe | |

**Notes:**
[1] Data from Labrador Iron Ore Royalty Corporation Annual Information Form
[2] 69.2 Mt of equivalent pellets or concentrate, calculate with a crude ore to concentrate ratio of about 3.0. Data from Cliffs Natural Resources Annual Report 2011
[3] NI-43-101 compliant resource estimate
[4] Data from Government of Newfoundland and Labrador

minor limonite and goethite; however, no large concentrations of DSO are known. Parts of the ore body contain significant manganese (1 to 2.5%), which can restrict sale of ore in some markets and therefore requires selective mining and/or additional processing.

The Kamistiatusset (Kami) project, about 10 km southwest of Wabush (Figure 3), is the most advanced iron-ore exploration project in Labrador. The project is centred on three main deposits, known as Rose Central, Rose North and Mills Lake. The Rose Central and the Rose North deposits consist of a series of upright to slightly overturned anticlines and synclines. To the south, the Mills Lake Deposit consists of a gently east-dipping tabular body. Mineralization comprises coarse-grained metataconites (similar to nearby deposits), and is mainly magnetite-rich with hematite-rich horizons. The current NI 43-101 mineral resource estimate includes a measured and indicated resource of 1100 Mt at 29.8% iron, and an additional inferred resource of 277.4 Mt at 29.5% iron. Manganese contents are intermediate between those of the Carol Lake and Scully Mine deposits, typically less than 1%.

The Julienne Lake iron-ore deposit (Figures 3 and 5) is a large undeveloped resource approximately 20 km north of Labrador City–Wabush. It was explored in the 1960s and 1970s by Canadian Javelin Corporation, but reverted to the Crown in 1975. In 2010, the Provincial Government conducted a drilling program and preliminary metallurgical study to further evaluate the potential of the resource for development. Based on this exploration program, a non NI-43-101 compliant measured and indicated resource of 867 Mt at 33.7% Fe was calculated.

## Schefferville Area

Numerous DSO deposits have been described in the Schefferville area, located within an ~8-km-wide area that stretches for 100 km northwest of Astray Lake along the Québec–Labrador border (Figure 6). Primary taconite iron formations are also abundant throughout


**Figure 5.** *Banded metataconite ore from the Julienne Lake deposit, displaying coarse-grained specular hematite.*

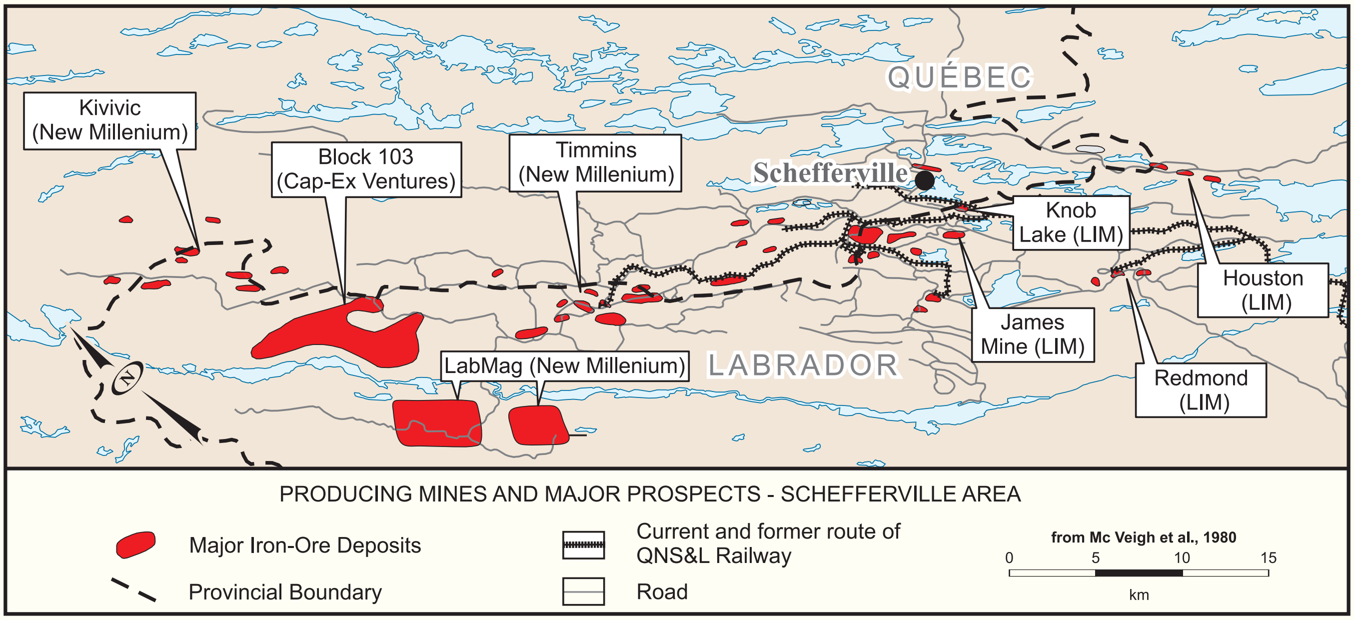


**Figure 6.** *Map showing distribution of DSO and taconite deposits in the Schefferville area (adapted from McVeigh* et al.*, 1980). LIM=Labrador Iron Mines.*

this area, but have never been exploited. These formations were folded, faulted and weakly metamorphosed during the Paleopro-terozoic, particularly in the east. Subsequent supergene enrichment is believed to be associated with the circulation of meteoric waters, preferentially in synclinal structures or down-faulted blocks. The apparent offsets of leached zones across faults imply that some were active during enrichment. Leaching of silica and carbonate produced a friable, granular iron ore and secondary limonite and goethite were deposited in pore spaces. The local presence of rubble and talus deposits containing Cretaceous plant and insect fossils indicates that at least some of the enrichment took place in the Mesozoic. These DSO deposits produced 250 Mt of ore from 1954 to 1982, but at least 200 Mt remained upon closure, which resulted from the preference for pelletized feed by the North American steel industry. There is now much interest in reactivating dormant DSO deposits, and also in the possible exploitation of the primary taconite deposits of the area.

In 2011, Labrador Iron Mines Ltd. (LIM) commenced production from the James Mine near Schefferville (Figure 7). Some 1.2 Mt of iron ore was mined in 2011, and there are plans for expansion and development of several other deposits. Indicated resource estimates from Stage 1 of this project are 22.2 Mt at 57.4% Fe. New Millennium Iron Corp. and joint-venture partner Tata Steel Minerals Canada are also advancing a DSO project near Schefferville. This will consist of 25 small near-surface deposits containing proven and probable resources of 64.1 Mt at 58.9% Fe. Production from the Timmins Mine (Figures 8 and 9) began in September 2012.

**Figure 7.** *Ongoing excavation at the James Mine (Labrador Iron Mines), Schefferville.*

The largest undeveloped iron-ore resource in the Schefferville area is the LabMag deposit, a near-surface taconite deposit located in the Howells River area (Figure 6). The extent of the Sokoman Formation in this area was recognized and partly delineated in the 1950s, but there was no interest in development because

*The largest undeveloped iron-ore resource in the Schefferville area is the LabMag deposit, a near-surface taconite deposit located in the Howells River area.*

**Figure 8.** *Aerial view of the Timmins No. 1 pit (IOC, exhausted) and construction of Tata Steel Minerals Canada processing facility.*

**Figure 9.** *Soft, friable DSO ore cut by leached silica veins from Timmins No. 4 deposit (Tata Steel Minerals Canada/ New Millennium Iron Corp.).*

the nearby high-grade DSO deposits were available. Taconite iron formations at Howells River are almost flat-lying and unmetamorphosed, and outcrop extensively over a total strike length of some 30 km. The potential ores consist of recrystallized chert and jasper interbedded with magnetite beds. The LabMag deposit has total reserve estimates (proven and probable) of 3500 Mt at 29.6% Fe, with a further 1000 Mt of measured and indicated resources (at 29.5% Fe). The KéMag deposit in adjacent Québec is estimated to contain a resource of some 2200 Mt (proven and probable) at 31.2% Fe.

Other exploration projects in the wider Schefferville area target both taconite and DSO resources. The Attikamagen Iron project is ~20 km east of Schefferville, and contains extensive folded taconite units on both sides of the provincial border. Drilling at the Joyce Lake target intersected 139 m (at 52.8% Fe), and 91 m (at 52.5% Fe), in separate holes, representing a previously undefined DSO accumulation. Initial drilling on the Block 103 deposit near Schefferville intersected high-grade magnetite-rich taconites, with intervals of 64.0 to 216.4 m grading from 26.7 to 30.2% total iron. Both projects are currently in the early stages, and no resource estimates have yet been developed.

## Other Deposits in the Labrador Trough

Several other iron-ore deposits of undefined potential are located beyond the established mining camps of the Labrador Trough (Figure 2). The Sawyer Lake deposit, approximately 65 km southeast of Schefferville, is a high-grade hard hematite ore (65 to 70% Fe). The deposit consists of dense blue massive hematite (Figure 10), with practically no goethite present, and there is no evidence of Cretaceous supergene weathering in the area. Exploration at Snelgrove Lake indicates extensive taconite deposits with several zones of similar high-grade hematite in the range of 55% to 64% iron. These unusual deposits are similar in many respects to large deposits known in Australia and Brazil, and also to the large Mary River deposit now under exploration on Baffin Island, Nunavut.

Weakly metamorphosed iron formations are also widely present in the northern fringe of the Grenville Province, between Churchill Falls and Labrador City (Figures 1 and 2). Drilling in 2012 at the Gabbro Lake deposit, on the eastern edge of the Labrador Trough, reported intersections of up to 125.17 m grading at 28.28% Fe. There are also many showings and indications of iron ore between Schefferville and Labrador City (Figure 2).


**Figure 10.** *Hard, blue hematite-rich DSO ore from the Sawyer Lake deposit (Labrador Iron Mines).*

This region has seen little exploration for iron ore since the pioneering days of the 1940s, but there remains potential for large primary taconite resources, and possibly also high-grade DSO targets.

## Iron-Ore Deposits Elsewhere in Labrador

Most iron-ore exploration to date has been confined to the Labrador Trough, but occurrences elsewhere in Labrador are also being evaluated for economic potential. Archean-banded iron formations exist on the southern shore of Saglek Fjord in northern Labrador (Figure 1), with historic grades of up to 28.8% Fe. Iron formations at Saglek Fjord are associated with nearby amphibolites and mafic granulites and are considered to be high-grade metamorphic derivatives of Algoma-type iron formations. These high-grade rocks are structurally complex, and have never been systematically assessed or drilled; similar iron formations in the Archean of Greenland (Isua area) contain potentially economic resources.

There has also been exploration in the Grand River region (Figure 1) for placer accumulations of heavy minerals including ilmenite, magnetite and titanomagnetite, which form discrete concentrations in widespread alluvial deposits associated with the Churchill River. The Churchill River drainage basin includes large areas of igneous rocks (anorthosites, gabbronorites, *etc.*) that contain primary oxide minerals. Extensive shallow drilling proves that oxide concentrations are widespread in alluvial sands and ancient beach deposits, and these may be extracted for production of high-quality pig iron using hydroelectric energy sources from proposed power developments.

Most other iron occurrences in Labrador are small concentrations of magnetite associated with igneous rocks, and most are not shown in Figure 1. However, the Kiglapait layered intrusion, located north of Nain, contains laterally continuous magnetite-rich layers developed in the upper part of the body. These have been investigated for PGE potential (with negative results), but also contain significant amounts of titanium and vanadium. The anorthositic intrusions of southern Labrador (the Grenville Province) may also have potential for magmatic Fe–Ti–V accumulations; equivalent rocks in the Québec North Shore region are important producers of titanium.

*The Bell Island mines were the longest-running mining operation in Newfoundland.*

## Iron-Ore Deposits in Newfoundland

In Newfoundland, the largest iron-ore resource is the Wabana deposit on Bell Island in Conception Bay (Figure 11). The presence of iron ore on Bell Island was first noted in the late 16th century, and these deposits were eventually developed by the New Glasgow Coal, Iron and Railway Co in the 1890s, to feed steel mills in Cape Breton. The Bell Island mines were the longest-running mining operation in Newfoundland and produced over 80 million tons of ore from 1895 to 1966. The mines ceased operations because the high phosphorus content of the ore was incompatible with the evolving steel-making technology of the 1960s, and the high-cost underground operation could not compete with low-cost open-pit DSO deposits.

The iron deposits are hosted by the Wabana and Bell Island groups, a sequence of fossiliferous Lower Ordovician sandstones, siltstone, and shales, with many intercalated oolitic ironstone beds. Ironstones were deposited in subtidal and intertidal environments, with precipitation of chamosite oolites during periods of sediment starvation and subsequent conversion to hematite during diagenesis. Three ironstone beds were of economic importance: the Dominion Formation (Lower), Scotia Formation (Middle) and Gull Island Formation (Upper), with the Dominion and Scotia formations mined offshore up to 3 km. Immense potential resources remain beneath Conception Bay (2 to 10 billion tonnes at 50% Fe), but the high cost of underground mining at such depths presents obstacles to any future redevelopment.

Magnetite and ilmenite concentrations are known from Precambrian and Paleozoic igneous rocks in western Newfoundland (Figure 11). The Four Corners iron-ore Fe–Ti–V deposit, located southeast of Stephenville (Figure 11) is currently under exploration. Although this deposit has potential for large-grade Fe ore tonnage, exploration is currently focused on titanium- and vanadium-enriched zones. The Bishop Deposit in western Newfoundland consists of a magnetite–ilmenite-rich dyke, averaging 54% Fe, 7% Ti and >0.2% V. In the mid-1990s, the Bishop Deposit provided 405 000 tonnes of dense ballast material for use in the construction of Hibernia offshore project.

The Workington deposit, near Lower Island Cove, Conception Bay, was mined briefly in the 19th century. Little is known about it, and it failed as a producer; rare loose material remaining at the site appears to be a fault-breccia with a hematitic matrix. Other, minor iron formations of probable Algoma-type are present in many areas of central Newfoundland, typically in association with volcanogenic massive sulphide deposits, but are not likely to ever be of economic interest, although some are hosts for epigenetic gold mineralization. The Mount Calapoose iron deposit on the Burin Peninsula (Figure 11) also consists of an <3-m-thick iron formation (Algoma-type) interbedded with shales.

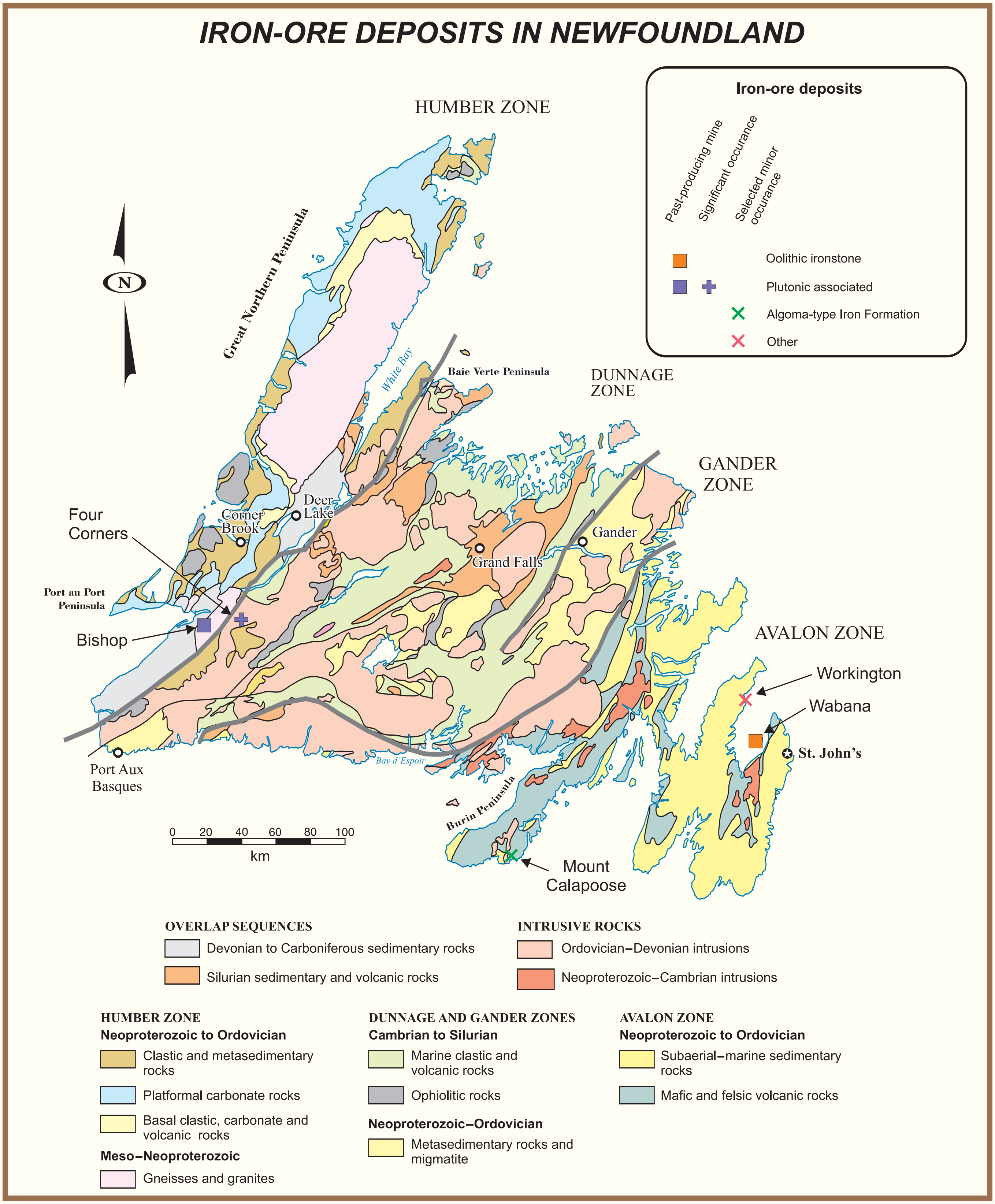


**Figure 11.** *Simplified geological map of Newfoundland, showing the locations of selected iron-ore deposits discussed in the text.*

## Exploration Models for Iron-Ore Deposits and their Implications

The renewed interest in exploration for iron ore in western Labrador reflects an increase in iron-ore prices, driven by demand from emerging Asian economies. Most exploration is understandably focused on the traditional mining camps of Schefferville and Labrador City–Wabush, where there is existing infrastructure. All known iron-ore deposits of potentially economic dimensions are now being re-examined, and there is also good potential for large undefined taconite and/or high-grade deposits in more remote and less-explored parts of the Labrador Trough. New high-resolution aeromagnetic surveys are now available for western Labrador and adjoining Québec, where they were completed as part of a joint Federal–Provincial project. The results define the vast extent of the Sokoman (Iron) Formation in a visually spectacular manner (Figure 12), and these new data are a powerful tool for exploration and discovery. Strong positive magnetic responses characterize magnetite-rich horizons, which may include potential taconite deposits. Direct estimation of size and grade from aeromagnetic data is difficult due to several factors including remnant magnetization effects and mineralogy, and ground mapping and prospecting are required to better evaluate individual responses. Hematite-rich deposits, of either the hard variety or DSO-type material, lack such strong responses, and may instead be characterized by magnetic low targets within positive anomalies of regional extent. Some DSO targets generate positive gravity anomalies, but many may have neutral or even negative gravity signatures as a consequence of their porosity. Regional gravity surveys are an important com-

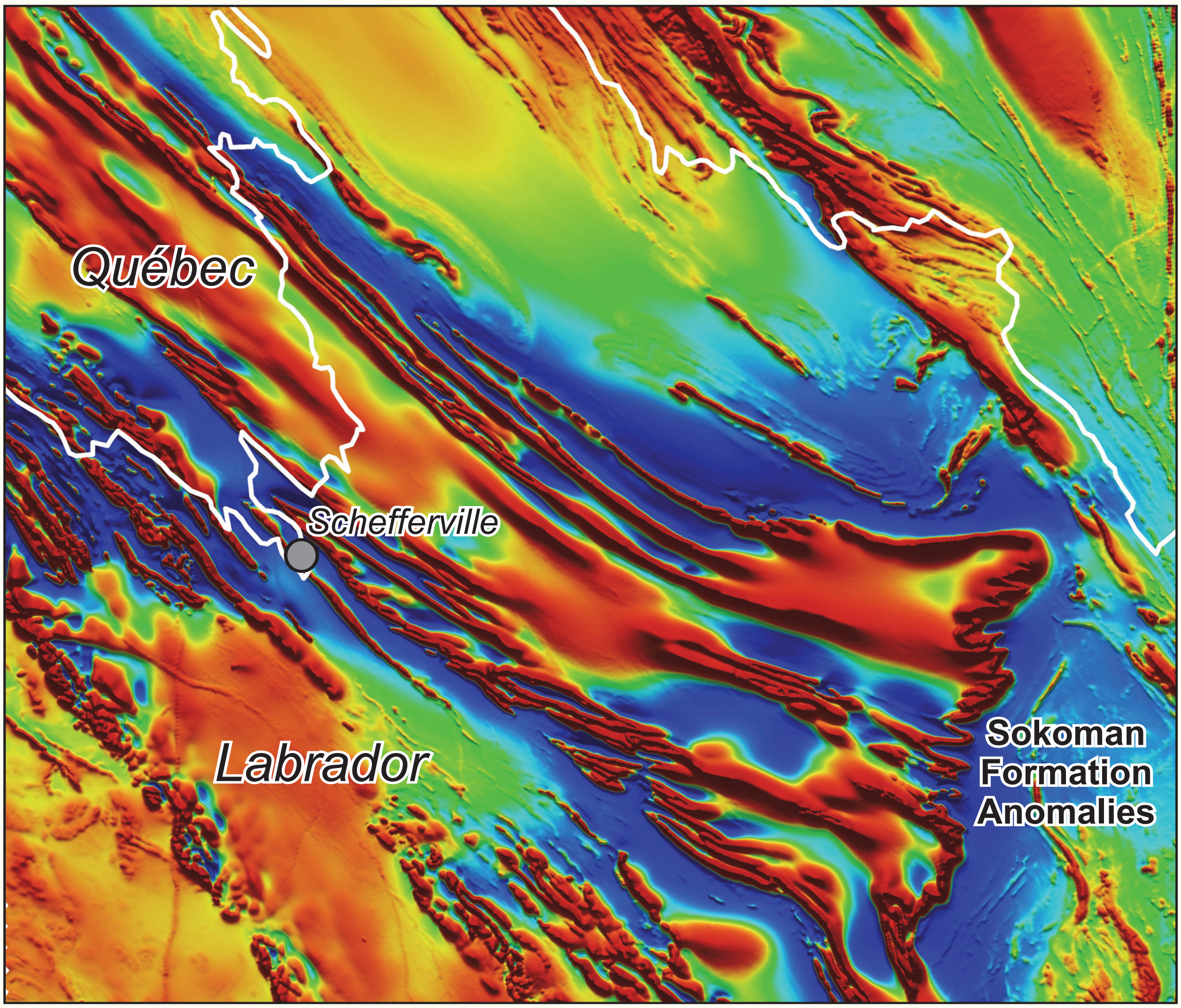


**Figure 12.** *Aeromagnetic data from Geological Survey of Canada Schefferville Survey, 2009, showing strong magnetic response of the Sokoman (Iron) Formation (red). Grid shows individual 1:50K map sheets. Image prepared by G. Kilfoil at GSNL.*

ponent of exploration programs in other iron-ore districts such as Australia and Brazil, and there is now much interest in the potential of airborne gravity methods as exploration tools.

There have also been many developments in genetic models for iron-ore deposits, although few of these are derived from work in North America. Recent research on iron formations in Australia and Brazil has emphasized the importance of structurally controlled hypogene alteration and upgrading of iron formations prior to supergene alteration. Important influences from magmatic fluids have been invoked to explain the origins of high-grade hematite ores in some Brazilian deposits. Such models carry the implication that not all high-grade iron ores are linked to surface weathering and leaching processes, which in turn implies that some ore bodies of this type may lack surface expression. In Australia, there are important examples of high-grade zones that sit beneath unaltered low-grade primary iron formations.

*Newfoundland and Labrador will continue to be a leading iron producer in Canada for the foreseeable future.*

Although Labrador and adjacent Québec represent one of the world's foremost iron-ore districts, much remains to be learned about the formation of these important and fascinating deposits. The renewed exploration effort, particularly in more remote and less-studied areas, should lead to the definition of new resources, and also to the evaluation of new techniques and the application of exploration models derived from those used elsewhere in the world. Newfoundland and Labrador will continue to be a leading iron producer in Canada for the foreseeable future, and may assume an even greater share of that production.

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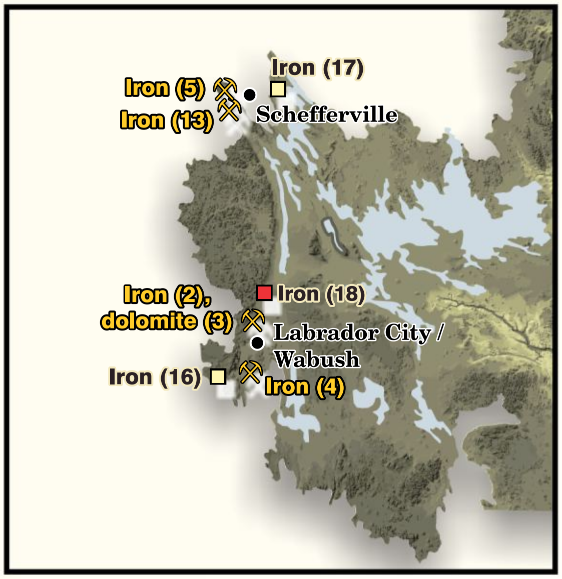
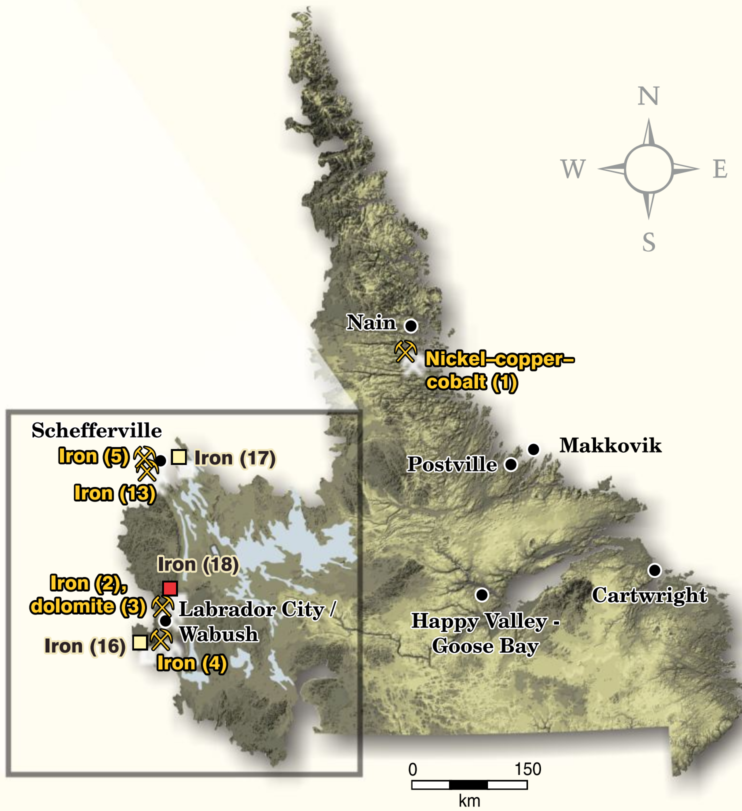
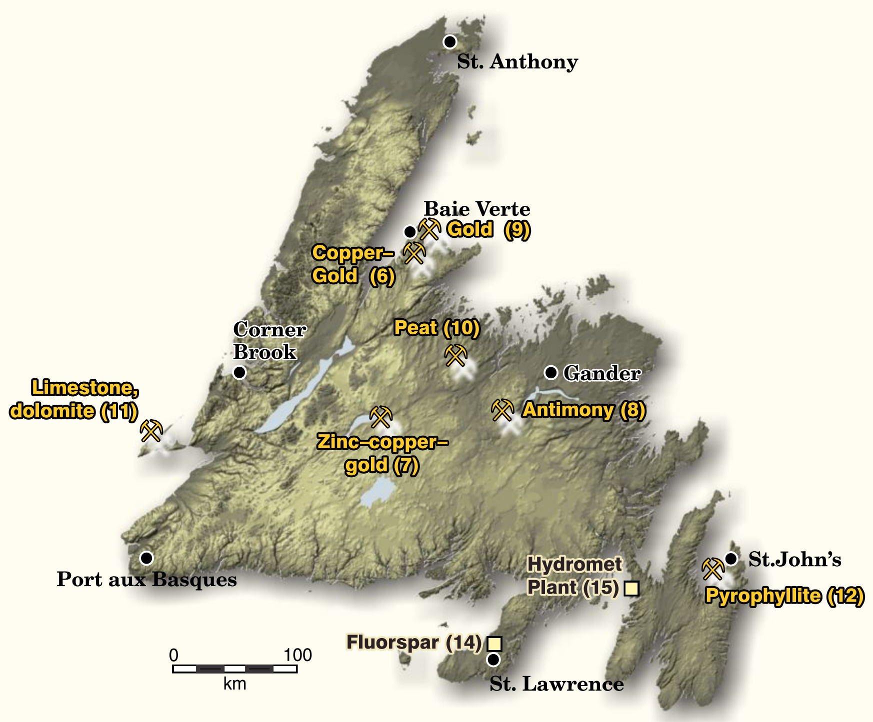
# PRODUCING MINES AND DEVELOPING PROPERTIES

## OCTOBER 2012




*Note scale differences of Labrador and Newfoundland maps*




### Producers

1. *Vale Newfoundland and Labrador Limited,*
   Voisey's Bay
2. *Iron Ore Company of Canada,*
   Labrador City
3. *Iron Ore Company of Canada,*
   Labrador City
4. *Wabush Mines,*
   Wabush
5. *Labrador Iron Mines Limited,*
   Menihek Area
6. *Rambler Metals and Mining Canada Limited,*
   Baie Verte Peninsula
7. *Teck Duck Pond Operations,*
   Duck Pond
8. *Beaver Brook Antimony Mine Inc.,*
   Beaver Brook
9. *Anaconda Mining Inc.,*
   Pine Cove
10. *Hi-Point Industries (1991) Ltd.,*
    Bishop's Falls
11. *Atlantic Minerals Limited,*
    Lower Cove
12. *Trinity Resources Ltd.,*
    Manuels
13. *Tata Steel Minerals Canada Ltd.,*
    Menihek Area

### Under development

14. *Newspar,*
    St. Lawrence
15. *Vale Newfoundland and Labrador Limited,*
    Long Harbour Hydromet Plant
16. *Alderon Iron Ore Corporation,*
    Labrador City/Wabush Area
17. *Labec Century Iron Ore,*
    Menihek Area

### Expression of Interest

18. *Julienne Lake,*
    Labrador City/Wabush Area