MINERAL COMMODITIES OF NEWFOUNDLAND AND LABRADOR

FLUORITE

Newfoundland Labrador
Natural Resources

Geological Survey
Mineral Commodities Series
Number 8

Mineral Commodities of Newfoundland and Labrador

Fluorite

Foreword

This is the eighth 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)
Fluorite (Number 8, 2013)

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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Compiled by T. Adams and A. Kerr, 2013

Front Cover: Complex internal structure in a fluorite vein from St. Lawrence. The red zones are hematite coatings on crystal surfaces that once projected into the vein.

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Fluorite

Introduction

Fluorite is widespread in Newfoundland and Labrador (Figures 1 and 2). The largest deposits of fluorspar (as it is commonly called in the industrial minerals sector) occur around St. Lawrence on the Burin Peninsula, and are the only economically viable deposits presently known. The first known observation of fluorspar came from geologist J.B. Jukes, who recognized it in a lead-rich vein in St. Lawrence Harbour in 1843. However, it is possible that Spanish and Portuguese seamen mined some fluorspar veins for their lead content in the seventeenth and eighteenth centuries, and the discovery of old tools in an adit located very close to St. Lawrence suggests some mining activity prior to 1825. The commercial production of fluorspar in St. Lawrence commenced in 1933 and continued until 1977. There has been intermittent production since that time, and significant fluorspar resources remain.

In Labrador, fluorite is common in the Makkovik area, where it is associated with molybdenum, uranium and base metals. Fluorite is also present within granitic rocks of the Strange Lake Intrusion, better known for its Zr–Nb–REE deposit. A small fluorite resource was defined by exploration in adjacent Québec, where it is associated with a breccia zone that is interpreted to surround the entire intrusion.

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Uses of Fluorite

Fluorite is the only common mineral that contains fluorine (F) in extractable quantities, and it has a variety of applications. ‘Fluorspar’ is the product of mining activities aimed at fluorite, but normally contains lesser amounts of other minerals. Commercial material is graded according to quality and specification. These grades are based on fluorite (CaF_2) content and the amount of impurities (*e.g.*, calcite, quartz, sulphur, arsenic, and lead). There are three main grade categories; acid grade, metallurgical grade and ceramic grade. The prices for all grades of fluorspar are historically variable, but ‘acid grade’ typically commands the highest price

The purest variety, ‘acid grade’ or *acidspar*, contains > 97% CaF_2, up to 1.5% $CaCO_3$, 1.0% SiO_2, 0.03–0.1% S, 10–12 ppm As, and 100–550 ppm Pb. Acidspar is the most versatile variety and is essential for a collection of applications. Its biggest demand is for the production of refrigerant gas (fluorocarbons) and synthetic cryolite, which is used for electrolylic smelting of aluminum. Other uses include metal surface treatment (metal pickling) for ferrous metals, copper and aluminum, petrochemical catalyst, fluorosilicic acid (fluoride source) and fluorine gas production.

‘Metallurgical grade’ or *metspar* contains > 80% CaF_2, with a maximum of 15% SiO_2, 0.3% S, and 0.5% Pb. Its use is primarily as a flux to lower the melting point of steel, and also in the smelting of aluminum.

‘Ceramic-grade’ fluorspar contains 80–96% CaF_2 and may contain up to 3% SiO_2. This grade is typically used in the production of cooking enamels, utensils and opalescent glass.

Mineralogy and Properties

Fluorine is the thirteenth most abundant element in the Earth’s crust, and has an average abundance of 650 ppm. Amongst common rocks, fluorine is most abundant in granites, which may contain several thousand ppm. It is a minor component of several silicate minerals, but most commonly occurs as fluorite. Pure fluorite (CaF_2) contains 51% calcium and 49% fluorine, but the mineral rarely approaches this composition. Impurities such as silicon, aluminum and magnesium are commonly present in inclusions and give the mineral a variety of colours, including purple, lilac, golden-yellow, green, blue, pink, champagne and brown. Fluorite can also be colourless and transparent. Petroleum compounds and water may also be present as fluid inclusions. In ideal growth conditions, fluorite forms euhedral cubic or octahedral crystals that are prized by mineral collectors (Plate 1). It shows a wide variety of textures, including massive or layered crusts, globular and botryoidal aggregates or coxcombs. Fluorite in any given occurrence may show all of these textures. Its measured density varies from 3.0 to 3.6 g/cm^3 and it has a melting point of 1403°C. The phenomenon of *fluorescence* was named after fluorite because it produces a variety of colours when irradiated by ultraviolet light, or strongly heated.

Fluorspar deposits commonly contain several other minerals, such as calcite, quartz, barite and celestite. Sulphide minerals such as pyrite, galena and sphalerite may also be present. The identities and the proportions of these other minerals, and the ease with which they can be separated from the fluorite, are important determinants of the viability for individual deposits.

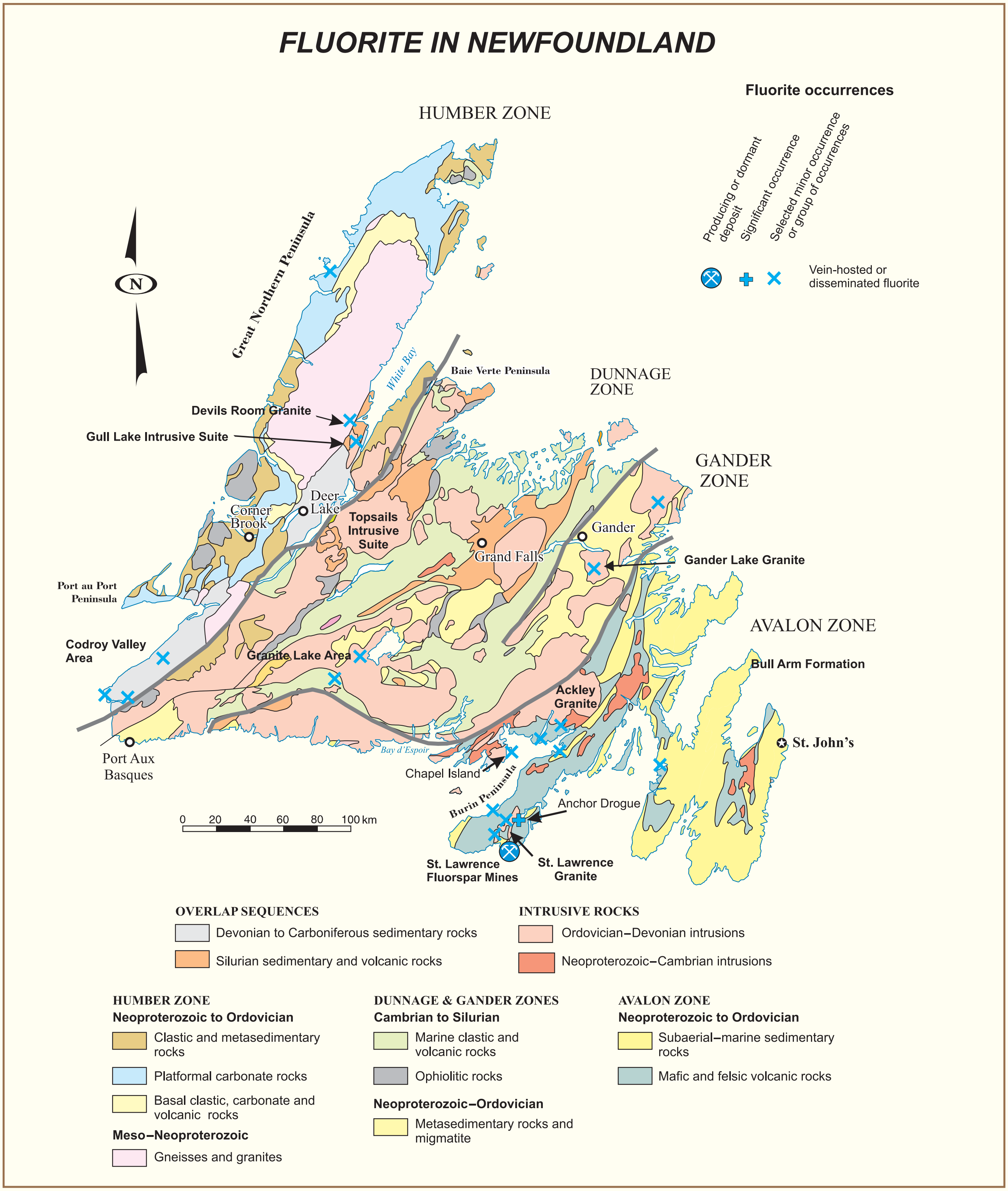

Figure 1. *Simplified geological map of Newfoundland showing the locations of fluorite occurrences or groups of occurrences.*

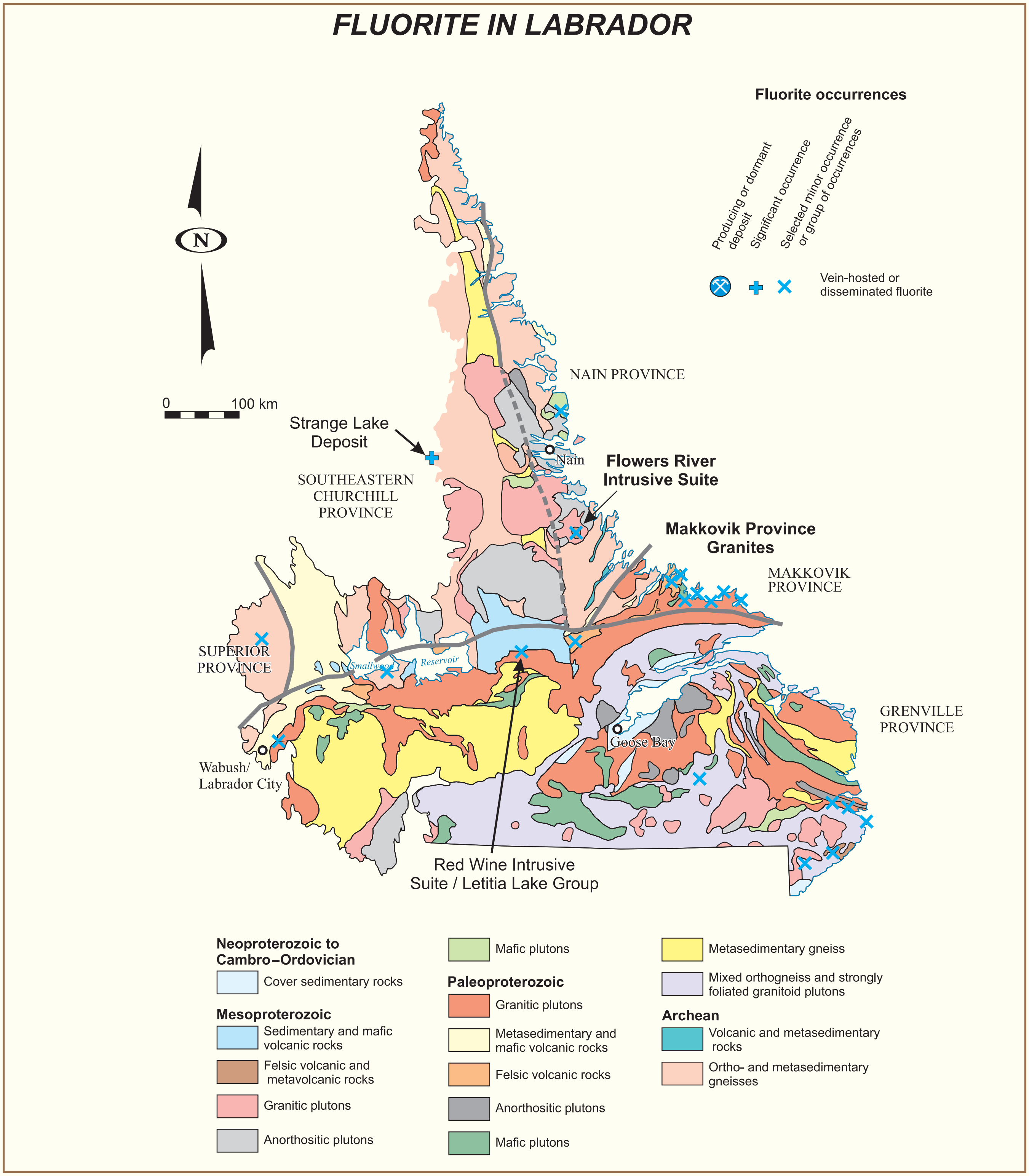

Figure 2. *Simplified geological map of Labrador showing the locations of fluorite occurrences or groups of occurrences.*

Plate 1. *Euhedral fluorite cubes from St. Lawrence (from the Mineralogical Association of Canada).*

Deposit Types and Associations

Fluorite is found in a variety of different geological environments but most commonly occurs as veins deposited from hydrothermal solutions, and in related replacement deposits. Fluorite-bearing veins may be hosted by granitic rocks, or by older rock types that form the country rocks to granitic bodies. In addition to fluorite-rich veins, fluorite is a common accessory mineral in sulphide-rich, metalliferous veins (typically containing lead, zinc and silver) and also in massive barite veins. Veins range from sheet-like, continuous bodies, to stockworks and masses of veinlets filling small fissures in brecciated rocks. All defined fluorite resources in Newfoundland and Labrador are hosted by such veins, or similar breccia zones. However, the most common style of minor fluorite mineralization is as disseminated material in granitic rocks.

Fluorite is the only common mineral that contains fluorine (F) in extractable quantities.

Replacement deposits are commonly developed through the interaction of hydrothermal fluids and carbonate rocks, or through metamorphic processes. Such zones are commonly controlled by structural breaks, faults or joints, or occur along contact zones of igneous intrusions. This style of mineralization is not widely documented in the province, although some examples are known in dolomitic rocks of western Labrador. Fluorite is also an accessory mineral in Mississippi Valley Type (MVT) Pb–Zn deposits, which are also commonly hosted by carbonate rocks.

Fluorite Deposits in Newfoundland

St. Lawrence Area

The St. Lawrence area is located near the southern end of the Burin Peninsula (Figures 1 and 3), and contains three main packages of rocks (Figure 3). The late Precambrian volcanic and sedimentary rocks of the Burin and Marystown groups are the oldest, and are overlain by mudstones, siltstones and limestone of the Cambrian Inlet Group. The Late Devonian St. Lawrence Granite intrudes the Precambrian and Cambrian rocks, and is believed to have been emplaced along north–south extensional faults. Its complex outcrop pattern (Figure 3) suggests that the roof of the original batholith lies close to the modern erosion surface. The granite is of evolved, peralkaline composition *i.e.*, enriched in sodium and potassium.

The St. Lawrence area contains one of the world's largest fluorite deposits, consisting of multiple veins. Mining began in 1933 from the Black Duck vein, and proceeded to several other veins including the Iron Springs, Lord and Lady Gulch, Blue Beach, and Hares Ears veins (Figure 3). Individual veins range from ~ 0.3 to 7 m in width and extend for 1 to 2.5 km. The continuity and consistency of the St. Lawrence veins are important factors in their economic viability. In total, more than 40 fluorite veins are known; about 20 of these are considered to have economic potential. Fluorite is mostly massive and coarsely crystalline, but is finely banded close to vein walls. Veins typically have higher grade cores and irregular amounts of mineralized granite breccia along their margins. The major gangue component is termed 'blastonite' and consists of brecciated fluorite cemented by microcrystalline quartz and fluorite. Calcite occurs in all fluorite veins, and other minerals such as barite, galena, and sphalerite are locally present. Typical examples of vein material are illustrated in Plates 2 and 3.

Three main types of fluorite-rich veins are generally recognized, *i.e.,* low grade, high grade and peripheral. Low-grade veins have an average width of 5 to 7 m, and grade ranging from 35 to 70% CaF_2. They typically trend at 140 to 160° (Figure 3), and some exceed 2 km in length. High-grade veins have a different structural trend (70 to 100°), and attain similar widths, but contain > 95% CaF_2 and virtually no gangue minerals. The veins follow faults that are interpreted to have experienced multiple episodes of deposition and movement, and extend into the surround-

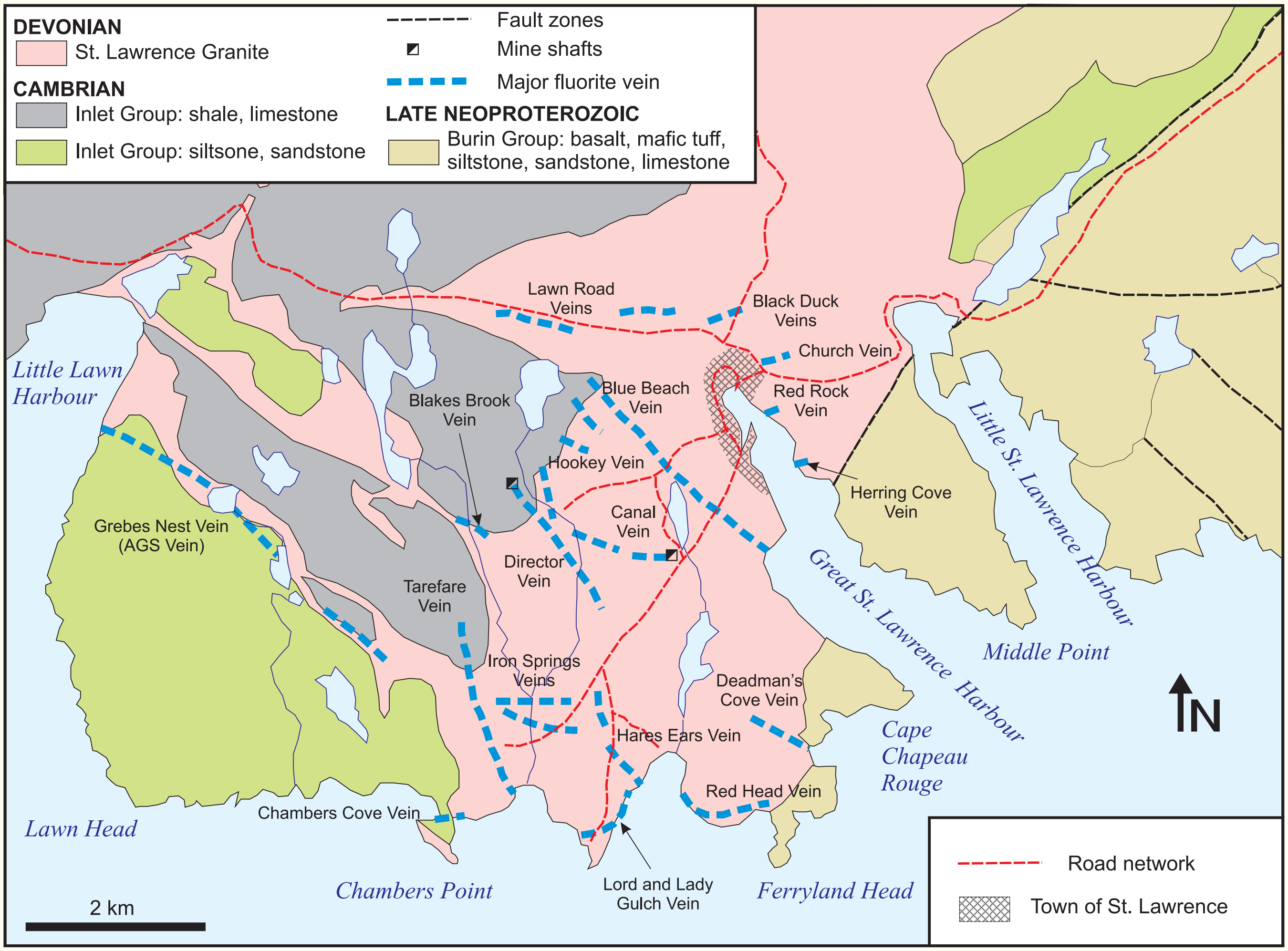

Figure 3. *Geology of the St. Lawrence area, Burin Peninsula, showing the distribution and extent of major fluorite veins within the mining district.*

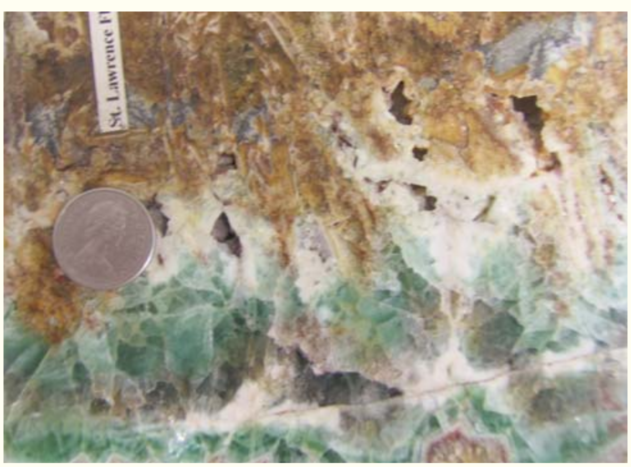

Plate 2. *Brown and green fluorite from St. Lawrence showing open cavities (vugs) within vein material.*

Plate 3. *Composite fluorite vein from St. Lawrence, showing pale yellow outer zone, well-formed cubic crystals representing growth into open space in the centre of the vein, and a final zone of white and green material.*

Table 1. Production and Reserves at St. Lawrence

Part 1: Mineral resource estimate of the Blue Beach North, Tarefare and Blowout veins, April 2009. Modified from a March 6, 2013 Canada Fluorspar (NL) Inc. NI 43-101 Technical Report

Vein	Category	Tonnes	% CaF_2
Blue Beach North	Indicated	4,390,000	39.0
Tarefare	Indicated	4,700,000	44.8
Total	Total Indicated	9,090,000	42.0
Blue Beach North	Inferred	355,000	30.0
Blowout	Inferred	595,000	31.8
Total	Total Inferred	950,000	31.1

Notes:
1. CIM definitions were followed for the resource estimate
2. Mineral resources are estimated at a cut-off grade of 20% CaF_2 and a minimum horizontal width of 2 m
3. Average density of mineralized rock is 2.9 t/m^3
4. Tonnage and average grade numbers are rounded
5. Mineral resources exclude mined-out areas from historical mining

Part 2: Total production from the St. Lawrence district (approximate)

Production Years	Crude Ore Milled (Tonnes)
1952-1978	3,532,300
1987-1989	374,300

Notes:
1. Values tallied from different companies over duration of production
2. Crude ore represents values taken from all producing veins during mining

ing rocks of the Inlet Group. Fluorite has mostly been mined in areas where the wallrocks are granite, but recent work suggests potential for veins hosted by sedimentary rocks. All veins in the St. Lawrence area pinch and swell in both vertical and horizontal directions, and discrete ore bodies within individual veins have a lenticular geometry. Mining operations at St. Lawrence involved nine discrete veins, including both high- and low-grade varieties. The most productive were the Director, Tarefare and Blue Beach veins (low grade), and the Black Duck, Lord and Lady Gulch and Iron Springs veins (high grade). The Blue Beach and Tarefare veins contain most of the remaining resource that could support renewed mining operations. Table 1 lists the tonnages mined at St. Lawrence, or which may be mined in the future. Note that not all of the veins are fully defined by previous exploration and drilling, so there remains potential for an additional resource definition.

The St. Lawrence area contains one of the world's largest fluorite deposits, consisting of multiple veins.

A third vein type occurs in areas distal to the main area of mining, and is characterized by abundant barite associated with fluorite. The Anchor Drogue vein, hosted by a Precambrian granite unit northeast of St. Lawrence, is the best known example of this type.

Other Fluorite Mineralization

Newfoundland contains many scattered fluorite occurrences, most of which are associated with granitic rocks (Figure 1). Most of these are minor occurrences of disseminated material or thin veinlets. Areas with notable concentrations include the Granite Lake area of southern Newfoundland, where granite-related molybdenum and tungsten mineralization is widespread, the Gander Lake granite, and the area around White Bay in northwestern Newfoundland. Fluorite is also reported in Carboniferous limestone rocks of the Codroy Basin in western Newfoundland (Figure 1), but the style of this mineralization is unclear. At present, none of these occurrences are considered to have any economic potential.

Fluorite Deposits in Labrador

Strange Lake Area

The 1240 Ma Strange Lake Intrusion hosts important deposits of Zr, Nb and REE (rare-earth elements) on both sides of the Québec–Labrador border (Figure 2). Fluorite occurs as an accessory mineral in these deposits. The intrusion is a small circular body of peralkaline granite about 8 km in diameter that intrudes metamorphic rocks of the Churchill Province and Mesoproterozoic quartz monzonite. In adjacent Québec, the outer margin of the intrusion is marked by an exposed fluorite-rich brecciated fault zone (Plate 4). Geophysical data from exploration work suggest that this feature continues all around the intrusion, including Labrador, where it is obscured by glacial deposits. The fluorite-bearing breccia zone has been tested by drilling in Québec, where a small historical resource (non NI 43-101 compliant) of 1.6 million tonnes at 3.6% F (about 7% CaF_2) was defined. The zone has been tested only in one area, and remains unevaluated in Labrador.

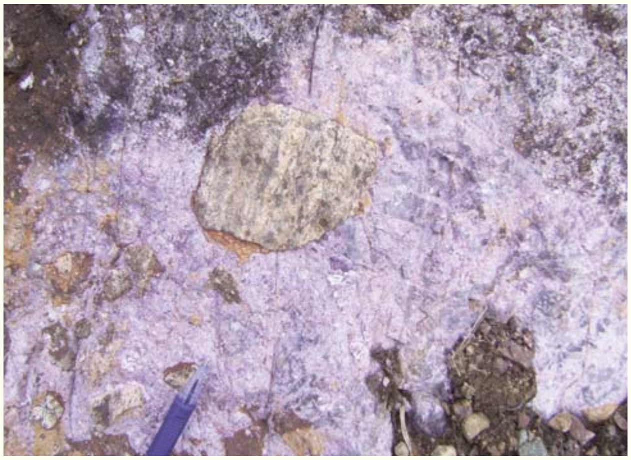

Plate 4. *Purple fluorite in the matrix of hydrothermal breccias in the margin of the Strange Lake Intrusion, Québec; similar zones are believed to extend into Labrador.*

Other Fluorite Mineralization

Labrador contains several other areas in which disseminated fluorite or small-scale fluorite veining is present (Figure 2). The Makkovik area, the Flowers River Intrusive Suite, and the Red Wine Intrusive Suite are all known to contain fluorite. The most widespread mineralization is in the Makkovik area, where fluorite is an accessory mineral in some vein-style uranium deposits and related skarn-like zones, believed to be associated with posttectonic granitic rocks. None of these occurrences are presently considered to have any economic value. Fluorite is associated with peralkaline intrusive and volcanic rocks of the Red Wine Intrusive Suite and Flowers River Intrusive Suite in northern Labrador (Figure 2), but these areas are currently of most interest for REE and associated elements. Similarly, fluorite occurrences are spatially associated with REE mineralization and granite rocks in southeastern Labrador (Figure 2).

In western Labrador, fluorite occurs as a gangue mineral within dolomitic marble of the Paleoproterozoic Denault Formation, from which two quarries have produced dolomite for use as a fluxing agent in local iron-ore pellet production. In the Plateau Quarry near Julienne Lake, fluorite is associated with muscovite, tremolite and minor pyrite (Plate 5), and is believed to have formed through interaction of hydrothermal fluids with the original carbonate rocks.

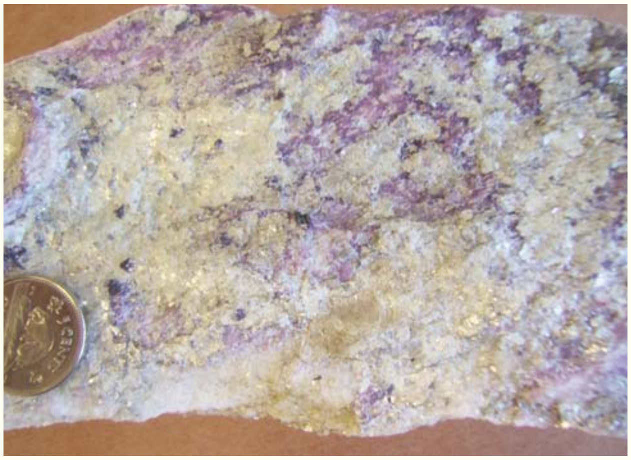

Plate 5. *Purple fluorite associated with muscovite, tremolite and granular dolomite, Plateau Quarry, western Labrador.*

Exploration Potential

It is likely that any future production of fluorite in the province will come from the St. Lawrence area, where significant resources and exploration potential remain (Plate 6). The grades of mineralization reported from the Strange Lake area (in Québec) are significantly less than those documented at St. Lawrence, but the potential for higher grade zones in Québec or in Labrador cannot be dismissed, given lack of exploration for this commodity. However, this area is remote, and further fluorite exploration is unlikely unless the Zr–Nb–REE deposits are developed in years to come. Other occurrences of fluorite in

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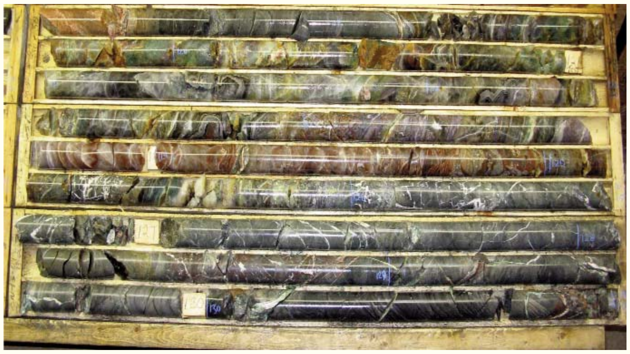

Plate 6. *Drillcore from the high-grade Arthur Gordon Stollery (AGS) fluorite vein at St. Lawrence (formerly known as the Grebes Nest Vein). In contrast to previously mined veins, this zone is developed within metasedimentary wallrocks, which have, to date, seen only limited exploration. (Photo credit, Canada Fluorspar Incorporated.)*

Newfoundland and Labrador are minor in extent and low in grade, and are not currently considered of economic significance.

There is a marked association between fluorite mineralization and igneous rocks of peralkaline composition, and such rocks are generally known for their high fluorine contents. The largest deposits at St. Lawrence are associated with well-known granite of this type, and similar associations are shown by much of the fluorite mineralization known in Labrador. However, some other large peralkaline igneous complexes, such as the Topsails Intrusive Suite in west-central Newfoundland, are not known to contain fluorite mineralization. Such areas may merit exploration in future years.

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