New Brunswick / Nouveau Brunswick

Energy and Resource Development

Antimony

Mineral Commodity Profile No. 12

Antimony (Sb) comes from the Greek words "anti" and "monos" (together meaning "not alone") and is named such because it is rarely found naturally in its pure form. It is a silvery-white, brittle, fusible and crystalline metalloid with a density of 6.61–6.71 g/cm^3. The Earth's crust contains approximately 0.2–0.5 parts per million (ppm) antimony and antimony is one of a few elements that expand as they freeze. Antimony is a poor conductor of electricity and heat, and can be toxic in some cases, but less so in solid form. More than 100 mineral species of antimony are known; however, it most commonly combines with sulfur to form antimony sulfide or "stibnite" (Sb_2S_3). It also combines with lead and sulfur to form the mineral jamesonite ($Pb_2Sb_2S_5$), with copper and sulfur to form tetrahedrite ($Cu_{12}Sb_4S_{13}$), or with iron and sulfur to form berthierite ($FeSb_2S_4$).

Antimony metal (crystal is 1 cm in length and 2 g in weight).

Stibnite crystals from the former Lake George Mine.

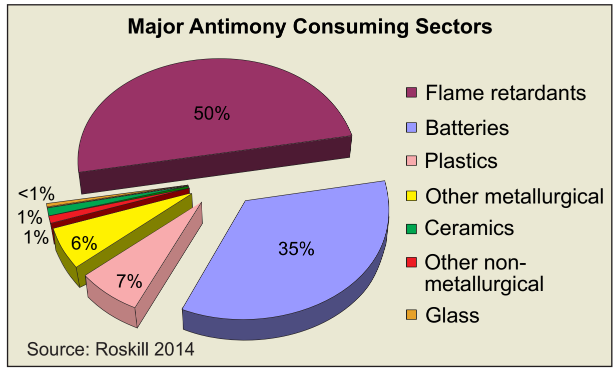
Uses

Antimony trioxide (Sb_2O_3) is the most commonly used form of antimony in industrial applications. When combined with halogens, such as bromine (Br) and chlorine (Cl), it acts as a flame retardant and is used widely in electronics, plastics, rubber, adhesives, textiles, furniture upholstery, as well as in children's clothing and car seats.

Antimony is often alloyed (or mixed) with other metals, for example lead-antimony alloys are used to strengthen and smooth metals, and in lead-acid batteries they enhance the charging characteristics of the battery. When alloyed with tin, copper, or lead, it is used for machine bearings. The antimony-tin alloy is also used for plates, pitchers, cups, and other dinnerware.

Antimony oxide is used as a yellow pigment in plastics, paints, and rubber.

Less commonly, antimony is used in the production of printing molds, medicine, and fireworks. High purity antimony (99.999%) is used in the manufacture of semiconductors and widely used in computers and televisions. Sodium antimonite (Na_3O_4Sb) is used as a decolorizing agent for optical glass in cameras, photocopiers, binoculars, and fluorescent light glass tubing. Antimony is recovered during the recycling process of lead-acid batteries and is subsequently reused to make new lead-acid batteries.

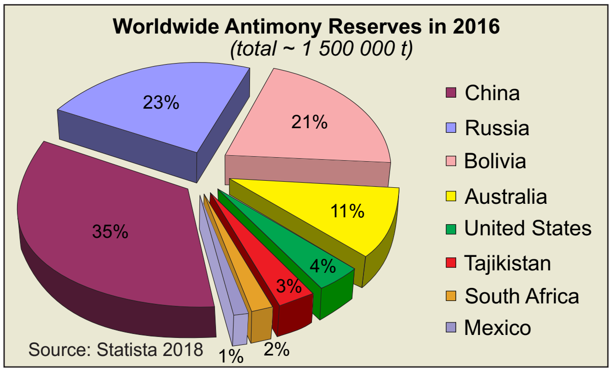


World Production and Reserves

Antimony prices have risen significantly since 2000. The average annual price of antimony rose to $US6.50/pound in 2011 from $US0.65/pound in 2001 (USGS 2017). In 2013, the antimony reserves worldwide were estimated to be 1 300 000 tons (Seal II et al. 2017). In 2016, countries with the greatest antimony reserves were China, Russia, Bolivia, Australia, United States, Tajikistan, and South Africa, with combined reserves of approximately 1 500 000 tons (USGS 2017).

In 2015, global antimony consumption was estimated to be approximately 184 000 tons, a small increase over the previous year. Half of the global antimony consumption is used in flame retardants, followed closely by lead-acid batteries and plastics.

The global antimony market has been dominated by China since the mid-1800s with the largest producing mine being the Xikuangshan Mine in Hunan Province. Antimony is considered a strategic mineral, which means production from Chinese mines is closely controlled. Chinese antimony products are mainly sold to Europe, South Korea, the United States, Japan, and Mexico.



Antimony Mining in New Brunswick

Stibnite was first discovered during road construction in the Lake George area (Fig. 1) around 1863. Between 1863 and 1896, several veins were discovered and three shafts were sunk on the Hibbard, Adams, and Lawrence properties (Caron 1996).

Multiple companies worked at the Lake George Mine from 1876 to 1890. In 1876, the Lake George Mining and Smelting Co. was formed and mined ore from the Prout vein on the Hibbard property, but mining ceased later that same year. The Hibbard Antimony Company built and operated the first smelter on the Hibbard property, but their work terminated in 1884 when the mill was destroyed by fire. Approximately 800 m to the west, the Adams property was developed between 1880 and 1884 and a mill was built near the Hibbard No. 6 shaft. The Hibbard and Adams properties were combined in 1885 by Brunswick Co., but operations ended in 1886. Sporadic work was conducted on the Hibbard vein until 1890 when all work was suspended (Caron 1996).

In 1907, the Canadian Antimony Co. Ltd. commenced mining on the Prout and Hibbard veins, but arsenic in the ore created an unresolvable metallurgical problem that caused the mine to close in 1910. From 1915 to 1938 the mine operated intermittently under various operators and ore was shipped around the world. A decrease in demand for antimony following the end of World War II resulted in mine closure. Consolidated Durham Mines and Resources Ltd. took over the property in 1969 and, in 1970, they drilled a geochemical soil anomaly that eventually outlined an ore zone associated with the Hibbard vein. The mine resumed operation from 1972 to 1981, and during that time, produced 34 417 tonnes of concentrate grading 65% to 66% Sb. From 1980 to 1981, a second ore zone containing one million tonnes grading 4% antimony was defined, and mined from 1985 to 1990 (Caron 1996). A drop in antimony prices triggered mine closure in 1990 and Durham sold the mine in 1995 to Apocan Inc. Chemical. The mine was then dewatered and ore production resumed in 1996 from the Hibbard, Adams, and Lawrence veins. 37 108 tonnes of ore was mined yielding 1659.6 tonnes of antimony concentrate (Carroll 1996). Apocan closed the mine in 1996 due to mechanical issues and a collapse of antimony prices (MRB & Associates 2014a).

Elsewhere in New Brunswick, antimony was recovered as a by-product from the smelting of base-metal sulphide ores from volcanogenic massive sulphide (VMS) deposits in the northern part of the province (see Fig. 1). In 2013, this resulted in 88 tonnes of antimony being produced from ores mined at the Brunswick No. 12, Half Mile, and Captain North Extension (CNE) deposits, collectively (NRCAN 2013).

Aerial view of the facilities at the former Lake George Mine (ca. 1980s).

New Brunswick Antimony Deposits

Most antimony deposits are thought to have formed from low temperature (epithermal), hydrothermal solutions at shallow depths. They generally occur as joint or fissure fillings, pegmatites, replacement lodes or hot-spring deposits. These types of deposits are not restricted to rocks of a particular age or type.

Mineralogically, antimony deposits can be categorized as simple or complex. The simple deposits tend to consist mainly of antimony minerals such as stibnite (and less commonly native antimony) with very minor quantities of other metallic minerals. The stibnite can be oxidized (weathered), in whole or in part, to antimony oxide minerals (such as kermesite (Sb_2S_2O), valentinite (Sb_2O_3), and stibiconite ($Sb_3O_6(OH)$). Mineralogically complex antimony deposits are composed of antimony-bearing sulfides and sulfosalts that may contain copper, mercury, lead, gold, or silver. In these deposits, antimony is commonly recovered as a by-product during processing of other ore minerals.

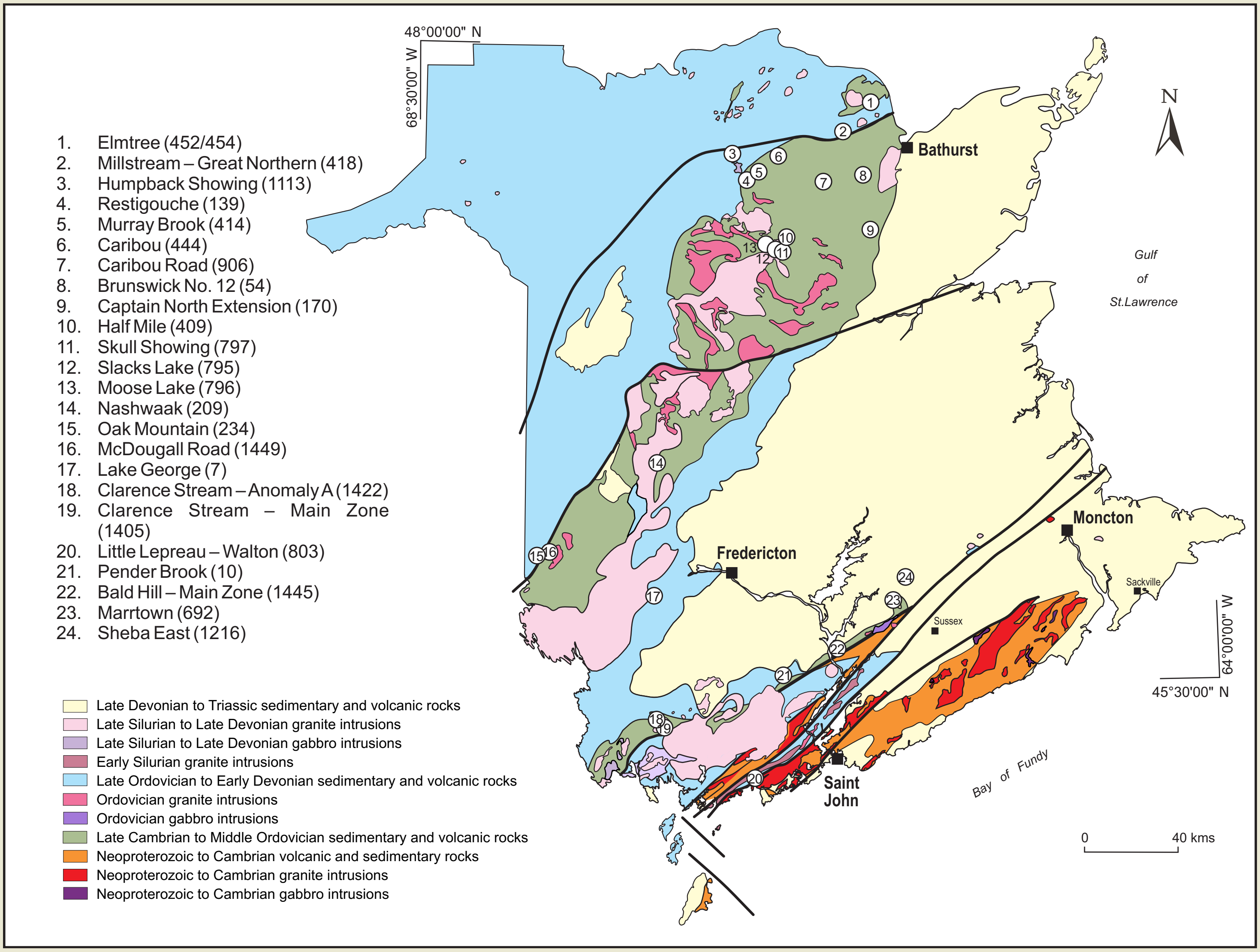


Figure 1. Geological map showing the antimony deposits and significant occurrences in New Brunswick. The numbers in brackets refer to the Unique Record Number in the New Brunswick mineral occurrence database.

Antimony mineralization occurs throughout New Brunswick; however, notable occurrences are concentrated within the Kingsclear, St. Croix, Mascarene, and Annidale belts in southern New Brunswick (Fig. 1). Here, antimony deposits commonly consist of stibnite-quartz veins, with the most significant deposit of this type being the former Lake George antimony mine. Other deposits that contain significant quantities of antimony are the Clarence Stream and Bald Hill deposits in southwestern New Brunswick and several volcanogenic massive sulphide deposits in northern New Brunswick where antimony was recovered as a by-product during mining operations.

Former Lake George Mine

The former Lake George antimony mine (17 on Fig. 1), located 45 km west of Fredericton, occurs within rocks of the Kingsclear Group. The mine was operated intermittently from 1876 to 1996 and was once the largest primary antimony producer in North America. The deposit shares characteristics with simple or vein-dominated antimony deposits, disseminated antimony deposits, and gold-antimony deposits. The two-stage Sb-Au-W-Mo mineralization at Lake George is associated with nearby granitic intrusions. The first stage of mineralization is a quartz veinlet stockwork with W-Mo and the second stage is Sb-Au-bearing quartz veins, which are hosted in shale, calcareous shale, limestone, quartzite, or granite (Scratch et al. 1984; Seal et al. 1988). The antimony mineralization is mainly hosted within three east-trending, shallowly-dipping veins (each <2 m in width) referred to as the Hibbard, Prout, and Brunswick veins; and the NNE-trending, shallowly-dipping 1 to 1.5 m thick Lawrence vein. Trace amounts of gold, occurring mostly in minor veins and as disseminations in the host rocks, are

Underground mining of the antimony vein at the Lake George mine.

associated with this deposit, but were not exploited during previous mining activity. The Lake George deposit is considered to be mineralogically simple and is very similar in geological setting to the Beaver Brook deposit in Newfoundland (Lake and Wilton 2006). In 2014, a new National Instrument 43-101 compliant resource estimate was calculated for the remaining deposit at Lake George and is reported in Table 1 (MRB & Associates 2014a).

Clarence Stream Deposit

The Clarence Stream deposit (18 and 19 on Fig. 1), located approximately 70 km SSW of Fredericton and 25 km NNW of Saint George, straddles the boundary between the St. Croix and Mascarene belts in southern New Brunswick (Thorne et al. 2008). Mineralization at Clarence Stream was initially discovered in 1998 by prospector Reginald Cox Jr. while investigating gold anomalies identified during a Geological Survey of Canada regional stream sediment and water geochemical reconnaissance survey (Friske et al. 1992). The gold-antimony mineralization occurs in two zones, referred to as the Main Zone and Anomaly A (Fig. 1), which are approximately 4 km apart and define a mineralized trend that parallels the northern margin of the Early Devonian Magaguadavic Granite, a phase of the Saint George Batholith. At the Main Zone, mineralization is hosted by volcaniclastic sedimentary and volcanic rocks of the Silurian Waweig Formation, East Branch Brook gabbroic dykes, and a number of felsic dykes.

The mineral assemblage is dominated by gold, aurostibite, and gold-stibnite intergrowths associated with a variety of sulphides (mainly pyrrhotite, arsenopyrite, gudmundite, sphalerite, and

Table 1. Indicated and Inferred Mineral Resources for the past producing Lake George Mine (from MRB & Associates, 2014a).

Lake George Project Mineral Resources including pillars

	Indicated			Inferred		
Cut off Grade (%)	**Tonnage (short ton)**	**Grade (%)**	**Sb (Short ton)**	**Tonnage (short ton)**	**Grade (%)**	**Sb (Short ton)**
1.0	257,864	2.70	6,954.4	1,252,481	2.01	25,153.2
1.5	153,147	3.73	5,706.5	718,046	2.61	18,707.2
2.0	116,012	4.37	5,067.7	467,901	3.08	14,405.1

Lake George Project Mineral Resources excluding pillars

	Indicated			Inferred		
Cut off Grade (%)	**Tonnage (short ton)**	**Grade (%)**	**Sb (Short ton)**	**Tonnage (short ton)**	**Grade (%)**	**Sb (Short ton)**
1.0	235,664	2.50	5,897.9	1,153,974	1.99	22,983.8
1.5	134,731	3.48	4,694.7	661,747	2.58	17,073.3
2.0	99,789	4.10	4,094.2	438,676	3.02	13,230.1

chalcopyrite), sulfosalts (berthierite, jamesonite, and tetrahedrite), and trace amounts of other antimony minerals (native antimony, andorite, and meneghinite) hosted by a series of quartz veins up to 3 m wide that occupy a northeast-trending shear zone (Thorne et al. 2008). At Anomaly A, the mineralogy is characterized by gold-bearing stockwork, massive and brecciated quartz-sulphide veins enriched in antimony relative to the Main Zone. Stibnite is the dominant antimony mineral in association with pyrrhotite, pyrite, arsenopyrite, and native gold (Watters et al. 2008). Other antimony minerals identified at Anomaly A include berthierite, jamesonite, gudmundite, kermesite, and lesser amounts of native antimony, aurostibite, nickel-bearing aurostibite, and nisbite (Cabri, unpublished report, 2002). The mineralization at both zones is mineralogically complex and is interpreted to be related to the emplacement of the Magaguadavic Granite (Thorne et al. 2008; Watters et al. 2008). A National Instrument 43-101 Compliant Inferred Mineral Resource of 22 million pounds of antimony was reported for the Main Zone and Anomaly A, collectively (SRK 2017).

Bald Hill Deposit

The Bald Hill deposit (22 on Fig. 1), located north of London Settlement in south-central New Brunswick, lies within the Cambro-Ordovician volcano-sedimentary sequence of the Annidale Belt. The area was explored for its base-metal potential intermittently from the late 1800s to the present. The discovery of several massive sulphide boulders containing up to 53% Sb, in addition to mineralized outcrops, lead to a comprehensive exploration program on the property by Rockport Mining and Tri-Star Antimony Canada beginning in 2008 and ending in 2015.

Massive stibnite found in boulder float on the Bald Hill property (quarter for scale).

The antimony mineralization is associated with the Bald Hill Suite comprising multiple rhyolite dome complexes and associated pyroclastic rocks of the Carpenter Brook Formation (Johnson et al. 2009). In addition to stibnite (locally massive), these rocks are also enriched in sulphides such as pyrite and arsenopyrite with minor galena and gold.

The antimony mineralization at Bald Hill is classified as a structurally controlled stibnite vein-style deposit with mineralized zones ranging in true thickness from less than a metre to more than 3 m (MRB & Associates 2014b). The northwest-trending mineralized veins cut across the northeast-trending regional fabric. Tri-Star Antimony Canada has delineated a potential quantity and grade of between 725 000 to 1 000 000 tonnes at grades between 4.11–5.32% contained Sb (MRB & Associates 2014b).

Interestingly, antimony mineralization occurs elsewhere in the 35 km long Annidale Belt. For example, some distance east of the Bald Hill deposit, near the eastern limits of the Annidale Belt, several occurrences of antimony-rich boulders containing up to 24% Sb (similar to Bald Hill) have been discovered (i.e., Sheba East and Marrtown occurrences, Fig. 1). The source of these boulders has yet to be determined.

Volcanogenic Massive Sulphide (VMS) Deposits

In northern New Brunswick, antimony was recovered as a by-product during the processing of base-metal sulphide ores from the Bathurst Mining Camp southwest of the city of Bathurst. The Bathurst Mining Camp is part of the Miramichi Belt, which is comprised of Early to Middle Ordovician volcanic rocks overlying a thick sequence of Cambro-Ordovician turbiditic sedimentray rocks. The volcanogenic massive sulfide deposits occur in the Tetagouche, California Lake and Sheephouse Brook groups, with the majority of the deposits hosted within the felsic volcanic rocks (Goodfellow et al. 2003). The largest of these deposits is Brunswick No. 12 (Fig. 1), which is considered a “supergiant deposit” that produced 136.6 Mt of ore grading 8.74 % Zn, 3.44 % Pb, 0.37 % Cu, and 102.2 g/t Ag (Bernard, pers. comm. 2013). The mine began production in 1964 and produced continuously until 2013 when reserves were exhausted.

The antimony grades in VMS deposits are very low (50–1000 ppm) and the antimony occurs as micro-inclusions or as solid solutions within various sulphide minerals and can be separated only by the process of smelting. Smelting refers to the process of heating and chemically reducing an ore so that only the metal remains. The lead concentrate produced from the VMS operations undergoes further refining in the smelter at Belledune where antimony-lead alloys, in addition to copper matte, silver-gold doré, and bismuth alloys are produced.

Summary

The primary antimony occurrences in New Brunswick typically consist of vein- and stockwork-related mineralization and can be mineralogically simple or complex. Although mineralization is commonly structurally controlled, the exact source of the metals and mineralizing fluids in these deposits remains poorly understood, primarily due to the limited amount of exploration and research. In general, the genesis of these deposits involves the deposition of antimony-bearing quartz veins along structural features with (1) the source of the hydrothermal fluids and metals being derived from a local felsic intrusion, (2) scavenging of metals from an antimony-rich sedimentary sequence by percolating fluids, or (3) some combination of both. New Brunswick was once North America's only primary antimony producer and given the remaining reserves at Lake George and significant antimony resources outlined at the Clarence Stream and Bald Hill deposits, there is considerable potential for additional discoveries and future production of antimony once again in southern New Brunswick.

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For More Information

For more information on antimony and other New Brunswick Mineral commodities, please see the New Brunswick mineral occurrence database (NBDERD 2018) or contact:

geoscience@gnb.ca

Telephone: 506.453.3826

Geological Surveys Branch
Energy and Mines Division
New Brunswick Department of Energy and
Resource Development
PO Box 6000, Fredericton, NB E3B 5H1

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