New Brunswick / Nouveau Brunswick

Energy and Mines
Minerals and Petroleum

Zinc

Mineral Commodity Profile No. 9

Zinc (Zn) is the 23rd most abundant element in the Earth's crust and accounts for approximately 0.0075% of the crust by weight. The name *zinc* is of German origin and may have been derived from the Persian word *sing* meaning *stone*. Zinc is included with the base metals, which are those common metals that are readily corroded by oxidization.

Pure zinc (Zn) is a bluish white metal and has a relative density of 7.14 g/cm^3, slightly less dense than iron (Fe), and has a melting point (420ºC) which is low relative to most other metals. Zinc readily combines with sulphur (S) to form the mineral sphalerite (ZnS), which accounts for the bulk of global zinc production. Other zinc minerals include franklinite ($ZnFe_2O_4$) and smithsonite ($ZnCO_3$).

Sphalerite (ZnS, dark brown) and pyrite (FeS_2, yellow) from the Nigadoo deposit in northern New Brunswick.

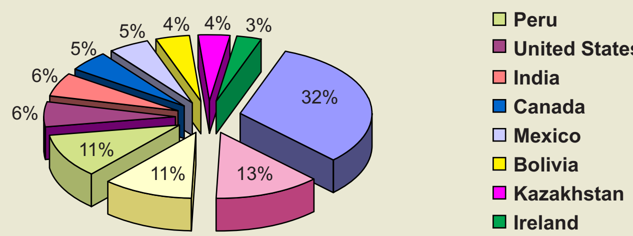
Hot-dip galvanization where steel parts are dipped in liquid zinc (bottom of photograph) to prevent corrosion of the steel.

Uses

Over half of the world's production of zinc is used as a protective coating on steel and iron to prevent rusting. Zinc is also used in the making of brass (an alloy of zinc and copper), in batteries and solder, and in medicinal compounds.

World Production

In terms of tonnage produced, zinc is fourth among all metals in world production behind iron, aluminum and copper. Zinc is produced in many countries, and annual global production is in the order of 12 million tonnes. In 2011, Canada ranked seventh in the world with an annual production of 670,000 tonnes. Approximately a third of this production came from mines in New Brunswick. In Canada, zinc production comes from a variety of deposit types that are exploited by open pit and underground mining methods.



Zinc Mining in New Brunswick

Almost all of New Brunswick's present and historical zinc production has come from the world famous Bathurst Mining Camp, located in the northeastern part of the province (Figure 1). Historically, production has come from open pit and underground mining operations at several volcanogenic massive sulphide (VMS) deposits (Figure 1), including: Brunswick No. 6 (1), Heath Steele (2), Caribou (3), Stratmat (4), Restigouche (5) and Halfmile (6). According to Lydon (2007), the value of total historical zinc production from the Bathurst Mining Camp is approximately $27.5 billion (2005 Canadian dollars). The majority of the production has come from the giant Brunswick No. 12 underground mine (7), which to the end of 2010 has produced 11.43 million tonnes of Zn metal as well as appreciable amounts of lead (Pb), copper (Cu), and silver (Ag).

Significant zinc mineralization also occurs in VMS-like deposits in Early Devonian submarine sequences dominated by volcanic and sedimentary rocks in northeast and west-central parts of New Brunswick (Figures 1 and 2), such as Nash Creek (8), Sewell Brook (9), and Gravel Hill (10). In addition, zinc mineralization occurs in granite-related polymetallic deposits such as Nigadoo (11), Keymet (12), Mount Costigan (13), and Mount Pleasant (14).

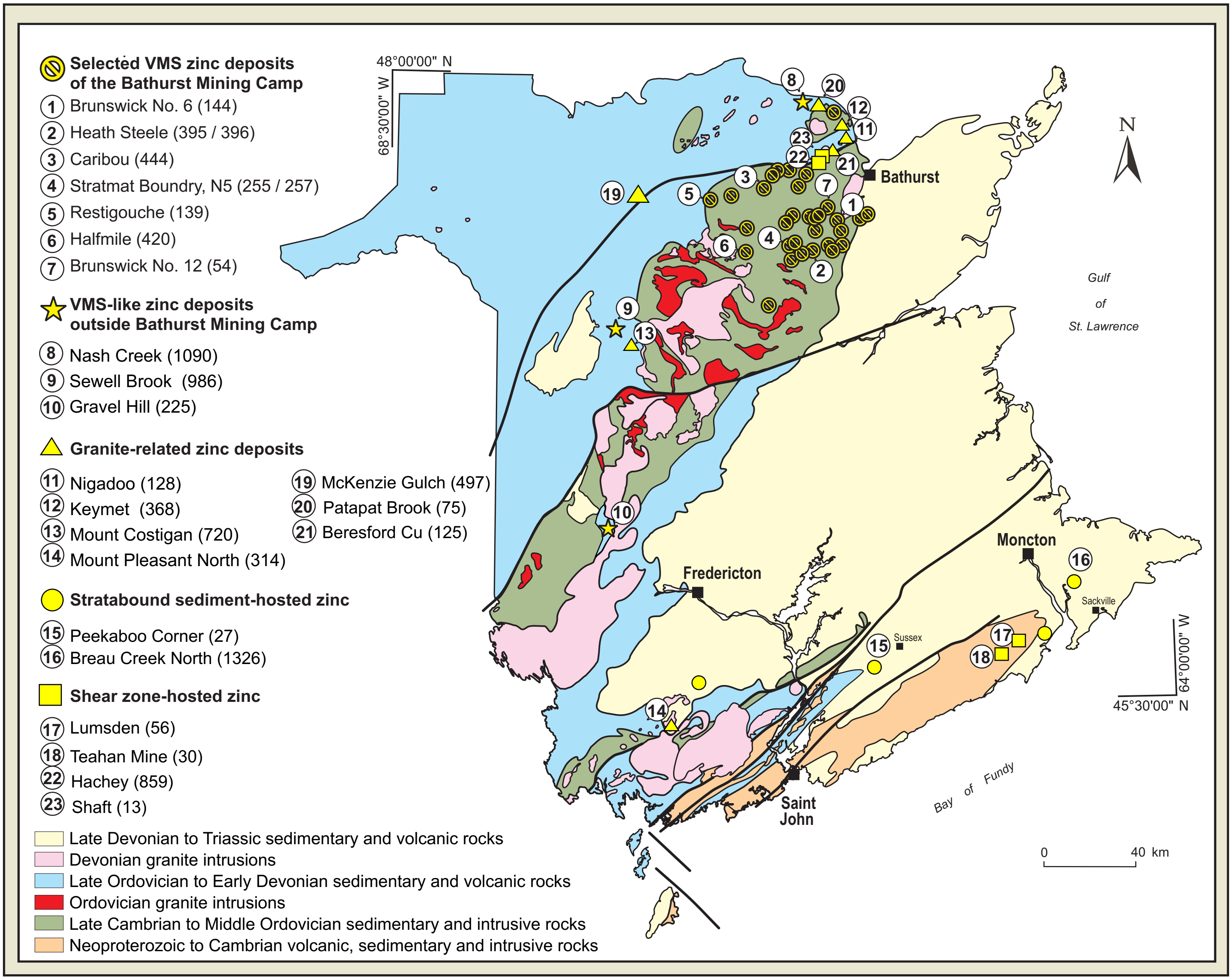


Figure 1. Significant zinc deposits in New Brunswick. Numbers in brackets correspond to the unique reference number in the New Brunswick mineral occurrence database (NBDEM 2013).

New Brunswick Zinc Deposits

Volcanogenic Massive Sulphide Deposits

New Brunswick zinc resources come primarily from VMS deposits associated with Ordovician felsic (silica-rich) volcanic rocks of the Bathurst Mining Camp (Franklin et al. 1981; McCutcheon et al. 2003; Goodfellow and McCutcheon 2003). VMS deposits form in marine basins that are undergoing extension, such as in backarc basins where new ocean floor is being generated by spreading along oceanic ridges (Figure 2, top). VMS deposits have accounted for the bulk of the world's primary zinc resource, which occurs almost exclusively in the mineral sphalerite. VMS deposits are bedded accumulations of Fe-, Zn-, Pb-, and Cu-bearing sulphides that have precipitated from hot metal-rich fluids discharged from hydrothermal vents (more commonly known as black smokers) located on the sea floor. (Figure 3) These vents commonly occur in clusters, which accounts for the distribution of the 46 known deposits in the Bathurst Mining Camp that collectively contained an estimated sulphide resource of 500 million tonnes. These deposits range in size from small bodies of about 100,000 tonnes to the giant Brunswick No. 12 with a size of 350 million tonnes. Likewise, grade can be highly varied among deposits, ranging from low grades of about 2% Zn + Pb to higher grade deposits containing 8% Zn and 4% Pb such as at Brunswick No. 12.

Sphalerite (dark brown) in high-grade massive sulphide ore from the Brunswick No. 12 deposit.

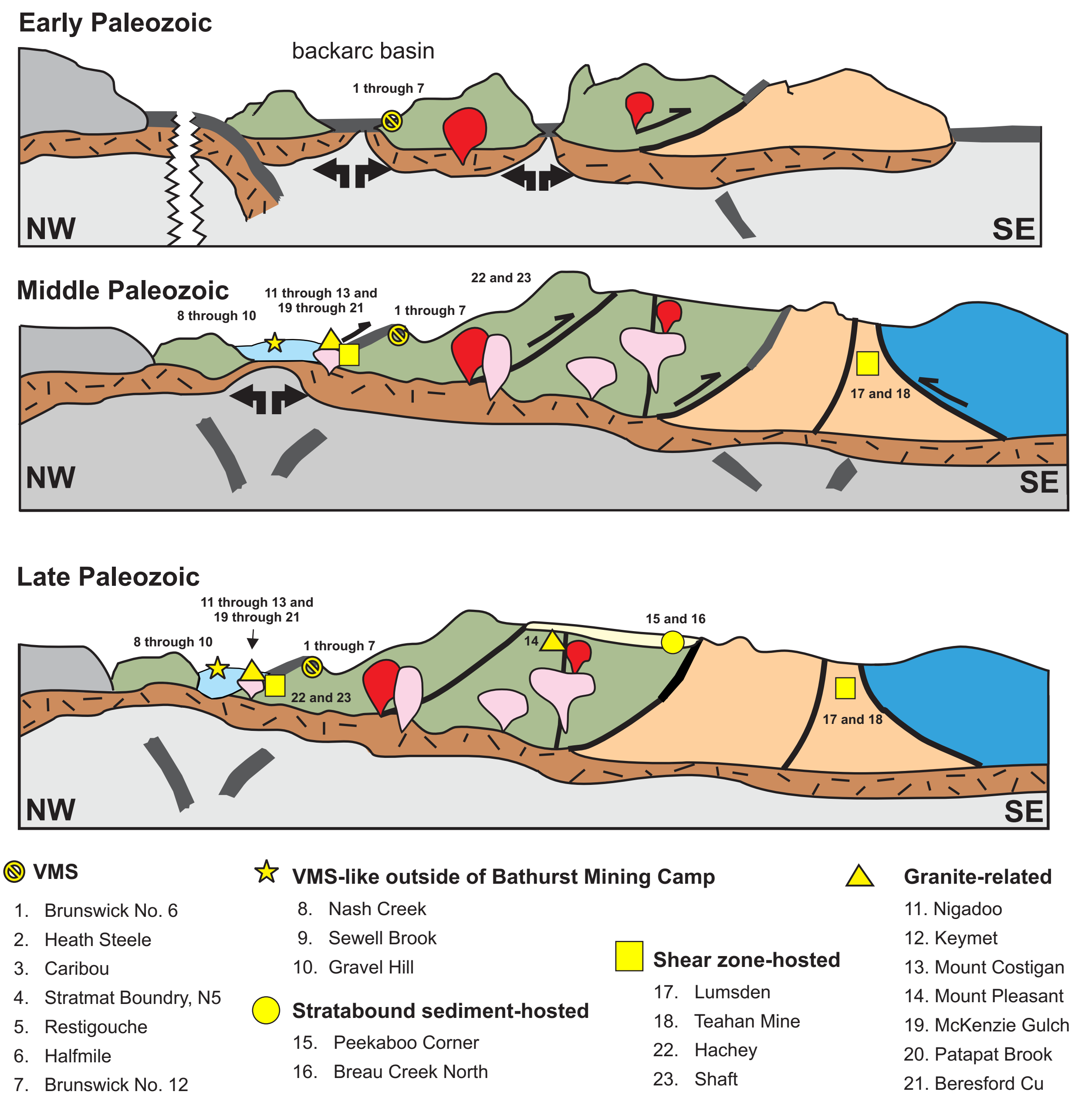


Figure 2. Schematic diagram showing geologic setting of New Brunswick zinc deposits. See Figure 1 legend for ages and types of host rocks (dark blue are Cambrian to Early Ordovician sedimentary rocks found in Nova Scotia).

Granite-related Zinc Deposits

Granite-related deposits in New Brunswick include three types of mineralization – endogranitic, polymetallic veins, and skarn (Figures 1, 2 and 4). These three types all formed from hot, hydrothermal fluids that were generated during the slow cooling and crystallization of granitic (silica-rich) magma as it rose high into the Earth's crust during the Devonian time period. Volatile-enriched fluids, containing CO_2, SO_2, and H_2S, and dissolved metals (including Zn, Pb, Cu, and characteristic granophile metals such as tungsten (W), molybdenum (Mo), tin (Sn), and antimony (Sb)), were released from the ascending magma as the confining pressure of the overlying rocks decreased. The expanding fluid fractured the overlying rock and the subsequent sudden decrease in pressure, and the cooling that accompanied it, favoured the precipitation of complex ore-mineral assemblages.

Sphalerite (ZnS) is an important accessory ore mineral in the Mount Pleasant polymetallic deposit located south of Fredericton (Figures 1, 2 and 4). The Zn and associated Sn in the North Zone at Mount Pleasant (14) occur in stockwork veins and as irregular lodes within subvolcanic granitic intrusions and so are referred to as endogranitic mineralization. Mount Pleasant contains an indicated resource of 12.4 million tonnes grading 0.86% Zn, and an additional inferred resource of 2.8 million tonnes grading 1.13% Zn (McCutcheon et al. 2012). The value of sphalerite at Mount Pleasant is enhanced by its content of the rare element indium (up to 300 grams per tonne of ore). Polymetallic vein deposits form when a single large quartz vein or sets of quartz veins precipitate from hydrothermal fluids injected into fractured country rocks surrounding granitic intrusions. Zn-rich veins of economic grade have been mined in New Brunswick at Nigadoo (11) and Keymet (12).

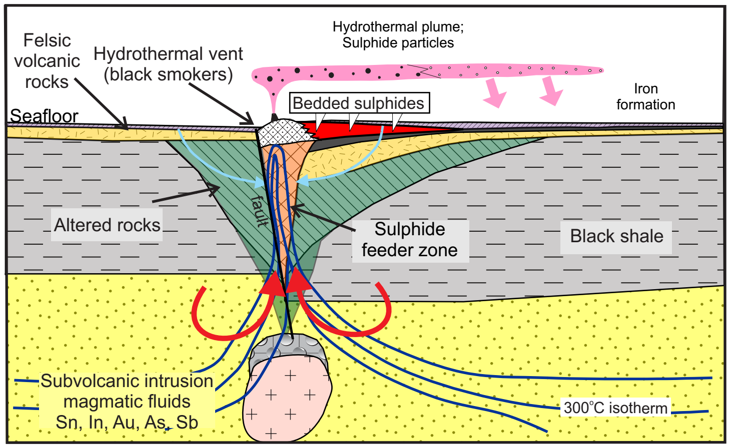


Figure 3. Model for the formation of volcanogenic massive sulphide (VMS) deposits. Modified from Goodfellow (2007).

Granite-related zinc deposits hosted by calcareous rocks are known as skarn deposits (Dawson 1996). Mineralization and alteration in these deposits are most commonly stratabound (concordant to bedding) although discordant mineralization can occur. These deposits are formed by the interaction of hot, metalliferous hydrothermal fluids, derived from crystallization of nearby granite, with surrounding contact metamorphosed, calcareous rocks. The presence of highly reactive $CaCO_3$ (limestone) in these systems leads to a unique set of alteration minerals including wollastonite, epidote, magnetite and garnet. Although Zn can be the dominant economic metal in skarn deposits, it is subordinate to metals such as Cu and Pb in examples from New Brunswick; for example, it is subordinate to Cu at McKenzie Gulch (19) and Beresford (21), and subordinate to Pb at Patapat Brook (20).

Shear zone-hosted Zinc Deposits

Zinc also occurs as sphalerite in shear zone-hosted quartz veins. These occurrences are associated with rock sequences that have been affected by intense shear deformation adjacent to major fault systems. Two such deposits occur in Neoproterozoic rocks in southern New Brunswick (Figures 1 and 2). The former Teahan mine (18) was exploited for Cu in the 1880's and is reported to contain up to 1% combined Pb and Zn, and the nearby Lumsden deposit (17) that was reported to contain Zn grades up to 14.1%. It should be noted that ore-metal ratios and host rock associations suggest the possibility that both Teahan and Lumsden may have originated as VMS deposits prior to being concentrated in shear zones. In northern New Brunswick, the Hachey (22) and Shaft (23) deposits occur in Ordovician sedimentary rocks adjacent to the Rocky Brook Millstream Fault and may represent shear zone-hosted deposits as well.

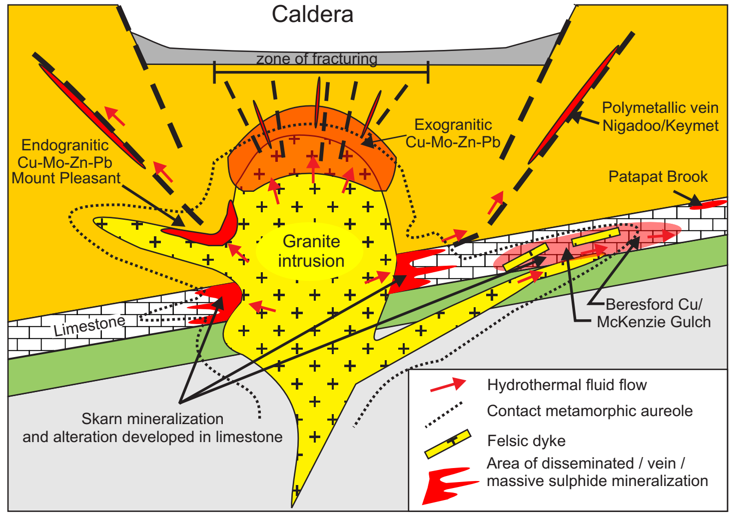


Figure 4. Model relating endogranitic, polymetallic vein, and skarn zinc mineralization to granitic intrusions with examples cited in text. Note that a significant example of an exogranitic zinc deposit has not been identified in New Brunswick.

Stratabound Sediment-hosted Zinc Deposits

A number of zinc occurrences are hosted within Carboniferous sedimentary rocks of the Maritimes Basin. The relatively low temperature (less than 150°C), metal-bearing fluids responsible for the formation of these deposits originated as pore fluids in terrestrial to shallow marine sedimentary subbasins (Figure 5). These fluids circulate in porous beds deep in the subsurface and can migrate upward towards the surface along structural breaks (faults). When these fluids contact sedimentary beds that are in chemical disequilibrium with the metal-bearing fluid, Zn-Pb-Cu sulphide precipitation can be initiated. These stratabound deposits can be broadly divided on the basis of host rock type (Figure 5); those hosted by clastic sedimentary rocks are included in the sandstone-type (Sangster 1996a), whereas those hosted by limestone are included in the Mississippi Valley-type (Sangster 1996b).

The Breau Creek North (16) occurrence represents sandstone-type Zn mineralization. Organic carbon in fossilized logs in Late Carboniferous terrestrial sandstone at this location interacted with subsurface, metal-bearing brines that initiated the precipitation of Zn-Pb sulphides through the reduction of the sulphate ion (SO_4^{-2}) to the sulphide ion (S^{-2}) (Figures 1, 2 and 5). This occurrence contains grades of up to 1.2% Zn (St. Peter and Johnson 2009).

The Peekaboo Corner occurrence (15) is the best example of Mississippi Valley-type zinc mineralization in New Brunswick (Figures 1, 2 and 5). The grade of mineralization is relatively low (widest interval was 54 m of 0.7% Pb and 0.2% Zn; Woods, 1992); however, Zn values up to 1.65% were obtained during exploration in the region. The host rocks are shallow-marine limestone beds that lie unconformably on Neoproterozoic volcanic rocks that have been uplifted along a fault structure to form a basement high (Figure 5). The zinc-lead mineralization occurs in a carbonate-cemented, volcanic-clast breccia that sits directly on the basement rocks. Zn-Pb sulphides were precipitated when metal-bearing brine flowing along permeable (porous) sandstone beds encountered the fault structure and migrated upward to interact with the limestone beds sitting on the basement high.

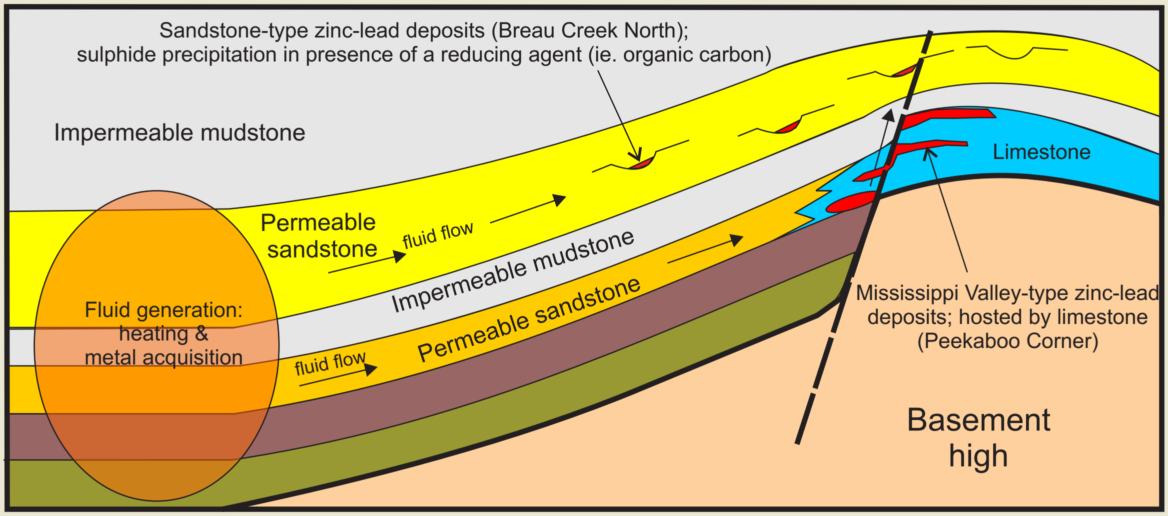


Figure 5. Conceptual model for the generation of sandstone-type and Mississippi Valley-type zinc-lead deposits, with New Brunswick examples. Compiled from Graves and Hein (1994), NBDEM (2013), and Sangster (1996a and b).

Summary

New Brunswick's diverse geology has provided favourable conditions for the formation of several types of zinc deposits. These formed in response to four main geological events: 1) opening of a backarc basin on the southern margin of the Paleozoic Iapetus Ocean resulted in the formation of Ordovician VMS deposits of the Bathurst Mining Camp in northern New Brunswick; 2) continental margin rifting following closure of the Iapetus Ocean and oblique continental collision of Gondwana (ancient Africa and South America) with Laurentia (ancient North America) led to the formation of Early Devonian VMS-like deposits in northeastern and west-central New Brunswick; 3) emplacement of granitic magmas generated by continental collision and resulting Appalachian mountain-building event led to the formation of the various granite-related deposits (endogranitic, polymetallic vein, and skarn) in the Devonian; and 4) fault movements during the waning stages of Appalachian mountain-building resulted in the formation of the various stratabound sedimentary-hosted zinc deposits in the Carboniferous. Shear zone-hosted zinc deposits occur in or proximal to the fault zones in older rocks (Neoproterozoic and Ordovician) that have undergone a long history of deformation.

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For More Information

For more information on zinc and other New Brunswick Mineral commodities, please see the NBDEM Mineral Occurrence Database (NBDEM 2013) or contact:

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