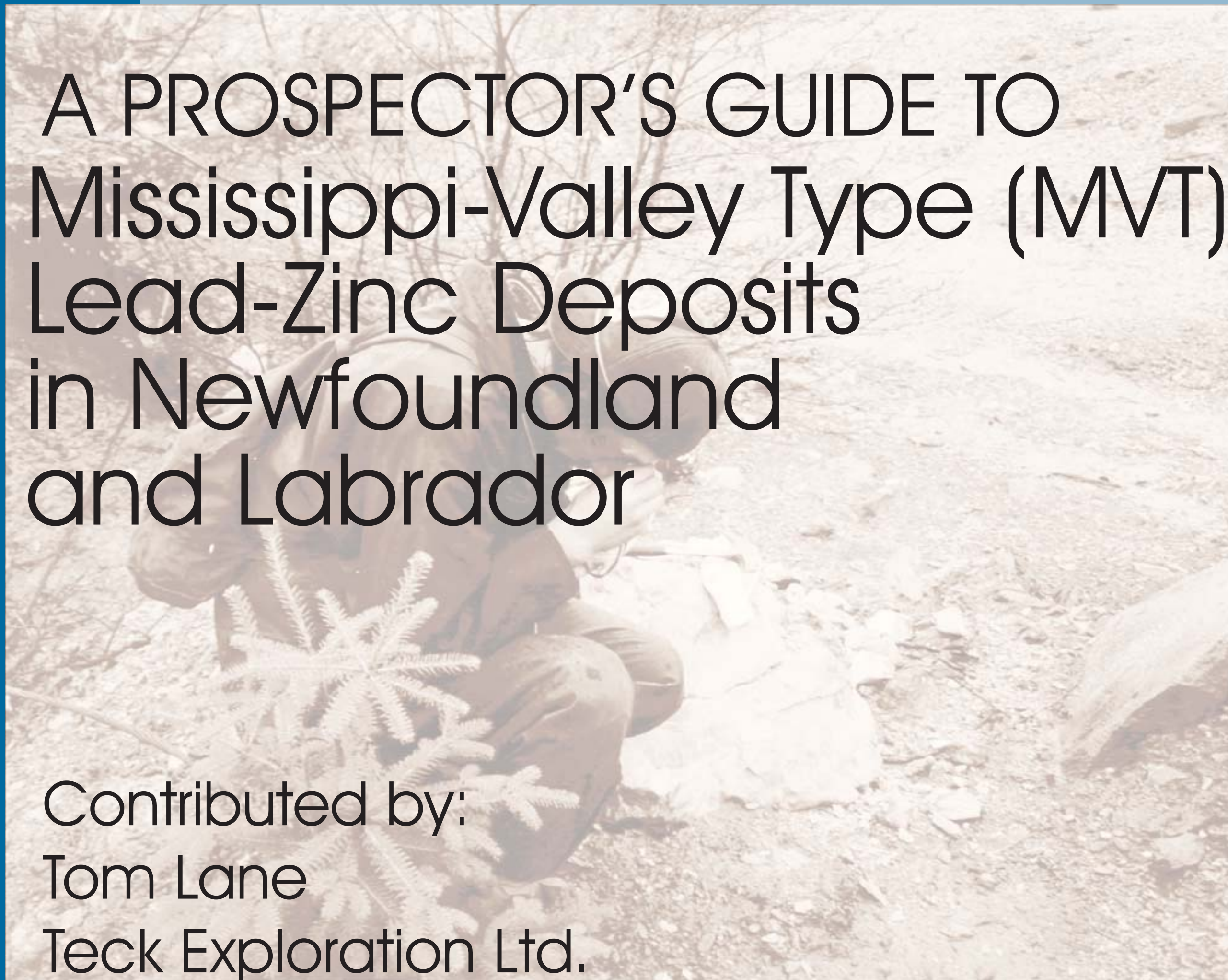

A PROSPECTOR'S GUIDE TO Mississippi-Valley Type (MVT) Lead-Zinc Deposits in Newfoundland and Labrador

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A PROSPECTOR'S GUIDE TO MVT DEPOSITS IN NEWFOUNDLAND AND LABRADOR

What are MVT Deposits?

MVT or Mississippi Valley Type Deposits are zinc and lead concentrations in carbonate sedimentary rocks. The ore minerals are sphalerite (zinc sulphide) and galena (lead sulphide), and these are commonly associated with the iron sulphides, pyrite and marcasite. Minor accessory minerals include barite (barium sulphate), gypsum (calcium sulphate) and fluorite (calcium fluoride). The host rocks to MVT deposits are sedimentary limestones and dolostones. The sulphides are commonly disseminated and have a preference to occur in open pores, vugs and veins. Where sulphides occur in mineable settings, they form massive to semi-massive beds that partially replace limestones and dolostones.

MVT deposits are named after the type area of the Mississippi Valley in the central United States, where many mines have extracted zinc and lead over the past 100 years. MVT deposits are part of a larger family of **Carbonate-hosted deposits**, all of which contain zinc. The MVT style of zinc and lead deposits formed at relatively low temperatures, from 90°C to 150°C. Other carbonate-hosted deposits can form at higher temperatures and commonly contain silver.

Where do MVT Deposits Occur in Newfoundland and Labrador?

MVT style mineralization occurs in carbonate sedimentary rocks from St. George's Bay to Cape Norman in western Newfoundland. Carbonate rocks in southeastern Labrador have limited potential. Also, Proterozoic carbonate rocks from Labrador City to north of Schefferville may have potential to host this style of mineralization.

The largest known MVT deposit in Newfoundland was near Daniel's Harbour, where nearly 7 million tonnes of zinc ore, with a grade of 8% zinc, was mined by Newfoundland Zinc Mines between 1975 and 1990. Several sub-economic concentrations of zinc are known in the area west of St. Anthony. Zinc is the only metal found in MVT-style mineralization in the Ordovician carbonate rocks of western Newfoundland. Both lead and zinc occur in Cambrian-aged carbonates. Silurian carbonate rocks south of Hampden and similar Carboniferous rocks near Stephenville have a significant amount of galena, barite and celestite (strontium sulphate).

How do MVT Deposits Form?

MVT types are stratabound deposits that tend to occur in specific carbonate rock layers or beds that have notable porosity and permeability, in the form of inter-crystalline pores, fractures, breccias and open cavities. The sphalerite–galena–pyrite deposits formed long after deposition and burial of the carbonate sediments. The sulphides crystallized as late cements in veins and pores and fractures, partially replacing the surrounding rock. Numerous studies of MVT deposits have found that the deposits formed when large volumes of warm, saline fluids, carrying low concentrations of metals, passed through the rocks. These fluids were forced through the rocks when they were folded and faulted, as during development of the ancient Appalachian Mountain Belt. Regional deformation of the rocks probably generated the necessary means of moving heated, metal-bearing fluids. Sulphides crystallized in significant concentrations in areas characterized by abrupt increases in rock porosity. The porosity increase may have been related to fracturing, to original rock type (e.g., porosity is higher in lithified reefs and carbonate sands than in some other carbonate rocks), or to the development of ancient weathering surfaces (paleokarst) where dissolution of the carbonate rocks occurred. The folding also helped to form traps for the metal-rich fluids, where zinc and sulphur could - under special chemical conditions - combine to form the sulphide minerals.

Where do Significant MVT Deposits Occur?

Large MVT deposits occur where buried fluids were focused and trapped. There are a number of geological settings in which this can happen. These include: where formations "pinch out" against a basement high; where porous carbonate rocks lie beneath impermeable rock formation barriers such as shales, finely crystalline dolostones or unconformities; and, lastly, along faults and the ends of fracture zones. Thick porous beds and concentrated areas of fractured rocks are required to form mineable thicknesses of ore.

What Formations Contain Zinc Deposits?

As noted above, zinc deposits occur within specific rock formations, commonly beneath unconformities and at the base of dolostone formations. Here is a list of the formations that contain MVT Pb–Zn occurrences in Newfoundland and Labrador. The distribution of these rock formations can be found on bedrock geological maps of this area, available at the Geological Survey of Newfoundland and Labrador. Occurrences in western Newfoundland and southernmost Labrador occur in carbonate rock formations of Cambrian and Ordovician age. Those in western Labrador occur in much older Proterozoic rocks.

Catoche Formation (Ordovician)

Dolostones at the top of the Catoche Formation contain the Daniel's Harbour zinc deposit. At the mine, sphalerite is distributed over 33 m of vertical stratigraphy; ore commonly was mined over 5 to 10 m thicknesses in dolostones above a contact with underlying limestones. The yellow and brown sphalerite is associated with coarsely crystalline, white dolomite that forms a "cement", filling in the open spaces and fractures that cut the tan to grey dolostone. The sphalerite also occurs in large bodies of carbonate "collapse" breccias that lie close to high-angle faults.

Boat Harbour and Watts Bight formations (Ordovician)

Occurrences near St. Anthony commonly occur in the carbonate rocks in both the Boat Harbour and Watts Bight formations, near the contact of these units. The mineralization is associated with white crystalline dolomite in zones of carbonate "collapse breccia", and in open spaces in dolostone beds below an unconformity.

Table Point Formation (Ordovician)

Sphalerite occurs in grey porous dolostones that replace limestones at the base of the formation at St. John's Island

Petite Jardin and March Point formations (Cambrian)

These Cambrian dolostones commonly contain scattered occurrences of galena and sphalerite, mainly in fractures and veins.

Sops Arm Group (Silurian)

Minor carbonate rocks associated with volcanic rocks contain galena in breccias at Turner's Ridge.

Big Cove Formation, Codroy Group (Carboniferous)

Fossil-rich carbonate mounds in narrow paleokarst valleys contain mineralized and cemented breccias and open spaces with sphalerite, galena, calcite, barite and celestite. Most of this mineralization occurs on the Port-au-Port Peninsula.

Denault Formation (Proterozoic), western Labrador

The same carbonate sedimentary rocks that occur near the iron formations of western Labrador are known to contain galena and sphalerite farther north in Quebec.

What to Look for on Maps and in the Field

The carbonate terrane of western Newfoundland have been the focus of several generations of mapping and prospecting. Even though many occurrences are recorded, the region still remains prospective. Large parts of the area are extensively covered by till. Zinc deposits can easily be hidden beneath barren rock, because they are non-magnetic and lack electromagnetic conductivity (and are thus hard to detect using most geophysical instruments). As a result, careful detective work could pay off in the discovery of new targets. A variety of important guides can be used. These are listed below and can serve as a handy checklist.

- ✓ ***Mineral occurrences:*** Minor mineral occurrences commonly surround major mineral deposits. Also, the presence of mineral occurrences indicates prospective rock units.
- ✓ ***Surficial geochemistry:*** It works. Lake sediment geochemistry and soil geochemistry effectively revealed covered zinc mineralization in the Daniel's Harbour area.
- ✓ ***Mineralized boulders:*** Boulder tracing led to the discovery at Daniel's Harbour. Recent studies of glacial ice flow can help you find the source of boulders.
- ✓ ***Geologic maps:*** Extensive bedrock mapping of western Newfoundland differentiates key mineralized formations and has identified a number of important faults. Utilize geological maps, along with mineral occurrence maps, to define prospective formations.

- ✓ ***Magnetic and gravity maps:*** Magnetic and gravity maps usefully indicate basement structures that were important fluid pathways for metal-bearing fluids, as well as sites of mineralization. These maps should be used, hand-in-hand, with geologic maps.

- ✓ ***Dolomites:*** Most MVT zinc deposits occur in dolostones and in formations characterized by regional dolomitization. More specifically, deposits occur at transitions between limestones and dolostones. In western Newfoundland, coarse-grained grey and white dolomites occur at these boundaries.Coarse-grained white dolomites, in mottled black and white rocks, called "pseudobreccia", host the zinc ore at Daniel's Harbour. Black dolostones are common around orebodies.

- ✓ ***Veins and Breccias:*** The dolostones around deposits contain abundant veins and breccias cemented by coarse-grained, crystalline white dolomite. In Carboniferous rocks near Stephenville, mineralized veins are cemented by coarse-grained calcite.

- ✓ ***Grey breccia bodies:*** Ore deposits at Daniel's Harbour are clustered around dolostone "karst" breccia bodies with a grey matrix. These bodies vary from metres to 2 km in diameter, are closely related to an unconformity and deeply penetrate 200 m into underlying rocks. Mineralization in the Watts Bight and Boat Harbour formations is also related to unconformity-related breccias.

- ✓ ***Fault systems:*** Dolomites, breccias and mineralization occur close to faults, in particular ones oriented northeast–southwest.

- ✓ ***Fold domes:*** The zinc deposits at Daniel's Harbour occur within a fold dome. Potentially, ore deposits formed within structural highs where trapped fluids may have precipitated ores.

Field Recognition of Dolostones and Sulphide Minerals

Limestones and dolostones are commonly distinguishable by their colour difference. Limestones weather light grey to darker "battleship" grey. Finely crystalline limestone weathers smooth, as if polished. Limestone also effervesces strongly in weak hydrochloric acid. The dolostone units that host the mineralization are typically made of fine- to medium-grained crystalline, "sucrosic"(or sugary-textured) dolostones that weather tan to brown. Coarse-grained dolostones that contain sulphide ores weather dark brown. Dolostones only effervesce in acid if they are ground to a powder.

Zinc and lead sulphides are not readily visible because they do not rust. Sphalerite is particularly tricky (the Greek meaning of its name). It is commonly honey brown, but may be pale yellow and indistinguishable from the dolostones. Its other colours are dark brown, red and black. On weathered surfaces, it forms a greenish zinc carbonate, smithsonite, in high relief to surrounding carbonates. The crystals are angular and pyramid-like in form. Check care-fully for sphalerite crystals among the coarse dolomite crystals. If in doubt, you can use "zinc zap" solutions (available from most commercial labs) that turn red in the presence of zinc. Also, a white hydrous zinc powder may encrust surrounding carbonate rocks.

Galena is easier to identify. The cubic crystals are shiny and silvery on a broken surface. The crystals on weathered rock are a dull blue-grey, in high relief relative to carbonate hosts.

What is an Attractive Target?

Many zinc–lead occurrences contain less than 1% zinc, in general. A viable mine requires an overall grade greater than 8% zinc, with ore beds of greater than 15% zinc, and mining thicknesses greater than 3 m. Such targets are buried, but may be indicated by minor min-eralization and dolomitization in overlying rocks and in adjacent beds over thicknesses of 3 or more metres. Such targets are close to faults that displace stratigraphic units. The presence of dolomitization along faults and along fold domes may suggest the presence of buried targets.

Location close to economic infrastructure favours mine development. The carbonate rocks in western Newfoundland are well situated, close to roads, power lines and seaports.

Who Would be Interested?

Junior and major mining companies are interested in MVT zinc deposits because of the good value of the clean zinc concentrate (with low iron content) and the inexpensive mining and milling costs. Preferred target areas would have the potential to host a deposit containing greater than 10 million tonnes of ore with grades of 8 to 10% zinc or greater.

What Does the Buyer Want to See?

Buyers are interested in a target that could contain a deposit with the above parameters. The features should fit the checklist of key characteristics. A target is most likely to be buried in a favourable formation and near a fault structure. Prospector's are advised to visit known occurrences, see mineralized rocks around the former Daniel's Harbour mine, examine drill cores in the Pasadena core library and talk to provincial geologists familiar with western Newfoundland.

HAPPY PROSPECTING!

Tom Lane
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Appendix: Some Terms Defined

dolomite: a common rock-forming mineral, consisting of calcium, magnesium and carbonate (CO_3). The term "dolomite" is also used to refer to a sedimentary rock, of which more than 50% is made up of the mineral dolomite.

dolomitization: the process by which limestone is partially or wholly converted to dolomite rock or dolostone. Buried, magnesium-bearing water percolating through limestones, changes the calcium carbonate (calcite) to magnesium-rich carbonate (dolomite).

dolostone: another name for the sedimentary rock *dolomite*; a carbonate rock composed primarily of the mineral dolomite.

limestone: a sedimentary rock, of which more than 50% is made up of the mineral calcite (Ca CO_3.

karst: a topography formed on limestone and related rocks exposed at or near the surface, by dissolution of these rocks in groundwater. It is characterized by caves, sink-holes and underground drainage channels. (A *paleokarst* is an ancient example of this style of topography.)