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Introduction

This article outlines aspects that may be important to the exploration for and evaluation of Mississippi Valley-type (MVT) lead-zinc mineralization in northeastern Alberta. It is not aimed at identifying areas that have high lead-zinc potential in northeastern Alberta, nor does it assess the possibility that there are commercial quantities of lead-zinc mineralization to be found in the region. Rather, the approach used here for mineral evaluation considers mineralization theories, potential host rocks and available regional geologic and stratigraphic information.

Characteristics

The characteristics of MVT lead-zinc deposits have been described by many authors, including Ohle (1980), Anderson and Macqueen (1982) and others. These characteristics include: (1) stratabound and epigenetic ores; (2) deposits commonly situated at or near the edges of basins or on arches between basins; (3) most deposits are in carbonates with a bias toward dolostones; (4) a lack of associated igneous rocks; (5) relatively simple mineralogy consisting of varying amounts of sphalerite and galena with minor amounts of fluorite and barite; (6) deposits are commonly found in passive structural regions; (7) some deposits are controlled by paleokarst development; (8) the temperature of ore forming fluids ranged from 80-200°C and salinities are 5 to 10 times that of seawater. Perhaps the most significant unknown aspect of MVT deposits is the timing of mineralization. Various dating methods have been attempted (summary in Sangster, 1983),

including paleomagnetism, K-Ar and Pb isotopes, but the results for all deposits are tentative at best.

Mineralization Theories

The numerous theories of MVT lead-zinc mineralization are variations on one of two themes, the "mixing" and the "non-mixing" models. Summaries of these models can be found in Anderson and Macqueen (1982) and Bethke (1986). These models assume that basinally derived brines form the mineralizing fluids. The similarities in composition and temperatures of basinal fluids and fluid inclusions obtained from MVT deposits are the strongest supporting data for this assumption. The mixing aspect is a feature dependent on the origin of the reduced sulphur needed to precipitate lead and zinc out of the mineralizing fluid. In the "mixing" models, precipitation of sphalerite and galena is assumed to occur in the presence of reduced sulphur. Therefore, reduced sulphur cannot be carried in solution with the Pb and Zn. In the "non-mixing" models reduced sulphur (e.g., Sverjensky, 1981) or sulphate (Dunsmore and Shearman, 1977) are carried with Pb and Zn in the mineralizing fluid. Precipitation of sphalerite and galena occur where or when the fluids encounter a certain set of physiochemical conditions or through the reduction of the sulphate to sulphide.

Examples of Pb-Zn Mineralization in Alberta

Evans *et al.* (1968) summarized the surface occurrences and some of the subsurface occurrences of lead-zinc mineralization in western Canada. The most notable surface showings of the Rocky Mountains occur in British Columbia just west of Alberta, including Monarch and Eldon, in dolostones of the middle Cambrian Cathedral Formation. Minor subsurface occurrences of galena and sphalerite, compiled from various sources, are summarized in Table 1. The majority of these are hosted in middle and late Devonian rocks, with a few examples in Mississippian and Triassic rocks.

To date no significant occurrences of lead or zinc mineralization have been recorded from northeastern Alberta. In the early 1960s, there were unsubstantiated reports of prospectors finding lead-zinc mineralization within Wood Buffalo National Park (Godfrey, 1985). Also, Carrigy (1959, p. 22) reported a galena showing in the Fort McMurray area.

Sangster and Lancaster (1976, p. 303) suggested that "small sphalerite occurrences can be regarded as a normal feature of carbonates". Anderson and Macqueen (1982, p. 109) reinforced this concept by commenting that "it is important to remember that MVT ore deposits are simply unusually large representatives of an ubiquitous phenomenon: occurrences of sphalerite and galena are commonplace in the carbonate succession".

Geological Setting of Northeastern Alberta

The Devonian stratigraphy of northeastern Alberta has been summarized by Norris (1973) and a regional synthesis of the depositional history of the region was presented by Basset and Stout (1967). Northeastern Alberta is characterized by a westerly, shallowly dipping sequence of Cambrian and Devonian siliciclastics, carbonates and evaporites, that unconformably overlies the Precambrian basement. The Devonian sequence is in turn unconformably overlain by Cretaceous siliciclastics.

Potential carbonate host rocks in northeastern Alberta are limited to the Devonian interval, which consists of, from the base upward, the Elk Point Group, Beaverhill Lake Group, Woodbend Group, and the Winterburn and the Wabamun Formations (Energy Resources Conservation Board, 1985).

Intrastratal karst is well developed in the Middle Devonian Prairie Evaporite Formation. The evaporite itself is not a likely mineral host, but collapse features developed in overlying carbonates could be a potential host for lead-zinc mineralization (see Simpson, 1988, this issue, p. 89-93).

Evaluation Strategy

Any exploration program or evaluation of the region for MVT deposits should consider, among other things, potential host rocks, mineralization settings and theories of mineralization that may point to regions having higher potential (see Anderson and Macqueen, 1982, p. 115; Anderson, 1978, p. 18, for features favourable to MVT mineralization). Among the most important aspects is the relative timing of the development of favourable host rocks with respect to the passage of mineralizing fluids.

Unconformities, and presumably the associated solution features that could act as mineralization repositories, occur at the upper surfaces of: (a) the Slave Point Formation; (b) the Upper Elk Point subgroup (locally); (c) the uppermost Devonian strata (Norris, 1973, fig. 6); (d) the Fort Vermilion Formation in the Wood Buffalo National Park area (Park and Jones, 1985).

In light of the mineralization theory proposed for Pine Point by Krebs and Macqueen (1984), in that major Precambrian basement faults act as conduits for mineralizing fluids, the strata above major basement structural zones should also be considered to have good potential. Based on aeromagnetic interpretations, major NNW- and NE-striking basement faults occur in the Athabasca-Fort McMurray area (Garland and Bower, 1959). Karst or solution-generated collapse structures proximal to basement fault locations could provide favourable settings for mineralization.

Table 1 List of mineralized wells in Alberta. Incomplete data is a result of dated and incomplete information source.

Well Name	Location	Pb/Zn Content	Host
Chevron Lutose	16-34-118-21 W5	Zn	Keg River
B.A. Saddle River	11-23-76-9 W6	Zn	Belly R./Spray R./Crctac
B.A. Zama Lake	9-5-114-8 W6	Zn	Keg River
B.A. Zama Lake A	6-33-113-7 W6	Zn	Keg River
Home KCL Chisholm	10-5-68-2 W5	Pb + Zn	lower Winterburn Group
IOE Rainbow	13-20-107-9 W6	Zn	Keg River
Calstan <i>et al.</i> Loon River	4-23-89-12 W5	Zn	Muskeg
BP Ethyl Whitburn 7-3	7-30-80-11 W6	Zn	Wabamun-Banff Transition
PCL Dome Oak	11-8-83-6 W6	Zn	Wabamun
Socony-Duhamel #29-11	11-29-45-21 W4	Zn	Top D3
Socony-Duhamel #29-14	14-29-45-21 W4	Zn	Top D2, Ireton, D3
Socony-Flint	13-17-45-21 W4	Zn	Top D3
Banff Aquitaine	7-32-109-8 W6	Zn	Muskeg
Sun-Orr #1 New Norway	44-21 W4	Zn	??
Texaco Wizard Lake	?	Zn	??
Imperial Golden Spike #11	?	Zn	??
Imperial Leduc 253	11-13-50-27 W4	Zn	??
Imperial Golden Spike #8	?	Zn	??

Subsurface Information as a Possible Data Base

The poorly exposed nature of the Paleozoic interval in the region may, to some extent, be overcome through the use of subsurface information. However, there are only a limited number of drillholes in areas of thin cover, resulting in a limited potential data base.

The data from petroleum exploration is available through the Energy Resources Conservation Board (ERCB) of Alberta. These data are stored in computer-based files and, for the most part, can be manipulated to obtain various styles and types of output. A complete listing of the types of information available is impractical here, but the main information pertinent to an exploration program includes: (1) well location; (2) formational picks; and, (3) core intervals.

The use of petroleum exploration geophysical logs as a tool for mineral exploration was given cursory evaluation by Dubord (1987). Sphalerite and galena mineralization of up to 3 volume percent combined does not have a characteristic density or resistivity log signature. No examples of mineralization greater than 3 percent were available for evaluation and it was not determined if greater amounts would be indicated by characteristic log signatures. This approach, however, may warrant detailed study in the future.

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