LEAD AND ZINC

by

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<u>NOTE</u>: This is a preliminary report and is subject to revision with a more comprehensive study. Information presented herein should not be published without prior approval of the Alberta Research Council.

Alberta Geological Survey
Alberta Research Council
1985

ACKNOWLEDGMENTS

This report forms part of a series of commodity studies for the Resource Evaluation and Planning Division, Alberta Energy and Natural Resources. This particular study resulted from the combined efforts of a team which incldued: Philip S. Chung, William G. Buchan, James L. Li, W.A. Dixon Edwards, Wylie N. Hamilton and Joe R. MacGillivray.

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INTRODUCTION

The series of reports attempts to review the status of geology-related studies (published and unpublished) which reflect on the evaluation of a specific resource or commodity.

Literature references are incorporated and classified according to the level and type of field exploration detail supplied.

These reports should provide the background and basis from which:

1. an assessment can be made of the level of exploration information currently available;
2. the most relevant literature can be selected through a system of classified references; and,
3. an economic feasibility for locating and/or developing a primary resource or commodity can be assessed from the geological characteristics and conditions as presently understood in Alberta.

The close geological and spatial relationships between these two metals (commonly found as co-existing galena and sphalerite) means that they can be conveniently described together in this documentation. The great lead-zinc deposits of the world are found in stratiform or stratabound configurations, and are most commonly hosted by carbonates. An important factor in the economic evaluation of many lead-zinc deposits is the grade of silver that accompanies the base metals. Other potential economic by-products to be noted include bismuth and cadmium.

Alberta has abundant and widespread carbonate sequences but there has been very little indication of a major lead-zinc deposit within Alberta.

Carbonate lithologies crop out in two major regions of Alberta:

1. Interior Plains of northeastern Alberta; and
2. Rocky Mountains.

In northeastern Alberta, Devonian carbonates onlap the Precambrian Shield crystalline basement and the Athabasca Group. The extent of the carbonate outcrop and subcrop is shown on figure 1. The carbonate bedrock in this region has been extensively eroded and now occupies low ground. Hence much of the potential outcrop area is hidden by wetlands and glacial cover.

Inliers of these Devonian carbonates are found to the south in the Athabasca and Clearwater River valleys (near Fort McMurray) and in the floor of the oil sands open pit excavations.

In the Rocky Mountains, the main ranges consist largely of carbonate lithologies. Outcrop is extensive and typically continuous, and despite the prohibition of any mineral exploration and development within the national parks, there is a good chance that any obvious metallic mineralization would have been noted by the countless hikers. Nothing significant has been thus far reported, formally or informally.

The closest major lead-zinc mining district is that of Pine Point, N.W.T., some 100 km north of the Alberta boundary. Here, a group of several major deposits are essentially strung along the ENE striking McDonald Fault at the south shore of Great Slave Lake. These deposits are hosted by a typically reefal facies of the Devonian Presqu'il Formation. The principal geological elements in the localization of these deposits hinges on the interplay of 1) the porous reefal carbonate host, and 2) the regionally important fault that not only seats in the underlying Precambrian basement but was also responsible for a significant vertical step in basement topography, thereby creating a warm, shallow-water environment on the south side, favourable for coral reef development.

The principal lead-zinc potential is in carbonate rocks, but there is some potential in other lithologies. For example, 1) the galena

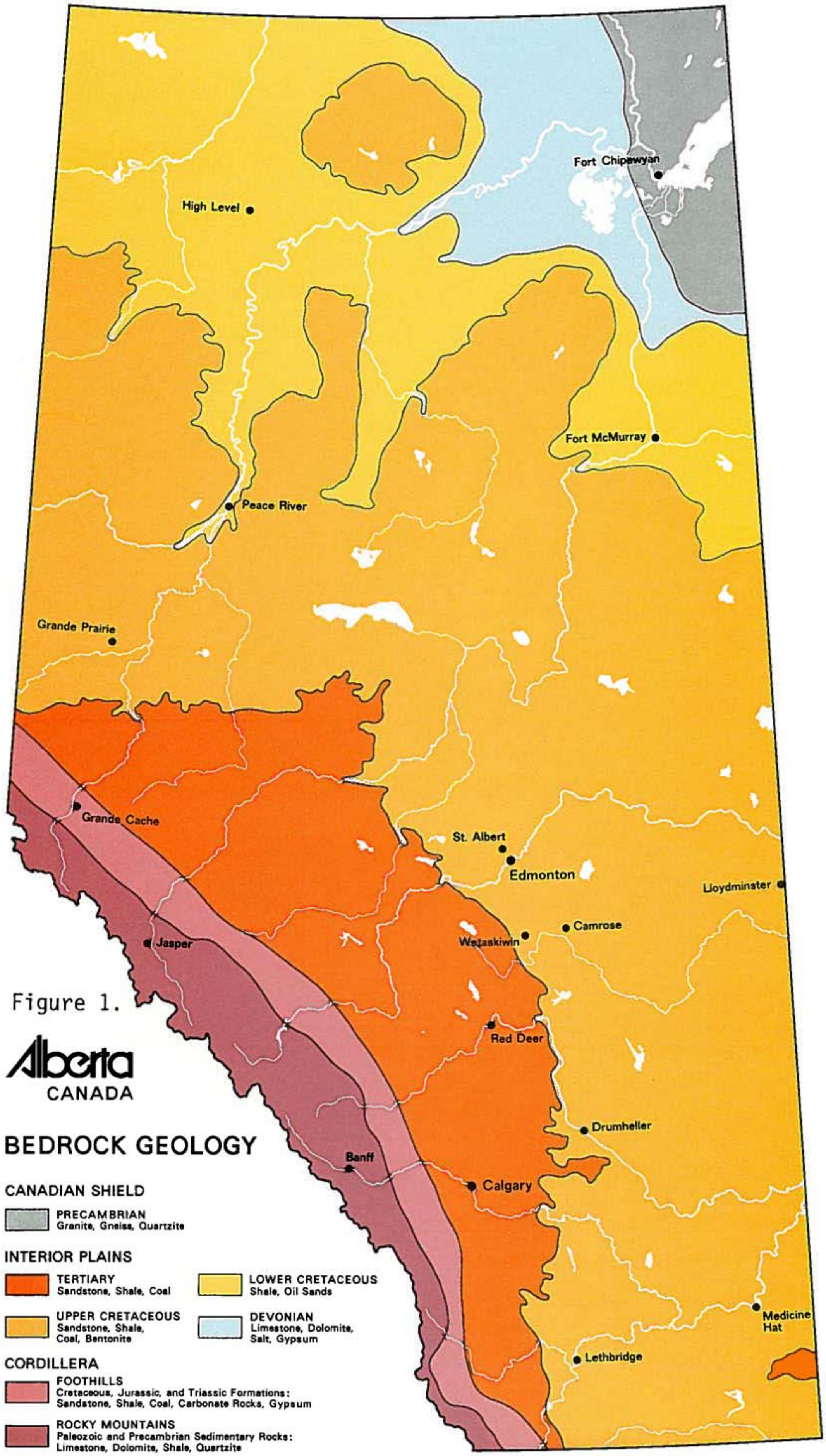

Figure 1.

Produced by the Alberta Bureau of Surveying and Mapping © 1983 mineralization intersected during the uranium exploration program of Golden Eagle in the Athabasca Sandstone, south of Lake Athabasca; and, 2) geochemical zinc anomalies in the late Proterozoic formations of the Clark Range in southwestern Alberta.

The Lead-Zinc Potential and Exploration Status For The Interior Plains Region

Much of this carbonate region is inaccessible and a combination of wetlands and glacial cover renders surface exploration a difficult, expensive and perhaps largely unsatisfactory exercise in exploration evaluation. An ideal exploration target would be the duplication of those geological controls associated with the Pine Point deposits.

Geological mapping on the Shield of northeastern Alberta reveals several regional faults in the crystalline basement that trend and extend westerly beneath the Devonian carbonate cover. Also, the southwesterly structural trend of Lake Athabasca (projecting along the northern flank of the Birch Mountains) qualifies as a speculative regional exploration target. The extensive Peace-Athabasca delta deposits obscure the bedrock in this region. The interpretation of aeromagnetic surveys and subsurface exploration data from the petroleum industry could be useful in the identification and position of possible subsurface fault structures.

Wood Buffalo National Park policy eliminates much of the prospective ground from exploration west of the Slave River. Stories of hand specimens with lead-zinc mineralization, reportedly from the park, were in circulation some 25 years ago. In the late 1950s or so, the Alberta Research Council conducted a survey in the park (Govett?) and geochemical samples were probably subjected to trace element analysis. This unpublished study should be examined and evaluated.

The Alberta Research Council (Green, 1971) undertook a reconnaissance scale geochemical exploration survey over a substantial area of northeastern Alberta where Paleozoic carbonates are in outcrop or subcrop. The survey area included all of Wood Buffalo National Park in Alberta, north of the Peace River. Till and stream sediment samples were collected and analysed for copper and zinc. Results in terms of possible lead-zinc occurrences were not encouraging. Low-level zinc anomalies are related to Cretaceous shale outcrops, and a copper anomaly is related to a known secondary copper occurrence in the regolith between basement rocks and the Paleozoic cover at Stony Islands (Godfrey, 1973).

Diamond drilling on the western edge of the Athabasca Basin in Alberta by the Saskatchewan Mining Development Corporation Ltd. (SMDC) intersected the thin erosional edge of Devonian carbonates which onlap the Athabasca Sandstone (Walker, 1981). It was suggested that the reefal facies and conditions generally were similar to those at Pine Point, and therefore favourable for lead-zinc occurrences.

The Lead-Zinc Potential and Exploration Status For The Rocky Mountains Region

For the size of the belt and the extent of outcrop, there has been very little indication of lead-zinc showings in the Rocky Mountains Region of Alberta.

A number of lead-zinc deposits and occurrences are listed below relative to the Central Rocky Mountain Belt of Alberta and adjoining British Columbia (figures 2 and 3):

1. Kicking Horse Mine (B.C.)
2. Monarch Mine (B.C.)
3. Baker Creek (Alta.)
4. Eldon (Alta.)
5. Hawk Creek (B.C.)
6. Spray Lake (Alta.)
7. Oldman River (Alta.)

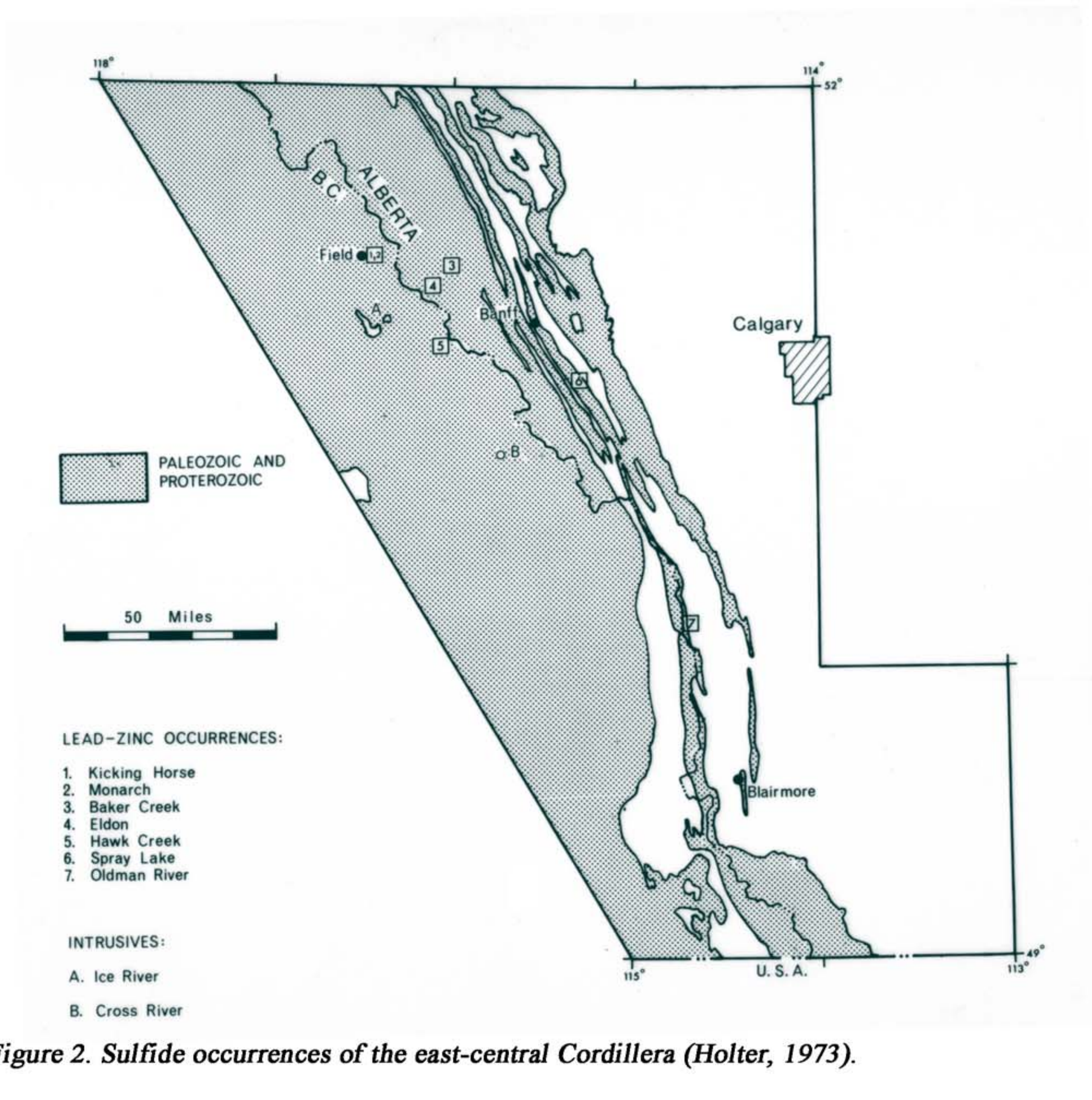

Figure 2. Sulfide occurrences of the east-central Cordillera (Holter, 1973).

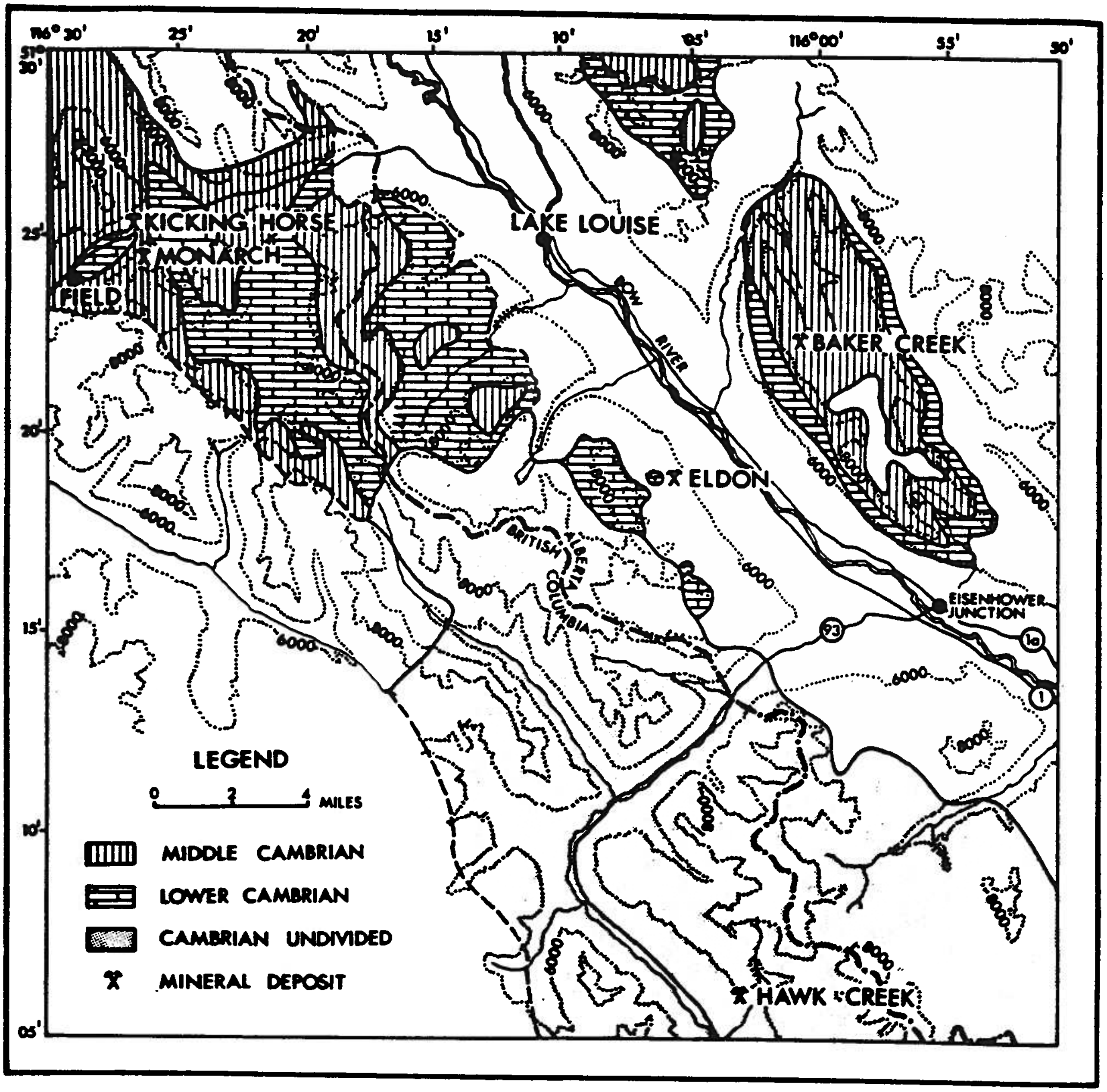

Figure 3. Detailed location of the deposits in the Banff-Field area (Evans, 1968)

Kicking Horse and Monarch Mines (B.C.) (1 and 2)

These lead-zinc deposits are treated together inasmuch as they exhibit very similar geologic characteristics and controls and are situated across from each other on either side of the Kicking Horse Pass. The Kicking Horse Mine on Mt. Field is located on the north side of the pass and the Monarch Mine is opposite on Mt. Stephen.

The ore bodies are hosted by dolomitic limestone beds in the Cathedral Formation of Middle Cambrian age. Mineralization consists of galena-sphalerite-pyrite within a brecciated dolostone. The sulfides replace the breccia, sharing some preference for the matrix, but locally the clasts are also replaced. Bands of massive ore in the order of one foot thick occur sporadically. The ore bodies have a flat, oval pad or cigar shape, about 2400 feet long. The ore controls are both structural and lithological. The orebodies are located at the intersection of northwest striking, steeply dipping faults with the contact of brecciated dolostone overlying thin bedded, black dolomitic limestone. The ore replaces brecciated dolostone accompanied by dolomite, and a little quartz and barite.

Baker Creek (Castle Mountain, Silver City) (3)

Very little technical information is available on this operation. It is little publicized, probably in keeping with the interests of the National Parks system. During the First World War there was some small production from galena-sphalerite mineralization on the flank of Castle Mountain, near Banff. A small community called Silver City was established to support this mining operation.

The mineral showings on the northwest flank of Castle Mountain occur in black dolomite veined by coarse-grained, white dolomite, of probable Middle Cambrian age. These rocks belong to the Cathedral Formation and resemble the host lithologies at the Kicking Horse-Monarch Mines. Galena, in small amounts, was the only sulfide mineral found at the entrance to an exploration adit.

Eldon Showing (4)

There is very little technical information on this copper-lead-zinc occurrence. However, the Alberta Research Council (Green, 1957) made a cursory examination of the site on Protection Mountain, Banff National Park, and Evans (1965) referred to this site in a survey of lead-zinc 'deposits' in western Canada. Green (1957) mentions three adits and reference is made to quartz veins with very minor copper mineralization and pockets of galena, all within a dolomite host. Evans (1965) states that the host calcareous and argillaceous rocks of probable Lower or Middle Cambrian age are cut by an east-striking shear zone dipping at 40° north. Mineralization in the adit dump includes: sphalerite, chalcopyrite, galena and minor pyrite along with a gangue of quartz and siderite. The presence of quartz, siderite and chalcopyrite makes this mineral occurrence unique with respect to most other showings in the Rocky Mountains.

Hawk Creek (5)

Henderson (1953) provides the best technical information on this base metal showing. The lithologies underlying the region are interbedded limestones and argillites of Upper Cambrian or Ordovician age. A northwesterly striking, steeply dipping shear zone is associated with the mineralization. Massive sphalerite replaces limestone at the intersection of the shear zone and a particular limestone bed, that is, there are both structural and lithologic controls. Small amounts of galena and pyrite accompany the sphalerite. With the aid of diamond drilling, Henderson estimates a cigar-shaped pod 250 feet long to contain 29 500 tons of ore grading 12.5 percent zinc.

Spray Lake (6)

At this point no literature can be referenced other than a location in Holter (figure 2, 1973).

Oldman River Lead-Zinc Occurrence (7)

The best summary of this mineralization is presented by Holter (1973) who examined the deposit along with W.N. Hamilton in 1970, on behalf of the Alberta Research Council. This report is essentially a summary of earlier work, no new information was presented.

Controls for the mineralization are related to the intersection of faults within a Devonian carbonate sequence. This mineralization has been explored underground by means of two adits and two short drill holes from which results were generally disappointing. Forty-six assays are reported, but a general lack of detail on the sampling procedures more or less reduces the category of the assay results to little more than grab samples.

The most meaningful assays are from a bulk sample (probably hand-cobbed) of unstated size, that gave 31.5 percent lead; 7.3 percent zinc; trace gold; and 2.2 oz/s.t. silver. The critical aspect of type of sample (for example, channel, chip, representative, grab) is not addressed for another 45 assays. Therefore it is not possible to assign any particular significance or weight to the assays and develop an average value or a value of relevance to a projected mining operation. The silver ratio is low.

In summary, the exploration to date is of a preliminary nature. No indication of base metal grade or tonnage can be given for this occurrence. Based on existing data, the outlook should be cautious, although there appears to be scope for further study. Reconnaissance exploration in the form of outcrop prospecting and geochemical exploration could be conducted.

Other Lead-Zinc Prospective Regions

(a) Clark Range, southwestern Alberta: Widespread exploration activity for stratabound copper mineralization in the late Proterozoic Grinnell and associated Formations also encountered geochemical lead-zinc anomalies (Halferdahl, 1971). Different segments of the exploration region (adjoining and north of Waterton Lakes National Park) were subject to exploration by various companies according to option agreements. The anomalous lead-zinc region appears to be associated with the Sheppard Formation in the following areas: north of Whistler Mountain, near Table Mountain, and south of North Kootenay Pass. Reports on this exploration work, carried out by Cominco, are not presently at hand for a more critical appraisal.

(b) Athabasca Basin: This basin constitutes a highly prospective uranium exploration target in northern Saskatchewan where it forms one of the world's leading uranium-producing districts. Ten percent of this sandstone-filled basin extends into Alberta. Diamond drilling to test deep uranium targets in Alberta intersected disseminated galena-sphalerite in one drill hole. The disseminated galena-sphalerite is associated with a 100 m thick fracture zone in sandstone at a depth of about 500 m (Nelson, 1978, and Wilson, in press).

OUTLOOK

1. The geological environments represented by the carbonate rocks of the Rocky Mountains and the plains of Alberta are considered to be clearly favourable for the development of Mississippi Valley-Type lead-zinc deposits. These deposits are characterizied by (Evans et al, 1968):

   1. Absence of an obvious igneous-related source of ore solutions,
   2. Simple mineralogy - that is, galena and sphalerite,
   3. Low precious metal content,
   4. Limestone or dolomite host,
   5. Replacement and vein mineralization, breccia zones,
   6. Tectonically undeformed regions,
   7. Low temperature of formation, that is, shallow depth, and,
   8. Structurally positive regions and solution features.

The abundant hydrogen sulphide gas phase commonly associated with petroleum in western Canada is a particularly attractive feature in terms of providing a source of sulphur for base-metal deposits. (The similarity in sulphur isotopic composition between the petroleum and lead-zinc occurrences of Alberta is considered to be highly significant in the genesis of these base metals. Similarly, this has proven to be the case for the Pine Point deposits).

The occurrence of highly porous reefs in the subsurface of Alberta is an additional distinctly favourable geologic feature for the development of base-metal deposits.

A small amount of shallow subsurface drill-testing for base metals (lead-zinc-copper) in Devonian carbonates has been done by Gulf Minerals Canada Limited (Germundson and Fischer, 1978). This 5-hole test in the Steen River area did not yield any significant geochemical anomalies and the exploration was terminated.

In view of the stratigraphic relationships of the Kicking Horse and Monarch Mines near Field, B.C., and several minor lead-zinc occurrences in the Rocky Mountains of Alberta, the Middle Cambrian formations appear to be particularly prospective in the mountain belt.

By contrast, in the plains region the Pine Point Mine deposits, and zinc occurrences in the plains subsurface (Haites, 1960), focus attention on reefal facies of the late Devonian.

2. The intensely explored subsurface of the Western Canada Sedimentary Basin offers an unparalleled opportunity to initiate a broad-based subsurface data search for base-metal deposits in Alberta. The situation is particularly attractive in view of the methodical filing of subsurface data and core under the jurisdiction of the ERCB authority.

3. In the Rocky Mountain carbonate belt, despite the extensive blocks held under the national parks system, there remains considerable opportunity for reconnaissance exploration in outcrop.

RESEARCH PROJECTS

1. Although much of the prospective outcrop/subcrop carbonate area of the Interior Plains lies within the Wood Buffalo National Park, other parts are available for surface exploration. Any program of geochemical-geophysical surface reconnaissance exploration would be based initially upon the interpretation and extrapolation of subsurface data collected in the course of petroleum exploration. Regional geophysical surveys and limited coverage by drill hole data would provide the basis for any lead-zinc exploration program in this region. The shallow-buried Devonian carbonates that fringe the Precambrian Shield would prove the most attractive because of the projected lower costs of mining.

   A great deal of potentially valuable data are available through the exploration efforts of the petroleum industry, particularly during the past 40 years or so. At surface, aeromagnetic, seismic and gravity survey data are available. In the subsurface downhole geophysical logs, lithologs, and core and cuttings samples are available. The amount of hard data could be awesome. Initially, an overview is desirable. This could be obtained through an interview or questionnaire process with selected exploration companies and personnel, seeking out those managers with long-term experience in Alberta. In this way some regions should be identified worthy of exploration targeting, for a further level of detail and refined evaluation.

   The next step would be to select one or two pilot test areas. Data should be assembled, compiled, and stored in a computer data bank for processing and readout in a suitable graphic and/or map form.

2. In the Interior Plains there is further scope for geochemical exploration additional to the broad reconnaissance reported by Green (1971) over part of this region.

3. In the Rocky Mountain belt there is considerable scope for surface exploration in the carbonates outside of the national parks. Geochemical surface sampling could be employed on a regional reconnaissance exploration survey. There are a few keys that could be used as guides. If a literature search proves unsatisfactory the Baker Creek (Silver City) lead-zinc occurrence might be studied in the field to ascertain the geological controls of the mineralization. Likewise, the past lead-zinc producers (Monarch and Kicking Horse Mines) in the Kicking Horse Pass near Field, B.C. (Ney, 1957) provide direction as to the favoured host stratigraphy and the structural control. The latter deposits are well documented and clearly the dolomitic phase of the Cathedral Formation is an exploration key.

   There is scope beyond the National Park boundaries to explore the favoured Cambrian and Devonian carbonates both in outcrop and by geochemical survey. A very good geological bedrock map base is already developed on which to base reconnaissance exploration.

   The present report on the lead/zinc resources of Alberta is based on an assessment using only selected and readily available references. A fuller, more accurate and meaningful study would result if time was available to assemble, catalog, and evaluate information from a wider spectrum of literature and enquiries; that is, functioning more in a research mode. This current report is a step towards that direction, but I feel that it is somewhat superficial at the moment in view of the limited effort possible in the short time available. Provision for an in-depth, comprehensive study for this commodity is recommended.

SUMMARY OF DATA GAPS

1. In the Interior Plains, where so much of the Paleozoic carbonate fails to crop out in the potential area of exposure, regional interpretation of aeromagnetic surveys would serve to provide data on the broad structural framework. The regional interpretive aeromagnetic coverage could be usefully extended into areas of thin Cretaceous overburden. Following the widely accepted geological assumption that Mississippian Valley-Type lead-zinc deposits are favoured by large-scale faults and reef accumulations, the interpretive aeromagnetic survey approach to defining such features in the Paleozoic carbonates should be an important step towards the identification of exploration targets.

2. Also in the Interior Plains, there is an almost overwhelming volume of well log and seismic data available from many sources, but much of it is housed by E.R.C.B. It would seem prudent to harness this mass of data on a selected target area basis and not for the Western Canada Sedimentary Basin as a whole in Alberta. A regional summary of the tectonics of this basin [now being assembled on a collaborative basis under the direction of Dr. Donald Cook (G.S.C., Calgary)] could provide some useful input to an initial regional structural analysis. Contact, discussion and enquiry with selected long-term management in the petroleum industry could introduce some useful bias and shortcuts in the selection of exploration areas for more detailed study.

OUTLINE FOR REFERENCE CLASSIFICATION: RESOURCE INVENTORY

A. Resource (Commodity) Evaluation References
   1. General Overview
   2. Specific Commodity Overview
   3. Exploration - Reconnaissance Scale
   4. Exploration - Site Specific Scale

B. Supporting References
   1. Concepts and Principles
   2. Indirect Exploration - Reconnaissance Scale
   3. Indirect Exploration - Site Specific Scale

C. Background and Miscellaneous References

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