A PROPOSAL

FOR

A Pb ISOTOPE-ORIENTED METALLOGENETIC STUDY OF MINERAL DEPOSITS IN THE CANADIAN CORDILLERA

by

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SUMMARY

1. Precise lead isotope analyses are accepted as an important key to unravelling many aspects of metallogeny of the Western Canadian Cordillera.

2. Adequate facilities are available at the University of B.C. to accomplish a comprehensive lead isotope study of Western Canada mineral deposits over the next decade. A capital grant of $15,000 by early 1979 will allow this same goal to be met in approximately 3 years.

3. Annual operating cost of the existing Pb isotope lab is about $24,000.00, about 65 percent of which is for a mass spectrometer operator.

4. We have to date produced about 100 high precision Pb isotope analyses related to projects in progress and one study which is already completed; An investigation of 33 carbonate-hosted Zn - Pb deposits in Mackenzie to Ogilvie Mountains has among other things verified two metallogenic epochs postulated on the basis of other work. Results have been presented publically (Geoscience Forum, Yellowknife, 1978) and a publication is in preparation.

5. Five additional projects are well under way as follows: (1) strata bound Zn-Pb deposits in the Selwyn Basin, (2) volcanogenic and vein deposits, Pelly Mountains,(3) volcanogenic and vein deposits, Southwestern B.C., (4) volcanogenic and related deposits, Northwestern B.C., and (5) vein deposits in and near the Keno-Hill camp.

6. Assistance with funding is requested for those projects in progress, other projects such as those mentioned elsewhere in this proposal, and as yet undefined studies that serve the overall aims of the project.

INTRODUCTION:

Common lead isotope data provide important restrictions on ore genesis, age of mineralization, and age and geochemical attributes of the source rocks of the radiogenic component of the leads (e.g. Sinclair, A.J., 1965, Econ. Geol., v. 60, p. 1533). Such studies, considered in the light of the abundant radiometric ages and stable isotope data now available, provide a powerful basis for examining metallogeny in the western Canadian Cordillera.

We propose a continuing study of Pb isotopes applied to metallogeny of the Canadian Cordillera to last a minimum of 3 years. Aim of the project is to provide new, high precision Pb isotope analyses of carefully selected samples of mineral occurrences in the Western Canadian Cordillera, to supplement these new data with existing published and unpublished data, and to apply the results to problems of metallogeny. In particular we anticipate that Pb isotope data will have a direct bearing on detailed problems of genesis such as:

(1) source and evaluation of massive sulphide deposits in the Coast Crystalline Belt;

(2) possible genetic relationship of Au-quartz veins near Hope, B.C., with the Ladner Creek (exhalite?) gold deposit of Carolin Mines;

(3) existence of a likely source bed for Au-quartz vein deposits of the Wells area;

(4) possible common origin of lead in deformed layered carbonate and undeformed veins at Northair Mines property, Callaghan Creek;

to name only a few. In addition, the data will provide important information regarding larger scale problems such as;

(1) age, extent and geochemical character of the crystalline basement throughout the western Cordillera (cf. Zartman, R.E., 1974, Econ. Geol., v. 69, p. 792).

(2) isotopic zonal distribution patterns in mining camps and their use in outlining "fossil hydrothermal convective systems" (cf. Lecouteur, P., 1973, Unpubl. Ph.D. thesis, UBC).

(3) evaluation of single-stage and multi-stage models for the origin of massive sulphide deposits of relatively young (Mesozoic) known ages.

(4) investigation of Pb-bearing deposits in specific tectonic environments of interest (e.g. Mackenzie Mountains, Selwyn Basin, etc.) and many others.

These examples represent only a few of the problems that can be considered both at the detailed and regional levels. All such studies contribute basic data to problems dealing with the metallogenetic evolution of the Cordillera.

STUDIES IN PROGRESS

We have already embarked in a general way on this project and have produced a total of about 100 analyses in the past seven months. Our philosophy is to deal with specific problems that to a large degree are self-contained but all of which, grouped together, will provide us with reasonable coverage of deposits throughout the Cordillera. With this in mind we began an extensive sampling campaign during the summer of 1978. Our first project however, dealt with a large research collection of suites for Zn-Pb deposits in the eastern and northern Yukon, a collection that had already been used as a base for fluid inclusion studies and the study of minor elements in sphalerites (C. Godwin and McLaren, 1979). Specific studies we are involved in at present include:

1. Carbonate-hosted, stratabound zinc-lead deposits, Ogilvie to Mackenzie Mountains, Y.T. and N.W.T. Thirty-four galena samples from 33 deposits have been analysed for lead isotope contents. Data and preliminary in-

terpretations have been presented at the Sixth Geoscience Forum, Yellowknife, N.W.T., December 1978 (abstract in appendix); a formal publication is in preparation.

2. Stratiform zinc-lead deposits, Selwyn Basin, Y.T. (includes also Gataga area, B.C.). Thirty-five samples have been collected and isotopic analyses are in progress.

3. Volcanogenic and vein zinc-lead deposits, Pelly Mountains, Y.T. (including MM and Ketza River). Twenty-five samples have been collected and isotopic analyses are in progress.

4. Volcanogenic deposits southwestern B.C. Fifteen samples (including Northair, Seneca and Britannia) have been analysed. Several more analyses are required to complete this project.

5. Volanogenic and related deposits in northwestern B.C. Ten samples (including Dolly Varden, Bayview, Big Missouri, Ecstall, and Granduc) have been analysed. Additional samples from Dr. N.C. Carter, B.C.M.O.M. are to be analysed from this area.

6. Vein deposits in the Keno Area (including Peso and Rex), Y.T. Fifteen samples have been analysed isotopically and at least an additional 15 will be studied.

FACILITIES

Sample preparation involving crushing and separation of relatively pure galena concentrates is done with facilities available in the Dept. of Geological Sciences. A small chemistry lab in the Dept. of Geophysics and Astronomy is at our disposal. Isotopic analyses are done on a 90 degree sector, 12 inch radius mass spectrometer (MS-1) in the Dept. of Geophysics and Astronomy. The instru-

ment produces high quality isotopic analyses with a precision of about one-tenth of one percent or better but because of the nature of its construction is limited in productivity to about one useful analysis per working day. Renovation of another mass spectrometer (MS-2) in the Deptartment to have a productivity of 3 samples per working day would require a capital outlay of approximately $15,000.00. In our view this is a desireable modification because it would provide a mass spectrometer dedicated almost exclusively for the next 3 years to the project outlined here. As things stand the existing facilities (MS-1) which have been used solely by us for the past months will have to be shared with at least two other major projects in one to two months time, thus seriously affecting the rate at which our analyses can be obtained. It is worth pointing out that with the modification of MS-2 for efficient productivity, the lab would be in a position to offer a service to government and industry at competitive rates.

PERSONNEL

The project is under the supervision of Professors A.J. Sinclair and C.I. Godwin of the Dept. of Geological Sciences. Dr. Barry Ryan will supervise and operate the chemical and mass spectrometry labs. Drs. R.D. Russell and W.F. Slawson of the Dept. of Geophysics and Astronomy are maintaining a close association with those involved more deeply in the project and are prepared to assist where necessary with modification to equipment and computer analysis. Shop personnel and facilities of the Dept. of Geophysics and Astronomy are available to assist us in modification of the mass spectrometer.

FUNDING

Parts of this project were first funded in the 1977-78 fiscal year and at present we forsee adequate if minimal funding sufficient to the end of the present fiscal year (i.e. until March 31, 1979). Sources of funding to date are Dept. of Northern Affairs, National Research Council of Canada and B.C. Ministry of Mines.

Monthy costs approximate $2,000.00 distributed as follows:

Salary and benefits - mass spectrometrist	1550.00
Routine upkeep of mass spec lab (ind. log. , incidental small items of equipment).	200.00
Chemicals	100.00
Misc. charges, report preparation, draughting, etc.	150.00

Consequently, approximately 24,000.00 per year is required for the full time operation necessary to achieve our projected aims in a period of 3 years.

As indicated previously, an additional $15,000.00 is required shortly if modifications are to be made to increase the productivity of the research team 3-fold over the anticipated 3-year minimum life of the project.

RESULTS:

Isotopic analyses will be made available at specific intervals attached to progress reports to all supporting groups. It is our intention to supply a specific product to each group supplying funds for the project. As an example, a contribution of $7,000.00 per year would be translated into a minimum of 35 precision Pb isotope analyses of samples chosen to investigate a problem or problems agreed upon mutually. In some of these studies we would anticipate

assistance with critical sampling required to carry out an adequate and thorough study.

It is our intention that all data and interpretation generated through the project be generally available and be free of any proprietary restrictions.

PRINCIPAL INVESTIGATORS

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Metallogenic Events in the Mackenzie Fold Belt Defined by Pb-Isotope Analyses of Galena from Carbonate Hosted Zinc-Lead Deposits

-by-

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Thirty-four isotopic analyses of lead in galena from 33 carbonate-hosted zinc-lead deposits in the Mackenzie Fold Belt N.W.T. and Y.T. define a 1.6 to 1.4 b.y. basement source for lead emplaced about 500 m.y. (Cambrian-Ordovician boundary) and 160 m.y. (Jurassic). Phlogopite from a breccia body cross-cutting Helikian strata in the Bonnet Plume River district has a potassium argon age of 1.5 b.y. A Stacey and Kramer model lead age for two deposits in Helikian carbonates in the Coal Creek Dome is about 1.44 b.y. The Precambrian basement source for the lead mineralization therefore is probably older than these ages.

Two major age groups of host rocks: older ones (Proterozoic to Lower Cambrian) and younger ones (Middle Ordovician to Devonian) are separated by a unit relatively barren of zinc-lead deposits. Probability graph analyses of minor elements in sphalerite typically define bimodal distributions consisting of relatively "enriched" and "depleted" populations. The "depleted" populations occur in sphalerite from the younger host rocks; the "enriched" sphalerites occur in older host rocks. Stratigraphic considerations indicate that the younger deposits might have resulted from dewatering of the Selwyn Shale basin. Karstic processes, suggested by major unconformities associated with the older host rock, might be important in formation of the older deposits. Therefore, a model of two metallogenic events (at different times and related to different processes of mineralization) one near the Cambrian-Ordovician boundary (about 500 m.y.) and one after the Devonian (less than 360 m.y.) provide restraints for the lead isotope model.

The majority of the Pb isotopic data plotted on a $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$ graph form two distinct clusters. Means of these two clusters do not overlap at one standard error of the mean and the variance of the two clusters differ. Slopes of lines for old and young deposits are defined by different data distributions. These slopes, when a source age of 1.6 b.y. is defined, yield model ages of about 500 m.y. and 160 m.y. which are within limits defined by geological constraints.

More definitive interpretations of lead isotopic data were possible using geological constraints. Carbonate hosted zinc-lead deposits in the Mackenzie fold belt appear to have been formed by events near the Cambrian-Ordovician boundary and near the Middle Jurassic. The 1.6 b.y. basement age is the first isotopic indication that a Hudsonian basement might occur in northwestern Yukon.

*For presentation at Geoscience Forum, Yellowknife, December, 1978.