



THE PALEOZOIC MASSIVE SULPHIDE PROJECT: AN INVESTIGATION OF YUKON-TANANA CORRELATIVES IN BRITISH COLUMBIA

JoAnne Nelson, Steve Sibbick, Trygve Höy, Peter Bobrowsky, and Michael Cathro

INTRODUCTION

Cominco's 1994 announcement of the discovery of significant stratiform sulphide mineralization in the ABM zone, later called the Kudz Ze Kayah project, generated a strong swell of staking and exploration in the Finlayson Lake area of the southern Yukon. One result was Westmin's optioning of claims held by Atna Resources Ltd., near Wolverine Lake 20 kilometres southeast of Kudz Ze Kayah. In 1995 Westmin announced several ore-grade sulphide drill intersections at Wolverine. These dual successes have spurred Yukon exploration to an all-time high in 1996, in terms of both expenditures and claims staked (J. Hunt, personal communication, 1996).

Kudz Ze Kayah and Wolverine lie within the Yukon Tanana Terrane. The volcanogenic massive sulphide orebodies are hosted by meta-morphosed sequences of Early Mississippian rhyolite, argillite, mafic tuff and coeval, probably cogenetic plutons. The Yukon Tanana Terrane is not confined to Yukon. In Alaska it extends into the Alaska Range, where it hosts the VMS deposits of the Delta and Bonfield districts. In British Columbia, Yukon Tanana extensions and correlatives include the Nisling Terrane in the Coast Mountains, which hosts the Ecstall deposit and which may be related to the Stikine Assemblage around the Tulsequah Chief deposit; pericratonic terranes of far northern B.C.; and the Kootenay Terrane, which hosts Late Devonian(?) VMS deposits in the Eagle Bay Assemblage north of Kamloops (Nelson, this volume, Figure 1).

This multidisciplinary project was undertaken by the Geological Survey Branch to emphasise the exploration opportunities afforded by these large tracts of promising but underexplored pericratonic terranes in British Columbia. The various component studies are designed to fill gaps in the present state of knowledge about parts of these terranes,

particularly in the style and distribution of known mineral deposits, and offer new ideas about how additional discoveries might be made.

The Yukon Tanana correlative terranes in the far north are poorly known, with little geologic mapping since initial 1:250,000 coverage by the Geological Survey of Canada in the early 1960's. They are also underexplored: prior to the 1994-95 discoveries, the Yukon Tanana Terrane was not considered to be highly prospective ground. Therefore, the northern bedrock project aimed at reconnaissance mapping of target areas scattered through these terranes, in order to locate Devonian-Mississippian volcano-sedimentary units that might host VMS deposits. This project is conducted by JoAnne Nelson.

In contrast, the Eagle Bay Assemblage in the southern part of the Kootenay Terrane is well-mapped and has been extensively explored by traditional methods. It is likely that new discoveries will be in drift covered or forested areas. The current focus there is on establishing geochemical dispersal signatures for known deposits via detailed till geochemistry surveys and biogeochemical orientation studies of selected examples of the region's key mineral deposit types, and on providing regional hydrogeochemical (stream water chemistry) data. Peter Bobrowsky and Steve Sibbick are responsible for this work.

The Kootenay Terrane as a whole, because of its easy accessibility, might be assumed to be well explored; but the discovery of a sulphide boulder train near Barkerville by Barker Minerals in 1994 (Ace property) emphasised that new grassroots finds are still possible. In a third contribution to this project, Trygve Höy is documenting the highly varied stratigraphic settings of syngenetic mineralization in the Kootenay Terrane. More than the Yukon Tanana, the Kootenay Terrane shows a prolonged history of continent margin extension and related hydrothermal systems, from Cambrian to Mississippian. These offer alternative models for exploration that should be

pursued along with the currently popular Devono-Mississippian scenario.

RESULTS

NORTHERN BRITISH COLUMBIA RECONNAISSANCE

With restoration of 450 kilometres of dextral displacement on the Tintina fault, the rocks of the Finlayson Lake area are on strike with the Teslin Tectonic Zone, which extends south into the Jennings River map area of northern British Columbia. Its equivalents there are the Big Salmon Complex (Gabrielse, 1969) and the lower part of the Dorsey Terrane, which forms a belt a few kilometres west of the Cassiar batholith. A third possible Yukon-Tanana correlative in northern B.C. is the Rapid River Tectonite in the Sylvester Allochthon, an assemblage of highly deformed rocks intruded by Early Mississippian plutons (Gabrielse and Harms, 1989). This year's brief reconnaissance of these three terranes yielded metamorphosed felsic volcanic rocks analogous to the stratigraphy hosting Kudzu, Ze Kayah and Wolverine at two separate localities, one in the Big Salmon Complex and one in the lower part of the Dorsey Terrane (Nelson, this volume). At the first locality, piedmontite-hematite meta-chert interbedded with the metarhyolite is similar to the hanging wall iron formation at Wolverine.

METALLOGENY OF THE KOOTENAY TERRANE, SOUTHERN AND CENTRAL BRITISH COLUMBIA

The Kootenay Terrane comprises intensely deformed, variably metamorphosed clastic sediments, subordinate volcanics and limestones ranging in age from Proterozoic to Triassic. Major rock packages in the Kootenay terrane include the Lower Paleozoic Lardeau Group, the Eagle Bay Assemblage, eastern assemblages of the Late Paleozoic Milford Group, and equivalent rocks in the highly metamorphosed Shuswap complex to the west. The Barkerville and Cariboo terranes farther north are similar pericratonic terranes. Reconnaissance work this past summer focused on the variety of massive sulphide deposits in these terranes, including SEDEX deposits in dominantly Cambrian successions and VMS

deposits in both Middle Cambrian and Devonian volcanic rocks.

Massive Pb-Zn deposits occur in basal Eagle Bay rocks of the Kootenay terrane on Adams Plateau and in possibly correlative Cambrian successions in marginal North American rocks. Large, highly deformed and metamorphosed Pb-Zn deposits, some with Broken Hill-type characteristics, also occur within paragneisses of the Shuswap Complex. One of these, Cottonbelt, is currently being explored by Canquest Resources, Inc. Volcanogenic massive sulphide deposits in the Index Formation, the basal unit of the Lardeau Group, record hydrothermal activity during Lower Paleozoic regional extension. The Goldstream deposit has closed recently; however, Rain continues to be actively explored as does the Ace prospect in the Barkerville Terrane near Likely.

Late Devonian arc volcanics in the Eagle Bay assemblage contain a number of polymetallic VMS deposits, including Rea and Homestake. Work this past summer concentrated, in part, on a disseminated copper sulphide deposit, Harper Creek, located near Vavenby (Höy, this volume). Reconnaissance work in the Barkerville terrane recognized possibly similar volcanic arc stratigraphy, associated with Late Devonian intrusive rocks, enhancing the exploration potential for massive sulphide deposits here as well.

EAGLE BAY HYDROGEOCHEMICAL SURVEY AND ORIENTATION STUDIES

The Eagle Bay Assemblage of the Kootenay Terrane is a 40 by 80 kilometre belt located between Shuswap Lake and Clearwater in south-central B.C. The area is well known for its volcanogenic massive sulphide deposits. Small, high-grade deposits such as Homestake (Kamad) have been explored and mined since the early part of the century. Exploration activity boomed from the mid-1960's to the late 1980's, fueled by the discoveries of Harper Creek, Chu Chua, Rea and Samatosum in 1966, 1978, 1983, and 1986 respectively. Despite the demonstrated high mineral potential, exploration has waned in recent years: since 1991 very few significant drilling programs have been conducted and numerous claims have lapsed. Numerous prospects and deposits are currently available for option.

The Eagle Bay Assemblage shares a similar geologic and tectonic history with the Yukon Tanana Terrane. Both terranes embrace a moderately to strongly deformed and

metamorphosed package of sedimentary and volcanic rocks deposited in a rifted continent-margin setting from Cambrian up to Late Devonian time, with a superimposed Devonian-Mississippian magmatic arc. Common elements include Devonian-Mississippian mafic to felsic metavolcanics and associated Kuroko-type polymetallic deposits and large areas of associated quartz-sericite-pyrite alteration; and plutons that are coeval and probably cogenetic with this magmatic event. Adjacent late Paleozoic oceanic terranes - the Anvil Assemblage in southern Yukon and the Fennell Group in southern B.C. - contain Cyprus-type massive sulphide copper deposits. The newly discovered Ice prospect of Expatriate Resources Ltd. in the Anvil Range is similar in setting and metal content to the Chu Chua deposit in the Fennell Group.

The Adams Lake- Clearwater area has moderate terrain, excellent infrastructure and access, and a very good database of geological and exploration information (Schiarizza and Preto, 1987). The completion of a Land and Resource Management Plan for the area in 1995 means that the land use situation is relatively stable, with no new alienation issues likely.

Exploration in the area has been hampered by the obscuring effects of metamorphism and deformation and the relatively small size of the target deposits in the region. The presence of carbonaceous interbeds in many of the prospective rock units makes the interpretation of electromagnetic geophysical data problematic. Extensive overburden cover is probably the most significant obstacle to mineral exploration. In future, geochemical exploration techniques will play a key role in new mineral discoveries.

Two exploration geochemistry programs were conducted as part of the Eagle Bay project (Sibbick *et al.*, 1997). These included a regional hydrogeochemical (stream water chemistry) survey and a detailed soil and biogeochemical orientation study of selected examples of the region's key mineral deposit types. The goals of the Eagle Bay Exploration Geochemistry program are to:

- Produce regional stream water geochemistry maps of major and minor elements.
- Determine critical geochemical exploration parameters for massive sulphide mineralization in overburden covered areas.

Details of this survey are reported in Sibbick *et al.* (1997). The hydrogeochemical survey involved the collection of stream waters

from primary and secondary drainages and the in-field measurement of the field parameters pH, redox potential, conductivity and temperature. Filtered and acidified water samples were analysed by ICP-MS for approximately 70 elements; sulphate was also determined on unfiltered sample splits. Results are currently being compiled for release in early 1997.

EAGLE BAY SURFICIAL GEOLOGY AND TILL GEOCHEMISTRY SURVEY

Quaternary geologic mapping and till geochemistry surveying was initiated and completed in 1996 by the B.C. Geological Survey Branch with assistance from the Department of Earth Sciences, Simon Fraser University. The study area, located northeast of Kamloops includes most of NTS 82M/4 (Adams Plateau) and 82M/5 (North Barriere Lake), or approximately 2000 square kilometres of rugged, drift-covered terrain, overlying economically interesting Devonian-Mississippian rocks of the Eagle Bay Assemblage. Work centred on two related components which rely on the use of drift covered terrain exploration methods:

Surficial mapping at a scale of 1:50 000 including airphoto interpretation and upwards of 50% polygon checking for ground truthing and sampling of basal till deposits as part of a reconnaissance level till geochemistry exploration project for analysis of major and minor elements by ICP and INA.

Surficial mapping completed on both sheets resulted in the identification of several types of deposits, which in order of abundance included basal till, ablation till, colluviated till, colluvium, glaciofluvial, fluvial, glaciolacustrine and organic sediments. Terrain geology maps have been published for the two map sheets (*cf.* Dixon-Warren *et al.* 1997b, Leboe *et al.* 1997). A total of 660 field stations were used to verify air photo interpretations. Details of the surficial mapping efforts are given in Dixon-Warren *et al.* (1997a). Samples collected as part of the survey were only obtained from deposits representative of the first four types. A total of 525 samples were collected and analyzed. Details regarding the till geochemistry component are presented in Bobrowsky *et al.* (1997).

Results of this work indicate that although the area was glaciated more than once, exposed sediments overlying bedrock are products of the final glaciation during the Late Wisconsinan.

Glacial ice which covered this area originated in the northwest and expanded south and southeastward towards the USA border between 22 000 and 11 000 years ago. This simple ice flow history is ideal for drift exploration purposes, as is the fact that overburden cover in the area is minimal, rarely exceeding a few tens of metres and commonly being less than a few metres thick. Coupled with the observation that most sediments are basal till in origin, the reliance on the surficial maps and till geochemistry survey maps thus provides a very good opportunity for further exploration activity directed toward buried mineralization.

REFERENCES

- Bobrowsky, P.T., Leboe, E.R., Dixon-Warren, A., and Ledwon, A. (1997): Eagle Bay Project: Till Geochemistry of the Adams Plateau (82 M/4) and North Barriere Lake (82 M/5) Map Areas; in Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J., and McArthur, G., Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-1, this volume.
- Dixon-Warren, A., Bobrowsky, P.T., Leboe, E.R. and Ledwon, A. (1997a). Eagle Bay Project: Surficial Geology of the Adams Lake Plateau (82M/4) and North Barriere Lake (82M/5) map areas; in Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J. and McArthur, G., Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-1, this volume.
- Dixon-Warren, A., Bobrowsky, P.T. Leboe, E.R. and Ledwon, A. (1997b): Terrain Geology Map of the Adams Plateau Area, NTS 82M/4, Scale 1:50 000; *B.C. Ministry of Employment and Investment*, Open File 1997-7.
- Gabrielse, H. (1969): Geology of Jennings River Map Area, British Columbia (104/O); *Geological Survey of Canada*, Paper 68-55.
- Gabrielse, H. and Harms, T.A. (1989): Permian and Devonian Plutonic Rocks in the Sylvester Allochthon, Cry Lake and McDame Map Areas, northern British Columbia; *Geological Survey of Canada*, Current Research Part E, Paper 89-1E, pages 1-4.
- Høy, T. (1997): Harper Creek: a Volcanogenic Sulphide Deposit within the Eagle Bay Assemblage, Kootenay Terrane, Southern British Columbia; in Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J. and McArthur, G., Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-1, this volume.
- Nelson, J.L. (1997): Last Seen Heading South: Extensions of the Yukon-Tanana Terrane into Northern British Columbia; in Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J. and McArthur, G., Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-1, this volume.
- Schiarizza, P. and Preto, V.A. (1987): Geology of the Adams Plateau-Clearwater-Vavenby Area; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1987-1.
- Sibbick, S.J., Runnells, J.L. and Lett, R.E.W. (1997): Eagle Bay Project: Regional Hydrogeochemical Survey and Geochemical Orientation Studies (82M/4 and 5) in Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J. and McArthur, G., Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-1, this volume.