

LOWER CAMBRIAN STRATA AND BASE METALS

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Introduction

The Western Cordillera of Canada presents the exploration geologist with a great diversity of rock types and structures. The selection of exploration targets within this heterogeneous terrain has been difficult, in part, because insufficient geological information has been available for large regions and, in part, because of the limited appreciation of the relationship between stratigraphy and mineral deposits.

It is now apparent that exploration programs must take cognizance not only of intrusive rocks but also of the age, lithology, and distribution of the stratified rocks. The importance of stratigraphy to mineral exploration is demonstrated by the numerous occurrences of copper minerals in volcanic rocks of Upper Triassic age (Souther, 1965; McKechnie, 1966; Ney, 1966; Souther and Armstrong, 1966) in contrast to the few occurrences known in volcanic-bearing Carboniferous and Permian strata. As another example, it has been evident for some time that Lower Cambrian (possibly including Eocambrian) strata are important host rocks for base-metal concentrations in the eastern part of the Western Cordilleran region. The purpose of this paper is to emphasize this aspect of metallogeny in part of the northern Cordillera.

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Distribution of Base-Metal Deposits

The accompanying generalized map (Fig. 1) shows the distribution of significant lead-zinc occurrences in south-eastern Yukon Territory, southwestern District of Mackenzie, and adjacent British Columbia. All but one or possibly two deposits are in strata older than Mississippian. One base-metal deposit near the Yukon Territory-British Columbia boundary and about 30 miles east of Teslin Lake consists of veins in Mesozoic granitic rocks. The age of metamorphic host rocks at the silver-lead-zinc showings

just north-east of Teslin River is unknown. The remaining prospects in strata other than Lower Cambrian or Eocambrian appear to occur in rocks that are stratigraphically near the boundary between the Middle and Upper Devonian. The great majority of significant deposits, however, has been found in strata of Lower Cambrian and (?) Eocambrian age.

Character of Mineral Deposits

Base-metal deposits in Lower Cambrian or Eocambrian rocks include the well known, large, massive sulphide bodies at Faro, Vangorda, and Swim Lakes in the Vangorda area and several other smaller but similar deposits east of Frances River and at Quartz Lake. These bodies are broadly concordant with enclosing strata and banding of sulphide minerals commonly reflects structures and bedding of the host rocks. All deposits appear to have been metamorphosed to some degree along with enclosing strata.

Tempelman-Kluit (1968) noted that the average grain size of sulphide minerals in the Faro, Vangorda, and Swim Lakes deposits bears a direct relationship to the grade of regional metamorphism. The Swim Lakes and Quartz Lake areas are characterized by low grade regional metamorphism whereas the Norquest area displays moderate regional metamorphism with widespread development of schist and gneiss (Green, 1966; Blusson, 1966). As a general rule, in the areas of highest grade regional metamorphism pyrrhotite content is relatively high.

According to Roots (1954), base-metal deposits of the Ferguson Group just south of Ingenika River in the Aiken Lake area occur in Lower Cambrian limestones. The mineralized zones are concordant with bedding and occupy the same stratigraphic intervals throughout. Original bedding structures of the limestone have been retained in the sulphides. This occurrence and those noted above may be referred to as strata-bound.

Many other lead-zinc occurrences are typical vein deposits in which galena and sphalerite are found with gangue minerals such as calc-silicates, dolomite, ankerite, barite, quartz, and siderite. Magnetite and manganese minerals are common in the McDame area in veins within the contact metamorphic aureole of the Cassair Batholith. In most cases these deposits are characterized by well defined, local

fault zones, and contacts between rocks of contrasting lithologies.

A third type of deposit includes small bodies within contact metamorphic aureoles of large granitic plutons. They are commonly discontinuous and rarely exhibit any clear structural or stratigraphic control of mineral deposition.

Local Controls for Mineralization

Local controls for the emplacement of sulphides in the Faro, Vangorda, and Swim Lakes deposits are not apparent (Tempelman-Kluit, 1968). The mineralized strata are fine-grained; in part possibly tuffaceous sediments which are relatively rich in quartz. In somewhat similar massive sulphide deposits at Norquest and Quartz Lake the sulphides are in limestones or dominantly calcareous strata within sequences of non-calcareous clastic rocks.

At the Tom Lake prospect about 30 miles north-northwest of Watson Lake galena and sphalerite occur in a coarse, calc-silicate skarn developed locally in lower Cambrian limestone (Gabrielse, 1966). The presence of the skarn is anomalous in this region of negligible regional metamorphism and suggests the possibility of nearby, underlying intrusive rock. Mineralization seems to be entirely confined to the thin, discontinuous Lower Cambrian limestone.

Near Coal River, galena and sphalerite occur with abundant barite in a major or fault zone cutting Lower Cambrian strata.

In Cassiar Mountains the base-metal deposits are most commonly related to faults in carbonate strata of the Lower Cambrian Atan Group. Locally, on and near Mount Haskin in the McDame area, mineralized skarns containing abundant pyrrhotite and sphalerite occur along a major north-west-trending fault zone cutting Lower Cambrian strata.

In Cassiar Mountains the base-metal deposits are most commonly related to faults in carbonate strata of the Lower Cambrian Atan Group. Locally, on and near Mount Haskin in the McDame area, mineralized skarns containing abundant pyrrhotite and sphalerite occur along a major north-west-trending fault as well as along or near the contact between clastic and carbonate rocks (Gabrielse, 1963). To the southeast, in the canyon of McDame Creek, galena and sphalerite with pyrite, pyrrhotite, chalcocoprite, and minor hematite and scheelite occur in a skarn of grossularite, diopside, and tremolite. Holland (1966)

massive lenticular replacements parallel with bedding, fills fractures that cross the bedding, and forms disseminations in the skarn zones. Another mineralized zone on the same property is localized by a strong fault that transects bedding in the host limestone.

Green (1968) describes the silver-lead showings in the Ketz River area as lacking a consistent pattern. They include veins, concordant lenses, and irregular bodies in several rock-units. Between Ketz River and Rancheria at least four base-metal prospects have been found in Lower Cambrian Limestone (Green, 1968). Green notes that "Generally, deposits of this type are in the form of galena- and sphalerite-bearing lenses that lie beneath thin layers of schist within the limestone. Some cross-cutting veins are also present."

Discontinuous, pod- or lens-shaped bodies of sulphide minerals locally occur within the contact metamorphic aureole of granitic plutons. Examples of this type are the base-metal prospects in limestone in the McDame area and the showings in limestone and calcareous argillite near Lucky Lake southwest of Flat River. These occurrences have many features typical of contact metamorphic mineral deposits.

The examples cited above illustrate the main characteristics of base-metal deposits that are in the Lower Cambrian and (?) Eocambrian rocks in the region under consideration. They occur in a wide variety of regional and local structural settings and, although all are within or near regions of granitic intrusions or regional metamorphism, they show no consistent spatial relationship to granitic or metamorphic rocks.

Relationship Between Base-Metal Occurrences and Sedimentary Facies

Figure 2 shows the distribution of facies in Lower Cambrian strata. Northeast of Tintina and Rocky Mountain Trenches the easternmost belt comprises thick sequences of sandstone, siltstone, and shale. Thick sequences of coarse polymictic conglomerate are present in the southeastern part of the region.

East of Coal River the clastic rocks are underlain by basic volcanic flows of either Early Cambrian or Late Proterozoic age. No base-metal occurrences have been reported from this belt.

In northern Rocky Mountains the conglomeratic clastic rocks grade westerly into fine-grained sandstones, siltstones, and shales. This facies in-

cyathid-bearing limestone. In the Coal River area and to the north, the coarse clastic facies grades westerly into a sandy, buff-orange weathering dolomite succession that locally contains thin basic volcanic flows. Limestones and calcareous argillites are prominent near the western margin. The pyrrhotite rich deposit at the Canada Tungsten Mine is in the western part of this belt but no significant base-metal occurrences are known.

Still farther west the Lower Cambrian succession consists of a lower, dominantly siltstone formation and an upper, dominantly limestone formation. These rocks include the base metal deposits in barite gangue near Coal River and the Lucky Lake prospect southwest of Flat River.

Finally, the westernmost and most widespread facies of lower cambrian rocks east of Tintina and Rocky Mountain Trenches comprises fine-grained clastic rocks, mainly siltstones and shales, variably calcareous and, in places possibly tuffaceous. Discontinuous limestone bodies are present locally. These rocks underlie much of Selwyn Basin (Gabrielse, 1967). In many places it is difficult or impossible to separate the fine-grained, clastic Cambrian rocks from similar lithologies of late Proterozoic age. The strata are therefore referred to as Eocambrian. The Lower Cambrian and (?) Eocambrian strata of Selwyn Basin contain the large massive lead-zinc bodies at Faro, Vangorda, Swim Lakes, Norquest, and Quartz Lake. So far no important base-metal discoveries have been made in the older clastic strata of Hadrynian (Late Proterozoic) age.

In most of the region southwest of Tintina and Rocky Mountain Trenches Lower Cambrian rocks comprise a lower sandstone formation, a relatively thin middle shale formation and an upper limestone formation. Almost all the base-metal occurrences in Cassiar Mountains are in or along the contact of the upper limestone. The limestone is also an important host rock in Pelly Mountains (Green, 1968).

In summary, no significant base-metal deposits have been found to date in the eastern clastic and sandy dolomite facies belts of Lower Cambrian rocks. On the other hand, strata of the more westerly fine-grained clastic and limestone facies are host to numerous base-metal concentrations. Thus exploration work carried out so far suggests that relatively large, strata-bound massive sulphide deposits may be confined largely to the fine-grained, variably calcareous facies.

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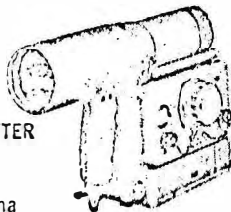
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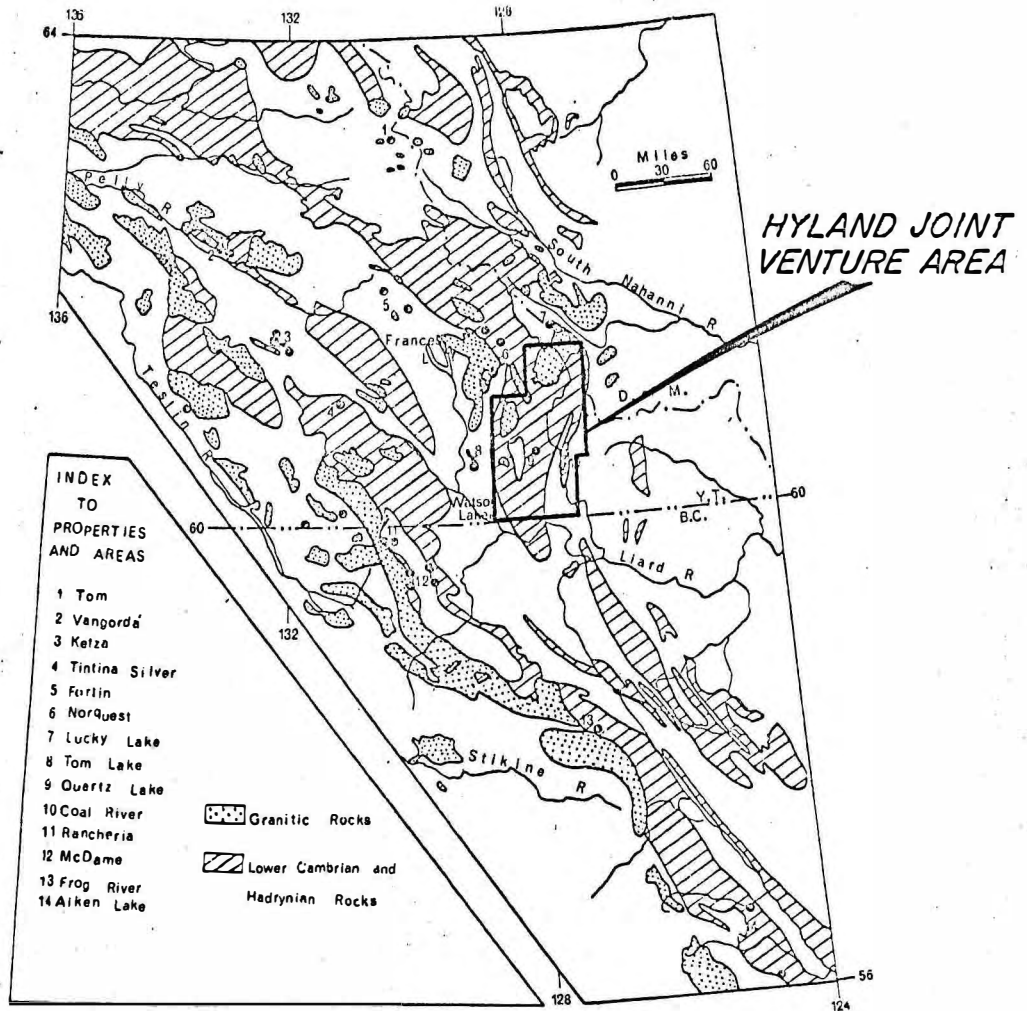


Figure 1
Distribution of Lower Cambrian and Hadrynian strata and Mesozoic granitic rocks. Base-metal deposits in Lower Cambrian and (?) Eocambrian rocks shown as solid circles; those in younger strata shown as half solid circles.

Comments

The empirical relationship between base-metal deposits and Lower Cambrian strata in the region discussed must be considered in any concept concerning ore genesis. Also, concepts of ore genesis should take into account the apparent lack of significant base-metal deposits in such widespread and lithologically varied sequences as the older Hadrynian strata; the Upper Cambrian - Lower Ordovician limestones, silty and argillaceous limestones, and calcareous argillites; the Siluro-Devonian carbonates; and the Upper Paleozoic rocks such as the Cache Creek Group, and much of the Sylvester Group. To the writer's knowledge the only relatively large base-metal deposit in the region that may be in strata younger than Cambrian is that on the Tom property near Canol Road (Green, 1965). The age of the host rocks there, however, is in doubt. Green considers them to be Ordovician or Silurian whereas Tempelman-Kluit (personal communication, 1967) considers them to be of

Late Devonian-Early Mississippian age. As noted above a number of small showings are in strata stratigraphically near the Middle Devonian-Late Devonian boundary.

The widespread distribution of base-metal deposits in varied lithologies of Lower Cambrian and (?) Eocambrian age and the lack of significant concentrations of these metals in most other stratigraphic assemblages are difficult to reconcile with concepts of epigenesis that require Mesozoic and Tertiary granitic plutons as source rocks. A more probable role of plutonic activity may well be that of concentrating metals previously dispersed in the host rock.

The McDame area provides a most interesting study in this regard. There the Lower Cambrian strata are underlain by several thousand feet of well-bedded limestones, argillites, siltstones, and slates of Hadrynian age. Overlying the Lower Cambrian rocks are strata ranging in age from Late Cambrian to Late Paleozoic and including a wide variety of lithologies.

only the Lower Cambrian limestone contains significant concentrations of lead and zinc. For the region as a whole the base-metal-Lower Cambrian relationship is even more remarkable in view of the wide variations in facies of the mineralized strata.

If the Lower Cambrian rocks are the source of the metals one must look for unique aspects of Early Cambrian tectonics and sedimentation that resulted in their unusually high base-metal content. Two contrasting possibilities are the following:

1. During the Early Cambrian and Late Proterozoic large volumes of cratonal Precambrian crystalline rocks were eroded. This resulted in the last great contribution of clastic sedimentary rocks to the Cordilleran geosyncline from the craton. Perhaps these sediments contained the metals that were later remobilized and concentrated to produce the base-metal deposits mainly in Lower Cambrian rocks.

Future work should contribute to an understanding of the relationship between Lower Cambrian and (?) Eocambrian strata and base-metal occurrences. In any event, the empirical relationship points to a number of exploration targets. For example, the belt of Lower Cambrian and associated strata that extends southeasterly from the McDame area to the Aiken Lake area would seem to merit careful prospecting. The northwesterly extension of this belt into the Ketza area has already yielded a number of showings. Those areas in Selwyn Basin that include Lower Cambrian and (?) Eocambrian strata appear

On a regional scale there is an impressive concentration of base-metal deposits in areas that include both Lower Cambrian and (?) Eocambrian strata and large granitic plutons. This applies to the Vangorda area and to a northeasterly trending belt extending from Rancheria and McDame to Lucky Lake. The northeasterly trending belt may be of major tectonic significance. Deep-seated structures with this trend are important in the eastern part of the northern Cordillera and in the crystalline basement of the adjacent Canadian Shield. In this regard it is interesting to note the apparent concentration of mineral deposits elsewhere in the Canadian Cordillera along or near northeasterly trending belts of plutonic rocks. Such belts are as follows: Stikine Arch (Souther and Armstrong, 1966); Skeena Arch (Souther and Armstrong, 1966); and the belt across southernmost British Columbia.

Conclusion

Lower Cambrian and (?) Eocambrian strata appear to be the most important host rocks for base-metal deposits in the region herein considered. This relationship is important for future exploration and for consideration in concepts of ore genesis.

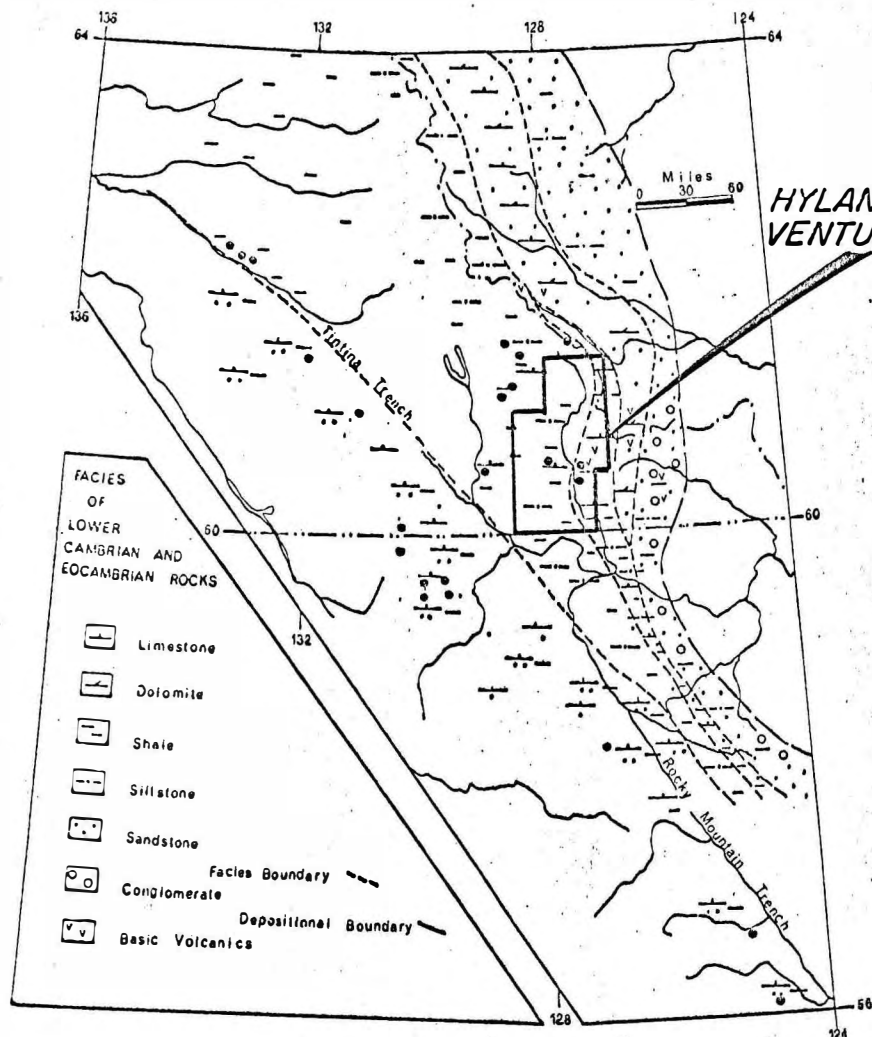


Figure 2

Distribution of base-metal deposits (solid circles) and facies of Lower Cambrian and Eocambrian rocks.

HYLAND JOINT VENTURE AREA

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