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S. Paradis and W. Goodfellow

Presented at the

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A Targeted Geoscience Initiative 3 and 4 Contribution

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A Contribution to a Session on
The Canadian Cordillera and its Mineral Deposits: A New Look

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SUMMARY

SEDEX (SEDimentary EXhalative) deposits are important resources of Zn and Pb. In addition to Zn and Pb, other potentially economic commodities are: Ag, Au, Cu, Cd, Sb, Sn, and barite. Major metallogenic districts in the Canadian Cordillera that host SEDEX deposits are:

- Mesoproterozoic Sullivan district in southeastern British Columbia, which hosts the world-class Sullivan deposit and other smaller deposits such as North Star and Kootenay King.
- Late Cambrian Anvil district in the Selwyn Basin of central Yukon, which hosts the Faro, Grum, Vangorda, DY, and Swim deposits.
- Early Silurian Howard's Pass district in the Selwyn Basin of the northeastern Yukon, which hosts the world-class Howard's Pass deposits (XY, Brodel, HC, Don, Anniv, OP, Pelly North).
- Late Devonian Gataga district of the Kechika Trough (southern extension of Selwyn Basin) in northeastern British Columbia, which hosts the Cirque, Driftpile, and Akie deposits.
- Late Devonian MacMillan's Pass district in the Selwyn Basin of northeastern Yukon, which hosts the Tom and Jason deposits.

The Sullivan deposit and two deposits of the Anvil district (i.e., Faro and Grum) are past-producers. Other deposits have seen or are undergoing intensive exploration and development work (e.g., Howard's Pass, MacMillan's Pass, Drifpile, Akie, and Cirque).

SEDEX deposits are defined as being predominantly composed of Zn and Pb hosted in sphalerite and galena that were deposited at or near the seafloor from basinal metalliferous fluids discharged into rift-controlled anoxic sedimentary basins. They consist of vent-distal and vent-proximal facies. The former is composed of interbedded sphalerite, galena, iron sulphides and clastic sediments, and the latter of variably veined, infilled and replaced bedded sulphides.

Cordilleran SEDEX deposits occur in intracratonic and epicratonic rifts within reduced marine basins. The architecture of sedimentary basins is characterized by rapid syn-rift subsidence and clastic sedimentation that is overlain by fine-grained clastic and carbonate sediments that accumulated during a post-rift sedimentation phase. Marine turbidites with interlayered mafic sills of the syn-rift phase host the Sullivan deposit, whereas organic-rich carbonaceous shales/mudstones of the post-rift phase host deposits of the Selwyn Basin. The deposits most likely formed at or just below the sea floor from warm to hot (~100° up to 300°C), saline (10 to 20% NaCl equiv.) basinal brines that ascended along basin-controlling synsedimentary faults. Deposition and sequestration of metals occurred by precipitation of sulphide minerals as a result of mixing of metal-transporting brine with locally derived H_2S produced by bacterial (and perhaps thermochemical) reduction of local seawater sulphate.

Important exploration vectors include the presence of:

1. Deep-seated synsedimentary faults expressed as abrupt changes in facies and isopachs, intraformational breccias, slumps, debris flows, and fault scarp talus.
2. Recognition of local fault-controlled paleoenvironments that represent restricted and stratified basins with anoxic H_2S-rich bottom waters.
3. Organic-rich sediments with >1% Corg.
4. Anomalous concentrations of redox-sensitive trace elements (e.g., V, Tl, Cd, U, V/Mo, and Re/Mo).

5. Widespread hydrothermal alteration (muscovite, carbonates, and silicates).
6. Laterally and vertically extensive distal sediments that are mineralogically and chemically zoned around seafloor vents.

INTRODUCTION

This open file contains slides of a talk given at a special session entitled "The Canadian Cordillera and its Mineral Deposits: A New Look" at the Prospectors and Developers Association of Canada (PDAC) convention held in Toronto, Ontario, March 4 to 7, 2012. The slides of the original talk have been augmented by additional notes and a reference list for citations on the slides. References to source of information are not always included in the descriptions if such information is already included in the slides. In view of the great interest shown by mineral explorationists in the content of the talk given at the PDAC convention in March 2012, the information is released as an open file so that it would be readily available to a wider audience.

The talk released in graphical form gives a synopsis of the geological attributes mentioned below. For each of the geological attributes mentioned, corresponding exploration criteria are presented.

1. Tectonic and sedimentary settings of the Cordilleran SEDEX deposits.
2. Ideal basinal architecture for the development of a hydrothermal reservoir leading to the genesis of metalliferous fluids and formation of SEDEX deposits.
3. Seafloor environment that dominated at the time of SEDEX formation.
4. Deposit morphology and genetic models.

Many of the exploration vectors mentioned are based on past research undertaken in the Purcell Basin by Höy et al. (2000), Lydon et al. (2000), Lydon (2007), and in the Selwyn Basin by MacIntyre (1982, 1992), MacIntyre and Sangster (1983), Paradis et al. (1998), Goodfellow et al. (1993), Goodfellow (2000, 2004, 2007), Goodfellow and Lydon (2007), Turner (1990) , and Turner et al. (2000).

CONCLUSIONS

This presentation lists some geological attributes and corresponding exploration criteria that are critical to the formation and discovery of SEDEX deposits in the Cordillera. The following attributes help identify sedimentary basins likely to contain abundant SEDEX deposits, in order of importance:

1. Epicontinental or intracratonic basins with thick accumulation of sedimentary strata (i.e., >4 km thicknesses) and large, long-lived basin-bounding faults.
2. Sedimentary strata comprised of sequences of coarse-grained permeable subaerial to submarine clastic rocks (syn-rift phase) overlain by marine basinal sediments including organic-rich mudstone and siltstone with more than 1% C_{org}.

3. A source of saline brines, a requirement in the formation of a SEDEX deposit, from evaporites (if present in the basin) or most likely from vast carbonate platforms adjacent to basins; the latter also provide the fluid drive to form a SEDEX deposit.
4. Basins containing known SEDEX deposits or occurrences should be highly prospective for additional deposits. Presence of MVT deposits in adjacent carbonate platforms also suggests that large fluid flow systems occurred in the region.
5. Geochemical anomalies in regional sedimentary sequences, tills and sediment and water samples provide useful vectors toward areas of the basin that are favourable for covered ore deposits.
6. Anoxic and H_2S-rich bottom water in second- or third-order basins. This is consistent with the presence of delicately laminated nonbioturbated carbonaceous sediments, and the absence of benthic fauna in Phanerozoic sediments.

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