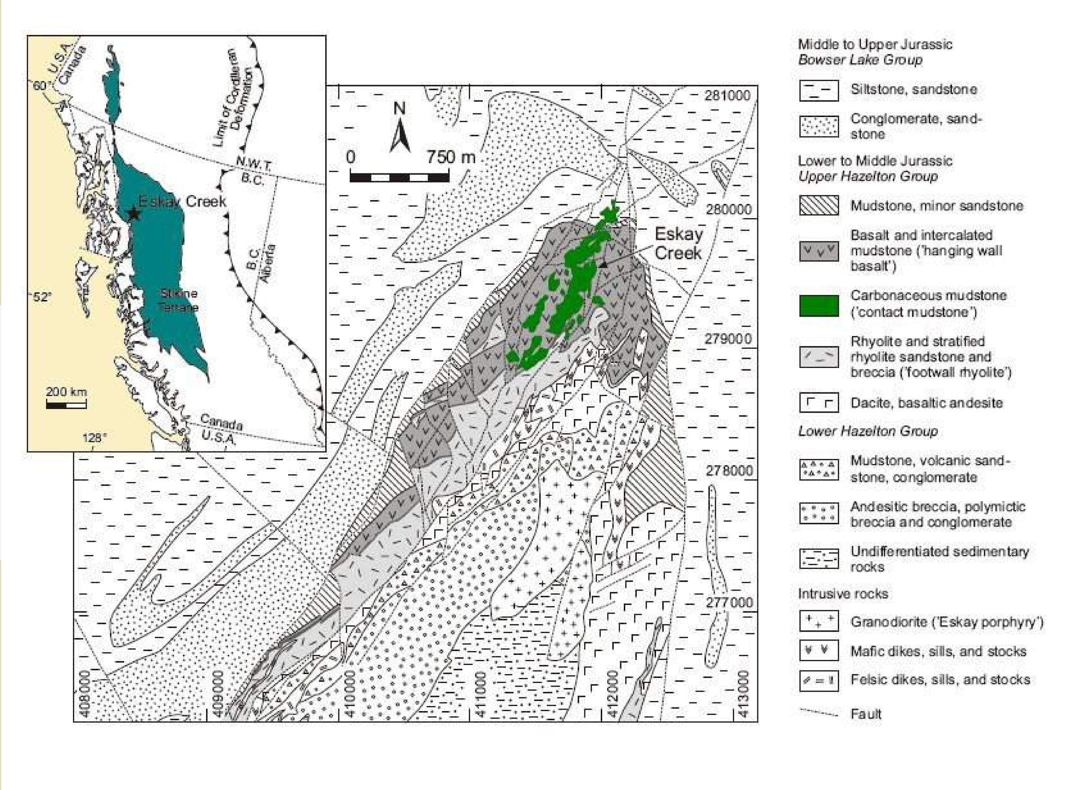
Nature and Origin of Carbonate Alteration at the Eskay Creek Massive Sulfide Deposit, BC

Tom Meuzelaar[1], Thomas Monecke[1], Richard Tosdal[2]
[1]Department of Geology and Geological Engineering, Colorado School of Mines
[2]Consulting Geologist, Bridgewater, NJ

Abstract

Eskay Creek represents an unusual precious metal-rich, polymetallic volcanic-hosted sulfide and sulfosalt deposit located in the Iskut River area of northwestern British Columbia, Canada. The bulk of the mineralization consists of stratiform clastic beds and laminations of commonly graded sulfide and sulfosalt debris that are hosted by a thick interval of carbonaceous mudstone at the contact between felsic volcanic rocks and overlying basalt. In addition to the stratiform orebodies, economic concentrations of precious metals have been recognized in discordant zones of sulfide veins and disseminations in the footwall rhyolite.

Detailed mineralogical investigations of the carbonaceous mudstone hosting the stratiform mineralization at Eskay Creek revealed the existence of a distinctive alteration halo around the deposit. Interaction of the host mudstones with hydrothermal fluids resulted in the wide-spread formation of carbonates. Qualitative and quantitative X-ray diffraction analysis showed that altered mudstone contains abundant ankerite, with ferroan magnesite, magnesian siderite, and siderite being locally present. Calcite was found to occur in the outer part of the alteration halo and forms an important component of mudstone away from the deposit. Carbonate alteration of the mudstone was accompanied by the formation of kaolinite as an abundant byproduct. The spatial distribution of the different carbonate species suggests that carbonate alteration of the fine-grained carbonaceous host rocks was largely restricted to areas overlying upflow zones of mineralizing hydrothermal fluids and associated discordant mineralization in the footwall rhyolite. Carbonate alteration in the halo around the deposit is interpreted to have taken place at low to moderate temperatures from fluids containing a high content of carbon dioxide.



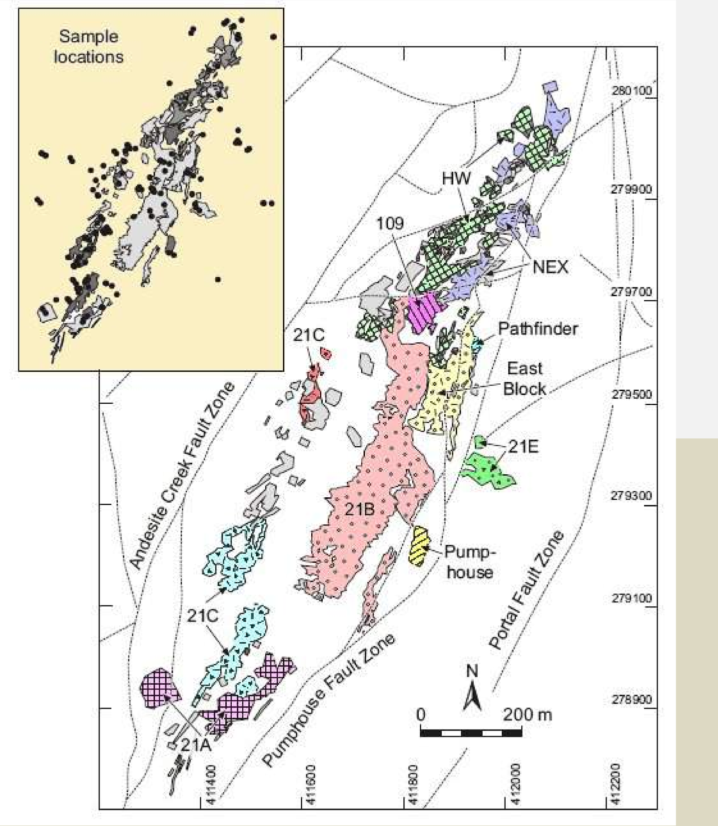
Geology

The Eskay Creek deposit is located in the Iskut River area at the western margin of the allochthonous Stikine terrane of the northern Canadian Cordillera (*above, inset*). Middle Jurassic submarine and subaerial volcanic and sedimentary rocks in the Iskut River area yield U-Pb zircon ages between 181 and 172 Ma (Childe, 1996). Deposit host rocks are folded into a shallowly north plunging, north-northeast trending, upright, open anticline (*above*). Stratiform mineralization at Eskay Creek occurs on the western limb of the fold, near the fold closure, and dips gently 30 to 45° to the west. The metamorphic grade in the mine area is lower greenschist (Roth et al., 1999).

The stratigraphic footwall to the mineralization is composed of multiple intrusive/extrusive rhyolite generations with a maximum apparent thickness of approximately 100 m in the mine area. Hydrothermal alteration is widespread throughout the footwall rhyolite. Secondary potassium feldspar and a moderate silicification occurs peripheral to the stratiform ore and in deeper parts of the footwall. Immediately underlying the mineralization, a more intense and texturally destructive alteration is seen in a tabular zone of pervasive chlorite and white mica formation.

The footwall rhyolite is overlain by carbonaceous mudstone, which hosts the sulfide and sulfosalt mineralization. The unit ranges from <1 m to >60 m in thickness. The mudstone is laminated, thinly bedded or massive and contains abundant intercalated, tan-colored beds of fine-grained volcaniclastic material. Carbon content decreases towards the top of the unit. Calcareous and siliceous intervals are present, but not common. Thin pyrite laminations are common throughout the unit. The occurrence of flame structures at the base of the pyrite laminations indicates that the pyrite is clastic in origin. Additionally, thin veins and veinlets of pyrite crosscutting bedding are widespread throughout the mine area. The mudstone unit also contains radiolaria, dinoflagellates, rare belemnites, and corals, confirming a marine depositional environment.

Basalt sills and dikes occur throughout the carbonaceous mudstone unit. The occurrence of mudstone-matrix basalt breccia along the bottom and top margins of coherent basalt intervals indicates that the lava intruded the still wet and unconsolidated mudstone. The relative proportion of basalt increases in the upper part of the mine succession. The hanging-wall basalt locally exceeds 150 meters in thickness and generally thins south-ward away from the deposit. The mafic rocks are intercalated with variably thick intervals of the carbonaceous mudstone, which is similar to the contact mudstone hosting the mineralization.

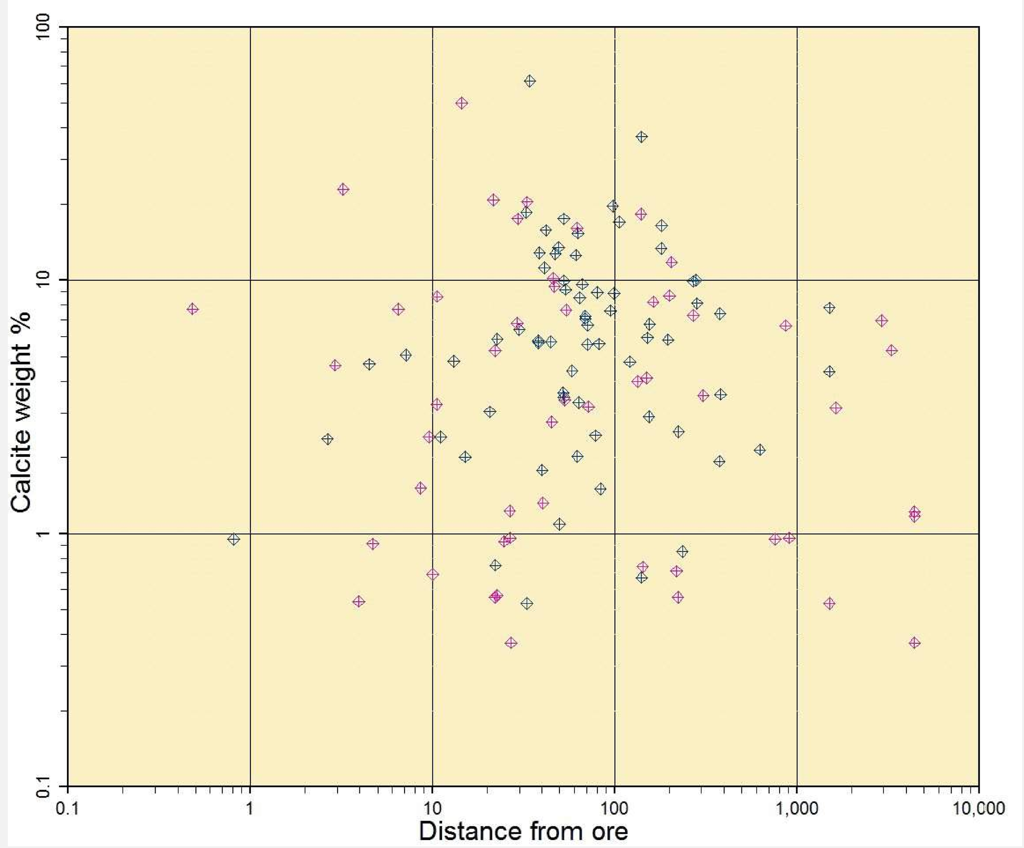


Purpose of Research

The Eskay deposit has generated significant interest because it is among the most Au- (52.5g/t) and Ag-rich (2,398 g/t) VMS deposits in the world, and several of its geological characteristics differ from ordinary VMS deposits. Key features include the bedded and commonly graded nature of the clastic ore, the high concentrations of precious metals and other elements more typically associated with epithermal environments, the complex ore mineralogy, and the low temperatures (<200 °C) of sulfide and sulfosalt deposition (Roth et al., 1999). The deposit has been considered to be a type example of a new group of volcanic-hosted gold deposits that formed in relatively shallow-water submarine environments where phase separation of the hydrothermal fluids represented an important control on the precipitation of metals (Hannington et al., 1999).

Economic concentrations of precious and base metals at Eskay Creek are mainly confined to laterally discontinuous, locally barren, stratiform clastic ore lenses hosted by a thick mudstone interval at the contact between felsic volcanic rocks and overlying basalt (*see map of primary ore zones above*). Although the mineralizing hydrothermal system was active over a quite extensive area, it is currently not well established whether mineralogical gradients within the footwall alteration halo and within the mudstone hosting the mineralization can be used for target vectoring. Due to the absence of readily recognizable alteration features in the carbonaceous mudstone, previous research has focused on the hydrothermal alteration pattern of the footwall rhyolite (Barrett and Sherlock, 1996). ***This study reports the initial results of a first comprehensive mineralogical study of the carbonaceous mudstone, and suggests that hydrothermal alteration of the fine-grained mudstone can be recognized up to tens to hundreds of meters from the orebodies.***

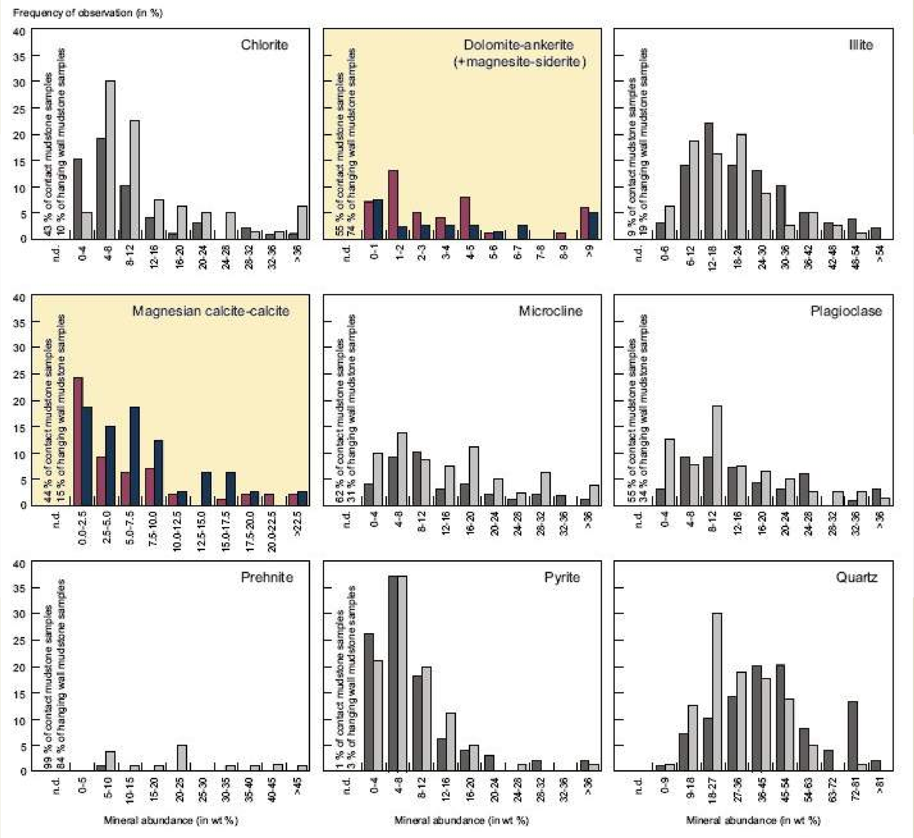
A total of 180 mudstone samples were selected from exploration drill core as well as surface and underground exposures (*inset, above*). The samples were collected at various distances from ore ranging from the immediate ore zones to a maximum distance of approximately 4.4 km from ore. Mudstone samples were further subdivided into contact and hanging-wall mudstones. The **contact mudstone** unit is defined as the mudstone between the upper surface of the footwall rhyolite and the lowest basalt unit in the hanging wall. Mudstone occurring further up stratigraphy in the mine succession is collectively referred to as the **hanging-wall mudstone**. Mineralogical compositions of the mudstones were determined by X-ray Diffractometer and quantitative phase analysis performed using the Rietveld method.



Results

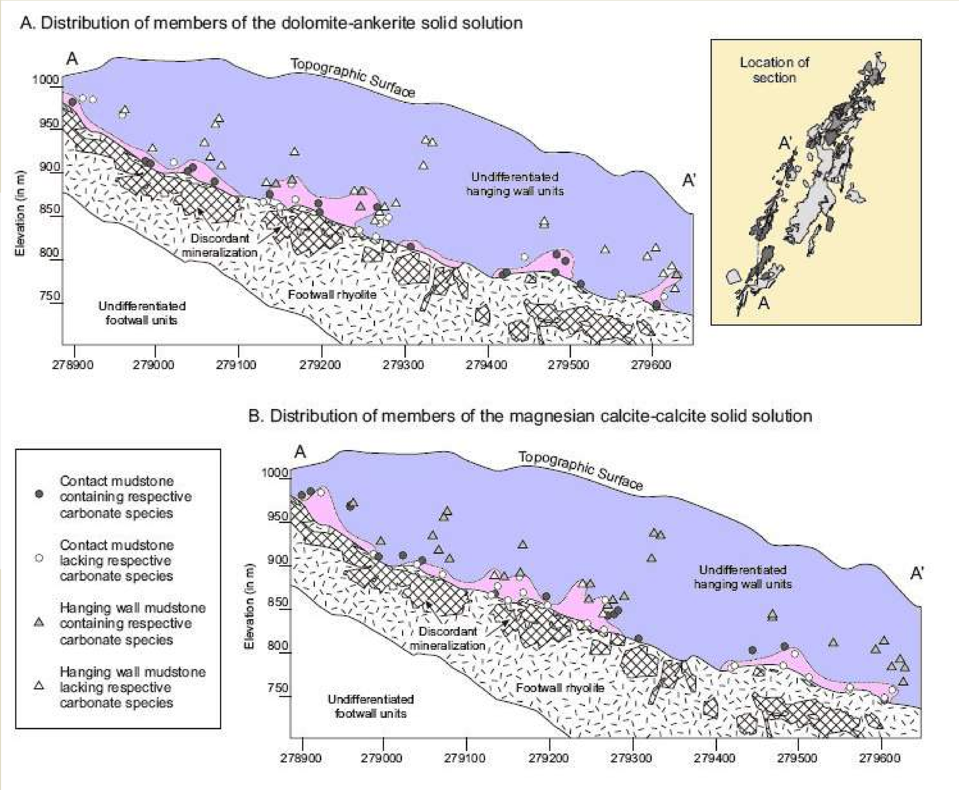
A log-log scatter diagram of Calcite mineral abundance (wt %) vs. distance from ore (*left, bottom*; **contact mudstones - pink**, **hanging wall mudstones - blue**) suggests a weak correlation between increasing Calcite and distance from ore. Stratiform ore at Eskay is laterally discontinuous and carbonate abundances do not initially appear strongly correlated to mineralization. However, they are correlated to distance from the rhyolite footwall.

Histogram plots of modal Dolomite [$CaMg(CO_3)_2$] - Ankerite [$CaFe(CO_3)_2$] and Magnesite [$MgCO_3$]- Siderite [$FeCO_3$] solid solutions (*below*) for contact and hanging wall mudstones (blue) clearly suggest these carbonates are more abundant in the contact mudstones which host the stratiform mineralization. The reverse is true for Calcite [$CaCO_3$] and Mg Calcites, which are increasingly abundant within the more peripheral hanging wall samples.



Interpretation

Carbonate alteration of the contact and hanging-wall mudstone at Eskay Creek is widespread, but ankerite (and locally ferroan magnesite, magnesian siderite, and siderite) appear to be restricted to areas overlying upflow zones of mineralizing hydrothermal fluids and associated discordant mineralization in the footwall rhyolite (*below*). This alteration may be used to indicate proximity to hydrothermal activity within tens to hundreds of meters to mineralization.



References

▪ Barrett, T. J., and Sherlock, R. L., 1996, *Geology, lithogeochemistry and volcanic setting of the Eskay Creek Au-Ag-Cu-Zn deposit, northwestern British Columbia*: Exploration and Mining Geology, v. 5, p. 339-368.
▪ Childe, F., 1996, *U-Pb geochronology and Nd and Pb isotope characteristics of the Au-Ag-rich Eskay Creek volcanogenic massive sulfide deposit, British Columbia*: ECONOMIC GEOLOGY, v. 91, p. 1209-1224.
▪ Hannington, M. D., Poulsen, K. H., Thompson, J. F. H., and Sillitoe, R. H., 1999, *Volcanogenic gold in the massive sulfide environment*: Reviews in Economic Geology, v. 8, p. 325-356.
▪ Roth, T., Thompson, J. F. H., and Barrett, T. J., 1999, *The precious metal-rich Eskay Creek deposit, northwestern British Columbia*: Reviews in Economic Geology, v. 8, p. 357-373.

Acknowledgements

The authors gratefully acknowledge Geoscience BC, Barrick Gold, the Michael-Jurgen-Leisler-Kiep Foundation, German Research Foundation and NSERC for supporting this study.