Hydrothermal Alteration of Carbonaceous Mudstones Hosting the Eskay Creek Au Deposit, British Columbia

Tom Meuzelaar* and Thomas Monecke

Department of Geology and Geological Engineering, Colorado School of Mines, 1516 Illinois Street, Golden, Colorado 80401

*E-mail, tmeuze@gmail.com

The Jurassic Eskay Creek deposit in the Iskut area of northwestern British Columbia is an unusual, precious metal-rich polymetallic volcanic-hosted massive sulfide and sulfosalt deposit. Economic concentrations of precious metals at Eskay Creek are mainly confined to stratiform ore lenses hosted by a thick interval of carbonaceous mudstone at the contact between a footwall rhyolite and overlying interval of basalt. Although alteration of the carbonaceous host rocks is cryptic and extremely difficult to recognize in hand specimen, these fine-grained rocks have been highly susceptible to hydrothermal alteration. Correlative microscopy, whole-rock mineralogical and geochemical investigations, and geochemical reaction path modeling were used to derive alteration vectors that can be used to identify alteration of the mudstone at distances of tens to hundreds of meters away from areas of intense hydrothermal upflow.

Previously conducted fluid inclusion research at Eskay Creek suggested that the hydrothermal fluids forming the deposit reached maximum temperatures of approximately 200°C. Hydrothermal alteration of the host mudstone at these low temperatures resulted in the destruction of volcanic glass and feldspars, causing decrease in whole-rock Na_2O contents. Alteration of the volcaniclastic component of the mudstone was accompanied by the formation of pyrite and abundant secondary clay minerals, presumably smectite and mixed-layer clays. During diagenesis and low-grade metamorphism, these phases were transformed to illite and chlorite now present in the carbonaceous mudstone. Electron microprobe analysis showed that chlorite in hydrothermally altered mudstone is distinctly enriched in MgO when compared to chlorite contained in least-altered rocks.

Carbonate alteration represents the most widespread style of hydrothermal alteration. Members of the dolomite-ankerite and magnesite-siderite solid solution series formed proximal to hydrothermal upflow zones from moderately acidic fluids. The presence of these carbonate minerals in mudstone correlates with whole-rock FeO, MnO, and MgO enrichment trends. Kaolinite occurs in trace concentrations in samples affected by intense carbonate alteration. Distal to the hydrothermal upflow zones, calcite is the predominant carbonate mineral, implying that mudstone alteration occurred under alkaline conditions. Geochemical reaction path modeling confirms that the observed zoning in carbonate mineralogy primarily reflects changes in fluid acidity and the mudstone composition. In addition to carbonate alteration, some mudstone samples collected close to the contact with the footwall rhyolite have been affected by silicification, which is presumably related to the rapid cooling of the hydrothermal fluids. K-feldspar alteration of mudstone has been locally observed distal to hydrothermal upflow zones.

The observed alteration characteristics are consistent with Eskay Creek representing a submarine hot spring deposit that formed at temperatures that were significantly lower than those typically encountered in base metal-rich black smoker systems. The fluids forming Eskay Creek contained elevated CO_2 concentrations. At the low temperatures of mineralization and alteration, CO_2 represented the main acid-generating species. There is no evidence for the presence of other acid species in the hydrothermal fluids, such as sulfuric acid produced through the disproportionation of magmatic SO_2. The chemical characteristics of the hydrothermal fluids at Eskay Creek are broadly comparable to those of geothermal liquids forming low sulfidation epithermal deposits in extensional settings on land.