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FLUID EVOLUTION OF THE VENT COMPLEX, SULLIVAN STRATIFORM SEDIMENTARY ZN-PB-AG DEPOSIT, B.C.

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Ore formation at Sullivan has been modelled from evidence in the vent zone, where fluids responsible for mineralization are recorded by alteration assemblages and fluid inclusions. Fluid evolution included several hydrothermal stages: 1) main stage ore formation (footwall tourmalinite alteration and pyrrhotite network, seafloor sulphide body, metasomatic pyrrhotite body); 2) late main stage (trace-metal rich network, chlorite or muscovite alteration); and 3) post-ore albite-chlorite-pyrite-calcite alteration associated with shallow level gabbro emplacement.

Alteration and fluid inclusion studies suggest that main stage ore deposition was from saline brines, 15-30 wt % $NaCl+CaCl_2+?MgCl_2$ at 300-350°C, that were able to transport Pb and Zn in significant quantities as chloride complexes. These fluids were in equilibrium with tourmaline and probably deposited tourmaline below, and to a lesser degree at, the seafloor. Ongoing hydrothermal upflow locally replaced the Pb-Zn sulphides of the orebody with massive pyrrhotite. Late main stage hydrothermal upflow resulted in local trace metal enrichment of the footwall and sulphide body, and altered tourmalinite to chlorite-pyrrhotite and muscovite. Post-ore fluids of lower salinity and temperature (10-15 wt% NaCl + ?KCl, 250°C) resulted in albite-chlorite-pyrite-calcite alteration in the footwall, ore zone and hangingwall, coincident with the emplacement of gabbro dykes and sills. Fracture controlled chlorite-pyrite overprints hangingwall albite alteration and is interpreted to represent collapse of the Na-brine plume and ingress of Mg-bearing seawater into the hydrothermal system.

Alteration accompanying main stage mineralization (tourmaline, sulphides, carbonate) is characterized by volume addition and gains of Fe, Mg and B with loss of Ca (except for carbonate alteration), Na and K. Muscovite alteration is typified by a lack of significant volume changes and gain of K accompanied by loss of Ca and Na. Chlorite alteration is characterized by volume loss (leaching of quartz) and significant gains of Fe, Mg and water; Si, Ca, Na and K are lost. Albite alteration at the time of gabbro sill and dyke emplacement is characterized by volume loss (leaching of quartz), and significant loss of Ca and K but addition of Na; locally abundant B is relict from former hangingwall tourmalinite.

The vent zone is surrounded by a Mn enrichment halo in garnet, carbonate, and chlorite. Calcic minerals such as plagioclase, tremolite and diopside are anomalous in the ore layers. The finely laminated nature of the major portion of the bedded ores, in which details of stratigraphy can be followed for up to 2 km, could reflect either brine pool precipitation or plume fallout; however, high salinities in the fluid inclusions are like those of the Red Sea brine pools (13.5-25.6%) and underlying anhydrite veins. At Sullivan, the presence of scapolite with a composition near dipyre (Cl-rich, Na > Ca), garnet coticule-bearing rocks and hypogene Fe-oxide-hydroxide minerals such as goethite and magnetite, all suggest a brine pool setting. Evaporites provide an attractive source for the high salinities of the fluid inclusions and the Cl content of the scapolite. Although the base of the host Aldridge Formation is not exposed, and evaporites are not known within the Aldridge, evaporites would be expected at the base of the section in a rift basin.