The Santa Maria Pb-Zn-Cu-(Au-Ag) Deposit, Camaquã Basin, Brazil: Insights into Hydrothermal System Evolution.

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Located on the Rio Grande do Sul state, the Santa Maria Pb-Zn-Cu-(Au-Ag) deposit is hosted by a volcano-sedimentary sequence of the Santa Bárbara Group, comprising siltstones, arkosic sandstones, sedimentary breccias and polymictic conglomerates with andesite flows and trachyte dykes. The ore is composed of sphalerite, galena and chalcopyrite with minor silver, gold, bornite and chalcocite in veins and disseminations in the sedimentary package.

Automated scanning electron microscopy mineral mapping (TESCAN TIMA) and SEM-EDS were carried out on 15 samples of unaltered and altered rocks. The original red sandstone has a framework composed of detrital K-feldspar, quartz, biotite, muscovite and apatite with calcite and hematite cements; weak sericitization of feldspars is sometimes observed. The hydrothermally altered rocks show cone inverted bodies associated with intersections of faults. The outer zone of hydrothermal alteration is marked by bleaching due to removal of the hematitic cement, stronger sericitization and illitization of K-feldspar and precipitation of barite. The inner sericite zone that envelops sphalerite, galena and minor chalcocite mineralization is defined by a quartz-sericite-pyrite paragenesis, with late siderite precipitation and incipient chloritization. Main copper mineralization occurs at greater depths as chalcopyrite disseminated or as vein-hosted, on a chlorite alteration halo associated with silicification and minor sericite.

EDS data from hydrothermal chlorite grains revealed compositions of brunsvingite, diabantite, pycnochlorite and ripidolite. Chlorite geothermometry temperatures range from 150 ºC to 360 ºC with lower temperatures distal to ore in the south of the deposit and higher in the north. The hydrothermal white mica is fine-grained, iron-rich muscovite; white micas interpreted to be detrital have muscovite composition. Fluorapatite was identified in two textural associations: one interpreted to be mainly detrital but a second in which it occurs associated with calcite and is possibly of diagenetic or hydrothermal.

LA-ICP-MS analyses of chlorite revealed enrichments in Ti approaching the Cu-rich veined core of the system while Zn, Pb and V contents being more enriched at shallower levels indicating a vertical advection of the fluid as it moves away from the vein system centre. In micas it revealed moderated Cu substitution closer to the ore veins; Cu, Pb and Zn in least-altered samples; higher Li in micas inside the chlorite halo and enrichment in Fe in micas at shallow levels in the north in relation to the ones in depth on the south.

Results shows an increasing acidity and sulfidation state of the fluid while ascending through structures of the wall rock. Chlorite temperatures are too high, implying that magmatism was associated and can be a proxy for the mineralization. Substitution of trace elements in alteration minerals shows a pattern of distribution of metals and possible assimilation of iron leached from wall

rocks to the fluid. Such conditions associated with magmatic signature of isotopic data ($\delta^{34}S_{sulfides}$: −2.6 to 1.1‰; $\delta^{34}S_{barite}$: 12 to 16.3‰; $\delta^{18}O_{H2O\text{-}chlorite}$: +7 to +3‰; $\delta D_{H2O\text{-}chlorite}$: −35 to −45‰) and tectonic setting from this and neighbour Cu-(Au) Uruguai mine deposit indicate the Zn-Pb as a shallow intermediate-sulfidation epithermal system emplaced during the rift phase of the basin on the Ediacaran.