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Mineralogical characterization and genesis of hydrothermal Mn oxides from the flank of the Juan the Fuca Ridge

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ABSTRACT

Several sites of active hydrothermal flow have been found on the eastern flank of the Juan de Fuca Ridge. These sites are typically located along the edge of basaltic outcrops where sediment is thin. We present data on Mn-oxides formed on such outcrops (Zona Bare and Grinin Bare). These oxides are either black-layered crust or soft micro-concretions found in partially altered sediments. X-ray diffraction (XRD) and scanning electron microscopy (SEM) analyses of Mn crusts indicate the presence of well-crystallized todorokite and birnessite encrusting detrital minerals and replacing siliceous fossil. Transmission electron microscopy (TEM) and energy dispersive X-ray spectroscopy (EDX) analyses were used to identify amorphous and poorly crystallized Mn-rich phases in partially altered sediments and crusts. TEM of impregnated samples showed textural evidence suggesting that amorphous Mn oxides are incrusting cellular structures that could be bacteria. The valence state of Mn in these oxides was determined by parallel electron energy loss spectroscopy (PEELS). Results indicate that todorokite and birnessite have an average valence state of about 3.7 whereas the poorly crystallized Mn-rich phases have a lower valence state. These data suggest that the formation of hydrothermal Mn concretions occurs in several steps. The initial step is the adsorption or precipitation of Mn, Fe, and Si around cell-wall bacteria, extracellular polymers, and siliceous fossil remains. These mineralizations are poorly crystallized phyllomanganates, which progressively increase in size and crystallinity to give the final birnessite and todorokite products. All of these Mn-rich phases are the result of interactions between hydrothermal fluid and sediments and formed in areas where hydrothermal fluids discharge through the sediment.