

Fluid and mineral geochemistry during experimental seawater-based serpentinization

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At (ultra-)slow spreading settings (mid-ocean ridges and rifted margins) mantle exhumation leads to the serpentinization of ultramafic rocks exposed at the seafloor. The hydrothermal alteration of primary iron bearing minerals such as olivine and pyroxene is often associated with the oxidation of the ferrous iron, coupled to the reduction of molecular water. Such a redox reaction leads to the release of molecular H₂, an energetic gas, also considered as a fuel-for-life in anaerobic environments. Additionally, serpentinization reactions may also be involved in the formation of (ultramafic-)volcanic massive sulfide (U-VMS) deposits in which numerous transition metals concentrate. The latter process implies important chemical fluxes, widely documented in the field, but still poorly investigated experimentally.

In order to understand the nature and intensity of chemical fluxes that occur during serpentinization, batch experiments including fresh lherzolite powder and natural seawater were conducted at 450 bar, from 225 to 325°C, and during 500 to 3290 h. Experimental products were characterized by SEM and XRD, and H₂ degassing was measured using gas chromatography. Major and trace element mobilities were investigated by: i) monitoring changes in fluid composition through time, and ii) analyzing reactant solid products at the end of experiments.

In all experiments the results show that primary minerals have been almost completely replaced by an assemblage of serpentine and magnetite. Minor amounts of calcite precipitate at 225, 280 and 325°C, while H₂ maximum production is achieved at 280-300°C, reaching 80-100 mmol/kg. Mass balance calculations show that transition metals such as Cr, Co, Ni and Zn are significantly transferred to the fluid, suggesting that serpentinite-derived fluids play a key-role in the formation of U-VMS. Hence, ophiolites bearing serpentinized mantle rocks may represent a potential resource of transition metals that may be targeted in exploration in the forthcoming years.