

Fluid circulation in the oceanic crust: The case of the alkaline springs of the Oman Ophiolite

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The Oman ophiolite is a very well preserved section of the oceanic lithosphere that has been thrust onto the Arabian continental margin during the Cretaceous. The role of fluids in the oceanic crust has been well documented by observations and data of high temperature fluid discharges at seafloor spreading centers collected during cruises over the last 30 years. The recent discovery of peridotite-serpentine outcrops at the Lost City site on the Mid-Atlantic ridge has shed light on a new type of hydrothermal activity producing high pH and low temperature fluids as well as large quantities of hydrogen. Similar alkaline waters are also found at springs located in the Oman ophiolites. The hydrothermal fluids of Oman originate from rain waters rather than seawater.

The aims of our project are the characterization of fluids reacting with peridotites exhibiting various degrees of serpentinization and the investigation of low temperature water rock interaction processes taking place at the springs (changes in fluid pH, formation of Ca and Mg hydroxides, carbonization reactions, fate of trace elements, etc).

A first exploratory field trip in December 2008 allowed us to collect samples of spring waters and precipitate at about twenty distinct locations over the entire Oman ophiolite. Most sites show evidence of degazing (hydrogen; A. Prinzhofer pers. com.). The precipitate samples analyzed by DRX and MEB analyses are composed of calcium carbonates (calcite or aragonite) and magnesium hydroxide (brucite). The springs waters are characterized by pH values and temperatures ranging from 6.6 to 12.2 and 20.2° to 65.5°C, respectively. The total alkalinity values vary between 0.9 to 5.9 mmol.kg⁻¹ compared to seawater at 2.3-2.4 mmol.kg⁻¹. Sr isotope compositions range between 0.705797 and 0.713106, and vary according to the fluid temperature. This is a first step toward an exhaustive geochemical and isotope study of the Oman ophiolite fluids discharge at the surface.

Mixing experiments of acid mine drainage and seawater

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High concentrations of yellowish and trace metal-bearing suspending nanoparticles of schwertmannite and non-crystalline Fe,Al oxyhydroxysulfate compounds occurring in the surface layers of estuarine and shoreline seawaters adjacent to the Chinkuashih acid mine drainage (AMD; pH = 2.8) area, northern Taiwan actuated our interest to investigate AMD-seawater interaction processes. Experimental products of laboratory mixing of Chinkuashih AMD and fresh seawater (pH = 8.0) at volume ratios up to 1 were analyzed by ICP-OES, ICP-MS, XRD, SEM, TEM and FTIR. The principal precipitates were identified to be schwertmannite and amorphous hydrous oxides of iron and aluminum (HFO & HAO) with increasing proportions of seawater during the transition of pH values from 3.0 to 7.8 in the mixed solutions. Three principal types of metal-element behaviors were observed in association with the precipitation during the mixing experiments including (1) rapid removals of Fe, As, Cd, Cr, and Pb at pH < 4-4.5 at high AMD/seawater ratios, (2) gradual and/or relatively small attenuations of Mn, Co, and Zn with increasing pH values, and (3) virtually no changes at low pH values and gradual or rapid removals of Cu and Al at pH > 4-4.5. The first phenomenon can be attributed to rapid crystallization and/or sorption of Fe, As, Cd, and Pb associated with the formation of schwertmannite. The third type of behavior can be ascribed to co-precipitation and/or sorption of Al and Cu in connection with the precipitation of the non-crystalline HFO-HAO compounds, while the second mode of actions might be simply a result of elemental sorption onto the solid precipitates. The results suggest that the precipitation/sorption of Cu and Al are greatly enhanced under conditions favorable for the formation of amorphous HFO instead of schwertmannite, concordant with the findings obtained from the Chinkuashih AMD-seawater mixing area.

