

## Mineral textures in Serpentine-hosted Alkaline Springs from the Oman ophiolite

Manolis Giampouras (1), Juan Manuel Garcia-Ruiz (1), Wolfgang Bach (2), Carlos J. Garrido (1), Karin Los (2), Dario Fussmann (2), and Monien Monien (2)

(1) Instituto Andaluz de Ciencias de la Tierra (IACT-CSIC), Avd. Palmeras 4, 18100 Armilla, Granada, Spain, (2) Geoscience Department, University of Bremen, 28359 Bremen, Germany

Meteoric water infiltration in ultramafic rocks leads to serpentinization and the formation of subaerial, low temperature, hydrothermal alkaline springs. Here, we present a detailed investigation of the mineral precipitation mechanisms and textural features of mineral precipitates, along as the geochemical and hydrological characterization, of two alkaline spring systems in the Semail ophiolite (Nasif and Khafifah sites, Wadi Tayin massif). The main aim of the study is to provide new insights into mineral and textural variations in active, on-land, alkaline vents of the Oman ophiolite. Discharge of circulating fluids forms small-scale, localized hydrological catchments consisting in unevenly interconnected ponds. Three different types of waters can be distinguished within the pond systems: i) *Mg-type*; alkaline ( $7.9 < \text{pH} < 9.5$ ),  $\text{Mg-HCO}_3$ -rich waters; ii) *Ca-type*; hyper-alkaline ( $\text{pH} > 11.6$ ),  $\text{Ca-OH}$ -rich waters; and iii) *Mix-type* waters arising from the mixing of *Mg-type* and *Ca-type* waters ( $9.6 < \text{pH} < 11.5$ ). Phreeqc geochemical speciation software was used to determine the saturation state and the relationship between the theoretical supersaturation ( $S$ ) and rate of supersaturation ( $S^\circ$ ) of solid phases. Simple mixing models using Phreeqc MIX\_code revealed good mixing correlation ( $R^2 \geq 0.93$ ) between measured and predicted values for K, Na, Cl, Mg and sulphate. Al, Ca, Si, Ba, Sr and TIC showed poorer correlations.

Mineral and textural characterization from different types of water and individual ponds were carried out by X-ray diffraction (XRD), Raman spectroscopy and field-emission scanning electron microscopy coupled to dispersive energy spectroscopy (FE-SEM-EDS). Aragonite and calcite are the dominant minerals (95 vol.%) of the total mineralogical index in all sites. *Mg-type* waters host hydrated magnesium carbonates (nesquehonite) and magnesium hydroxycarbonate hydrates (artinite) due to evaporation. Brucite, hydromagnesite and dypingite presence in *Mix-type* waters is spatially controlled by the hydrology of the system and is localized around mixing zones between *Ca-type* with *Mg-type* waters. Residence time of discharging waters in the ponds before mixing has an impact on fluid chemistry as it influences the equilibration time with the atmosphere. Acicular aragonite is the main textural type in hyper-alkaline *Ca-type* waters, acting as a substratum for the growth of calcite and brucite crystals. Low crystallinity, dumbbell shaped and double pyramid aragonite dominates in *Mix-type* water precipitates.

Rate of supersaturation is essential for precipitation intensity and textural variation among the mineral assemblages in the different water types. Low  $S/S^\circ$  ratios in *Mg-type* and *Ca-type* waters ( $< 1$ ) reveal limited precipitation. Chemical reactions that lead to rapid mineral formation are enhanced in cases of *Mix-type* waters characterized by higher  $S/S^\circ$  ratios ( $> 1.2$ ). Detailed investigation of individual spring sites allowed the determination of geochemical and hydrological factors controlling the phases and textures of mineralogical assemblages in active, serpentinization-related, alkaline environments.

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