OLIVINE AQUEOUS ALTERATION UNDER LOW T CONDITIONS IN THE PRESENCE OF AMMONIA – A CASE FOR OCEAN MOONS

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Introduction: Hydrothermal processes are proposed to be one of the most important geological processes that affect the cycling of bio-essential elements not only on Earth but on other planetary bodies of the Solar system. The most popular environments for aqueous alteration processes on Earth are hydrothermal systems such as those found in Lost City, the active alkaline hydrothermal field discovered in 2000, at the mid-Atlantic ocean.

One of these alteration processes, and the one we are currently working on, is called serpentinization and consists in the aqueous alteration of olivine to form minerals of the serpentinite group. On Earth, they are part of rocks from the ultramafic upper mantle and mafic oceanic crust.

The hydrothermal alteration studies under these constraints is of paramount importance for the experimental validation and characterization of geochemical models suggesting the existence of a potential habitable water ocean in contact with active hydrothermal vents on the seafloors beneath the icy shell of ocean worlds (e.g. Europa and Enceladus). Recent discoveries and spacecraft-based observations point to ongoing hydrothermal activity on Enceladus [1] and the presence of such activity is also proposed for Europa [2, 3]. The chemical species detected by the INMS (Ion and Neutral Mass Spectrometer) instrument aboard Cassini support the hydrothermally active scenario, the internal structure of Jupiter's moon, Europa, is proposed to be similar to Enceladus. This work is focused on how material and energy exchanges between the rocky and aqueous layers.

Methodology: Laboratory experiments are conduced under low pressure, relative low temperature (90ºC), and starting pH ~8. Ten distinct series were prepared and incubated in 27 ml vials, gassed with N_2.

Results and Discussion: Structural and compositional studies were performed, using XRD, IR and SEM-EDS, of the resulting minerals of he series incubated for 51, 125, 215 and 344 days. We could observe the formation of rosette-like structures, on the surface of both hortonolitic glass and crystalline forsterite. The growth and complexation of these structures accompanies the addition of higher quantities of awaruite catalyst to the system; it could also be observed substantial visual differences between the rosettes grown with and without ammonia present, the combination of these two elements increases further the growth rate of these honeycomb and rosette-like structures. Mobilization of elements during the alteration is registered.

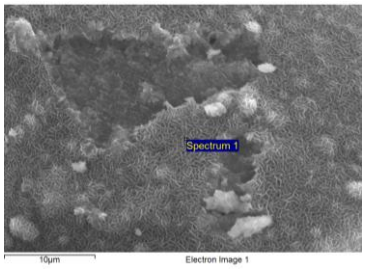

Figura 1: Reaction surface exhibiting rosette-like structures from a vial containing ammonia, awaruite and hortonolitic glass (Sample designated by Vial 5 Series 2 – incubated for 215 days - Image obtained with SEM – JEOL 5600 LV.)

Exploration and Study of Ocean Worlds: Experiments such as this are important to understand and detect the kind of aqueous alteration processes that occurred (are still occurring) on ocean worlds. Through them we can use the data collected by Cassini on Enceladus' plumes and in the future by the missions exploring Europa to better know identify the processes behind the results obtained *in situ*.

References: [1] Hsu H.W. et al. (2015) *Nature*, 519, 207-210 [2] MCCollom T.M. (1999) *J.G.R.*, 104-E12, 30.729-30.742 [3] Zolotov M.Y. and Shock E.L. (2003b), *J.G.R.*, 108 (E4), 5022

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