

SERPENTINIZATION ON OCEAN WORLDS – A STUDY IN INFRARED. J. Neto-Lima¹, M. Fernández-Sampedro¹ and O. Prieto-Ballesteros¹, Centro de Astrobiología, INTA-CSIC, Carretera de Torrejón a Ajalvir, km4, 28850 Torrejón de Ardoz – Madrid Spain (jlima@cab.inta-csic.es).

Introduction: We report the results obtained from laboratory experiments in which we reacted basaltic glass with anoxic basic carbonate saturated solution at constant temperature of 90°C, the lowest temperature where formation of methane occurs on Earth [1]. The mineral alterations are monitored in the presence of different amounts of a Fe-Ni catalyst (awaruite) and ammonia, using XRPD, IR, SEM-EDS and RAMAN. Our initial focus is to monitor the evolution of the Fe-rich basaltic glass, from this analysis we will use more techniques to characterize and possibly quantify the reactions that are taking place throughout the incubation period each series is submitted to. These studies are important to understand serpentinization processes and its role on the geological evolution and potential habitability of the planetary bodies of the Solar System and beyond. The latest planetary missions confirmed the existence of global oceans or paleo-oceans [2], therefore understanding the constraints of aqueous alteration reactions such as serpentinization is paramount to perceive the geochemical reactions responsible for the evolution of these worlds. This is the first long term study and monitoring of a low temperature and low pressure serpentinization simulation experiment, where it can be observed the production of serpentine group minerals and serpentinization secondary minerals (p.e. hydrated minerals).

Serpentinization as geological driver of key chemical elements. Some of the ocean worlds, are far from the sun and rely mostly on the energy provided by tidal stress heating while orbiting their main planet, so the high temperatures registered in some serpentinization systems on Earth are hardly expected to occur. Therefore this work focuses on the lower end of the temperature where serpentinization occurs and can lead to the formation of methane [1].

Serpentinization Simulation Experiment: These incubation experiments use Fe-rich basaltic glass, under low pressure (1bar) and low temperature (90°C). Ten distinct series were prepared and placed in sealed 27 ml borosilicate vials, gassed with N₂ and placed in an oven [3][4].

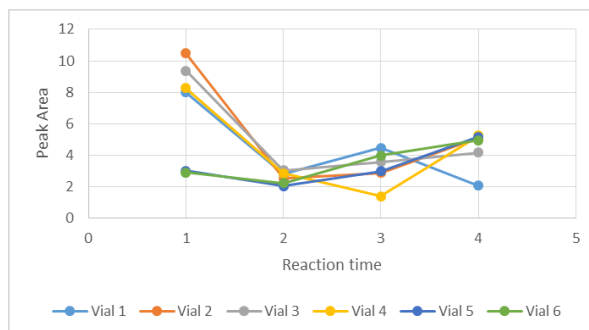
Results and Conclusions: These results presented here are for the MIR analysis performed on the Experimental Series 1 through 4.

	Incubation Days
Serie 1	125 days
Serie 2	215 days
Serie 3	344 days
Serie 4	436 days

Table 1 - Incubation Periods

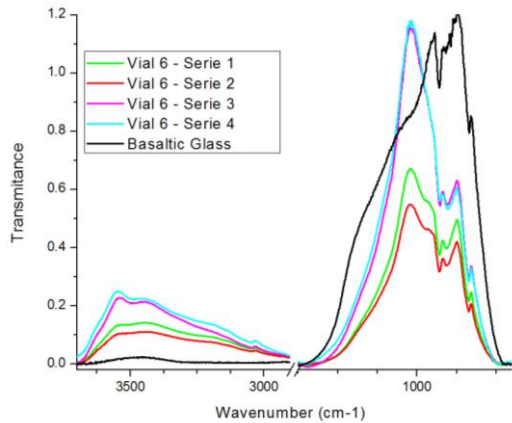
The FTIR spectra were obtained using a Nexus 670 spectrometer, equipped with an IR light source, a KBr beamsplitter and a DTGS KBr detector. For each analyzed sample, 128 scans are performed in the 4000-400cm⁻¹ spectral range with a resolution of 2cm⁻¹. Fine powders of the samples were prepared for infrared analysis using CsI (extra pure Cesium Iodide from Riedel-de Haën, for optical use) and pressed using the disk technique.

After 436 days of incubation, we detect the presence of a new group of bands in the MIR spectra of our samples, at around 3700cm⁻¹ to 3000cm⁻¹, corresponding to the Si-OH band vibrations of hydrated minerals, the intensity of these bands also increases with time and when ammonia is present in the system.



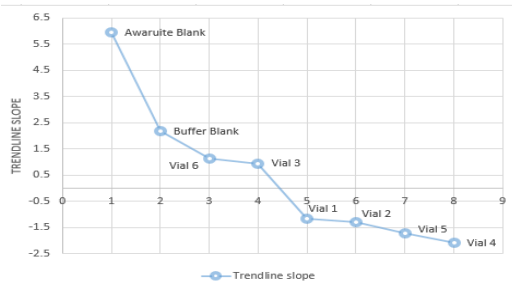
Graph 1 - H₂O bending vibration - Band peak Intensity Timestep (reaction time from day 125 to day 436).

It is also observed the shift of the Si-O-Si asymmetric stretch of the basaltic glass towards higher frequencies, which indicates that a cation is being incorporated into the mineral structure [5].



Graph 2 - Timestep MIR spectra stack of Vial 6 (reaction time from day 125 to day 436)

It was also observed that the vials that contained higher amounts of Ni-Fe catalyst (awaruite), were also the ones that presented the highest oxidative state, only second to the blank vials with no awaruite or no carbonate buffer solution.



Graph 3 - Oxides Band Assignment - Trendline slope Variation

In some vials with the catalyst, was observed appearance of N-O band even in samples where no ammonia was introduced in the system. We believe that our catalyst could be responsible for the mobilization of the N_2 used to gas the vials, after such long incubation period [6].

References: [1] Horita, J., and Berndt, M.E. (1999), *Science*, 285, 1055-1057. [2] OPAG (2017), RTOW. [3] Neto-Lima J. et al. (2017) LPSC. [4] Neto-Lima J. et al. (2016) LPSC. [5] Povarennykh, A.S. (1978), *American Mineralogist*, 63, 956-959. [6] Smirnov, A. et al. (2008), *Geochemical Transactions*, 9:5.