

**LOW TEMPERATURE APPROACH TO SERPENTINIZATION PROCESSES ON OCEAN WORLDS** – J. Neto-Lima<sup>1</sup>, M. Fernández-Sampedro<sup>1</sup> and O. Prieto-Ballesteros<sup>1</sup>, 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, in the presence of different amounts of a Fe-Ni catalyst (awaruite) and ammonia, at constant temperature of 90°C, the lowest temperature where formation of methane occurs on Earth [1]. The mineral alterations are monitored using XRPD, IR, SEM-EDS, XPS and RAMAN. The latest planetary missions confirmed the existence of several global oceans or paleo-oceans [2] throughout our solar system, 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 and their potential habitability. 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. oxides).

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

**Serpentinization Simulation Experiment:** Due to our interest in methane formation during serpentinization through Sabatier and FTT reactions, we opted to focus mostly on experimental batches with a Fe-rich basaltic glass [3], with a Mg-rich olivine series as control as means of comparing the effect of Fe or Mg-rich starting materials in the final mineralogy. It is known that the release of the dihydrogen that will be used for the formation of methane comes from the oxidation of the iron from the olivine to iron oxides (p.e. magnetite, goethite), hence the importance of an iron-rich olivine. When serpentinization fluids contact with a CO<sub>2</sub>-rich solution, under certain pH and temperature conditions it can lead to the formation of hydrocarbons.

**Results and Conclusions:** We followed mineral changes during low temperature serpentinization by MIR analysis and the oxidation state of the elements by XPS of the Experimental Series 1 through 4 (from 125 days to 436 days of incubation). Fine powders of the

samples were prepared for analysis with CsI and using the disk technique.

Regarding MIR, features of serpentinization are:

The O-H stretching band is clearly observed in evenly reacted vials. Located in the range from 3700cm<sup>-1</sup> to 3000cm<sup>-1</sup>, corresponding to the Si-OH band vibrations of hydrated minerals. The intensity of these bands increases with time, when ammonia is present in the system and when awaruite nanoparticles are added to the system. The asymmetry of this band is due to the presence of two individual bands: one at ~3600cm<sup>-1</sup> and another at ~3400cm<sup>-1</sup> [4]

The Si-O-Si asymmetric stretch of the basaltic glass also shifts towards higher frequencies, which indicates that a cation is being incorporated into the mineral structure [5][6].

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.

The appearance of two bands at ~3030cm<sup>-1</sup> and ~2800cm<sup>-1</sup> occurs in vials where NH<sub>3</sub> was added, vials with larger amounts of awaruite and with longer periods of incubation. We can attribute these two bands to the C-H stretch (asymmetric and symmetric respectively). Also, in some vials with awaruite it was observed the appearance of N-O band even in samples where no ammonia was introduced in the system at ~1400cm<sup>-1</sup>. Preliminary XPS results confirm the presence of Nitrogen in these vials. So we believe that our catalyst could be responsible for the mobilization of the N<sub>2</sub> used to gas the vials, after such long incubation period [7]. We can attribute the appearance of these bands to the formation of organic compounds (such as aldehydes and nitrogen-bearing composites.) throughout the duration of the incubation.

**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] Smith, B.C., (1999), *CRC Press LLC*. [4] Osawa, T. et al. (2005), *Met. & Plan.Sci.*,40,71-86. [7] Smirnov, A. et al. (2008), *Geochemical Transactions*, 9:5.