

**PHASE STABILITY EXPERIMENTS OF HYDRATED MAGNESIUM SULFATES AT ENVIRONMENTAL CONDITIONS OF MARTIAN SURFACE.** O. Prieto-Ballesteros<sup>1</sup>, D. Fernandez-Remolar<sup>1</sup>, E. Mateo-Martí<sup>1</sup>, M. Fernandez-Sampedro<sup>1</sup>, J.S. Kargel<sup>2</sup>, L. R. Friedlander<sup>3</sup>, J.A. Martín-Gago<sup>1,4</sup> and R.E Arvidson<sup>3</sup>, <sup>1</sup>Centro de Astrobiología-INTA, Ctra. Ajalvir km. 4, 28850 Spain ([prietobo@inta.es](mailto:prietobo@inta.es), [fernandezrd@inta.es](mailto:fernandezrd@inta.es), [mateome@inta.es](mailto:mateome@inta.es), [fernandezsm@inta.es](mailto:fernandezsm@inta.es)). <sup>2</sup>Dept. of Hydrology and Water resources, University of Arizona, Tucson, USA ([kargel@hwr.arizona.edu](mailto:kargel@hwr.arizona.edu)). <sup>3</sup>Washington University in St. Louis, MO 63130, USA ([lrfriedl@artsci.wustl.edu](mailto:lrfriedl@artsci.wustl.edu), [arvidson@wunder.wustl.edu](mailto:arvidson@wunder.wustl.edu)). Instituto de Ciencia de Materiales de Madrid (CSIC), Cantoblanco 28049 Madrid, Spain ([gago@icmm.csic.es](mailto:gago@icmm.csic.es)).

**Introduction:** Spectroscopic signals of hydrated magnesium, calcium and hydroxylated iron sulfates have been recently detected on surface of Mars [1, 2, 3]. Magnesium sulfate may appear with different hydration states in terrestrial environments ( $n\text{H}_2\text{O}\cdot\text{MgSO}_4$ ), such as in soils and evaporitic lakes of arid and semiarid regions and in volcanic fumaroles. Common minerals include epsomite ( $n=7$ ), hexahydrate ( $n=6$ ) and kieserite ( $n=1$ ), which are among the most stable phases reported in many laboratory studies, but other hydration states also are found in nature and in the laboratory under various conditions. Stability of sulfate hydrates at the environmental conditions of the martian surface are being explored [4].

Reflectance spectroscopy data from spacecraft and rovers are usually interpreted with mineral databases obtained for terrestrial conditions. However, environmental conditions at martian surface could produce alterations on the standard mineral spectra. Expected effects on hydration states include extremely high hydration states due to low temperatures ( $n=11$  or  $12$  when ice is also present) and reduction of hydration states due to extremely low relative humidities prevalent in many regions or low water fugacities caused by extremely acidic conditions in some circumstances. Extreme thermal and humidity cycling (diurnal and annual cycles) are expected to be very important in causing changes in the hydration states of some sulfates on the surface and in the near subsurface layers. While perhaps not geologically significant, these are the zones that are optically sensed or which may be penetrated by rover wheels and simple coring and trenching devices; hence, they are important to understand so that geological and geochemical models may account for the changes that may occur in the soil and rock layers accessible to our surface instruments and orbiting sensors. These surficial layers also may be important during diagenesis of primary deposits, and so the geologic rock record at deeper buried levels may record evidence of those diagenetic surficial environments.

Severe ionizing ultraviolet radiation also may damage hydrate sulfate crystal lattices, amorphize them, or break down the sulfates all together, as apparently is

common on Europa both from UV and magnetospheric charged particles.

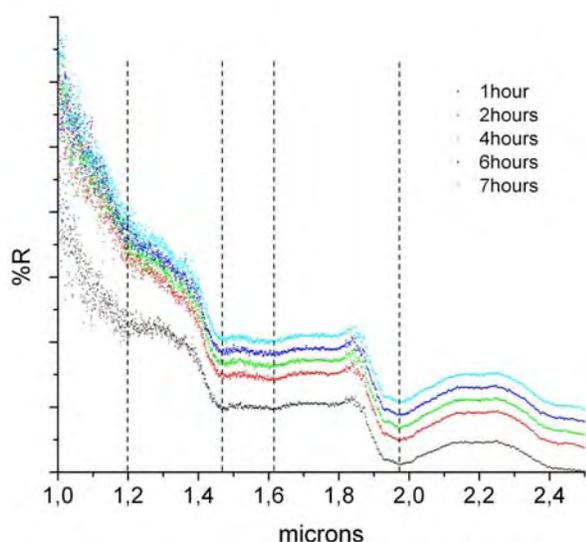
Some experiments using environmental conditions of the martian surface (temperature and pressure ranges; atmospheric composition, including water vapor content; and ultraviolet radiation) of different sulfates have been performed in order to both, constrain the stability of the hydrated phases and detect any possible modification in their spectra. Here we present the preliminar results for hydrated magnesium sulfates.

**Methods. The simulation chamber:** Experiments have been done in a simulation chamber located in Centro de Astrobiología, Madrid. The equipment has been developed for a wide range of simulation conditions, including a range of irradiation sources, and the implementation of analytical techniques, including IR and UV spectroscopy and mass spectrometry. The equipment consists of a main vacuum chamber with dimensions of 50 cm long x 40 cm diameter, a second internal chamber connected by differential pumping with the main one, and a third side chamber for the gases analysis using a mass spectrometer. Chambers pressures are monitored by different pirani-penning gauges. A liquid nitrogen cooling system is connected to the sample holder, and a gas system allows the mixing of gases and water [5].

For simulating the surface of Mars 6 mbars has been used as the average atmospheric pressure of the planet, temperature cycles were programmed from 140 to 300K, and the composition of the atmosphere used was 95%CO<sub>2</sub>, 2.7% N<sub>2</sub>, 1.6% Ar and 0.6% H<sub>2</sub>O. The UV radiation environment was provided by a deuterium lamp from 200 to 400 nm.

Experiments have been conducted in three series of runs in order to evaluate each parameter independently: a) temperature, b) radiation, and c) relative humidity. All runs used epsomite samples as the starting phase. Each phase was confirmed by ex-situ XRD before and after the experiments in the simulation chamber. Temperature and relative humidity analysis have been also performed using a DSC for controlling the thermal stability of the hydrated phases and constrain-

ing the phase diagram of this sulfate at surface conditions of Mars.



**Fig. 1.** Spectral evolution of epsomite during 7 hours of ultraviolet irradiation.

**Spectra at martian conditions:** Spectra of the magnesium sulfate phases have been obtained at martian pressure and every 20 K in the range of temperature from 140 to 300 K. Epsomite is stable at martian surface conditions until 280 K, but at 300 K is transformed to hexahydrate.

Ultraviolet radiation was applied while maintaining the sample at 200K and 6 mbars. These environmental conditions maintained epsomite stability during the 7 hours of experiment, but the spectral band at 1.2 microns became less obvious after the first hour of irradiation; thereafter for the remaining 6 hours of the experiment, this altered phase remained spectroscopically constant (Fig.1).

The analysis of the spectral evolution related to the relative humidity in the martian atmosphere is already in progress.

**References:** [1] Gendrin A. et al. (2005) *Science* 307, 1587-1591. [2] Langevin Y., et al. (2005) *Science* 307, 1584-1586. [3] Ardivison R.E., et al. (2005) *Science* 307, 1591-1594. [4] Vaniman D.T., et al. (2004) *Nature* 431, 663-665. [5] Mateo-Martí, E., et al. (2006) *Measurement Science & Technology* 17 (8), 2274-2280.