EPSC Abstracts
Vol. 15, EPSC2021-11, 2021, updated on 26 May 2022
https://doi.org/10.5194/epsc2021-11
Europlanet Science Congress 2021

Characterization of NH_4-montmorillonite coexisting with NH_4Cl salt at different aggregation states. Application to Ceres.

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Ceres, dwarf planet of the main asteroid belt, is considered a relic ocean world since the Dawn mission discovered evidences of aqueous alteration and cryovolcanic activity [1]. Unexpectedly, a variety of ammonium-rich minerals were identified on its surface, including phyllosilicates, carbonates, and chlorides [2]. Although from the Dawn's VIR spectroscopic data it was not possible to specify the exact type of phyllosilicates observed, montmorillonite is considered a good candidate owing to its ability to incorporate NH_4^+ in its interlayers [3]. Ammonium-rich phases are usually found at greater distances from the Sun. Hence, the study on their stability at environmental conditions relevant to Ceres' interior and of its regolith can help elucidate certain ambiguities concerning the provenance of its precursor materials.

In this study, it was investigated the changes in the spectroscopic signatures of the clay mineral montmorillonite after (a) being immersed in ammonium chloride aqueous solution and, subsequently, (b) washed with deionized water. After each treatment, samples were submitted to different environmental conditions relevant to the surface of Ceres. For one experiment, they were frozen overnight at 193 K, and then subjected to 10^{-5} bar for up to 4 days in a Telstar Cryodos lyophilizer. For the other, they were placed inside the Planetary Atmospheres and Surfaces Chamber (PASC) [4] for 1 day at 100 K and 5.10^{-8} bar. The combination of different techniques, i.e., Raman and IR spectroscopies, XRD, and SEM/EDX, assisted the assignment of the bands to each particular molecule. In this regard, the signatures of the mineral external surface were distinguished from the interlayered NH_4^+ cations. The degree of compaction of the samples resulted crucial on their stability and spectroscopic response, being stiff smectites more resistant to low temperatures and vacuum conditions. In ground clay minerals, a decrease in the basal space with a redshift of the interlayered NH_4^+ IR band was measured after just 1 day of being exposed to vacuum conditions.

Acknowledgments

This work was supported by the Spanish MINECO projects ESP2017-89053-C2-1-P and PID2019-107442RB-C32, and the AEI project MDM☐2017☐0737 Unidad de Excelencia "María de

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