CRYOVOLCANIC LABORATORY EXPERIMENTS ON CARBONACEOUS CHONDRITES

J. Nava[1], A. Maturilli[2], F. Zambon[3], C.Carli[3], G. Alemanno[2], J. Helbert[2], S. Genovesi[4] and M. Massironi[1],
[1]University of Padova, Department of Geosciences, Via G.Gradenigo 6, 35131 Padova, Italy (jacopo.nava@phd.unipd.it), [2]Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany, [3]IAPS-INAF, Istituto Nazionale di Astrofisica e Planetologia Spaziali, Roma, Italy, [4]Università degli Studi di Bologna, Dipartimento di Geologia, Bologna, Italy.

Introduction: Cryovolcanism is a process that affected many different planetary bodies such as asteroids, satellites and TNOs like Ceres [1], Europa and Enceladus [2-3] and Charon [4]. Although prerequisites for cryovocanicm have been delineated by [5], cryovolcanic processes and related products are still not well understood. For this reason we made some experiments in laboratory with Carbonaceous Chondrites (CCs) and ices to try to recreate a cryovolcanic process.

Methods: Experiments were carried out at the DLR PEL laboratory in Berlin. We powdered 3 CCs: FRO90006, FRO99040 and MCY14014. We mixed FRO99040 with deionized water and FRO90006 and MCY14014 with ammoniated water (mixtures were aroud 20-30% water and 80-70% meteorite). We put the mixtures in the dryer for around 30 minutes to avoid the formation of atmospheric frost and then we froze them at -80°C. Once frozen the mixtures were put in a cup with liquid nitrogen to preserve the temperature and then transferred into a vacuum chamber equipped with plates capable of heating up the samples. Samples were heated from around -100°C (due to liquid nitrogen) up to 100°C in few minutes. Once the experiments finished we acquired reflectance spectra in the NIR range and compared them with spectra of the original samples acquired before the experiment.

Petrography: FRO99040 and FRO90006 are CO3 chondrites while MCY14014 is a CM2. FRO99040 and FRO90006 are mainly made of olivine and pyroxene, metal is abundant (~10%) and also CAIs containing fassaite, garnets, spinel and melilite are found. MCY14014 is mainly composed of olivine, widespread phyllosilicates, minor calcite crystals often associated to troilite, FeNi alloys are generally rare.

Results: During the heating process the samples started to outgas fine particles at T~ -20°C. Between around -5°C and 0°C FRO99040 and MCY14014 also experienced a violent episode, after which outgassing of fine particle ceased. This outburst was not observed during FRO90006 heating, which gradually stopped outgassing particles. The ejected outgassed powders of FRO90006 and FRO99040 always show absorption bands around 3.4-3.5 µm while previous of the degassing process and on the powders that remained in the sample holder this feature is not seen. Ejceted outgassed powders of MCY14014 still show the absorptions at 3.4-3.5 µm, but less prominently.

Discussion: The 3.4-3.5 µm absorption bands may thus be tracers for hydrothermal-cryovolcanic processes. This band is usually attributed to organic compound [6]. This experiment also gives information on the temperature and pressure range over which cryovolcanism and hydrothermal activity may be active on an icy body. In fact, outgassing of particles started at T~20°C with an explosive event around 0°C. Considering that on bodies like Ceres brines and salts are also involved in cryovolcanism [1], these temperatures may be even lower. Pressure in the evacuated chamber was ~ 10^{-4} Bar. Furthermore the shallow 3.4-3.5 µm bands in the MCY14014 sample compared to the prominent ones in FRO99040 and FRO90006 suggest that the primary mineralogies play an important role on the formation of cryovolcanic material and rule out laboratory contaminations of the samples. On the contrary the composition of the fluid (deionized water versus ammoniated water) doesn't seem to strongly affect the products characteristics.

Acknowledgements: Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208. We are also grateful to the MNA (Museo Nazionale dell'Antartide, Siena, Italy) for the loan of the meteorite samples, in particular we want to thank Luigi Folco and Sonia Sandroni for the support.

References: [1] Ruesch O. et al. 2016. *Science* 353:6303. [2] Quick L.C. et al. 2017. *Icarus* 284:77-488. [3] Postberg F. et al. 2009. *Nature* 459:1098-1101. [4] Desch S.J. and Neveu M. 2016. *Icarus*, *287*:175-186. [5] Neveu M. et al. 2015. *Icarus* 246:48-64. [6] De Sanctis M.C. et al. 2017. *Science* 355:719-722.