**SPECTRAL INVESTIGATION OF HYDROTHERMALLY ALTERED VOLCANIC DEPOSITS OF MILOS AS A MARTIAN ANALOG.** K. Stephan[1], S. Xydous[2], S. Manimanaki[2], R.J. Wagner[1] and A. Solomonidou[3], M. Baque[1] K. Rammelkamp[4] [1]Institute of Planetary Research, DLR, Berlin, Germany, [2]Agricultural University of Athens, Athens, Greece, [3]Hellenic Space Center, Athens, Greece, [1]Institute of Optical Sensor Systems, DLR, Berlin, Germany, (Katrin.Stephan@dlr.de).

**Introduction:** For the study of past environmental conditions on Mars, the knowledge of complete inventories of minerals characteristic for specific geologic environments are essential [1]. Previous studies of regions on Earth suitable as analog for studying geological processes on planetary surfaces such as Vulcano island (Italy) [2] already enabled the identification of numerous secondary sulfate minerals formed by acid alteration of volcanic deposits due to fumarolic activity. VIS-NIR spectra of these minerals are useful for the comparison with spectral data acquired by past and present Mars missions. In this work, we present the first results of a new comparative study of alteration minerals that could be measured on the volcanic island Milos (Greece) during field work performed in 2024.

**Geological Setting:** Milos is a volcanic island in the Aegean Sea and a part of the subduction-related South Aegean Volcanic Arc [3].

In several locations, the volcanic rocks of Milos display variable degrees of hydrothermal alteration. The hydrothermal activity changed the initial composition of the rocks and led to the formation of various secondary minerals - making the island an ideal location to complete our spectral library, coupled with geologic context information.

**Measurement Locations:** Spectral measurements presented here were performed with a portable VIS-NIR spectrometer operating at wavelengths between 0.35 and 2.5 µm, in two locations on the island: 1) a persistently active fumarolic field in the area of Kalamos Dome and 2) an abandoned sulfur mine at Paliorema, where sulfur was mainly extracted from underground deposits.

**Detected Mineral Assemblages:** Both locations reveal a variety of alteration minerals, in particular sulfates next to native sulfur. Similar to what could be identified on Vulcano, alteration minerals on Milos are dominated by Fe and Al bearing sulfates. However, whereas sulfate minerals such as jarosite ($KFe_3^{3+}[(OH)_6|(SO_4)_2]$) and alunite ($KAl_3[(OH)_6|(SO_4)_2]$) being dominant on Vulcano, different hydrous phases, such as copiapite ($Fe^{2+}Fe^{3+}_4[(OH)_2|(SO_4)_6]$ x $20H_2O$) and alunogene ($Al_2[SO_4]_3$ x $17H_2O$) are prominent in the area of the Kalamos. This also accounts for hydrated silica, the typical alteration residue. In contrast to Vulcano, where silica occur as amorphous silica gel [4], silica on Milos have a higher water content and crystallinity, mainly identified as chert and chalcedony (Fig. 1).

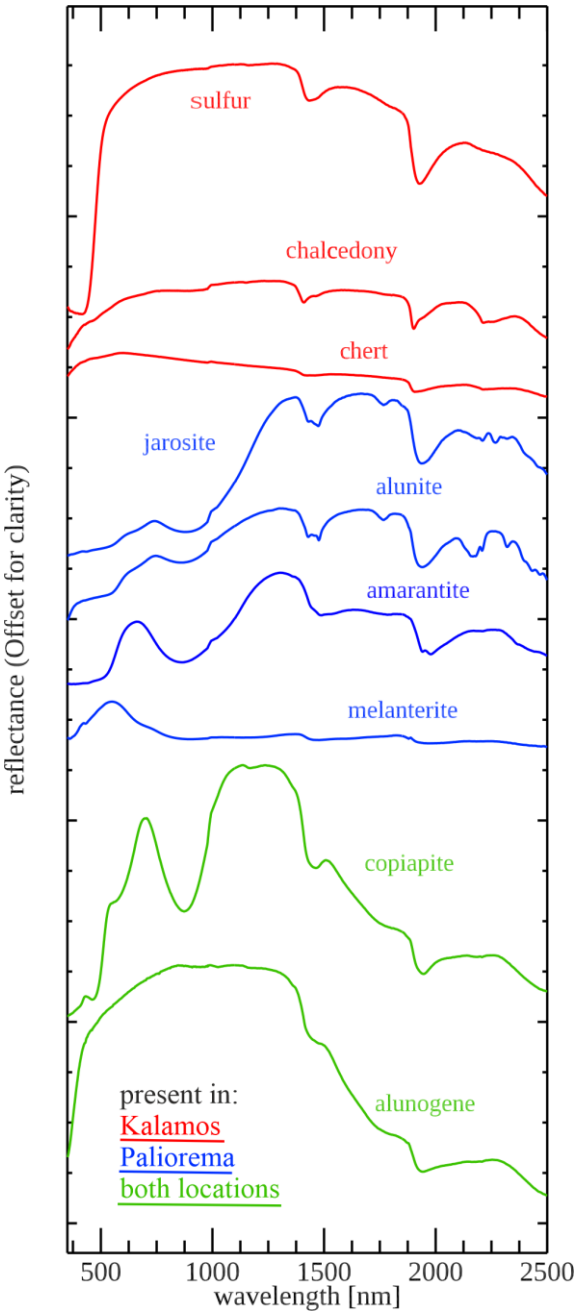


Fig. 1: Minerals identified based on the field spectra measured in the area of the Kalamos Dome and the sulfur mine of Paliorema.

The fossilized hydrothermal system at Paliorema displays more mineralogical diversity. There we have identified jarosite and alunite and also alunogene and copiapite (Fig. 1). Additionally, we see spectral evidence for secondary mineral phases such as melanterite ($Fe^{2+}SO_4$ x $7H_2O$) and the rare secondary minerals amarantite $Fe_2^{3+}[O|(SO_4)_2]$ x $7H_2O$).

**Discussion:** The identified minerals are known to occur in the vicinity of fumaroles and are expected to result from the direct interaction between the surface material of the volcanic rocks and fumarolic gases [4]. Secondary minerals form through leaching of the volcanic rock surface leaving silica behind. Some minerals can also directly precipitate from volcanic gases. The diversity of hydrous minerals compared to what could be observed on Vulcano island in Italy [2] implies more complex aqueous settings in the formation environments and possible dehydration pattern. The study of altered volcanic deposits on Milos, with its diverse mineralogical assemblages, provides valuable analogs for understanding similar processes on Mars.

For instance, the detection of sulfates, hydrated silica, and other secondary minerals on Milos mirrors mineralogical findings from Martian regions like Gale Crater and Meridiani Planum [5]. These parallels suggest that fumarolic and hydrothermal systems on Mars may have fostered similar alteration processes, offering clues about the planet's past habitability.

**Future Work:** Future work will involve detailed laboratory analyses of Milos samples using VIS-NIR, LIBS, and Raman spectroscopy to expand the mineralogical inventory and refine the spectral library [1]. Comparative studies with Mars mission datasets and further fieldwork in unexplored areas of Milos will follow to validate findings and enhance the calibration of instruments for future planetary missions. These efforts aim to deepen the understanding of hydrothermal alteration processes and their implications for Martian geology and habitability.

**References:** [1] King P. L. and McSween H. Y. (2005) JGR, 110, E12, doi:10.1029/2005JE002482. [2] Stephan K. et al. (2024) EPSC, Abstract #830, doi:10.5194/epsc2024-830. [3] Fytikas M. et al. (1986) J. Volcanol. Geotherm. Res., 28, 297-317. [4] Rice et al. (2013) Icarus, 223, 499 – 533. [5] Vaniman D. T. et al. (2004) Nature, 431, 663–665.