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Pedogenetic processes on Mars

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Clay minerals, such as Fe/Mg smectite and Al-rich phyllosilicates (i.e. montmorillonite and kaolinite) were detected in the last years on Mars by numerous missions[1,2]. These minerals can be formed by fluid/rock interaction. Therefore, their study may provide important information on the climatic conditions and consequent habitability of the Martian surface. In this work we compare the mineralogy observed with CRISM data in the eastern part of Valles Marineris (Coprates-Ganges-Capri-Eos Chasmata), Margaritifer Terra and Margaritifer Chaos regions, with soils sampled on the Etna volcano (Sicily) and Cerviero Mount (Calabria, Southern Italy). We use an integrated approach of remote sensing coupled with pedological, petrographical and mineralogical investigations. Our purpose, here, is to find possible analogies between some Andosols developed on the basaltic substrates of Etna and Cerviero Mount, and the Martian soils, based on their spectral response and formation processes.
CRISM data show poor abundance of clay minerals, such as illite, smectite and montmorillonite, in the eastern part of Valles Marineris. On the contrary, these phases are widely exposed in the Margaritifer Terra and Margaritifer Chaos, where we detected allophone (poorly crystalline clay), vermiculite, chlorite and other phyllosilicates belonging to the smectite group, such as saponite and nontronite. The surrounding area shows dominant signatures of basaltic composition.Our preliminary analysis on terrestrial soil profiles, using X-ray diffraction analysis, shows similar characteristics to Mars in terms of bedrock composition and clay mineralogy. Etnean soils, formed from lavas and pyroclastics of various ages (from 12 ka to 122 BC) [3] show the presence of clay minerals, such as kaolinite and small amounts of illite. The Cerviero Mount soils, developed on pillow basalts of Maastrichtian-Paleocene ages [4] are composed of vermiculite, illite, chlorite and interstratified clays such as, kaolinite/smectite and vermiculite/chlorite. These clay minerals likely form through weathering processes of plagioclase (andesine) and mica minerals (chlorite and muscovite) from the basaltic substratum. The alteration of glass in hydrothermal conditions could be an additional hypothesis to explain the occurrence of these minerals on Mars. Furthermore, CTX and HIRISE images showed that these clay deposits are generally located in morphological depressions, where we also observed polygonal structures (size range between 10-35 m) resembling mud cracks, as an evidence of small lacustrine basins. Although weathering processes are reasonably faster under humid and warm climate conditions on Earth, we suppose that they may occur as analogues on Mars.

References: [1] Mustard et al.,2008, Nature,454,305-309; [2]Carter et al.,2013,JGR,118,1-28; [3]Branca et al.,2011, Italian Journal of Geosciences,130,3; [4]Iannace et al., 2007, Journal of the Geological Society of London, 64, 1165-1186.