Clay formation in Margaritifer Chaos, Mars

Lucia Marinangeli

Dep. of Psychological, Health & Territorial Science (DiSPuTer), Univ. G. d'Annunzio, Chieti, Italy

e-mail: lucia.marinangeli@unich.it

Anna Chiara Tangari, Loredana Pompilio

Dep. of Psychological, Health & Territorial Science (DiSPuTer), Univ. G. d'Annunzio, Chieti, Italy

Fabio Scarciglia, Eugenio Piluso

Dipartimento di Biologia, Ecologia e Scienze della Terra (DiBEST), Università della Calabria, ,

87036 Arcavacata di Rende, Italy

Abstract: Clay formation processes on Mars is thought to have been occurred early in its geological history, however reactivation of slope features (RSL) likely due to brine melting during the summer season has been extensively observed on recent data (Muskin, 2010; McEwen, 2014) suggesting that chemical alteration of bedrock still occurs at places. The OMEGA and CRISM spectrometers revealed the presence of different hydrated minerals, including clay minerals, sulfates, carbonates and chlorides (Bibring et al.,2006; Mustard et al., 2008), located in several areas of the Martian surface.
The formation processes of clay minerals on Mars (Chevrier et al., 2007; Ehlmann et al., 2013; Meunier et al., 2012; Bristow et al., 2015) is crucial to reconstruct the weather conditions and also, the potential habitability of the planet. We found diagnostic clay signatures in Margaritifer Chaos which are different from those found in the nearby Valles Marineris. The spectral signature of allophane (poorly crystalline clay), vermiculite, chlorite and other phyllosilicates belonging to the Fe/Mg smectite group, such as saponite and nontronite characterise the Margaritifer study area (Figure 1). This may suggest either a different alteration origin or an overlapping of different formation processes. Polygons features are often associated to the clay signatures, suggesting the occurrences of desiccation processes.

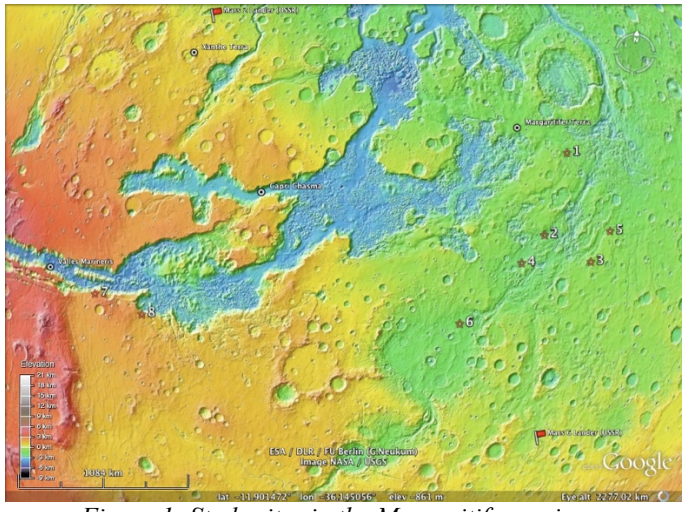

Figure 1: Study sites in the Margaritifer region.

The fingerprint of hydrothermalism may also be inferred by the mineral paragenesis. The presence of clay is identified in small spots, while large surrounding areas are dominated by basaltic composition with no evidence of diagnostic bands of clays or other phillosylicates. This may indicate the scale-dependency of the sedimentary processes. The mineralogical study of martian soils based on CRISM data confirmed the presence of clay minerals in several localities of the studied area suggesting an intense and widespread water-bedrock interaction. In order to better understand the potential role of pedogenetic processes on Mars, with a special focus on the formation of clay minerals, we used both terrestrial soils as Martian analogues and laboratory experiments. We compare the clay mineralogy observed in Margaritifer regions and Coprates Chasma on Mars and selected soils developed on basaltic substrata of the Etna and the Cerviero Mounts (southern peninsular Italy and Sicily,

respectively) (Figure 2) using a multidisciplinary approach which integrates remote sensing with pedological, petrographic, mineralogical and chemical investigations.

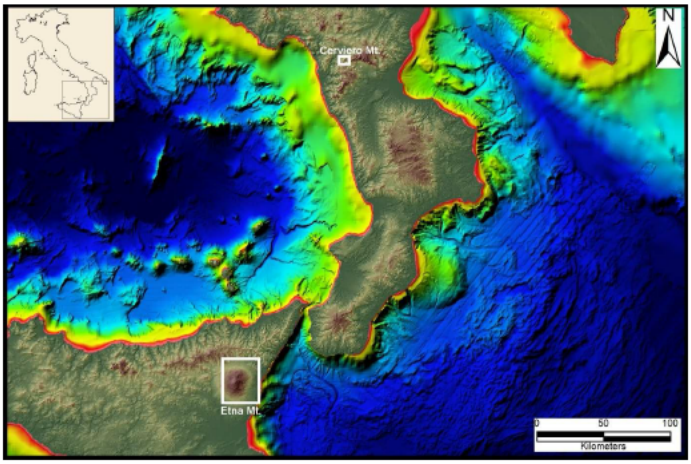

Figure 2: Sampling site in volcanic province in southern Italy.

We focused on Margaritifer regions of Mars because they represent the most interesting areas where studying weathering processes, due to the strong evidence of past hydrological activity, which includes numerous, well-preserved valley networks and channels (Grant & Paker 2002, Salvatore et al., 2016), and many impact craters that have, in their interior, deltas, sedimentary layers and hydrous mineral-bearing outcrops (e.g. Pondrelli et al., 2011). Furthermore, this area together with Coprates Chasma region show widespread exposure of Noachian phyllosilicates (e.g. Le Deit et al., 2012) suggesting a prominent exobiological potential.

Our ultimate goal is the possible timing of soil formation in the Martian study area and attempting a reconstruction of the corresponding major climatic conditions. In order to constrain the conditions required for the formation of clay minerals on the Martian surface, we reproduced the weathering process experimentally in the laboratory, under acidic conditions directly on basaltic rock samples.

We were able to preliminary associate the identified clays minerals to different formation processes such as: a) chemical weathering of the main primary minerals present in the bedrock (i.e. feldspar (plagioclase) and pyroxenes); b) neoformation processes from different clays; c) Hydrotermal alteration of volcanic glass.

Albeit to we cannot totally exclude hydrothermal events at places due to the presence of allophane and chlorite, the geological settings of the studied region of Mars seems to support the presence of standing body of water and thus the weathering of existing bedrock appears to be the most likely origin for the clay formation.

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