Thesis subject

Name of the laboratory: LAM

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Subject's title:

Origin of the Martian clays : formation mechanism and exobiological potential

Subject description:

During its ancient past, Mars was globally altered by liquid water which lead to the formation of various secondary minerals, but mostly a type of phyllosilicate clay (*Bibring et al., 2006*). These clays are the tracers of past water-bearing environments, and their study helps better constrain the highly debated ancient climate of Mars. The known capability of clays to sequester organic matter makes them the prime target of in-situ exploration at Mars e.g. with MSL, M2020, and ExoMars 2028 (*Vago et al., 2017*). Clays are also enriched in water which was captured during their formation, to such an extent that a large fraction of the initial reservoir of Mars liquid water may be trapped in them, for lack of recycling mechanism as is on Earth.

This thesis deals with the study of these extensive but poorly understood clay deposits of ancient Mars. The objectives are: 1) to quantify the amount of water trapped in the clays using orbital remote sensing data, 2) to study the formation mechanism(s) of these clays in a Martian context using experimental work on the mineralogy and comparing with orbital data, 3) to interpret the impact clay formation had on the global geological and climatic evolution of Mars, as well as the habitability potential of their initial water-bearing environments.

The proposed work on the Martian clays would be multi-disciplinary. Initially, the distribution, volume, mineral composition and geomorphological context of the clays will be studied using remote sensing data (including imaging and imaging spectroscopy instruments such as OMEGA, CRISM and TES). A global map of the Martian clay distribution now exists (*Carter et al., 2022*) which will serve as the basis of the work. Focus will be put on pre-identified sites of interest.

Another part of the work involves mineral synthesis experiments in the lab so as to understand the precise formation conditions of Mars-like clays in a realistic environment. Measurements on such samples will be carried out using spectral (IR, Raman) and structural (DRX, MET) tools, some of which are similar to instruments on Mars orbital and in-situ missions. This work will be done in collaboration with labs locally.

Finally, a third work project will involve the development of a simple numerical model of the physical evolution of the ancient crust of Mars, to better constrain the initial volumes of clays then in turn better understand their impact on the geologic and climate evolution.

This work is in direct link with the ExoMars 2028 rover mission, which landing site was chosen specifically for its clay content and their relevance for exobiology (*Quantin, Carter, et al., 2021*).

The PhD work will take place at LAM, with local collaborations within AMU. The PhD student will benefit from a direct link to Mars exploration and instrument data, through the PhD advisor who is PI of the OMEGA instrument on Mars Express, co-lead proposer of the ExoMars landing site and involved in several instruments of the upcoming Mars rover.

The candidate should have a background in astrophysics or planetary sciences. Knowledge in remote sensing, mineralogy and geomorphology is sought after. Programming skills for data analysis is desirable, so is having an interest in performing some laboratory work.

Bibliography:

Bibring, J.-P. et al., Science, 2006, 10.1126/science.1122659
Carter, J. et al., Icarus, 2022, 10.1016/j.icarus.2022.115164
Quantin, C. et al., Astrobiology, 2021, 10.1089/ast.2019.2191
Vago, J. et al., Astrobiology, 2017, 10.1089/ast.2016.1533