PhD - Andrew Alberini

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Thesis title

Esperimenti di laboratorio per supportare il rilevamento di sostanze organiche su Marte da parte del rover NASA Mars 2020 Perseverance e delle future missioni di esplorazione delle superfici planetarie

Laboratory experiments to support detection of organics on Mars by the NASA Mars 2020 Perseverance rover and future exploration missions of planetary surfaces

PhD project

Mars is one of the primary astrobiological targets of international planetary exploration programs. Indeed, despite its current extreme and dry environment characterized by mean temperature of about -50°C, absence of magnetic field and thin atmosphere (6 mbar) of carbon dioxide that allow galactic cosmic rays, solar energetic particles and UV radiation to reach and sterilize the surface of the planet, the past and current exploration missions of this planet have by now ascertained its past habitability, i.e., during its first billion years Mars possessed environmental conditions much more similar to Earth and the hydro-geochemical complexity necessary for life to be maintained. During the same timeframe (the Noachian era, about 4.1-3.7 billion years ago), the first unicellular lifeforms appeared on Earth. By analogy, it is plausible that simple microorganisms developed on Mars under analogous favorable conditions, and traces of their past existence might be still found today in the most ancient rocks, that are still preserved on Mars given the absence of plate tectonics.

The main goal of this PhD project is to create a database of spectroscopic features of martian analog samples to support the interpretation of data collected by present and future rover exploration missions of Mars like the NASA Mars 2020 [1] and the ESA ExoMars missions [2]. This objective will also expand the availability of laboratory spectra for remote sensing interpretation of rocky planetary surfaces. The rational is that laboratory studies simulating realistically the martian environment are indispensable to support analysis of in situ spectroscopic observations since molecular spectroscopic features can be strongly affected by interaction with minerals and salts, presence of oxidants and exposure to the harsh martian conditions of temperature, pressure and high irradiation [3]. Therefore, the aim of the project will be to: (i) prepare analog samples composed of relevant minerals, salts, oxidants, and organic compounds, using methods mimicking natural processes possibly occurred through time at Jezero Crater and Oxia Planum; (ii) process the analog samples under mid-UV and ion irradiation, to investigate possible transformations of organics under martian-like conditions and define more accurately molecular targets; (iii) characterize samples pre- and post- irradiation using Mars 2020 and ExoMars analog payload instruments, to perform detectability/sensitivity tests. The project will be carried out in collaboration with the INAF-Astrophysical Observatory of Arcetri, where the expertise and equipment necessary for sample

preparation and VISIR characterization are available. Specifically, VISIR reflectance measurements will be performed using a VERTEX 70v (Bruker) FT-IR interferometer and μIR microscope with sample stage at controlled temperature (77-873 K) thanks to an interfaced cryostat. This setup is equipped also for in situ UV irradiation under a variety of temperature and pressure conditions, using a Newport Xenon enhanced UV 300 W lamp (wavelength range 185-2000 nm) focused directly on the sample through an optical fiber inserted into the sample chamber of the interferometer, in order to measure infrared spectra of the sample *in situ* during UV irradiation and analyze the photodegradation kinetics in real time.

References

1. Williford K. H. et al., (2018) The NASA Mars 2020 Rover Mission and the Search for Extraterrestrial Life. In *From Habitability to Life on Mars* Elsevier. pp. 275–308.

2. Vago J. L. et al., (2017) Habitability on Early Mars and the Search for Biosignatures with the ExoMars Rover. *Astrobiology* **17**, 471–510.

3. Fornaro, T. et al., (2018) Catalytic/Protective Properties of Martian Minerals and Implications for Possible Origin of Life on Mars. *Life*, 8, 56.