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The CAPSULA Project: a laboratory for planetary analogues

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Introduction: The comprehension and interpretation of VIS-IR spectra from space missions to Solar System rocky bodies is generally based on the qualitative/quantitative comparison with standard laboratory datasets [1,2,3,4], i.e. spectra often acquired in laboratory at room pressure/temperature, so dominated by water bands [5]. We developed the new laboratory setup CAPSULA (Chamber for Analogues of Planetary Surfaces Laboratory), consisting of an environmental chamber equipped with a FTIR spectrometer to acquire spectra of planetary analogues in various conditions. The chamber allows to obtain (i) high vacuum ($<10^{-6}$ mb); (ii) high (>1000 K) and cryogenic T (<80 K). With this setup planetary analogues of terrestrial planets surfaces as well as of icy moons and meteorites can be studied in a wide spectral range and in different environmental conditions. The opportunity of recording spectra on analogs and meteorites in the lab at conditions similar to extra-terrestrial environments is key to improving our interpretation of spectra acquired remotely from orbital and landed missions at remote sites in our Solar System.

Setup description: The CAPSULA setup is hosted at INAF-IAPS C-Lab laboratory (fig.1). It is constituted by (i) a Bruker Fourier Transform Infrared (FTIR) spectrometer, equipped with an MCT and DLATGS detectors and (ii) a large high vacuum chamber 50x60 cm, in which the samples to be analyzed are placed. The chamber and the spectrometer are coupled by means of optical fiber bundles, each composed by seven 200/260- μ m core/cladding fibers. Although the FTIR detectors are sensitive up to 20 μ m, currently the fibers, in Indium Fluoride Glass, allow the signal to be transmitted in the 0.35-5.5 μ m range. The illumination spot on the sample (at angle of 30°) and the collection spot (at 0°) are <1 mm. Several samples (up to 15) can be simultaneously processed in high vacuum in order to be analyzed by means of reflectance spectroscopy in the VIS-IR range. A heating system consisting of five rectangular Si₃N₄ heaters, placed just below copper sampleholders cups, allows to heat samples up to 1073K in high vacuum. A liquid He compressor connected to a cold head within the chamber permits to cool down the samples at cryogenic temperatures below 80K.

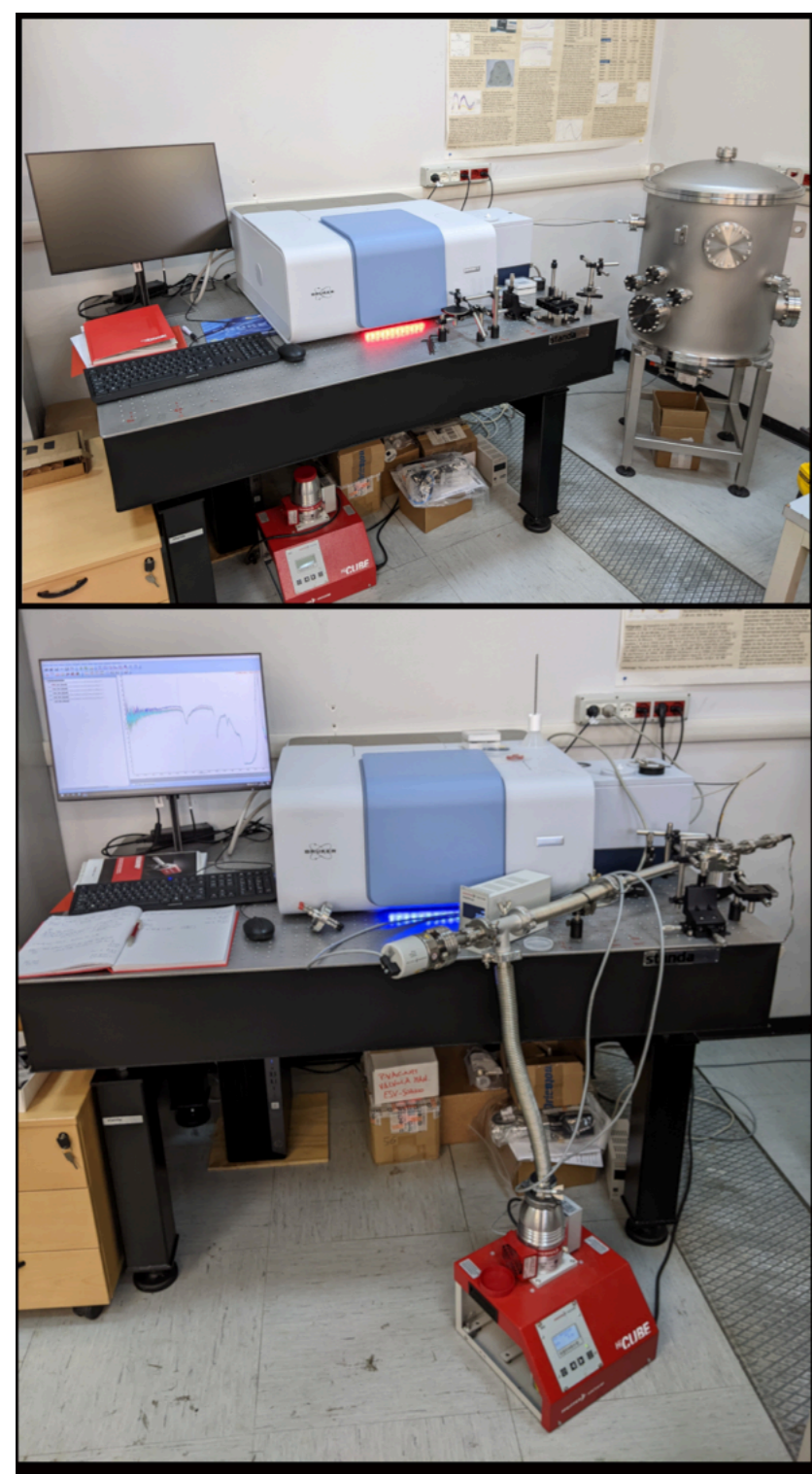


Fig.1. Pictures of the CAPSULA experimental set-up (top) and of vacuum tests (bottom).

Preliminary tests and measurements: As preliminary activity the optical fibers have been extensively characterized in the laboratory in terms of spectral transmission, in the 0.35-5.5- μ m range, resulting in an average transmission of at least 80% for each fiber.

With the aim of starting to test the setup, preliminary spectral measurements have been performed on a powder sample of ammoniated montmorillonite (NH₄-SCa3) [6,7] (fig.2). The sample, in the form of <100 - μ m powder, has been preliminarily analyzed in the 1-5 μ m range. This spectral range is currently defined by the optical fibers transmission (0.35-5.5 μ m) convolved with MCT detector cut-on wavelength (>1 μ m) and NIR source spectrum cut-off (<5 μ m). A Labsphere Infragold has been used as reference target. Reflectance spectra have been acquired in vacuum at room temperature (18°C), with pressure variable from ambient (10^3 mbar), then at 5, 4, 3 mbar and down to 10^{-6} mbar. Each spectrum (both reference and sample) is acquired by doing 512 scans with the FTIR interferometer, which takes about 2'. During this time the pressure changed very slowly, i.e. by less than 5%. It can be seen how dehydration proceeds during the pumping, as seen by the decrease of H₂O bands at 1.5, 2 and 3 μ m. Correspondingly absorption features due to NH₄⁺ become clearly visible (1.55, 2.1-2.2, 3.1 and 3.25 μ m) (fig.3).

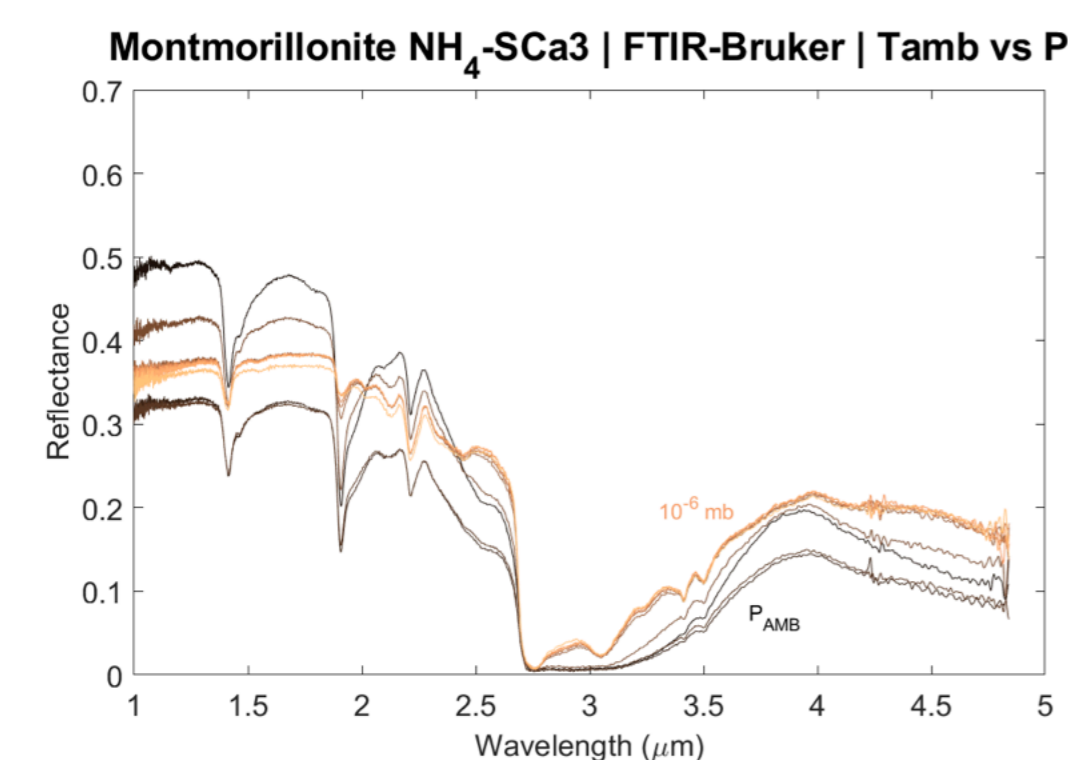


Fig.2. Reflectance spectra of NH₄-SCa3 acquired in the range 1-5 μ m. Spectra have been acquired at room temperature and different values of pressure, from 10^3 down to $10^{\text{exp}-6}$ mbar.

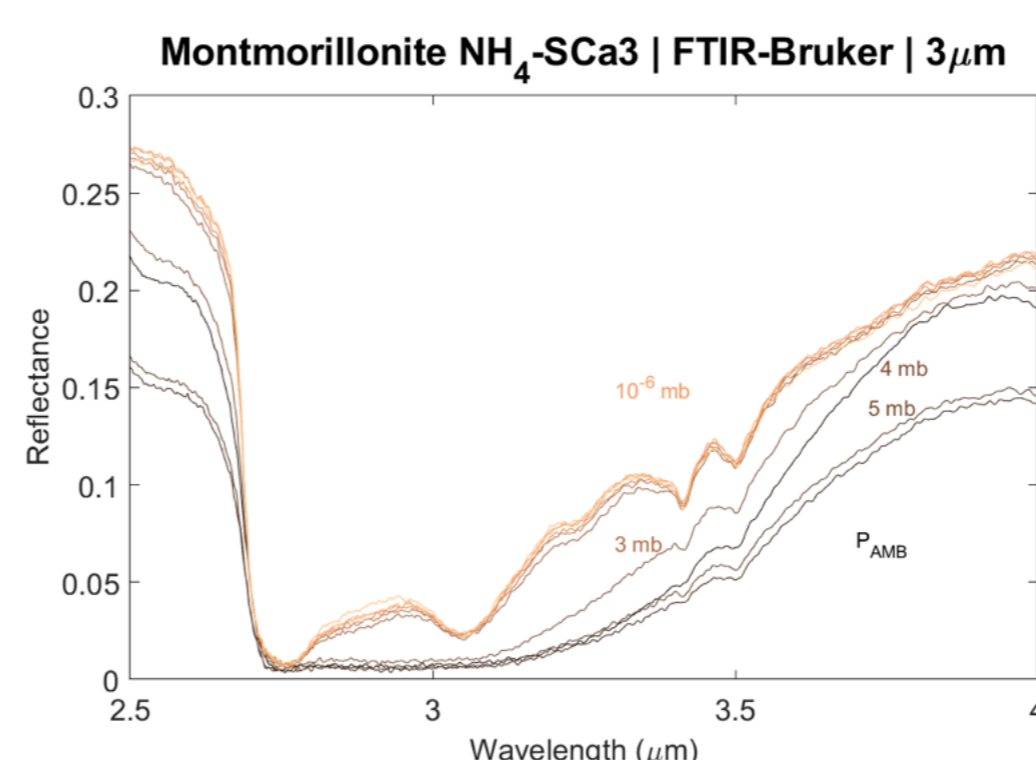


Fig.3. Zoom on the 3- μ m spectral region. The absorption features due to NH₄⁺ become clearly visible (3.1 and 3.25 μ m) as dehydration proceeds.

Future work:

We are currently testing the different subsystems of the setup (cooling/heating system) and working on several upgrades of the experimental system, including the extension of the spectral range in the mid-IR (above 5 μ m) through the use of mirrors. We are in parallel starting to carry out scientific measurements on analogues of different planetary rocky objects (Mars, Ceres) with the current setup.

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Discussion

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