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HYPERSPECTRAL NON-DESTRUCTIVE ANALYSES OF MARTIAN RETURN SAMPLES UNDER QUARANTINE.
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Introduction: In preparation for the upcoming sample return missions containing potential biohazards which may have withstood the rigors of space travel we present a hyperspectral method of *in-situ* analysis of grains combining several non-destructive imaging diagnostics, performed in BSL4 quarantine conditions. This offers an alternative to the analyses in facilities at large, using optimized experimental setups while keeping the samples in conditions of quarantine. Our methodology was tested during analyses of meteorites [1-2] and cometary and interstellar grains from the recent NASA Stardust mission [3-5].

Synchrotron Radiation protocols: X-ray fluorescence and absorption spectroscopies and diffraction were performed on chondritic test samples using focused micron-sized monochromatic beams at the ESRF synchrotron in Grenoble, France. 2D maps of grain composition down to few *ppb* concentrations and polycrystalline structure have simultaneously been acquired, followed by X-ray absorption performed on elements of $Z \geq 26$. Ideally, absorption micro-tomography should then be performed in full-beam mode to record the 3D morphology of the grain and also fluorescence-tomography in focus mode may complement this picture with a 3D elemental image of the grain.

Lab-based protocols: Raman and IR-based spectroscopies have been performed for mineralogical imaging of the grains in the laboratory using commercial microscopes. The spatial resolution varied in the 1-5 μm range. Laser limited penetration of opaque samples permits only 2D imaging of the the few nanometer-thick outer layers of the grains.

Sample Holder: A miniaturized sample-holder has been designed and built to allow direct analysis of a set of extraterrestrial grains confined in a triple container and remotely positioned in front of the X-ray or laser beams of the various setups. The grains are held in several thin walls (10 μm) silica capillaries which are sufficiently resistant for manual/remote-controlled micro-manipulation but semitransparent for the caracteristic X-rays, Raman and IR radiations.

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