QESA - Quarantine Extraterrestrial Sample Analyses: methodology and setup

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Introduction: For the upcoming Hayabusa II, Osiris Rex and NASA Mars Sample Return missions, bringing to Earth samples containing potential biohazards, we have implemented a hyperspectral method [1] of analysis of grains, performed under quarantine conditions, by combining several non-destructive imaging diagnostics. Our methodology was patented [2] and tested on meteorite grains [3, 4].

Synchrotron Radiation protocols: XRF, XRD and XAS micro-imaging were performed on chondritic samples at the ESRF synchrotron in Grenoble, France. 2D hyperspectral maps of grain composition ($\geq$ *ppm* concentrations) and polycrystalline structure have simultaneously been acquired, followed by XAS on elements of $Z \geq 26$. Full beam absorption μ-tomography has been added to the new setup under development to record the 3D morphology of the grain, followed by fluorescence-tomography to complement the picture by a 3D elemental image of the grain.

Lab-based protocols: Raman and IR spectroscopies of the outer layers only of grains were performed in reflection mode for mineralogical imaging using commercial microscopes. Spatial resolution varied in the 1-10 μm range. Raman mineralogical maps are now routinely acquired at sub-μm scales through the 3 container walls of the holder, followed by IR few-micrometer spot measurements of C-based and potential H_2O alteration distributions.

Sample Holder: the new sample-holder allows direct analyses of extraterrestrial grains, confined in a thin walls (10 μm) silica capillary by three layers of containment and remotely positioned and scanned in front of the X-ray or laser beams. Pressure/temperature sensors in each container periodically broadcast the status of integrity of the ensemble, to satisfy the stringent BSL4 planetary protection requirements enforced by NASA, ESA and CNES. The ensemble can also be used for analyses of toxic, radioactive or other hazardous materials in biology or environmental studies.

References:

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