An X-Rays tomographer (Tomox) for in situ planetary exploration

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Keywords: planetary exploration, XRD, XRF, tomography.

The TOMOX instrument has been selected under the ASI DC-EOS-2014-309 call. The TOMOX objective is to acquire both X-ray fluorescence and diffraction measurements from a sample in order to: a) achieve its chemical and mineralogical composition; b) reconstruct a 3D tomography of the sample exposed surface; c) give hints regarding the sample age. Nevertheless, this technique has applicability in several disciplines other than planetary geology, especially archaeology. The word 'tomography' is nowadays used for many 3D imaging methods, not just for those based on radiographic projections, but also for a wider range of techniques that yield 3D images. Fluorescence tomography is based on the signal produced on an energy-sensitive detector, generally placed in the horizontal plane at some angle with respect to the incident beam caused by photons coming from fluorescence emission. So far, a number of setups have been designed in order to acquire X-rays fluorescence tomograms of several different sample types. The proposed instrument is based on the MARS-XRD heritage, an ultra miniaturised XRD and XRF instrument developed for the ESA ExoMars mission. The general idea of TOMOX is to distribute both sources and detectors along a moving hemispherical support around the target sample. As a result, both sources move integrally with the detectors while the sample is observed from a fixed position, thus preserving the geometry of observation. In that way, the whole sample surface is imagined and XRD and XRF measurements are acquired continuously along all the scans. We irradiate the target sample with X-rays emitted from ^{55}Fe and ^{109}Cd radioactive sources. ^{55}Fe and ^{109}Cd radioisotopes are commonly used as X-ray sources for analysis of metals in soils and rocks. The excitation energies of ^{55}Fe and ^{109}Cd are 5.9 keV, and 22.1 and 87.9 keV, respectively. Therefore, the elemental analysis ranges are Al to Mn with K lines excited with ^{55}Fe; Ca to Rh, with K lines excited with ^{109}Cd. ^{55}Fe will be primarily dedicated to XRD measurements, as it has been already tested for the MARS-XRD development. ^{109}Cd will be used to reinforce the efficiency of ^{55}Fe source in the production of fluorescent X-rays generated in the sample as a consequence of irradiation and to extend the analytical range of elements.Two different detectors will be used in order to increase the total amount of events collected and allow the spatial distribution of events to be recorded as well. The detectors we plan to use are SDD (Silicon Drift Detector) and stand-alone CCD (Coupled Charge Detector). SDD has higher count rate and stability and has been successfully used for XRF applications. CCD is able to record the spatial position of each event of X-ray emission, together with its energy. Therefore, we plan to dedicate this detector to XRD measurements, where the spatial position of the event is directly correlated to the type of crystal through the Bragg's law. So far, the SDD has been tested while the full prototype will be completed soon.