

## Abstract

In-Situ Resource AnalyzerDan Scheld<sup>1</sup>, Dan Ladner<sup>1</sup>, Joe Martin<sup>1</sup>*1. N-Science Corp,*

An instrument is presented with a triple measurement system to work as a robotic field geologist on remote planetary surfaces such as the moon or Mars. The In-Situ Resource Analyzer (ISRA) is a miniature instrument that employs X-ray scattering and visual imaging to determine *nondestructively* the mineralogy of a rock sample in-situ. Its key distinguishing feature is the ability to characterize minerals without destroying, damaging, or removing the sample from its in-situ location. ISRA addresses key questions regarding the target terrain relating physical and chemical surface properties. ISRA provides an inventory of elements, minerals, and rock and soil types to help answer these questions. The questions are different for different targets but the methodology and measurement system is the same.

The ISRA X-ray fluorescence (XRF) for element composition and X-ray diffraction (XRD) for mineralogy are achieved by scattering from an opaque sample at a glancing angle, collecting the resulting forward-scattered XRF and XRD X-rays simultaneously with a CCD detector. This design is very much based on the MICA (Mineral Identification and Composition Analyzer) previously developed and on lessons learned in that development. An imaging camera embedded in the unit for color imaging has a close-up lens with depth of field augmentation to show rock morphology, crystallinity, surface textures and other mineralogy clues. The 320 x 45  $\mu\text{m}$  x-ray footprint on the sample is centered in the camera field of view (FOV) 2.9 x 3.8 mm that has a spatial resolution of  $\sim 5.5 \mu\text{m}$ .

A MICA prototype was developed and built under NASA MIDP (Mars Instrument Development Project) and was demonstrated (in 2006) with calibration samples and natural rocks on the NASA K-9 test rover robotic arm end effector.

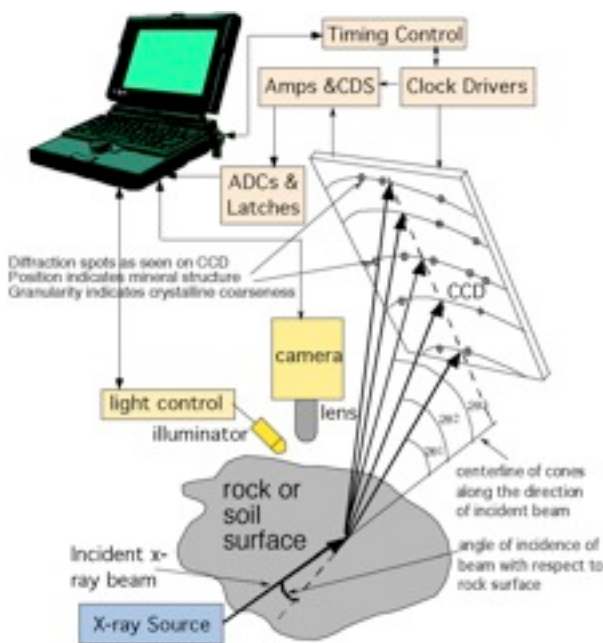


FIGURE 1 (a) Operational Schematic for MICA/ISRA. (b) MICA prototype at quartz rock on rover arm

Operationally, the instrument is placed by a robotic arm against a targeted rock or regolith sample. Contact analyses can be conducted on undisturbed materials, or on samples that have the outer surface removed by an abrasion tool. ISRA serves as a reconnaissance tool, providing rapid, 10-30 minute, analyses for making decisions about further analysis, sample collection or sample return from a remote planetary surface.

The mechanical configuration's upper rectangular section contains five electronics boards plus the imager. The lower cylindrical section houses the X-ray source and X-ray CCD that operates at or below 208 K (-65 deg C) with a thermoelectric cooler (TEC). For thermal control, a part of the rectangular surface serves as "upper" radiator for electronics and X-ray source dissipation, while another portion of the rectangular section along with the cylindrical surface comprise the "lower" radiator for the CCD subsystem when the TEC is operating. The two radiators are thermally decoupled and operate at different temperatures.

Rover test data seen in Figure 2a shows an XRD data screen, with a piece of undisturbed quartz rock below the sensor head, showing the spotty XRD arc segments characteristic of large granular size in a natural rock, giving information on grain size while still allowing identification of the quartz mineral as seen in Figure 2b.

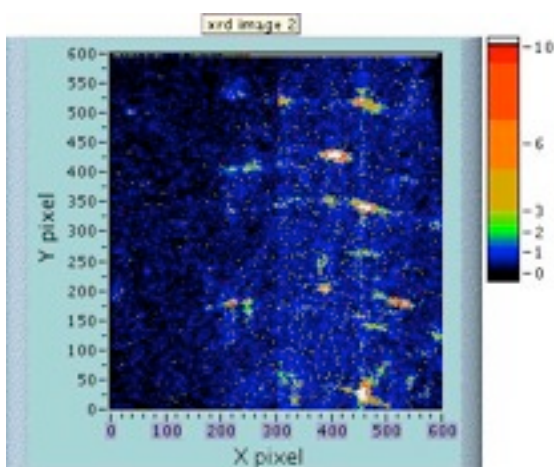


Figure 2a. XRD data screen for quartz rock

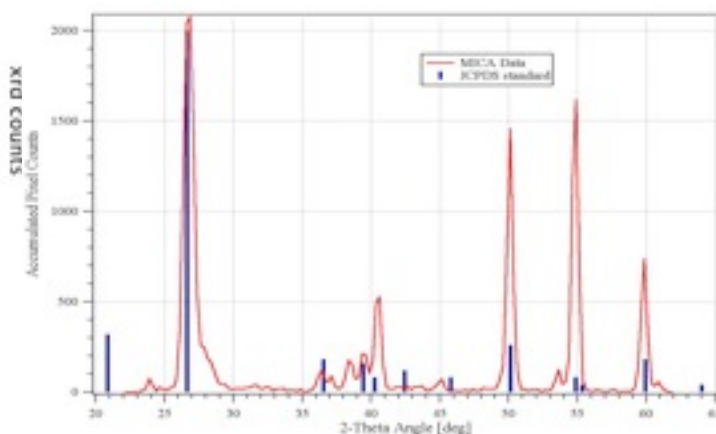


Figure 2b. JCPDS Match-up of quartz rock XRD pattern