MÖSSBAUER/XRF MIMOS INSTRUMENTATION AND OPERATION DURING THE 2012 ANALOG FIELD TEST ON MAUNA KEA VOLCANO, HAWAII.

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Introduction: Field testing and scientific investigations were conducted on the Mauna Kea Volcano, Hawaii, as part of the 2012 Moon and Mars Analog Mission Activities (MMAMA). Measurements were conducted using both stand-alone and rover-mounted instruments to determine the geophysical and geochemical properties of the field site, as well as provide operational constraints and science considerations for future robotic and human missions [1]. Reported here are the results from the two MIMOS instruments deployed as part of this planetary analog field test.

Instrumentation: The two MIMOS instruments deployed during the 2012 MMAMA activities were the Miniaturized Mössbauer Spectrometer MIMOS II [2] and the combined Miniaturized Mössbauer and X-Ray Fluorescence Spectrometer MIMOS IIA [3]. Both instruments are backscatter spectrometers, designed and developed specifically for planetary surface exploration. The innovative design allows for the instruments to be placed in contact with a rock or soil sample, providing *in-situ* analysis with no sample preparation. Designed explicitly for the demands of robotic exploration, these instruments are small, with low mass and minimal power requirements. In the first application of extraterrestrial Mössbauer spectroscopy, the twin Mars Exploration Rovers (MER) used MIMOS II instruments to analyze Martian surface materials beginning in 2004 [4-6]. The MIMOS IIA, currently under development for future planetary missions, is an advanced version of the instrument. The MIMOS IIA has enhanced Mössbauer (MB) capability (e.g., new detector technologies and electronic components) to significantly increase the sensitivity and performance while simultaneously acquiring quantitative X-Ray Fluorescence (XRF) data for chemical analyses [7]. Both these instruments have participated in numerous previous field tests and mission simulations [8-11].

Objectives and Methods: The following science and instrument objectives were defined for the 2012 field deployment: (1) to integrate the MIMOS II (MB) and MIMOS IIA (MB/XRF) instruments onto rover and stationary platforms as part of the analog field test including science, operation, and robotic simulations; (2) to develop, demonstrate, and evaluate the operation of an independent solar-powered MIMOS instrument configuration; (3) to characterize the various geologic materials of the field sites by determining the mineralogical composition of iron-bearing minerals using Mössbauer spectroscopy and the chemical composition using XRF; and (4) to demonstrate and evaluate the technology advancements associated with the new MIMOS IIA instrument. To accomplish these objectives we configured and operated the MIMOS IIA as part of the rover-mounted instrument payload that was operated in the Apollo Valley region of Mauna Kea for three simulated mission days. The instrument was mounted to a bracket extending from the rover chassis (Fig. 1), allowing for quick and simplified (i.e. without a robotic arm) deployment of the sensor head to the surface utilizing the JUNO II rover's tilting capability. During rover-mounted operations, the MIMOS IIA measured quantitative Fe-mineralogy and the chemical composition for 1 soil and 8 rock samples. Integration times varied from 30 to 90 minutes. Instrument data was processed and reported on a tactical timeline.

Figure 1: MIMOS IIA senor head deployed from the JUNO II rover on a rock target in Apollo Valley.

The MIMOS II was deployed and operated to demonstrate and evaluate the solar-powered configuration on a cinder cone in the vicinity of Hale Pohaku. This stand-alone configuration incorporated the instrument sensor head, electronics box, remote communication system, and power system into a single compact field box that can be easily deployed for long duration surface analysis. The intent of this configuration is to provide a self-sustaining instrument system that can be deployed and recovered by both robotic and/or human means. Specifically, the solar-powered design incorporated commercially available portable solar technology using a 12 W solar flexible array, a 13,000 mAh rechargeable lithium polymer battery, and a solar converter (Fig. 2). In this configuration, the MIMOS II measured quantitative Fe-mineralogical composition for 2 soils and 6 rock samples near Hale Pohaku. Both MIMOS II and IIA instruments measured 3 common samples for comparison of Mössbauer performance.

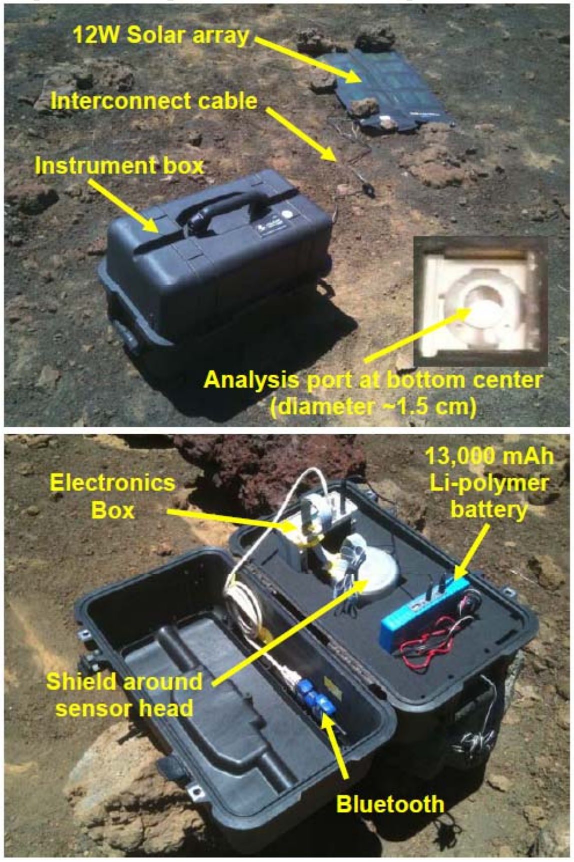


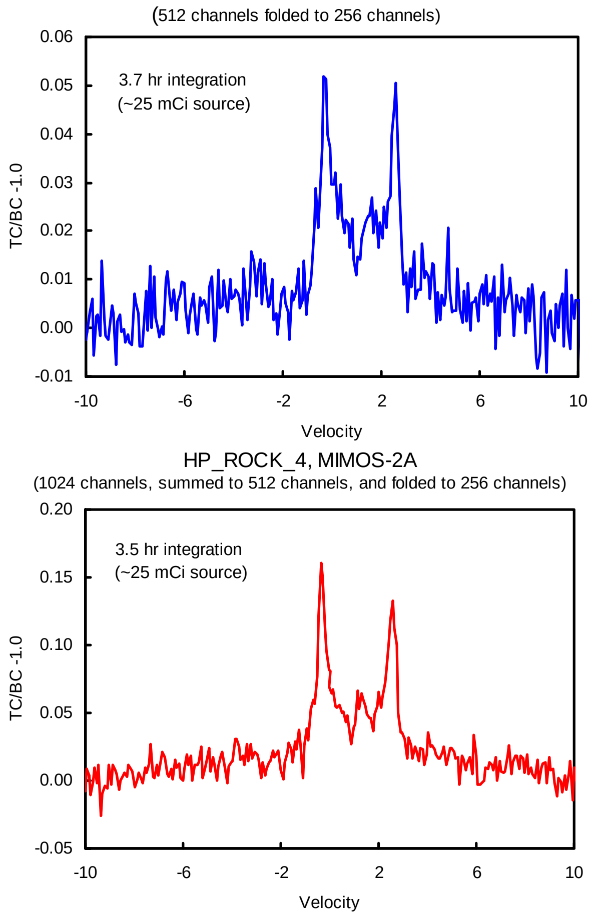
Figure 2: MIMOS II solar-powered field portable configuration.

Results and Discussion: All the MIMOS science and instrument objectives for the 2012 field deployment were successfully completed. The integration of the MIMOS instruments, configured for both rover-mounted and stand-alone operations, demonstrates the versatility of the instrument system. The simplified tilt-based JUNO II rover deployment was sufficient for this field simulation; however additional camera views and/or sensors would be required for completely remote operations. In addition, the tilt-based deployment design limits target selection to largely horizontal rock and soil surfaces.

The solar-powered configuration allowed for continuous operation of the MIMOS II instrument, independent of any external power source, for the duration of the field test. This configuration can be further reduced in size and mass for future terrestrial and space exploration concepts.

Mössbauer sample characterization identified several Fe-bearing phases including olivine, pyroxene, ilmenite, magnetite, hematite, basaltic glass, and nanophase ferric oxide (npOx). The Mössbauer performance of the MIMOS IIA is enhanced by at least a factor of 3 compared with the MIMOS II, reducing the integration time by a factor of at least 3 to produce spectra having the same quality (Fig 3).

Figure 3


HP_ROCK_4, MIMOS-2

(512 channels folded to 256 channels)

HP_ROCK_4, MIMOS-2A

(1024 channels, summed to 512 channels, and folded to 256 channels)

References: [1] Graham et al. (2013) *LPSC44*. [2] Klingelhöfer et al. (2003) *JGR*, 108(E12), 8067. [3] Klingelhöfer et al. (2012) *Instrumentation for Planetary Missions*, #1079. [4] Klingelhöfer et al. (2004) *Science* 306, 1740-1745. [5] Morris et al. (2004) *Science* 305, 833-836. [6] Morris et al. (2010) *Science, 329*,421-424. [7] Blumers et al. (2010) *Nucl. Instr. and Meth. A*, 624, 277-281. [8] Arvidson et al. (1998) *JGR*, 103(E10). [9] Klingelhöfer et al. (2002) *Hyperfine Interactions*, Vol. 144/145. [10] Schröder (2011) *Geochemistry: Exploration, Environment, Analysis*, v11. [11] Klingelhöfer et al. (2011) *LPSC42*, #2810.