EPSC Abstracts
Vol. 6, EPSC-DPS2011-1327-1, 2011
EPSC-DPS Joint Meeting 2011

In Situ Visible to Short Wavelength Imaging Spectroscopy with the Ultra Compact Imaging Spectrometer (UCIS): Case Studies from the Mars Exploration Rovers.

D. Blaney, P. Mouroulis, R. Green, J. Rodriguez, G. Sellar, B. Van Gorp, D. Wilson. NASA Jet Propulsion Laboratory / California Institute of Technology, 4800 Oak Grove Drive, MS 264-528 (Diana.L.Blaney@jpl.nasa.gov)

Abstract

In Situ imaging spectroscopy provides a way to address complex questions of geological evolution for both aqueous and igneous processes by mapping mineral composition at the spatial scale of rocks and outcrops. Examination of locations studied by the Mars Exploration Rovers Spirit and Opportunity can provide examples of the potential utility and define the needed measurement requirements. A compact instrument is needed to be able to adequately address these science questions from a rover platform. The Ultra Compact Imaging Spectrometer (UCIS) is an instrument designed to address the science need and implementation constraints.

1. Visible to Short Wavelength Infrared Imaging Spectroscopy

Spectroscopy from 500-2600 nm is an established technique for measuring the mineralogy of igneous and sedimentary rocks. Minerals and rocks exhibit absorption features in the Visible to Short Wavelength Infrared (VSWIR) that are highly diagnostic of their structure and composition (Figure 1).

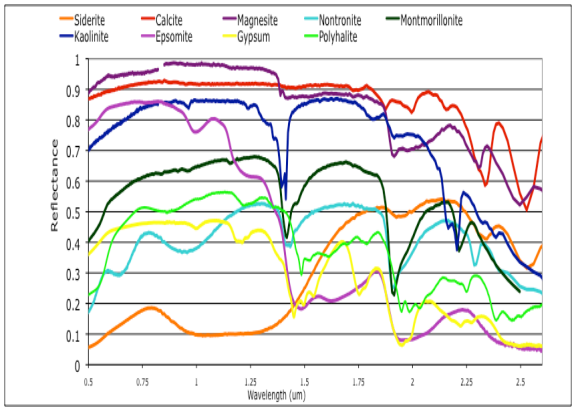

Figure 1: Diagnostic clay, sulfate, and carbonate spectra (from Clark et al 2007 [1])

2. Examples from the MER Mission

Mars contains a wide range of aqueous minerals. Opportunity found extensive evaporite sequences at Eagle Crater, Endurance Crater, and Victoria Crater in Meridiani Planum. Hematite, jarosite, plus other unidentified sulfate and silicate minerals form a complex layered structure with gradients in elemental composition [e.g.,2, 3, 4]. Meanwhile at Gusev Crater Spirit has explored complex alteration sequences including potential clays [5], hydrothermal deposits [6], silica-rich deposits [7,8] and carbonates [9]. Examples of these deposits will be presented and the potential for imaging spectroscopy will be explored to resolve key unanswered questions.

3. The Ultra Compact Imaging Spectrometer (UCIS)

In Situ instrumentation is highly mass and power constrained. The Ultra Compact Imaging Spectrometer (UCIS) is an imaging spectrometer operating from 500-2600 nm with 10 nm spectral sampling. UCIS is an Offner spectrometer with Moon Mineralogy Mapper (M^3) heritage. However, the optics of UCIS are much more compact than M^3 (Figure 2). This allows for significantly lower instrument mass and volume. Imaging spectrometers have strong thermal design constraints that impose stringent requirements for operating temperature and stability. UCIS thermal design uses a cryo-cooler to reach its operating temperature in conjunction with a Variable Conductance Heat Pipe for thermal control (Figure 3). Key characteristics of the UCIS spectrometer are provided in Table 1.

A proto-type UCIS spectrometer is currently under development at the NASA Jet Propulsion Laboratory. The instrument incorporates flight-like optics and detectors. However, commercial off the shelf

non-flight thermal design since it is being designed to work in terrestrial field demonstrations. Instrument completion is expected in early 2012.

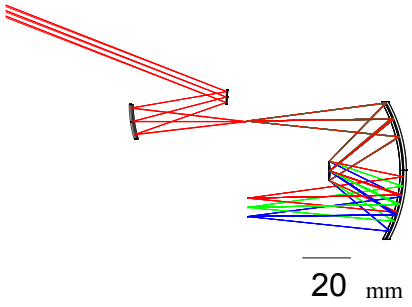

Figure 2: Optical Schematic of the UCIS Instrument Spectrometer.

Table 1: Key UCIS Characteristics

Characteristic	Value
Wavelength Range	500-2600 nm
Wavelength Resolution	10 nm
IFOV	2 mrad
FOV	32°
Focus	1.5 m-∞
Optical Head	2.5 kg
Electronics Mass	2.0 kg
Optical Head Volume	18cm x 18cm x 18cm
Electronics Volume	10cm x 6cm x 2cm
Operating Power	6.9-8.9 W

Acknowledgements

This work has been conducted at the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration.

References

[1] Clark, R. N et al.: USGS digital spectral library splib06a: U.S. Geological Survey, Digital Data Series 231. http://speclab.cr.usgs.gov/spectral-lib.html, 2008.

[2] Squyres, S. W. et al.: "The Opportunity Rover's Athena Science Investigation at Meridiani Planum", Mars. Science 306, 1698–1703, 2004.

[3] Squyres et al., Two Years at Meridiani Planum: Results from the Opportunity Rover, Science 8,: 1403-1407. [DOI:10.1126/science.1130890], 2006.

[4] Squyres et al., Exploration of Victoria Crater by the Mars Rover Opportunity, Science 22 May 2009: p 1058-1061. [DOI:10.1126/science.1170355], 2009.

[5] Clark, B. C. et al, Evidence for montmorillonite or its compositional equivalent in Columbia Hills, Mars, JOURNAL OF GEOPHYSICAL RESEARCH-PLANETS Volume: 112 Issue: E6 Article Number: E06S01, 2007.

[6] Squyres et al., Pyroclastic Activity at Home Plate in Gusev Crater, Mars Science: 738-742. [DOI: 10.1126 /science.1139045], 2007.

[7] Squyres et al., Detection of Silica-Rich Deposits on Mars, Science 23 May,: 1063-1067. [DOI: 10.1126 / science.1155429], 2008.

[8] Ruff et al., Characteristics, distribution, origin, and significance of opaline silica observed by the Spirit rover in Gusev crater, Mars, JOURNAL OF GEOPHYSICAL RESEARCH-PLANETS Volume: 116 Article Number: E00F23, 2011.

[9] Morris RV et al, Identification of Carbonate-Rich Outcrops on Mars by the Spirit Rover, SCIENCE Volume: 329 Issue: 5990 Pages: 421-424, 2010.

Figure 3: Cooling Architecture of the UCIS Instrument Optical Head.