EPSC Abstracts
Vol. 8, EPSC2013-401-1, 2013
European Planetary Science Congress 2013

The Effects of Varying Environmental Conditions on the Emission Spectra of Meteorites

I.R. Thomas (1), N.E. Bowles (1), H.C. Connolly Jr. (2), M. Kilgore (3), and D. S. Lauretta (3).
(1) University of Oxford, Oxford, UK, (2) CUNY, New York, NY, USA (3) University of Arizona, Tucson, AZ, USA
(thomas@atm.ox.ac.uk)

Abstract

With NASA's OSIRIS-REx mission due to launch to asteroid 101955 Bennu (previously known as 1999 RQ36) in 2016, preparations are well underway [4]. Once there, the OTES (OSIRIS-Rex Thermal Emission Spectrometer) instrument will map the asteroid's surface to derive thermal and compositional properties [4], by comparing spectra to those of known samples measured in the laboratory. Previous studies have shown that samples can exhibit differences in emission spectra due to composition, grain size and the environmental conditions in which they are measured [3,5,7], however the magnitude of these variations for asteroidal material require more study. The aim of this work is to determine whether laboratory samples need to be measured in a thermal environment like that on the asteroid's surface for correct interpretation of returning data from OTES: to do this, the Lunar Environment Chamber in the Planetary Spectroscopy Facility at Oxford University [7] was used to simulate the expected conditions on Bennu while a selection of ground meteorite samples were measured.

1. Introduction

1.1 OSIRIS-REx

The main objectives of the OSIRIS-REx mission are to map the surface properties of asteroid Bennu, and to return a surface sample of at least 60g back to Earth for laboratory analysis [4]. Bennu is a primitive, near-Earth, carbonaceous asteroid [4], with a low albedo surface likely containing volatile-rich material [6]. Onboard the spacecraft are five instruments, including OTES, an infrared mapping spectrometer operating from 200-2500cm^{-1} at 10cm^{-1} resolution, capable of making one measurement every 2 seconds to build up a spectral map of the entire surface including the sampling site [4].

1.2 Thermal Environment

The aim of the simulated asteroid environment (SAE) measurements is to induce a temperature gradient in the sample that matches as closely as possible to the one hypothesized to be present on an airless body's surface. Such a gradient is induced due to the thermal environment of the asteroid: the surface is heated by the sun, which is typically capable of penetrating several centimetres [e.g. 3], but the surface re-radiates only in the thermal infrared. This radiation is emitted only from the top few hundred microns, cooling the very top layers, and hence a gradient is induced. Without an atmosphere, convective heat transport does not equalize this gradient as it would on Earth, therefore this must also be simulated in the laboratory.

1.3 Environmental Emission Chamber

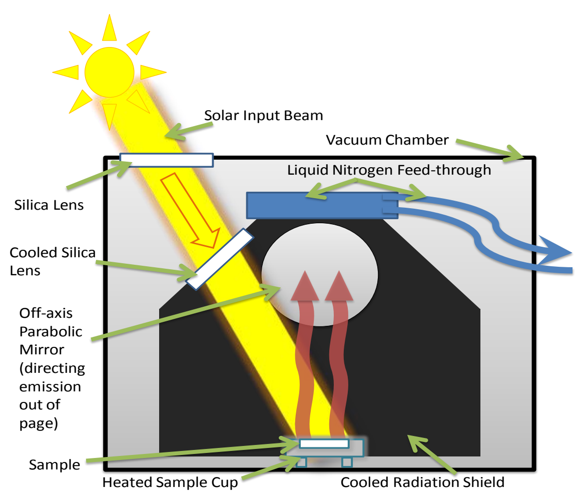

Figure 1: Schematic layout of the thermal environment emission chamber.

The lunar environment chamber (Figure 1), described in more detail elsewhere [7], consists of a vacuum chamber capable of maintaining a pressure of

<1 x10^{-3} mbar (typically around 1 x 10^{-5} mbar). Within the chamber the sample is placed in a cup capable of being heated to 150 C and is surrounded by a radiation shield that can be cooled to temperatures <150K. A solar-like lamp illuminates the samples, heating up the surface, simulating the effect of solar radiation on an airless body. Radiation emitted from the sample is reflected into an FTIR spectrometer by a focusing mirror positioned above the sample.

To create the correct temperature gradient, the temperature of the sample at the bottom of the sample cup needs to match the expected temperature at that depth on Bennu. Given that this is an unknown, spectra are taken with several different sample cup temperatures, typically 5C, 80C and 100C. The lamp output is then altered until the sample's surface brightness temperature is equal to that of Bennu [2].

1.4 Sample Suite

Table 1 shows the samples measured so far for this study.

Sample	Type	Particle Size
NWA 5515	CK4	0-75µm
NWA 5515	CK4	250-425µm
Graphite	N/A	0-75µm
Graphite	N/A	250-425µm
SWCB-3	N/A	0-75µm
SWCB-3	N/A	250-425µm
Murchison	CM2	150-425µm
NWA 502	CO3	0-75µm
NWA 502	CO3	0-150µm
NWA 502	CO3	150-425µm
NWA 502	CO3	250-425µm
Allende	CV3	0-75µm
Allende	CV3	0-150µm
Allende	CV3	250-425µm

Table 1: Description of samples measured at present.

2. Results

Diffuse reflectances of a selection of samples are shown in Figure 2. From the results of previous work investigating thermal gradients in lunar analogues and Apollo samples, variations in spectra would be expected [6], especially around 8µm.

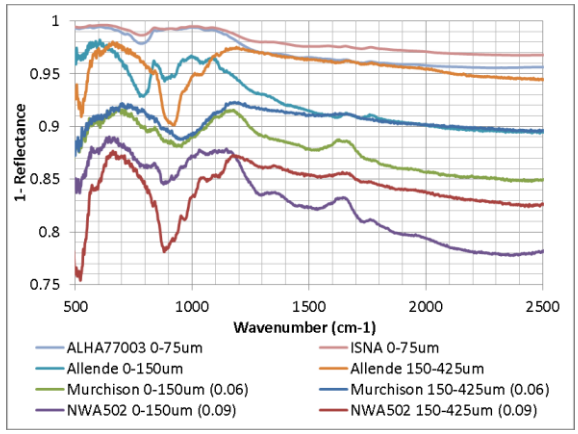

Figure 2: Diffuse reflectance of a selection of meteorites, from the ASTER spectral library (ALHA and Isna 0-75µm [1]) and of those measured in the study. Spectra have been offset (by the number in brackets) for clarity.

Analysis so far appears to show that the majority of materials measured exhibited no alteration between ambient and asteroidal conditions; however during the course of the investigation complications were encountered due to the unusual samples, which appeared to affect some of the results. At this time more work is required to investigate these variations, and how these observations can be explained.

Acknowledgements

We would like to acknowledge the work of the AOPP electronic and mechanical workshops for their invaluable help and expertise and the Science and Technology Facilities Council (STFC) for supporting this work financially.

References

[1] Baldridge, A. M. et al. (2009) Remote Sensing of Environment, 113, pp. 711-715.

[2] Delbo, M. et al (2011) ApJL, 728, L42.

[3] Henderson, B. et al. (1996) JGR, 101, pp. 14969-14975.

[4] Lauretta, D. (2012) An Overview Of The Osiris-Rex Asteroid Sample Return Mission, LPSC XLIII, Abstract 2491.

[5] Logan, L. et al. (1973) JGR, 78, pp. 4983-5003.

[6] Mueller, T.G. et al. (2012) A&A, 548, A36.

[7] Thomas, I.R. et al. (2012) Rev Sci Instrum., 83(12), 124502.