REXIS FIRST RESULTS: REGOLITH X-RAY IMAGING SPECTROMETER ABOARD OSIRIS-REX.

Richard P. Binzel[1], Branden Allen[2], Jaesub Hong[2], Daniel Hoak[2], David Guevel[2], Jonathan Grindlay[2], Rebecca Masterson[1], Mark Chodas[1], Carolyn Thayer[1], Madeline Lambert[1], Andrew Cummings[1] , Lucy F. Lim[3], Beth E. Clark[4], Timothy J. McCoy[5], William V. Boynton[6], Dante S. Lauretta[6].

[1]Massachusetts Institute of Technology, Cambridge, MA, USA. [2]Harvard University, Cambridge, MA, USA. [3]NASA Goddard Space Flight Center, Greenbelt, MD, USA. [4]Ithaca College, Ithaca, NY, USA. [5]Smithsonian Institution National Museum of Natural History, Washington, DC, USA. [6]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA.

Introduction: The Regolith X-ray Imaging Spectrometer (REXIS) is the student collaboration experiment flying aboard OSIRIS-REx. REXIS measures x-ray fluorescence stimulated by solar x-rays impinging on the surface of asteroid Bennu. We will present REXIS's first results in measuring elemental abundances in the regolith of Bennu and discuss how these results complement the other payload instruments.

REXIS is an x-ray spectrometer designed to take advantage of the incident solar x-ray flux that generates a diagnostic fluorescence signature from the asteroid's surface. REXIS joins a lineage of x-ray fluorescence experiments flown in space dating back to the Apollo era and previously demonstrated for asteroid science [1]. REXIS [2] consists of two components: a main imaging spectrometer with a coded aperture mask and a separate solar X-ray monitor to account for the Sun's variability. The REXIS main spectrometer employs a detector array consisting of four MIT Lincoln Laboratory CCID-41 charge-coupled devices (CCDs) in a 2×2 array allowing measurement of the x-ray spectrum over the range of 0.4 to 8 keV with an energy resolution (FWHM) of <220 eV at 5.9 keV. REXIS seeks to measure fluoresced lines in the Fe-L, Al-K, Mg-K, S-K, and Si-K complexes. The detector array was protected from background radiation during the cruise by a front cover that was successfully opened in response to commands sent from the ground in September 2018, two years into flight.

Characterization of the X-ray fluorescence measured from Bennu requires knowledge of the incoming solar X-ray flux. REXIS's second component is a solar X-ray monitor (SXM) designed to measure the variable incoming solar flux and its energy distribution. The SXM utilizes an Amptek XR-100SDD silicon drift diode (SDD) with a collimated effective area of about 0.8 mm^2, providing spectral coverage over the range of 1 to 20 keV.

REXIS Operation: REXIS utilizes measurements of astrophysical x-ray sources (Crab Nebula, Sco X-1) to measure the boresight offset of the instrument and calibrate the quantum efficiency of the CCDs. Internal sources of Fe-55 enabled performance monitoring during the cruise phase and continue to provide an ongoing measure of the detector charge transfer efficiency. In flight at Bennu, six nodes of 256 x 1024 pixels each are delivering low noise and a stable energy resolution signal for acquisition of science data.

REXIS asteroid science measurement operations at Bennu were executed in July 2019 during the Orbital B phase of the OSIRIS-REx mission. The first science results to be produced are "spectral mode" characterization of the elemental abundance ratios (relative to Si) of Bennu's regolith. Laboratory reference measurements for meteorite elemental abundance ratios [3] form the foundation for interpreting the REXIS results. Key ratios to be examined in the REXIS data include Mg/Si and Fe/Si to independently determine whether the asteroid's composition closely resembles that of carbonaceous chondrites, as interpreted from the main payload suite.

Acknowledgements: This material is based upon work supported by NASA under Contract NNM10AA11C issued through the New Frontiers Program. We are grateful to the entire OSIRIS-REx Team for making the encounter with Bennu possible and to the large number of REXIS students who have contributed to this project.

References:

[1] Nittler, L. R. et al. (2001) Met. Plan. Sci. 36, pp. 1673–1695.

[2] Masterson, R.A. et al. (2018) Space Sci Rev. 214, 48.

[3] Nittler, L. R. et al. (2004) Antarctic Meteorite Research 17, 231–251.