MINERAL AND CHEMICAL MAP PRODUCTION FOR THE OSIRIS-REX MISSION. H. H. Kaplan[1], V. E. Hamilton[1], B. E. Clark[2], E. S. Howell[3], S. Ferrone[2], J. R. Brucato[4], G. Poggiali[4], D. S. Lauretta[3], and the OSIRIS-REx Team. [1]Southwest Research Institute, Boulder, CO (kaplan@boulder.swri.edu), [2] Ithaca College, Ithaca, NY, [3]University of Arizona, Tucson, AZ, [4]INAF-Astrophysical Observatory of Arcetri, Firenze, Italy.

Introduction: The Origins, Spectral Interpretation, Resource Identification, Security–Regolith Explorer (OSIRIS-REx) spacecraft has arrived at its target, asteroid (101955) Bennu, where it will characterize the chemistry and mineralogy of the asteroid surface before returning a sample to Earth. The spacecraft has two spectrometers onboard to investigate the spatially resolved composition of the asteroid. These spectrometers are the OSIRIS-REx Visible and Infrared Spectrometer (OVIRS), which covers visible and near-infrared wavelengths (0.4–4.3 µm; ~25000–2304 cm^{-1}) with a ~20-m footprint for global mapping [1,2], and the OSIRIS-REx Thermal Emission Spectrometer (OTES), which measures the thermal infrared (5.5–100 µm; ~1820–100 cm^{-1}) with a 40-m footprint globally [3].

Compositional maps from OVIRS and OTES data will provide input for the sample site selection. We have already observed spectral features consistent with hydrated minerals in both OVIRS and OTES data and will be examining these features at higher spatial resolution prior to sample site selection [4,5]. Band depths and mineral abundances associated with the OH/H_2O spectral features will be mapped onto the surface shape model, as will any other absorption features that are resolved as we get closer to Bennu.

To produce these maps, we use a number of methods to derive band depths or mineral abundances from each spectrum and then register those values on the shape model. We discuss these methods and the steps taken to validate them with laboratory and simulated datasets. In addition, we describe how the map products themselves will be validated before being used for mission operations (i.e., sample site selection). Finally, to demonstrate map production routines, we will present proof of concept maps produced from our Preliminary Survey of Bennu.

Methods: Methods in this section pertain to the automated procedures the OSIRIS-REx team has developed for deriving mineralogy and chemistry from the spectra and mapping these values onto the irregular surface of Bennu.

OVIRS: A large number (n > 100) of spectral indices were developed to parameterize OVIRS data to create maps that are akin to the CRISM "summary products" for Mars [6]. We derived these spectral parameters from the existing literature and re-formulated them to work with the OVIRS spectral resolution. The indices measure absorption features associated with many minerals and chemicals (olivines, pyroxenes, phyllosilicates, carbonates, sulfates, hydrated and iron-bearing minerals, and organics) as well as slopes for detecting space weathering trends [e.g.,7]. An error value is calculated for every parameter and reflectance at 0.5 µm is reported.

OTES: We will interpret and map OTES spectral features >5% using meteorite and mineral analog spectra for context. A library of spectra of relevant materials was assembled, with many of the spectra being measured specifically for this purpose. For instance, meteorites and pure minerals were measured in the University of Oxford's Simulated Lunar Environment Chamber (SLEC) and in situ spectra were collected with a µ-FTIR on mineral grains in meteorite thin sections for phases that are difficult to obtain outside of this context. This spectral library can be used for non-negative linear least squares (NNLS) fitting of the OTES spectrum at wavelengths < 25 µm (> 390 cm^{-1}) [e.g. 8]. We have also developed a set of spectral indices for the OTES data in the event that the endmember library proves to be unsuitable for Bennu.

Mapping: Our mapping procedure takes data values from the spectrometer observations and assigns them to the facets of the shape model using SPICE pointing information. Because the spot size of the instrument footprints is large compared to the facets, multiple spectral spots are combined for each facet. As a result, the mapping procedure also returns that spot's fractional coverage for each facet. We combine overlapping spectral data with one of seven different algorithms: an average, a weighted average, a median, the nearest spot value, the highest quality spot, the most recent spot, and an average that allows a standard deviation cut off (sigma clip). For all operations, the errors are propagated appropriately.

Validation: Validation of any spectral detections is an important step in mineral/chemical map production. We tested the procedures for deriving mineral and chemical information from OVIRS and OTES data using laboratory spectra of Bennu analogs (carbonaceous chondrite meteorites and mixtures of analogous minerals) [9, 10] during development of these methods. The process of mapping spectral data on the shape model was likewise tested with a simulated spectral dataset, which we discuss here along with the strategy for validating the actual maps.

Validation of Mapping Methods: We studied the artifacts that can result from our unique method for mapping the circular spectrometer footprints onto the triangularly tessellated three-dimensional shape model [11]. When mapping simulated data, we observe minor artifacts including smearing and contrast reduction. The nearest distance selection algorithm performs better than the other algorithms retaining sharp borders of contrasting spectral regions. And we do observe small improvements in spatial fidelity when we combined all observations from more than one global survey as opposed to a single survey.

Validation of the Maps: A number of criteria will be used to vet OVIRS and OTES data prior to mapping. To start, band depths or mineral abundances with large error values will be removed from the dataset. The cutoff values for acceptable errors will be determined for each spectral index taking into account the signal-to-noise of the data. Where possible, we will combine spectral data from multiple surveys using only footprints that fall completely on the body with similar spatial resolutions. If there is a priori knowledge of bad data, these values can also be automatically removed from the maps. Finally, we can select spectra based on illumination conditions, viewing geometry, or any other observation parameters.

Once these selection criteria are met, the final maps will be validated by the team. By mapping standard deviations from the overlapping spectral footprints, we can find facets or regions of interest. We will analyze spectra from these facets either confirming the presence of an absorption feature or approving the linear least square fits. Noisy or unusual spectra will be flagged and removed from the dataset for further analysis.

First Map Results: We will produce and display the first maps from low-spatial-resolution OVIRS and OTES data collected during Preliminary Survey (December 3 – 26, 2018). The Preliminary Survey data were not intended for detailed mapping, and resulting maps will be used primarily as proof of concept for all steps of mapping and map validation. Given our distance from Bennu during Preliminary Survey, both spectral and spatial quality will be low compared to the maps produced during the rest of the mission. We will focus on spectral indices including slopes and band ratios, which will be less affected by ongoing calibration, to get a sense of their distribution at the broadest spatial resolution.

From these data, we will report our preliminary assessment of the utility of our spectral indices and the different mapping algorithms for the Bennu data. Specific spectral features, such as the 2.7 μm absorption, will be discussed by [12].

Conclusions: OSIRIS-REx mission science will include mapping of mineralogy and chemistry using hyperspectral data collected with two instruments with near continuous coverage from 0.5 to 100 μm. We have tested all steps of the mapping process on laboratory/simulated data and will report these results along with first analyses of the mapped OVIRS/OTES spectral data for Bennu.

At minimum, maps of the sample site will be archived with the Planetary Data System (PDS), and other maps that reflect the composition of Bennu may also be archived. Ultimately, a full analysis of Bennu's composition will include spatially resolved mineral/chemical data from both spectrometers that will be collected during a Detailed Survey phase.

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