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The OSIRIS-REx mission to RQ36: nature of the remote sensing observations

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1. Introduction

OSIRIS-REx is an asteroid sample-return mission that was selected by NASA in May 2011 as the third New Frontiers Mission. The name is an acronym that captures the scientific objectives of the mission: **O**rigins, **S**pectral **I**nterpretation, **R**esource **I**dentification, and **S**ecurity **R**egolith **E**xplorer. OSIRIS-REx will Rendezvous with near-Earth asteroid 101955 (1999 RQ36), which is both the most accessible carbonaceous asteroid and one of the most potentially hazardous asteroids known. The primary objective of the mission is to return a pristine sample from this body to advance our understanding of the generation, evolution, and maturation of regolith on small bodies.

1999 RQ36 was discovered in September 1999 by the LINEAR survey and is an Apollo NEO with a semi-major axis of 1.126 AU. Observations of 1999 RQ36 were performed by team members using ground-based telescopes [1] the Spitzer Space Telescope [2] the Arecibo Planetary Radar System [3], and other assets. These data strongly support the presence of abundant regolith, comprised of fine gravel (4-8 mm), ideal for sampling. 1999 RQ36 comes within 0.003 AU of the Earth and has the highest impact probability of any known asteroid [4].

Although by far the most important objective of this mission is to collect and return a pristine sample, it will also significantly improve our understanding of details of this body from data collected from remote observations. This work will provide a brief overview of the mission followed by a more detailed discussion of the planned remote sensing observations to be taken in proximity to the asteroid.

2. Science Overview

OSIRIS-REx's detailed characterization of 1999 RQ36 and return of pristine samples will significantly enhance our understanding of the initial stages of planet formation and the sources of organics that may have ultimately led to the origin of life. Bodies from the main asteroid belt are believed to be the dominant source of primordial terrestrial organics and water. OSIRIS-REx has five mission objectives:

1. Return and analyze a sample of pristine carbonaceous asteroid regolith in an amount sufficient to study the nature, history, and distribution of its constituent minerals and organic material.
2. Map the global properties, chemistry, and mineralogy of a primitive carbonaceous asteroid to characterize its geologic and dynamic history and provide context for the returned samples.
3. Document the texture, morphology, geochemistry, and spectral properties of the regolith at the sampling site *in situ* at scales down to the subcentimeter.
4. Measure the Yarkovsky effect on a potentially hazardous asteroid and constrain the asteroid properties that contribute to this effect.
5. Characterize the integrated global properties of a primitive carbonaceous asteroid to allow for direct comparison with ground based telescopic data of the entire asteroid population.

2. Mission Overview

OSIRIS-REx will launch in September of 2016 and arrive at RQ-36 near the end of 2019. During the next year OSIRIS-REx will gradually move in to ever shorter ranges to the surface collecting data to both help us understand aspects of asteroid science as well as to inform our decision on the optimum location for collecting the sample to be returned to Earth.

The highest priority for choosing a sample site is that it has physical characteristics that make it very likely we can safely collect a viable sample. Characteristics such as local slope and abundance of rocks will be important factors in choosing a suitable sampling site. After that, the site will be selected based on compositional remote sensing data returned from the instruments.

3. Planned Observations

The OSIRIS-REx spacecraft carries a comprehensive set of 5 instruments, including a 3-camera instrument suite, to address objectives 2 through 5 given above. The OSIRIS-REx Camera Suite (OCAMS) is composed of three cameras: a narrow-angle PolyCam, a mapping camera, MapCam, and a wide-angle, SamCam. There are three spectrometers: the OSIRIS-REx Thermal Emission Spectrometer, OTES, the OSIRIS-REx Visual and Infrared Spectrometer, OVIRS, and the Regolith X-Ray Imaging Spectrometer, REXIS. In addition, there is the OSIRIS-REx Laser Altimeter, OLA.

The narrow-angle PolyCam provides long-range RQ36 acquisition and sub-mm imaging of the surface. The MapCam supports optical navigation during proximity-operations, global mapping, and sample-site reconnaissance. The wide-angle SamCam performs sample-site characterization and sample-acquisition documentation. Each imager is equipped with its own filter wheel and focal plane.

The PolyCam acquires RQ36 when it appears as an 11 V magnitude point source. These images are used to refine the ephemeris of RQ36 and enable the Flight Dynamics team to design the Asteroid Approach Maneuver, which is executed two months later. Throughout this Approach Phase, PolyCam observes RQ36 as a point source to determine its astrometric and photometric properties. As the S/C-to-RQ36 distance decreases, RQ36 is resolved at progressively higher resolution using PolyCam, enabling construction of an initial shape and rotation model.

After OSIRIS-REx arrives at RQ36, imaging by MapCam and PolyCam are used to refine the shape model to discover rocks that could provide a hazard to sampling. Following this imaging, OSIRIS-REx collects OVIRS and OTES spectra with global coverage and spatial resolution on the order of 40m and 20m, respectively. In addition, color images from MapCam are made to provide compositional information at a resolution on the order of 0.4m. The spectroscopic and color information will be used to select on the order of twelve candidate sampling sites from those areas that appear to be safe for sampling.

The candidate sampling sites will be examined at closer range to provide very high resolution imaging data for a down selection to about four sites for very detailed examination. During these closer range observations, the REXIS instrument will collect x-ray fluorescence spectra to determine the abundances of several key elements.

These four sites will be reconnoitered at a close range of a few hundred meters to collect spectral data with spatial resolutions on the order of a few meters and imaging data with sub-centimeter resolution. These data will be the basis for the final selection of the prime and backup sampling sites.

The remote sensing data will provide compositional and physical data on an unprecedented small spatial scale and should substantially increase our understanding of this asteroid and of asteroid science in general. The data will become even more valuable after the collected sample is returned to Earth, and the spectroscopic data can be compared to an excellent ground-truth sample.

References

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