OSIRIS-APEX: A PROPOSED OSIRIS-REX EXTENDED MISSION TO APOPHIS. D. DellaGiustina[1], D. R. Golish[1], Scott Guzewich[2], M. Moreau[2], M. C. Nolan[1], A. T. Polit[1] and A. A. Simon[2]. [1]Lunar and Planetary Laboratory, University of Arizona, Tucson AZ, USA, (dellagiu@arizona.edu). [2]NASA Goddard Space Flight Center, Greenbelt, MD, USA.

Introduction: The OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer) mission characterized and collected a sample from asteroid (101955) Bennu. After the capsule containing the sample is released to Earth in 2023, the spacecraft (S/C) will divert into an orbit around the Sun, allowing for subsequent close Earth flybys. On this trajectory, the S/C will approach Earth alongside asteroid (99942) Apophis in 2029, enabling a second mission with the same unique capabilities that led to OSIRIS-REx's groundbreaking scientific results: OSIRIS—APEX (Apophis Explorer), or "APEX" for short.

On April 13, 2029, the ~340-m-diameter Apophis will fly within ~32,000 km of Earth's surface, <10% the lunar distance. Apophis will be the largest object to pass Earth this closely in recorded history and will captivate the world. Leading up to the 2029 encounter, nearly 1 billion people in Europe and Africa will be able to see an asteroid move across the night sky with the naked eye—a first for human civilization. This rare planetary encounter will alter Apophis' orbit, subject it to tidal forces that change its spin state, and may seismically disturb its surface.

An extensive ground-based telescopic campaign will occur ahead of the 2029 Apophis-Earth encounter, but observing conditions degrade just hours after the closest approach as the asteroid passes within 20° of the Sun. Immediate aftereffects of the tidal interaction will be impossible to examine from the ground—but will be witnessed by APEX.

Mission Concept: APEX will begin observations of Apophis as a point source on April 2, 2029, at a distance of 5×10^6 km; orbital mechanics prohibit an earlier rendezvous. APEX will observe Apophis from 50,000 km during its close encounter and capture the evolution of its spin state in real time, revealing the consequences of a near-Earth object undergoing tidal disturbance by a planet. APEX will enter a 1.4-km Apophis orbit four months after the asteroid's close Earth approach. Orbital observations will uncover any signs of mass wasting that the tidal encounter triggered, revealing centimeter-scale topography via lidar and millimeter-scale morphology via images.

Chronicling the tidal encounter is only the beginning of APEX's journey with Apophis. Having already challenged our fundamental understanding of "carbonaceous" (C-complex) asteroids during its exploration of Bennu, the S/C instrument suite will provide first-of-its-kind high-resolution data of a "stony" (S-complex) asteroid—dramatically advancing our knowledge of this asteroid class and its connection to the meteorite collection. Global spectral mapping at meter scales and across a wide range of wavelengths (0.4–100 μm) will determine the composition of Apophis and identify any volatiles on its surface. Optical and radiometric tracking data will reveal Apophis' mass and structure. We will also search for signatures of mass shedding, whether due to the tidal encounter or an episodic process like that observed at Bennu. After 15 months of orbital operations, APEX will perform a maneuver called Regolith Excavation by S/C Thrusters (REST, Fig. 1) to mobilize surface material, as demonstrated at Bennu. Observations during and after excavation will provide otherwise inaccessible insights into space weathering and the surface strength of stony asteroids.

Although scientific discovery is APEX's prime motivator, Apophis' bulk structure and surface strength have critical implications for planetary defense. As an S-complex object, Apophis represents the most common class of potentially hazardous asteroids, and knowledge of its properties can inform mitigation strategies. Monitoring Apophis after Earth approach provides the first opportunity to witness a change in Yarkovsky force—a nongravitational effect that influences an asteroid's likelihood of striking Earth.

Figure 1. *The REST maneuver shown in this cartoon will use the spacecraft's thrusters to mobilize surface material, providing insight into the near-surface properties of Apophis.*

Acknowledgement: This work was supported by the NASA contract number NNM10AA11C and the University of Arizona Space Institute.