Exploring Our Past, Securing Our Future By Returning Pristine Samples from a Carbonaceous Asteroid

OSIRIS

Asteroid Sample Return Mission

OSIRIS
Regolith Explorer (REx)

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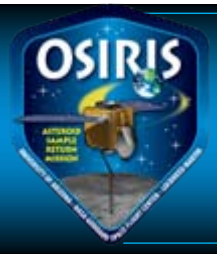
ORIGINS • SPECTRAL INTERPRETATION • RESOURCE IDENTIFICATION • SECURITY

University of Arizona, Goddard Space Flight Center, and Lockheed Martin

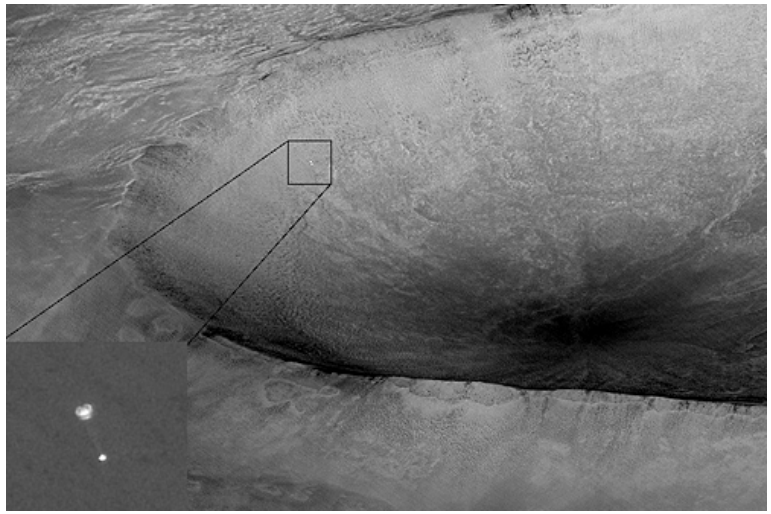


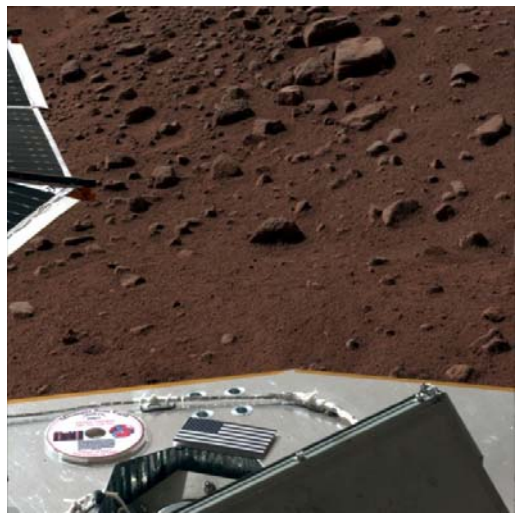
NASA Planetary Science PI-led Mission Programs

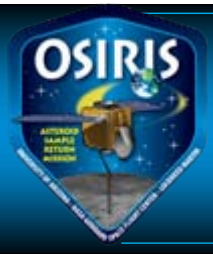
- Scout
  - –Low-cost Mars exploration
- Discovery
  - –Low-cost Solar System exploration
  - –Excludes Mars since Scout program created
- New Frontiers
  - –Medium-class missions for more ambitious Solar System exploration
  - –Focused on select targets defined by NRC

Mars Scout Program

- First selection in 2003
  - Phoenix
  - Landed safely on May 25
- Scout 2 currently in extended Phase A
  - MAVEN
  - The Great Escape

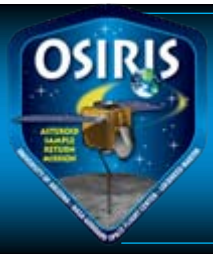






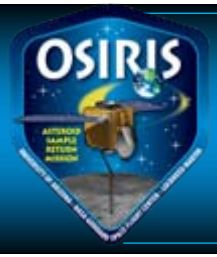
Discovery Program

- Eleven Missions Selected to date:
  - Mars Pathfinder
  - Near-Earth Asteroid Rendezvous (NEAR)
  - Lunar Prospector
  - Stardust
  - Genesis
  - Comet Nucleus Tour (CONTOUR)
  - Mercury MESSENGER
  - Kepler
  - Deep Impact
  - Dawn
  - Gravity Reconnaissance and Interior Laboratory (GRAIL)
- Four Missions of Opportunity
  - ASPERA-3
  - Moon Mineralogy Mapper (M^3) on Chandranaryan
  - Stardust Next
  - EPOXI



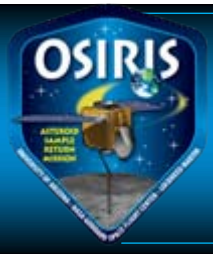
New Frontiers

- Two Missions Selected to date:
  - New Horizons
  - Juno
- New Frontiers 3 Competition Upcoming
  - Draft AO in September, 2008
  - Official AO in December, 2008
  - Step-1 Proposal due March, 2009
  - Phase-A selections in August, 2009
  - Launch 2015-2018



Opening New Frontiers in Space

- **Recommendation 2:** NASA should expand the list of potential missions in the next New Frontiers announcement of opportunity to include the three remaining candidate missions:
  - South Pole-Aitken Basin Sample Return
  - Venus In Situ Explorer, and
  - Comet Surface Sample Return
- and also the five additional medium-size missions mentioned in the decadal survey:
  - Network Science
  - Trojan/Centaur Reconnaissance
  - Asteroid Rover/Sample Return
  - Io Observer and
  - Ganymede Observer.
- There is no recommended priority for these missions. NASA should select from this set of missions based both on science priority and overall mission viability.



Opening New Frontiers in Space

- **Recommendation 1:** NASA should emphasize the science objectives and questions to be addressed, not specify measurements or techniques for the implementation.

- **Recommendation 3:** NASA should consider mission options that are outside the 3 remaining and 5 additional medium-size missions from the decadal survey but are spurred by major scientific and technological developments made since the decadal survey. However, NASA should limit its choices to the eight specific candidate missions unless a highly compelling argument can be made for an outside proposal.

NF Asteroid Rover/Sample Return

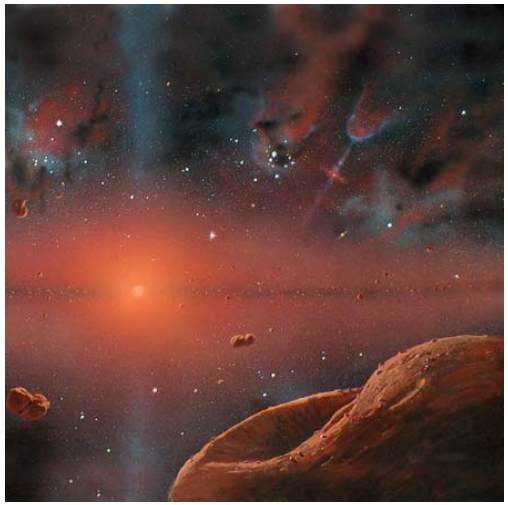
- A primary motivation for an asteroid sample return mission is the desire to both acquire samples with known geologic context and to return materials that are either unlikely to survive passage to Earth (e.g., friable, volatile-rich material) or would be compromised by terrestrial contamination upon their fall (e.g., extraterrestrial organics).
- The unique scientific value of organic-rich targets may elevate them for consideration when compared to the type of asteroid visited by the NEAR mission emphasized by the decadal survey.
- Such a mission should have the following science objectives:
  - Map the surface texture, spectral properties (e.g., color, albedo) and geochemistry of the surface of an asteroid at sufficient spatial resolution to resolve geological features (e.g., craters, fractures, lithologic units) necessary to decipher the geologic history of the asteroid and provide context for returned samples.
  - Document the regolith at the sampling site in situ with emphasis on, e.g., lateral and vertical textural, mineralogical and geochemical heterogeneity at scales down to the sub-millimeter.
  - Return a sample to Earth in amount sufficient for molecular (or organic) and mineralogical analyses, including documentation of possible sources of contamination throughout the collection, return and curation phases of the mission.

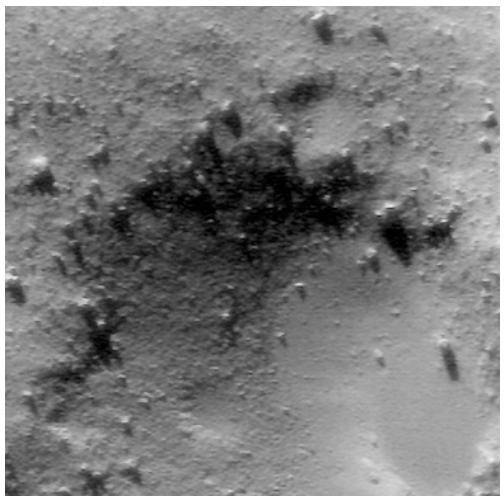
What is OSIRIS?

- **OSIRIS is a sample return mission** that will return at least 150 g of regolith from a NEO
- First proposed to the NASA Discovery 11 opportunity (2004)
- Completed Phase A in the NASA Discovery 12 program last year ($425M cap)
- Re-propose to the New Frontiers 3 opportunity ($650M cap + LV)
- **OSIRIS is an acronym**
  - **Origins**
    - Provide pristine sample to reveal the origin of organics that led to life on Earth
  - **Spectral Interpretation**
    - Provide ground truth for spectral observations of a carbonaceous NEO
  - **Resource Identification**
    - Identify carbonaceous NEO resources that we might use in human exploration
  - **Security**
    - Quantify the Yarkovsky Effect, thus providing a tool to aid in securing the Earth from future asteroid impacts

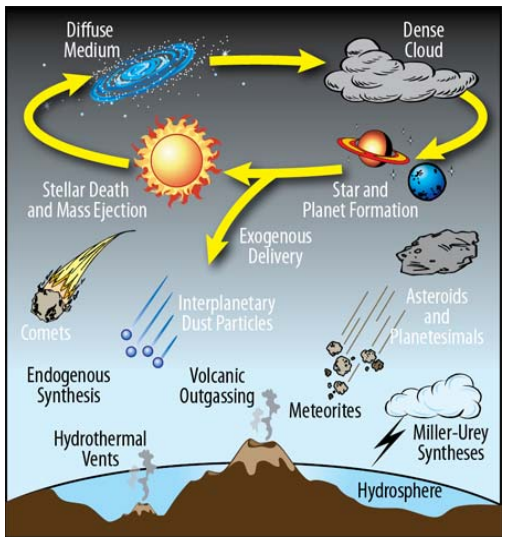
OSIRIS Flight System design has been through many iterations and is mature

Focused Investigations – Exploring Our Past





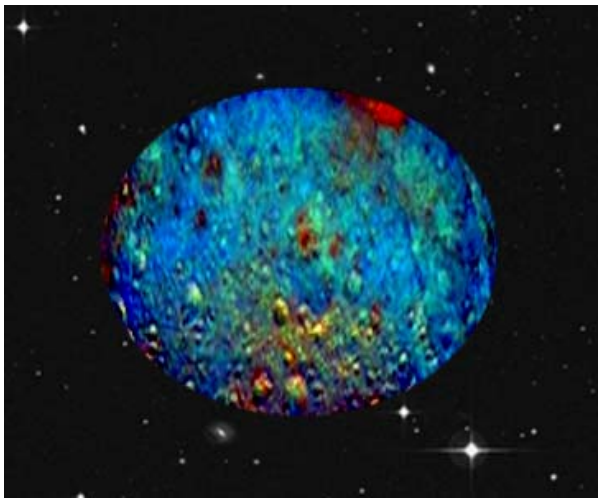
Investigation 1: Understand the processes that determined the original characteristics of a NEO



Investigation 2: Study the nature, history, and distribution of organic and prebiotic material in a carbonaceous NEO

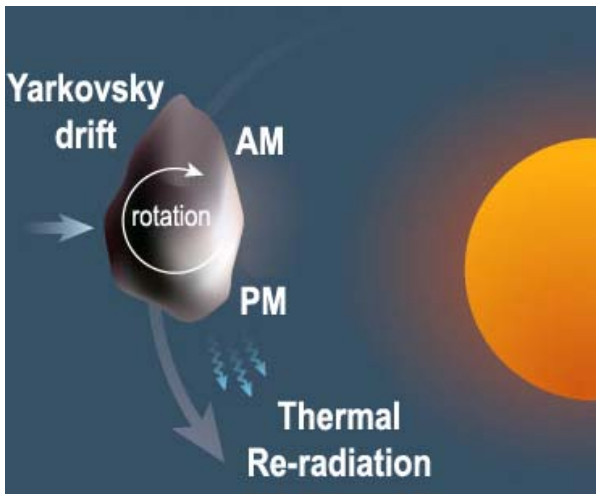
Investigation 3: Characterize the geologic and dynamic history of a carbonaceous NEO

Focused Investigations - Securing Our Future



Investigation 4: Evaluate the spectral properties, surface chemistry, and mineralogy of a carbonaceous NEO

Investigation 5: Determine the abundances of materials in carbonaceous NEOs and develop successful proximity operation procedures



Investigation 6: Measure the magnitude of the Yarkovsky effect on the orbital evolution of a potentially hazardous NEO

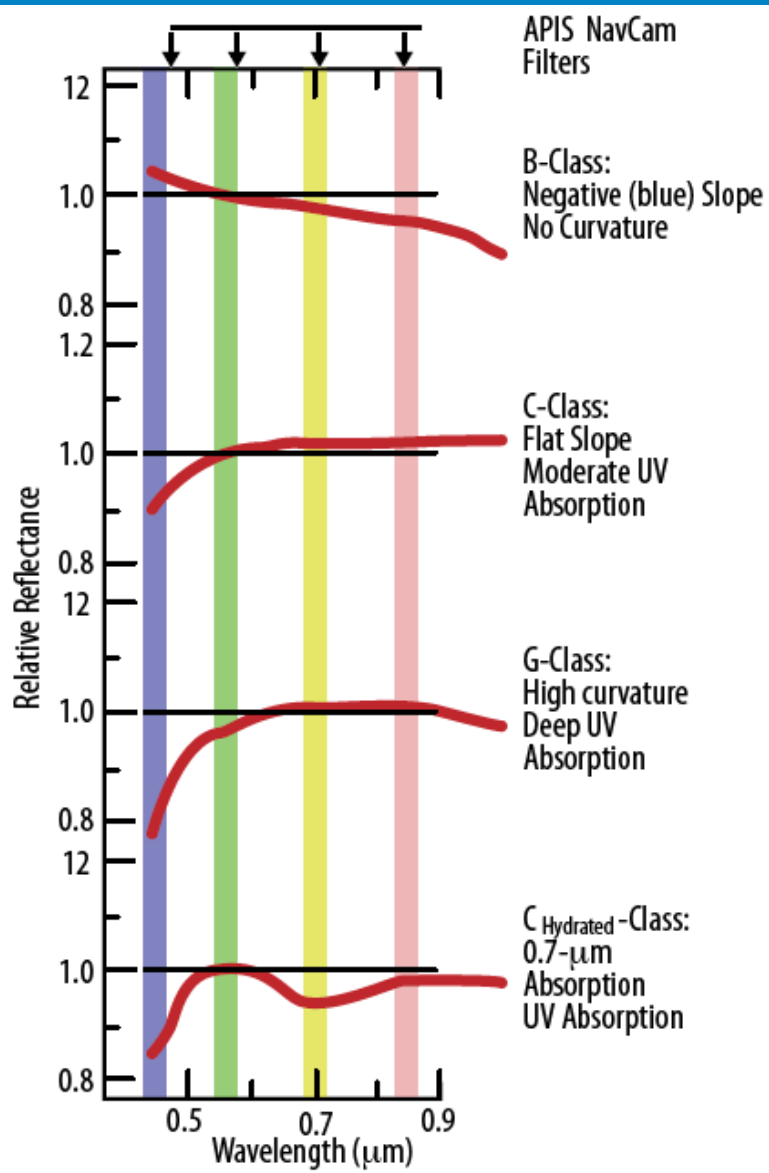
OSIRIS scope is being redefined

- The jump from Discovery to New Frontiers allows significant science enhancement
- New targets being evaluated
- Level-1 requirements expanded, more asteroid science
- Considering additional payloads

- Foreign contributions are welcome

OSIRIS Rex Target Selection

- Top Candidates:
  - 1999 RQ36 – B-type, Radar, Spitzer, low ΔV
  - 1999 JU3 – Cg-type, low ΔV
  - 2002 AT4 – D-type, low ΔV
  - 2001 SG286 – D-type, low ΔV
  - 1998 UT18 – C-type, Radar, moderate ΔV
  - 1989 UQ – B-type, Radar , moderate ΔV
  - 4015 Wilson-Harrington, B-type, comet activity, moderate ΔV



Possible NASA Contributions to Marco Polo

- NASA is interested in contributing to Marco Polo as a Mission of Opportunity ($35M)

- Possible contributions:
  - Science Team members
  - Proposal Review board members
  - OSIRIS flyby of Marco Polo target
  - Surface package
  - Impactor experiment
  - Sampling Mechanism + Arm
  - Sample Return Capsule
  - Recovery at UTTR
  - Curation planning
  - Navigation participation
  - Data Analysis and Archiving

Final Thoughts

- OSIRIS development continues and future opportunities approach
- Great opportunity for synergy between OSIRIS and Marco Polo
- The heterogeneity of the asteroid population requires multiple sample return from diverse targets
- Parallel development of key payloads, sub-systems, and procedures for the two missions reduces costs, risks, and increases science return