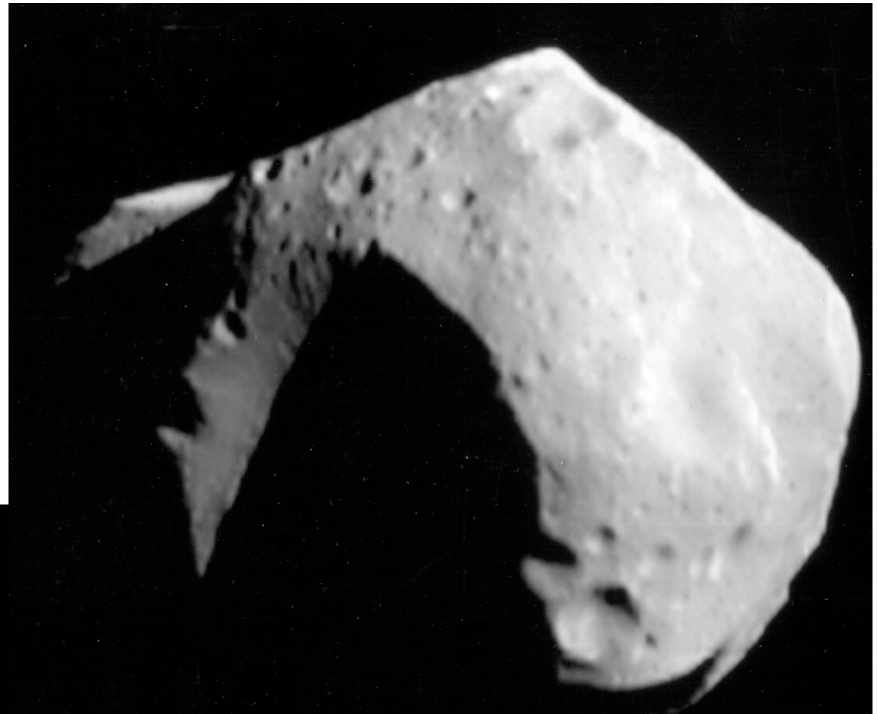
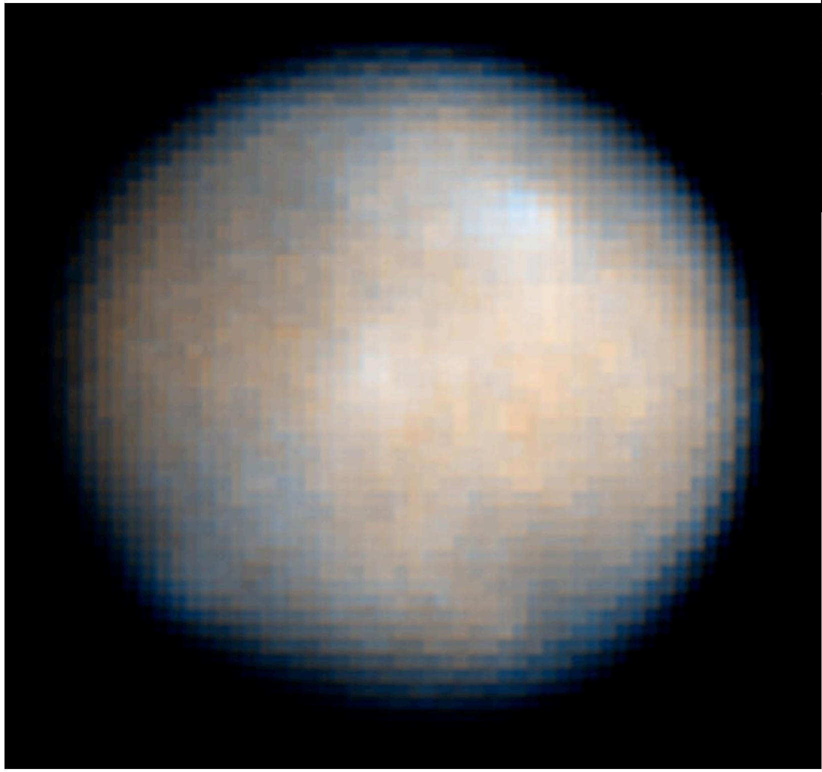
Galahad





Primitive Asteroid Sample Return for New Frontiers

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Asteroids and Solar System Origins

- Asteroids are remnants from the beginnings of solar system formation
  - They preserve materials from the first few million years of solar system history
- Primitive asteroids are the building blocks of terrestrial planets
  - Dust accreted to form asteroid-sized planetesimals, which then accreted to form planetary embryos
  - Some of these planetesimals, or largely unaltered fragments of them, survive to the present epoch
- Primitive asteroids preserve evidence of the processes and conditions of planet formation
- Primitive asteroids delivered organics and volatiles to early Earth – but which ones, and how much?
  - What role did these organics play in the development of life?

Why asteroid sample return?

- Meteorites have provided invaluable data about origins and evolution of planetary materials, but meteorites provide *biased and incomplete samples of asteroids*
- Returned samples may provide *fragile material* which could not survive Earth atmospheric entry intact
- Returned samples are *uncontaminated* by time spent in a terrestrial environment
- Returned samples *represent the diversity* of material in an asteroid, possibly including material *absent from the meteorite collection*
- Sample return provides *geologic context* for meteorites in our collection, plus clues to the nature and the evolution of the source body

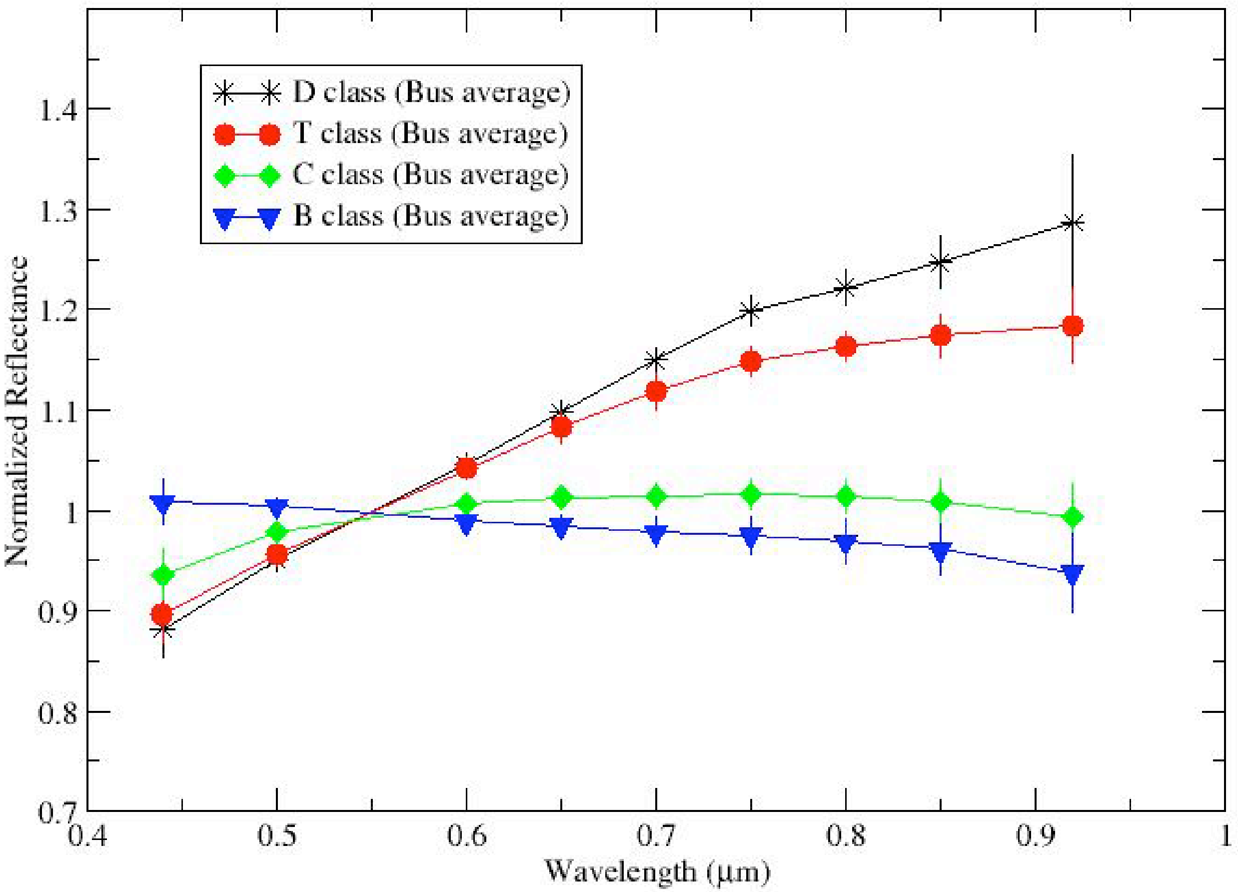
Science Goals

- Understand origins of organic-rich solar system material
- Understand processes and conditions of habitable planet formation
  - Return samples from a body little changed from those that were assembled to form Earth, its oceans and biosphere
- Understand the population of asteroids that may someday impact Earth

Asteroid Spectral Classes

- **Spectral classes are based on visible data, though interpretation is informed by IR/radar/albedos**
- **Three main spectral "complexes": C, X, S**
- **S complex includes Gaspra, Ida, Eros, Itokawa, Apophis…**
  - Dominant type in near-Earth population
- **C complex includes Mathilde, Ceres**
  - Dominant types in main belt
  - Related to carbonaceous chondrite meteorites?
- **X complex includes Nereus, metallic objects?**
- **Outlying D class looks like comets, Trojans, Deimos…**
  - Planetary protection requirements for D-asteroid samples

Asteroid Spectral Classes



Select Target Possibilities Considered

	Type	H	D (km)	P(hrs)	Considered By
(4015) Wilson-Harrington	CF	15.99	~4	6.1	Marco Polo
2002 AT4	D	20.9	~0.4		Marco Polo
2001 SG286	D	20.9	~0.4		Marco Polo
(162173) 1999 JU3	Cg	19.1	1.0	7.6	Marco Polo
(175706) 1996 FG3	C (bin.)	17.8	1.4,0.4	3.6	Marco Polo
(101955) 1999 RQ36	B	20.8	0.6	4.3	OSIRIS (Disc.)
2001 AE2	T	19.0	~1.0		

Sample Analyses

- Isotopic sample analyses will be able to:
  - Identify pre-solar materials, formed around stars other than Sun.
  - Determine isotope ratios in hydrated minerals and organics and compare them to values for terrestrial, cometary, meteoritic materials.
  - Date formation and evolution events for primitive materials, including nebular condensation, chondrule formation, impact metamorphism and aqueous alteration.
- Organic Sample Analyses
  - Search for biochemically important molecules (e.g., sugars, amino acids)
  - Understand formation and evolution of organic species
- Mineralogic Sample Analyses
  - Study thermal and aqueous alteration history of planetesimals and parent bodies
  - Establish chemical, thermal and aqueous context for interpretation of isotopic and organic analyses.
  - Comparisons of Top-Surface and “Bulk” Samples to elucidate effects of space weathering and improve understanding of asteroid spectra

Remote Sensing

- Mineralogies, colors, albedos for surface features
- Structures, densities and surface regolith distributions
  - Is the object a rubble pile?
- Geologic context of sampling site
- Payload instruments under consideration: multi-spectral visible imaging, infrared spectral mapping, sample acquisition and transfer mechanisms.