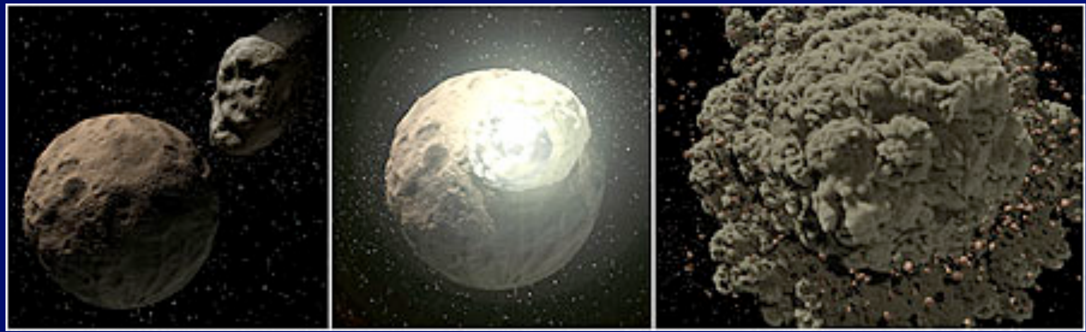
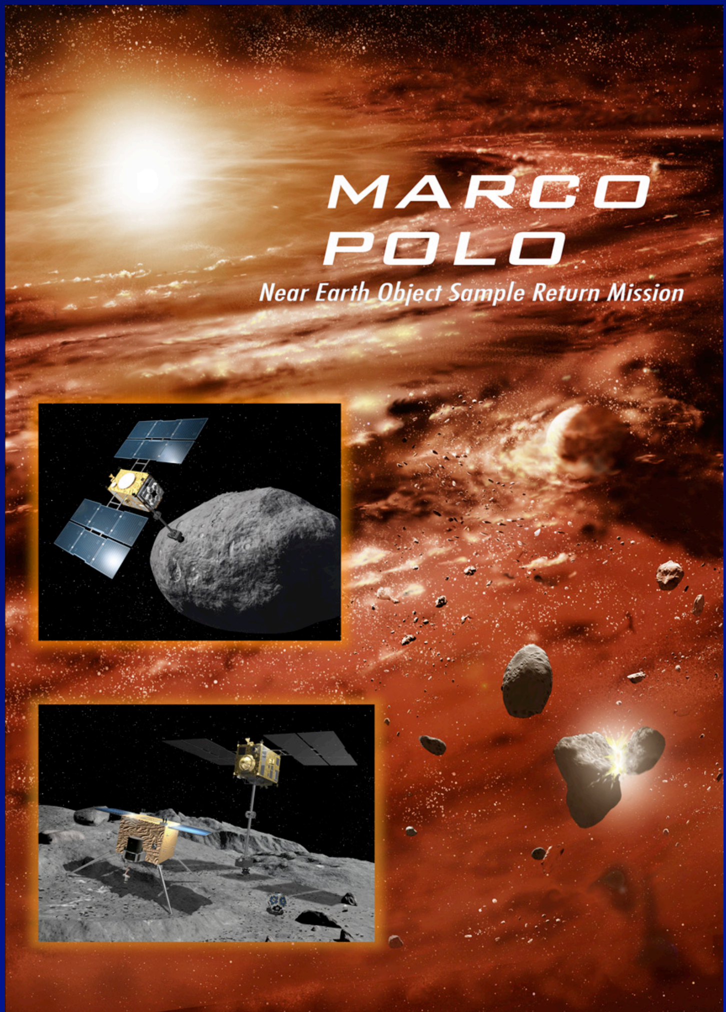
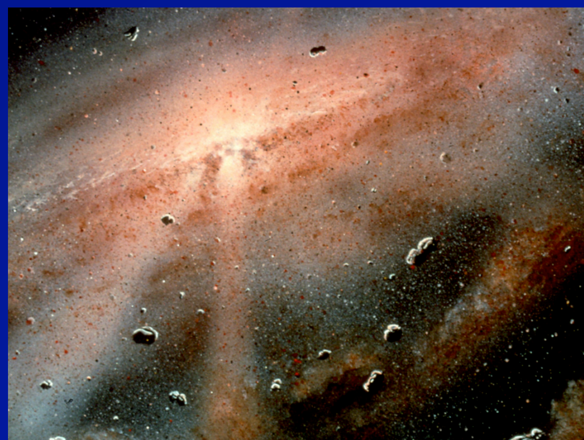


Scientific Rational of Marco Polo

Patrick Michel

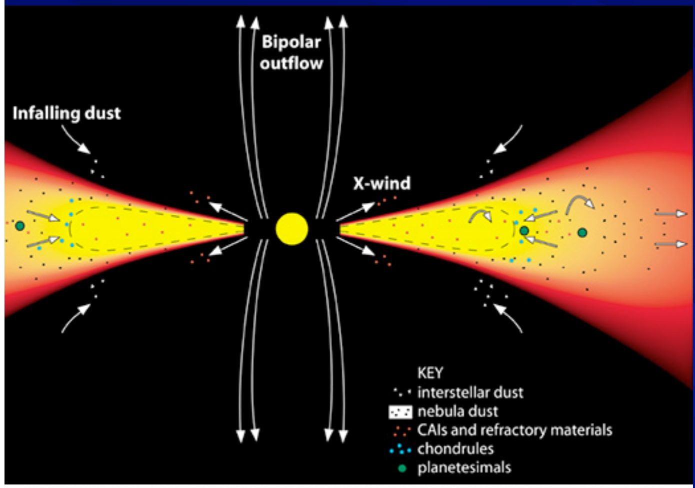
Marco Polo Science Team



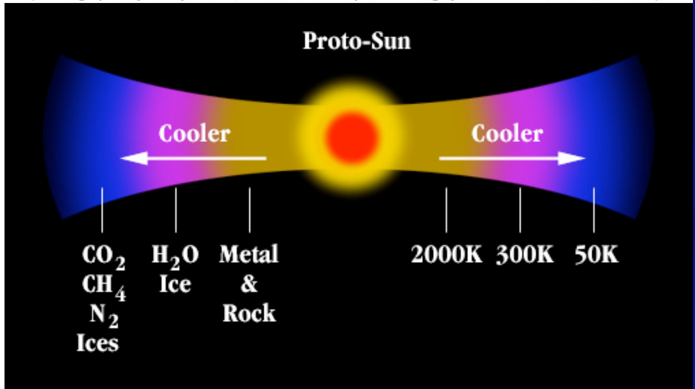


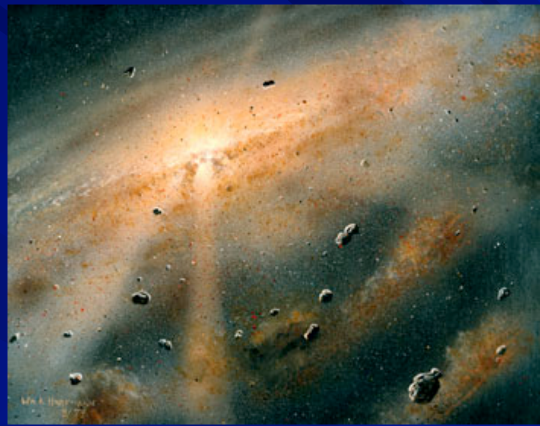
The DNA of the Solar System

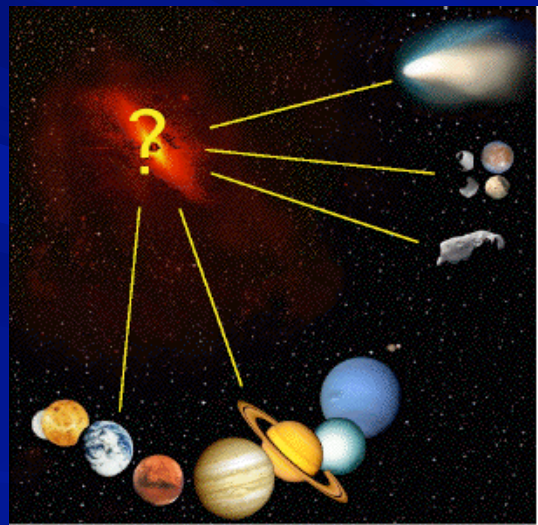
Asteroids are remnant of solids of the protoplanetary disk in which planets were formed



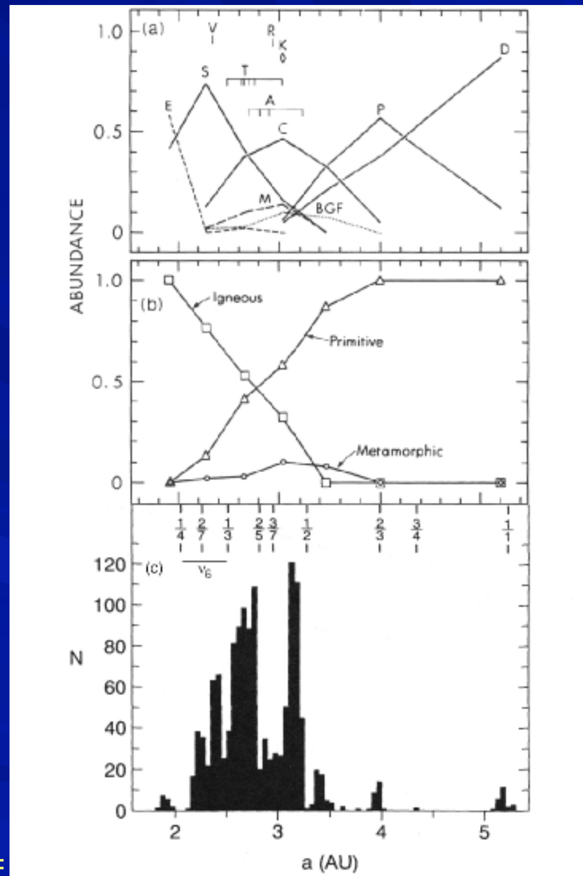
(PSRD graphic by Nancy Hulbirt, based on a conceptual drawing by Edward Scott, Univ. of Hawaii.)







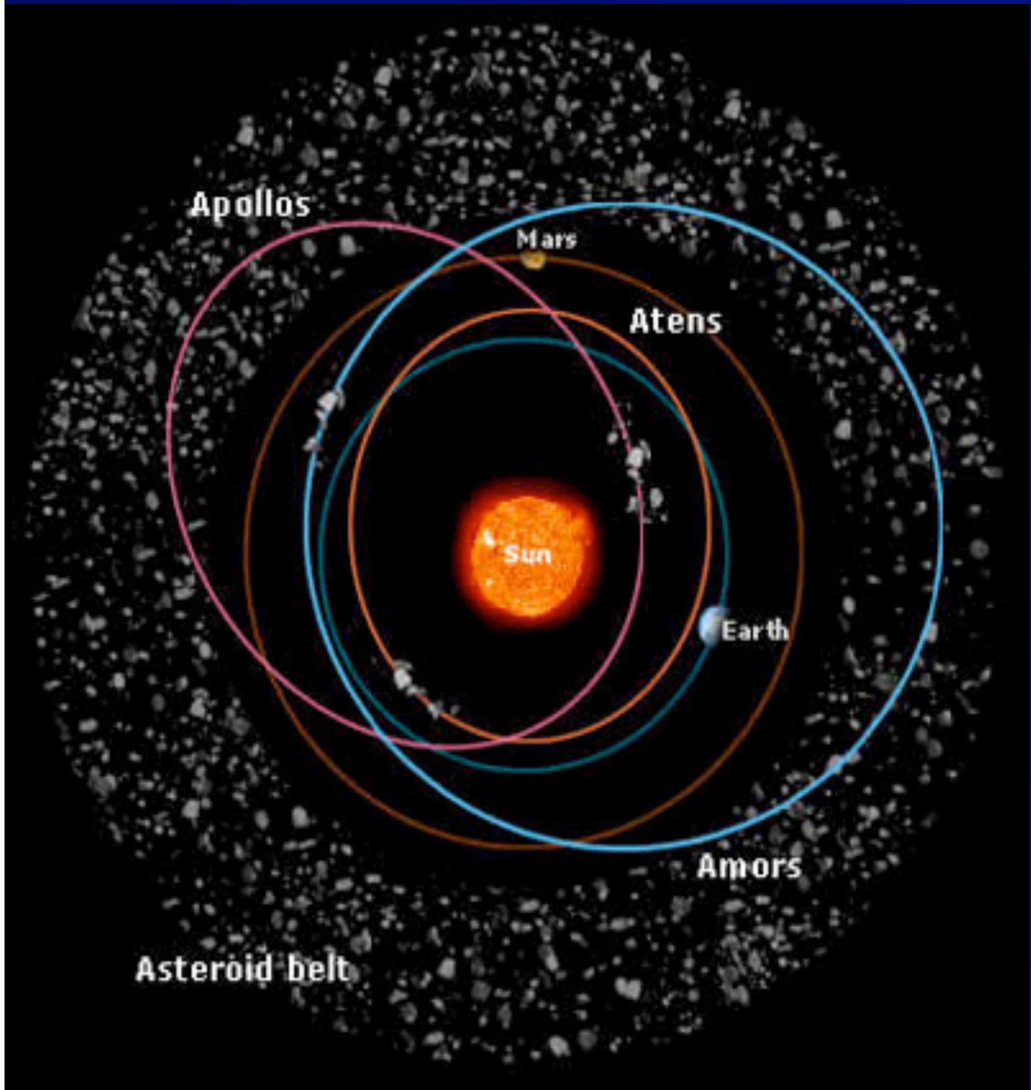
Asteroid Spectra, Composition and number



Dark (C, D) type asteroids ⇐ are the most primitive

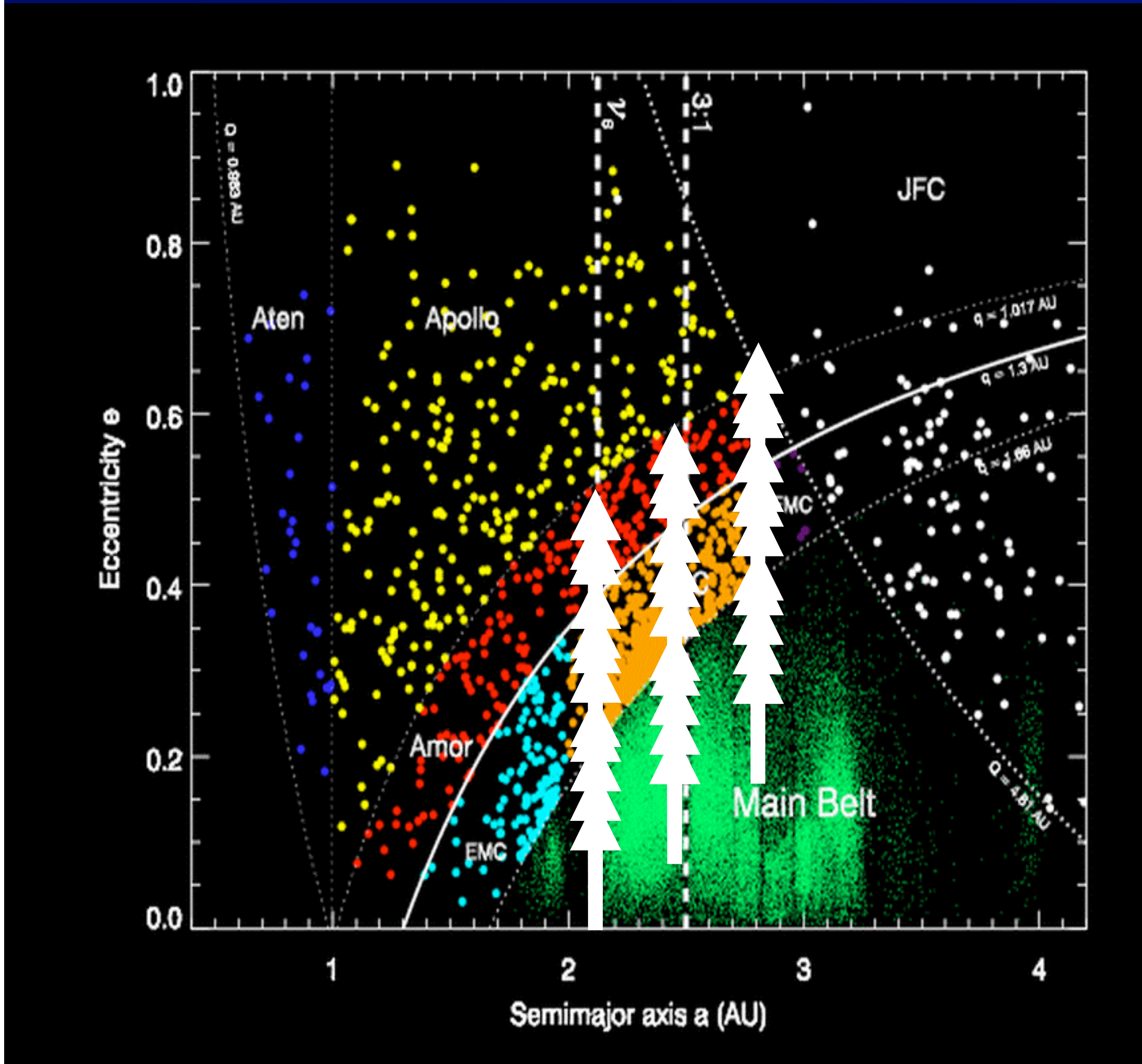
Mean distance to Sun

The NEO population



NEOs offer many advantages:

- Accessibility
- Identified links to other small body populations
- DNA of the Solar System
- Great diversity of physical and compositional properties
- Hazard



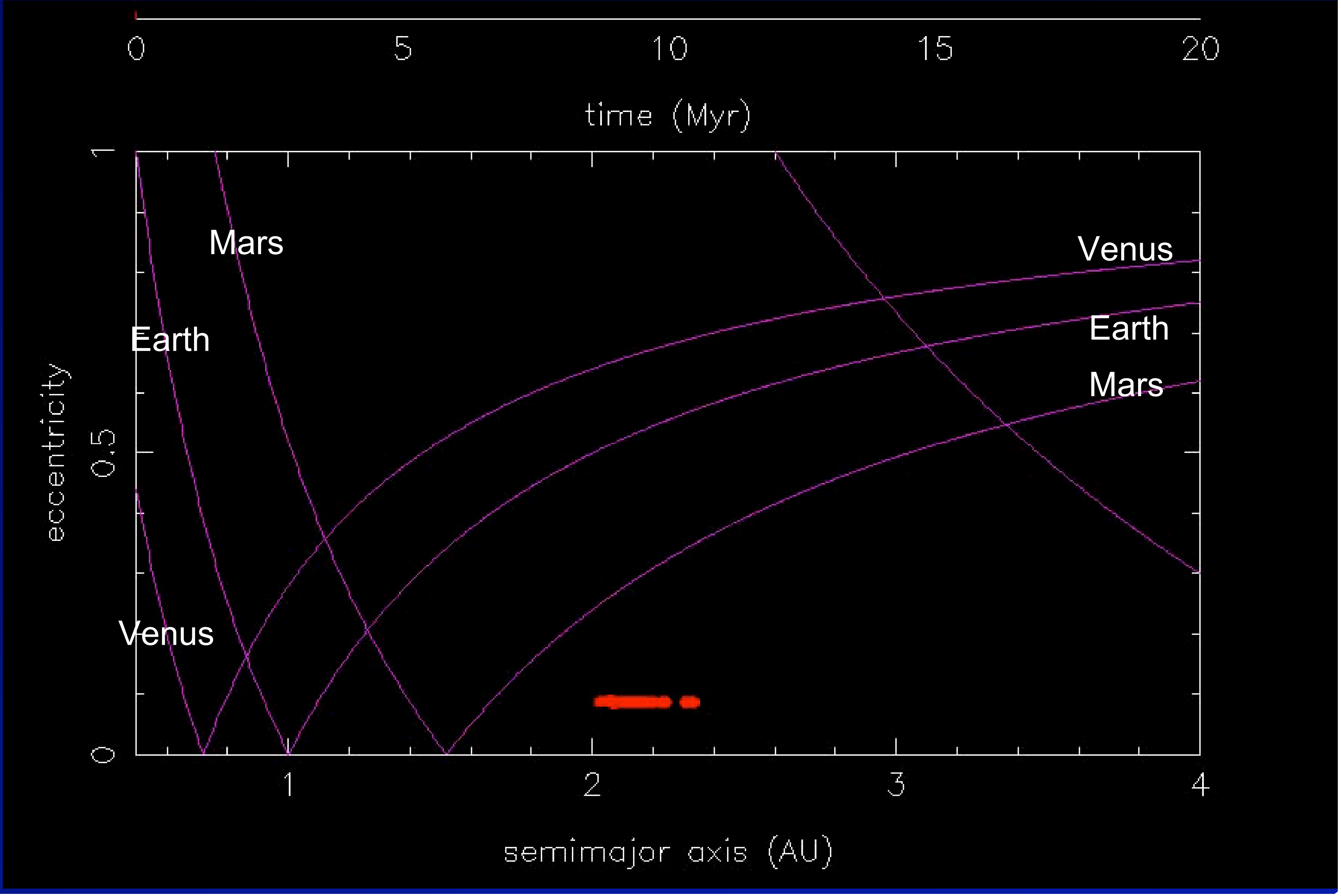
Mean distance to the Sun (AU)

Origin of NEOs

Asteroids from different regions of the Main Belt (MB) are injected into resonances which transport them on Earth-crossing orbits

A small fraction (6-8%) of NEOs come from Jupiter-family comets

Fast resonances: Main Belt Asteroids become rapidly NEOs by dynamical transport from a source region (in a few million years)



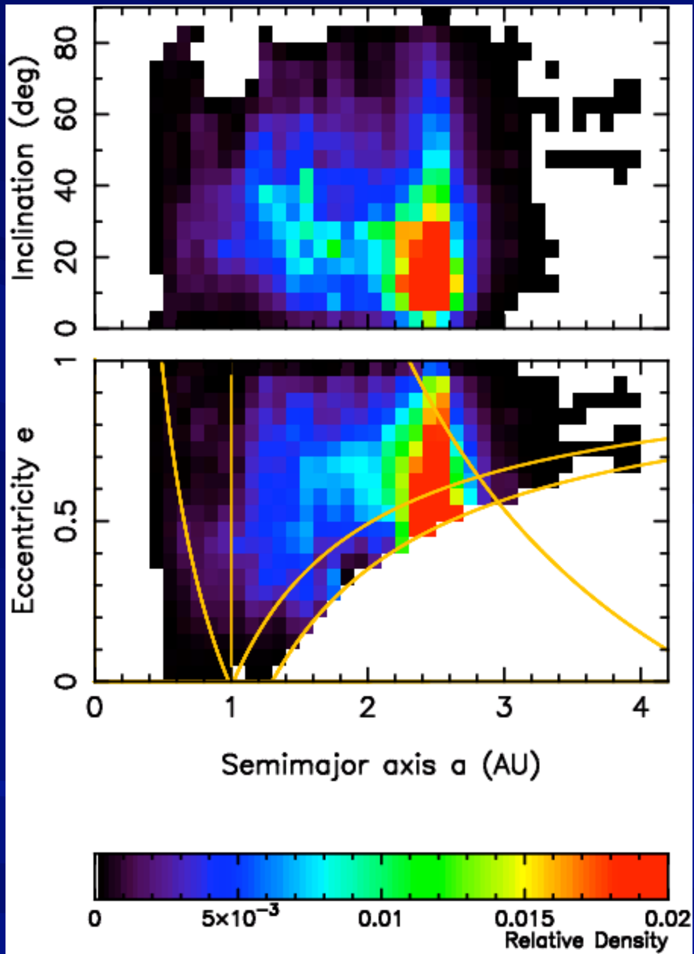
Four main sources of NEOs have been identified

- Main Belt (MB) asteroids injected into the 3/1 mean motion resonance with Jupiter
- MB asteroids injected into the ν_6 secular resonance
- Outer Main Belt Asteroids (beyond the 3/1)
- Intermediate Mars-crossers
- Jupiter-family comets

The dynamics of bodies from each source has been investigated numerically in details and led to the determination of their distribution once in the NEO space

(Bottke et al. 2002, Icarus 156, 399)

Example: likely origin of 1999JU3



From its current orbit:

a=1.19 AU, e=0.19, i=7.22°

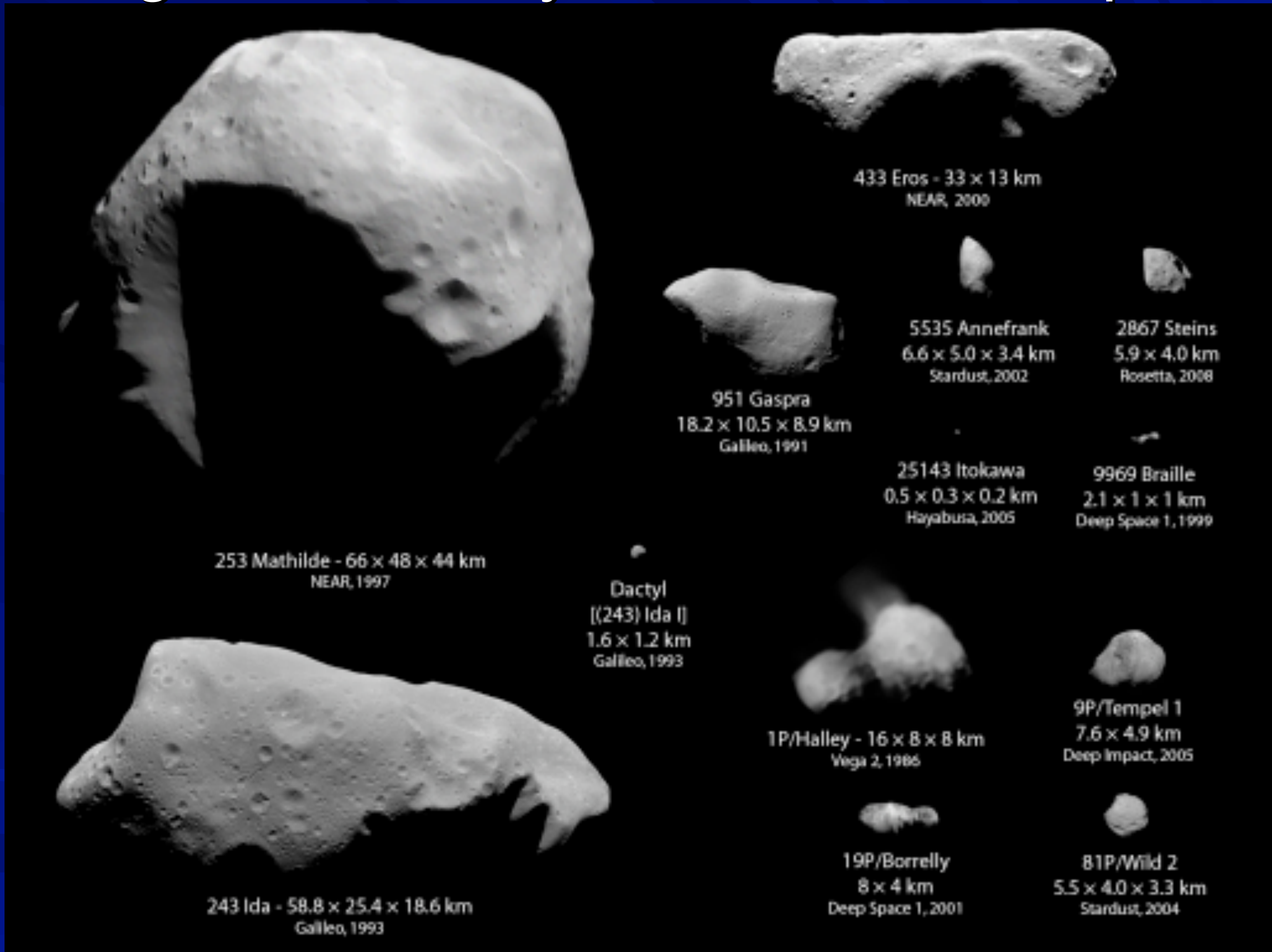
8.37% chance of coming from the 3/1 Mean motion resonance with Jupiter (a=2.5 AU)

91.63% chance of coming from the ν_6 secular resonance (a=2.26 AU)

⇒ Being a C-type (most numerous in the Outer belt) 1999JU3 may be linked to the Baptistina family, a C-type family close to ν_6

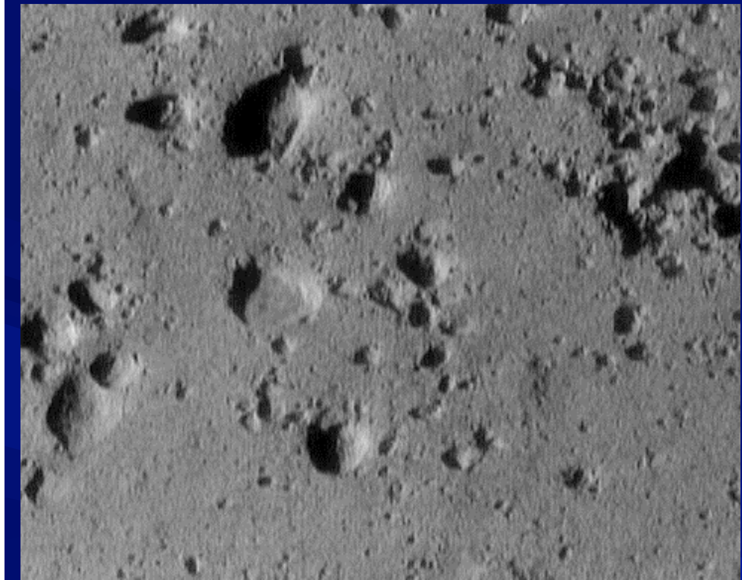
Density plot of NEOs coming from the 3/1 resonance
(red=large number, black=small number, white=none

A great diversity of sizes and shapes



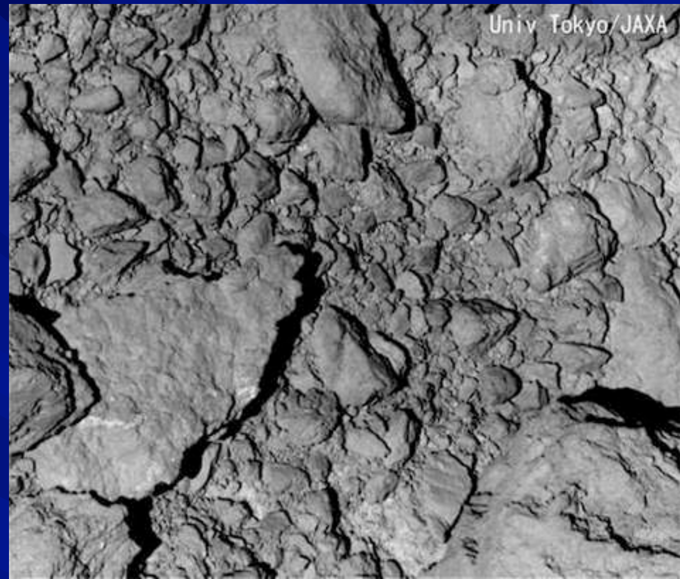
Note: only two asteroids have been visited so far, and are of the same type (S)
No such information exist for a primitive (dark type) asteroid

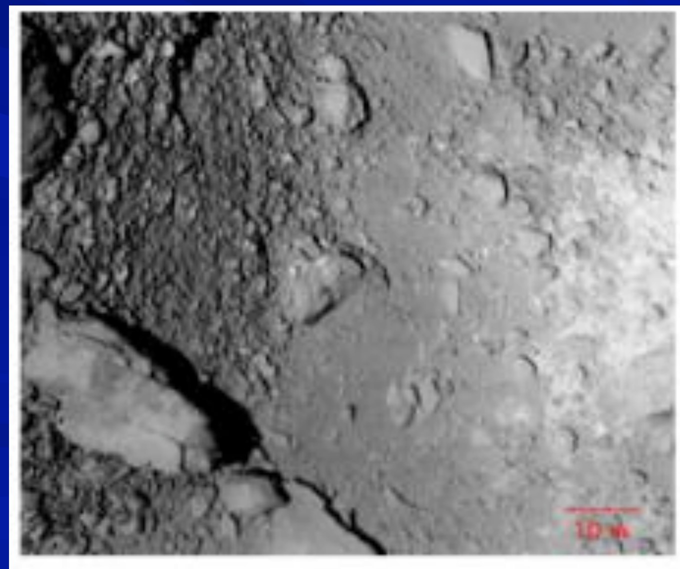
Eros surface taken from 823 feets
(NEAR)



Layer of fine regolith, 10-100 m depth
1 m to 100 m-size boulders

Itokawa surface: gravel, pebbles
(Hayabusa)





Outer regolith layer with mean depth about 44 cm

The two visited asteroids: both S taxonomic type and totally different surface properties

Asteroid Mathilde 253

C-type
low albedo
(<0.1)

1.3 g/cm^3

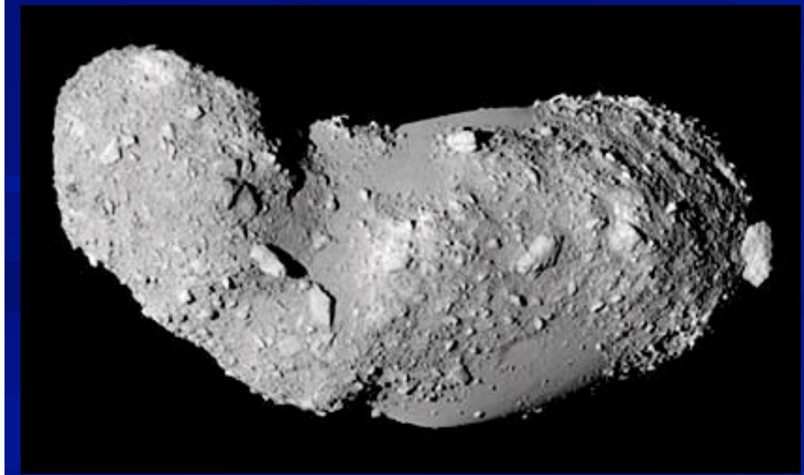
Asteroid Eros

S-type
high albedo
(> 0.15)

2.7 g/cm^3

Note: even two bodies of same spectral type can be very different!

Asteroid Itokawa



S-type

1.9 g/cm^3

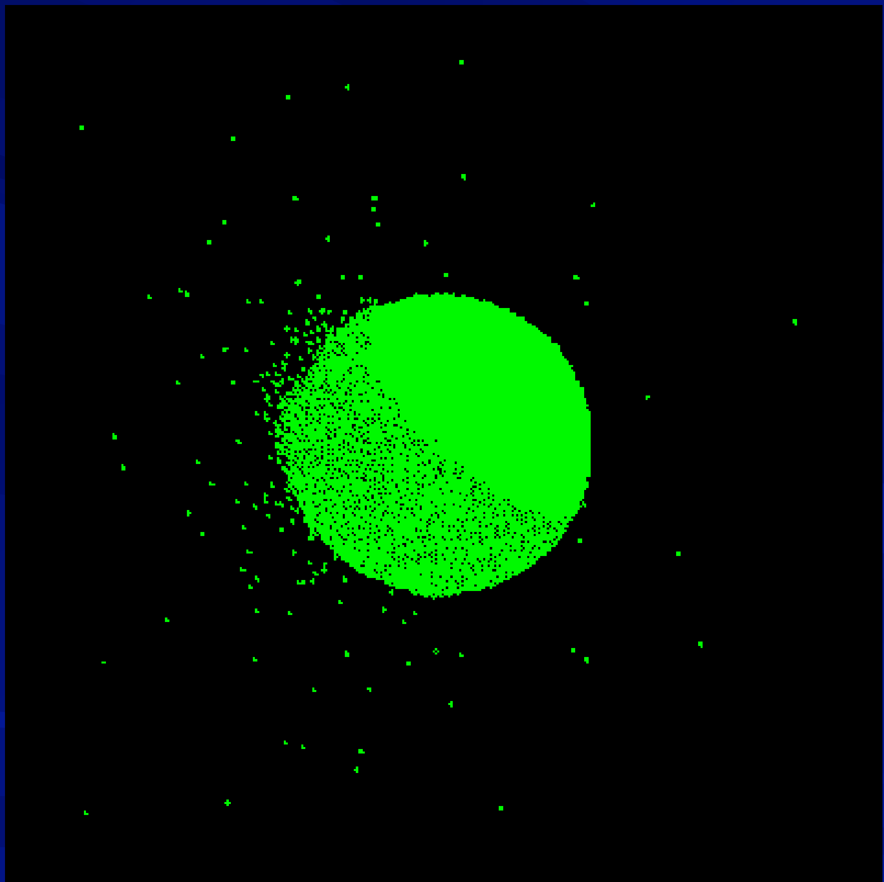
Great diversity of structures

⇒Importance of bulk density estimate

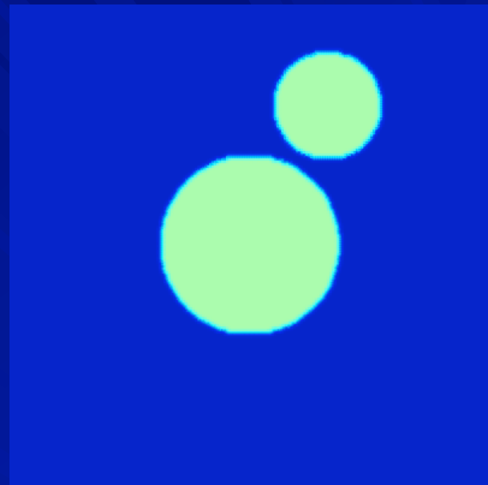
⇒Can tell us something about the collisional history of asteroids

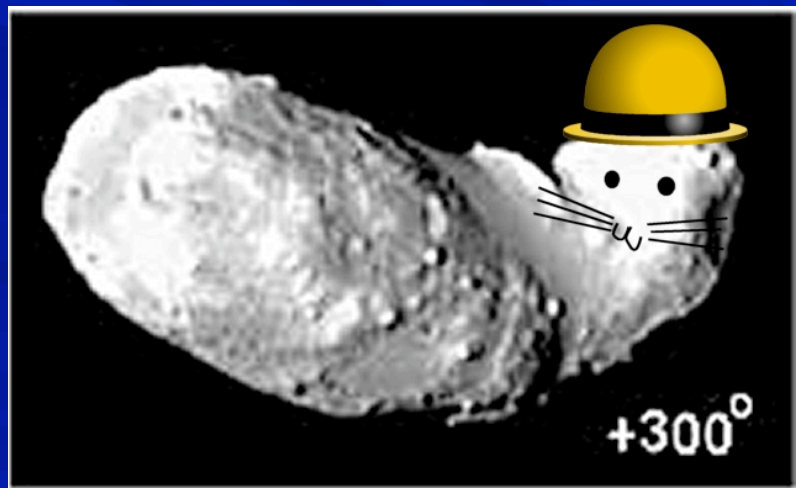
In-situ observations and modelling can improve our understanding of formation processes of NEOS

Gravitational phase of a disruption



Disruption by impact of a large asteroid: fragmentation phase computed with properties of terrestrial rocks;
⇒would benefit from the knowledge of real properties of an asteroid thanks to sample analysis!

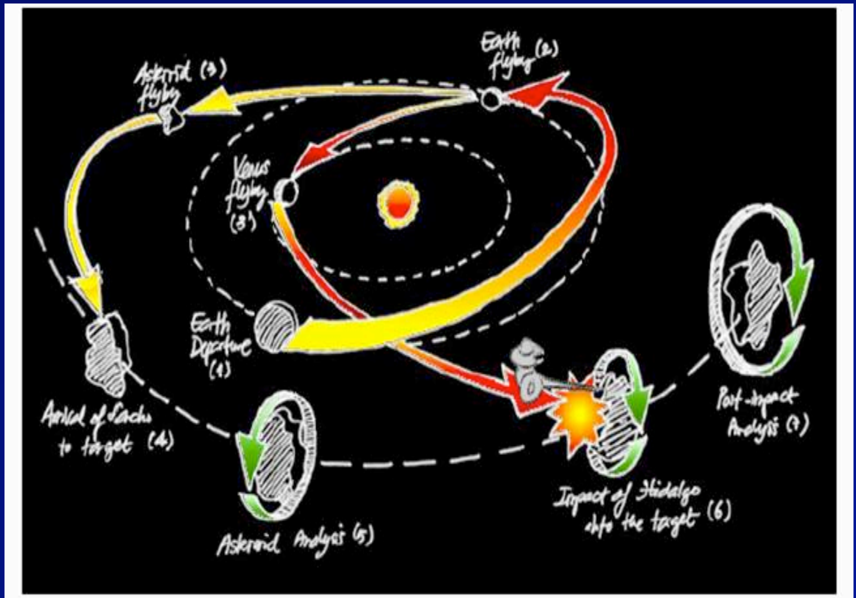




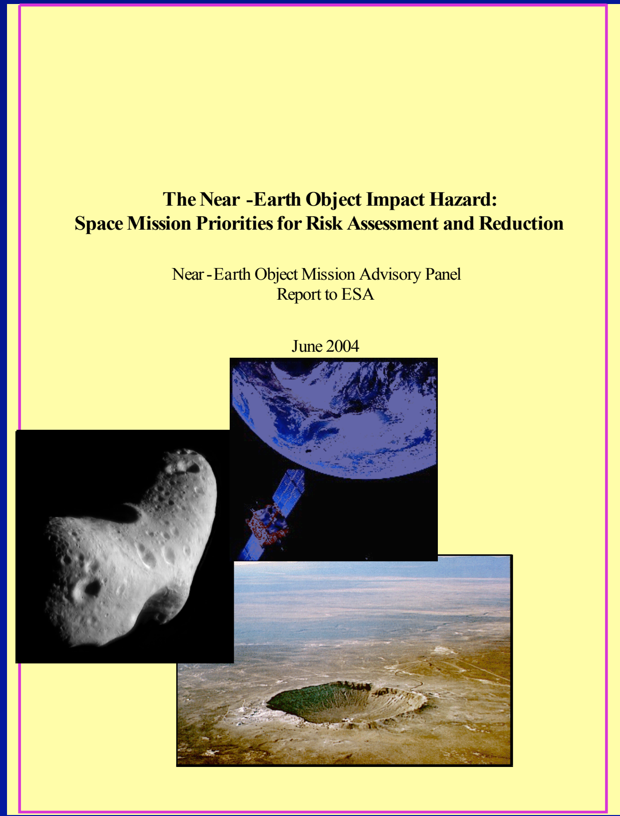
Michel P., Benz W., Richardson D.C. 2001. 2002, 2003, 2004a, b
Michel P. 2006, Lecture Notes in Physics
Michel P. 2009, Lecture Notes in Physics

Surface and internal properties: crucial information for hazard mitigation

• **Example: Mission Don Quijote: phase A studies at ESA (final presentation: 17-18 Avril 2007)**



The momentum transfer efficiency highly depends on the surface properties (e.g. porosity) and internal properties (e.g. Monolithic vs. Rubble pile)



The Near -Earth Object Impact Hazard:
Space Mission Priorities for Risk Assessment and Reduction

Near - Earth Object Mission Advisory Panel
Report to ESA

June 2004

So far, we have no information at all concerning a dark type NEO

Conclusions

NEOs are ideal targets for a sample return mission:

- Easily accessible
- The likely source region of an object can be identified
- Have kept (at least part of) the memory of the Solar Nebula in which planets formed
- Primitive ones contain information of great interest for exobiology
- Can tell us about the geological (and other) processes that they undergo during their history (e.g. reaccumulations, seismic shaking)
- Represent a hazard which requires information on their internal and surface properties

And finally, high level of public outreach!

+

€403,000,000

esa Space Science
European Space Agency

Cosmic Vision: M-class Mission

€300,000,000