MARCOPOLO-R: ESA SAMPLE RETURN MISSION TO THE POTENTIALLY HAZARDOUS ASTEROID 2008 EV5





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MP-R ESA SST:

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MarcoPolo-R will rendezvous with the primitive NEA 2008 EV5:

- scientifically characterize it at multiple scales, and
- return a sample to Earth unaffected by the atmospheric entry process or terrestrial contamination.

http://www.oca.eu/MarcoPolo-R/

European Community Supporters:

682 scientists (March 1st, 2013) (25 countries)

+ USA, Japan, Brazil etc

International collaborations (junior partners) are possible

MarcoPolo-R is on Faceboook:

http://www.facebook.com/pages/MarcoPolo-R-Space-Mission/40232049502



Cosmic Vision

Space Science for Europe 2015-2025



Cosmic Vision 2015-2025

- 1) What are the conditions for life and planetary formation?
- How does the Solar System work?

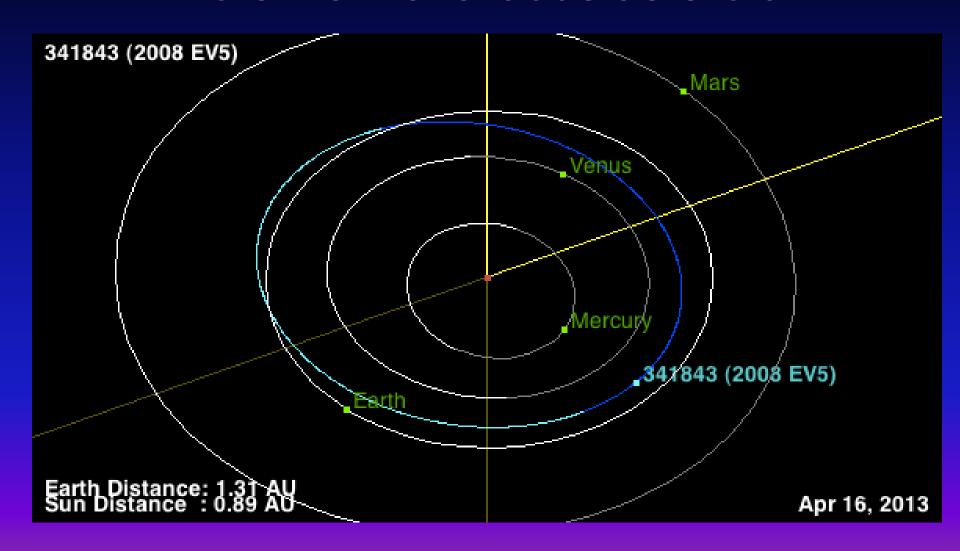




Mitigation



The attractive NEA 2008 EV5 Potential hazardous asteroid



The attractive NEA 2008 EV5

Potential hazardous asteroid

- Size and shape from radar:
 - 400 +/- 50 meters oblate spheroid (Busch et al. 2011)
- Rot Period = 3.725 ± 0.001h (retrograde)
- Pole -- Ecliptic: 180 ° , -84 ° ± 10 °
- Spectral type: belongs to the C complex
- Albedo: 0.10-0.12

From Reddy et al (2012) albedo, negative slope, and circular polarization ratio, EV5 could be similar to CI Orgueil (band at 0.48µm due to aqueous alteration)

- probably accreted in a volatile-rich region.





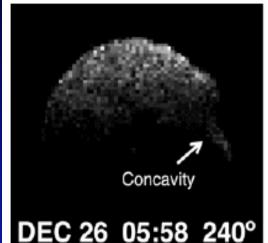


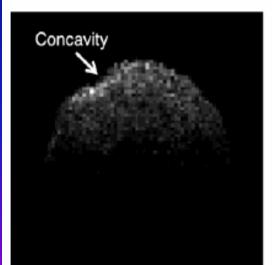
320 meters

New data revealed very high interest for science & mitigation Advantage: allows a very short & cheap mission (sample return in 4.5 years)

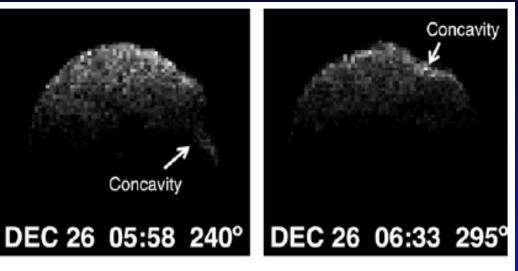
Arecibo delay-Doppler images of 2008 EV5 from 2008 December 23-27

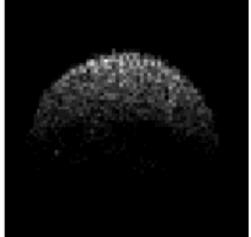






DEC 26 07:08 350° DEC 27 06:27 115°





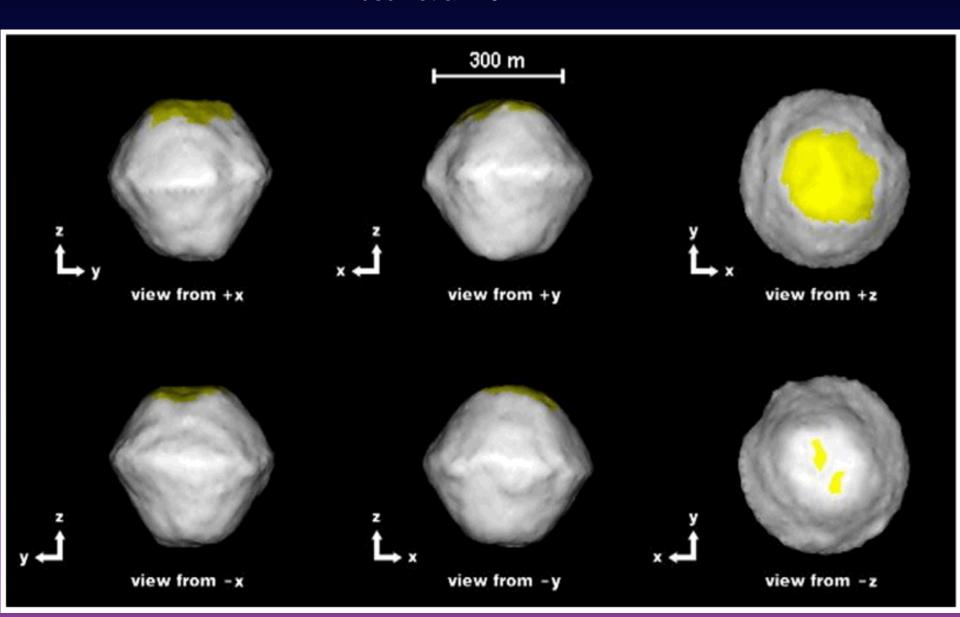
Concavity of 150 meters

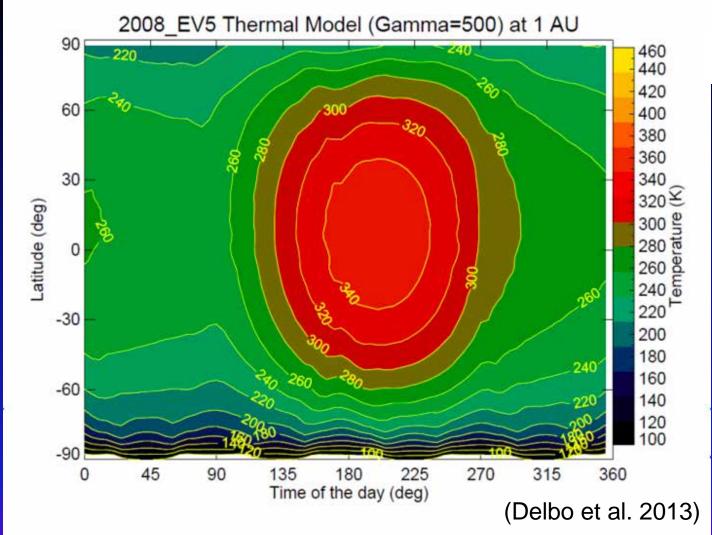
Few or no large blocks evident in the 7.5 m-resolution Arecibo images

Busch et al. 2011

Principal axis views of 2008 EV5 shape model

Busch et al. 2011





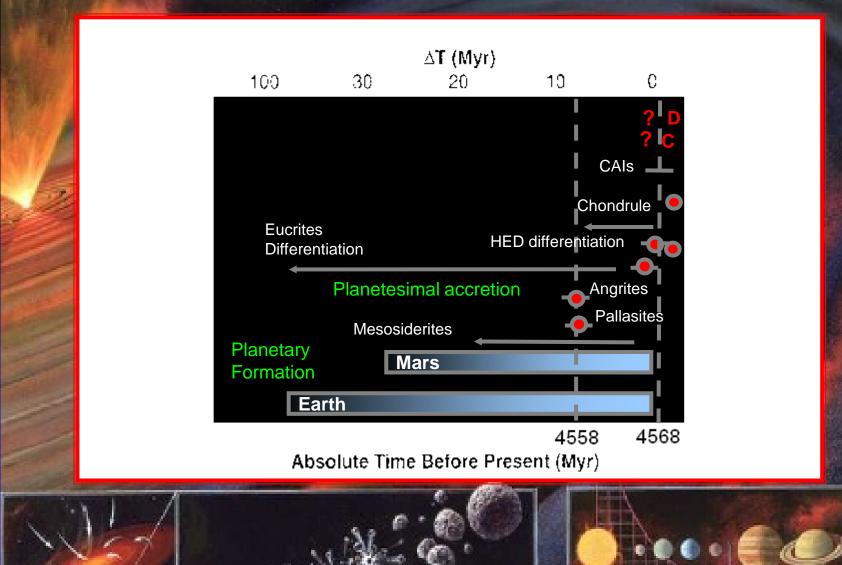
Thermal Inertia Γ of about 450 +/- 100 J s-1/2 K-1m-2 Using the method by Gundlach and Blum (2013) Delbo et al (2013) derived an average grain size of the regolith of the order of 0.5 - 1 cm



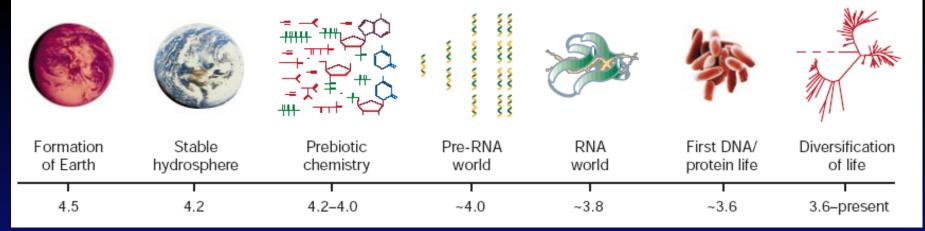
Why MarcoPolo-R mission?

Tracing the origins ...









Current exobiological scenarios for the origin of life invoke the exogenous delivery of organic matter to the early Earth

The planets of the inner solar system experienced an intense influx of organic-rich material for several hundred million years after they formed.

The earliest evidence for life on Earth coincides with the decline of this bombardment.

Many biologically important molecules are present in the organic materials.

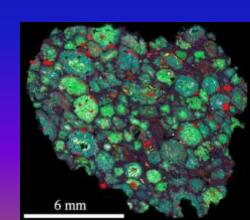
Laboratory investigation of returned samples



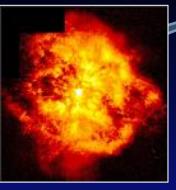
High spatial resolution and analytical precision are needed:



- Ø High precision analyses including trace element abundances to ppb levels and isotopic ratios approaching ppm levels of precision
- **Ø** High spatial resolution a few microns or less
- Ø Requires large, complex instruments − e.g. high mass resolution instruments (large magnets, high voltage), bright sources (e.g. Synchrotron) and usually requires multi-approach studies



MarcoPolo-R addresses a wide range of objectives



Stars

Stellar nucleosynthesis Nature of stellar condensate grains





The proto-solar nebula

Accretion disk environment, processes and timescales



Planetary formation

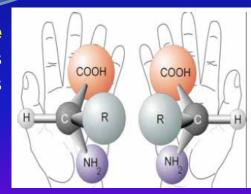
Inner Solar System Disk & planetesimal properties at the time of planet formation



Asteroids

Accretion history, alteration processes, impact events, regolith

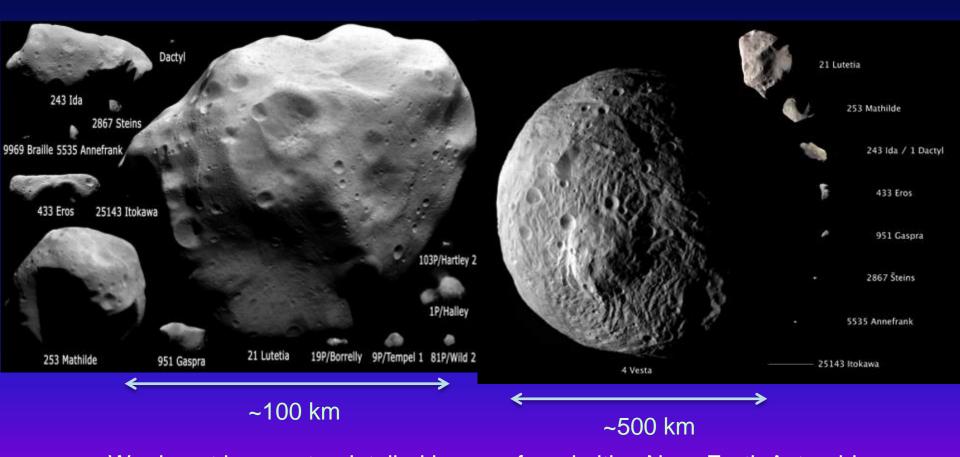
Life Nature of organics in NEOs





The Earth Impact hazard Evolution of life on Earth

Small bodies: a wide variety of physical & compositional properties



We do not have yet a detailed image of a primitive Near-Earth Asteroid We need several missions to obtain a comprehensive knowledge of primitive materials



Look different, but common origin



NEOShield EU project:

High priority

multiplicity

composition,

thermodyn. and

mechanical prop.,

porosity, multiplicity,

Mass

shape

Mass, porosity,

mechanical prop., size,

shape, rotation prop.,

Mass, elem. and chem.

Kinetic

impactor

<u>Gravity tractor</u>

Blast deflection

Medium priority

density, thermal

Shape, density

properties

Surface composition,

distribution, mechanical

properties, multiplicity

Acoustic properties,

density, rotational

properties

Low priority

Rotational

properties

Thermal

properties

Albedo

Mitigation	Physical properties
D2.2. Requir	ements for infugation precursor reconnaissance

	_	
Mitigation		Physical properties
technique		

Mitigation	Physical properties
technique	

Schedule for ESA M3 class mission



Advisory structure

Selection of 5 missions

2011

2012

2013

2014

ESA-internal studies in Concurrent Design Facility

Industrial studies (2 competing for each mission)

Phase A

Final selection (February 2014)

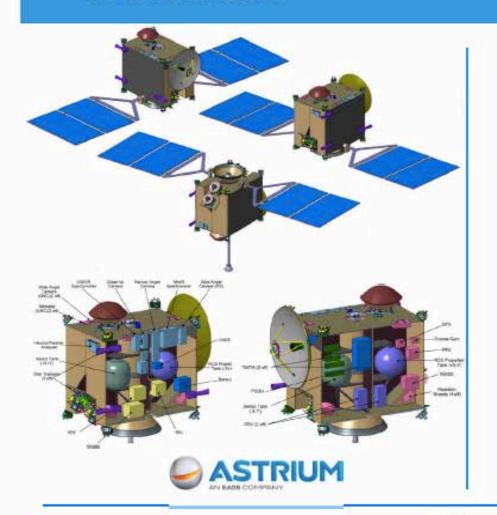
Phase B1 kick-off March 2014 for selected mission

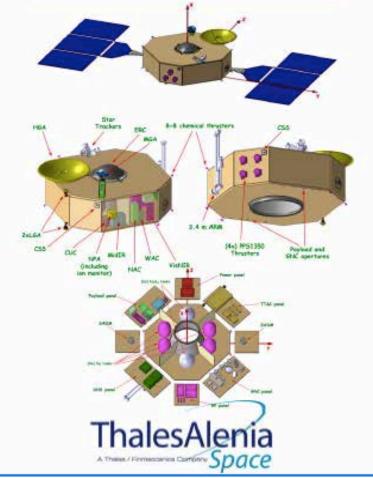
Implementation phase in industry,

launch 2022 - 2024

Mission design: The spacecraft Main features









MarcoPolo-R payload summary



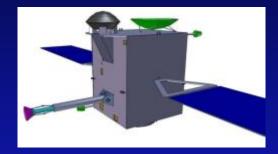
Name	Туре	Mass	PI (Lead & partners)
MaNAC	Narrow Angle Camera	10.6 kg	G. Cremonese (Osservatorio Astronomico Padova, Italy)
CUC	Close-up Camera	0.8 kg	JLuc Josset (Space Exploration Institute, Switzerland)
MaRIS	Visible near Infrared imaging Spectrometer	6.2 kg	A. Barucci (LESIA, France)
THERMAP	Mid-infrared spectro imager	4.4 kg	O. Groussin (LAM, France)
RSE	Radio Science Experiment	none	T. Andert (Universität der Bundeswehr, Germany)
VESPA/ VISTA2	Thermogravimetric analysis (one sensor out of a larger instrument package)	1.0 kg (tbd)	tbd
		23.0 kg	

+ LIDAR for navigation by JAXA

MarcoPolo-R - 2008 EV5

	Spatial resolution			
	VIS	VIS/IR	Mid-IR	
	imaging	spectrometer	instrument	
Global characterisation	Order of	Order of	Order of	
	dm	m	10 m	
Local characterisation	Order of	Order of	Order of	
	mm	dm	dm	
Context measurements	Hundred μm	•	-	





After a first assessment, the precise mission analysis is now available at ESA-ESOC

Q Primary launch opportunities:

- ü Launch in December 2022, 4.5-year duration, arrival at the asteroid ~ January 2025, return to Earth in June 2027
- ü Launch in December 2023, 4.5 year duration, arrival at the asteroid ~ December 2025, return to Earth in June 2028

Ø Backup opportunity:

ü Launch in December 2024, 6.5 year duration, arrival at the asteroid ~ November 2027.



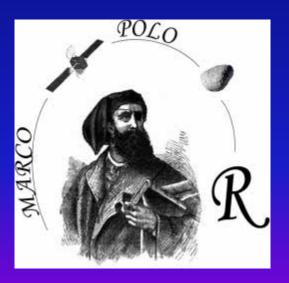
MarcoPolo-R – 2008 EV5



Compared to the mission to 1996FG3, a 2008EV5 mission features:

- Ø Shorter mission duration (approx. 4.5 vs. 7 years)
- Ø Reduce required mission delta-V ([3-4] km/s vs. [5-6] km/s)
- Ø Shorter distance between Earth and spacecraft (higher data rate and simpler communication system)
- Ø Have a "constant" distance from the sun (good for thermal design)
- Ø Have a lower sample capsule reentry speed (smaller ERC)





Technology activities MP-R is not a critical mission in terms of TRL level



High-precision Guidance, Navigation & Control (GNC) was found to need more attention in the previous Marco Polo study. Phase 2, 500 k€ (completed – successful).

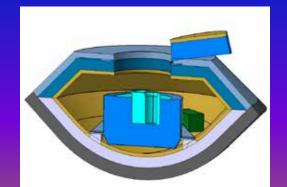
Conclusion: high-precision landing on a small body works

For touch and go: Sampling tool mechanism for low-gravity bodies, activity funded by MREP, 700k€, split into two phases. Phase 2 will test sampling tool in microgravity, i.e. parabolic flight

(Study Kick-Off in July 2012): various concepts

□ Earth re-entry - in various technology activities









In total, ESA is investing close to 11M€

in activities directly relating to MP-R and other technologies developed in other programmes which are indirectly related to MP-R

in addition nationally funded activities regarding the ESA selected scientific instruments are going on

NASA financed (Aug.14, 2012) APL-JHU, for a study of a possible Sample mechanism for MP-R

Possible contribution by JAXA (LIDAR-GNC)



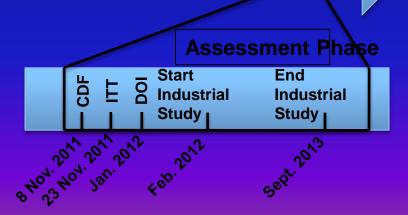


A new ERA of Sample Return



MarcoPolo-R (ESA)

- different primitive object
- particuliar C-type
- different sampling







üallow Europe to contribute in a timely manner to the international sample return effort

üallow scientists to unravel mysteries surrounding the birth and evolution of the solar system

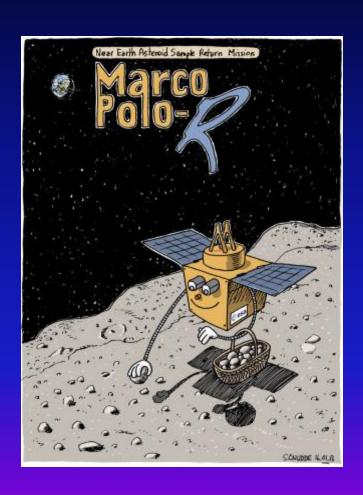
uretain samples for future advances through a Curation and Distribution Facility

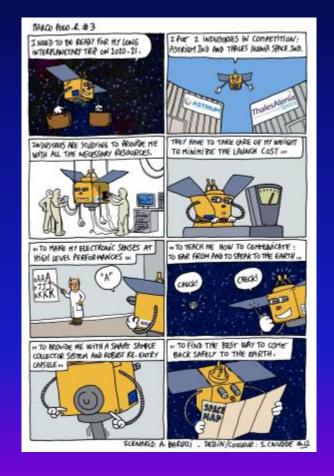
Support mitigation strategies

Next MarcoPolo-R meeting

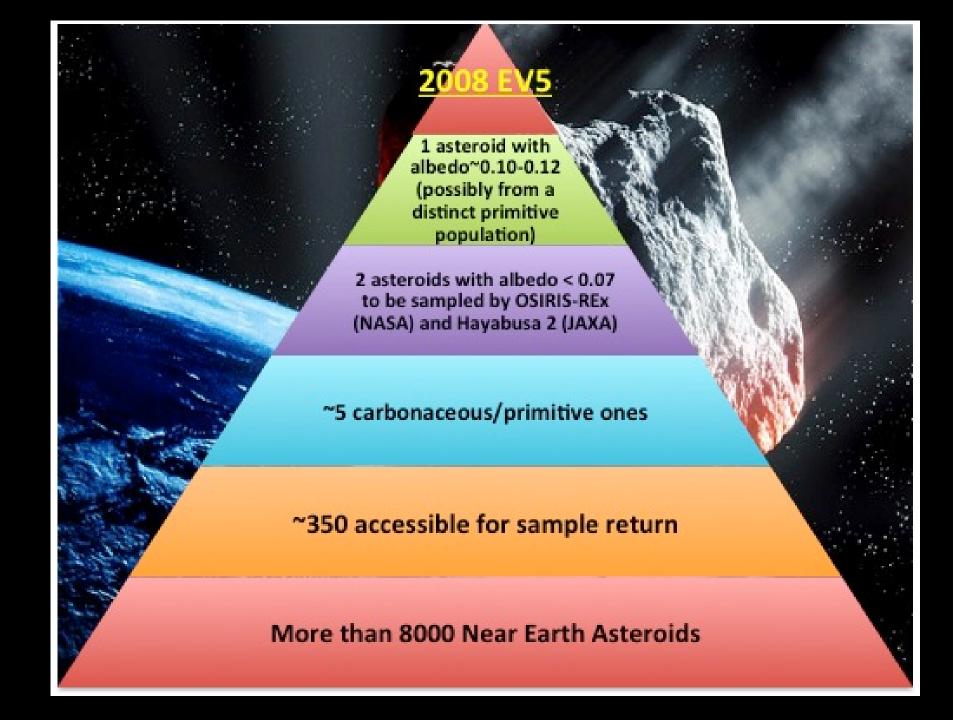
Juin 3rd-4th, 2013 ESA-ESTEC, The Netherland







http://www.sciops.esa.int/The_science_of_MarcoPolo-R





We need

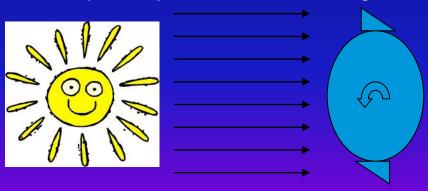
- more than one sample return mission
- an European NEA return mission

HY2 + O-Rex + MP-R >> 3

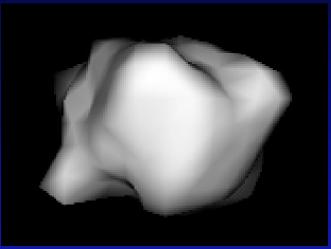
(Shogo Tachibana, Hayabysa-2 Sampler Science PI, Paris, 17.12.2012)

Spin-up by YORP

- 1. Even sunlight, such as the "YORP" effect, can spin-up and disrupt asteroids.
- 2. Depends on body size and distance from Sun.
- 3. Spin-up timescale ~Myr.



Taylor et al. (2007)



54509 YORP: 12.2-minute rotation and speeding up!

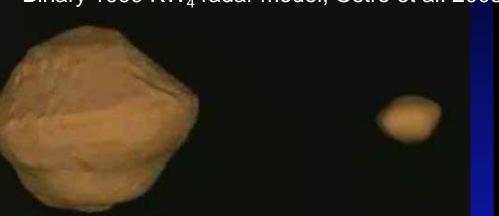
Asteroid must be nearly strengthless to

disrupt.

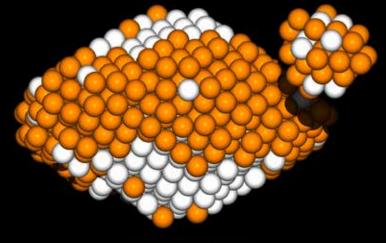
Both EV5 and FG3 have Top Shapes and a Ridge and same rotation period ...

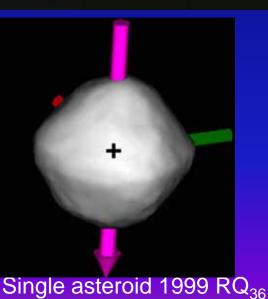


Binary 1999 KW₄ radar model, Ostro et al. 2005

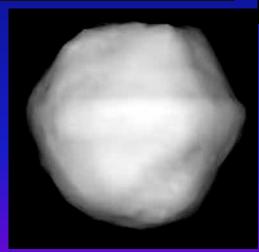


YORP spinup sims, Walsh et al. 2008

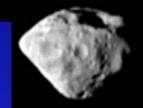




Howell et al. 2008, ACM



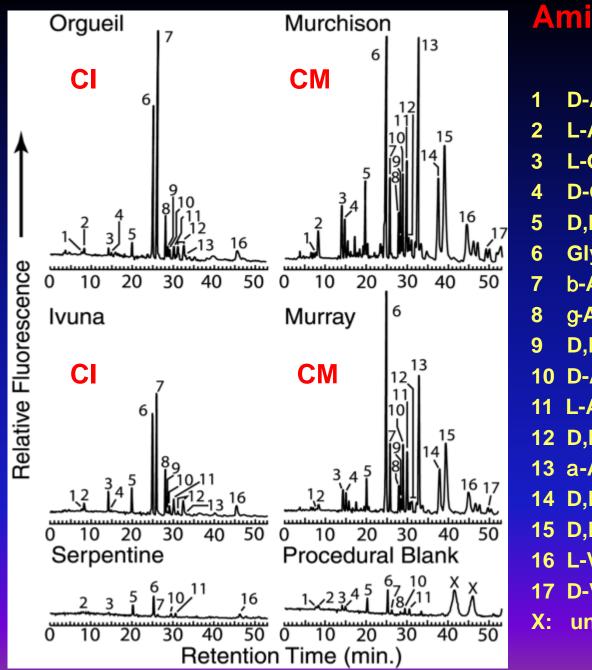
Binary 2004 DC Taylor et al. 2008, ACM



Šteins (Rosetta Images)



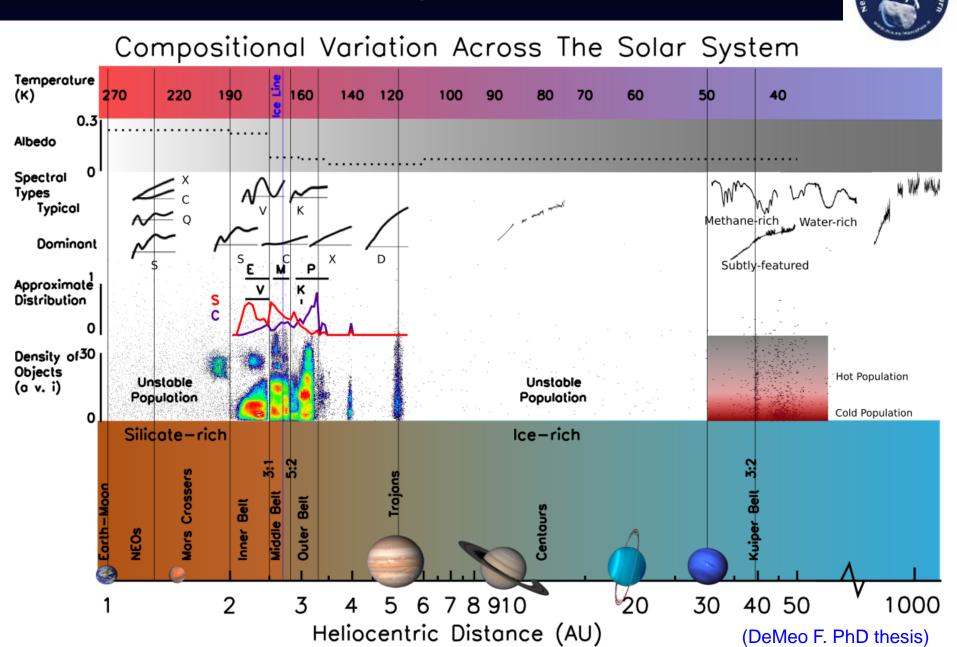
Single 2008EV5 Busch et al. 2011



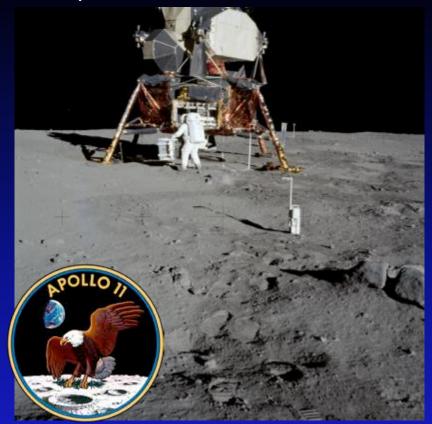
Amino Acids in Meteorite Extracts

- **D-Aspartic Acid**
- **L-Aspartic Acid**
- **L-Glutamic Acid**
- **D-Glutamic Acid**
- **D,L-Serine**
- **Glycine**
- b-Alanine
- g-Amino-n-butyric Acid (g-ABA)
- **D,L-b-Aminoisobutyric Acid (b-AIB)**
- **D-Alanine**
- L-Alanine
- 12 D,L-b-Amino-*n*-butyric Acid (b-ABA)
- 13 a-Aminoisobutyric Acid (AIB)
- 14 D,L-a-Amino-*n*-butyric Acid (a-ABA)
- 15 D,L-Isovaline
- 16 L-Valine
- **D-Valine**
- unknown

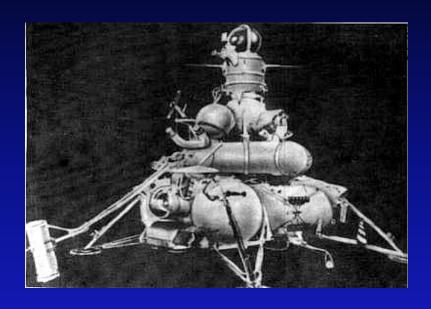
Why NEA?



Apollo 11, US 1969



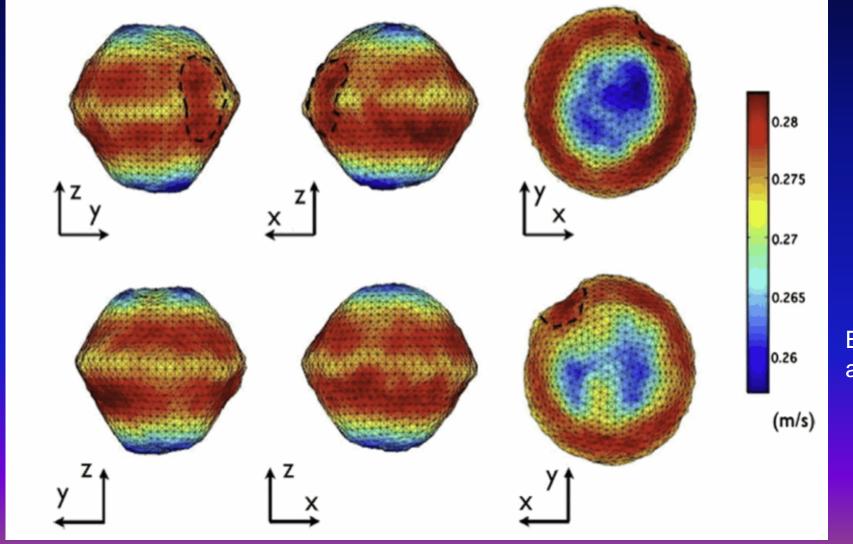
Luna 16, US 1970



A new ERA of sample return

Geopotential mapped as equivalent velocity over the surface of the 2008 EV5 shape model (assuming a bulk density of 3 g/cm³)





Busch et al. 2011