

Marco Polo Workshop Summary

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- Cannot summarise all that has been presented
- Will concentrate on a few important issues
My personal (biased?) opinions

Target

- Primary objective is to return a sample from a primitive NEO
- This means a C, D, B, T, or related type
 - featureless spectrum, low albedo
- “Spectral type is just a letter” [Binzel]
 - but the best guide we have to select a target based on spectra and meteorite studies [Clark]
- 1999JU3 launch opportunities not ideal in 2017/18 [Kawaguchi]
 - many potential targets will be available soon [Michel]

NEO will not be unprocessed

- heating and weathering inevitable + collision/accretion
- chosen types most likely to be primitive enough to retain primordial signatures
- Missions always reveal the unexpected
 - but this leads to new insight e.g. Stardust [Gounelle]

Sample collection

- Samples of regolith are a mix of materials:
 - Many samples to cover range of possible materials
 - Large grains to avoid weathering processes
(and to study these processes [Brunetto])

Greatest constraints for organics and pre-solar material (g samples and cm-sized pebbles). [Franchi] [Brucato]
- Total mass required – 10g to 30g

Total sample mass not just defined by analysis requirements

- 1g on interior of a pebble = pebble of mass several g
 - How many small grains to sample regolith diversity?
- Spacecraft is part of the sampling mechanism [Yano]
 - landing accuracy, site characterization, touch+go vs. landing

Sample collection

- Asteroids observed so far are all different
 - e.g. surfaces of Itokawa and Eros, both S types but different structures/porosity [Michel]
- Assumption that C-types are high porosity based on one case
 - Mathilde is a large body
- Small (sub-mm) grains missing on km-sized NEOs?
 - Imaging of Itokawa
 - Moderate thermal inertia [Campins] [Mueller]
 - radiation pressure dissipation before post-collision re-aggregation [Q+A?]
 - Electrostatic levitation?
 - Seismic shaking of rubble piles?
- Thermal history – need to sample few cm deep [Delbo]
What is regolith turnover timescale?

Sample collection

- Sampling mechanisms demonstrated
 - Revised Hayabusa type [Yano] Ability to collect pebbles?
 - Sticky pad [Lees] Contamination issues?
 - Pushers/corers [Lees] [Hazan] Tests on non-ideal surfaces?

Need design to cope with wide range of potential surfaces

- success with Itokawa-like surface?

Informed by study of behaviour of granular materials in μg [Yano]

- Importance of collection confirmation
 - Close-up camera [Boehnhardt] [Ogawa]
 - Device in sample chamber?

Payload

- 1) Enable safe operations and facilitate sample site selection
- 2) Place the samples in their global and local context
- 3) Provide complementary NEO science (not achieved from samples)

Orbiter Instruments

	<u>1</u>	<u>2</u>	<u>3</u>
Radio Science	●	○	●
Wide & narrow angle cameras	●	●	●
Close-up camera	●	○	
Laser Altimeter	●	○	○
Visible/Near-IR Spectrometer		●	●
Mid-IR spectrometer	○	●	●
Neutral particle analyser		●	●

[Romstedt] [Paetzold] [Takagi] [Boehnhardt] [Ogawa] [Josset] [Colangeli]
[Milillo & Plainaki] [Bowles] [Groussin] [Licandro] [Reess] [Leblanc]

Payload

- Lander provides exciting additional science return on NEOs
[Ulamec] [Bibring] [Richter] [Jambon] [Cottin] [Roland]
[Palomba] [Klingelhofer]

Some lander instruments in category 2) context

some in category 3) additional NEO science

Particular value in subsurface measurements, multiple locations

Many lander instruments duplicate returned sample science

- a luxury we cannot accommodate?

- BUT compelling arguments for lander
 - contingency
 - valuable science
 - aids sample site delection
 - involves community

Where does the best balance lie?

– cost limits the options, not ambition!

Mission Status

- Baseline mission is JAXA lead (s/c with SEP, sample collection)
with ESA providing launch + ERC + operations + lander?
- ESA industrial studies are for an ESA-led mission with chemical propulsion to 1999JU3
- ESA standpoint on JAXA collaboration [Coradini]:
 - Issues with: sample size (not 10s of g)
(mechanism and touch + go)
launch date (2017 at earliest)
 - “Matrix of possibility”

JAXA-ESA	ESA-JAXA
NASA-ESA	ESA-NASA
 - Solar Orbiter: “supported by Science Committee so will be selected”
“...only if ready. Still an open competition”

Clear definition of options not realistic
in time frame for 2009 down selection ?

???

Mission Status

- JAXA standpoint on ESA collaboration [Kawaguchi (video)]:
 - Hayabusa “follow-on” mission (H2)
 - Selection time frame in July
 - JAXA sees MP as option to H2 (H2 being studied now)
 - JAXA can't delay to ESA timetable: need earlier launch to keep continuity of team
 - JAXA wants to do joint mission,
BUT with 2015 (2016?) launch
modified Hayabusa sample collection mechanism
 - Confident H2 proposal can go through
can have ESA involvement if MP not selected
 - 10s of g of sample ideal – but not possible as surface is not known

3 Key political issues for Marco Polo

1) Can ESA and JAXA reconcile mission plans?

- collaboration agreement on timescale for selection?
- sample size (collection mechanism)?
- launch date?

2) Is an ESA-led mission viable?

- within cost (or close enough to be competitive)?
- is this the only issue?

3) Has any planetary mission a chance to be selected against Solar Orbiter?

- or does this rule out an ESA-led medium mission scenario?

Probably not.

In either case, can we repair the damage done by indecision on collaboration?

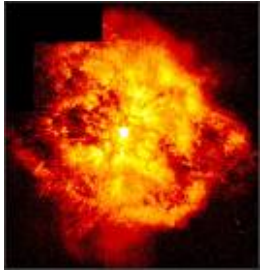
3 Key science/technical issues for Marco Polo

- 1) Robust mechanism for collection of 10s of grammes of sample from range of potential NEO surfaces
- 2) Robust mechanism for collection of 10s of grammes of sample from range of potential NEO surfaces
- 3) Robust mechanism for collection of 10s of grammes of sample from range of potential NEO surfaces

What can we do?

- Be Positive!
 - We have the most exciting mission in Cosmic Vision
(evidenced by range of proposals to different programmes
[Kawaguchi] [Lauretta] [Cheng] [Landis])
 - Most accessible and interesting to public
 - Mission is scientifically feasible
 - Cost of ESA-only mission is over M budget (?) but there are options
 - The other candidates are in worse shape!
- Mobilise the sample analysis community to support the mission now
 - samples may be 16 years away but we need to demonstrate large community and ongoing investment in preparation for science exploitation
- Sell Marco Polo to the wider astronomical community

Holy grail for small bodies research is sample return of unaltered material



Stars Stellar nucleosynthesis
Nature of stellar condensate grains

The Interstellar Medium

IS grains, mantles & organics



The proto-solar nebula

Accretion disk environment, processes and timescales

Planetary formation

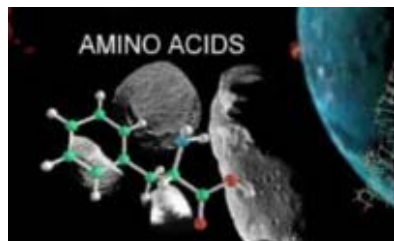
Disk & planetesimal properties
at 2 - 5 AU at time of planet formation



Asteroids Accretion history, alteration
processes, impact events, regolith

The Earth

Impact hazard



Life Nature of organics in NEOs
Role in development of life on Earth?

Marco Polo is not just an asteroid mission!