PHOOTPRINT

An ESA mission study

previously: MMSR
(Martian Moon Sample Return)

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And the MMSR Science
Definition Team
MMSR Study Team

Science Experts:

- P. Michel (Obs. Cote d’Azur, Nice, France) -> asteroids
- J. Brucato (INAF Italy) -> ground-based analysis
- B. Gondet (IAS, France) -> Phobos, remote sensing
- O. Koralev (IKI, Russia) -> Phobos-Grunt
- N. Schmitz (DLR, Germany) -> in-situ instrumentation
- K. Willner (TU Berlin) -> Phobos, 3-D reconstruction
- A. Zacharov (IKI, Russia) -> Phobos-Grunt

ESA

- D. Koschny (ESA Study Scientist)
- D. Agnolon (ESA Study Manager)
- J. Romstedt (ESA Payload Manager)
Science goals - 1

Top-level science goal:

*Understand the formation of the Martian moons Phobos and Deimos and put constraints on the evolution of the solar system.*

- Constrain the moon formation scenario by analysing returned samples
- Constrain dynamical models of the early solar system by showing how often a large impact occurs
Science goals - 2

(a) capture of objects coming close to Mars (Bursa et al., 1990);
(b) co-formation with Mars (see e.g. Burns 1992 and references therein);
(c) Impact of a large body onto Mars and formation from the impact ejecta (Singer 2007, Craddock 2011, Rosenblatt 2012).
Science goals – 3

Returned sample will allow:
- Detailed chemical analysis (much more than in-situ), mineralogy, texture…
- Dating

⇒ Better constrain formation mechanism
e.g.: Martian material? Asteroidal material?

\[
\delta^{15}N (\text{‰}) \quad \delta^{13}C (\text{‰})
\]

Gas chromatograph + Rosetta Ptolemy (isotope ratio accuracy 0.01 % vs. 1 %)

Meteorites
- CI,CM
- CO,CV,CK
- Enstatite
- Ordinary
- SNC
- Basaltic Achondrites
- Ureilite

Grady, 2004
Sample mass

< 50 mg : noble gas measurements, other bulk elemental and isotopic measurements

50 mg : for spectroscopy such as IR, X-ray, Mossbauer (50 mg per technique and therefore per laboratory)

1 g : a polished section (or thin lame) can be done. On one section most of the mineralogy, elemental and isotopic compositions can be determined.

several g : perform age measurements, aqueous alteration

‘Pebbles’ needed (particles with size >0.5 mm) to have material without cosmic ray effects available

Sampling mechanism can sample very fine dust up to larger pebbles

=> Sample about 100 g
Baseline payload

Will put sample in context:
- Wide angle camera
- Narrow angle camera
- Close-up camera
- Vis/NIR imaging spectrometer (0.4–3.3 µm)
- MIR spectrometer (5–25 µm)
- Radio science

More to be discussed, depends on available mass

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
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<tr>
<td>Mass [kg]</td>
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<tr>
<td>Power [W]</td>
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<tr>
<td>Data volume [Gbit]</td>
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Phobos or Deimos?

Thomas et al. (1996): 200 m regolith, “…from the ejecta being accreted … long after the impact…”

Credit: HiRISE, MRO, LPL (U. Arizona), NASA
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Conclusions

- Excellent science case: Moon formation => Solar system formation
- Detailed science requirements available
- Baseline payload: minimum to give context to sample