EPSC Abstracts
Vol. 12, EPSC2018-227, 2018
European Planetary Science Congress 2018

Will Europe never have a small body sample return mission?

M. A. Barucci (1), I. A. Franchi (2), J.R. Brucato (3), S. Green (2) and P. Michel (4)
(1) LESIA – Observatoire de Paris, CNRS, UPSL, UPMC Univ. Paris 06, Univ. Paris-Diderot, 92195 Meudon, France, (2) School of Physical Sciences, Open University, Milton Keynes, UK, (3) INAF-Astrophysical Observatory of Arcetri, Firenze, Italy, (4) Laboratoire Lagrange, Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Nice, France (antonella.barucci@obspm.fr)

1. Introduction

Small bodies, as primitive leftover building blocks of solar system formation, offer a record of the chemical mixture from which the solar system and its planets formed some 4.6 billion years ago. The outstanding success of the ESA Rosetta mission demonstrates the importance of having access to the composition of these bodies. The Rosetta mission has provided unique new insight into the nature of comet 67P/Churyumov-Gerasimenko, but the instruments aboard Rosetta and Philae could not analyse key elements and isotope systems with the detail necessary to establish a precise chronology and investigate the nature of organics to provide the detailed composition of these objects. It is today clear that the major advances in our understanding of the origin of the solar system, and how solar system processes and materials shaped the origin of Life on Earth can be achieved only by obtaining an unaltered sample from a primitive body and analysing it on Earth with the most precise instruments.

2. Present missions

We are in a new era of high international interest in sample return missions. NASA New Frontieres OSIRIS-REx mission will start its close proximity operations to the primitive asteroid Bennu in December 2018 with sample return to Earth in 2023. JAXA has its Hayabusa2 mission at present close to the asteroid Ryugu with a sample return in 2020, and is deeply studying the MMX mission, a sample return to the Martian moon Phobos to be launched in 2024 and return to Earth in 2029, and perhaps even a sample return to Trojans. CNSA is planning several sample return missions, including to the Moon and to Near Earth Asteroids. A new sample return mission to the comet 67P/Churyumov-Gerasimenko - CAESAR (Comet Astrobiology Exploration Sample Return) has been pre-selected by NASA for a one-year study with final selection at the end of 2018 for a possible launch in the mid-2020s.

3. European studies

With the COSMIC VISION 2015-2025 Program, created in 2005, ESA started to study small body missions within the Science and Exploration Programs. Several studies were performed for sample return missions to the Martian satellites Deimos and Phobos and detailed studies were dedicated to sample return from near Earth asteroids in the framework of M-class mission selection.

Marco Polo (ESA/SRE(2009)3) and MarcoPolo-R (ESA/SR(2013)4) have been studied at ESA in their Concurrent Design Facility (CDF) and as phase A studies by several european industries. These studies helped advance key technologies and triggered additional activities developing critical sub-systems. The key sampling and return capabilities, i.e. asteroid navigation, touch and go, sampling mechanism and the re-entry capsule have already all benefited from industrial studies maturing TRL (5-7) and identifying technology development solutions. The NEOShield-2 project, financed by EC (2015-17) in the framework of EU H2020 program, also studied autonomous GNC and IP technology for a Sample Return S/C mission scenario to land on a small asteroid.

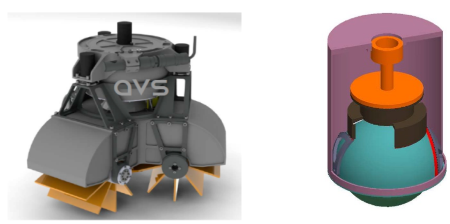

Figure 1: *SATCS Sampling Tools by AVS (left), Selex Galileo (right).*

The detailed study of MarcoPolo-R demonstrated that a dedicated sample return mission to a primitve NEO was entirely feasible and fitted within the M-Class budget of the Cosmic Vision Programme. However, subsequent evolution of the proposal for the M5 launch opportunity (MarcoPolo-M5) was deemed technically or programatically outside the scope of an M Class mission, for some, as yet unknown, reason.

Among the numerous studies carried out by European Industries, examples of the sampling tools are shown in Figures 1 and 2 following dedicated technology activities under the lead of AVS in Spain, Selex Galileo in Italy and Airbus in UK. The tool design is the result of a very large prototyping campaign where many different concepts were looked at and tested, and of modelling of sampling in microgravity. For the Earth Re-entry capsule, the development by Astrium of the "ASTERM" Thermal Protection System material shown in Figures 3 has also been very successful. This material is a lightweight ablative Carbon Phenolic, similar to the US PICA material (Stardust, MSL, Dragon) and has already reached TRL 5 with successful plasma tests in relevant sample return re-entry conditions, with heat fluxes up to 14-16 MW m^{-2} at relevant pressure. It is also to be noted that in order to demonstrate the manufacturability of an ASTERM-based mono-block heat shield, an approximately 7:10 scale front heat shield was successfully built.

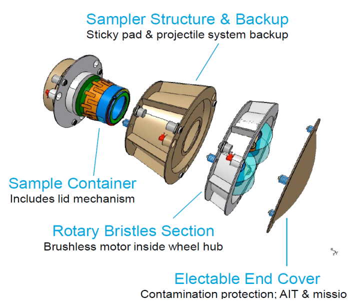

***Figure 2**. Different option of sample tool*

4. Curation facility

For any sample return mission, a curation facility is a necessary development. Concerning the European curation, a project called EURO-CARES for European Curation of Astromaterials Returned from Exploration of Space has been financed by the European Commission in the framework of Horizon 2020. The objective of the EURO-CARES project was to create a roadmap for the implementation of a European Extra-terrestrial Sample Curation Facility (ESCF). A long-term curation of extra-terrestrial samples implies deep studies to keep the samples as clean as possible from any possible contaminants, while ensuring they remain contained in case of biohazards. The requirements for both high containment and ultraclean facilities and how they could be combined were defined in detail, helping identify the path for the development of a highly specialised and unique facility and the development of novel scientific and engineering techniques.

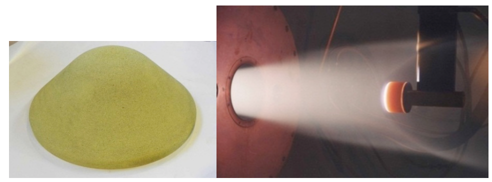

***Figure 3:** Heat shield material prototype (left) and heat shield plasma tests in DLR (right)*

5. Conclusion

Near Earth Objects are the most accessible targets containing primitive materials for scientific research missions and some of them are more accessible than the Moon. The NEOShield-2 project allowed characterization of a large number of NEO candidates for space missions. A significant number of NEOs of D-type, particularly appealing for their content in organics and pre-biotic material have been identified at low ΔV (Barucci et al. 2018, MNRS, 476, 4481).

We note that while outside Europe two sample return missions are on the way and several others under study for launch in the next decade, despite all the studies and expertise existing in Europe, despite schools such as the Alpach School devoted to this topic in Summer 2008 and 2018, all past projects have been rejected and none is even considered anymore on this continent! It is legitimate to wonder about this situation.

The current status of some of the key European technologies will be presented and discussed.