Deciphering compositional processes in inner airless bodies of our Solar System

F. Zambon (1), F. Tosi (1), S. Besse (2), R. Brunetto (3), C. Carli (1), J.- Ph. Combe (4), O. Forni (5), R. Klima (6), K. Krohn (7), D. Rothery (8), K. Stephan (7), K. Donaldson-Hanna (9), O. Barraud (10,11), and J. Nava (12)

1) INAF - IAPS, Via del Fosso del Cavaliere, 100, I-00133 Rome, Italy (francesca.zambon@inaf.it); 2) ESA/ESAC, Villafranca del Castillo, 28692 Villanueva de la Cañada, Madrid, Spain; 3) Institut d'Astrophysique Spatiale (IAS), Campus d'Orsay, Orsay 91405, France; 4) Bear Fight Institute, 22 Fiddler's Road, Winthrop WA 98862, USA; 5) IRAP-CNRS, Université de Toulouse 9, av. du Colonel Roche, F-31028 Toulouse, France; 6) Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel MD 20723, USA; 7) Institute of Planetary Research (DLR), Rutherfordstrasse 2, D-12489 Berlin, Germany; 8) The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK; 9) University of Central Florida , 4111 Libra Drive, Physical Sciences Building (PSB) 430 ,Orlando, Florida 32816-2385; 10) University of Paris Sciences et Lettres (PSL), Laboratoire d'études spatiales et d'instrumentation en astrophysique (LESIA); 11) Observatoire de Paris-Meudon, 5 Place Jules Janssen, 92190 Meudon, France;12) University of Padua, Department of Geoscience, Via Gradenigo 6, I-35131 Padua, Italy.

Introduction

The primary goal of this two-year project, selected in the framework of the "ISSI/ISSI-BJ Joint Call for Proposals 2019 for International Teams in Space and Earth Sciences", is to quantify similarities and differences in the surface mineralogy of Vesta, Mercury and the Moon, substantially enhancing the scientific return of individual instrumental datasets and/or individual space missions. Here, we present the project and the main goals.

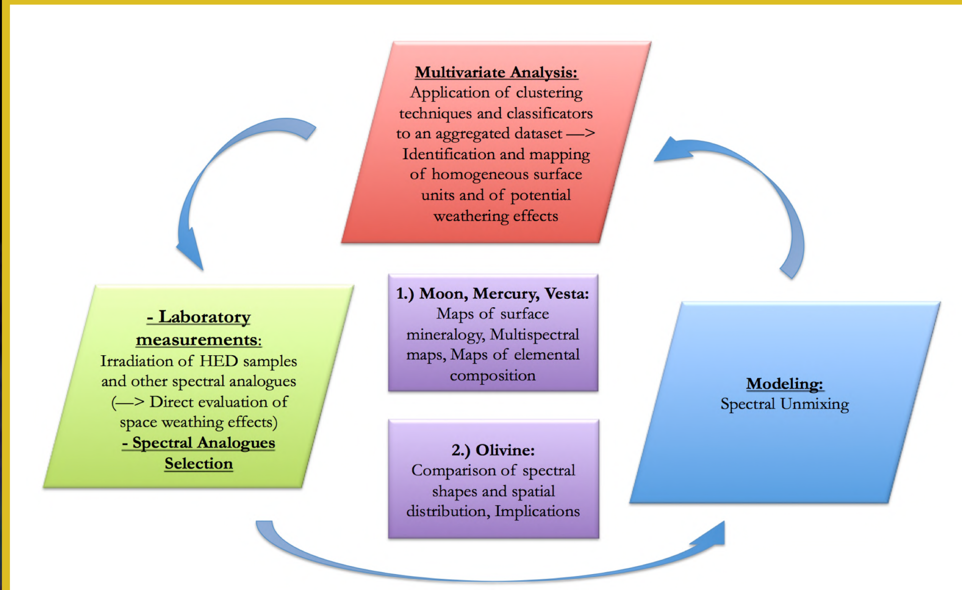
Space weathering on Vesta

Space weathering is the term used to describe how the surfaces of airless planetary bodies change over time as a result of exposure to the space environment [1]. The relevant mechanisms for space weathering include impacts (shock, vaporization, fragmentation, heating, melting, and ejecta formation), radiation damage and sputtering (due to cosmic rays or solar wind), diurnal thermal cycling [2] and ion implantation (due to solar wind).

Q1: Why do chemical changes induced by space weathering in the surface regolith appear to be different on Vesta, Mercury and the Moon, and what is the role and importance of mineralogy and composition?

To address this question, irradiation experiments will be carried out on selected HED meteorite samples to directly simulate space weathering effects on Vesta [3].

Project workflow



Olivine on Vesta

Olivine has been identified on the Moon [4], it was reported on Vesta [5,6], although with some uncertainties, and it was not observed on Mercury.

Q2: What are the implications for all of these three planetary bodies? We will specifically address the ambiguous case of Vesta: Is olivine really present only in a limited number of specific sites, or is it rather widespread with a relatively low volumetric abundance?

An answer to this question requires a precise identification of olivine in the most up-to-date spectroscopic datasets, and understanding the relationship existing between olivine and other associated mineral phases.

Laboratory irradiation experiments

We selected four samples of HED meteorites, one diogenite and three eucrites. The samples considered for this study have been provided by Museum of Planetology of Prato and Natural Historical Museum of Univerity of Florence.

Samples	mineral chemistry
Diogenites	
NWA6232	yes (ol,px,chr,op)
Eucrites	
NWA4968	yes (pl, px, op)
NWA7234	yes (pl, px, op)
NWA6909	yes (pl, px, op)

Pellets (grain size 50-75 µm) and chips for each sample will be irradiated with He at 40 Kev and ion fluence of 10^{16}, $3*10^{16}$ and $6*10^{16}$ ion/cm^2. The experiments will be carried out at the Institut d'Astrophysique Spatiale, Orsay, France.

References

[1] Pieters et al., 2010, MAPS, [2] Helbert et al., 2013, [3] Fulvio et al. 2012, A&A, [4] Yamamoto et al., 2010, NatGeo, [5] Ammannito et al., 2013, Nat., [6] Ruesch et al., 2014, JGR, [7] Palomba et al., 2015, Icarus.

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