POTENTIALLY OPEN PHD POSITION AT 3SR LABORATORY ON:

Effect of thermal cycling and mechanical impacts on the regolith formation

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Thesis co-director: Marco Delbo (Laboratoire Lagrange, Nice) and/or Dan Britt (Center for Lunar and Asteroid Surface Science, University of Central Florida, Orlando, US)

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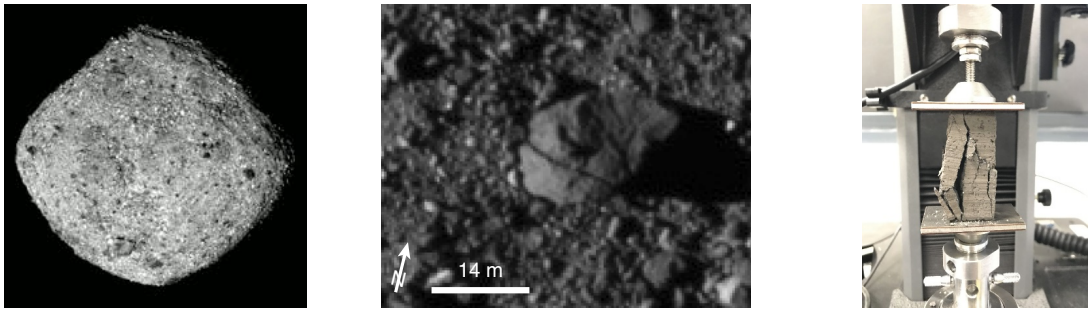
Project summary

Surfaces of asteroids are covered by a layer of granular material called regolith [1]. Understanding the origin of regoliths and asteroids and other planetary bodies is a central goal in planetary science, because it would provide important information on the creation of the surfaces of these planetary bodies. Two possible physical processes might be capable of producing regolith by damaging rocks: **impacts of other spatial bodies** that hit surface rocks at speed of several km/s [2] and the **thermal cracking and fragmentation.** The latter is induced by the mechanical stresses due to large temperature variations between day and night that are present on atmosphere-less bodies (several hundreds of K within a few hours). A study from the Laboratoire Lagrange team [3] suggests that the second process can be very effective. Moreover, images of Bennu, obtained in December 2018 by OSIRIS-REx NASA sample return space mission, show the presence of several boulders that have been broken into parts [4,5]. For these boulders, the fragments stayed in place instead of being ejected in the surroundings, which supports thermal cracking scenario. The objective of this project is to gather experimental data to distinguish between these two processes and help estimate their respective importance in the Solar System history. Mechanical and thermal tests will be conducted on analog materials specially designed to mimic regolith.



(a) (b) (c)

Figure 1 : (a) Picture of Bennu asteroid (b) image of a boulder fracturing in place on the urface of the aseroid Bennu (from Walsh et al. 2019) (c) simple compression test on regolith analogs.

The current PhD project will include:

1. Thermal cyclic tests between ambient and liquid nitrogen temperature (Δt = 200 K);
2. Mechanical testing and x-ray image analyses at different steps during thermal cycles to quantify the induced damage in terms of microstructural fractures;
3. Numerical modelling (DEM and/or FEM) based on the most faithful possible reproduction of the microstructure to predict thermo-mechanical stresses;
4. Comparison between experimental (thermo mechanical tests and images) and numerical results;
5. Comparison of the obtained results with the images of true asteroids regolith from Hayabusa2 and Osiris-Rex to evaluate the mechanical and thermal contribution to fracturing.

Location and practical aspects

The project will be in cotutelle between the Université Grenoble Alpes and the University of Central Florida, in Orlando. It is based on the collaboration between the 3SR Laboratory in Grenoble, the University of Central Florida in Orlando, the Laboratory Lagrange, Observatoire de la Côte d'Azur in Nice, the Impact Laboratory, CAPS, School of Physical sciences, Canterbury, UK and the Center for Lunar and Asteroid Surface Science, University of Central Florida (UCF), US.

Applications

Candidates holding a master degree or equivalent in solid mechanics, material and structural engineering are expected. Interests in planetology and skills in experimental and/or numerical modelling of geomaterials behaviour will be positively considered. Interested candidates should send their **CV**, a **cover letter** and **official transcripts of the last two years** before 2019, May the 25th to Alice Di Donna (alice.didonna@3sr-grenoble.fr)

[1] Murdoch, N., Sánchez, P., Schwartz, S. R., and Miyamoto, H. (2015). Asteroid Surface Geophysics. *in Asteroids IV (P. Michel, et al. eds.) University of Arizona Press, Tucson.*, pages 767–792.
[2] Basilevsky, A. T., Head, J. W., Horz, F. & Ramsley, K. (2015) Survival times of meter-sized rock boulders on the surface of airless bodies. Planetary and Space Science 117, 312–328.
[3] Delbo, M., Libourel, G., Wilkerson, J., Murdoch, N., Michel, P., Ramesh, K. T., Ganino, C., Verati, C., and Marchi, S. (2014). Thermal fatigue as the origin of regolith on small asteroids. Nature, 508, 233–236.
[4] Lauretta, D. S. et al. The unexpected surface of asteroid (101955) Bennu. Nature 568, 55–60 (2019).
[5] Walsh, K. J. et al. Craters, boulders and regolith of (101955) Bennu indicative of an old and dynamic surface. Nature Geosci 12, 242–246 (2019).