EPSC Abstracts
Vol. 8, EPSC2013-902, 2013
European Planetary Science Congress 2013

Learning about space weathering in undifferentiated asteroids from laboratory spectra of chondrites

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Abstract

Direct association between meteorite groups and asteroids has been only rarely achieved. Laboratory analyses of the reflectance properties of primitive meteorites can provide clues to identify the surface mineralogy of primitive asteroids, but their reflectance spectra differ with those produced by real Solar System asteroids. Several physical processes participate in space weathering at work in asteroidal surfaces.

1. Introduction

Undifferentiated asteroids are bodies of less than 100 km of radius which have partly conserved their primordial properties. They are considered remnants of the early stages of the Solar System formation. These bodies are usually studied through the comparison of the remote data obtained directly from them and the data obtained in the laboratories from chondritic meteorites, whose parent bodies should be this kind of low albedo undifferentiated asteroids [5]. We are mainly interested on the reflectance spectra of these bodies, but there are differences between the spectra of asteroids and meteorites. This is due to several factors: for example, with remote spectroscopic techniques we are only able to study the surface of asteroids, while meteorites can be samples excavated from deeper layers in their parent bodies. Understanding the different space weathering processes, which imply surface alteration, becomes thus of vital importance to properly compare the spectra of these objects.

2. Space weathering effects

Space weathering includes several processes which produce chemical, physical and structural changes, like the meteorite and micrometeorite bombardment, the solar radiation, the solar wind and the cosmic rays exposure [1] (Fig. 1). These processes were discovered and first studied on the Moon, and today their effect on our satellite's surface is well-studied [3]. However, the degree of space weathering experienced in the diverse taxonomic groups of asteroids are not the same ones that affect the Moon, so the models which describe these effects need to be adapted and extended to different circumstances [1].

Space weathering on asteroids was first observed by the Galileo mission, showing that low-gravity surfaces are modified at a relatively fast rate [7]. Meteoroid impacts on asteroids produce a regolith layer on the surface, which is a mixture of the particles ejected and reassembled after large impacts and the small meteoroids that are directly incorporated into the surface. By the other hand, the high energy particles that collide with the asteroid, like the solar or cosmic rays, promote the formation of new molecules including some organics, an effect which is stronger in the outer layers of the asteroid [6] Therefore, the material that can be remotely studied on the surface of asteroids has been altered by space weathering and thus can be very different from the one we find on meteorites.

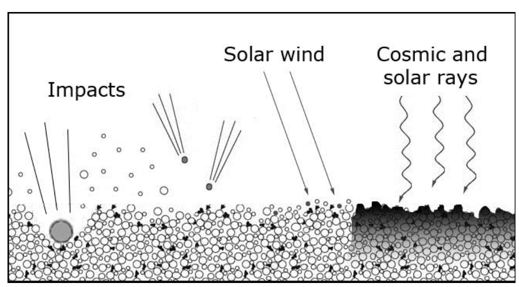

Figure 1: Cartoon exemplifying the processes that affect the surfaces of asteroids. Meteoroids and solar wind contribute to the formation of regolith, while cosmic rays and solar radiation mainly modify the materials from the outer layers.

3. Summary and Conclusions

Our group studies meteorites from an interdisciplinary approach with the goal of better understanding the processes which modify the reflective properties of the undifferentiated bodies in the Solar System. We know from previous work that the main size of the surface particles and the porosity of the regolith, together with other features of this layer, show some effect on the reflectivity [4]. Also, the shock produced by impacts can darken the spectra and shift or broaden the absorption bands [2]. As explained, high energy particles modify the surface mineralogy, and thus the shape of the spectra obtained. This is why we are currently obtaining IR and UV-Vis-NIR spectra from several Antarctic meteorite sections provided by NASA, together with other sections from private collections, and comparing them with the asteroids spectra that can be found in different catalogues. We are mainly working with carbonaceous chondrites, undifferentiated meteorites with a high content in carbon, trying to compare their spectra with the one from possible parent bodies. It is not an easy task as the differences in the spectrum shape produced by space weathering can be the result of several effects, and thus it becomes difficult to precisely determine the main biasing factors that asteroids suffer in interplanetary space. Our group is thus interested in performing experiments and developing new techniques for comparing reflectance spectra of asteroids and meteorites. Also, in the context of the MarcoPolo-R Space Weathering Group we plan to irradiate meteorites to simulate asteroid surfaces, in order to obtain new insights on the effects of radiation on these minor bodies.

Acknowledgements

We acknowledge the NASA Meteorite Working Group and JSC curators for providing the samples of Antarctic meteorites. We also acknowledge the Centre for Research in Nanoengineering, in the UPC, and Jordi Llorca for the IR and UV-Vis-NIR analysis.

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