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Investigation of Mobility-related Surface Features on Asteroids and their Relation to Volatiles

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Abstract

The identification of regolith material and mass movement processes on icy planetary bodies has grabbed the attention of scientist in the past decades. The well preserved signatures of these materials have been well studied on Moon and Mars. In fact, studies show strong synergy between these physical processes and chemical properties of the planetary objects. With the aim to get better understanding of asteroid surface we plan to analyse mobility related features and establish an inventory.

1. Introduction

Recent space missions provided the opportunity to study the complex surface signatures of asteroids and comets. Observations include regolith covered terrains [1] that show uneven distribution of ejecta and large number of degraded craters [1],[11],[12]. Through these signatures, it is possible to reconstruct the interior and surface geological processes that asteroids might have undergone in the past. Our view will soon be complemented by the Hayabusa2 and Osiris-Rex Missions arriving at their target asteroids this year.

2. Evidences of regolith motion on asteroids

Regolith is defined as the layer or pile of debris which consists of loose material and forms the upper surface of a planetary object [10]. Depending upon the material properties the debris consist of small particles or large boulders [8] that are held together by gravity, cohesive forces or bonding between the particles. Regolith covered surfaces are characteristic for asteroids and have been observed on Eors [2], Vesta [4], Luteia [5] and Itokawa [9].

Depending upon the particle size, gravitational pull and material properties, there are differences in the geomphological properties of regolith. For example, the regolith of Eros is 20-40 m thick and may have been produced and redistributed by seismic activity. In agreement, Eros shows an abundance in impact craters [6]. The debris of regolith is usually confined in sloppy terrain with preserved signature of aprons on Eros (Fig. 1A) [6]. Whereas the regolith surface of Ikotawa is smooth and rough [9], with relatively few craters (<100). Itokawa's rough terrain consists of large boulders (up to 40 m in size) (Fig. 1C). In case of Vesta, extensive evidences of regolith studies have been conducted [4]. Debris avalanches show lobate tong like features (Fig. 1B) with dark and bright material at the rims or walls of craters, scarps at the top of the dislocated material [3,14] and the presence of large boulders (up to 200 m) [3,14] with confined boundaries. This is interpreted as a gravity driven mass wasting process or impact induced melt phenomena [3,14]. The regolith surface of Lutetia shows a diverse range of an active regolith layer [1] (Fig. 1B). The thickness of the regolith layer is ~ 600 m [13] with an uneven distribution of slopes of 30º or less [2,10].

Other than dynamical surface processes, regolith studies also help to understand the processes that may include volatiles. However, the presence of volatiles on asteroid surfaces is debated and volatiles may have been delivered through meteorite impacts [2], as it has been suggested for the asteroid Vesta. The abundance of volatile elements tells us about the local geochemistry and enriches our knowledge about the evolutionary processes of asteroids.

3. Future Study

Currently, high resolution data from various missions provide valuable information on the morphologies and composition related to sublimation and out-gassing of volatiles on asteroid surfaces. The active processes and distribution of ices on asteroids and comets are of particular interest to understand the distribution of water and other volatiles in our Solar System. Volatiles are often trapped along with minerals.

Here we present an inventory of regolith features on asteroids related to dynamic processes such as landslides, debris aprons and particle sorting. Based on the image data provided by space missions, we aim to characterize and classify these features and correlate them with the properties of the host body, such as the gravity, internal structure, and volatile content. The effect of volatiles on the dynamic features will be constrained by comparison with cometary surface features.

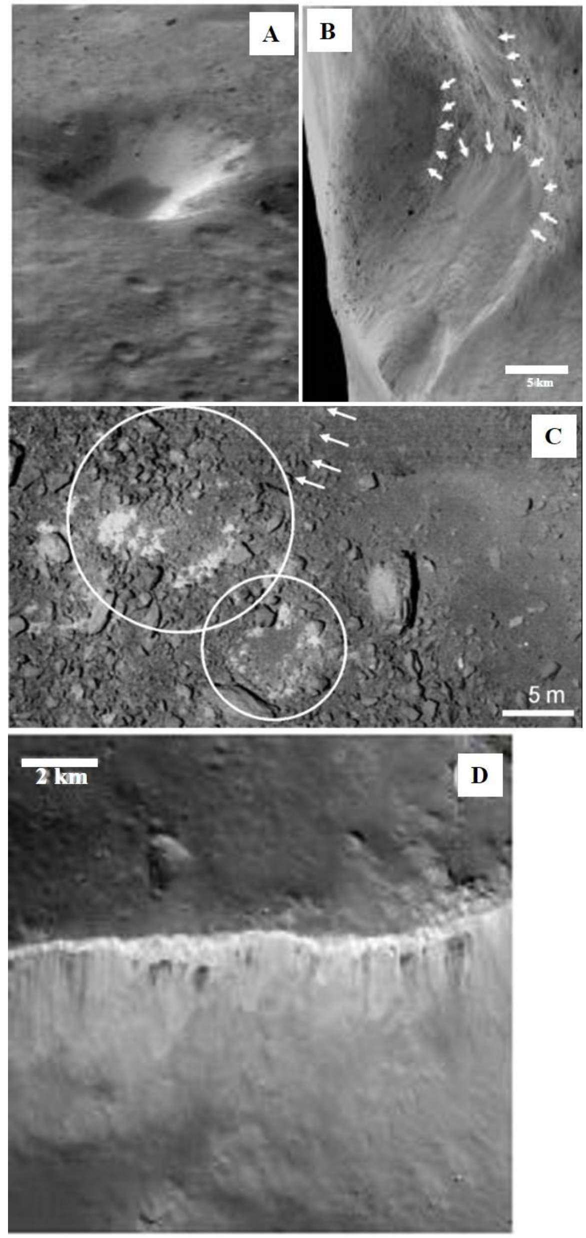

Figure 1 Evidences of regolith movements on various asteroids (A) Eors, pond like feature shows displaced material [6] (B) Lutetia, the arrows shows landslide material [6] (C) Itokawa, arrow indicates debris material piled up, circle indicates circular feature like crater [5] (D) Vesta, fresh bright material at crater rim [6]. Image credit: (A)http://ser.sese.asu.edu/near.html (B) ID 216820, ESA 2010 MPS for OSIRIS Team MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA. (C) Miyamoto et al., 2007(D)NASA/JPLCaltech/UCLA/MPS/DLR/IDA/LPI/ASU.

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