Electrostatic removal of fine-grained regolith on sub-km asteroids

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Surfaces of the asteroids (25143) Itokawa, (162173) Ryugu, and (101955) Bennu, the targets of recent sample return missions, are dominated by boulder fields without the presence of fine-grained ponded deposits, indicating an active regolith removal process at work (Fujiwara et al., 2006, Yano et al., 2006, Riner et al., 2008, Lauretta et al., 2019, Grott et al., 2019, Jaumann et al., 2019). Here, based on recent laboratory and space experimental results, we show that, at 1AU heliocentric distance, asteroids smaller than 1 km in radius experience a net loss of surface fine-grained material (Hsu et al., submitted). This is because the regolith loss driven by electrostatic dust lofting (Wang et al., 2016) dominates the production from fragmentation caused by thermal fatigue and meteoroid impacts, mainly because of the low-gravity environment of these small bodies. Our result suggests that the surface of (99942) Apophis likely shows a desert pavement-like scenery, as seen on other similar-sized asteroids (Fig. 1).

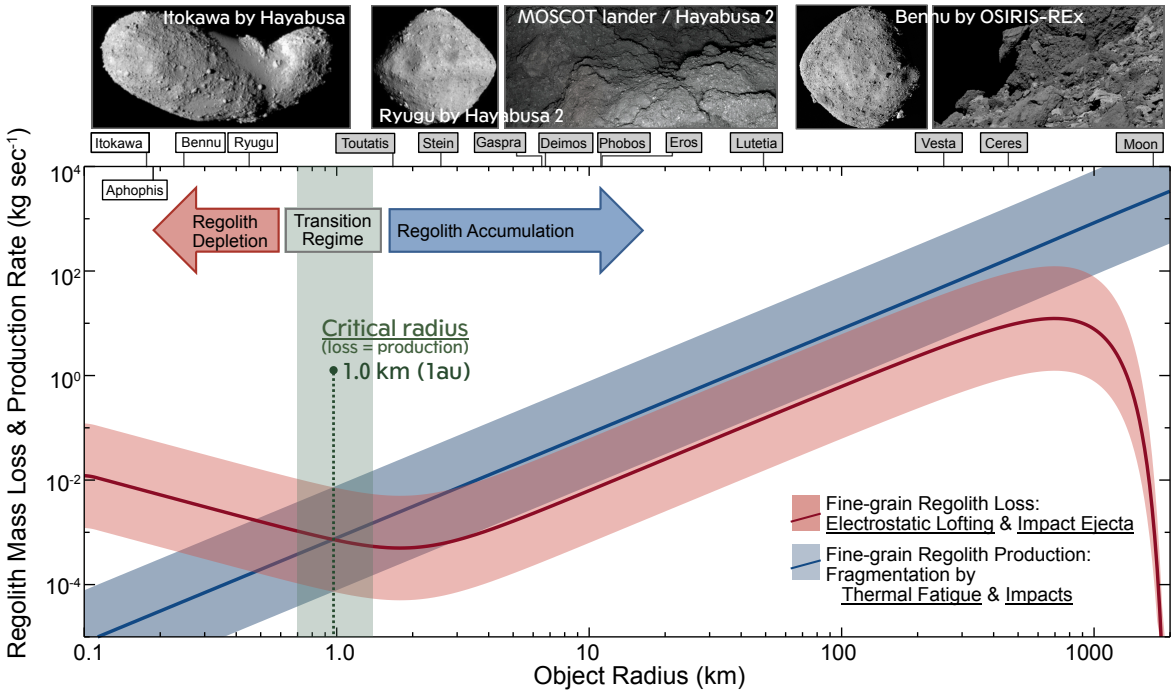

Figure 1. Fine-grained regolith mass production and loss rates as a function of object radius. The loss (red) and production (blue) rates as a function of object size calculated based on space and laboratory results. It shows that, at 1AU, objects will radii < 1 km experience net regolith loss dominated by electrostatic ejection, consistent with the lacking of fine-grained ponded deposits on asteroids Itokawa, Ryugu, and Bennu (Yano et al., 2006, Lauretta et al., 2019, Grott et al., 2019, Jaumann et al., 2019). Our result also suggests that Apophis is in the same "Regolith Depletion" regime and its surface is expected to be more similar to Itokawa than 433 Eros.

Reference

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