

Rock Porosity Controls Fine-Regolith Production on Asteroids

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Here we present how the porosity of constituent rocks plays a central role in driving the diversity of asteroids' surfaces in terms of abundance of sub-centimeter particles [Cambioni et al. 2021 *Nature*, 1]. Regolith blankets of sub-centimeter particles (fine regolith) have been observed to be present on stony asteroids like (25143) Itokawa [2]. Ground-based telescopic data suggested regolith blankets to be present also on carbonaceous asteroids such as (101955) Bennu [3] and (162173) Ryugu [4]. However, the NASA OSIRIS-REx sample return mission and the JAXA Hayabusa 2 mission found that asteroids Bennu and Ryugu lack extensive areas covered in sub-centimeter particles [5, 6], despite observations of the signatures of meteoroid bombardment [7] and thermal cracking [8], which are processes able to comminute boulders into unconsolidated materials [7, 9]. We used a new machine-learning thermophysical model [10] to tackle the big-data problem of deriving the abundance of sub-centimeter-sized particles on Bennu and the porosity of nearby larger rocks from thermal emission data collected by the OSIRIS-REx thermal emission spectrometer OTES [11]. We found that the abundance of fine-grained material and the porosity of nearby rocks are inversely correlated on the surface of Bennu (**Figure 1a**): where rocks are more porous, the abundance of fine regolith is lower [1]. We interpret this finding to mean that the build-up of sub-centimeter regolith is frustrated where rocks are highly porous, which is most of the surface [12, 1]. This is consistent with laboratory experiments of hypervelocity impacts [13, 14], which show that highly porous rocks are compressed rather than fragmented by meteoroid bombardment, and with models of thermal cracking, which we find to proceed more slowly in higher porosity rocks (**Figure 1b**). We argue that regolith blankets are uncommon on carbonaceous asteroids, which are the most common asteroid by type [15]. This group includes also asteroid Ryugu, where rocks have similar porosity than Bennu [16] and whose surface similarly lack extensive areas covered in fine regolith [6]. Regolith blankets should be instead common on stony asteroids, which are the second-most populous group by composition [15] and whose rocks tend to be less porous than those on carbonaceous asteroids. This is important to understand the geology and evolution of asteroids and to plan future sample return missions.

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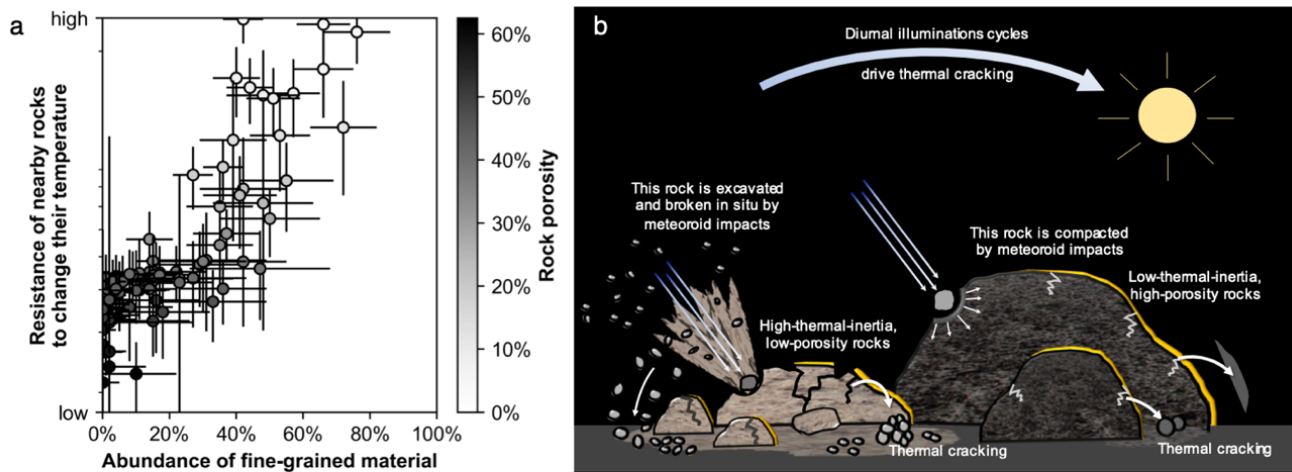


Figure 1. **a**, correlation between thermal inertia of the rocks (which is a monotonically decreasing function of rock porosity [17]) and the abundance of fine-grained materials (sub-centimeter-sized particles) on the surface of Bennu. **b**, Proposed scenarios of regolith formation on asteroids as a function of rock porosity. On asteroids, meteoroid impacts compact high-porosity rocks rather than excavating them [14]. Less dense rocks experience weaker thermal stresses than do denser rocks [8], which means that the former could be less prone to comminution than the latter.