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Mixing of exogenic impactor materials on the surface of asteroids: Disruption, penetration, and consolidation

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Dawn observation found dark materials on the surface of the hypothesized HED meteorites' parent body, asteroid 4 Vesta. The dark materials are interpreted to be fragments of carbonaceous chondrite impactors, while HED meteorites were known to include carbonaceous chondrite clasts. Meteorite fall named Almahata Sitta, originally was an asteroid 2008 TC_3, is a polymict ureilite with various foreign materials such as enstatite chondrites, ordinary chondrites, one carbonaceous chondrite, etc. Dust particles returned from comet 81P/Wild 2, a Jupiter-Family Comet (JFC) contained materials condensed at high temperature formed near the Sun. It shows that materials of different temperature histories were mixed into the comet at some point during its formation and evolution. Mixing process of materials of different origins occurred ubiquitously or repeatedly on small bodies.

We performed impact experiments of simulated small bodies as targets using various impactors including rocks, metals, and porous sintered materials in order to examine the degree of disruption, penetration, and consolidation of impactors in relation with the material properties and impact velocity for the purpose of understanding the mixing process of materials due to collsion. We found that (1) degree of impactor's disruption can be described by the ratio of initial pressure to dynamic strength of the impactor, (2) penetration depth of silicate impactor is only up to 100 times of its size even when it collides with an icy body of 90% porosity, however, (3) impactor with large porosity can survive with larger fraction and can penetrate deeper, probably because local microscopic collapse of pores inhibits growth of overall fracture, and (4) when impacted on fine regolith at high velocity, mutual consolidation of impactor fragments and also with regolith particles occurs owing to temperature increase due to compaction of pores in regolith.

We will summarize these results in relation with porosity, size of impacting body, and impact velocity and will discuss them in comparison with observational evidences, especially, of asteroids.

Keywords: asteroids, collision, laboratory experiments, meteorites, regolith