FRAGMENTATION AND CONSOLIDATION OF BRITTLE IMPACTORS DUE TO HIGH-VELOCITY COLLISIONS WITH THE REGOLITH.

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Introduction: Mutual collisions among small bodies in the solar system deliver exotic materials to the surface and subsurface of other bodies. Polymict breccia is the meteorite that contain components of exotic origin [1]. Some are fragments of ordinary chondrites with carbonaceous chondrite clasts as minor components, and some are howardite–eucrite–diogenite (HED) meteorites that also have a small amount of carbonaceous clast.

The fraction of polymict breccia that contain finite-size exogenic clasts depends on the survivability of the impactor. Fragmentation of the larger body (the target) has been studied within a wide parameter space in laboratory experiments and numerical simulations [2]. However, a smaller number of laboratory studies have shown the fate of brittle impactors [3-9]. Laboratory experiments of the impact of basalt and metal impactors onto highly porous sintered-glass bead targets at velocities higher than 2 km/s and those of basalt and pyrophyllite impactors at velocities of up to 1 km/s onto silica sand targets, showed that impactor destruction occurred when the impact-induced pressure was about 10 times the static tensile strength [4, 5]. In this study, we examined the largest fragment mass fraction at higher initial pressures.

Impact Experiments: We performed laboratory impact experiments using a two-stage light-gas gun at the Institute of Space and Astronautical Science. Brittle impactors composed of basalt and Allende meteorite were accelerated by up to 2 km/s and 5 km/s. The size of the impactors ranged from 1 to 3 mm in diameter. Silica sand particles of different grain sizes were used as targets. The impact was normal to the target surface. We collected the impactor fragments after the shot, weighed their mass and observed them through an optical microscope and a scanning electron microscope.

Results and Discussion: The impactors fragmented when the initial pressure was roughly equal to the dynamic tensile strength of the impactor material. The degree of impactor fragmentation decreased with the initial pressure. However, when impactors struck fine sand at high velocity, the mass fraction of the apparent largest fragment increased. According to the microscopic images, consolidation of the impactor fragments themselves and of the fragments with sand particles occurred. This consolidation may have resulted from the temperature increase as well as from compression. Therefore, impactor survivability, as represented by the apparent largest fragment mass fraction, in a high-velocity impact is greater than would be expected from the extrapolation of the results of previous lower-initial pressure experiments [4, 5]. The measured crush strength of the consolidated fragments ranged from sub-MPa to tens of MPa. Our results suggest that loosely consolidated mixture of gravels with variety of compositions such as Almahata Sitta meteorite [10] can be natural consequence of impacts with the regolith.

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