THE EFFECT OF TEMPERATURE AND IMPACT VELOCITY ON CRATER SHAPE ON THE SURFACE OF IRON BODIES.

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Introduction: Iron bodies that were the cores of differentiated bodies are sources of iron meteorites, and are considered to have been formed early in the terrestrial planet region before migrating to the main asteroid belt [1]. The surface temperature and mutual collision velocity differ between the terrestrial planet region and the main asteroid belt. Therefore, if these parameters influence the shape of craters on iron bodies, the collision environment and possibly also the orbital migration of the bodies, could be constrained by the crater shape distribution on their surface. A previous laboratory study reported brittle behavior during the crater formation of low temperature iron targets [2].

Laboratory and numerical cratering experiments: Impact experiments were conducted for targets of about 150 K and room temperature with impact velocities ranging from 0.8 to 7 km/s using a 7-mm bore two-stage light-gas gun at the Institute of Space and Astronautical Science and a 15-mm bore powder gun at Kobe University. The projectiles were dunite and basalt cylinders, alumina spheres, and metal cylinders and spheres, and the targets were blocks of Gibeon iron meteorite and cubes of SS400 steel and Fe-Ni alloys. The SS400 steel has a similar strength and brittle-ductile transition temperature to the iron meteorite, and was also used in a previous study [2]. The targets were pre-cooled to 77 K using liquid nitrogen. The temperature of the targets was monitored during evacuation of the chamber and did not greatly exceed 150 K. The diameter and depth of the craters were measured using a laser profiler. Numerical simulations were performed using the iSALE shock physics code [3-5]. The Johnson-Cook model [6] was used as a strength model. The parameters of the Johnson-Cook model for the iron meteorite were estimated based on the stress-strain curve of Henbury iron meteorite [7]. First, we confirmed that the simulation reproduced the diameter and depth of the craters produced by the laboratory experiments conducted at room temperature and low temperature conditions. Then we simulated the cratering process on iron targets with impact velocities higher than 7 km/s, or with an impactor 1 km in diameter.

Results and Discussion: In this study, a brittle-ductile transition in crater shape was not clearly detected, in contrast to the previous study [2]. The diameter and depth measurements were compiled using non-dimensional parameter sets based on the PI-group crater scaling relation [8]. Both crater depth and diameter decreased as the target strength increased, due to cooling and decreased impact velocity. However, the decreasing tendency was more prominent for depth than for diameter, i.e., the depth-to-diameter ratio was lower for the low temperature and low velocity conditions. Craters formed by rock projectiles were shallower than those formed by metal projectiles, but the temperature and velocity dependence were consistent with those of the metal projectiles. Our results suggest that the frequency distribution of the depth-to-diameter ratio of craters on the surface of iron bodies peaks at a smaller value in the main asteroid belt than in the terrestrial planet region.

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