On the possible detection of collisional environment from the crater shape distribution on iron bodies

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Iron bodies that are sources of iron meteorites are considered to be remnants of the cores of differentiated bodies formed early in the terrestrial planet region (Bottke et al., 2006). On the other hand, M type asteroids including asteroid 16 Phyche, which are candidates for the iron bodies, are located in the main asteroid belt. The surface temperature and the mutual collision velocity are different in the terrestrial planet region and the main asteroid belt. Therefore, if temperature and impact velocity influence the shape of craters on iron bodies, the collision environment and possibly the orbital evolution of the bodies could be constrained by the crater shape distribution on the surface.

We performed laboratory impact experiments and numerical simulations of metal projectiles and targets of SS400 steel, which has similar strength and brittle-ductile transition temperature to the iron meteorite (Ogawa et al., 2016, JpGU), and added data of Gibeon iron meteorite target (Ogawa et al., 2016, JSPS fall meeting) and rock projectiles. The experiments were conducted for targets of 150 K and room temperature with impact velocities ranging from 0.8 to 7 km/s. Formation of craters at impact velocity higher than 7 km/s or with an impactor 1 km in diameter on metal targets was simulated numerically using iSALE-2D code. The ANEOS equation of state of iron (Thomson, 1990), Johnson-Cook model (Johnson and Cook, 1983) as strength model were used. The parameters of the Johnson-Cook model for the iron meteorite were estimated based on the stress-strain curve of Henbury iron meteorite (Furnish et al., 1994), which is the same octahedrite meteorite as Gibeon iron meteorite. As a result, we confirmed that the numerical simulation reproduced experimental results.

Strength of Gibeon iron meteorite and SS400 increases by 150-200 MPa by cooling (Gordon, 1970; Furnish et al., 1994; Pennet et al., 1966; Sakino, 2015). Both crater depth and diameter became smaller as the strength increased due to cooling and the impact velocity decreased. However, the decreasing tendency appeared more remarkably in the depth than in the diameter. Consequently, the peak of frequency distribution of depth-to-diameter ratio of craters on the surface of iron bodies is expected to be smaller in the main asteroid belt than in the terrestrial planet region.

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