IMPACT EXPERIMENTS ON COLLISIONAL EVOLUTION OF IRON REGOLITH. T. Katsura[1], A. M. Nakamura[1], A. Suzuki[1], and S. Hasegawa[2], [1]Graduate School of Science, Kobe University, 1-1 Rokkodai, Nada-ku, Kobe, Japan (093s409s@stu.kobe-u.ac.jp), [2] Institute of Space and Astronautical Science

Introduction: M-type asteroids which are characterized by medium albedo in visible wavelength have been supposed to have metallic composition. According to recent findings such as absorption feature around 3 μm band due to the OH fundamental band [1], most of them are inconsistent with pure metallic composition, but some M-type asteroids are still believed to be metallic based on high radar albedo. However, their bulk density is much lower than the expected for actual metallic solid bodies, e.g., 4.0 g/cm^3 for 16Psyche [2], 3.6 g/cm^3 for 216Kleopatra [3], and 3.5 or 4.3 g/cm^3 for 21Lutetia [4], although Lutetia is classified to W-type asteroid. Such low density M-type asteroids may be rubble piles [3] and collection of small fragments, i.e., regolith. The polarization data of M-type asteroids were shown to correspond with tens μm iron powders [5]. Therefore, the surface of some M-type asteroids may be covered by metallic regolith.

In this study, we performed high-velocity impact experiments onto iron targets, and examined whether iron fragments with sufficiently low ejection velocities that cannot escape from hundreds km iron bodies were formed using a high-speed camera. We also performed catering experiments onto iron particles which are simulated iron regolith in order to examine if cratering scaling relationship for gravity regime can be applied to the iron regolith surface.

Experiments: Two iron cylinder targets of 40 mm in diameter and 20 mm in height were impacted by iron meteorite discs of 3.2 mm in diameter and 2.1 mm in height perpendicularly at 5 km/s using a two-stage light-gas gun at Institute of Space and Astronautical Science (ISAS). Fragments of the targets were ejected from the surface and impact craters were formed. We took images using a high speed camera at 62500 fps with exposure duration of 2 μs. Figure 1 shows an example of the images. We tracked the fragments on the successive images and estimated the two dimensional (2D) ejection velocities. The maximum projected area of the each fragment was also measured on the images. The mass and the area relationship was determined using still images taken for the recovered fragments and was used for estimating the mass of the fragments in the high-speed camera images.

We separately performed low-velocity cratering experiments onto iron particles as simulated iron regolith. We put spherical iron particles in diameter of 400 μm in a basin of 280 mm in diameter and 100 mm in depth. The bulk density of the iron particles is 4.6 g/cm^3, and porosity is about 40 %. We shot aluminum cylinder of 10 mm in diameter and 10 mm in height into the target vertically at 2 - 80 m/s using a He gas-gun at Kobe University. The diameter and the depth of the impact craters were measured using a caliper and compared with the craters on glass beads in previous studies [6].

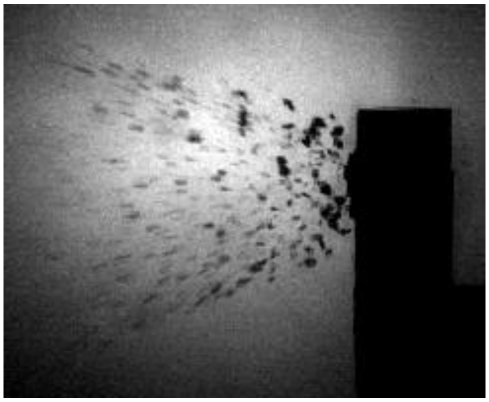

Figure 1. High speed camera image taken at about 40 μs after impact. The moment of impact was estimated from the pre-impact projectile position and the impact velocity. We estimated the ejection velocities of the fragments from the successive images

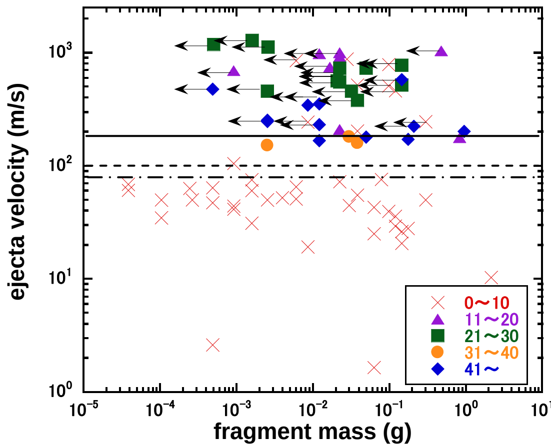

Figure 2. Mass and 2D ejection velocity of the iron fragments. Different marks correspond to different ejection angles (degree) measured from the surface normal to the target. Solid, dashed, and dashed-dotted lines on the graph show approximate escape velocities of asteroids, Psyche (170 m/s), Kleopatra (100 m/s) , and Lutetia (80 m/s), respectively. The marks with arrows show upper limit.

Results: Figure 2 shows fragment mass versus 2D ejection velocity of one of the two shots. The 2D ejecta speed ranges from about 7 to 2600 m/s. Since the maximum ejection angle is about 45 in degree, the 3D velocity should be less than 1.5 times of the 2D velocity. The diameter of the iron meteorite parent bodies was estimated to be from 10 to 200 km based on kamacite plates of the Widmanstätten pattern [7]. The corresponding escape velocity for the bodies of this size with density of 7.8 g/cm^3 ranges from 10 to - 210 m/s. Our results show that some ejecta from iron targets have velocity lower than the escape velocity of iron meteorite parent bodies and some M-type asteroids. Therefore, it is expected that the surface of iron meteorite parent bodies is covered with iron regolith.

Figure 3 shows depth versus diameter of the craters. The data of laboratory experiments on cratering of glass beads are also shown [6]. The depth-diameter ratio of the craters formed on iron particles and fine glass beads are very similar. Thus, it is expected that we cannot distinguish whether the surface of an asteroid is covered with iron regolith or rocky regolith from the shape of craters. We also compared their volume using PI-group scaling law for crater [8]. Figure 4 shows that data of iron particles and glass beads lie on the same line, and indicates that the scaling law is applicable for iron particles. These results suggest that cratering process and the morphology of craters on iron regolith are not so different from those on rocky regolith.

References: [1] Rivkin, A. S. et al. (2000) *Icarus 145*, 351–368. [2] Baer, J. and Chesley, S. R. (2008) *CeMDA 100*, 27-42. [3] Descamps, P. et al. (2010) *Icarus*, in press. [4] Drummond, J. D. et al. (2010) *A&A 523*, A93 [5] Dollfus et al. (1979) *Icarus 37*, 124-132. [6]Yamamoto et al. (2006) *Icarus 183*, 215-224. [7] Haack, H. and McCoy, T. J. (2005) in *Meteorites,Comets, and Planets: Treatise on Geochemistry, 1 (Ed. Davis, A.M.),Elsevier*, pp.325-341. [8] Holsapple, K. A. (1993) *AREPS 21*, 333-373.

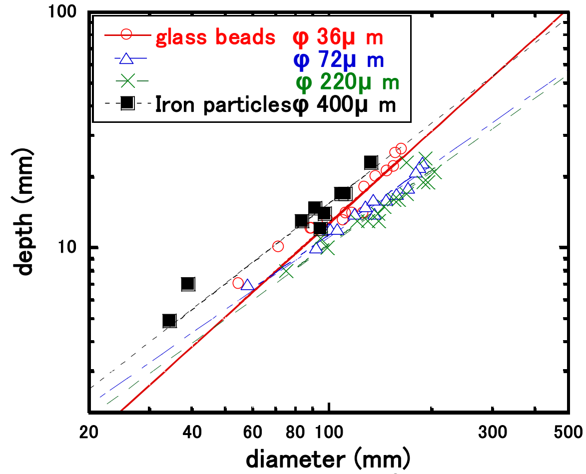

Figure 3. Diameter versus depth of the craters on iron particles and glass beads.

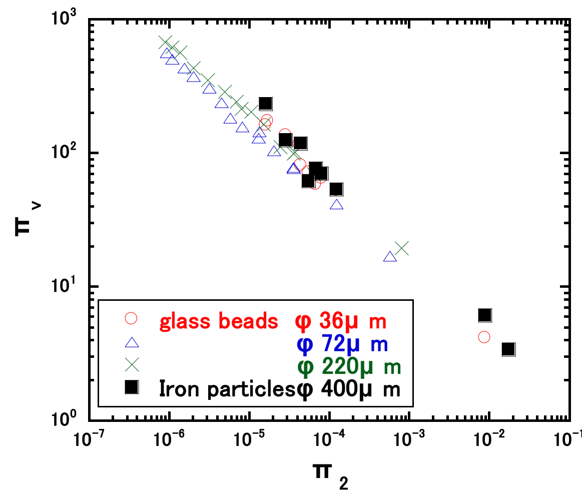

Figure 4. π_2 versus π_v [8] of craters on simulated regolith, where $\pi_2 = ga/U^2$ and $\pi_v = \rho V/m$. Note that g, a, U, ρ, and V denote gravity acceleration, projectile radius, impact velocity, target density, and volume of crater, respectively.