IN-SITU FLASH X-RAY OBSERVATION OF PROJECTILE PENETRATION AND CRATER FORMATION IN POROUS ASTEROID ANALOGUE. M. Yasui[1], M. Arakawa[2], S. Hasegawa[3], Y. Fujita[4], and T. Kadono[5], [1]Org. Adv. Sci. & Tech., Kobe Univ. (minami.yasui@pearl.kobe-u.ac.jp), [2]Grad. School Sci., Kobe Univ., [3]ISAS, JAXA, [4]Grad. School Env. Studies, Nagoya Univ., [5]Inst. Laser Eng., Osaka Univ.

Introduction: In order to understand the impact histories related to the porous asteroid formation processes, it is very important to study the impact craters found on the surfaces of asteroids. So, we should study the crater formation mechanism on the porous materials and establish the formation theory of the impact crater based on the physical mechanism. The target internal structure changing with time during the crater formation process has not been studied yet by laboratory experiments because it is difficult to observe the target interior by visible light. In this study, we tried to visualize the interior of the target during the crater formation process by using a flash X-ray generator to study the elementary processes of the crater formation. And, we observed the projectile penetration and the cavity expansion in the target.

Experimental Methods: We prepared the targets of porous gypsum having cylindrical shape with two different sizes, a diameter of 34 mm and a height of 65 mm, and a diameter of 64 mm and a height of 70 mm. Impact experiments were conducted by a two-stage H-gas gun in ISAS/JAXA. The impact velocities were 1.9-2.4 km/s (low-velocity) and 5.4-6.1 km/s (high-velocity) by using three types of projectile, stainless (SUS) spheres with diameters of 1.6 and 3.2 mm, and Al sphere with 3.2 mm. We set two flash X-ray generators to take two images at different times for one test. The trigger timing was controlled by a piezo-gauge. Furthermore, we observed the ejection of impact fragments by using a high speed camera at the frame rates of 2.5×10^5 frames/s.

Results: *Crater mode.* From the analysis of X-ray images, three types of crater cavity shapes for target were found, depending on the impact velocity and the projectile type. In the case of low-velocity collisions, the SUS3.2 projectile penetrated through the porous gypsum target without deformation and the penetrated hole was formed, while the Al3.2 projectile deformed due to the collide the target surface and the hemispherical cavity was formed. In the case of high-velocity collisions, the SUS3.2 projectile deformed and destructed, and the hemispherical cavity was formed, accompanied with some elongated pits on the cavity front. Finally, the target was destructed to many pieces. In the case of SUS1.6 projectile, the projectile collided the target surface and the hemispherical cavity was formed.

Penetration Depth. We measured the penetration depth of projectile (d) with time to study the drag coefficient (C_d) which controlled the motion of projectile penetration by a decerelation model [1]. The results are shown on Fig. 1. The D_p means the projectile diameter. In the case of penetration, the d increased with the time monotonically. In the cases of hemispherical cavity, the d for SUS projectile was larger than that for Al projectile on the whole. Furthermore, the behavior was quite different from with that for penetration. The d increased with the time until 20 μs, and after that, the d stopped. In the case of high-velocity collisions for SUS projectile, the d increased beyond 60 μs, due to the progress of some disrupted projectile and the ejection of many impact fragments. We calculated the C_d by using data until 20 μs in the cases of hemispherical cavity. As a result, the C_d for penetration was about 0.9 and consistent with those for some low-density materials obtained in some previous works [e.g., 1]. On the other hand, that for hemispherical cavity was about 2-3, higher than that for penetration. This high value might be caused by the deformation of projectiles [2].

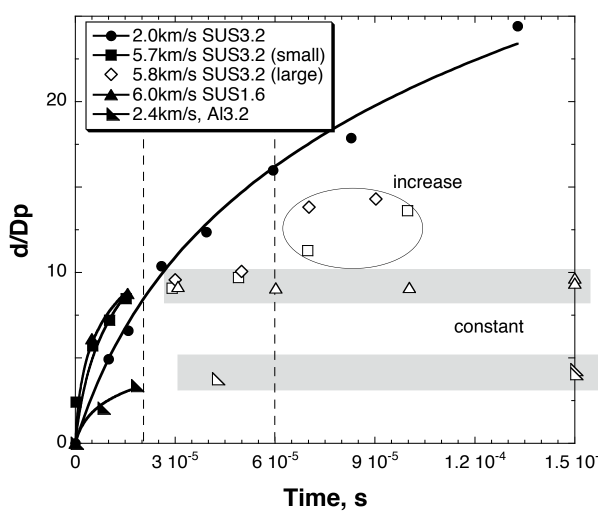

Figure 1: Penetration depth d normalized by the diameter of projectile D_p vs. time t. The square symbol means the results for small target, and the diamond symbol means that for small target.

References: [1] Niimi R. et al. (2011) *Icarus*, *211*, 986-992. [2] Tamaki F. & Hinada M. (1966), *Seisankenkyu*, *18*, 219-221 (japanese).