Experimental study on impact crater formed on sea floor with the subsurface structure of sediment and oceanic basalt

Koji Dohi[1]; Masahiko Arakawa[2]

[1] Earth & Planetary Sciences, Nagoya Univ.; [2] Grad. School Env. Studies, Nagoya Univ.

Impact crater formation is a key physical process to affect surface environment on the earth. Meteoric impacts continuously occur on the earth, and they have been supposed to change the surface environment of the earth drastically and to have a special relationship to origin and evolution of life. We found many impact craters not only on the continents but also on the sea floor with various ages depending on distance from the mid ocean ridge. The sea floor is the most outer layer of oceanic crust and the oceanic crust is composed of oceanic basal beneath the surface sediment. Therefore, we made impact experiments on the target with two-layer structure in order to clarify the effect of layered structure on the crater formation: we should consider the three-layer structure composed of sea water, sediment and basalt when the sea floor impact was supposed. The effect of seawater might be studied in future at the time when we finish the construction of a vertical type two-stage light gas gun. The vertical gun, which stands in the direction parallel to the gravity, is necessary to conduct the cratering experiments for fluids because of the difficulty related to the fluid sample set up before shot. In this experiment, we simulated the two-layer structure below sea floor in order to study the effect of sediment on the crater formation on underlay basalt. The sediment is usually supposed to have strength because of diagenesis. Then, we used several kinds of model sediments to simulate a wide range of strength.

We prepared three types of targets (gypsum-basalt, cement-basalt, and silica-basalt): we choose gypsum, cement and porous silica as model sea floor sediment. Then the relationship between the crater shape and sediment type was studied. The sediment thickness was changed to clarify the dependence on the crater morphology. The impact experiment was conducted by using two-stage light gas gun set in our lab. The nylon projectile was launched at the constant velocity of 4km/s and was impacted on the target surface by head-on-collision.

As a result, we found that the craters were classified into three types (bowl-shaped, flat-floor, and concentric crater): they will appear when the sediment thickness changed. Moreover, the crater volume, diameter, and depth systematically changed with the sediment thickness, and the criterion corresponding to the boundary among the different crater types strongly depends on the sediment type. That is, the crater type easily changes for the impact on the silica layer but it is difficult to appear for the impact on the cement layer. The crater depth (d_p) formed on the surface of basalt substrate was observed to be controlled by the sediment thickness (T) and the physical properties. The semi-empirical equation showing the relationship between d_p and T is written by the following equation,

$d_b = d_{bi} \exp(-T/l)$,

where l is a characteristic length showing the intensity of the drag force on the projectile caused by the sediment; l is proposed to be inversely proportional to the sediment density according to the theoretical consideration.