Strength Regime Craters on Small Porous Bodies: Explosive Crater Experiments with Gypsum Targets

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Crater size on a small body is determined by material strength when an impact excavates the bedrock beneath the regolith layer. Laboratory experiments using rocks and analogue materials, such as gypsum, have been conducted to obtain crater scaling relationships in the strength regime. The results of such experiments have revealed the general tendency that cratering efficiency decreases as the bulk porosity of the target increases. However, the cratering process on a porous target is complex. For example, the morphology of craters varies depending on the density ratio of the impactor to the target (Okamoto and Nakamura, 2017). Therefore, it is difficult to express the cratering efficiency of a porous target with a unified relationship by simply adding the effects of the bulk porosity of the target to the existing cratering scaling relationship in the strength regime (Nakamura, 2017).

In addition to experimental impact data, explosion crater data have been used to develop crater scaling relationships in the gravity regime to deepen understanding of the cratering process (e.g., Holsapple, 1993). Such experiments are particularly effective for simulating large craters that are impossible to simulate in impact experiments. In this study, we conducted explosion crater experiments using an analogue material of a small porous body and compared the results to impact crater experiments.

We prepared 12 cylindrical gypsum targets with diameters of 28–40 cm, heights of 16–33 cm, and a density of 1.1×10^3 kg/m^3. We used the SEP explosive formed into a cylindrical shape with a diameter of 1.6 cm, height of 2.3 cm, density of 1.3×10^3 kg/m^3, and mass of 6 g. The explosive was buried to a depth of 0 to 4.5 cm from the top of the gypsum target cylinder. As the energy density of the SEP explosive is 4.158×10^6 J/kg, the explosion energy was 2.5×10^4 J. The energy is equivalent to the kinetic energy of an impactor with the same mass as the SEP explosive and with a velocity of 2 km/s.

Targets with small diameters were totally or partially destroyed depending on the diameter of the target and the depth of burial of the explosive. Partially destroyed targets were reconstructed, and the diameter and depth of the crater were measured. Craters had ball-shaped depressions (pits) at the center of larger shallow depressions (spall zones). When the explosive was buried more deeply, the crater tended to have a larger volume. The spall diameter with respect to the pit diameter tended to be smaller than the result with a two-stage light-gas gun. We intend to repeat these experiments using different amounts of explosive, to compare the data with data from impact craters.

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