Scaling law deduced from impact-cratering experiments on basalt targets

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Since impact-cratering phenomena on planetary bodies were the key process which modified the surface topography and formed regolith layers, many experiments on non-cohesive materials (sand, glass beads) were performed. On the other hand, experiments on natural rocks were limited. Especially, experiments on basalt targets are rare, although basalt is the most common rocky material on planetary surfaces. The reason may be the difficulties of obtaining basalt samples suitable for cratering experiments. Recently, we obtained homogenous and crackless large basalt blocks. We performed systematic cratering experiments using the basalt targets.

Experimental Procedure: Impact experiments were performed using a double stage light-gas (hydrogen) gun on the JAXA Sagamihara campus. Spherical projectiles of nylon, aluminum, stainless steel, and tungsten carbide were launched at velocities between 2400 and 6100 m/sec. The projectiles were 1.0 to 7.1 mm in diameter and 0.004 to 0.22 g in mass. The incidence angle was fixed at 90 degrees. The targets were rectangular blocks of Ukrainian basalt. The impact plane was a square with 20-cm sides. The thickness was 9 cm. Samples were cut out from a columnar block so that the impact plane might become perpendicular to the axis of the columnar joint. The mass was about 10.5 kg. The density was $2920 \pm 10 \mathrm{kg/m^3}$. Twenty eight shots were performed. Three-dimensional shapes of craters were measured by an X-Y stage with a laser displacement sensor (Keyence LK-H150). The interval between the measurement points was 200 micrometer. The volume, depth, and aperture area of the crater were calculated from the 3-D data using analytical software. Since the shapes of the formed craters are markedly asymmetrical, the diameter of the circle whose area is equal to the aperture area was taken as the crater diameter.

Results: The diameter, depth, and the volume of the formed craters are normalized by the π parameters. Experimental conditions are also expressed by the π parameters. The figure shows the relation of the normalized volume and the π_3 parameter. A clear dependency on the projectile density is shown in the figure. Multiple regression analyses yield the relation $\pi_V \propto \pi_3^{-1.04\pm0.14}\pi_4^{0.45\pm0.18}$. Other results and comparisons with those of previous studies are presented in the paper.

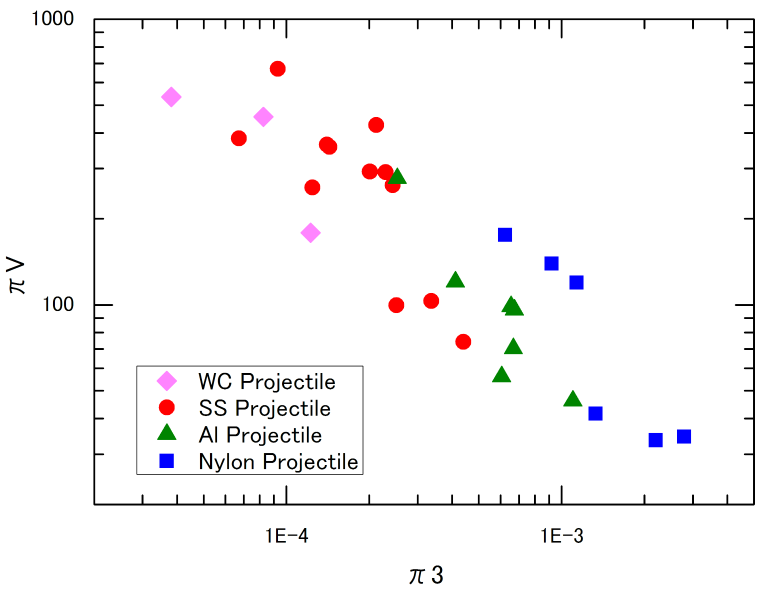

Figure: Relation of the normalized volume and the dimensionless pi_3 parameter.

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