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The attenuation behavior of shockwaves induced by hypervelocity impacts investigated using the iSALE shock physics code

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The dominant geographical features on airless planets and/or satellites are impact craters. Such craters are an evidence that planets and satellites suffered a numerous number of hypervelocity impacts during their histories. The kinetic energy of an impactor is transferred into a target body as a strong shockwave, leading to phase changes, including vaporization, melting, and the transition into a high-pressure phase, and characteristic feature by fracture, i.e., shutter cones. Quenched high-pressure minerals and the impact-induced geological features in strata on the Earth provide us useful information to investigate the surface history of the Earth. Recently, such high-pressure minerals have found from the Apollo rock samples and meteorites by new techniques for analyses. A physical model, which describes shockwave attenuation after a hypervelocity impact under a wide range of impact conditions, is necessary to investigate the impact history on such small bodies based on such shock indicators. However, the impact outcomes on such small bodies have not been fully understood because the effects of surface gravity, porosity, strength, and temperature profile on the shock propagation into a target body have not been studied well.

In this study, we conducted a series of numerical calculations using the iSALE shock physics code to investigate the shock attenuation under a various impact conditions. We are able to numerically solve the attenuation behavior of an impact-generated shockwave due to an interaction between the shockwave and a rarefaction wave from a free surface by using the iSALE. In addition, iSALE includes various material models, including granular materials, rocks, and metals, and a porosity compaction model. Thus, iSALE is highly suitable for our purpose. We obtained preliminary results as described following; (1) the target porosity significantly enhances the degree of the shock attenuation, (2) the degree of the shock attenuation for visco-elast-plastic bodies is larger than that for an inviscid fluid, (3) the internal friction of the target material changes the wave profile of the shockwave, (4) a higher target temperature leads to a higher degree of the shock attenuation. We are planning to construct the physical model based on a number of numerical results under a wide range of impact conditions.

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Keywords: Hypervelocity impacts, Shock propagation, High-pressure minerals, Shutter cones, Shock physics code