

Enhancement of impact heating in strength-supported media

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Hypervelocity mutual collisions between small bodies, which include the asteroid Ryugu, occur throughout the history of the solar system. A strong compression and thermal pulse caused by an impact can produce various unique features, such as a change in spectral properties, mosaicism, planar deformation features, high-pressure minerals, atomic diffusion, volatile loss, shock veins, impact melt, and so on. We can obtain these features in samples returned from Ryugu, collected by the Hayabusa2 spacecraft. When we have a reliable model connecting the degree of shock metamorphism with the impactor/target conditions, we can reveal the impact history of Ryugu more correctly.

Frequently, the table from Stöffler et al. (1991, 2018) is used to deduce the shock stage of meteorites using observed shock features, which are subsequently used to infer impact velocities on target bodies. Recently, Kurosawa and Genda (2018) reported that the degree of heating in low-velocity impacts (<10 km/s) is expected to be much higher than previously expected. This is caused by the irreversible heating during plastic deformation against material strength. Low-velocity impacts do not produce large-scale impact melting, but trigger a comminution of both impactor and target materials. Although the materials experiencing compression do not have a tensile strength, they still have a compressive one. Thus, the required impact velocities for producing the unique features produced mainly by the rise in temperature is greatly lowered as shown by Kurosawa and Genda (2018). Another work also confirmed the importance of plastic deformation during impacts to a target embedding hydrous minerals (Wakita and Genda 2019). The experienced temperature at a given shock stage defined by Stöffler's table would be revised to somewhat higher temperatures, which would mean that impact histories derived from shock features using the previous table would need to be revised. For example, the target bodies are likely to experience many fewer high-speed energetic impacts than previously expected.

We are planning to revise the Stöffler's table by using the state-of-the-art numerical shock physics code, iSALE, which includes both recent equation-of-state (EOS) models and various constitutive models. The Hayabusa2 spacecraft is planning to return to Earth with Ryugu samples in 2020. The revised table would largely help to reproduce the impact history of Ryugu.

In the presentation, we will introduce the work done by Kurosawa and Genda (2018) using the iSALE-2D model and will present some preliminary results from the three-dimensional (3D) model. We newly investigated the effects of impact obliquity using iSALE-3D. As a preliminary result, the enhancement of the impact heating in strength-supported media at oblique impacts becomes larger than the case at vertical impacts to the tangent plane. Although it is widely accepted that the degree of heating correlates well with the vertical component of the impact velocity, our preliminary results show that oblique impacts (45-degrees) produce nearly the same amount of heated volume as vertical impacts do. We are also going to discuss the strategy for reproducing Ryugu's impact history.

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