Change in boulder surface spectra on asteroid Ryugu induced by touchdown operations of Hayabusa2

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The Hayabusa2 spacecraft arrived at the asteroid Ryugu in June 2018, and various static observations have revealed a large number of boulders on Ryugu's surface and its low bulk density of 1190 kg/m^3, suggesting its "rubble-pile" structure (Watanabe et al., 2019). Sugita et al. (2019) reported two main types of boulders on Ryugu: a type 1 boulder is dark and rugged and a type 2 boulder is brighter and has smooth surfaces. The variety of boulders might be the results of sampling from different lithologies in its parent body.
On 21 February 2019, Hayabusa2 successfully touched down for the first time. During the touchdown operation, the optical navigation cameras (ONCs) onboard Hayabusa2 obtained high-resolution images. These imagesshow that boulder's surfaces swept by the sampling projectile impact and thruster gas jets apparently changed in brightness. In this study, using the high-resolution image data we investigated quantitatively the brightness and spectra of the boulders before and after the touchdown to understand the intrinsic optical characteristics of the boulders.
We analyzed 43 continuous images taken by ONCs when the spacecraft gradually descended from an altitude of 10 meters and touched down on Ryugu's surface and then the thruster made it lifted up. Multiple images show that the existence of a variety of boulders even in a few cm scale. The thruster gas jets during the touchdown produced a large amount of debris from Ryugu's surface, and the entire field of view was darkened. Finally, the surface of area near the touchdown site was covered by the dark debris.
We focused on a boulder nicknamed "Turtle Rock", which is classified as type 1. The boulder seems to become brighter immediately after the touchdown. We measured its relative brightness to a boulder that was defined as a reference of brightness because it wasn't covered by the debris through the touchdown. The result shows that the relative brightness of "Turtle Rock" increased by 5~20% compared with before the touchdown and became as bright as type 2 boulders. In addition, a comparison of its spectra before and after touchdown shows that the boulder became bluer after the touchdown. The results are summarized as follows. "Turtle Rock", which is dark and redder and is classified as type1, became brighter and bluer after the touchdown. These results suggest that spectral characteristics of the boulders changed from "type1" to "type2" by sweeping of the dark debris from the boulder surface, suggesting that the variations in boulder surface spectra might be caused by geologic processes on Ryugu such as space weathering and thermal metamorphism not by processes on the parent body.

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