SPECTROSCOPIC ANALYSIS OF BRIGHT BOULDERS INSIDE THE SCI CRATER ON ASTEROID RYUGU. M. Aoki[1], C. Sugimoto[1], K. Yumoto[1], E. Tatsumi[2,1], T. Morota[1], Y. Cho[1], Y. Yokota[3,5], M. Arakawa[4], R. Honda[5], S. Kameda[6], N. Sakatani[3], T. Kouyama[7], M. Hayakawa[3], M. Matsuoka[3], M. Yamada[8], C. Honda[9], H. Suzuki[10], K. Yoshioka[1], K. Ogawa[3,4], H. Sawada[3], S. Sugita[1,8], SCI team, [1]Dept. Earth and Planetary Science, Univ. of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo, Japan (maoki@eps.s.u-tokyo.ac.jp), [2]Instituto de Astrofísica de Canarias, [3]JAXA/ISAS, [4]Kobe University, [5]Kochi University, [6]Rikkyo University, [7]AIST, [8]PERC, Chiba Institute of Technology, [9]University of Aizu, [10]Meiji University.

Introduction: Previous studies have shown that the surface of the asteroid Ryugu has bright boulders (BBs), which exhibit reflectance much higher than the average reflectivity of Ryugu [1-4]. Detailed studies on BBs show that they can be divided into two groups (S-type and C-type) based on spectral properties [2]. S-type BBs are considered exogenous, most likely fragments of the impactors that collided Ryugu's parent body [2,4]. C-type BBs are thought to be endogenous because it has a spectral shape similar to the average spectrum of Ryugu [2,4].

However, these BBs must have received space weathering on the surface. In fact, Sugimoto et al. [4] have shown that S-type BBs follow classic space weathering trends of ordinary chondrites. In contrast, because the space weathering of C-type asteroids is very complicated [e.g., 5], the spectral interpretation of C-type BBs is more difficult. In fact, the color of the top layer (~1m) on Ryugu may have been significantly affected by solar heating or space weathering [6]. Thus, investigation of sub-surface material newly excavated by the artificial impact experiment SCI (Small Carry-on Impactor) [7] is extremely important for understanding the space weathering of C-type BBs. In fact [3] found three C-type BBs inside the SCI, but not all the high-resolution images of SCI crater have been investigated.

In this study, we analyze BBs inside the SCI crater based on images obtained by the ONC-T onboard Hayabusa2 [1,8].

Analysis method: We analyzed ONC-T images with seven bands (ul: 0.40 µm, b: 0.48 µm, v: 0.55 µm, Na: 0.59 µm, w: 0.70 µm, x: 0.86 µm, p: 0.95 µm), and found 21 BBs in the SCI crater. Using the spectral analysis method by [4], we analyzed BBs larger than 9 $pixel^2$ among the newly discovered BBs in the SCI crater: BB ID numbers from S13 to S25 (Fig. 1). After obtaining the spectra, we focused on two features, v-x slope and ul index defined by [2] in order to compare the spectra with those of BBs outside the SCI crater [4] and those of carbonaceous chondrites [9,10].

BBs spectrum inside SCI crater: All 13 BBs inside the SCI crater analyzed had C-type spectra (Fig. 2). The range of the reflectance normalized at 0.55 µm is mostly between 0.9 and 1.1, as in the BBs spectra outside the SCI crater. On the other hand, BBs with u-band (0.40 µm) and p-band (0.95 µm) spectra larger than the v-band (0.55 µm) reflectance were also found, such as S24 and S25.

Spectrum comparison on v-x slope - ul index: Fig. 3 shows v-x slope and ul index of C-type BBs both inside and outside the SCI crater as well as carbonaceous chondrites. As seen in Fig. 3, the distribution trend of the spectral features of C-type BBs in the SCI crater is generally consistent with that of C-type BBs outside the SCI crater. More specifically, the trend found for SCI BBs is similar to thermal evolution track of Murchison meteorite with distinctive increase and subsequent decrease in v/x slope in the mid temperature range. Thus, the C-type BBs may not be greatly affected by solar heating and space weathering.

However, some spectral difference is seen between BBs inside and outside the SCI. Some BBs inside the SCI crater exhibit high ul index values that are not found in BBs outside the SCI crater. It is possible that this feature is lost due to space weathering. In addition, the 13 BBs inside the SCI crater analyzed in this study do not show the spectra of BBs outside the SCI crater, which are obtained when Murchison is heated at low temperatures. However, since the number of data points in this study is still small, more examination is necessary to determine whether this trend is real.

Prospect for sample analysis: Hayabusa2 succeeded in collecting samples twice and returned to Earth at the end of last year [11,12]. One of the two touchdowns took place on the area where ejecta from the artificial impact experiment SCI (Small Carry-on Impactor) is expected. Thus, Ryugu materials with little space weathering and heating effects may be contained in the returned sample. Thus, comparison between such samples and BBs inside SCI crater would be great importance for understanding the space weathering of BBs on Ryugu.

Conclusions and future work: All the BBs analyzed in this study were C-type BBs, which are thought to be endogenous. Solar heating is estimated to reach only <1m layer of Ryugu, which is shallower than the excavation depth of SCI crater, and the spectral trends of the C-type BBs outside and inside the SCI crater are similar. These suggest that the spectra of C-type BBs on Ryugu is not drastically affected by either solar heating or space weathering.

On the other hand, BBs with a high ul index value spectrum were found inside the SCI crater, which was not found outside the SCI crater. This may be a feature that is lost due to space weathering and requires additional investigation. Furthermore, there are features that were found in BBs outside but not inside the SCI crater. The BBs outside the SCI crater show spectral features similar to those obtained when Murchison is heated at low temperatures, but the BBs inside the SCI crater do not. However, the BBs analyzed in this study is limited to a relatively large size (>9 pixel^2) due to the analysis method and the population of data points is small. Thus, improvement in analysis method may allow us to extract accurate spectra of such small C-type BBs inside SCI; about ten more C-type BBs can be added to the data.

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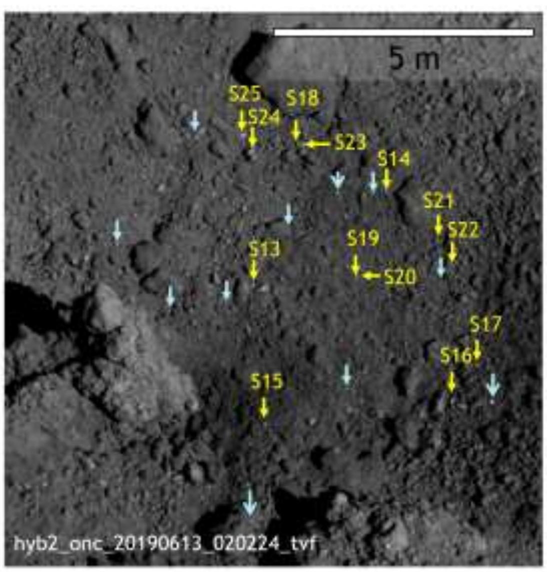

Fig. 1 : BBs analyzed (S13 ~S25)

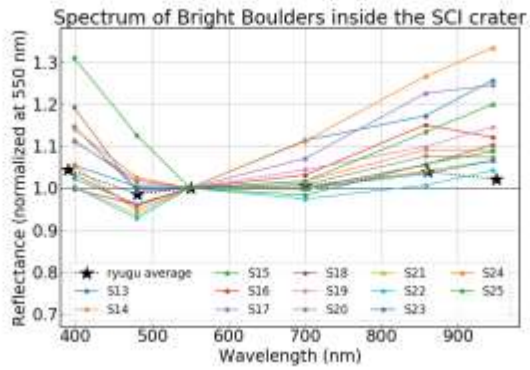

Fig. 2 : BBs spectrum inside SCI crater

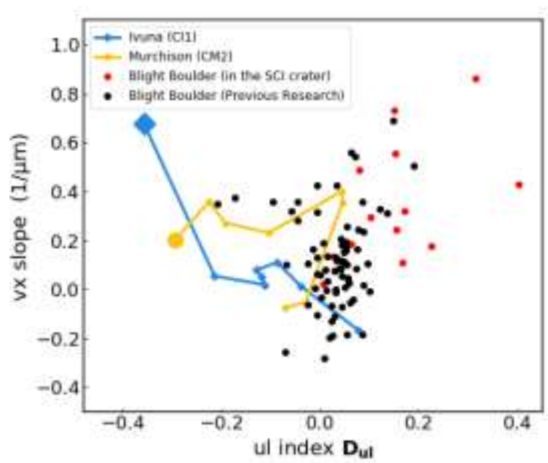

Fig. 3 : Spectrum comparison on vx slope - ul index