FINE-GRAINED REGION WITH LOW THERMAL INERTIA IN CRATERS ON RYUGU. N. Sakatani[1], S. Tanaka[1], T. Okada[1], H. Senshu[2], T. Arai[3], H. Demura[4], K. Suko[4], Y. Shimaki[1], T. Sekiguchi[5], J. Takita[6], T. Fuhuhara[7], M. Taguchi[7], T. Müller[8], A. Hagermann[9], J. Biele[10], M. Grott[10], M. Hamm[10], M. Delbo[11], S. Sugita[12], R. Honda[13], T. Morota[12], M. Yamada[2], S. Kameda[7], E. Tatsumi[14], Y. Yokota[1], T. Kouyama[15], H. Suzuki[16], C. Honda[4], K. Ogawa[17], M. Hayakawa[1], K. Yoshioka[12], M. Matsuoka[1], Y. Cho[12], H. Sawada[1], and A. Miura[1]. [1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (3-1-1 Yoshino-dai, Chuo-ku, Sagamihara, Kanagawa, Japan, sakatani@plaenta.sci.isas.jaxa.jp). [2]Chiba Institute of Technology, Japan. [3]Ashikaga University, Japan. [4]University of Aizu, Japan. [5]Hokkaido University of Education, Japan. [6]Hokkaido Kitami Hokuto High School, Japan. [7]Rikkyo University, Japan. [8]Max-Planck Institute for Extraterrestrial Physics, Germany. [9]University of Stirling, UK. [10]German Aerospace Center, Germany. [11]Observatoire de la Côte d'Azur, CNRS , France. [12]University of Tokyo, Japan. [13]Kochi University, Japan. [14]Instituto de Astrofisica de Canarias, Tenerife, Spain. [15]National Institute of Advanced Industrial Science and Technology, Japan. [16]Meiji University, Japan. [17]Kobe University, Japan.

Introduction: The Hayabusa2 spacecraft is surveying asteroid Ryugu from June 2018. Global observation by thermal infrared imager TIR revealed low thermal inertia around 200-300 J m^{-2} K^{-1} s$^{-0.5}$ [1]. The expected grain size from this thermal inertia was several centimeters [2]. However, the surface of Ryugu is globally filled with larger boulders [3]. These observational results indicate highly porous nature of the surface boulders with low thermal inertia, unexpectedly different from the carbonaceous meteorites we have. Local observations by MARA radiometer onboard MASCOT lander supported it [4, 5].

In addition to the global observation, close-up imaging by TIR during descending operations, including MINERVA and MASCOT releases, touch-down operations and their rehearsals, were conducted. The high resolution TIR images revealed local temperature anomaly related to the boulders [6] and craters, which showed local variation in thermophysical properties.

In this study, we show survey of thermally-unusual craters on Ryugu using these close-up images. The unique feature were found as hot spot around the center of some small craters.

Observation: We checked all TIR images acquired below 250 m altitude during the descending operations. TIR took the images every 256 seconds during the descending sequence. The spatial resolution of TIR is 0.051°/pix, so that it is about 8.9 cm/pix at 100 m altitude, for example [7]. The surface area of this survey is only 5% of the total area of Ryugu, due to spacecraft trajectory of the descending sequence.

Hot spot in craters: We have found three craters with anomalously higher temperature region near the center. Figure 1A and B shows TIR and ONC images for the most remarkable one, observed during MINERVA rover release operation at 21st Sep. 2018. The diameter of this crater is about 14 m, and the size of the hot spot region is about 5 m. For comparison, Figure 1C and D shows the images of a crater without hot spot.

To understand the nature of this hot spot, we carried out thermal calculation using a global shape model at the observation epoch, with various thermal inertia. Comparison with the simulated data and observed data revealed that the temperature of the hot spot is consistent with the calculation with thermal inertia of 50 J m^{-2} K^{-1} s$^{-0.5}$, while the other region including the inner wall of the crater and the outside seems to have thermal inertia from 200 to 400 J m^{-2} K^{-1} s$^{-0.5}$.

Although the detailed nature of the hot spot region cannot resolved from ONC-T image in Fig. 1B, but it seems smooth, and the low thermal inertia implies presence of fine-grained deposit, like lunar regolith. The thermal inertia of 50 J m^{-2} K^{-1} s$^{-0.5}$ corresponds to grain size of several hundred micrometers or smaller [2]. The other hypothesis of the material of the hot spot is super-porous rock with low thermal conductivity. According to a model of thermal conductivity of rock [4, 8], the porosity of the rock is estimated to be around 58%.

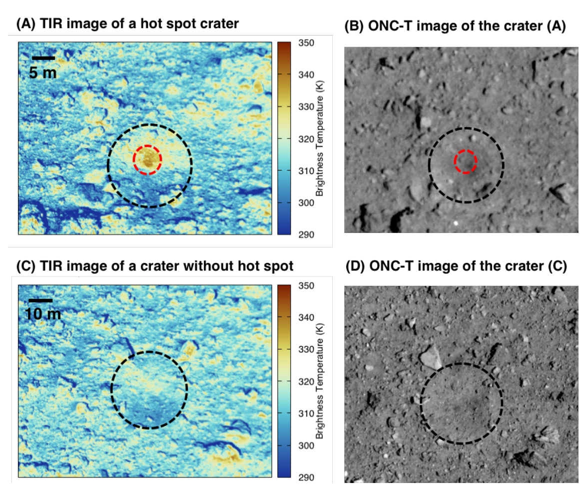

Figure 1. (A) A TIR image of a crater with central hot spot. (B) An ONC-T image of the same crater. (C) A TIR image of a crater without hot spot. (D) ONC-T image of the same crater.

The other two craters are smaller than this crater. Size of the hot spot does not relate to the diameter of the parent crater.

Discussions: If formation of the hot spot, or fine-grained deposit, is a universal process in the crater formation, the fact that only small craters have the hot spots would indicate that these craters are flesher than the other similar-sized craters. At the same time, the erasure process of the fine-grained deposit from the bottom of crater would be required. A probable way is collapse of pebbles from inner wall of the crater into the center, and/or lift-up of the large pebbles from the underground activated by seismic shaking, which masks the fine-grained layer. The required size of the pebbles is larger than the diurnal thermal skin depth (several centimeters). The resurfacing timescale of top 1 meter layer on Ryugu is less than 1 Myr [3]. The timescale of the hot spot erasure process should be much shorter than this, because change of the surface temperature is sensitive to the top several centimeters layer.

Acknowledgments: The authors would express thanks to the Hayabusa2 team members for their technical and operational supports and for helpful scientific discussions, This study was supported by Japan Society for the Promotion of Science (JSPS) Core-to-Core Program "International Network of Planetary Sciences". N.S. is supported by JSPS Grant-in-Aid for Scientific Research on Innovative Areas (Aqua Planetology, No.17H06459). MDB acknowledges support from CNES.

References: [1] Shimaki et al. (2019) *This conference.* [2] Wada et al. (2018) *PEPS*, 5:82. [3] Sugita et al. (2019) *Science*, 364 (6437), eaaw0422. [4] Grott et al. (2019) *Nature Ast.* [5] Jaumann et al. (2019) *Science*, 365 (6455) 817-820. [6] Sakatani et al. (2019) *LPSC 50th*, #1732. [7] Okada et al. (2017) *SSR*, 208, 255-286. [8] Henke et al. (2016) *Astron. Astrophys.* 589, A41.