3D MAPPING OF STRUCTURAL FEATURES ON RYUGU. H. Kikuchi[1], R. Hemmi[1], G. Komatsu[2], H. Miyamoto[1], N. Hirata[3], N. Hirata[4], C. Honda[4], T. Michikami[5], Y. Cho[1], T. Morota[6], R. Honda[7], S. Kameda[8], E. Tatsumi[1], Y. Yokota[9], T. Kouyama[10], H. Suzuki[11], M. Yamada[12], N. Sakatani[9], M. Hayakawa[9], K. Yoshioka[1], M. Matsuoka[9], O. S. Barnouin[13], S. Sasaki[14], M. Hirabayashi[15], H. Sawada[9], S. Sugita[1], [1.]University of Tokyo, Tokyo, Japan. [2.]IRSPS, Università d'Annunzio, Pescara, Italy. [3.]Kobe Univ, Kobe, Japan. [4.]Aizu University, Aizu, Japan. [5.]Kinki University, Hiroshima, Japan. [6.]Nagoya university, Nagoya, Japan. [7.]Kouchi Univ, Kochi, Japan. [8.]Rikkyo Univ, Tokyo, Japan. [9.]ISAS/JAXA, Sagamihara, Japan. [10.]AIST, Tsukuba, Japan. [11.]Meiji Univ, Tokyo, Japan. [12.]Chiba Tech, Narashino, Japan. [13.]Johns Hopins Univ, Laurel, MD, United States. [14.]Osaka Univ, Osaka, Japan. [15.]Auburn University, Auburn, AL, United States. (kikuchi@seed.um.u-tokyo.ac.jp)

Introduction: Linear structures such as troughs, grooves, and ridges have been observed on the surface of some asteroids, such as (951) Gaspra, (243) Ida, (433) Eros, (21) Lutetia, and (4) Vesta) [1-3]. However, Itokawa does not clearly have such features, which are interpreted to be due to its rubble-pile nature. Nevertheless, Ryugu, a C-type rubble-pile asteroid, seemingly has structural features. For example, the equatorial region of Ryugu is surrounded by a continuous ridge (Ryujin Dorsum), which has an almost circular shape when viewed form the poles [4]. In addition, two elongated depressions (Tokoyo and Horai Fossae) are identified in the southern hemisphere [5]. Some other lineaments are identified in lower-resolution images obtained at earlier stage of Hayabusa2 observations of Ryugu.

For understanding the formational processes responsible for such linear features, three-dimensional analysis over the irregular shape of the asteroid can be especially important [6]. Although Ryugu at distance appeared to be quite symmetric, at higher-resolution Ryugu exhibits many irregularities in its shape due to irregular depressions and uplifts. The aim of this study is to identify potential structural features existing on Ryugu, and map them on a numerical shape model in order to clarify their origins.

Analysis: We notice there are lineaments formed by a series of aligned boulders (Fig. 1). In addition, some lineaments occur as albedo bands/streamers, while other lineaments appear to lack boulders (Fig. 1). It is important to note that illumination of randomly arranged boulders, may result in shadows which have a linear trend perpendicular to the illumination direction [7]. Because Hayabusa2 spacecraft observed Ryugu on the equatorial plane of Ryugu, the lightning conditions are not dramatically changed. Therefore, when boulders seem to be lining up on a straight line in the image, lighting condition need to be changed manually in order to confirm the presence of the lineaments. We used the AiGIS software to derive the shape model of Ryugu [8] and used various incidence angles to confirm the features (Fig. 2). After identifying the linear structures, we map them on the numerical shape model. We also calculate the angle and direction of a gravity slope using the shape model, considering the recent rotation rate and assuming homogeneous density distribution. we investigate the relationships between the orientation of lineaments and the gravity slope.

In order to confirm the location of Ryujin Dorsum, we define the exact center line by using local maximum in the gravitational potential along the equatorial region. We use the SBMT software to map the center line on to the shape model [9]. Because the dorsum is interrupted by craters or some depressions, we divided it into 6 segments (A through F) (Fig. 3). In order to investigate the planarity of each segment, we calculate the best-fitting plane to them. To confirm the robustness of the

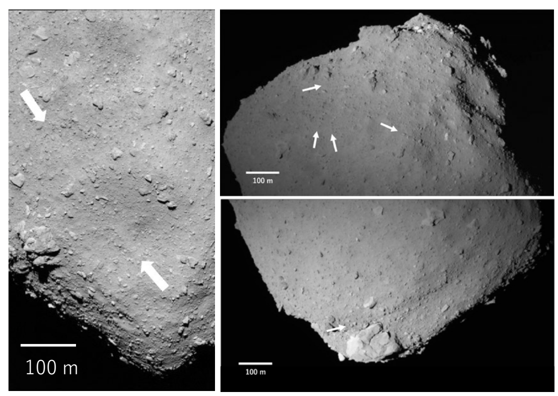

Figure 1. Candidate lineaments. We observe albedo bands/streamers or lack boulders (left) and a series of aligned bounders (right).

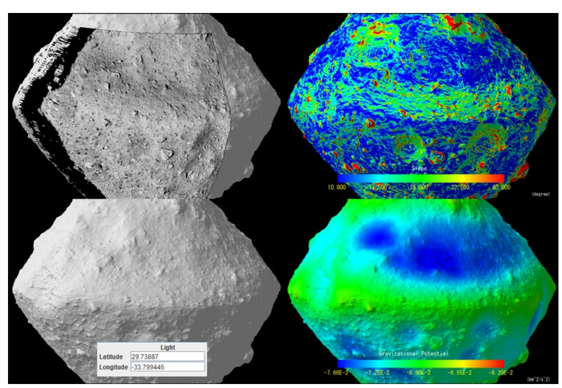

Figure 2. 4 views: overlapped ONC image (upper left), shape model under curtain lighting (bottm left), slope (upper right), and gravitational potential (bottm right) on the shape model of Ryugu.

data to the plane, we compute the R-squared value (1 means a stronger fit).

In order to confirm the location of Tokoyo and Horai Fossae, we map the local minimum in the gravitational potential.

Results: We identify numerous candidate lineaments. Some of them seem to be aligned ridges which may host boulders. While some of the candidate lineaments are preferentially oriented perpendicular to the direction of gravitational slope (Fig. 4), other does not show any particular relationships with the slopes.

The R-squared of segment A through F is 0.97, 0.77, 0.84, 0.98, 0.32, and 0.69 respectively. This indicates that the number of data points is insufficient or the data do not show planarity. To remove the effect of the former, we group the data into longer segments: AB, BC, CD, DE, EF, and FA. The R-squared are 0.96, 0.98, 0.64, 0.94, 0.82, and 0.99 respectively. This grouping improves the R-squared value somewhat, but low values remain. Therefore, we make two groups (FABC and DE), which have large R-squared values. Thus, the structural feature of Ryujin Dorsum may be clarified into 2 parts (FABC and DE).

The length of Tokoyo fossa is 0.56 km and that of Horai fossa is 0.33 km. They show similar orientations. They do not show relationships with the gravitational slopes.

Discussions and Implications: When we investigate the relationships between the aligned boulders and the directions of the current gravitational slopes, the boulders prefer to be aligned perpendicular to the direction of the slopes. This may be evidence of the regolith or boulder migration on Ryugu, but less apparent than Itokawa [10]. The boundary of Ryujin Dorsum segments, based on planarity analyses, coincides with the location of two fossae. Combined with the facts that the orientation of Tokoyo and Horai Fossae are similar, the formation process of Ryujin Dorsum, Tokoyo Fossa, and Horai Fossa might be connected.

Conclusion: Using high-resolution images and the shape model of Ryugu, we mapped lineaments which include the Ryujin Dorsum, 2 fossae, and candidate lineaments. We find that some candidate lineaments have a relationship to gravitation slopes. It indicates that the regolith or boulders migration occur on Ryugu. Also, we find that Ryujin Dorsum could be divided into two part based on planarity analyses. The orientations of Tokoyo and Horai Fossae have similarity. This indicate that the process of Ryujin Dorsum might be connected with the two fossae.

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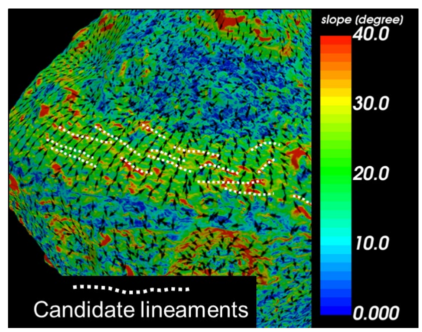

Figure 4. Comparison between the distribution of condidate lineaments with the diretion of gravitational slopes.

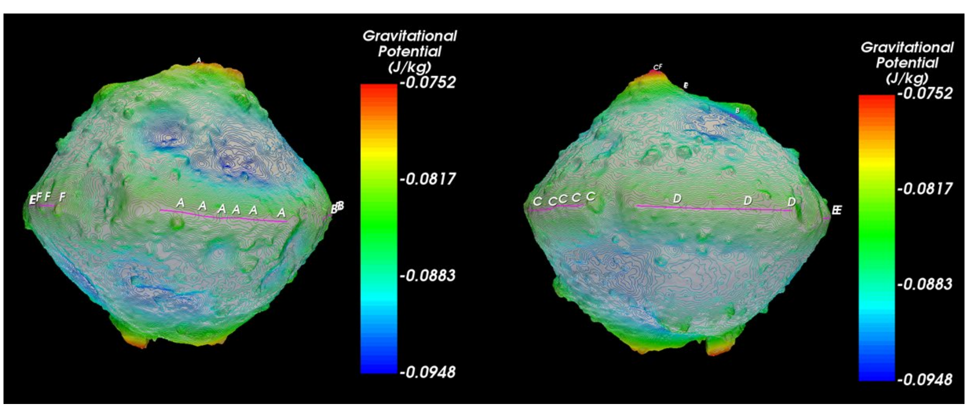

Figure 3. Ryujin Dorsum overline on the high resolution shape model. We divided it into 6 segments (A, B, C, D, E, and F).