[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2021年6月6日(日) 10:45 ~ 12:15 | Ch.04 Zoom会場04

[P-PS04] 太陽系小天体：はやぶさ２等の宇宙ミッションからの新展開

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小惑星、彗星、衛星、惑星間塵など太陽系小天体は、われわれの太陽系の起源と進化の謎を理解するため、また人類を含む生命の誕生をもたらした材料物質を供給源として、きわめて重要である。小天体は地球上や周回軌道からの望遠鏡や現地訪問する探査機による観測的研究によって多くの新発見がなされてきた。隕石や宇宙塵に加えてサンプルリターンによる帰還試料の分析的研究によって太陽系史の新たな描像が加わった。それらの結果と数値シミュレーションを組み合わせた理論的研究や実験的研究によって検証され、また新たな視点が形成されている。本セッションでは、太陽系小天体に関するあらゆる方法論での最新の科学的成果の報告や、新規の方法論の提案を歓迎する。特に「はやぶさ２」での観測結果や帰還試料の分析結果、MMX、Destiny+、Hera、Comet Interceptor, Hayabusa2延長ミッションなど将来のミッションでの期待される成果や準備状況などについての報告を期待する。

10:45 ~ 11:00

[PPS04-07] **Predicted strength, microporosity, thermal conductivity and grain density of Ryugu rock samples**

*Jens Biele[1]、Matthias Grott[2]、Patrick Michel[3]、Tatsuaki Okada[4]、Seiji Sugita[5]、Naoya Sakatani[6]、Wladimir Neumann[2,7]、Shingo Kameda[6]、Tatsuhiro Michikami[8]、Chikatoshi Honda[9] (1.German Aerospace Center, Cologne, Germany、2.German Aerospace Center, Berlin, Germany、3.Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France 、4.Japan Aerospace Exploration Agency, ISAS, Sagamihara, Japan、5.University of Tokyo, Tokyo, Japan、6.Rikkyo University, Tokyo, Japan、7.Klaus-Tschira-Labor für Kosmochemie, Institut für Geowissenschaften, Universität Heidelberg, Heidelberg, Germany、8.Kindai University, Hiroshima, Japan、9.University of Aizu, Aizu-Wakamatsu, Japan)

11:00 ~ 11:15

[PPS04-08] **Analysis of the temperature distributions of boulders on C-type asteroid 162173 Ryugu observed in low altitude operation of the asteroid explorer Hayabusa2**

*大杉 歩[1,2]、坂谷 尚哉[3]、嶌生 有理[2]、千秋 博紀[4]、荒井 武彦[5]、出村　裕英[6]、神山 徹[7]、関口 朋彦[8]、田中 智[2]、福原 哲哉[3]、岡田 達明[1,2] (1.東京大学　理学系研究科、2.宇宙航空研究開発機構 宇宙科学研究所、3.立教大学 理学部　物理学科、4.千葉工業大学 惑星探査研究センター、5.足利大学 工学部 創生工学科 システム情報分野、6.会津大学 コンピュータ理工学部、7.産業技術総合研究所、8.北海道教育大学)

11:15 ~ 11:30

[PPS04-09] 小クレーターの統計に基づく小惑星リュウグウのボルダー表面年代

*高井 雄大[1]、諸田 智克[1]、湯本 航生[1]、本田 理恵[2]、亀田 真吾[3]、巽 瑛理[1,4]、長 勇一郎[1]、吉岡 和夫[1]、澤田 弘崇[5]、横田 康弘[2,5]、坂谷 尚哉[3]、早川 雅彦[5]、松岡 萌[5]、山田 学[6]、神山 徹[7]、鈴木 秀彦[8]、本田 親寿[9]、小川 和律[5,10]、杉田 精司[1] (1.東京大学、2.高知大学、3.立教大学、4.カナリア天文物理学研究所、5.宇宙航空研究開発機構、6.千葉工業大学、7.産業技術総合研究所、8.明治大学、9.会津大学、10.神戸大学)

11:30 ~ 11:45

[PPS04-10] Space weathering of bright boulders inferred from the spectral comparison between SCI crater and blue regions on Ryugu

*青木 美波[1]、杉本 知穂[1]、湯本 航生[1]、高木 直史[1]、巽 瑛理[2,1]、諸田 智克[1]、横田 康弘[3]、荒川 政彦[4]、杉田 精司[1] (1.東京大学大学院理学系研究科地球惑星科学専攻、2.カナリア天体物理研究所、3.JAXA/ISAS、4.神戸大学)

11:45 ~ 12:00

[PPS04-11] Estimation of space weathering timescale using the number of mottles on the boulder in Hayabusa/AMICA images

*Sunho Jin[1]、Masateru Ishiguro[1] (1.Seoul National University)

12:00 ~ 12:15

[PPS04-12] The Chemical Composition of Interstellar Dust in Light of the DESTINY$^+$ Mission: A Novel Tool to Measure the Elemental Abundances and Ionization of the Local Interstellar Cloud

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Predicted strength, microporosity, thermal conductivity and grain density of Ryugu rock samples

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In this presentation, we summarize the findings and interpretations of the physical and thermophysical properties of C-type asteroid 162173 Ryugu obtained from Hayabusa2 remote sensing as well as from MASCOT radiometer (MARA) data. For a typical rock on Ryugu's surface, we find a thermal inertia of 295 ± 18 $Jm^{-2}K^{-1}s^{-1/2}$ (Hamm+ 2020), a microporosity of 50 ±3% (Grott+ 2020, Hamm+, 2020), and assuming a CM chondrite composition and thus an inferred specific heat capacity of cp=890 J/kg/K (±10%, at an average temperature of 277K), we estimate a thermal conductivity of 0.069 ±0.012 J/m/K at ˜277 K. These estimates are based on MARA surface brightness temperature measurements of an arguably (Biele et al, 2019) dust-free boulder at MASCOT's landing site obtained over a full diurnal cycle. Those values are consistent with the TIR instrument's global findings (Okada+ 2020). The very high deduced microporosity lets us reasonably estimate the tensile strength of those abundant "cauliflower rocks" (Jaumann+ 2019), ˜200-280 kPa (Grott+, 2019).

Furthermore, also from orbital data (ONC imaging and counting, plus radiometric data for GM), we have estimated the macroporosity of Ryugu, assumed to be a homogeneous rubble pile, based on granular mixing theory and the size-frequency distribution of boulders ranging from ˜0.1 m to ˜100 m diameter. We find (Grott+, 2020) that the macroporosity of Ryugu is very low, 16 ±3% and that if the underlying homogeneity assumption is true, taken together with Ryugu's bulk density and the average microporosity of its boulders, the average grain density can be estimated as 2.85 ±0.15 g/cm³, consistent with the mineralogy of CM meteorites or the ungrouped carbonaceous chondrite Tagish Lake.

It will now be extremely exciting to compare these values with actual laboratory measurements of the returned samples. For example, if our values for Ryugu's macroporosity and rock microporosity (and/or grain density) do not agree with what is found from the samples, the assumption of homogeneity might be wrong. This would mean that the surface of Ryugu has a significantly different boulder SFD than its interior. Or, simpler, the assumed relationship between rock porosity and thermal conductivity is incorrect.

As for the strength of rock pieces, besides possible size (scale) dependencies and sampling bias, a higher strength than predicted here would have to be reconciled with the very low thermal conductivity of Ryugu's blocks, which dictates rather small grain-to-grain (sinter or volatile condensate or 'salt') neck diameters.

References

Hamm, M., et al. (2020). "Thermophysical modelling and parameter estimation of small Solar system bodies via data assimilation." Monthly Notices of the Royal Astronomical Society **496**(3): 2776-2785.

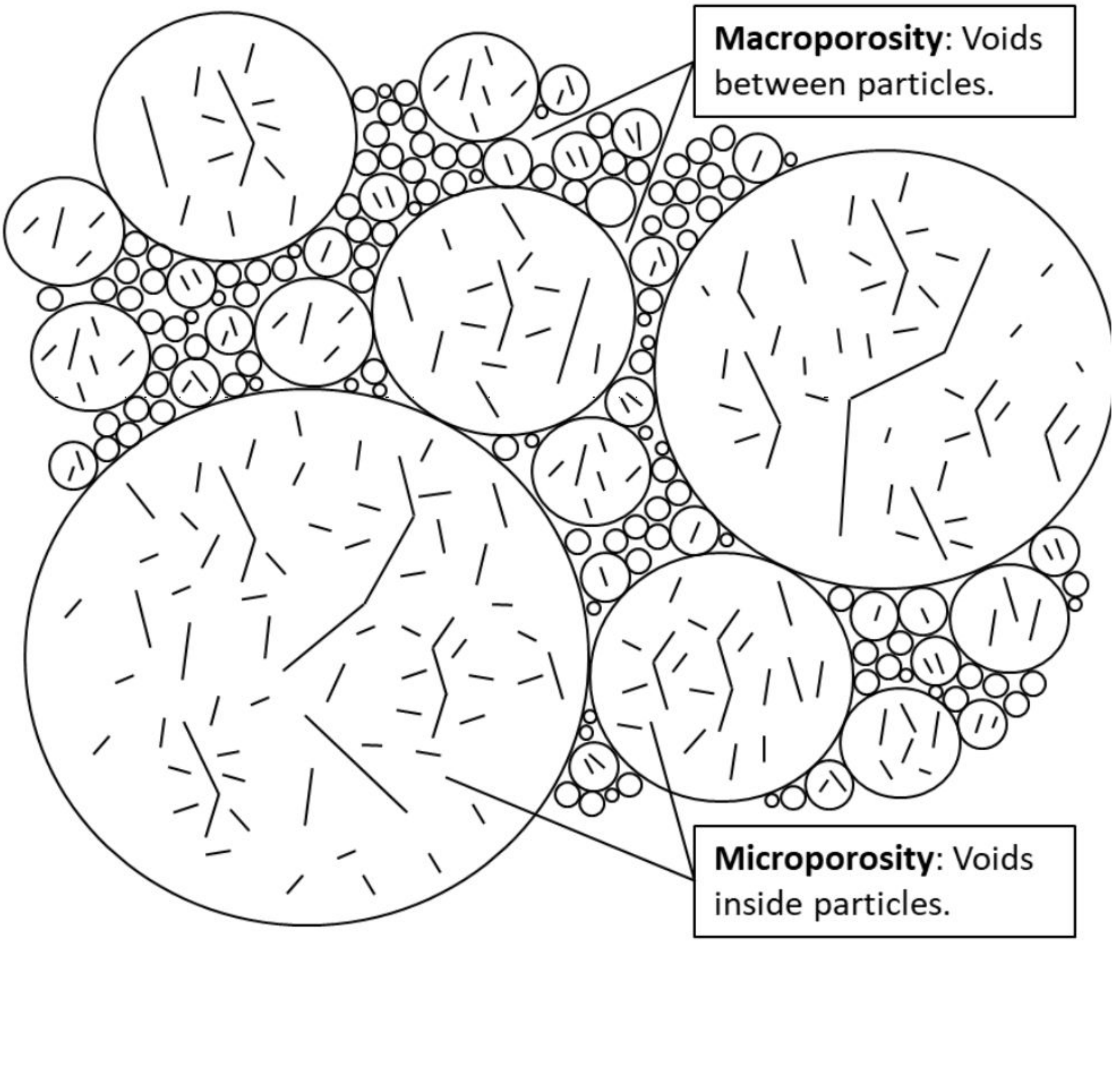
Grott, M., et al. (2019). "Low thermal conductivity boulder with high porosity identified on C-type asteroid (162173) Ryugu." Nature Astronomy **3**(11): 971-976.

Biele, J., et al. (2019). "Effects of dust layers on thermal emission from airless bodies." Progress in Earth and Planetary Science **6**(1): 48.

Okada, T., et al. (2020). "Highly porous nature of a primitive asteroid revealed by thermal imaging." Nature **579**(7800): 518-522.

Jaumann, R., et al. (2019). "Images from the surface of asteroid Ryugu show rocks similar to carbonaceous chondrite meteorites." Science **365**(6455): 817-820.

Keywords: rubble pile asteroid, Ryugu, material properties



Analysis of the temperature distributions of boulders on C-type asteroid 162173 Ryugu observed in low altitude operation of the asteroid explorer Hayabusa2

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The asteroid explorer Hayabusa2 [1] has the Thermal Infrared Imager (TIR) [2,3] which obtains the digital thermal images to indicate the thermal radiation from C-type asteroid 162173 Ryugu. In this study, to obtain detailed thermal properties of boulders at Ryugu, we analyzed TIR images taken below the altitude of 500 m and investigated temperature variations of boulders and their physical state in the specific regions.
TIR has a field of view (FOV) of 16.7°×12.7° and the effective pixels of the detector of 328×248, resulting in the spatial resolution about of 0.051° per pixel [2]. The temperature range which TIR covers is 150 to 460 K and the well-calibrated temperature range is 230 to 420 K. We used TIR images taken during the release paths for the MINERVA rover (MNRV) and the MASCOT lander (MSCT). We identified boulders taken with more than 100 pixels and calculated the temperatures. The total numbers of detected boulders were 355 (MNRV) and 312 (MSCT), and the detection errors were obtained as ±5.2 % and ±5.5 % by Wald inequality [4]. In MNRV, the averages and the standard deviations of minimum, average, and maximum temperatures were 286 ±11.2 K, 314 ±5.65 K, and 332 ±5.74 K, respectively. In MSCT, the averages and the standard deviations of minimum, average, and maximum temperatures were 287 ±11.0 K, 313 ±5.53 K, and 332 ±5.99 K, respectively. From the normal Q-Q plots, where the x-axis is the observed value and the y-axis is the expected value which is assumed the detected value follows a normal distribution, the temperatures could follow the normal distribution. The YORP effect [1,5] might lead to the normality of the temperature distributions. Furthermore, the calculated slopes of the size-frequency distributions (SFD) divided by measured altitudes were in the range of 0.30 to 4.0 and these values were consistent with those investigated by Michikami T et al., (2019) [6], who suggested the existence of boulders formed when Ryugu's parent body was destroyed and those covered with regolith layers.
Moreover, the range of thermal inertias [7] was calculated as low as 34.6-385 J m^{-2} $s^{-0.5}$ K^{-1} (hereafter, tiu) with the one-dimensional heat diffusion equation [8]. Our results are consistent with that of the global average estimated as 225 ±45 tiu by Shimaki et al. (2020) [9]. In this study, we assumed that the surfaces of boulders were confronted to the images so that further detailed study considering the surface local slopes is needed to estimate more accurately.
In summary, the total numbers of detected boulders were 355 (MNRV) and 312 (MSCT) and the normal

Q-Q plots suggested that the average temperature distributions of boulders were close to the normal distribution. Moreover, the values of slopes of SFD and thermal inertias suggested the existence of boulders formed when Ryugu's parent body was destroyed, boulders covered with regolith layers, and porous and fluffy boulders. In the future, we will investigate other areas taken at low-altitudes.

Acknowledgments

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References

[1] Watanabe S. et al., Science 364, 268-272 (2019), [2] Okada, T. et al., Space Sci. Rev., 208, 255-286 (2017), [3] Okada, T. et al., Nature 579, 518-522 (2020), [4] Kurihara, S., Introduction to statistics: from testing to multivariate analysis and experimental design, Ohmsha Ltd., pp.336 (2011), [5] Walsh et al., Nature 454, 188-191 (2008), [6] Michikami, T et al., Icarus 331, 179-191(2019), [7] Okada, T. et al, 13th Space Science Symposium, ISAS/JAXA, P2-117 (2013), [8] Takita, J. et al., Space Sci Rev, 208, 287-315 (2017), [9] Shimaki Y. et al., Icarus 348, 113835 (2020).

キーワード：はやぶさ２、温度、岩塊、リュウグウ
Keywords: Hayabusa2, Temperature, boulder, Ryugu

小クレーターの統計に基づく小惑星リュウグウのボルダー表面年代

Surface Age of Ryugu's Boulders Based on Small Crater Statistics

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The Hayabusa2 spacecraft arrived at the asteroid Ryugu on June, 2018. Detailed observations by Hayabusa2 have revealed a large number of boulders on Ryugu's surface and its low bulk density of 1,190 kg/m^3, suggesting its "rubble-pile" structure [Watanabe et al., 2019; Michikami et al., 2019; Hirabayashi et al., 2019]. Unraveling the lifetime of boulders is important for understanding the surface processes, such as thermal fatigue, impacts and surface flow, and its timescale on Ryugu's surface.

During two touchdown rehearsal operations on October 15 and 25, 2018 (Japan Standard Time) before the first touchdown operation, the Optical Navigation Camera (ONC) onboard the Hayabusa2 spacecraft [Sugita et al., 2019; Kameda et al., 2017; Suzuki et al., 2018; Tatsumi et al., 2019], which took multiple high-resolution images (~1 cm/pixel). Moreover, during the touchdown operations on February 22, 2019 and July 11, 2019, the ONC took even higher-resolution images (~0.1 cm/pixel), showing topographic features of Ryugu's surface on the scale of a few centimeters. Because the characteristic size of the Ryugu's boulder is estimated to be 3 m [Sugita et al., 2019], low-altitude imaging allowed us to observe small craters on the boulder surface.

Using these high-resolution images of Ryugu's surface, we investigated 2,152 boulders and identified 22 several-centimeter-sized circular depressions on the boulder surfaces that are candidates for small impact craters. We also built a cratering chronology model of small craters on Ryugu's boulders, based on the Pi-group crater scaling law under the strength regime [Holsapple, 1993] and the size-frequency distribution model of near-Earth object population [Brown et al., 2002; Suggs et al., 2014].

Based on the size-frequency distributions of small crater candidates and the cratering chronology model for Ryugu's small craters, the surface age of Ryugu's boulders was estimated to 0.01 to 1 Myr, younger than the global surface age of Ryugu (~8 Myr) [Sugita et al., 2019; Morota et al., 2020; Cho et al., submitted]. Moreover, Ryugu's boulders have lower crater density than Bennu's boulders, whose surface age was estimated to be 1.75 ±0.75 Myr [Ballouz et al., 2020]. We will discuss the disruption and resurfacing processes of boulders, based on the estimated survival time of boulders and comparisons with the crater densities of large craters on Ryugu and mini craters on boulder surface of asteroid Bennu.

キーワード：リュウグウ、はやぶさ２、クレーター、ボルダー
Keywords: Ryugu, Hayabusa2, crater, boulder

Space weathering of bright boulders inferred from the spectral comparison between SCI crater and blue regions on Ryugu

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Boulders with reflectance ≧1.5 times the surrounding background have been discovered on Ryugu [1-4]. These are called bright boulders (BBs). Based on spectral features, they are classified into S-type and C-type BBs. The former is likely exogenous, and the latter is likely endogenous [2-4]. Detailed spectral analysis using principal component analysis have revealed that S-type boulders on Ryugu experienced different degrees of space weathering. However, the degrees and patterns of space weathering of C-type bright boulders on Ryugu have not been understood well yet. Because Hayabusa2 collected samples near the SCI crater, which excavated fresh materials from depth that is not intensively influenced by either space weathering or solar heating [5], optical navigation camera telescope (ONC-T) have captured many high-resolution images of fresh materials. Analysis of 13 BBs inside the SCI crater indicate that all these 13 turned to be C-type BBs [6]. In this study, we extend our analysis of C-type BBs inside the SCI crater to understand the nature of space weathering on these C-type materials.

First, we compared the spectra of C-type BBs inside and outside the SCI crater with those of the heated carbonaceous chondrites [7, 8] in v-x slope/ul-index space. Results showed that the distribution of BBs inside the SCI crater is generally consistent with that of BBs outside the SCI crater. Also found is that the spectral trend of C-type BBs in v-x slope/ul-index space is generally similar to the trend formed by heating experiments with carbonaceous chondrites (CCs). However, there is significant difference between C-type BB trend and that of heated CCs; some BBs inside the SCI crater have a high ul-index value that is not found in BBs outside the SCI crater. Thus, this spectral feature may be lost due to space weathering.

Second, we further investigated whether the new spectral shape (e.g., excess ul-index) not seen in BBs outside the SCI crater is unique to BBs that have not undergone space weathering. Previous studies have found that Ryugu surface have both reddish and blueish regions [1]. Results of geologic analysis have shown that the reddish regions may have been exposed for a long time and experienced solar heating and/or solar wind irradiation [9]. Blueish regions are stratigraphically younger than reddish regions; they probably experienced some kind of resurfacing relatively recently [1, 9]. Thus, BBs in blue regions may be less affected by space weathering than those in reddish regions. Then, we have three different stages of solar heating and/or space weathering on Ryugu. Comparison of spectral properties of C-type BBs in these three different regions would give us important clue for understanding space weathering on C-type BBs. Preliminary analysis results suggest that C-type bright boulders on bluish regions, whose surface exposure ages are estimated to be ~0.3 to ~8 Myr [9], do not exhibit statistically significant excess ul-index. Thus, if the decrease in ul-index excess is caused by space weathering, then this mode of space weathering may occur at such short timescales. In the presentation, we will present the up-to-date results of our analyses of this comparison.

[1] Sugita, S. et al. (2019) Science, 364, eaaw0422 1-11.
[2] Tatsumi, E. et al. (2021) Nature Astron. 5, 39-45.
[3] Sugimoto, C. et al. (2021a) Icarus in review.

[4] Sugimoto, C. et al. (2021b) Icarus in review.
[5] Arakawa, M. et al. (2020) Science, 368, 67-71.
[6] Aoki, M. et al. (2021) LPSC, #1989.
[7] Hiroi, T. et al. (1996a) LPSC XXVII, 551-552.
[8] Hiroi, T. et al. (1996b) Meteorit. Planet. Sci, 31, 321–27.
[9] Morota, T. et al. (2020), 368, 654-659.

キーワード：小惑星、人工クレーター、明るい岩塊
Keywords: asteroid, SCI Crater, Bright Boulder

Estimation of space weathering timescale using the number of mottles on the boulder in Hayabusa/AMICA images

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The remote-sensing images of the Hayabusa mission target asteroid (25143) Itokawa (Sq-type) indicates the coexistence of both matured terrains by space weathering and fresh regions with newly exposed materials. Several resurfacing mechanisms (e.g., tidal interaction with terrestrial planets) [1] are proposed to explain the formation of these regions. The estimation of space weathering timescale is essential to constrain the possible mechanisms to rejuvenate the asteroid.

Note that there is an unignorable discrepancy between the timescale derived from different techniques. The timescale estimated from the solar flare track density and the weathered rim thickness of regolith samples acquired by Hayabusa spacecraft range from 10^2 to 10^4 years [2][3], while those estimated from laboratory simulations range from 10^4 to 10^6 years [4][5]. Besides, there are inherent insufficiencies of these age estimation methods. Since evidence of regolith migration is found on the surface of Itokawa [6], particles on the very surface would be rejuvenated by granular convection. Meanwhile, laboratory experiments are indirect stimulations of the space weathering process, which would have possibilities to be different from the actual process present in the asteroid. Thus, we focus on estimating the surface exposure age using bright mottles on the large boulders, where the materials are insusceptible to the regolith migration. These mottles are expected to be formed by impacts of mm to cm-sized interplanetary particles.

In this work, we used three AMICA (Asteroid Multi-band Imaging Camera) v-band images. These images were taken on November 12th, 2005, during the close approach to the asteroid. First, we masked boulders large enough to detect mottles. Then, we determined the size distribution of these mottles. We also derived theoretical size distribution with various timescales of space weathering with the well-known size distribution of interplanetary dust particles (e.g., Grün, 1985 [7]). By comparing these two distributions, we estimated the time needed to form mottles before becoming dark again by space weathering.

As a result, we found surface exposure timescales of these boulders are an order of 10^3 –10^4 years, consistent with those previously estimated from laboratory simulation with light ions, such as Hydrogen and Helium. We also plan to discuss possible resurfacing scenarios to expose fresh materials during such short time intervals at this meeting.

[1] Binzel et al. (2010), Nature, Volume 463, Issue 7279, p. 331-334.
[2] Keller and Berger (2014), Earth, Planets and Space, Volume 66, article id.71
[3] Noguchi et al. (2014), Meteoritics & Planetary Science, Volume 49, Issue 2, p. 188-214.
[4] Bonal et al. (2015), Meteoritics & Planetary Science, Volume 50, Issue 9, p. 1562-1576.
[5] Brunetto et al. (2006), Icarus, Volume 184, Issue 2, p. 327-337.
[6] Miyamoto et al. (2007), Science, Volume. 316, Issue 5827, p. 1011-1014.
[7] Grün (1985), Icarus, Volume 62, Issue 2, p. 244-272.

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The Chemical Composition of Interstellar Dust in Light of the DESTINY $^{+}$ Mission: A Novel Tool to Measure the Elemental Abundances and Ionization of the Local Interstellar Cloud

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The chemical composition of interstellar dust is directly linked to the depletion of elements in the gas phase of the interstellar medium (ISM), owing to the complementarity of elements in the solid and gas phases of the ISM. It has, therefore, been common practice to derive the elemental abundance of interstellar dust from the measured depletion of dust-forming elements in the gas phase of the ISM. The chemical composition of both solid and gas phases in the ISM would be a crucial factor for the evolution of the presolar molecular cloud, from which the Sun and the Solar System formed about 4.5 billion years ago. In particular, the organic and rocky components of interstellar dust would provide seeds for the origin of life and habitable planets.

On the one hand, the determination of elemental abundances in the solid and gas phases of the ISM is not a straightforward task if partially ionized, unless the ionization fractions of every elements are known a priori. This is exactly the case for the Local Interstellar Cloud (LIC) around the Sun, which is known to be a partially ionized warm cloud with an extension of several parsecs. On the other hand, recent technological advances in space missions have provided us direct information on the chemical composition of dust in the LIC by means of laboratory analyses (Stardust) and in situ measurements (Cassini).

The DESTINY^{+} Dust Analyzer (DDA) onboard DESTINY^{+} is a successor of Cassini's Cosmic Dust Analyzer (CDA) equipped with an impact ionization detector and a time-of-flight mass spectrometer. The DDA will measure the chemical composition of interstellar dust streaming into the inner Solar System from the LIC, similar to the CDA, but with an elevated performance in terms of mass resolution and sensitive area. We have analyzed astronomical deta on the depletion of elements in the gas phase of the LIC and the ionization states of the elements, derived the elemental abundances of dust in the LIC from the depletion, and compared them with space mission data. We found that DDA's data on the chemical composition of interstellar dust will constrain the gas-phase abundances and ionization states of elements undetectable by remote astronomical observations. In this talk, we will demonstrate that the DDA is a novel tool to measure the composition and ionization of the LIC.

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