Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG30-01 Room:A02 Time:May 26 12:00-12:15

Optical survey of cometary dust trails with the Kiso Schmidt telescope

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The maximum size of dust particles contained in cometary nuclei is an important parameter to understand the formation and evolution of comets. Existing of cm-sized particles is confirmed by the EPXI mission when the spacecraft flew by Comet 103P/Hartley. In addition, the Rosetta spacecraft is beginning to take amazing images of Comet 67P/Churyumov-Gerasimenko. Obviously, in situ observations with spacecrafts are powerful, however, it is impractical to send spacecrafts to a number of comets to search the size distribution of dust particles for each comet. Cometary dust trail is a good object to study this issue through remote observations. Dust trail is a structure extending along the orbit of the parent body, it is composed of dust particles large enough not to be blown off by the radiation pressure of the Sun. This structure was first discovered for eight short-period comets by the Infrared Astronomical Satellite in 1983. Then, Reach et al. reported that dust trails are a generic feature of short-period comets based on the observations with the Spitzer Space Telescope. Although their deep imaging was sufficient for detection, the field of view was not enough to examine the particle size accurately. In this study, we present wide-field images of dust trails taken with the Kiso Schmidt telescope, we estimate the size of dust particles composing them, and discuss similarity or difference among observed comets.

Keywords: comet, dust trail, interplanetary dust, meteor, ground-based observation

PCG30-02 Room:A02 Time:May 26 12:15-12:30

Study of the opposition surge of Asteroid 4 Vesta

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We present the results of photometric observations for the asteroid 4 Vesta in the B, Rc, and z' band at the minimum phase angle 0.1 deg has been performed at four small telescopes.

The magnitude reduced to unit distance and phase angle: $M_B(1, 1, 0)$ = 3.85 +- 0.05 mag, M_{Rc} = 2.71+-0.04 mag, and $M_{z'}(1, 1, 0)$ = 2.98 +- 0.03 were obtained in this study.

The absolute magnitude under the IAU H-G function are about0.1 mag darker than the magnitude at the phase angle of 0deg based on the Shevchenko function model and the Hapke model.

Porosity of the optically active regolith on Vesta are estimated with the Hapke model yielding rho = 0.4–0.7.

We found that the opposition effect for Vesta is made a contribution to not only the shadow-hiding effect but also the coherent backscattering effect which appears from around 1deg.

The amplitude of the coherent backscatter opposition effect of Vesta increases as the reflectance is brightening.

We suggested that multiple-scattering in optically active scale may contribute to the amplitude of the coherent backscatter opposition effect, B_{C0}, from the comparison with those for the other solar system bodies.

Keywords: asteroid, Vesta, opposition effect

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PCG30-03 Room:A02 Time:May 26 12:30-12:45

Exploring hydrated minerals on asteroids with ground-based observatories and space-borne telescope

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The knowledge of hydrated minerals among asteroids is important for understanding a wide range of solar system formation, evolutionary processes, and thermal history. Formation of hydrated minerals occurs in environments where anhydrous rock and water are together. The distribution of hydrated minerals in the main belt region is a clue to solve the questions of the homogeneity of the solar nebula, the existence of heat sources, and how much mixing of planetesimals occurred. The presence of hydrated minerals indicates that conditions in the past were more conducive to the presence of liquid water on small bodies.

Many asteroids are known to exhibit a broad absorption feature in the 3 micron band due to hydrated minerals, water ice, and organics. Spectral range between 2.5 and 2.85 micron contains a strong absorption band of typical hydrated minerals. However, this spectral range is largely obscured by the terrestrial atmosphere and we need space-borne telescopes to observe these features in detail. The Infrared Camera (IRC) onboard the AKARI infrared satellite has a spectroscopic capability in the near-infrared (between 2 and 5 micron) with a high sensitivity. We observed 70 asteroids with the IRC, carried out in its warm mission phase. From these observations, wide variety of the absorption feature of hydrated minerals on asteroids has been obtained. Especially, the peak region of the absorption around 2.7 and 2.8 micron has been clearly observed in asteroid spectra for the first time with AKARI. This distinctive spectral shape is considered as the evidence for hydrated minerals, and their detailed features vary among asteroids depending on the origin of the associated hydrated minerals.

In this talk, we report the observations of search for hydrated minerals on asteroids in the 3 micron band with AKARI/IRC and other ground-based observatories, and discuss the distribution of hydrated minerals in the main belt regions.

Keywords: asteroids, hydrated minerals, near-infrared spectroscopy

Japan Geoscience Union Meeting 2015
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PCG30-04 Room:A02 Time:May 26 14:15-14:30

The tidal rupture mechanism of CERRA by Jupiter perturbation,Moon hypothesis that the mantle piece collides with Earth.

TANEKO, Akira[1*]

[1]SEED SCIENCE Labo.

There is No inevitability to hypothesis of Moon formation mechanism until now. No consistent story that further illustrate the Earth evolution and present condition.

1. Multi-impact hypothesis: MI is a new hypothesis to Moon and Planet Earth's evolution is New answer to the unified understanding of "mystery of Earth".
1. New mechanism of the moon formation
(1). "Origin hypothesis of the moon and the deep ocearn-floor by multi-impact muntle picedes" was proposed New collision mechanism at the Earth. The differentiated Mars size of primitive planetichiusu Bourdais'law that has not been proven, was formed in the asteroid belt position.
Why was broken by perturbing tidal forces of Jupiter and flattening of the orbit of primitive planet CERRA by whether?
= Jupiter perturbation protoplanetary Serra was desripted.
(2). "Giant planet collision hypothesis: GI (Cameron etc.)" Difficult problems, etc. that can not be solved are shown below.
The differentiated Mars size of primitive planet, due to the collision (dependent upon only good lucky) from the revolution surface obliquely backward. =Impossible.
Hypothesis that forms the moon of only mantle component, it is not possible to explain the Earth's evolution and current status.
= Just a hypothesis for the origin of the moon.

2. Comparison the moon formation hypothesis >>***Multi-impact hypothesis : MI **vs **Giant impact hypothesis : GI ***
(0). History of collision body >>Mantle piece in the tearing mechanism of differentiated planet CERRA vs Differentiated Mars size protoplanetary (No mechanism)
(1). The impact velocity at the time of moon formation>>Theory calculation , multi-collision MI (12.4km / s , 36.5 degrees) vs GI giant impact. (~8km / s: the most die about 30 degrees)
(2). In Collision energy, >>MI (8.01 . 10^{30}J). vs GI (2.05 . 10^{31}J) which is about 2.56 times as huge as MI
(3). Collision probability and time mechanisms >>by high chance about 4 billion years ago , inevitable mechanism vs by low chance about 4.6 billion years ago
(4). Earth's situation at impact >>Differentiation and Solid Crust solidification and inside Semi-molten vs Melt and Differentiation Magma Ocean core
(5). Partial peeling of the crust Mantle cracking>>Was realized , Partial peeling of the crust was realized The plate boundary vs None Crust becomes thinner, cracking not occur
(6). Front and back hemispherical differences of Moon,>>It can be explained by peeling the crust and mantle emitted from the Earth vs Need another solution
(7). Formation position of the moon (Earth radius: RE) >>60 $*R_E$ (about Moon position) vs 3 $*R_E$ (Limit position of Roche)
(8). Earth's deep ocearn- floor, Plate boundary formation, Land and sea distribution >>All can be formed, vs All Impossible Formation.

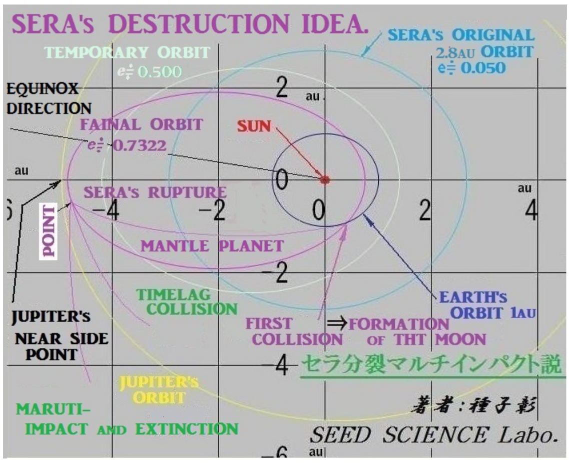
3. It is possible unified understanding of the effect of multi-impact hypothesis *************to "Mystery of Earth." ******
(1). Whether the five times biological large extinctions have occurred in the earth ? It is caused by the multiple of debris has collided to Earth.
(2). Why the Earth's core eccentricity (about 10%) has occurred?
Earth's mantle by CERRA debris collision to the Pacific Ocean position is missing, is due to isostasy to complement it.

<<The conclusion>>In this way, the origin of Moon and the Earth evolution according to the multi-impact hypothesis, serves the interpretation the future of unified understanding.
This hypothesis can be explained the evolution and current status of the Earth, than the giant impact hypothesis.

Keywords: Rupture mechanism of CERRA, Transition of Cerra orbit by Jupiter perturbation, CERRA's rupture due to tidal forces,

PCG30-04 Room:A02 Time:May 26 14:15-14:30

Moon is formed by the Mantle peace collision to the Earth, Frequency curve showing a two-peak, Velocity12.4km/s,36.5degree



PCG30-05 Room:A02 Time:May 26 14:30-14:45

Thermal Infared Imager TIR on Hayabusa2: Initial Check and Future Operation Plan

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TIR is a thermal infrared imager on Hayabusa2, based on two dimensional uncooled micro-bolometer array. It aims at mapping the thermos-physical properties of the surface of asteroid (162173) 1999JU3 to investigate and constrain its formation and evolution processes, which will be applied for a study of physical properties of small solar system bodies such as asteroids, comets, or planetesimals in the ancient solar nebula. TIR is also to give information for sampling site selection, such as the thermal environment and the distribution of hazardous boulders for assessment of safe touchdown operation, as well as the typical particle size of surface regolith for better sample collection.

Thermal radiometry is among the typical methods in planetary missions. It determined what the surface condition is like such as fine regolith, full of pebbles, many boulders, or rocky basement rock. Multi-filtered thermal mapper has been used for mapping from orbiters (i.e., Viking, Mars Odyssey, and Mars Reconnaissance Orbiter). Recently small bodies such as 9P Tempel-1, 103P Hartley-2, or 4 Vesta was mapped with near-infrared spectroscopy at 3 to 5 micrometer range. These method is only applicable for hot surface regions (the sub-solar points).

In Hayabsua2, TIR images the asteroid surface in 10 micrometer band, with relatively high spatial resolution (0.05deg/pixel, 17m/pixel from 20km altitude). This method has an advantage to image the colder surface, meaning that the dawn-dusk regions (even the night side if thermal inertia is high enough) are also imaged. TIR will take images of asteroid every several minute from the Home Position, 20km Earthward from the asteroid surface, with Sun angle from 0deg to 40deg to the surface normal. The whole asteroid surface is imaged by asteroid rotation in 7.6 hours. The temperature profile of each site is traced, and the thermal inertia of each site is determined by the peak temperature and its delay from the sub-solar time.

We conducted the initial check of TIR after the launch of Hayabsua2 on 3 December 2014. Functionality and performance has been checked on 11 and 17 December, respectively, and we found no uncomfortable problems compared to those of pre-flight tests. After that the monthly health and performance checks are planned for TIR. Attitude control of spacecraft is not requested so that TIR points to the deep sky. Readout value varies from pixel to pixel so that a couple of images taken during the shutter open and close must be subtracted to derive a thermal image by reducing the offsets. During the Cruise Phase of Hayabsua2, a long-term trend of damage or degradation of the imager is investigated by the monthly operation. The performance of TIR is highly influenced by temperature, so the temperatures of TIR optics and mounting panel are controlled by spacecraft the thermal control system of spacecraft. The on/off setting temperature as well as the percentage of heater on can be set by commands, and we are searching for the best settings during the in-flight monthly operation. Currently the temperature can be controlled within 0.2 ℃. In addition, TIR will image the Earth and the Moon 10 to 2 days just before the Earth swing by for gravity assist of trajectory change. The geometry of Sun-Earth-Spacecraft angle is almost 50deg, and the observation time is limited but this may be the only chance for TIR to image the bodies of known thermal radiation. The Earth and the Moon will be seen as more than 10 or 3-4 pixels of diameter, respectively, which is a good opportunity before asteroid arrival.

Keywords: Hayabusa2, thermal inertia, thermo-physical property, mid-infrared, asteroid, thermograph

Japan Geoscience Union Meeting 2015
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PCG30-06 Room:A02 Time:May 26 14:45-15:00

Separation of effects of albedo and emissivity on the thermal evolution of asteroid by using TIR on board Hayabusa-2

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Surface temperature of an air-less body is thought to be determined by balance of the energy received from the sun and the energy emitted as black body radiation. The energy received from the sun per unit area is calculated as a function of the solar distance, D, and the albedo of the body, A. The energy emitted as black body radiation per unit area is calculated as a function of the surface temperature, Ts, and emissivity, E. Thus it is said that the resulting surface temperature is simply calculated as a function of D and (1-A)/E. However this is only the case for a thermally non-conductive body.

For the case of time evolution of surfae temperature is affected by thermal flux from/ to the underground. The effect can be observed as time-delay of peak temperature relative to sub-solar longitude. This indicate that a time-series observation of surface temperature allow the separation of effects of albedo and emissivity on the evolution.

In this presentation, we will show our storategy to estimate the albedo and the emissivity of the target asteroid of Hayabusa-2,1999JU3, by using TIR (Thermal InfraRed) imager.

Keywords: Hayabusa-2, TIR, albedo, emissivity

PCG30-07 Room:A02 Time:May 26 15:00-15:15

Can Hayabusa-2 reveal the distribution of organics on asteroid surface?

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Japanese asteroidal mission "Hayabusa-2" aims at bringing back samples of a C-type asteroid to the Earth, which is expected to extend our knowledge about the early evolution of the solar system and the origin of Earth's life through the on-ground analysis of the returned samples. To maximize its scientific outputs, it is important to reveal the distributions of hydrated minerals and organics on the asteroid surface by remote sensing. Although we can examine the distribution of hydrated minerals by using the near-infrared spectrometer on-board the Hayabusa-2 spacecraft, the method to examine that of organics has not been established yet. Since the total amounts of carbon including carbonaceous meteorites show a clear negative correlation with their absolute reflectance in visible, the absolute reflectance might become a useful index for estimating the organics content. However, the absolute reflectance also depends on the physical properties such as particle size and porosity. Then, we considered discerning the organics content and particle size by using the photometric properties in addition to the absolute reflectance, and performed an experiment to verify this idea using analog materials of asteroid surface. The samples that we used are dunite and humic acid as silicate and organics analogs, respectively. We measured the photometric properties of (1) silicate-organics mixtures and (2) dunite samples with different particle size in the phase angle range of 5-60 degrees. The measurements were performed with a gonio-spectrometer developed in University of Aizu. As a result, in the case of increasing the organics content, the reflectance becomes lower and backward scattering becomes stronger. While in the case of increasing the particle size, the reflectance becomes lower and forward scattering becomes stronger. Also we found that those variations could be matched with the predictions from a theoretical model. Thus, we conclude that it is possible to discern the organics content and particle size based on the absolute reflectance and photometric properties. We need more experiments to examine the effect of space weathering.

Keywords: Hayabusa-2, asteroids, organics, photometric properties

PCG30-08 Room:A02 Time:May 26 15:15-15:30

The accuracy of geometric albedo of the 1999JU3 estimated from observation by the LIDAR and the following results

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The Japanese asteroid explorer 'Hayabusa2' was launched at end of 2014 to explore the near-Earth C-type asteroid '1999JU3'. In this mission, we have a plan to apply the laser altimeter (LIDAR) on board the Hayabusa-2 to investigate the distribution of geometric albedo of the 1999JU3 at the laser wavelength (1064 nm). The LIDAR has functions to measure the intensities of sending laser pulse and receiving laser pulse reflected from the asteroid surface in addition to measurement of distance between the spacecraft and the asteroid. We can evaluate the geometric albedo on the 1999JU3 using the measured intensities of sending and receiving pulses.

We have evaluated how accurately we can estimate geometric albedo of the C-type asteroid from the intensities of lasers measured by the LIDAR. We investigated the characteristics of the LIDAR required to estimate the geometric albedo through some performance tests before the launch. Firstly, the characteristics and the expected accuracy of geometric albedo estimated using data from the LIDAR with the characteristics will be described. Then, intensity of receiving laser pulse can vary depending on degrees of inclination and roughness of the asteroid surface. We will also describe effects of the inclination and roughness on estimation of the geometric albedo.

We consider three types of scientific topics evaluated from information of the geometric albedo distribution of the 1999JU3 estimated from the LIDAR data at 1 μm and reflectance investigated from other equipment in other wavelengths. The topics are (1) rock and mineral category of the 1999JU3, (2) degree of water content on the asteroid surface and (3) variation of the asteroid surface caused from space weathering and/or exterior material. We will report prospects to obtain information about these science topics applying the LIDAR which has our evaluated performance.

Keywords: Albedo of asteroid, C-type asteroid, 1999JU3, Hayabusa-2, Laser altimeter

PCG30-09 Room:A02 Time:May 26 15:30-15:45

Dust detection by using laser altimater on board Hayabusa-2

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[1]Planetary Exploration Research Center, Chiba Institute of Technology, [2]RISE Project Office, National Astronomical Observatory of Japan, [3]ISAS, JAXA, [4]Hayabusa-2

LIDAR (LIght Detection And Ranging) on board Hayabusa-2 is basically used to measure the distance between the satellite and the target asteroid, 1999JU3. This instrument can also measure the absolute reflectance at the wavelength of 1064nm by itself since it monitors the energies of the laser pulse and receiving signal. The accuracy of determining the reflectance is so far estimated no better than 25%, but it would become better through further calibration tests using a pre-flight model of the LIDAR.

Dust count mode is one of the operational modes of LIDAR on board Hayabusa-2 in which it detects faint scattered light from dust grains on the line of sight. The distribution of dust grains along the line of sight is determined from the time resolved energy profile of received light. We need the optical property of a dust grain and size distribution function of dust grains to obtain the true number density. The optical property of a dust grain is modeled by using Mie scattering model assuming that a diameter of dust is larger than the wavelength of laser and that the complex dielectric constant of a dust grain is same as typical value of dirty silicatate cosmic dust analogue. The distribution function of dust grains above the surface of an asteroid can be modeled assuming photoelectric dust levitation, but we need to know the initial condition of dust at the surface to carry out the model. Dust observation by LIDAR on board Hayabusa-2 is the first-ever direct observation of the distribution of dust grains around an asteroid and would constrain the models on the origin and evolution of dust grains on and above the surface of an asteroid.

Keywords: Hayabusa-2, LIDAR, dust

PCG30-10 Room:A02 Time:May 26 15:45-16:00

HARMONICS2 for camera operations on Hayabusa2 as a visualization tool

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We had developed HARMONICS (HAyabusa Remote MONitoring and Commanding System) as a visualization tool of camera's FOV and spatial geometry of the spacecraft Hayabusa and the targeted asteroid, Itokawa for camera operations. This tool was used for evaluating the shape model of the asteroid, optical navigations. Now we have Hayabusa2 as the successor of Hayabusa. The tool has been also updated to HARMONICS2. This updated tool also has following functions: to visualize FOV, to show geometry of the spacecraft and target body, to comparison a simulated image and an obtained one. These functions are calculated with following items: positions and attitudes of the spacecraft, pointing vectors of instruments, shape model of target and ephemeris of the asteroid, etc. GUI of the previous HARMONICS was adoped GTK, but on the other hand HARMONICS2 is done Qt, which is available for cross-platform environments such as Windows, LINUX, and MacOS. We have added new function of interactive operations where users change positions and attitudes of the spacecraft, then variations are reflect in FOV. HARMONICS2 exports SPICE kernels as time sequential data sets of spacecraft positions and attitudes. We'll also add another function of visualizing footprint for scientific observations based on 3-D GIS interface. Users find whether the the they imaged an area or not if the tool visualizes footprint.We'll demonstrate current version of HARMONICS2 and hear feedbacks from users.

Keywords: Hayabusa2, Visualization, CG, Exploration, asteroids, SPICE

Japan Geoscience Union Meeting 2015
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PCG30-11 Room:A02 Time:May 26 16:15-16:30

Study on asteroid sample collection for Hayabusa-2 spacecraft

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Hayabusa-2 is the follow-on sample return mission of Hayabusa. Hayabusa-2 spacecraft was launched by H-IIA rocket from Tanegashima Space Center in 2014 to retrieve rock samples from C-type asteroid called 1999 JU3. The spacecraft will return to Earth in 2020 to deliver the samples of 1999JU3. C-type asteroids are believed to be more primitive than S-type asteroids such as Itokawa explored by Hayabusa. The rock sampling from C-type asteroid is crucial to understanding of the interactions among minerals, water and organics in the planetary system. The sampling system of Hayabusa-2 spacecraft was designed to efficiently collect asteroid samples from the unknown surface. The sampling method is impact sampling by a powder gun which enables to be applied to the various surfaces from silicate hard bedrock to regolith layers with gravel. The sampling system is composed of powder guns, a metal horn and a catcher. Impact cratering on the asteroid surface is performed by the powder gun. After its shot, the asteroid fragments are collected in the catcher along the inside wall of the metal horn. In this study, we performed impact experiments at JAXA using the analog sampler which is faithfully reproduced its flight-model in order to clarify the elementary process of sample collection by the sampling system. Furthermore, we conducted numerical simulations using a hard sphere model to expand experimental data under 1G into estimation of collection mass under microgravity. Therefore, we experimentally and numerically clarified the process of sample collection from C-type asteroid by Hayabusa-2.

Keywords: Hayabusa2, spacecraft, cratering, asteroid

PCG30-12 Room:A02 Time:May 26 16:30-16:45

Novel analytical/transportation system of extraterrestrial materials: Are we ready for Hayabusa 2 returned sample?

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The Hayabusa 2 is the exploration mission to the C-type asteroid 1999JU3. The spacecraft will arrive at the asteroid in 2018, and a minimum 1g of the piece of asteroid will be returned 2 years later (e.g., Tachibana et al., 2014). During the remote sensing investigation for 1.5 years at the asteroid, sample collection from the asteroid surface will perform for three different locations. The sample will be consisted of a mixture of anhydrous/hydrous minerals and organic materials. It is a key material providing critical evidence of evolution of the Solar System including planetesimals, and nature and origin of organic materials and life.

The Hayabusa 2 returned sample might be sensitive to terrestrial contamination during curation, transportation, preparation and analysis. Several reports mentioned that the Hayabusa sample contained carbon-rich particles, inorganic particles, metals and organic materials as terrestrial contaminants (e.g., Uesugi et al., 2014; Ito et al., 2014; Yabuta et al., 2014; Yada et al., 2014). Therefore, it requires to avoid contaminations to the Hayabusa 2 sample from any environmental conditions, to identify possible contaminants if any, and to prepare the proper curation and analytical flow/system in a few years. Uesugi et al. (2014) reported an optimized sample-handling system including transportation between institutes and the sequence of the analytical flow through the examination of Hayabusa category 3 organic materials and meteoritic samples as analogues of Hayabusa 2 returned sample.

JAXA Extraterrestrial Sample Curation Center is taking a lead to work on above problems of unexposed sample transportation, a coordinated analytical system including micro-Raman spectroscopy, FT-IR, XANES, ToF-SIMS, focused ion beam (FIB), transmission electron microscopy/scanning transmission electron microscopy (TEM/STEM) and NanoSIMS. This coordinated analysis is essential to acquire maximum information including abundances of major/trace elements and isotopes, characterization of organics, and petrographic textures from nanometer- to micrometer-scale samples. This technique has been applied to carbonaceous materials by Stardust cometary dust return mission (e.g., Sandford et al. 2006; Matrajt et al. 2008), and can be used for samples obtained by future missions such as Hayabusa 2 and Osiris-REX.

In this talk we will discuss about detailed analytical and comprehensive system for small samples, and future developments of curation, transportation and analysis under air-isolated and/or cryo condition.

Keywords: Hayabusa 2, Extraterrestrial organics, Micro analysis

Japan Geoscience Union Meeting 2015
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PCG30-13 Room:A02 Time:May 26 16:45-17:00

Construction of the initial description analysis flow for Hayabusa2 sample

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The Hayabusa 2 was successfully launched in December 2014, and now it is heading to the C-type asteroid 1999JU3. Before the spacecraft will return to the Earth in 2020, the extraterrestrial sample curation team (ESCuTe) of JAXA is planning to work on designing a new clean chamber during FY2015. We present the initial description analysis flow (IDAF) draft of Hayabusa 2 returned sample.

The IDAF is a flow that most of the returned samples follow. Essentially, in this flow, non-destructive and non-atmospheric exposure analysis must be carried out by ESCuTe. Both initial analysis and international Announcement of Opportunity (AO) for “Hayabusa” sample investigation has been performed based on the information obtained by the IDAF. In Hayabusa 2 mission, it is also expected that the IDAF would be performed by ESCuTe before the any other detailed analysis. Since the IDAF is the most upstream in all analysis flows, not only the acquisition of information for sample allocation, but also minimizing contamination and damage has been required.

The IDAF has been studied to date is as follows.

1. Assembling of sample container to clean chamber in JAXA curation facility.

2. Analysis of volatile elements released from samples into sample container during transformation from the landing site to JAXA.

3. Optical microscopic observation for identification of sample size and volume after opening the sample container.

4. X-ray CT in descending order for understanding of detailed sample texture.

5. Analyses for organic and inorganic components. As analysis for inorganics, we observe petrography and mineralogy by using SEM/EDS and identify constituent minerals of the sample. On the other hand for organic components, analysis technique has been still studying in cooperation with experts in that field.

6. Separating the sample into roughly equal parts. One is for storage and the remaining is for a detailed analysis such as initial analysis and international AO.

ESCuTe has constructed the IDAF in consultation with researchers from various fields. To maximize science gain from the Hayabusa 2 returned sample, damage evaluation of each analysis and development of non-atmospheric exposure container becomes necessary at the same time with the specification examination of the clean chamber. We introduce the analysis flow of the latest version including these problems that should be resolved in the near future.

Keywords: Hayabusa 2, curation, initial description analysis, 1999JU3, carbonaceous chondrite

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PCG30-14 Room:A02 Time:May 26 17:00-17:15

Imaging strategy of DCAM3 equipped on Hayabusa2 based on radiance prediction of imaging objects

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Hayabusa2, the next Japanese asteroid explorer successfully launched at 13:22:04 on December 3, 2014 from the Tanegashima Space Center toward a C-type asteroid 1999JU3, brings a deployable camera called DCAM3. Separated from the mother ship Hayabusa2, DCAM3 will observe an artificial impact on the surface of 1999JU3 performed using Small Carry-on Impactor (SCI) [1, 2]. DCAM3 has two camera systems: a monitoring camera (DCAM3-A) and a scientific camera (DCAM3-D). DCAM3-D possesses a high resolution ($<$1 m/pix at a distance of 1km) and wide angle (74 degrees) optical system for the following two objectives. First objective of DCAM3-D is to image an impact crater produced by SCI and fragments (i.e., ejecta) thrown out of the crater. Second objective is to image Small Carry-on Impactor (SCI) before explosion, which will float several hundred m above the surface of 1999JU3 and $\simeq$1 km away from DCAM3. Imaging SCI enables us to estimate the location of SCI explosion and the impact direction that is an important parameter to interpret the artificial impact experiment. In addition, to estimate the position of DCAM3 itself, images of a part of 1999JU3 surface should be taken by DCAM3. DCAM3-D is, therefore, prepared for imaging three objects with different radiance in different positions: impact ejecta, floating SCI, and the surface of 1999JU3 including the crater cavity produced by SCI. In this presentation, we introduce how to predict the radiance of these three objects and the imaging strategy of DCAM3-D based on the prediction.

SCI is approximated by a cylinder of 15 cm x ϕ 30 cm, smaller than the pixel resolution of DCAM3-D located at a distance of $\simeq$ 1 km, but Beta cloth with a diffusive reflectance of $\simeq$ 80 % is attached on the lateral surface of SCI. Assuming SCI surface is a uniform diffuse reflector (i.e., lambertian), we estimate the radiance of SCI and the signal to be detected with DCAM3-D. Since 1999JU3 is a C-type asteroid, its surface is dark with a geometric albedo ˜0.05. We estimate the radiance of the surface of 1999JU3, assuming Hapke model with Hapke parameters for 1999JU3 [3] as well as other C-type asteroids [4, 5] and comets [6, 7]. It is difficult to predict the radiance of ejecta because we have not yet known the surface condition producing ejecta and the size and the material property of grains consisting of ejecta from 1999JU3. On the other hand, a preliminary trial to generally construct a light scattering model of impact ejecta is in progress by means of Monte Carlo method [8]. We use such preliminary results to estimate the ejecta radiance.

These radiance predictions were checked by some experimental tests and reflected to the imaging strategy of DCAM3-D, namely to decide imaging parameters such as timing, exposure time, and gain setup. Consequently, we prepared three imaging modes specialized for each imaging object: SCI mode, ejecta mode, and 1999JU3 mode. These modes were adequately mixed in a sequence of 1 fps imaging to cope with every situation we can assume at around the time of SCI impact. Since we have no route to access the FPGA of DCAM3 in space, its imaging parameters had to be completely set up before launch. That is, we have already released the shutter of DCAM3. GOOD LUCK!

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Keywords: asteroid, planetary exploration, Hayabusa2, scientific payload

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A future perspective for Japanese explorations of small solar system bodies: The value of Martian moons

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Background: The main theme of solar system (SS) explorations in the next decades will be focused on the elucidation of prebiotic environmental evolutions. In Japan, along with lunar landing missions and Mars landing missions, we should promote explorations of small bodies, utilizing the sample return (SR) technologies succeeded in the *Hayabusa* series, for constraining the evolution and supply of life substance in the early SS. Following to the near Earth asteroids Itokawa (S-type) and 1999 JU_3 (C-type), the candidates for SRs from more primitive bodies may be comets or main-belt or Trojan asteroids. Though these SR missions would be possible within Japanese capabilities, it takes long time (>10 years) to bring back samples from these bodies. Thus, Martian moons are worth noting because of the shorter periods for SR from them. Further, for Japan being behind to USA and Europe in Mars explorations, the Martian moon mission has strategic values for constructing an original exploration program for Mars toward the landing.

Except for the Earth's moon, Martian moons Phobos and Deimos are the only two satellites of terrestrial planets. Both are low-albedo small bodies with surface reflectance spectra like D/C-type asteroids and have circular equatorial orbits. As to their origin there is still a controversy between capture of primitive asteroids and accretion in a possible circummartian debris disk. Past fly-by observations are insufficient to reveal surface material owing to their featureless optical and NIR spectra. There have been no missions succeeded in the rendezvous or landing.

If the moons have captured, the surface material are not only primitive but also less thermally altered by harsh solar radiation, because they have kept away from the Sun. The density of the moons are low, so that they may have icy material inside for the capture scenario or volatile-depleted highly porous material for the disk accretion scenario. From the view of comparative theory of satellite formation, collaboration with science community interested in the formation of the Earth-Moon system is expected. Anyway, the moons have a key role in clarifying life substance supplied to Mars.

Mars moons SR mission: We propose a SR mission from one of the two moons considering the international circumstance. The mission includes high-resolution remote-sensing observations of surface material and internal structure. The objectives are to constrain (1) the origin and history of the moons (early SS information for the capture scenario and planetary growth and alteration processes for the disk accretion scenario) and (2) Mars collisional and atmospheric escape histories that determine the surface environment.

The mission will solve the controversy of the origin of the moons by measuring oxygen isotopes of returned sample and comparing with those of Martian meteorites and future returned samples of Mars. The dating of possible Mars material on the moon and isotope measurements of implanted Mars escaping atmospheric atoms should be done by returned sample analyses. The same side of the moon always faces Mars, so that multiple sampling enabling comparisons between near and far sides or leading and trailing sides is desirable. We can determine the initial value of the D/H ratio for the Mars environmental evolution from measurement of the moon's material originated from ice.

High-level international collaborated mission: There are several exploration plans on Phobos: Russian and ESA's *Phootprint* SR mission candidate and *PADME* fly-by mission candidate for the next NASA Discovery Mission. Is it too late for Japan to participate in the race? The answer is no, because Mars has two moons. If Europe chooses Phobos as the SR mission target, then Japan should target on Deimos, the less recognized outer satellite. Then the both missions will provide a synergy effect on deciphering the origin of the moons and the Mars environmental evolution through the comparative approach.

Keywords: Asteroids, Planetary exploration, Sample return, Phobos, Deimos, Prebiotic environmntal evolution

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PCG30-16 Room:A02 Time:May 27 09:00-09:15

Formation of carbon-rich grains of the Chelyabinsk and Nio meteoritic showers.

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Introduction: Carbon-rich sources of carbon-bearing materials are so many changed in cosmic space from carbon-star formation to any celestial bodies, where main dynamic process is considered to be collision impact process with celestial bodies to planets (including Earth). Recently we have pointed out recently that many carbon-rich grains can be obtained at collision explosions in terrestrial atmosphere by meteorite showers of the Nio and Chelyabinsk meteorites[1-4]. The purpose of the present paper is to elucidate the formation of carbon-rich grains formed by meteoritic showers in air as new carbon-rich source.

Carbon-rich grains of the Nio meteorite: The Nio meteorite (H3-4) fallen at Niho to Miyano, Yamaguchi, Japan (night on 8th August, 1897AD) shows meteoritic shower exploded above ground, where we have collected many fragments of 1,212 spherules and ca.36 pieces with my laboratory students on the old rice-fields at the Niho- to Miyano-towns separately[2] as follows. 1) Japanese rice-paddy with many soil-layers can be stored fallen meteoritic fragments which we can still collect in the grounds of 4 to 5 concentration sites, though the reported fragments of the meteorites are 2 to 3 pieces. 2) Carbon-rich grains can be obtained as FeC in compositions at xenoliths-like materials in the spherules.

Carbon-rich grains of the Chelyabinsk meteorite: The Chelyabinsk meteorite (LL5) fallen recently (15th February, 2013) showed meteoritic shower which have been collected many fragments of ca. 400 pieces on the fields (ca. 3.5kg in total). The samples in this study are collected at Deputaskiy, Russia (Nos.CH-19 to 21) and falllen field (sample No.CH-50 similar to No.CH-20)[5-6] as follows. 1) Sample No. CH-19 shows iron-rich sulfides, carbides and isolated carbon-bearing grains, where irregular void- rich textures shows larger evaporating process in local sites. This indicates that meteorite shower produces carbon-rich grain[4]. 2) Sample No. CH-20 shows primordial chondritic composition with considerable carbon contents. 3) Sample No. CH-21 shows SiC in composition. This indicates that meteorite shower produces single grains of moissanite SiC[2]. 4) All exploded fragments in air contain significant carbon contents with the analytical FE-SEM (JEOL) instrument. Carbon-separation to show the most carbon-rich grains (>80%C) are obtained at the completely mixed sample (No.CH-19)[2].

Carbon concentration sites: Terrestrial carbon sources are considered to be complicated from the deep interior to shallow surface in active planet Earth, though there are no consideration on sources of meteoritic asteroids concentrated on meteoritic shower explosions in air (not from terrestrial rocks). The present results are considered to be new carbon- concentrated source within terrestrial air by meteoritic shower process, which might be clues also for carbon materials on the air planet of the Solar System [2, 3].

Summary: 1) Carbon separation and concentration process can be found at explosions of meteorite shower in air of the Chelyabinsk (Russia) and Nio (Japan) meteorites[4]. 2) The present results suggest that two meteorite shower produce carbon-rich FeS and moissanite SiC grains which were considered to be originated from the comet and/or previous sediments of impact sites[2]. 3) Carbon concentration process by explosions of meteoritic is considered to be new site and sources between extra-terrestrial and terrestrial locations. 4) The present result can be explained new carbon source of impact-related sites (without any remained craters or meteorites).

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Keywords: Russian meteorite shower, Niho meteorite shower, Carbon-rich grains, Air explosion, Extraterrestrial source, SiC

PCG30-17 Room:A02 Time:May 27 09:15-09:30

The possibility of np-Fe production by solar wind protons on the airless body surfaces.

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In HAYABUSA2 mission, we must decide the sampling site using characterization of mineralogical and textural heterogeneities on the asteroid surface by remote sensing data. The reflectance spectra of asteroidal surface have information of mineral composition, but the surface spectra was changed by weathering effects which contain the micro-impacts and the implantation of solar wind ions and cosmic ions. The spectra of S-type asteroids show the reddening and darkening, on the other hand the C-type asteroids show the bluing and darkening [1].

A lot of experimental approaches tried to reproduce the weathering effects. Sasaki et al. (2001) found the nanophase iron particles within the amorphous vapour-desposited rims of laser-irradiated olivine grains using transmission electron microscopy (TEM) [2]. On the other hand, the simulation of implantation for endmembers of lunar and S-type using H^+ ions at keV energy and MeV energy protons implantation show only small changes in visible and near infrared spectra [3, 4].

Then we simulate weathering effect for minerals that would be contained in C-type asteroid. We prepared three minerals, olivine, antigorite and saponite. The weathering simulation of solar wind protons was achieved using ion implantation device at the Wakasa Wan Energy Research Center (WERC). The total amount of implanted H_2^+ with 10 keV was 10^{18} ions/cm^2. The reflectance spectra were measured by FTIR at WERC, and the TEM observation was at Kyoto University. In our simulation, vary with previous study, olivine irradiated H^+ ions shows reddening and darkening like laser-irradiated olivine. On the other hand, another samples did not show large change. Here we report the TEM observations of H_2^+ irradiated samples.

References: [1] Nesvorny, D., et al., (2005) Icarus, 173, 132-152. [2] Sasaki, S., et al., (2001) Nature, 410, 555-557. [3] Hapke, B., et al., (2001) JGR, 106, 10039-10073. [4] Yamada, M., et al., (1999) EPS, 51, 1255-1265.

Keywords: space weathering, asteroid, Hayabusa 2, np-Fe

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PCG30-18 Room:A02 Time:May 27 09:30-09:45

Experimental study on low velocity impact onto granular media:Dependence on gravity acceleration and ambient pressure

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Because gravitational acceleration at an asteroid surface is very small, it is not known which scaling should determine the size of an impact crater, gravitational scaling or strength scaling. In order to estimate the evolutional processes of asteroid surfaces it is important to understand the gravity dependence of crater diameter. However, not many impact cratering experiments under low gravity conditions have been conducted. Some hypervelocity impact experiments were conducted under increased gravities (*Schmidt and Housen, 1987*) and under low gravities (*Gault and Wedekind, 1977; Takagi et al., 2007*). These studies show different gravity dependences and further study is required to understand why the results look inconsistent.

We developed a drop mechanism which can simulate gravities smaller than 1 G: a target container was suspended by springs of constant force. We conducted experiments under a gravity range of 0.25-1 G. We used silica sand of diameter 140 μm and glass beads of diameter 500 μm as the target material. Stainless steel sphere of 8 mm diameter was dropped and impacted onto the target. The impact velocity was between 1 and 4 m s^{-1}. As a result, the crater diameter formed under the gravity range between 0.5-1 G was proportional to -0.188$\pm$0.008 power of the gravity acceleration for the silica sand and -0.183$\pm$0.007 for the glass beads. These values are roughly in agreement with previous studies at hypervelocity (*Schmidt and Housen, 1987; Gault and Wedekind, 1977*).

We conducted new experiments in which the container was fallen freely and simulated gravity was about 0.01 G. In this case the crater diameter was smaller than the expected value by the above gravity dependence. We estimated the adhesion of the target material based on a theoretical model (*Rumpf, 1970*), and we found that the effect of the target strength on the crater size is not negligible. On the other hand, when we conducted similar experiments in an evacuated chamber the crater diameter was larger than the one under 1 atm. There is a possibility that the smallness of the crater under 0.01 G is due to atmospheric effects.

In order to evaluate the above effects, it is important to understand the atmospheric effects on crater formation. *Schultz (1992)* conducted hypervelocity impacts under the ambient pressure range between 10^3-10^5 Pa and the crater volume was found to become larger as the ambient pressure becomes lower. Mostly impact experiments in the past were conducted under the ambient pressure range approximately between 1-10^3 Pa and it is unknown whether or not these results could apply to the ultra-high vacuum condition.

We conducted impact experiments under the ambient pressure range between 1-10^5 Pa. Target was silica sand and projectile was stainless steel sphere which were the same ones used in our study on the dependence of gravity. Impact velocity was 2.5 m s^{-1}. As a result the crater diameter was found to become larger as the ambient pressure becomes lower and this result has the similar tendency to the previous study conducted at hypervelocity. It may be due to the change of the air drag which affects the motion of particles or of the internal friction of target material. It is known that crater diameter formed in the particles with smaller internal frictional angle tends to become larger. We measured the angle of repose (which is approximately similar to internal frictional angle) of silica sand and found that the one under 20 Pa was smaller than the one under 1 atm. Conversely, it is shown that the internal frictional angle under ultra-high vacuum was larger than the one under 1 atm (*Perko et al., 2001*). The mechanism for the change of internal frictional angle is not understood, however it is suggested that the change of ambient pressure may affect the crater size through the change of the internal frictional angle. We will further investigate the effect of ambient pressure on crater diameter and will present the results.

Keywords: Asteroids, Impact craters, Laboratory experiments, Microgravity, Ambient pressure

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Cratering experiments on coarse-grained targets: application to the resurfacing age of a rubble-pile asteroid Itokawa

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Introduction: The crater-like morphologies on Itokawa are observed by the spacecraft Hayabusa (Hirata et al., 2009). The crater-retention ages on asteroids would provide valuable information on their dynamical evolutions. Because crater-retention age is influenced sensitively by crater size scaling, accurate age estimation requires an accurate crater scaling law. It is not obvious if cratering on rubble-pile asteroids, whose surface is composed of coarse grains, is controlled by material strength or gravity. Although crater experiments on coarse-grained targets have been conducted (e.g., Guettler et al., 2012; Holsapple and Housen, 2014), their results are not necessarily consistent to each other. Michel et al. (2009) estimated the crater surface age based on the strength crater scaling as 75Myr - 1Gyr. Furthermore,the cosmic ray exposure (CRE) ages and Ar degassing ages of returned samples show a variety of ages. To interpret these ages with linking to dynamical phenomena, the accurate crater scaling is needed for crater-retention age estimates. The purpose of this study is to experimentally examine what crater scaling rule should apply for estimating crater age on a possible rubble-pile asteroid Itokawa.

Experiments: The impact experiments were conducted at low velocities (70-200 m/s) and high velocities (1.5-5.3km/s): 10-mm diameter projectiles for low velocities and 4.6-mm diameter projectiles for high velocities. We used pumice as boulder simulants and loose 200μm glass beads as regolith simulant. Two types of targets were used: (1) two-layer targets with a block layer on a regolith substrate, (2) a uniform block layer. We measured the rim-to-rim (crest) diameters of craters.

Mechanism of armoring: There may be three mechanisms of armoring depending on impact energy. (1) If impact energy is low enough that the target grains are rarely disrupted, target grains move as receiving momentum from a projectile discussed by Guettler et al. (2012). (2) The energy slightly increase when the projectile disrupts only the surface grains because of the low impact energy, fragments are ejected without transferring momentum efficiently to grains deeper in the target and crater size increases only gradually. (3) When impact energy becomes large enough for the projectile to penetrate into a certain depth, the fragments from disrupted surface grains can also transfer their momentum to surrounding grains very efficiently, and resulting crater size approaches the gravity scaling.

Experiment results would predict the minimum size for craters formed on coarse surfaces; the minimum crater size is $\sim$60% of the gravity scaling on dry soils. Thus, the armoring effect suppresses the excavation energy by $\sim$40% at most.

Discussion: Our experimental results show that the crater sizes formed on the coarse surfaces are in between the gravity scaling and the gravity scaling with armoring (the 40% suppressed from the gravity scaling). Avoiding the effect of seismic shaking or other erasure processes, the formation of five of 100-m sized craters on Itokawa would take 0.4-8.4 Myr including statistical error of 50%. The crater retention age may be younger than the age estimate based on the strength scaling law (Michel et al., 2009) by more than an order of magnitude. Our age is rather close to the CRE ages of the returned samples (Nagao et al., 2011; Meier et al., 2014) and the space weathering age from spectra analysis (Koga et al., 2014) which suggest as young as $<$10 Myr. More recently an old ^{40}Ar/^{39}Ar age (1.26$\pm$0.24 Gyr) was reported (Park et al., 2014), which probably corresponds to a catastrophic disruption of Itokawa's parent body. Take into account of these ages, our age can be interpreted on two scenarios. One is the resurfacing time scale by escape of the regolith which is suggested by Nagao et al. (2011) and another possible scenario is that Itokawa might be disrupted more than once and so our crater age may reflect the latest event age.

Keywords: asteroid, Itokawa, impact experiment, rubble-pile, crater, age estimation

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PCG30-20 Room:A02 Time:May 27 10:00-10:15

Hypervelocity cratering experiments on ice-silicate mixture targets

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Introduction: It is well known that ice-rock mixtures could be a main component of icy satellites, and the crust of asteroid Ceres. Especially, Dawn space craft of NASA will arrive at Ceres in March 2015 and several types of remote sensing will be carried out. Ceres is a member of main asteroid family, so the icy crust could be impacted by various asteroids with different components and physical properties. Therefore, we should obtain various information from the investigation of the observed crater morphologies such as material properties of impacted asteroids and the internal structures of the icy crust and more. To do these investigation, the laboratory experiments would be necessary. Impact experiments on ice-rock mixtures have been conducted systematically by changing the impact velocity from 0.1 to 7km/s and by using the projectile with different densities. However, the cratering experiments on ice-rock mixtures were quite limited at the rock contents below 50wt.%. When we apply our results to the crater on Ceres, the results are not enough to discuss the crater morphology right now. Therefore, we made cratering experiments on ice-rock mixtures with the rock content higher than 80wt.%, and the several types of the projectile were used to compare the results with the previous works.

Experimental method: Impact experiments were conducted by using a two-stage light gas gun at Kobe University. We prepared the targets of ice-rock mixtures simulating the Ceres icy crust. The target consisted of water ice and quartz sand having a particle size of about 100 and 500μm, and the water content was from 20 (porosity=0%) to 2.5wt%(porosity=42%). The ice-sand mixture was made in a cylindrical metal container with the height of 5 to 10cm and the diameter of 15cm. The water-sand mixture was frozen in a freezer with the temperature from -23 ℃ to -15 ℃. Spherical projectiles were used and their diameter were 2mm (aluminium, zirconium, titanium, copper, stainless steel), 1mm (alminium, titanium, stainless steel). We launched a projectile at 1.5 ~7.0km/s with a nylon sabot, and the sabot was separated from the projectile before the impact. A target was set in a vacuum chamber just before the impact, and to prevent the target from melting, the chamber was evacuated for thermal insulation. The air pressure in the chamber during the experiments was kept in the range of 150 ~230Pa. A crater formation process was observed by high-speed video cameras. The crater shape formed on the recovered target was measured by a caliper and a laser displacement meter.

Results: In the case of a non-porous target with 20wt.% water content, we found a conical hole called as ‘Pit’ at the collision point and a shallow trace called as ‘Spall’ around the pit. Hiraoka et al. 2004 investigated how the spall diameter depended on the rock content of targets, and reported the results below 50wt.% of the rock content: the spall diameter decreased with the increase of the rock content. However, our result for the rock content of 80wt.% (water content 20wt.%) showed that the spall diameter was almost the same as that obtained for the rock content of 50wt.%. Then, we found the spall diameter could be constant between 50wt.% and 80wt%. The pit diameter linearly increased with the decrease of the water content between 20wt.% (porosity=0%) and 2.5wt.% (porosity=42%). This might be caused by the target strength decreasing with the increase of the target porosity. The ratio of the pit depth, H, to the pit diameter, d, (H/d) was found to decrease with the decrease of the water content from 20wt.% (porosity=0%) to 2.5wt.% (porosity=42%), and this ratio was clearly small compared with the previous results for pure ice by Burchell and for non-porous ice-rock mixtures by Hiraoka. Then, we might speculate that H/d decreased simply with the decrease of the water content, but we should consider the effect of target porosity in the future.

Keywords: icy body, impacts, experiment, water content, strength regime, cratering

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PCG30-21 Room:A02 Time:May 27 10:15-10:30

Ejecta velocity distribution for impact crater formed on quartz sand: Effect of projectile density on crater scaling law

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In order to clarify the effects of projectile density on ejecta velocity distributions for a granular target, impact cratering experiments on a quartz sand target were conducted by using eight types of projectiles with different densities from 11 g cm^{-3} to 1.1 g cm^{-3}, and they were launched at about 200 m s^{-1} by a vertical gas gun at Kobe university. The scaling law of crater size, the ejection angle of ejecta grains, and the angle of the ejecta curtain were also investigated. The ejecta velocity distribution obtained from each projectile was well described by π-scaling theory of $v_0/\sqrt{gR}=k_2(x_0/R)$^(-1/μ), where v_0, g, R and x_0 are ejection velocity, gravitational acceleration, crater radius and ejection position, respectively, and θk_2 and μ are constants mostly depending on target material properties (Housen and Holsapple, 2011), and then it was found that k_2 is almost constant of 0.7 for all projectiles except for a nylon projectile, while μ increases from 0.43 of a low-density projectile to 0.6 - 0.7 of a high-density projectile with the increase of the projectile density. On the other hand, μ was obtained to be 0.55 from the π-scaling theory for crater size, and it was close to the average of the μ obtained from ejecta velocity distributions. The ejection angle, θ, of each grain decreased slightly from higher than 45^o near the impact point to 30^o - 40^o at 0.6 R with the distance. The ejecta curtain angle is controlled by two elementary processes of ejecta velocity distribution and ejection angle; it gradually increased from 52^o to 63^o with the increase of the projectile density. The comparison of our experimental results with the theoretical model of the crater excavation flow called as Z-model revealed that the relationship between μ and θ obtained by our experiments couldn't be described by the Z-model (Maxwell, 1977). Therefore, we used the extended Z-model by Croft (1980) that could be applied to the crater excavation process when the point source was buried at the depth of d under the target surface, and then all the experimental results of μ and θ were reasonably explained by suitable Z and d of the extended Z-model.

Keywords: Impact processes, Regoliths, Cratering, Asteroid surfaces, Ejecta curtain, Scaling Law