Japan Geoscience Union Meeting 2014
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U06-P01 Room:Poster Time:April 28 18:15-19:30

Photometric Properties of (162173) 1999 JU3 in Preparation for JAXA Hayabusa 2 Sample Return Mission

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A near-Earth asteroid, (162173) 1999 JU3 (hereafter 1999 JU3), is a primary target asteroid for Hayabusa 2 sample return mission. We conducted a worldwide campaign to make photometric observations of the asteroid to determine the physical properties. 1999 JU3 is classified into C-type asteroid having a nearly spherical shape and the synodic rotational period of 7.6312±0.0010 hr.

In this presentation, we will report further information about 1999 JU3 determined since last JpGU meeting in 2013. We investigated the magnitude-phase angle relation. We obtained the parameters for IAU H-G formalism, H =19.20±0.12 and G=0.077±0.011 (V-band, 550nm), respectively. In combination of our result with infrared photometry, the geometric albedo is updated to be 0.05 (Mueller et al. in preparation), which is typical to but slightly smaller than the average of C-type asteroids in main-belt. We found that the magnitude-phase angle relation has a linear behavior in a wide range of the phase angles (5-80 degree) and show a possible non-linear opposition brightening within the phase angle of ‹ 5 degree. The phase slope is consistent to those of tens-km C-type asteroids, that is, 0.04 mag degree^{-1}. The opposition effect amplitude, ≈10% or less, is slightly weaker than that of a precursor C-type mission target body, (253) Mathilde, but the difference seems to reflect the diversity of C-type asteroids. Recently, Shevchenko & Belskaya (2010) reported that ˜20% of all studied low albedo asteroids did not show detectable opposition effect. We explore the significance of 1999 JU3 data with remote-sensing devices in terms of the opposition effect.

Keywords: Hayabusa 2, 1999 JU3, Ground-based observations

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Observation of geometric albedo of the C-type asteroid by the laser altimeter on Hayabusa-2 spacecraft

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The Japanese asteroid explorer 'Hayabusa2' will be launched at end of 2014, and it will probe the near-Earth C-type asteroid '1999JU3'. In this mission, we have a plan to utilize the laser altimeter (LIDAR) to investigate the distribution of geometric albedo of 1999JU3 at laser wavelength (1064 nm). The LIDAR on-board Hayabusa2 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 of the 1999JU3 using the measured intensities of sending and receiving pulses.

In this presentation, we will indicate results of the performance tests of the LIDAR and expected accuracy of the albedo evaluated from the results of the tests. We will also describe not only effect of characteristic of the LIDAR but also effects of inclination and roughness of the asteroid surface on estimation of the albedo.

In our study, three types of scientific topics using information of the albedo on asteroid surface estimated from the LIDAR data with other equipment data are considered; they are (1) rock and mineral category of 1999JU3, (2) degree of water content on asteroid surface and (3) variation of 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

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Performances of Flight Model of NIRS3: the Near Infrared Spectrometer on Hayabusa-2

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NIRS3: the Near Infrared Spectrometer is one of the candidate scientific instruments which will be equipped on Hayabusa-2 mission. It aims to observe near infrared spectroscopy at the wave length band of 1.8-3.2 micrometer to detect specific molecular absorption lines, including the absorption by hydrated minerals at 3 micrometer, on the target C-type asteroid. The major purpose of NIRS3 is to observe the absorption bands of hydrated minerals in the 3 micrometer band on the candidate target C-type asteroid 1999JU3. C-type asteroids are thought to be mother celestial bodies of carbonaceous chondrites (C-chondrites). C-chondrites have been classified into sub-groups by their composition, organization, and isotope ratio of oxygen. The spectra of C-type asteroids have also been classified into sub-types by their inclination and the existence of absorption bands detected in ground observations. However, the relationship between the sub-groups of C-chondrites and the sub-types of C-type asteroids has not been clarified due to the effects of solar radiation and space weathering. Therefore, we will directly observe the surface of a C-type asteroid without the terrestrial atmospheric absorption in the 3 micrometer band using NIRS3. Detecting younger terrain by global mapping of the asteroid and the ejecta of new crater by the Small Carry-on Impactor (SCI) will also provide the spectra of surface less affected by space weathering. To estimate the quantities of the hydrated minerals with accuracies of 1 to 2 wt%, we designed the NIRS3 system to have a signal-to-noise ratio (SNR) exceeding 50 at 2.6 micrometer for global mapping.

The ground tests for NIRS3 flight model started in 2013. Results of the flight model tests implied that the dark current at the InAs sensor is much lower than that of the engineering model which improves SNR. The projected on-board SNR was confirmed to be sufficient during the one-year observation period of 1999JU3 assuming the asteroid surface temperature estimated from the heliocentric range and solar phase angle. The SNR exceeds 300 after 2.5 ms integration and 1024-stacking at the home position observations. The data obtained after the vibration tests and thermal-vacuum tests indicate that NIRS3 is sufficiently durable for the launching and on-orbit environments. The observed spectra for samples of serpentine, olivine, and C-chondrites (Murchison, Murray, and Jbilet Winselwan) demonstrated that the derived reflectances are almost the same as those obtained by Fourier-transform infra-red (FTIR) spectroscopy. These design results show that NIRS3 has sufficient performance for scientific objectives.

Keywords: Hayabusa-2, asteroid, 1999JU3, NIRS3, near infrared, spectrometer

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Thermal Infrared Imager TIR on Hayabusa2: Instrumentation and Ground Calibration

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Thermal Infrared Imager TIR onboard Hayabusa2 is to map thermo-physical properties of Near-Earth C-class asteroid (162173) 1999JU3 through thermal imaging. Scientific significance must be placed on physical properties of asteroids as well that imply the planetesimal formation in solar nebula and its mechanical evolution to current small bodies, although planetary material science is often more focused in small body missions.

In the typical solar system evolution scenario, very fluffy porous bodies are formed in solar nebula and then become denser due to high-speed collision and thermal metamorphism. Some C-class asteroids are less dense, implying a highly porous assembly of densely compacted rocks or a loosely bound rubble-pile of porous rocks and soils. Those features will be identified by thermo-physical properties derived with TIR. Some C-class asteroids must have experienced dehydrated process whose clues might be found as veins or grooves on the asteroid. Those features are expected to be investigated by TIR. Granular flows which were found on asteroid Itokawa and ejecta sediments around impact craters will be measured by TIR as different thermal inertia zones because they have smaller particle size or higher porosity. Floating boulders (or moons), surrounding dust or vapor clouds ejected from asteroid surface could be detected by TIR if they exist sufficiently. Furthermore, on-site TIR observation will contribute to more confident and accurate determination of asteroid thermo-physical properties by ground observation.

TIR is a thermal infrared imager using two-dimensional micro-bolometer array, which has 328 x 248 effective pixels, 16 x 12 degrees field of view, and 0.05 degree per pixel, so that pixel resolution is 20m when observed from 20km altitude Home Position (HP), and less than 1m from 1km altitude covering 280m x 210m. The imaging feature is suitable for obtaining asteroid global feature from HP and investigating local geological context before and after sample collection. Hayabusa2 will observe asteroid 1999JU3 at the heliocentric distance from 0.96 to 1.42 AU and the dayside surface temperature is estimated -40 to 150 ℃ assuming the albedo is 0.05 and emissivity is 0.90 to 0.95. Detection range of TIR is 8 to 12 μm, which is best for observing thermal radiation from asteroid.

We have calibrated TIR performance for the target temperature ranging from -40 to 150 ℃. Goal is to construct the calibration curves for each pixel by 3 ℃ absolute temperature as well as 0.3 ℃ NETD. The apparatus for TIR calibration are the vacuum chamber for cold target and the clean-booth for hot target, with adjusting the optics and mounted panel temperatures. It is ideal that a single OFPN (Onboard Flat Pattern Noise) data is applicable for all the temperature range. Now efforts have been taken to improve its performance by interrelation between cold and hot calibration cases, adjusting bias levels due to different thermal energy input to detector, as well as geometric calibration. Instrumentation and results of calibration for TIR will be reported in detail.

Keywords: asteroid, Hayabusa2, thermo-physical property, Thermal Infrared, bolometer, planetary exploration

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Relationship between Regolith Particle Size and Porosity on Small Bodies

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Planetary small bodies are covered by a particulate layer called regolith. The particle size and porosity of the regolith surface of small bodies are important physical properties. The responses of the surface to solar irradiation are dependent on the particle size and porosity. The particle size and porosity have influences on the dynamic responses of the surface, such as cratering efficiency. By Apollo missions, the particle size was directly measured and estimated the mean porosity of the regolith 51% (Mitchell et al., 1974). The near-surface bulk porosity of asteroid was estimated using ground-based radar data to have a mean of 51∓14% (Magri et al., 2001). The angular width of opposition surge in optical reflectance was interpreted in terms of porosity and particle size distribution : surface porosities of S-class asteroidswere ranging from 40 to 80 % (Hapke, 1986; Domingue et al., 2002).

An empirical relationship between porosity and the ratio of the magnitudes of the interparticle force that was estimated as the capillary force and gravity which act on a particle was presented by Yu et al. (2003). The porosity was measured for the particles in the loose packing state and different porosities were interpreted as due to the difference of particle size. In this study we assume that the van der Waals force is predominant in the interparticle forces. A model formula of the van der Waals force in which the effect of adsorbate molecules is taken into account by a parameter is defined as

$Fv=AS^2r/48\Omega^2$ (1)

where A is Hamaker constant, r is particle radius, Ω is diameter of an O^{-2} ion, S is cleanliness ratio which shows the smallness of a number of the adsorbate molecules (Perko et al., 2001). It was shown that cleanliness ratio, S, is approximately 0.1 on the Earth, and is almost unity in the interplanetary space. In addition to the data of the several past studies, our own measurement result of micron-size fly ash particles in atmospheric condition.

We calculate Fv of all data using Eq.2, and obtain a revised relationship between porosity and the ratio RF of the magnitudes of the van der Waals force and gravity Fg , $R_F = F_V/F_g$. An empirical formula used in the previous study (Yu et al., 2003) ,

$p=p_0+(1-p_0)\exp(-mR_F^{-2})$ (2)

is applied to fit the data, where p_0, m and n are constants. Substituting Eq.1 to Eq.2 yields,

$p=p_0+(1-p_0)\exp\{-m(AS^2/64\pi\Omega^2\rho gr^2)^{-n}\}$ (3)

where $\rho$is particle density and g is gravitational acceleration.

We apply Eq. 3 to the conditions of small bodies ' surfaces to derive the relationship between particle radius and porosity. For example, we obtained the relationship for asteroid 25143 Itokawa surface. The particle size of Itokawa is ranging from millimeter to centimeter in the area of fine particles, smooth terrain of the Muses Sea (Yano et al., 2006). The result shows the range of porosity would be 0.55-0.8. Similarly, we can calculate the above relationships for other small bodies.

Gundlach and Blum (2013) estimated the particle size of small bodies by using the thermal inertia data and a heat conductivity model for regolith. By combining the relationship described for Eq.3 with those of Gundlach and Blum (2013), we can estimate the particle size and the porosity of regolith for the small bodies simultaneously.

Keywords: asteroid, regolith, porosity

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How to detect a small crater produced by Small Carry-on Impactor (SCI) using Thermal InfraRed Camera (TIR)

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In Hayabusa-2 mission, a crater will be formed on the surface of a C-type asteroid 1999JU3 using Small Carry-on Impactor (SCI) and the crater should be quickly detected from the mother ship. The detection, however, will become difficult when the crater is very small with a diameter of only 30 cm, near to the resolution limit of on-board cameras. On the other hand, Thermal InfraRed Camera (TIR) mounted on Hayabusa-2 has a possibility to detect such a small crater even if the crater size is sub-pixel of TIR resolution, because the temperature on the surface of a small crater is expected to be different from that around the crater. We, therefore, have started examination about the possibility and method to detect a SCI-formed small crater using TIR. In this presentation, we introduce the basic idea and the preliminary results of our modeling.

Keywords: Hayabusa-2, Impact, SCI, TIR, cater thermal model, asteroid

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Hayabusa 2/SCI: calibration impact experiments

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SCI (Small Carryon Impactor" boarded on "Hayabusa 2" is a hollow Cu sphere with a mass of 15 kg, a diameter of 15 cm, which will impact a surface of asteroid 1999JU3. To estimate the conditions of the surface of the asteroid, such as composition and structure, we should investigate the results of the impact experiments with similar projectiles and various targets. We carried out impact experiments with gypsum and basalt targets and small hollow projectiles accelerated by a two-state light-gas gun at ISAS/JAXA, and sand targets and real scale projectiles at Kamioka. We report a summary of the results of these experiments.

Keywords: Hayabusa 2, Small Carryon Impactor, Impact experiments

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Impact crater formation on quartz sand: the effect of projectile density on ejecta velocity distributions

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Introduction : Regolith formation and surface evolution on asteroid are caused by high velocity impacts of small bodies. The ejecta velocity distribution is one of the most important physical properties related to the crater formation and it is necessary to reconstruct the planetary accretion process among planetesimals. The surface of small bodies in the solar system has a various property on the porosity, strength and density. Therefore, the impact experiment on the target with the various properties is necessary to clarify the crater formation process applicable to the small bodies in the solar system. However, there have not enough studies on the effect of projectile density on the ejecta velocity distribution. Therefore, we would try to determine the effect of projectile density on the ejecta velocity distribution using 8 projectiles with different density by means of the observation of the each ejecta grain.

Experimental method: The cratering experiment was made by using a vertical type one-stage light gas gun (V-LGG) set at Kobe Univ. We used 3 types of targets: that is, they are the 100micron-glass beads target (porosity 37.6%), the 500 micron-glass beads target (porosity 37.6%), and 500-micron quartz sand (porosity 44.7%). These granular materials were put into the stainless steel container with the diameter of 30cm and the depth of 11cm. The target container was set in a large chamber with the air pressure less than 10^3 Pa or 10^5Pa. The material of the projectile that we used was a lead, a copper, an iron, a titanium, a zirconia, an alumina, a glass, and a nylon (1.1-11.3g/cm^3), and it had a diameter of 3mm and was launched at the impact velocity (v_i) of 24 to 217m/s.

We made an impact experiment using 8 types of projectiles on the 500-micron quartz sand target and observed each ejecta grain by using a high speed digital video camera taken at 2000-10000 FPS. Then, we measured the ejection velocity and the initial position of each grain. We successfully obtained the relationship between the initial position and the initial ejection velocity or ejection angle for the quartz sand grains.

Result: In (Eq.1), mu is proportional to density of projectile in the range less than 6g/cmˆ3. (Eq.2)

$v_e/v_i=a(x/R)^{(-1/mu)}$?(1)

, where ve is an ejection velocity of grain, x is the initial position of ejecting quartz sand grains and R is the crater radius.

mu=0.05ρ+038 -(2)

Moreover, we obtain the relation between crater size and projectile density.(Eq.3)

[R$*$(ρt/m)ˆ(1/3)]=11$*$[ρt/ρp]ˆ0.096 ?Eq(3)

The ejection angle of quartz sand grains is also obtained. For all projectiles, the grain that ejects from near impact point have high ejection angle and the more distant that grain ejects from, the lower the eject angle is. There are no effect of projectile density.

The obtained empirical equation between the ejection velocity and the initial position is as follows Eq(4),

$ve/vi=1.5*10^{-3}(x/R)^{-1.8}$ (0.3<x/R <0.9) -(4)

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Impact cratering experiments on granular slopes

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Impact cratering is an important process for the evolution of planetary surfaces. Many experiments of impact cratering into granular media have been conducted to understand its basic physics (e.g., Walsh et al., 2003, de Vet and Bruyn, 2007). These studies have shown that as impact energy becomes larger, simple craters transform into complex craters. In addition when gravity is more important than the target strength, the crater diameter increases in proportion to the 1/4 power of the impact energy. Peculiar craters on asteroids have been discovered in recent planetary missions. Some craters on asteroids are likely to be in the transitional regime between the gravity and strength dominated regimes. In order to better understand how such craters may have formed, we have recently conducted experiments around the transitional regime (Takita and Sumita, 2013). In addition, because asteroids have large topography relative to its size, some craters seem to have formed by impact on slopes (Jaumann et al., 2012). However, since most previous experiments were performed on horizontal targets, impact cratering on slopes is still poorly understood. In this study, we report the results of experiments to understand the effects of slope angle on crater formation.

The experiments in this study were performed by dropping spherical projectiles into an inclined granular target. Projectiles are made of stainless steel (density: 7.70g/cm^3) and their diameters are 11.0mm and 22.2mm. We use sand (mean diameter of 0.204mm, density of 2.66g/cm^3, angle of repose of 37.2○, volumetric packing fraction of 0.56) for the granular target. The slope angle ϑ was 0○,11○,16○,22○,34○. Impact energy E was 0.055 , 0.073 and 0.58 J. Crater formation process was recorded by a high speed camera. The 3-D topographies of the granular target before and after the impact were measured by a laser displacement meter which we move by a stepping motor. Resolution of the laser displacement meter is about 0.024mm for vertical direction, and about 0.1mm for horizontal direction. The stepping motor moves at 0.2mm intervals. We obtained the vertical displacement of the granular target caused by the impact by subtracting the topography of the target before and after the impact. We defined the maximum vertical displacement as the crater depth, the length of the crater in the dip direction projected to the horizontal plane as the crater length, and the width in the strike direction as crater width.

We find that the part of the crater rim disappears when ϑ is larger than about 20○. From studying the images recorded by high speed camera, we find that when ϑ becomes large, the slope above the impact point collapses and this causes the partial disappearance of the rim.

Comparing with the Vestan craters (Jaumann et al., 2012), we find that both laboratory and Vestan craters have common asymmetric shape with ejecta spreading down slope and the location of the maximum depth also shifted towards downslope. We find that the crater depth decreases with ϑ . On the other hand, crater length and crater width remains unchanged from 0○to 22○and increased when ϑ was larger than 22○. As a result, the depth / length ratio decreased from 0.25 to 0.05 with the increase of ϑ.

We also analyzed the impact energy dependence of the crater scales and fit them by a power law relation AE $\wedge$ α. We find that with the increase of ϑ, both the prefactor A, and the exponent α changes. This shows that the scaling law obtained for the horizontal granular target cannot be directly applied to impacts on slopes.

References:

de Vet and Bruyn., 2007. Phys.Rev E 76, 041306
Jaumann et al., 2012. Science 336, 687
Takita and Sumita, 2013. Phys.Rev E 88, 022203
Walsh et al., 2003, PRL 91.104301

Keywords: impact cratering, granular matter

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Size Dependence of Impact Disruption Threshold of Iron Meteorites

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Iron meteorites and some M-class asteroids are generally understood to be fragments that were originally part of cores of differentiated planetesimals or part of local melt pools of primitive bodies. On these primitive bodies and planetesimals, a wide range of collisional events at different mass scales, temperatures, and impact velocities would have occurred between the time when the iron was segregated and the impact that eventually exposed the iron meteorites to interplanetary space.

In this study, we performed impact disruption experiments of iron meteorite specimens as projectiles or targets at room temperature to increase our understanding of the disruption process of iron bodies. Our iron specimens (as projectiles or targets) were almost all smaller in size than their counterparts (as targets or projectiles, respectively), with one exceptional shot. Experiments of impacts of steel specimens were also conducted for comparison.

The fragment size distribution of iron material is different from that of rocks because in iron fragmentation, a higher percentage of the mass is concentrated in larger fragments, probably due to its ductility. The largest fragment mass fraction is dependent not only on the energy density but also on the size of the specimen. We show the largest fragment mass fraction has a power-law dependence to initial peak pressure normalized by a dynamic strength, which is defined to be dependent on the size of the iron material.

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Keywords: Small Bodies, Iron Meteorite, Impact Process

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Cratering chronology models for the near-Earth asteroid 1999 JU3

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The Japanese asteroid explorer Hayabusa-2, that is scheduled for launch in 2014, will be observe a near Earth C-type asteroid 1999 JU3 and will return to Earth with its samples. In this study, we model cratering and crater erasure processes on 1999 JU3 to provide an age estimate for 1999 JU3 based on high-resolution images that will be obtained by Hayabusa-2. The impact rate on 1999 JU3 is calculated from population models of main-belt asteroids (MBAs) and near-Earth asteroids (NEAs) and the average collision probabilities for the main belt and for NEAs. By converting the impactor size to the size of consequent crater based on crater scaling law and the average collision velosities for the main belt and for NEAs, the cratering rate on 1999 JU3 is calculated. For comparison, we use two population models of asteroids, two crater scaling laws and five conditions of surface of 1999JU3. In addition, two crater erasure processes, seismic shaking and saturation of craters, are considered in our model. As a result, our models indicate that age estimate of 1999 JU3 primary depends on crater scaling laws used and assumptions of surface conditions of 1999 JU3 rather than population models of asteroids.

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Scaling analysis of cavity morphology and disruption threshold for highly porous targets

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The morphology of the cavity formed by an impact can be dependent on parameters such as porosity, bulk density and strength of target bodies and size, bulk density, strength and impact velocity of impactors. Laboratory impact experiments have been conducted and cavity diameter and depth have been studied in previous studies in which highly porous targets up to 60% in porosity were used (e.g. gypsum, sintered glass and snow). Based on recent spacecraft missions and ground-based observation, it is shown that small bodies have even higher bulk porosities up to 86% (Consolmagno et al., 2008). Experiments using further highly porous targets are necessary for understanding collisional evolution of such bodies in the formation period. We study cavity morphology of highly porous targets and compile the result with previous studies. We also study disruption threshold of targets and compile the results.

We prepared porous targets with three different porosities, which have porosity of 94%, 87% and 80% (Okamoto et al.,2013). Various projectiles with different density and strength were used; titanium, aluminum, stainless steel and nylon spheres of 1 and 3.2 mm in diameter, and basalt cylinder of 3.2 mm in diameter and 2.0 mm in height. The impact velocity was ranged from 1.7 to 7.2 km/s.

The track was long and thin, in carrot-shape, when the projectile was intact, while it was short and thick, in bulb-shape, when the projectile was fragmented. We report the results of bulb-shape cavity in this presentation.

We apply crater scaling law in strength regime for maximum diameter and entrance hole diameter of the cavity. We compile data of previous studies and ours to obtain empirical relationships. A correlation is shown between the distance from entrance hole to maximum diameter and characteristic depth where initial kinetic energy of projectile becomes 1/e. Characteristic length is a function of drag coefficient. Since the drag coefficient depends on the fragmentation degree of projectile, it is shown that disruption of projectile affects the distance from the entrance hole to the maximum diameter.

Volume, maximum diameter and depth of cavity during its growth were measured on flash X-ray images. Normalized cavity volume and time (Schmidt and Housen., 1987) are applied for the analyses of the results. They have a power law relationship. The power law index for shots with larger density ratio (target density / projectile density) is slightly larger than those with smaller density ratio. Similarly power law relationships between normalized depth of cavity, maximum diameter and normalized time were obtained, respectively. The power indices are consistent of the power index determined for the normalized volume and time. Thus the growth of cavity volume can be explained by growth of maximum diameter and depth.

The threshold energy density for disruption $Q^*$is defined by energy density leading to a largest remnant having half the mass of the target. Q^*increases slightly with porosity of the targets. $Q^*$for the targets with equal diameter-height ratio is slightly larger than those with longer shape (diameter /height=0.5). In this presentation, we will discuss scaling of $Q^*$with various previous study.

Keywords: impact experiment, small body, crater, catastrophic disruption

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U06-P13 Room:Poster Time:April 28 18:15-19:30

A consortium study of the largest particle of Hayabusa-returned samples

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Hayabusa-returned samples retrieved by the Hayabusa spacecraft were already distributed and investigated in the preliminary examinations and international A/Os. Through the investigations, several insights have been obtained on the formation process of 25143 Itokawa and surface processes occurred on the asteroid, as well as the confirmation that the particles were certainly regolith particles from there [1-6].

There are several particles, however, which have not been distributed for those examinations because of their rare features appeared in the initial description done by extraterrestrial sample curation team (ESCuTe) of JAXA. Though those particles will provide us further information for Itokawa and evolution of the asteroid, the samples should be investigated as carefully as possible to reduce consumption and damage of the samples. RA-QD02-0136-01 is currently the largest sample of Hayabusa-returned samples recovered from the sample catcher. The major axis of the particle ra is around 310 μm, and weight of the particles is estimated around 20 μg, assuming the volume V= $4/3\pi r_a r_b r_c \sim 4/3\pi/(2\sqrt{2})r_a{}^3$ and density of the particle as 3.4 g/cm^3, where r_a, r_b and r_c are major axis, semi-major axis and minor axis, respectively. The RA-QD02-0136-01 is mainly composed of Ca-rich pyroxene, and also contains minor amount of low-Ca pyroxene, olivine, plagioclase and troilite. In order to maximize scientific gain from the Hayabusa-returned samples, we decided to investigate this particle by constructing a specific consortium for the analysis.

6 teams were joined the consortium, and following analyses were proposed.
M. Uesugi and A. Tsuchiyama : CT observation of 3D texture and surface observation
J. Park and Rutger team : Ar age analysis to determine the shock ages
K. Nishiizumi and K. Nagao : Analysis of cosmogenic nuclides to estimate the erosion rate of Itokawa
N. Kita and D. Nakashima : O-isotope analysis of high-Ca pyroxenes and plagioclases by SIMS
F. Langenhorst : TEM observation of the dislocations for estimating shock effect by small impacts
L. Keller : TEM observation of the space weathering rims

Currently, we prepare the sample cutting method, and evaluate effect of the cutting and sample transfer on the subsequent analysis. We will report the sequential flow of the analyses and results of the rehearsals.

References: [1] Nakamura et al. 2011. Science 333:1113-1116. [2] Yurimoto et al. 2011. Science 333:1116-1119. [3] Ebihara et al. 2011. Science 333:1119-1121. [4] Noguchi et al. (2011) Science 333:1121-1125. [5] Tsuchiyama et al. 2011. Science 333:1125-1128. [6] Nagao et al. 2011. Science 333:1128-1131.

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Present status of a consortium study of a NaCl bearing Itokawa particle

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Hayabusa spacecraft returned samples from S-type Near-Earth Asteroid (NEA) Itokawa in June 2010. After the return, Extraterrestrial Sample Curation Team (ESCuTe) of JAXA have recovered particles from a sample catcher of Hayabusa, and more than 400 particles initially described have been presented in public (Yada et al., 2014). Among them, some types of particles having rare features are assigned to consortium studies, because they are supposed to be applied by multiple proposals so that they could not be distributed. Members of the ESCuTe would lead consortium studies to ask for research plans from worldwide researchers, discuss a research flow for the particles with the researchers to maximize their scientific gain, and push the plan forward.

One of the consortium studies is for a silicate particle bearing NaCl. The sample ID RA-QD02-0129 is 40 micron in size, mainly composed of silicate similar to plagioclase in chemical composition, and have euhedral NaCl particles of 3-5 micron in size on its surface. This is the only silicate particle bearing NaCl among those initially described so far.

In planetary material samples, NaCl is very rare and unique component. It has been discovered only in Monahan and Zag H chondrites among all ordinary chondrites so far. Trace of extinct 129I was discovered in the NaCl in the meteorites, which means that it should have formed in their parent body(ies), H chondrite or other, in the early solar system and involved in the meteorites in some processes afterward (Zolensky et al., 1999; Whitby et al., 2000). The formation of NaCl should be linked with water in their parent bodies, so it could provide important information about the origin of its parent body. Additionally, water and salt should be closely linked with organic material revolution and might provide interesting suggestion for the origin of life.

One of the most important purposes of this consortium is to prove extraterrestrial origin of the particle (silicate) and NaCl. And next step is to clarify whether its parent body would be Itokawa and/or LL chondrite parent body or other ones. What can prove the extraterrestrial origin of the NaCl is (1) discovery of solar flare tracks in the NaCl, (2) detection of solar wind He on its surface, (3) presence of space weathering layer on its surface. Transmitted electron microscope (TEM) observation for ultrathin section of the NaCl made by focused ion beam (FIB) system will be necessary for (1) and (3), and a laser ionization mass spectrometer is necessary for (2). In the research plan so far, terrestrial NaCl with instrumentally implanted He and NaCl in Monahan meteorite will be prepared for the rehearsal analyses to establish analytical techniques and then we will try the real particle.

References:
Abe M. et al. (2011) LPS XLII, Abstract #1638.
Whitby J. et al.(2000) Science 288, 1819.
Yada T. et al. (2014) LPS XLV, Abstract #1759.
Zolensky M. E. et al. (1999) Science 285, 1377.

Keywords: Itokawa, asteroid, NaCl, consortium

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Three-dimensional structures of aggregate-type Itokawa particles

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Regolith particles, which should have been formed by fragmentation and abrasion due to impact and impact-induced vibration, exist on surfaces of minor bodies. Their formation processes and causes will tell us physical and chemical condition of the surfaces of the minor bodies and their parent bodies.

Hayabusa spacecraft returned samples from S-type Near-Earth Asteroid (NEA) Itokawa in June 2010 (Abe et al., 2011). Among the returned regolith particles, we focus on aggregate-type particles composed of tiny component grains to analyze their three-dimensional (3D) structure in order to clarify their formation processes and environments.

In this study, we chose five aggregate-type Itokawa particles, which are 55-128 micron in size, assigned for JAXA's research among more than 400 particles initially described. They were firstly analyzed by synchrotron X-ray computed tomography (CT). Because they might be fragile, they were placed inside tiny, upside-down pyramid-shaped sample holder made of SiN. They were irradiated in beam line (BL) 47XU of SPring-8 by photon light source of both 7keV and 8keV in energy and obtained their transmitted X-ray images. The obtained images were calibrated by computers, and their 3D structure could be reconstructed. Mineral species in the particles could be estimated by the different X-ray adsorption factors of different energy X-ray in each of the minerals.

The obtained data are under calibration so far. We will clarify their 3D structure and discuss about their formation processes. Additionally, we are planning to make their ultrathin sections by focused ion beam fabrication system (FIB) and confirm detailed structures between the tiny component grains with transmitted electron microscope (TEM).

References:

Abe M. et al. (2011) LPS XLII, Abstract #1638.
Tsuchiyama et al. (2013) GCA 116, 5.

Keywords: Itokawa, asteroid, aggregate, three-dimensional structure, synchrotron CT

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Consortium Study of Troilite and Phosphate-bearing HAYABUSA Returned Samples

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HAYABUSA returned samples have been shown as Itokawa origin by the preliminary examinations (e.g. Nakamura et al., 2011). Furthermore, international AO study has begun last year, and a formation process of asteroid Itokawa is becoming revealed.

HAYABUSA returned samples are described initially by JAXA Extraterrestrial Sample Curation Team (ESCuTe), and a sample catalogue is prepared based on the data of initial description (e.g. Yada et al., 2014). More than 400 returned samples were described so far. These described samples are classified into four categories. A number of samples of each category to be distributed for international AO are decided based on the sample catalogue. But it is difficult to distribute such samples with rare characteristics in composition, mineralogy, structure, or size, although those samples should maintain scientifically important information.

Therefore, in JAXA, ESCuTe started to organize the consortium studies in order to obtain the scientific information as many as possible from these samples (e.g. Yada et al., 2014; Uesugi et al., 2014). In this paper, we report the research plan for the particles mainly composed of FeS and which contain phosphate minerals.

RA-QD02-0245 composed mainly of FeS (40 micron) with smaller attached olivine and pyroxene grains. This particle was analyzed by X-ray CT at SPring-8 for 3D texture without atmosphere. Two ultra-thin section will be made from the edge of this particle by FIB. The ultra-thin sections will be examined by TEM in detail for space-weathering effect on FeS surface. The main mass of this particle will be analyzed for chemical composition. Especially, the siderophile element composition gives us information on the formation process of Itokawa parent body.

Some particles including phosphate mineral were found by the initial description. Because Ca-phosphate tends to be enriched in incompatible elements such as REEs, Th and U, we propose the investigation of U-Pb systematics using Nano-SIMS in order to study the history recorded in the phosphates. We will perform the U-Pb dating of the phosphates as many as possible and aim to understand the thermal history of Itokawa parent body such as crystallization age and the catastrophic collition if recorded.

Keywords: HAYABUSA, Itokawa, troilite, phosphate, siderophile element, U-Pb dating

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Asteroid Shape Reconstruction by Structure-from-Motion Method with Bundler and PMVS2

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Here we report results on application of open source shape reconstruction tools to an asteroid image data set. We test two tools that cooperatively work to reconstruct an object shape from images. Bundler is an open source implementation of a stereo shape reconstruction method called Structure from Motion (SfM). PMVS2 gives a more dense shape model, since Bundler only estimates 3D locations of a limited number of feature points. A global image data set of the asteroid Itokawa taken by AMICA on board the Hayabusa spacecraft is employed to our test data set. An obtained model satisfies that most requirements from the Hayabusa-2 mission on the shape model that used during the mission phase. An important advantage of these new tools compared to previous ones is its short processing time. This advantage will be effective in quick evaluation of observation data and decision making during the mission operations. More precise and high definition models will be reconstructed by other method such as shape-from-shading or photometric stereo.

Keywords: Asteroid, shape reconstruction, bundler, PMVS2, Structure-from-Motion, Hayabusa-2

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Feature matching in planetary images with multiple spatial resolutions by using SIFT algorithm

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This study uses feature matching in planetary images with multiple spatial resolution. To know where lower altitude images are taken in high altitude images is performed based on images without the position and attitude of spacecraft in this study. The lower altitude images of AMICA on-board the Hayabusa spacecraft, asteroid probe are found as a correspondence of image features (keypoint) in higher altitude images. We adopted the Scale Invariant Features Transform (SIFT) to represent a kind of key-point of image for image feature matching. In generally, the SIFT keypoint is robust to scale transition, change of lighting condition, parallel displacement, and rotation of image, so this keypoint is suitable to feature matching of planetary image which contains of scale and rotation between different images. As a result, for the improvement of accuracy of feature matching, it is important to have a preprocessing of image (e.g., equalizing).

Keywords: planetary image, SIFT, feature matching, AMICA

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Grooves on Phobos: Spatial distributions and their implications to the formational mechanism

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Grooves are roughly-defined as trough-like depressions commonly found on asteroids and small satellites. Among the various features categorized as grooves, the most typical are considered as those found on the surface of Phobos. Grooves on Phobos are the most extensively-existing geological features on the satellite, and thus are documented and discussed for years. However, their formational processes remain controversial. Previously-proposed hypotheses are (1) grooves are some kind of intentional fractures and (2) they are results of impacts caused likely by linearly-aligned impactors ejected from Mars.

Former hypothesis has difficulty in explaining the geographical distribution of grooves (Murray 2011). In fact, because of this difficulty, Murray (2011) concluded that the latter (i.e., secondary impactors derived from Mars) could only be the reasonable explanation for the observed characteristics of grooves on Phobos, including their morphological features, distributions, and hemispheric coverage. Nevertheless, Ramsley and Head (2013) recently showed that, in order to form grooves well organized as those found on Phobos, each of fragments ejected from Mars should have no relative velocity, which is difficult to be achieved for ejecta from Mars. They also showed that most grooves on the northern hemisphere cannot be formed as secondary impacts from Mars because the impactors ejected from Mars do not impact in the directions normal to the equatorial plane of Phobos. Therefore, neither hypothesis remains satisfactory to explain the observational facts.

We carefully reevaluate previous hypothesis based on recently-acquired data, which are partly not available at the time of previous studies. We scrutinize all of the high-resolution images obtained so far to map them out on a numerical shape model. As a result, we identify 488 grooves, whose spatial distributions are precisely mapped three dimensionally. We newly find that each of grooves is always aligned on a certain plain even though it sometimes appears to be an undulating curved depression. We consider this strongly indicates that a groove is a result of a series of impacts of aligned fragments.

We statistically study the angle between the equatorial plane of Phobos and the plane, which contain each groove and find that the distributions of the angles have three peaks at 25, 90 and 155 degrees (hereafter we call A, B, and C type, respectively). Most of the B type grooves exist on the northern hemisphere.

To explain our mapping results, we propose a new hypothesis for the formation of Phobos as follows: (1) An asteroid of a collection of smaller fragments held together by self-gravity in the form of a rubble-pile is pulled apart and stretched straightly by tides during a close approach to Mars; (2) The asteroid (now separates into a train of fragments) is caught by the Mars gravity and revolves around Mars; (3) Every time it revolves around Mars, a part of the fragments hit Phobos and form a lineated depression, which is observed as a type A or C groove; (4) When the eccentricity of the impartor becomes low until the overlapping the trajectory of Phobos, type B grooves are formed.

Our hypothesis is along the idea that grooves are formed by aligned impactors as proposed by Murray (2011) but essentially different in the origin of the fragments, which can resolve the difficulty pointed out by Ramsley and Head (2013). Not only that, our hypothesis has advantage of completely satisfying both the morphological and geographical characteristics of grooves on Phobos. Furthermore, our hypothesis can also explain the deficiency of grooves on Deimos.

Reference

[1]Murray, J.B., Iliffe, J.C., 2011. Geomorphology. Geol, Soc, Spec, Publ., London, pp.21-41
[2]Ramslay, K.R., James, W. H., 2013. Planetary and Space Science, 69-95

Keywords: Phobos, groove, Mars, tidal-disruption, impact

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Visible wavelength spectroscopy of sub-km-sized Near-Earth Asteroids with low delta-v

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We present a unique data set of the taxonomic type of near-Earth asteroids (NEAs) accessible with available spacecraft.

The research on NEAs has entered a new phase thanks to sample-return space explorations together with state-of-the-art large ground-based telescopes. We made observations of twelve asteroids with Subaru, GEMINI-North, GEMINI-South and Okayama 188cm telescopes. They have low delta-v orbits with potential to be investigated by manned/unmanned spacecraft. Also, ten sub-km-sized bodies are included in them, and are one of remarkable characteristics in terms of an evolutionary scenario.

We find that eleven asteroids are classified as S-complex and one asteroid as V-type. Most S-complex asteroids (eight out of eleven, $\sim$70%) have spectra similar to subgroups of Q or Sq-type, suggesting that these objects are less matured against space weathering.

In this presentation, we show their spectra and discuss dominance of S-complex asteroids based on the previous research.

Keywords: asteroid, visible spectroscopy, taxonomic classification

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Development of a wide-band optical filter optimized for deep imaging of small solar-system bodies

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We developed a newly designed wide-band optical filter and evaluated its performance. It is optimized for deep imaging of small solar-system bodies. The new filter, which we denote as *Wi*, is designed to reduce contamination by light pollution from street lamps, especially strong mercury and sodium emission lines. For the reasons that (1) much of artificial light pollution concentrates in the *V* band, (2) the photon numbers peak at a wavelength of 6350 $\AA$ in the spectrum of sunlight, and (3) many asteroids have their peak/plateau reflectance at around 7000 $\AA$ in the optical range, the new filter's cut-on wavelength is set to 5880 $\AA$ by using an OG590 Schott color glass filter. On the other hand, the cut-off wavelength, which is achieved by a short-pass interference coating, is set to 9380 $\AA$ in consideration of worst of the OH night sky emission and the atmospheric water vapor absorption band at 9400 $\AA$.

Compared with the use of a commercially available long-wave cut wide-band filter (*W* filter, 4900-9100 $\AA$), the sky brightness is 10-20 % reduced by the *Wi* filter under bright-sky conditions by not only artificial light pollution but scattered moonlight. In the detection of asteroids, the detected total flux of an asteroid through the *Wi* filter has been 3% larger than that through the *W* filter, though the width of the *Wi* filter response function is 16% narrower than that of the *W* filter. By using the *Wi* filter, the S/N ratios in the detection of asteroids were improved by about 6%, on average, compared with the use of the *W* filter, and the improvements were slightly larger in a brighter sky. The use of the CCD with high sensitivity at longer wavelength, such as the back-illuminated, fully-depleted CCD, will show a larger improvement in the S/N ratio by using the *Wi* filter.

Reference:
Wide-Band Optical Filter Optimized for Deep Imaging of Small Solar-System Bodies,
Okumura *et al*. Publications of the Astronomical Society of Japan, **64**, 47 (2012)

Keywords: optical, small solar system body, light pollution, wide-band filter

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Prediction of Phoeincid in 2014

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Phoenicid appeared in 1956 is a meteors yielded by the comet 289P/Blanpain founded in 1819. We calcurated a prediction of Phoenicid in 2014.

Comet Blanpain has a mean motion resonance of 9:4 with Jupiter. Therefore Phoenicid has 95 year cycle. The next big apparition will be in 2051.

Keywords: Meteors

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Solidified and mixed materials on Asteroid body

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The results of the present study are summarized as follows:

1) Study of the Asteroids provides characteristic formation processes of primordial terrestrial and extraterrestrial celestial bodies.

2) Identification of crystalline solids are almost similar between the Asteroids and Earth, though the Asteroid rocks might be formed by similar formation processes of terrestrial rocks based on the crystalline parts. However, extraterrestrial Asteroids show irregular mixtures of multiple states solidified amorphous solids.

3) Formation of non-spherical Asteroid body formed mainly by impact-related melting process is observed as heterogeneous and irregular distribution of impacted grains.

4) Local fluid-bearing depositions irregularly distributed on the surface and interior of the Asteroids might be based on storages on the interior formed by solidified mixtures of multiple states triggered by impact process on the Asteroids.

5) Different processes of solids between the Asteroids and Earth can be observed silica Si-O frameworks which can be obtained by the ion bombardment experiments. Crystalline rocks with hard silicate structures on Earth show higher ion-peaks of alkali ions (Na, K and Ca etc.), whereas solid-aggregates of the Asteroids show higher ion-peaks of Si and Al ions which are relatively destroyed by ion bombardments.

6) Ion-peaks by the sputtering of terrestrial impact-breccias are clearly higher than those of the Asteroid meteorites, which the main differences are not rock textures of breccias but atomic bonding of slow or rapid cooling process.

7) The air- and water-less Asteroids with solidified materials with multi-states are formed from nano-grains to macroscopic rocks by impact-related evolution process,

8) The primordial planet Earth with remained heterogeneous surface by impact-related process is considered to be cyclic system of three material states (air, liquid and solid) with macro-life activity which is formed by huge production from the interior triggered by huge collision process of the giant impact. On the other hand, the Asteroids without global cyclic changes of three materials states, microscopic quasi life-like materials might be locally found (mainly by high-resolution electron microscopy on in-situ or returned samples finally).

9) It should be avoided to collect artificial impacted samples, because irregular mixtures of solidified amorphous solids from vapor and liquid states are easily destroyed to be escaped to be exaggerated solids with less volatiles.

Keywords: Asteroids, solid aggregates, amorphous materials, fluid, ion bombardment run, micro quasi life-like materials

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The Origin of The Moon and The Earth in Multi-Impact Hypothesis

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Origin of the moon and the earth in the multi-impact hypothesis

This new hypothesis to the origin of the Moon and Earth,This is the proposal of solutions that satisfy unified manner new hypothesis
to the origin of the Earth and the Moon, all of the following questions.

(1).Why, large biological extinction of five times or more were happened on the earth?
(2).The meteorite falling on Earth, why stony-meteorites, stony-iron meteorite, iron-meteorite, such as differentiated and undifferentiated chondrites, what mixed in there?
(3).The old theory, why cosmic dust or did not become a planet in the asteroid belt?I think Itokawa's aggregate piece of crust differentiated?
(4).We have proposed a theory of the origin of the original description to solve the problems of the giant planet collision theory, all of the earth and the moon and deep sea bottom.
(5).Why, protoplanetary Serra did they destruction? = The tragedy caused by tidal forces and deformation due to Jupiter orbit perturbation.
(6).Increase in the aspect ratio of Serra orbital perturbation by Jupiter, destruction by tidal force of the approaching Jupiter.
(7).Plate boundary formation of plate tectonics,I suggest the formation origin of the deep sea bottom crust by peeling.
(8).The origin of deep-sea bottom update and continental drift and Mystery of the driving force was solved.
(9).Why diamond pipe did formed in South Africa?
(10).Why core eccentric (about ten percent) of what is happening? Radiation anomaly of Brazil over the Van Allen belt.
(11).New hypothesis at the origin of Jupiter's Great Red Spot, I think about How and Why to that Mystery !
(12).Why is whether the silicate star (asteroid now) Pluto of the outer planets?

Until now, Giant impact hypothesis is a theory only for making the moon.Protoplanet is the result of accidental collision with the Earth there Mars core size to the Earth,
It only has to calculate the conditions formed by the mantle further moon.

It is the original collision hypothesis.

Protoplanetary Serra was born in Ceres position of Bode's law.The planet Serra that differentiated, elliptical orbit was flattened by the Jupiter perturbations.
Major axis is constant because of energy conservation law.Eccentricity of Serra increases, the orbit that focus of the solar get closer so as to extend to the point of near-side Jupiter.
Just before the collision with Jupiter, Serra was rupture in tidal forces of Jupiter.By the mantle debris collides with the Earth, the moon was formed.
Position Serra collides to the Earth becomes the Pacific Ocean, it becomes the origin of the plate boundary crack.In addition, deep-sea of multiple formed with Impact of Multi-attack which is the time difference.
Eccentricity of the moment of inertia is estimated to be the driving force of the seabed update theory and theory of continental drift.
Mantle debris energy is large becomes Pluto, heavy and high density Koaritchi debris became Mercury with scattered to the inner planet side.
I estimated that the debris of Serra collide to Jupiter, it became the origin of the Jupiter's Great Red Spot.
The fact that iron meteorites, stony-iron meteorites, stony meteorites are differentiated, and chondrite undifferentiated are mixed, Ceres is present in the asteroid belt, the origin of the meteorite is convinced straightforwardly with this hypothesis.
Multi-impact theory be the basis of large organism extermination repeated, it is also the reason sea accounts for 70%, it was possible to understand the origin of the plate boundary crack.
Multi-impact hypothesis can be explained in a unified manner present condition of the earth as well as make the moon in this manner.

It is believed that asteroid Itokawa could check a set? Like Serra crust, then it becomes even proof of this hypothesis.

Keywords: Serra tidal disruption, Perturbation of Jupiter, Orbit transition of Serra, Match of the planets revolving surface, Feedengue zone (integrated range), Origin of Deep Sea Bottom