Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P01 Room:Poster Time:May 2 16:30-17:30

Development of ILOM using DOE and situation of trial manufacturing of DOE

KASHIMA, Shingo[1*] ; ARAKI, Hiroshi[1] ; HANADA, Hideo[1] ; TSURUTA, Seiitsu[1] ; SUZUKI, Hirofumi[2] ; YASUDA, Susumu[3] ; UTSUNOMIYA, Shin[3]

[1]RISE Project Office, National Astronomical Observatory of Japan, [2]Mechanical Engg.,Chubu University, [3]Japan Aerospace Exploration Agency

We have a plan to install the photo-zenith telescope on the moon as part of a next SELENE project. The purpose is to explain the internal structure and the origin of the moon by measuring the small vibration and movement with very high accuracy. In this presentation, we show the development of ILOM using DOE that actualize the very high performance, i.e.,1 mas, in the severe thermal condition of the moon and show the situation of the trial manufacturing of DOE that is the key technology of this telescope.

Keywords: ILOM, DOE, SELENE

PPS23-P02 Room:Poster Time:May 2 16:30-17:30

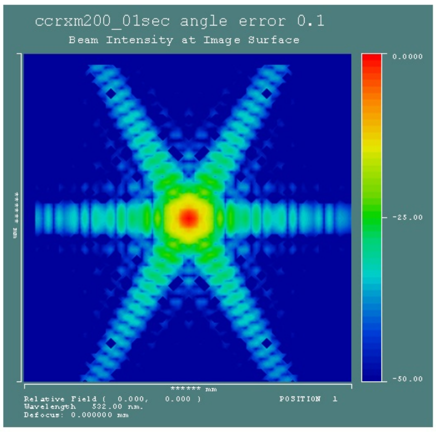
Angle, deformation and DAO (Dihedral Angle Off-set) Analysys of the corner cube mirror for LL

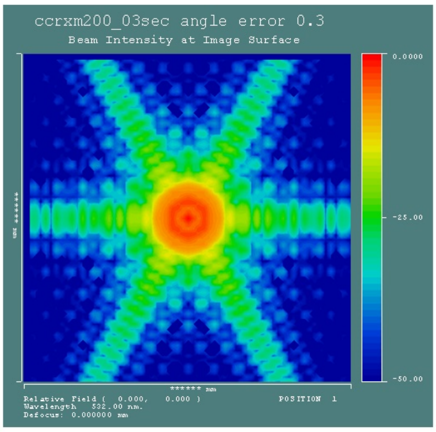
KASHIMA, Shingo[1*] ; NODA, Hirotomo[1] ; ARAKI, Hiroshi[1] ; HANADA, Hideo[1] ; KUNIMORI, Hiroo[2] ; OTSUBO, Toshimichi[3]

[1]RISE Project Office, National Astronomical Observatory of Japan, [2]National Institute of Information and Communications Technology, [3]Social Sciences, Hitotsubashi University

We have a plan to install the corner cube mirror which has about 20cm aperture on the moon as part of a next SELENE project. The purpose is to explain the internal structure and the origin of the moon by measuring and analysing the distance between the moon and the earth with cm order accuracy. In order to actualize such a precise measurement, we have to manufacture the CCM with 0.1 sec angular precision and less the lambda/10 flatness for the mirror surface. In this presentation, we show the optical response analysis for deriving these degree of precision.

Keywords: LLR, CCM, SELENE





Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P03 Room:Poster Time:May 2 16:30-17:30

Development of the Retroreflector on the Moon for the Future Lunar Laser Ranging

ARAKI, Hiroshi[1*] ; KASHIMA, Shingo[1] ; NODA, Hirotomo[1] ; KUNIMORI, Hiroo[2] ; CHIBA, Kouta[3] ; OTSUBO, Toshimichi[4] ; UTSUNOMIYA, Makoto[5] ; MATSUMOTO, Yoshiaki[6]

[1]National Astronomical Observatory of Japan, [2]National Institute of Communication and Technology, [3]Iwate University, [4]Hitotsubashi University, [5]Japan Aerospace Exploration Agency, [6]PLANET Co. Ltd.

Lunar Laser Ranging (LLR) data are important for the investigations of the lunar rotation, tide, and lunar deep interior structure. The range accuracy of LLR has been less than 2 cm for the last 20 years due to the progress of laser transmit/receive system on the ground stations and the atmospheric signal delay model, however, one order or more accurate ranging than 2cm is needed for better understanding of the lunar deep interior. We are developing 'single aperture and hollow' retroreflector (Corner Cube Mirror; CCM) to be aboard future lunar landing missions. The aperture of CCM is 20cm because the reflection efficiency of that size is found to be higher than that of Apollo 11 array CCP (Corner Cube Prism). For the CCM ultra low expansion glass-ceramic (ClearCeramRZ-EX, OHARA Inc.; hereafter CCZ-EX)' or 'single crystal Si' is selected for candidate material of CCM taking into account small |CTE|/K (Thermal expansion coefficient over thermal diffusivity) and large specific Young modulus. The optical performance of CCM deformed by lunar gravity or solar illumination in the holder model is presented for some cases.

Keywords: LLR, corner cube mirror, hollow, single crystal Si, deformation, optical performance

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P04 Room:Poster Time:May 2 16:30-17:30

Lunar Laser Ranging Trial at Koganei SLR station

NODA, Hirotomo[1*] ; KUNIMORI, Hiroo[2] ; ARAKI, Hiroshi[1]

[1]National Astronomical Observatory of Japan, [2]National Institute of Information and Communications Technology

Introduction: The Lunar Laser Ranging (LLR) is a technique to measure the distance between laser stations on the Earth and retroreflectors on the Moon, by detecting the time of flight of high-powered laser emitted from the ground station. Since the Earth-Moon distance contains information of lunar orbit, lunar solid tides, and lunar orientation and rotation, observation data of LLR have contributed to the lunar science, especially for the estimation of the inner structure of the Moon through orientation, rotation and tide. There are five refroreflectors on the Moon, Apollo 11, 14, 15 (U. S. A.), Lunokhod 1 and 2 (french-made, carried by former U. S. S. R.). The Apollo 15 has largest aperture among them, and almost 75 % of the total LLR data are from Apollo 15 site.

System Description: Since there is no Japanese station which can range the Moon so far, a precursor ranging experiment by using the Satellite Laser Ranging (SLR) facility in the NICT Koganei campus in Tokyo is ongoing. The SLR station has a 1.5 m Cassegrain telescope with Coude focus. Normally it is equipped with a laser with 20mJ, 20Hz repetition rate, and 35 picoseconds pulse width for satellite ranging. In addition to it, a wide-pulse width laser (3 nanoseconds, which corresponds to 45 cm in 2-way range) with energy of about 350 mJ per shot, repetition rate of 10Hz, wavelength of 532 nm is introduced to detect photons from the lunar retroreflectors for demonstration. As the pulse width is broad, the high accuracy ranging is not expected, therefore it is solely used for the confirmation of the optical link budget between the ground station and retroreflectors on the Moon. As the photon detector, we use a SPAD (Single Photon Avalanche Diode) and also an MCP (Micro Channel Plate) photo multiplier whose quantum efficiency is twice as much as that of the SPAD in use. For the pointing, a CCD imager is also available in the same detector box. They can be switched by reflecting mirrors. To suppress the background noise, a bandpass filter (0.3 nm FWHM, 50 % transparency) and spatial filter (pinhole) with diameter of 400 microns are installed and checked. For better link budget, the contamination of optical elements of the telescope and on the optical bench was checked. The alignment of the laser emission path with respect to the laser receiving path and laser beam divergence has been adjusted to maximize the efficiency of the laser emission.

Pointing: Because the retroreflectors are small and they are not visible from ground telescopes, we point the telescope to known small-sized craters (~10 km in diameter) whose positions are known in selenographic coordinate and thus in topocentric coordinate at the observation site. Then the offset angles in azimuth and elevation direction from the predicted pointing direction are determined so that the center of the crater comes to the center of the CCD images which are coalligned with the SPAD and the MCP. This procedure confirms the pointing of the telescope.

Observations: Trials for the lunar return have been conducted since autumn 2013. As of the date of submission, the ranging to the Moon is not successful. Therefore we need to detect the return from the Apollo 15 site by using the nanosecond laser pulse for the first step. As the next step, we need to know the condition on which lunar ranging is successful in Koganei, for example, lunar phase, distance to the retroreflectors, libration angles, and atmospheric conditions.

Keywords: Lunar Laser Ranging, Satellite Laser Ranging, Moon, internal structure

PPS23-P05 Room:Poster Time:May 2 16:30-17:30

SELENE-2/Lunar ElectroMagnetic Sounder (LEMS): a test of inversion

MATSUSHIMA, Masaki[1*] ; SHIMIZU, Hisayoshi[2] ; TOH, Hiroaki[3] ; YOSHIMURA, Ryokei[4] ; TAKAHASHI, Futoshi[1] ; TSUNAKAWA, Hideo[1] ; SHIBUYA, Hidetoshi[5] ; MATSUOKA, Ayako[6] ; ODA, Hirokuni[7] ; OGAWA, Kazunori[6] ; TANAKA, Satoshi[6]

[1]Tokyo Institute of Technology, [2]ERI, University of Tokyo, [3]Kyoto University, [4]DPRI, Kyoto University, [5]Kumamoto University, [6]ISAS/JAXA, [7]AIST

Understanding of lunar origin and evolution can be advanced through investigation of the lunar interior structure. The present thermal state of the Moon can be clues to the Moon's thermal history. In the SELENE-2 mission, we propose a lunar electromagnetic sounder (LEMS) to estimate the electrical conductivity structure of the Moon, which can be used to deduce the thermal structure of the Moon.

Temporal variations in the magnetic field of lunar external origin induce eddy currents in the lunar interior depending on the electrical conductivity structure and frequencies of the temporal variations. The eddy currents, in turn, generate temporal variations in the magnetic field of lunar internal origin. Therefore electromagnetic response of the Moon is obtained from magnetic field measurements by magnetometers onboard a lunar orbiter and a lunar lander. The response function is then used to estimate the electrical conductivity structure by solving an inverse problem. Here we assume a one-dimensional structure for electrical conductivity distribution. We show some results for a test of inversion.

PPS23-P06 Room:Poster Time:May 2 16:30-17:30

Moonquake observation and lunar interior exploration by one penetrator station

YAMADA, Ryuhei[1*] ; ISHIHARA, Yoshiaki[2] ; KOBAYASHI, Naoki[2] ; MURAKAMI, Hideki[3] ; SHIRAISHI, Hiroaki[2] ; HAYAKAWA, Masahiko[2] ; TANAKA, Satoshi[2]

[1]National Astronomical Observatory of Japan / RISE Project, [2]Japan Aerospace Exploration Agency, [3]Kochi University

The penetrator developed through Japanese lunar explorer 'LUNAR-A' mission is system to deploy on-board sensors on the planetary surface by free-fall from an orbiter. The penetrator is smaller and lighter than typical soft-landers because it does not require complicated landing system and thermal control system, and it has an advantage to construct geophysical network on the planetary surface. However, on-board sensors require high shock durability to survive a penetrating impact. Through previous studies, we have already shown that seismometers for the penetrator can maintain the performance to detect moonquakes even after a shock over the impact to the lunar surface (Yamada et al., 2009) and the communication instrument on the penetrator properly operate for data transmission (Tanaka et al., 2010).

Although high shock durability of the penetrator was established, deployment of the penetrator has not been executed due to cancel of the LUNAR-A mission. We, therefore, have a plan to load the penetrator on a small satellite launched by the Epsilon Launch Vehicle. In the plan, we can carry only one penetrator due to strict weight limitation of the vehicle. For the reason, we currently study the expected scientific results obtained from the observation by one penetrator station.

The seismometers deployed through the NASA Apollo missions have detected some types of moonquakes; deep moonquake, shallow moonquake and meteoroid impacts. The seismometer for the penetrator has performance capable of observing these moonquakes, and verification of activities of these lunar seismic events through comparison with results from the Apollo mission will be one of important topics. Then, we can expect to obtain information about the lunar crustal thickness and structure if we can locate meteoroid impacts by their impact flashes from ground observation. In this presentation, we report that expected detection numbers of the lunar seismic events can be observed by the penetrator and the scientific results, and appropriate installation locations of the one penetrator to obtain good scientific results be described. Then, we also discuss the prospects for future network observation using the penetrator after the small satellite exploration.

Keywords: Penetrator, Moonquake Observation, Lunar Interior Exploration, Small Satellite Exploration, Meteoroid Impact Flash

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P07 Room:Poster Time:May 2 16:30-17:30

On the attenuation of reflected echoes of Lunar Radar Sounder onboard Kaguya

TOH, Hiroaki[1*] ; KUMAMOTO, Atsushi[2]

[1]Graduate School of Science, Kyoto University, [2]Graduate School of Science, Tohoku University

The successful Japanese Moon probe, KAGUYA, was equipped with a variety of state-of-the-art scientific instruments including the Lunar Radar Sounder (LRS; Ono et al., 2010). LRS is a frequency modulated continuous wave (FMCW) radar with carrier frequencies from 4 to 6 MHz, and succeeded in observing distribution of reflectors beneath almost all the Moon's surface (Ono et al., 2009). Pommerol et al. (2010) further pointed out that the presence of the reflectors in lunar maria is negatively correlated with abundance of TiO2 because of its high electrical conductivity.

Loss tangent is defined as a ratio of the conduction to displacement current within an electric medium and hence an indicator of high electrical conductivity. If loss tangent is small enough, the permittivity and the electrical conductivity of the Moon's surface can be determined at the same time by comparing the reflected echo of LRS with its source pulse. Namely, by estimating the complex ratio of the received signal to the transmitted pulse, the dielectric constant can be known from the phase difference while the electrical conductivity can be derived by the observed amplitude attenuation and the permittivity obtained from the phase difference.

However, determination of the complex ratios is not straightforward because the reflected echoes are the product of a pulse compression technique and thus needs deconvolution to restore the true amplitude and phase of the echoes. Preliminary analysis of the LRS waveform data collected at the end of the fast down-link (21.3 Gbpd) mode [Jun. - Sep. 2008] showed that quality of the data is sufficient enough to perform necessary deconvolution. This implies that LRS can also be used as a ground penetrating radar.

In this presentation, the principle and the method for estimating the permittivity and electrical conductivity are first described in addition to the data used. Interpretation of the derived complex ratios and its spatial distribution on the Moon's surface is finally discussed and summarized.

REFERENCES

Ono, T. et al., Lunar Radar Sounder Observations of Subsurface Layers Under the Nearside Maria of the Moon, Science, 323, 909-912 doi:10.1126/science.1165988, 2009.

Ono, T. et al., The Lunar Radar Sounder (LRS) onboard the KAGUYA (SELENE) spacecraft, Space Sci. Rev., 154, 145-192, doi:10.1007/s11214-010-9673-8, 2010.

Pommerol, A. et al., Detectability of subsurface interfaces in lunar maria by the LRS/SELENE sounding radar: Influence of mineralogical composition, Geophys. Res. Lett., 37, L03201, doi:10.1029/2009GL041681, 2010.

Keywords: Ground penetrating radar, Electrical conductivity, Permittivity, Source pulse, Reflected echo, Loss tangent

PPS23-P08 Room:Poster Time:May 2 16:30-17:30

The accmulation ages of subsurface layer in Mare Imbrium based on the SELENE observation data

ISHIYAMA, Ken[1*] ; KUMAMOTO, Atsushi[1] ; NAKAMURA, Norihiro[1]

[1]Graduate School of Science, Tohoku University

Lunar Radar Sounder (LRS) onboard SELENE succeeded in detecting the electromagnetic wave reflected at subsurface layer in low-titanium regions [Ono et al., 2009; Pommerol et al., 2010]. Multiband Imager (MI) and Terrain Camera (TC) onboard SELENE respectively investigated the lunar surface composition [e.g., Otake et al., 2012] and the eruption ages of lunar lava flows [e.g., Morota et al., 2011]. Besides, the studies combined the LRS, MI, and TC data revealed the subsurface structure around the impact crater [Oshigami et al., 2012], and suggests the brittle subsurface layer with a high-porosity [Ishiyama et al., 2013]. This study investigates the accumulated age of subsurface layer in lava flow units (Unit 12 and 8 [Bugiolacchi and Guest, 2008]) in the north Mare Imbrium. This investigation is significant for discussing lunar volcanic activity because we can estimate a eruption rate of lunar lava flow.

We identified three subsurface echoes under Unit 8 from the LRS data, and revealed that the margin of the deepest subsurface echo was consistent with the surface boundary between Unit 12 and Unit 8; Unit 8 is accumulated on Unit 12. These ages of the units were estimated to be 3.31 ± 0.19 Ga [Bugiolacchi and Guest, 2008]. However, the previous study estimated these ages by using a lunar map data with a low spatial resolution (60 – 150 m/pixel). This low spatial resolution data causes a large error for estimating the age. Thus, this study used the lunar high-resolution ortho map data obtained from TC, which has 10 m/pixel. The age of Unit 12 was estimated to be $\sim$3.6 Ga, which was older than the age of Unit 8. This result is consistent with the order of the stratification identified from the LRS data.

In addition, we identified that Unit 8 can be divided into several units by using the plagioclase, FeO, and TiO2 Map data, produced from the MI data. We investigate the correspondence relationship between the subsurface echoes and the identified units, and then the history of lunar volcanic activity will be discussed in the presentation.

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P09 Room:Poster Time:May 2 16:30-17:30

Experimental evidence for the deep high-Ti basalt magma in the lunar mantle

IGARASHI, Mako[1*] ; SUZUKI, Akio[1] ; OHTANI, Eiji[1] ; ASAHARA, Yuki[1] ; SAKAMAKI, Tatsuya[1]

[1]Division of Earth and Planetary Materials Science, School of Science, Tohoku University

The existence of high seismic attenuation zone at the depths greater than about 800 km implies that the lower mantle of the Moon could be partially molten (Nakamura et al., 1973; 1974). There is a longstanding hypothesis that the last fraction of the lunar magma ocean crystallized into a layer of dense Ti-rich cumulates at the shallow depths (~100 km) early in the lunar history. It has been suggested that the cumulates subsequently sank into the deep interior of the moon because of its gravitational instability (e.g., Ringwood and Kesson, 1976). It is necessary to investigate the melting relations of the high-Ti basalt that may be erupted from the depths at high pressure (>4 GPa).In this study, melting relations of Apollo 14 black glass (Delano, 1986), the most Ti-rich lunar ultramafic glasses, were experimentally determined at the pressure of 4 GPa and the temperature range from 1300 C to 1450 C.

The high-pressure and high-temperature experiments were performed by using 3000 ton Kawai-type multi-anvil apparatus of Tohoku University. The samples were packed into graphite capsules and the experimental temperatures were measured by using W-Re thermocouples. The compositions of run products were analyzed by using FE-SEM (Field Emission Scanning Electron Microscopy). Our experiments depicted that the liquidus and solidus temperatures were determined to be 1450 C and 1325 C respectively at 4 GPa.

The liquidus phase is garnet, and the first consuming phase is ilmenite. Estimated temperature profile of the Moon at depths of 700 km -1200 km are between 1100 C and 1400 C (e.g., Gagnepain-Beyneix et al., 2006). The densities of partial melts and total melt were calculated by using the partial molar volume of the oxide components at one atmosphere (Lange and Carmichael, 1987) and the Birch-Murnaghan equation of state (Sakamaki et al., 2010). The densities of the melts formed by partial and total melting of the Apollo 14 black glass were heavier than those of the lunar deep mantle. Crystal-liquid density crossover is inevitable at the depth around 800 km, the pressure corresponding to 4 GPa. Therefore, the high-Ti basalt magma can exist stably if the lunar temperature profile is close to the upper bound of the estimated lunar temperature profile, suggesting existence of the low-velocity and low attenuation anomalies caused by chemical heterogeneities in the lunar deep mantle.

Keywords: high pressure, lunar mantle, high-Ti basalt, mantle over turn

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P10 Room:Poster Time:May 2 16:30-17:30

History of heavenly bodies collision of the solar system inside of the past one billion years studing from a lunar crate

KATO, Mami[1*] ; MOROTA, Tomokatsu[1]

[1]Nagoya University Graduate School of Environmental Studies

The moon preserve the record of the bodies impact history of the past 4.0 Ga as a crater, it is important the information to solution impact and orbit evolution of the bodies of the solar system.

Standard lunar cratering chronologies have been based on combining Luna and Apollo sample radiometric ages and impact crater densities. However, the bombardment history cannot be resolved in the past 3.0Ga because of the absence of samples with radiometric age ranging from 3.0 to 1.0 Ga. On the other hand, from crater density of lunar rayed craters, radiometric ages of lunar glass spherules, and statistics of terrestrial craters it has been suggested the hypothesis that the production function has increased in recent.

In this study, we determine formation ages of rayed craters using SELENE image data. Based on the finding, we will discuss a temporal variation of the cratering rate in the past 1.0 Ga.

Keywords: Moon, crater, cratering chronology

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P11 Room:Poster Time:May 2 16:30-17:30

Formation process of linear gravity anomalies and thermal evolution of the Moon

SAWADA, Natsuki[1*] ; MOROTA, Tomokatsu[1] ; ISHIHARA, Yoshiaki[2] ; HIRAMATSU, Yoshihiro[3]

[1]Graduate School of the Enviromental studies, Nagoya University, [2]JAXA, [3]Graduate School of Natural Science and Technology, Kanazawa University

The investigation of the subsurface structure in the Moon through a gravity distribution is one of means to understand the early evolution history of the Moon. Andrew-Hanna et al. (2013) analyzed gravity data, obtained by GRAIL (The Gravity Recovery and Interior Laboratory) and identified linear gravity anomalies (LGAs). They suggested that the LGAs resulted from ancient intrusions formed by magmatism with globally expansion. We can expect that such intrusions leave other evidences on the surface. In this study, we analyze topography data and FeO concentration distribution to find some characters corresponding to the LGAs and magma intrusion, and, together with the thermal history of the Moon, discuss the formation process of the LGAs on the Moon.

In this study, we focus 20 of LGAs reported by Andrew-Hanna et al. (2013) that show clear gravity anomaly. We use the 1/1024-degree gridded lunar topographic data from LOLA and the 10pixel/degree lunar FeO concentration distribution map from Clementina.

For topography data analysis, we set a study area that ranges 300km in orthogonal direction from a LGA. We apply a filter to remove topographical perturbation due to small craters. On a vertical profile to a LGA, the average, the standard deviation, and the average gradient of relative altitude are calculated with a reference altitude on a LGA. We define a vicinity area as an area within 50km from a LGA and a surrounding area as an area farther than 100km from a LGA on a vertical profile. Based on topographical features of both a vicinity area and a surrounding area, we categorize the topographic feature of LGAs into three types: mountain type, valley type, and unclassified type.

For FeO concentration data analysis, we calculate the average and the standard deviation of FeO concentration in vicinity areas of a LGA from the FeO concentration map.

The topographical data analysis reveals that most of the LGAs regions are categorized as the valley type. This result suggests that the LGAs regions are distributed over trough regions formed by tensile stress in the early history of the Moon. The FeO concentration distribution analysis reveals that the average FeO concentration of the vicinity areas in highland is 6.72 ± 1.62 wt%. This value is higher than that in the highland (<6 wt%) of the Moon, suggesting that an ancient intrusion is possibly exposed by later crater gardening.

We propose a following hypothesis on the formation process of the linear structures as a cause of LGAs from these results and the thermal history of Head and Wilson (1992). The stress state in the early period of the Moon is tensile stress for thermal expansion process. After crack formation due to the tensile stress before 4.0 Ga, the linear structures are formed by magma intrusion. The linear structures are covered by magmatism that forms mare during 4.0-3.0Ga. Ridges are formed in mare during 3.8-3.0Ga because of the compressive stress with the cooling of the Moon or in the impact basin. The formation of the ridges occurs in association with cracks near the linear structures.

Keywords: magmatism intrusions event, expansion, ridge, FeO concentration, Lunar topography data

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P12 Room:Poster Time:May 2 16:30-17:30

Source of the lunar magnetic anomalies estimated with the prism model

YOKOYAMA, Takashi[1*] ; TAKAHASHI, Futoshi[1] ; TSUNAKAWA, Hideo[1]

[1]Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Many magnetic anomalies have been observed on the Moon since the Apollo project, although the Moon has no global intrinsic magnetic field at present. The lunar magnetic anomalies are considered to be caused by remanent magnetization of the lunar crust. Several models of the lunar magnetic anomalies have been proposed (e.g. Hood et al., 2001, 2013; Richmond et al., 2008; Purucker et al., 2012; Nicholas et al., 2007; Hemingway and Garrick-Bethell, 2012; Wieczorek et al., 2012). However, the magnetized material and its magnetizing process have been still controversial. In the present study, we have analyzed several magnetic anomalies with the prism model, in which three dimensional position, size, horizontal direction and magnetization are parameterized. The observation data by Lunar Prospector and Kaguya at the low altitude were used in the analysis. We adapt a forward modeling approach, in which the source parameters are changed iteratively till the minimum RMS (Root-Mean-Squares) misfit between the model and data is achieved. The optimal number of the prisms for modeling is objectively determined using Akaike's Information Criterion.We will discuss possible source materials on the basis of the modeling results.

Keywords: moon, magnetic anomaly, prism source model, swirl

PPS23-P13 Room:Poster Time:May 2 16:30-17:30

Lunar Electromagnetic responses to the stepwise changes in the IMF

HIGA, Tetsuya[1*] ; YOSHIMURA, Ryokei[2] ; OSHIMAN, Naoto[2] ; SHIMIZU, Hisayoshi[3] ; MATSUSHIMA, Masaki[4] ; TAKAHASHI, Futoshi[4] ; SHIBUYA, Hidetoshi[5] ; TSUNAKAWA, Hideo[4]

[1]Graduate School of Science, Kyoto University, [2]Disaster Prevention Reseach Institute, [3]Earthquake Research Institute, University of Tokyo, [4]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, [5]Department of Earth and Environmental Sciences, Kumamoto University

The electrical conductivity structure of the lunar interior provides us very important information for investigation of the lunar origin and evolution. We attempted to estimate on the lunar electrical conductivity from magnetic field measurements by LMAG on board KAGUYA (SELENE) during the period from 21 December 2007 to 31 October 2008, when KAGUYA was in the orbit of 100-km altitude.

Magnetic fields are induced in the moon by changes in the interplanetary magnetic field (IMF). In order to confirm whether the lunar electromagnetic induction signals are observed in KAGUYA data, we compared KAGUYA data and data of ACE and WIND satellites, which locate around the Lagrange point (Sun-Earth L1), when the stepwise changes are shown in each data. LMAG measured the sum of the inducing and the induced fields, while ACE and WIND measured only the inducing field. It was found that LMAG recorded the lunar electromagnetic responses to the stepwise changes in the IMF.

Dyal and Parkin (1971) gave the homogeneous moon model and estimated lunar conductivity. Their estimation was carried out using the data measured by Apollo 12 magnetometer fixed on the lunar surface. In this study, we applied their method to the data of the orbiting satellite, KAGUYA. The homogeneous moon model was able to explain the electromagnetic response against the stepwise changes in the IMF well, and the estimated homogeneous lunar conductivity was 1×10^{-4} - 4×10^{-4} S/m. On the other hand, we found that LMAG data also recorded the anomalous signals in the minor components, not predicted from the above model. In order to confirm whether such signals are unique to KAGUYA data, we scrutinized the data obtained by Apollo and Lunar Prospector. As a result, we concluded that such signals are common when the stepwise changes penetrate the moon.

In this presentation, we will report the new analysis results of KAGUYA, Apollo, and Lunar Prospector data, and discuss the anomalous signals in the minor component of the responses to the stepwise changes in the IMF.

Keywords: Moon, KAGUYA, SELENE, LMAG, induction, conductivity

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P14 Room:Poster Time:May 2 16:30-17:30

Plasma observations above strong lunar crustal fields in the solar-wind wake

NISHINO, Masaki n[1*] ; SAITO, Yoshifumi[2] ; TSUNAKAWA, Hideo[3] ; TAKAHASHI, Futoshi[3] ; YOKOTA, Shoichiro[2] ; MATSUSHIMA, Masaki[3] ; SHIBUYA, Hidetoshi[4] ; SHIMIZU, Hisayoshi[5] ; FUJIMOTO, Masaki[2]

[1]Nagoya University, [2]ISAS/JAXA, [3]Tokyo TECH, [4]Kumamoto University, [5]Earthquake Research Institute, The University of Tokyo

Plasma signature around crustal magnetic fields is one of the most important topics of the lunar plasma sciences. Although recent spacecraft measurements are revealing solar-wind interaction with the lunar crustal fields on the dayside, plasma signatures around crustal fields on the night side have not been fully studied yet. Here we show evidence of plasma trapping on the closed field lines of the lunar crustal fields in the solar-wind wake, using SELENE (KAGUYA) plasma and magnetic field data at 15 km altitude. In contrast to expectation on plasma cavity formation at the strong crustal fields, electron flux is enhanced above one of the strongest crustal fields, Crisium Antipode (CA), where the magnetic field along the spacecraft orbit is as strong as 80 nT. The enhanced electron fluxes above CA are characterized by bidirectional beams in the lower energy range (typically lower than 100 eV), which shows that these electrons are trapped on the closed field lines of the crustal magnetic fields, although a possibility of opened field configuration with cusps is not totally excluded. The observed electrons on the closed field lines may come from the lunar night side surface, while the mechanism of electron supply onto the closed field line remains to be solved.

Keywords: Lunar crustal field, Lunar plasma environment, Lunar wake, SELENE (KAGUYA)

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS23-P15 Room:Poster Time:May 2 16:30-17:30

A long-term all-sky imager observation of lunar sodium tail

NISHINO, Masaki n[1*] ; SHIOKAWA, Kazuo[1] ; OTSUKA, Yuichi[1]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University

The Moon possesses long tail of neutral sodium atoms that are emitted from the lunar surface and transported anti-sunward by the solar radiation pressure. Since the earth crosses the lunar sodium tail for a few days around the new moon, the resonant light emission from sodium atoms can be detected from the ground. Although it has been reported that bright emissions from sodium atoms of the tail is observed during the Leonids meteor shower, only few events without meteor shower have been investigated so far. Here we show a long-term (over 15 years) observation of the lunar sodium tail using all-sky imager at Shigaraki Observatory (35N, 136E), Japan. We have surveyed our database of all-sky sodium images at a wavelength of 589.3 nm to find that a bright spot emerges around the anti-lunar point for a few days around the new moon. Although the sodium spot is the brightest during the Leonids meteor shower, a weaker sodium spot is detected in the period without meteor shower as well. The sodium spot gradually moves eastward (roughly, 0.2 hours a day), which shows that the sodium tail is strongly affected by the earth's gravity. We will present the latest results of our data analysis to discuss signatures of the lunar sodium tail as well as the origin of the lunar sodium exosphere.

Keywords: Lunar sodium tail, Lunar exosphere, All-sky imager observation