The Next Japanese Lunar Mission, SELENE-2: Present Status and Science Objectives.
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Introduction: Moon is placed as one of the most important targets of Japanese planetary exploration programs since 1990's. Three missions, HITEN, LUNAR-A, and SELENE were approved and have been developed so far. HITEN was successfully achieved to make insertion of lunar orbit in 1990. SELENE (Kaguya) was also successfully launched in 2007 and now is at the nominal operation phase. On the other hand, LUNAR-A, which was planned to deploy two penetrators on the Moon was canceled in Feb. 2007 due to the difficulty of the penetrator technology. Based on our technological heritage, Japan Aerospace Exploration Agency (JAXA) has perspectives for the next two decades to promote lunar explorations both for science and future utilization. This paper introduces outline and science objectives of the next lunar exploration program, SELENE-2.

Japanese future lunar mission: JAXA has started its Phase-A investigation for the SELENE-2, a lunar lander, which will be launched in the middle of 2010s. The SELENE-2 will carry both scientific instruments and utilization research payloads on it. It possesses the top objective of securing Japan's own landing capability to place and deploy the payloads on the surface intended.

In the present design, SELENE-2 consists of a lander, a rover, and a communication relay orbiter, but detailed configuration - landing site(s), number of the landers and the rovers, mission life and so on- is now under investigation. An image view of one example of the mission is shown in Fig.1. As shown in the figure, one possibility is to launch two landers which will deploy both polar and equatorial regions.

The SELENE-2 will be followed by advanced version of SELENE-X, whose mission contents are still under investigation ranging from Sample & Return to Logistics Demonstrator. JAXA believes the future real lunar exploration will have to accompany an International Cooperation inevitably, and is currently seeking Humans Transportation means with other agencies. JAXA is sure its missions will complement the international lunar exploration activity. Some keywords of the concepts of the present and future missions with respect to the various aspects (technology, science, utilization, and international collaboration) are summarized in Table 1.

Science objectives of the SELENE-2 mission: As described above, the science motivation is not the main objectives of the SELENE-2 mission, but some

Fig.1 An example of image view of the SELENE-2 landing mission.

observations will be scientifically meaningful in conjunction with the future utilization.

For the geological aspects of the Moon, the top priority of the lunar science is to clarify the process of magma ocean which was experienced at an early stage of planetary evolution not only on the Moon but also on the larger size of solid planets and satellites. The results of Clementine, Lunar Prospector, and recent progress of sample analyses of lunar meteorites have revealed the complexity of crustal evolution [1],[2],[3]. We need detailed sample analyses at some representative geological units such as PKT (Procellarum KREEP Terrane), FHT (Feldspathic Highlands Terrane), and SPA(South Pole-Aitken Basin). The landing mission has a possibility to conduct this, but only the bulk chemical composition of the sampled materials of the landing site is not effective. We should find some crucial evidences in the limited part of polymict breccias which can be found in "rake samples" in the regolith. Therefore, sample collection and processing (cutting, polishing and so on) technique, and high precision chemical analyses of millimeter size region must be the key technologies to achieve this science goal [4]. The chemical composition of the sampled material must be utilized for the investigation of resources for the human activities, and the autonomous sample processing system may be also utilized for un-manned sample return missions.

Geophysical observations are also indispensable, and among them, seismic observation is most important to directly and clearly clarify the internal structure of the Moon. The existence and size of core, and velocity profile of the mantle will provide us to estimate bulk abundance and thermal state which will drastically progress to infer the origin of the Moon. One of the geophysical instruments is considered to deploy broad band seismometers with high sensitivity. By using 100 seconds period of seismometer with having a sensitivity equivalent or one order higher to that of the LUNAR-A seismometer, we expect to get information of the heterogeneity of the lunar crust and the upper mantle only by one observation station. If the largest class of the moon quake which had been observed by the Apollo mission occurred during the mission, we also expect to obtain the bulk layered structure by detecting free oscillations [5]. Recent situation which arises the landing missions by other countries is more preferable to deploy the seismometer to conduct global network observations. Seismic observation will also give us effective information for the future manned mission(s) to asses the seismic and meteoroid risk before planning any type of permanent settlement. Other geophysical observations especially related to the geodesy has also a strong tool to clarify the deep internal structure. Some of the instruments, which are placed as the cornerstone of the construction of the astronautical observatory, should be related to the future utilization of the Moon.

References:

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	Kaguya （SELENE）	**SELENE-2**	**SELENE-X**	**Human exploration**
Technology development	**Lunar orbit insertion and observation from the orbit**	**Landing Surface mobility Long-term stay**	**Several mission candidates exist. Large scale lander Construction demonstration on the moon Sample return Lunar observatory Seismometer network**	**In-situ activity by Japanese astronauts**
Planetary science	**Remote sensing of surface material, gravity field.**	**In-situ observation of geology and geophysics**		
Investigation for lunar utilization	**Remote sensing of surface environment and material resources.**	**In-situ investigation of surface environment and resource utilization**		
International collaboration Public outreach	**Data exchange for science and future exploration HDTV**	**International payload sharing HDTV? University small sat?**		

Table1.Key concepts to promote the Japanese lunar exploration program.