MORPHOLOGY OF LARGE LUNAR CRATERS: VIEWS FROM LISM/ KAGUYA. N. Hirata[1], J. Haruyama[2], M. Ohtake[2], T. Matsunaga[3], Y. Yokota[2], T. Morota[2], C. Honda[2], Y. Ogawa[3], M. Torii[2] H. Demura[1], and N. Asada[1], [1]The University of Aizu, Ikki-machi, Aizu-Wakamatsu, Fukushima, 965-8580, JAPAN, [2]The Institute of Space and Astronautical, Japan Aerospace Exploration Agency, [3]National Institute for Environmental Studies, Corresponding author's e-mail address: naru@u-aizu.ac.jp

Introduction: Morphology of a crater interior and exterior give important clues to reconstruct and understand impact cratering. Large and fresh lunar craters are best targets for such investigations, because only space weathering and limited degradations by small impacts are major processes that disturb original structures of ejecta units. Lunar Imager/Spectrometer (LISM), which onboard the Kaguya lunar explorer, will provide high-resolution and multi-spectral mapping data of the Moon [1-3]. Combination of high-resolution images, digital terrain models, multi-band images, and spectral profiles is a complete set for geologic mapping of a crater and its surroundings. The purpose of this study is to reveal details of impact cratering processes with the data from LISM. We here describe scientific objectives, observational targets, and strategy of analysis.

Scientific Objectives: Processes of impact cratering can be divided into three stage [4]; the contact and compression stage, the excavation stage, and the modification stage. Our scientific objectives are focused on several key issues for reconstruction of these three stages.

Amount of impact melt. Impact melt is a product of high temperature condition at the contact and compression stage. An amount of impact melt gives clues to a scale of an impact, the impactor size and the impact velocity. Field researches on terrestrial craters give constraints on model estimations of the amounts of impact melt [5], because thick melt sheets are preserved within terrestrial craters. Since erosive processes are limited on the lunar surface, impact melts of lunar craters remain not only as melt sheets within a cavity but also as small melt deposits within or around a cavity, and as glassy materials. As impact melt glasses spread around a rim of a crater, they are observed as dark rings in Clementine UVVIS images. We have already demonstrated that the total amount of impact melt could be estimated from multi-spectral images [6]. Images from LISM will give better constraints than previous studies. Size and distributions of melt deposits, which have not been considered in the previous study, can be investigated with high-resolution images. Extent of a dark ring will be clearer in high-resolution images, and glass contents of dark ring materials will be able to estimate with spectroscopic data.

Secondary craters and rays. Non-melting materials ejected from a transient cavity form continuous ejecta, secondary craters and rays around a primary crater. Secondary craters and rays are furthest from a primary, and formed by ejecta that have high ejection velocities. At an oblique impact, distributions of secondary craters and rays show an asymmetric pattern [7]. As the spatial distributions of these far ejecta around the primary crater reflect a radial structure of an ejecta curtain, it can be utilized for reconstructing elemental processes at the excavation stage of an oblique impact. Recent laboratory experiments can reproduce asymmetric pattern of an ejecta curtain for an oblique impact, and detailed nature of asymmetric ejecta is investigated [8]. Analyses of the LISM data will be able to connect experimental works and observational works, and to make better theoretical understandings on cratering mechanics.

The size-frequency distribution, the size-velocity relationship, and the total mass of ejecta fragments can be derived from the size-frequency distribution and the spatial distribution of secondary craters [9]. Because the studied sites of the previous paper are limited, it is not clear that these relationships are valid generally. Data from LISM will bring a more comprehensive understanding on fragmentation and transportation process of high-speed ejecta.

Massive ejecta. Continuous ejecta account for most of ejected materials. However, it is difficult to reconstruct directly their transportation processes from current observable morphology, because continuous ejecta form a single and large continuous unit. We argue that the distribution of the glassy materials can be utilized as a marker to trace overall transportations of ejecta. The source of impact melt is regarded as localized at the contact point, and melt flow with other ejecta in an excavation flow. Small-scale features on the surface of continuous ejecta will also give important information on emplacement processes of ejecta flows.

Observational Targets: To investigate these scientific objectives, we select preliminary targets of LISM observations from fresh Copernican craters: Vavilov (D = 99 km), Copernicus (D = 93 km), Tycho (D = 85 km), King (D = 77 km), Jackson (D = 71 km), Ohm (D = 64 km), Crookes (D = 49 km) and Olbers A (D = 43 km) (Fig. 1). As most of them are on the farside of the Moon, and pre-Kaguya data are quite limited. They have bright ray systems with secondary craters, Vavilov, Tycho, Jackson, Ohm, and Olbers A have clear asymmetric ray systems, which suggest that oblique impacts formed these craters. They are large enough to investigate substantial amounts of impact melt. All of them except for Copernicus have dark rings [6]. Copernicus and Tycho rouse special interests, because they show different distributions of impact melt glasses in Clementine UVVIS images [10].

Strategy of Analysis: High-resolution images of Terrain Camera (TC) will be used for fundamental mapping of various surface features within and around target craters. Counting of secondary craters is an important step of our research. Digital terrain model derived from stereo-pairs by TC will help to distinguish between small primaries and secondaries. Multi-band imager (MI) will be employed for mapping distributions impact melt, e.g. dark ring of glassy melt. Ray systems are also important targets of MI observations, because they are easy to recognize in multi-band images taken at high illumination angles. The optical maturity index is useful to map distributions of far ejecta, which excavate mature local material and expose immature layers [11-12]. Spectral profiler (SP) will provide detailed spectra to determine glass contents of dark ring materials, and melt compositions. Since global mapping by LISM will continue throughout the nominal operation period of Kaguya, the complete data set of LISM including TC, MI, and SP data for a target crater will be not available until the end of the nominal mission.

References: [1] Haruyama J. et al (2008) *Earth Planets and Space*, in press. [2] Ohtake M. et al. (2008) *Advances in Space Research*, in press. [3] Matsunaga, T. et al. (2001) *Proc. SPIE*, 4151, 32-39. [4] Melosh, H. J. (1989). *Impact cratering*. [5] Cintala M., J., and Grieve R., A. F. (1998) *MAPS*, *33*, 889-912. [6] Hirata N. et al. (1999) *LPS XXX*, Abstract #1350. [7] Herrick R. R., and Forsberg-Taylor N. K. (2003) *MAPS*, *38*, 1551-78. [8] Anderson J. L. B., Schultz P. H., and Heineck J. T. (2003) *JGR*, *108h*, 13-11. [9] Hirata N., and Nakamura A. M. (2006) *JGR*, *111*, 03005. [10] Pieters C. M. et al. (1994) *Science*, *266*, 1844. [11] Grier J. A. et al. (2001) *JGR*, *106*, 32847-62. [12] Hirata N. et al. (2000) *LPS XXXI*, Abstract #1615.

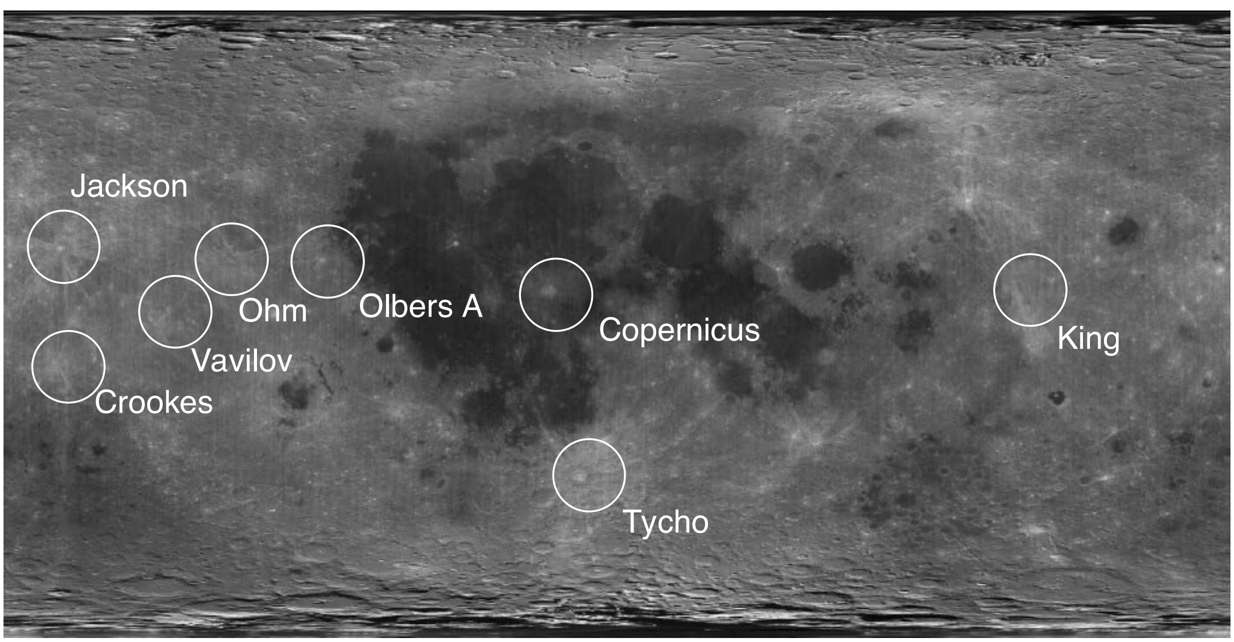

Figure 1. Target craters for analysis shown in Clementine UVVIS basemap