FRAMEWORK OF LUNAR LANDING SITE SELECTION AND RESOURCE ANALYSIS FOR THE 2020 KOREAN LUNAR MISSION. K. J. Kim[1], S. van Gasselt[2], G. H. Ju[3], S.-R. Lee[1], C. Wöhler[4], J. A. P. Rodriguez[5], A. A. Berezhnoy[6]. [1]Planetary Geology Department, Korea Institute of Geosciences and Mineral Resources, Daejeon, South Korea (kjkim@kigam.re.kr), [2]Department of Earth Sciences, Freie Universitaet Berlin, Berlin, Germany, [3]Korea Aerospace Research Institute (KARI), Daejeon, South Korea, [4]Image Analysis Group, TU Dortmund University, Dortmund, Germany, [5]Planetary Science Institute, Tucson, AZ, USA, [6]Sternberg Astronomical Institute, Moscow State University, Moscow, Russia.

Introduction and Aims: As part of the national space promotion plan and presidential national agendas, South Korea's institutes and agencies under the auspices of the Ministry of Science, Information and Communication Technology and Future Planning (MSIP) are currently working on a phase-A study for a Korean Lunar Exploration Program (KLEP) [1]. A Korean pathfinder lunar orbiter (KPLO) is to be followed by a Korean Lunar Explorer (KLE) which constitutes an orbiter and a lander unit equipped with a small rover with a mass of approximately 20 kg (Fig. 1). Key goals of the Korean lunar mission are (1) investigations of lunar geology and space environment, (2) exploration of lunar resources, and (3) testing of future space and planetary exploration technology which will assist in future human activities on the Moon and beyond.

KPLO's main scientific return is considered to be composed of visual and spectral image data, space environmental measurements and data related to lunar resources. For the exploration of lunar resources two major exploration areas need to be considered: (1) resources in polar regions for the potential establishment of lunar bases or (2) future energy resources such as Helium-3 and precious rare earth elements along with radioactive resources like Uranium. KPLO is planned to operate in a circular polar orbit at an orbit altitude of 100 km. Its size will be 1.9 x 1.7 x 2.3 (m) with a dry mass of 550 kg. The total science payload mass will amount to approximately 40 kg with instruments contributed by the *Korean Aerospace Research Institute (KARI)* and other Korean research institutes and centers, as well as NASA. The development periods for KPLO and KLE are considered to be 2016–2018 and 2017–2020, respectively [1].

To accomplish the main goals of the mission, a set of candidate lunar landing sites need to be considered. During the first three years, an investigation of prospective landing sites needs to be performed using not only the results of KPLO but also those from previous international lunar missions. The task of landing-site selection will comprise identification of (1) regions for potential resource exploration and (2) regions of scientific interest. Furthermore, a focus will be put on the identification of technologically feasible and safe landing areas under consideration of engineering constraints which will be imposed by mission, spacecraft and payload layout. While resource investigations have been prioritized, engineering studies and demonstrators are likely to play an additional integral role.

Investigations and Methodologies: In order to perform investigations for prospective landing sites, derivation of auxiliary datasets and spatial data analyses are required using visual, multi- and hyperspectral data as well topography measurements. Investigations are then performed by (1) extraction of regional subsets based on high-level constraints, (2) identification of sites for potential resource exploration, (3) narrowing down operation sites based on low-level constraints, such as hazards.

High-level requirements imposed by engineering and mission constraints need to be investigated at smallest map scales first in order to extract regional and local subsets (e.g., time, altitudes, small-scale long-wavelength slope patterns, roughnesses). These systematic and automatic analyses and evaluations [2] are performed within information system environments using mostly (near-) global datasets that are publicly available and which may require additional co-registration work in case of residual misalignments.

Regional subsets will provide the settings for refined analyses at larger map scales which are based on science and resource criteria. These analyses are mainly conducted using stand-alone environments with dedicated routines and require visual interpretation and manual interaction. For the Korean mission package both mineralogical and elemental data need to be investigated as well as remote sending data associated with water resources such as neutron data.

Figure 1. Depiction of the Korean rover, lander and orbiter in operation on the lunar surface (source: KARI).

The main step to identify resource-bearing regions as potential landing sites is the analysis of orbital visual and near-infrared spectral data sets, such as *Clementine* UVVIS and NIR multispectral image data [3], *Kaguya Multiband Imager (MI)* data [4], visual and NIR hyperspectral image data of the *Chandrayaan-1 Moon Mineralogy Mapper (M³)* [5] or NIR point spectrometer data of the *Chandrayaan-1 SIR-2* instrument [6]. A framework for the topographic and thermal correction of M³ hyperspectral image data and their normalization to a standard observation and illumination geometry is described in [7], which can be used to routinely construct maps of the spectral reflectance, of the topography and of spectral parameters characterizing the absorption features near 1 and 2 µm related to pyroxene [e.g. 8] for arbitrary lunar regions. In combination with elemental abundance maps of low resolution [9], the spectral parameter maps allow for the construction of high-resolution maps of the abundances of the main refractory elements (Ca, Fe, Mg, Ti) [7] [10], see also [11]. The strength of the absorption around 3 µm related to hydroxyl (OH) can also be mapped [12]. M³ and SIR-2 data have been shown to be suitable for the detection of localized deposits of "exotic" minerals such as spinel or olivine which do not occur on large spatial scales [13]. Spectral unmixing methods [e.g. 14] can be used to determine the constituent minerals of the surface material (e.g. orthopyroxene, clinopyroxene, plagioclase, ilmenite, olivine, spinel) along with their fractional abundances based on the available orbital visual and NIR spectral data [e.g. 15; 16]. For the search for rare mineralogies the technique of mapping distances of estimated composition from three end-member plane has been shown to be powerful. In order to conduct such studies, high-resolution maps of abundances of Fe, Mg, and Al are needed [17].

Once candidate regions exhibiting resource-bearing minerals have been identified spectrally, they can be mapped topographically at high vertical and lateral resolution based on the combined stereo and intensity-based image analysis framework described in [18] applied to LRO Narrow Angle Camera (NAC) [19] images [20; 21]. This will also allow for a prediction of possible hazards e.g. due to boulders, steep slopes or impact craters, and include analyses for permanent shadows. This will further narrow down the selection of potential landings sites. A validation of such potential hazards for lander units will be conducted visually as well as semi-automatically [e.g., 22].

Potential landing sites: Among prospective landing sites are regions with anomalous mineralogical and elemental composition, such as high-abundance KREEP terrain or the South Pole-Aitken basin, and/or regions with confirmed high abundance of He-3 [1].

The thermal neutron enriched areas on the northern parts of the Moon were found to have very high Samarium and gadolinium [23]. Interestingly, Change'-3 found Yttrium on the landing site soil [24]. Regions with high contents of Ti-rich basalts are considered to be feasible from the viewpoint of utilization of lunar resources [25], as He-3 isotope content is correlated with regions of high Ti content [26]. Studies of Ti content at high spatial resolution will be helpful for understanding the correlation between main element abundances at resolutions of several km and element abundances at meter scale, which becomes important for arriving at an understanding about the practical utilization of lunar resources [cf. 27]. Other regions of interest are, e.g., swirls that are often considered to form during recent cometary impacts [28]. Studies of magnetic anomalies, regolith structure, and volatile content in swirls such as the Reiner-Gamma feature will be extremely helpful for explaining the origin of these structures.

It is planned to set up a Korean Lunar Mapping Project for the first period to jointly work on definitions for science conduct and resource exploration. Once low-level engineering constraints will become available at required detail, targeted data analyses can be performed.

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