NEW GEOLOGIC MAP OF THE LQ-19 (MARE NUBIUM) QUADRANGLE ON THE MOON. Jianzhong Liu[1], Jinzhu Ji[1,2], Li Zhang[1], James W. Head[3], Dijun Guo[1,2,3], Juntao Wang[1,2], Lin Luo[1,2], Shengbo Chen[4], Jianping Chen[5], Xiang Wang[5], Zongcheng Lin[6], Jian Chen[6], Xiaozhong Ding[7], Kunying Han[7] and Ziyuan Ouyang[1], [1]Center for Lunar and Planetary Science, Institute of Geochemistry, Chinese Academy of Sciences, 99 Lincheng West Road, Guiyang 550051, China, Email: liujz@nao.cas.cn . [2]University of Chinese Academy of Sciences, Beijing 100049, China. [3]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912 USA. [4]Jilin University, 2199 Jianshe Street, Changchun 130000, China. [5]China University of Geosciences (Beijing), Xueyuan Road 29, Beijing, 100083, China. [6]Shandong University (Weihai), 180 Wenhua West Road, Weihai 264209, [7]China. Institute of Geology, Chinese Academy of Geological Sciences, 26 Baiwanzhuang Road, Beijing 100037, China.

Introduction: Lunar geologic maps are an integration of the morphology, lithology, chronostratigraphy, cratering, tectonism, and volcanism of the Moon. A lunar geologic mapping program, funded by the Ministry of Science and Technology of China, aims to complete a renewed global geologic map of the Moon with the advantages of the latest data from the Chang'e project and other missions [1, 2]. We will complete the geologic maps of 30 quadrangles at 1:2,500,000 scale, which is consistent with the scheme of Gaddis et al. (2004) [3, 4] (Figure 1). We have completed a preliminarily map of LQ-19 (Mare Nubium Quadrangle), providing a pilot lunar geologic map to demonstrate the techniques, procedures and methods for the program.

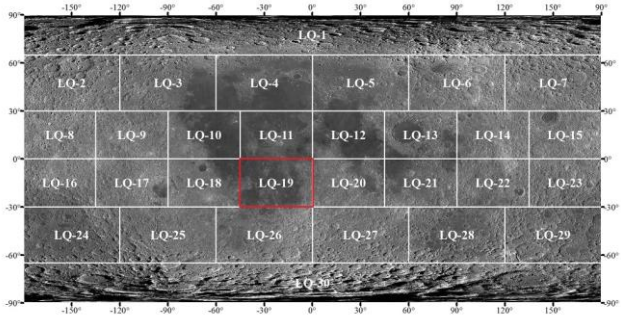

Figure 1 Mapping scheme for lunar geologic maps at 1:2.5M scale. LQ-19 quadrangle is marked with a red outline. Basemap is the Chang'e-1 CCD image mosaic.

Geologic Setting: The LQ-19 quadrangle area is located in the southern nearside hemisphere of the Moon (0°–30°S, 0°–45°W). This region is mainly occupied by Mare Cognitum, Mare Nibium and Mare Humorum, part of Mare Insularum, and a small highlands region in the east. Large craters (e.g. Alphonsus, Gassendi, Bullialdus) and distal ejecta deposits (e.g. Copernicus ejecta and Tycho ejecta) provide stratigraphic markers. Linear structures, such as wrinkle ridges and grabens, and circular mare structures are widely distributed.

Data and Methords: China started its lunar exploration with the Chang'e-1 (CE-1) mission in 2007, followed by Chang'e-2 in 2010 and Chang'e-3, with the Yutu rover in 2014 [5-7]. This mapping program mainly relies on data from Chinese lunar exploration missions, including CE-1 images (120 m/px), CE-2 images (50 m/px), OMAT (200 m/px), imaging interferometer spectral data (200 m/px), X-ray and Gamma-ray Spectroscopy (5°×5°) data of CE-1. These data satisfy the requirements for detailed study of lunar albedo, texture, topography, and geochemistry. Data from other missions (e.g. LOLA, Chandrayaan-1 M^3, Clementine UVVIS) are used to complement these data. To fulfill the requirements of distributed collaborative mapping and large dataset processing, we developed a GIS-based mapping system to process data and share results. For the LQ-19 quadrangle, the map is rendered in ESRI ArcMap.

Preliminary Mapping Results: The contents of the geologic map consist of crater materials with different ages, different rock types, structures formed by geologic and geodynamic processes and other features.

Time scale. From the perspective of lunar geologic/geodynamic processes and history, the new lunar chronology subdivisions, three Eons (Neolunarisian/NL, Paleolunarisian/PL and Eolunarisian/EL) and six periods (Pre-Aitkenian/PA, Aitkenian/A, Necterian/N, Imbrian/I_1/I_2, Eratothenian/E_1/E_2 and Copemican)[8, 9], were used in this geologic map.

Crater materials. Craters formed in different eras and in different abundances characterize the surface of the Moon. We determined the age of craters based on their state of degradation, superposition relationships and referencing previously published results. Craters with diameters >5 km have been highlighted in the LQ-19 map. Utilizing high-resolution images, the continuous ejecta deposits, discontinuous ejecta deposits and crater rays can be distinguished [10, 11]. Based on the different distributional characteristics of fresh complex crater materials from CE-1 CCD, IIM and OMTA data with substantial variation in optical maturity and in reflectance and morphology, five units of crater materials are distinguished: central peak materials (*cp*), floor materials (*f*), wall materials (*w*), rim materials (*r*) and radial rim materials (*rr*). However, simple craters or degraded craters contain only some of these units. We have mapped 699 crater materials units in the LQ-19 quadrandgle.

Structures. Lunar structural features, reflecting both the influence of endogenic and exogenic geolog-

ic/geodynamic processes, are abundant in the LQ-19 quadrangle; we have recognized and mapped 7 linear structure types: grabens (59), fractures (116), rilles (23), wrinkle ridges (353), crater floor-fractures (116), crater rim-fractures (63) and crater chains (12). We have also mapped 3 types of circular structures, which are basins (4), craters (389), possible craters (48).

Rock types. Unlike the Earth, rock types are relatively simple because of a geological environment without water and atmosphere. In this program, we mainly used CE-1 IIM data, combined with other new research results. Rock types have been classified into three groups: (1) Highland rocks, which are ferroan anorthosite, alkali suite [12], KREEP rock, silicic rock [13]; (2) Mare rocks, which are very low Ti basalt, low Ti basalt, medium Ti basalt, high Ti basalt and very high Ti basalt; (3) Special rocks, which include pyroclastic rock [14], pure anorthosite [15] and pink-spinel anorthosite [16] are mapped by point-location features. A rock type map and guidebook will be published independently.

Other features. Two landing sites and thirteen volcanos [14] are marked as point features in the LQ-19 quadrangle. We have also included isopach contours of basalt thickness [17], and the thickest basalt in LQ-19 is located in the center of Mare Humorum.

Summary: Our LQ-19 Mare Nubium quadrangle is a pilot lunar geologic map to display the geologic features and units, their stratigraphic relationships, and the their characteristic morphology, mineralogy and petrology, taking full advantage of new data and research results to further advance our understanding of lunar geology. We demonstrate the technical specifications, procedures and methods for the global lunar geological maping program, and a GIS-based mapping system to process data and share results.

Acknowledgements: This work was supported by the National Science and Technology Infrastructure Work Projects (Grant No. 2015FY210500) and the National Natural Science Foundation of China (Grant No. 41490634 and No.41373068).

References: [1] Liu J. Z., et al. (2016) *LPSC XLVII, 2039*. [2] Han K. Y., et al. (2016) *LPSC XLVII, 1852*. [3] Wilhelms, 1972, *USGS Interagency Report: Astrogeology 55, 36 pp*. [4] Gaddis L., et al. (2004) *LPSC XXXV, 1418*. [5] Ouyang Z., et al. (2008) *Chin. J. Space Sci., 5, 361-369*. [6] Zou X. D., et al. (2014) *Icarus, 348-354*. [7] Ip W. H., et al. (2014) *Res. Astron. Astrophys., 12, 1511-1513*. [8] Guo D. J., et al. (2014) *Earth Science Frontiers, 21(6): 45-61*. [9] Guo D. J., et al. (2016) *LPSC XLVII, 1744*. [10] Ohman T., et al. (2014) *J Geophys Res-Planet, 6, 1238-1258*. [11] Lucey P. G., et al. (2000) *J. Geophys. Res-Planet, E8, 20377-20386*. [12] Jolliff B. L., et al. (2006) *New Views of the Moon. Mineralogical Society of America*. [13] Glotch T. D., et al. (2010) *Sci, 5998, 1510-1513*. [14] Gustafson J. O., et al. (2012) *J. Geophys. Re.s-Planet, E12, E00H25*. [15] Yamamoto S., et al. (2012) *GRL, L13201*. [16] Prissel T. C., et al. (2014) *Earth Planet. Sci. Lett, 144-156*. [17] Liu W. S., et al. (2014) *Earth Science Frontiers, 21(6): 102-106*.

Figure 2 Preliminary geologic map of LQ-19 Mare Nubium quadrangle