THE MONS RÜMKER VOLCANIC COMPLEX OF THE MOON: A CANDIDATE LANDING SITE FOR CHANG'E-5 MISSION. J. Zhao[1,2], L. Xiao[1], L. Qiao[1]. [1]Planetary Science Institute, China University of Geosciences, Wuhan, 430074, P. R. China (jnzhao@cug.edu.cn), [2]Department of Geosciences, Stony Brook University, Stony Brook, NY 11794

Introduction: Chang'E-5, to be launched in 2017, will be China's first lunar sample return mission. The northern Oceanus Procellarum is a candidate landing region, where Mons Rümker is an outstanding volcanic complex and is a priority landing site for Chang'E-5. This volcanic complex is centered at 301.7°E, 40.7°N and covers an area of ~4000 km^2. Smith (1974) has made a geological map of the region based on Lunar Orbiter mosaics [1], but this work is sketchy due to the lack of high-resolution image and spectral data. Other studies have analyzed the morphometry, rheology and mode of the emplacement of Mons Rümker [2], acquired the surface property with Earth-based radar data [3], and studied the pyroclastic mantles with new spectral and photometric data [4]. However, there is no detailed and comprehensive study of this area, which cannot meet the requirement of landing site selection for a sample return mission. In addition, geological evolutionary history of Mons Rümker is still unclear. Therefore, this work uses the latest high-resolution image and spectral data to comprehensively study the geology of Mons Rümker to support the Chang'E-5 mission.

Data and method: High-resolution DTM is obtained from stereopair images (10 m/pixel) of Terrain Camera (TC) onboard SELENE [5]. FeO and TiO_2 abundances are estimated with data acquired by Multispectral Imager (MI) onboard SELENE using the method in [6]. As the spatial resolution of MI data is 20 m/pixel, we can get better results than those derived from Clementine data. Data from Moon Mineral Mapper (M^3) onboard Chandrayaan are processed to analyze the mineral type [7]. Detailed analysis of geomorphologic features is based on images of LRO Narrow Angle Camera and TC.

Results: *Topography.* Mons Rümker is approximately circular in shape and stands up to more than 500 m above the surrounding mare surface (lower than -2400 m). Its central and southern parts are higher with the maximum elevation reached in the summit of a dome, which is about -1250 m. Slope map derived from TC DTM shows that 75% of Mons Rümker are less than 3°. The marginal area of the volcanic complex and some domes can have higher slopes, which can be 5-8°. The steepest part is the inner wall of some craters, which can be more than 15°.

Mineral and rock type. The Mons Rümker region has relatively lower TiO_2 (~2 wt.%) and FeO (~15 wt.%) abundances compared to the surrounding mare region (Fig. 1). According to the TiO_2 abundance, rocks in Mons Rümker should be low-Ti basalt [8]. Spectroscopic observation from Moon Mineralogy Mapper (M^3) shows that the southern Mons Rümker has a similar mineral composition with its adjacent mare deposits (Fig. 2), with a high-calcium pyroxene dominated composition. While the northern part shows blue on the M^3 spectral parameter map, indicating a weaker 1 μm mafic absorption band (Fig. 2), probably due to the existence of pyroclastic mantling deposits [4].

Geomorphology. A variety of landforms can be found in Mons Rümker region. Domes are the most prominent features in Mons Rümker. More than 30 volcanic domes have been identified in this area and they are classified into three types based on their morphology [1]. In high-resolution images, we found some of the type EId3 domes proposed by [1] should be volcanic cones. Therefore, we proposed a new classification scheme and the domes are divided into two types: steep-sided domes and low domes. Steep-sided domes (eg. "2" in Fig. 3) usually have steeper side slope (>5°). Most domes of this type have a summit crater which may be the volcanic crater. Low domes (eg. "1" in Fig. 3) are usually characterized by gentle side slope and smooth transition between the dome and the surrounding region. Only a small portion of this type have summit craters.

Craters in Mons Rümker are mostly bowl-shaped simple craters. They are usually smaller than 2 km in diameter. There are also many irregular craters and chain craters which should be secondary craters from some young large primary craters nearby (eg. Rümker E crater to the southeast of Mons Rümker). However, it should be noticed that some craters with irregular shape should be volcanic craters or related to rilles.

Scarps and ridges have been studied in [1] and are considered to be controlled by regional structural direction in Oceanus Procellarum. However, we think original landform and contraction of cooling lava can also result in the formation of scarps and ridges. Besides, in high-resolution images, we found no craters destroyed by the scarps and ridges, which indicates that these features are relatively old in age.

Surface age. Crater size-frequency distribution measurements are performed to acquire the model age of Mons Rümker. We select a large low dome and a steep-sided dome, part of the lineated terrain in the northwest (considered as Fra Mauro Formation by [1]) and a non-dome region (Fig. 3) to perform crater counting so that we can compare the formation sequence of each region. Results show that the oldest age occurs in the lineated terrain, which is 3.67 Ga. The low dome has an absolute model age of 3.34 Ga, and its adjacent non-dome area is 3.40 Ga, while the age of the steep-sided dome in the southern Mons Rümker is 3.16 Ga.

Discussion: *Geological evolution of Mons Rümker*. Firstly, lineated terrain formed at 3.67 Ga ago. These materials may be ejacta from Iridum crater as the lineations trend east-northeast and are nearly radial to Iridum crater [3]. Then magma intruded and erupted in Mons Rümker and covers most of the surface in about 3.4 Ga. In the terminal stage of the volcanism, some domes formed and they may be active last to 3.16 Ga or even longer. However, to better constrain the duration of volcanism in Mons Rümker, more extensive age dating should be carried out. At last, formation of some large Copernican craters nearby results in the crater chains in Mons Rümker.

Landing site suggestion. We proposed two candidate landing sites for sample collection. One is the steep-sided dome ("A" in Fig. 3). By analyzing the composition of rocks, it can provide us information on the formation mechanism of lunar domes. Meanwhile, age dating of rocks can help us better constrain the duration of volcanism in Mons Rümker and improve the CSFD method. The other landing site is in the northern Mons Rümker and near the boundary of lineated region ("B" in Fig.3). This area may have complicated compositions and different stratigraphy. Sampling the rocks in the surface and the subsurface can help us analyze the evolutionary history of Mons Rümker and confirm the source of materials in the lineated terrain, which may shed light on the age of some large impact events on the Moon.

Summary: We analyze the topography, mineral and rock types, geomorphologic features, and the evolutionary history of Mons Rümker. Two candidate landing sites were proposed for Chang'E-5 sample return mission.

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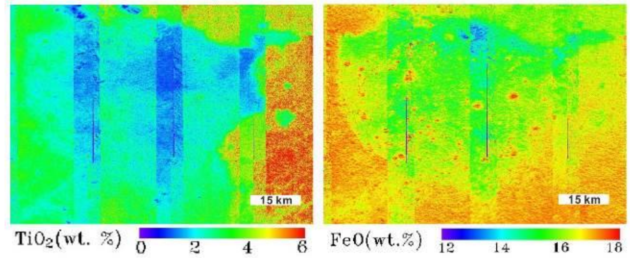

Figure 1 TiO_2 (left) and FeO (right) abundances in Mons Rümker derived from MI onboard SELENE.

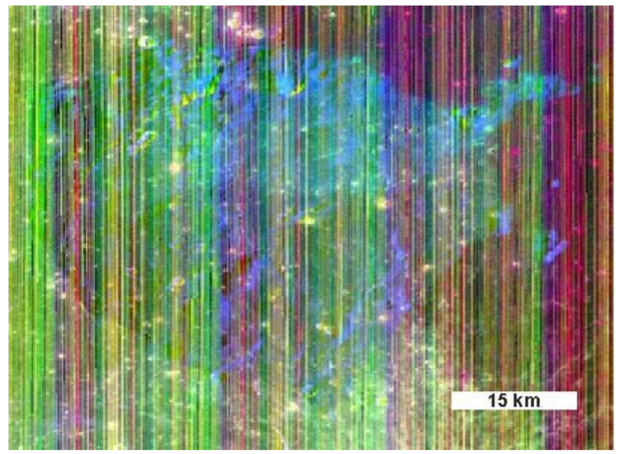

Figure 2 M^3 spectral parameter map of Mons Rümker and surrounding mare regions. R: 1 μm integrated band depth (IBD), G: 2 μm IBD, B: 1578 nm reflectance.

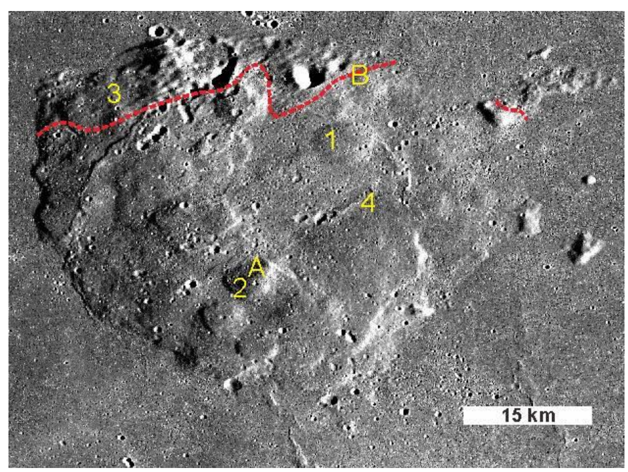

Figure 3 TC image of Mons Rümker. Numbers denote the area we perform crater counting: 1, Low dome; 2, Steep-sided dome; 3, Lineated terrain; 4, Non-dome region. Letters denote the two candidate landing sites. Dashed lines denote the boundary of lineated terrain.