A CONCEPT MISSION FOR LONG-DISTANCE EXPLORATION IN SCIENCE-RICH LUNAR MARE FECUNDITATIS REGION. S. Zhao[1], Y. Qian[1], L. Xiao[1], J. Zhao[1], Q. He[1], J. Huang[1], J. Wang[1], H. Chen[2], and W. Xu[2], [1]Planetary Science Institute, School of Earth Sciences, China University of Geosciences, Wuhan, China (siyuanzhao@cug.edu.cn), [2] Aerospace System Engineering Shanghai, Shanghai, China.

Introduction: Soviet Union, United States, Europe, China, Japan, and India have successively conducted their lunar robotic or crewed missions since 1960s. Tremendous of scientific discoveries have been made but even more questions have been raised, including (1) bombardment history, (2) lunar interior, (3) crust and regolith, (4) polar region and volatiles, (5) volcanism and thermal evolution, (6) impact process, and (7) space weathering [1], and more scientific landing sites across the Moon have been proposed [2–7]. The short detection distance (less than 39 km, made by Lunokhod 2 in 1973) of previous missions limits the complete scientific documentation of the investigation area and makes explore multiple sites in large distance at one mission is impossible. However, with the development of technologies, both China and United States may conduct multi-target long-distance missions in the near future [8,9]. The Intrepid mission concept [8] is one of the examples. In this study, we investigated the geological features in the Mare Fecunditatis, including various volcanic and tectonic features, and proposed a long-distance concept mission to conduct a comprehensive exploration. The mission could answer many of the outstanding questions as listed above.

Geology and geomorphology of Mare Fecunditatis: Mare Fecunditatis (centered at 53.7°E, 7.8°S) is in the low-latitude area on the eastern nearside of the Moon, covering an area of ~310,000 km^2. The basin was formed in the Pre-Nectarian epoch, while the mare basalts were mainly filled in the Imbrian period and continued until the Eratosthenian period [10–12]. Mare Fecunditatis (Fig. 1) has a diversity of volcanic features (mare deposits, sinuous rilles, lava tube, pyroclastic deposits, domes, irregular mare patches, ring-moat dome structures, etc.), tectonic features (graben and wrinkled ridge), craters, and other features (swirl, pit crater). In-situ investigation of these features may provide a window to study the lunar volcanism and interior processes.

Pit craters. Lunar pit craters formed by the collapse of underground space. A total of 15 pit craters have been discovered on the maria and 5 on the highlands [13]. The entrance to the central Mare Fecunditatis (Fig. 2) is about 125×100 m in size and 35 m in depth. Deposits lie on the southeast and northwest wall. The deposits on the northwest wall extend ~30 m laterally, with a slope of 20-65°. The southeast wall has collapsed severely, with a relatively gentle slope (10-35°). Most of the deposits are finer than the resolution of the NAC image (~1.1 m), with only a few meter-level rocks at the bottom of the pit crater.

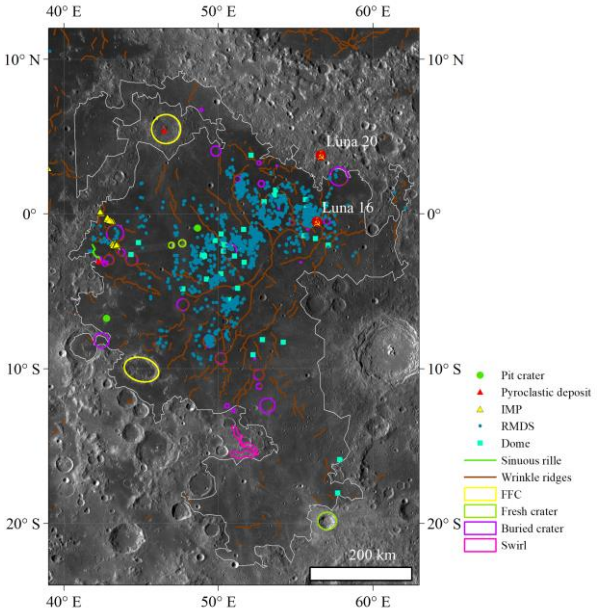

Fig. 1 Geological features in Mare Fecunditatis

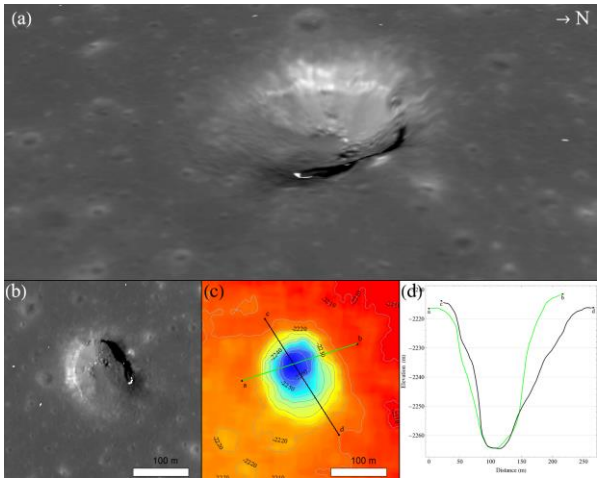

Fig. 2 Pit crater (48.660°E, 0.917°S) in the central Fecunditatis. (a) 3D image (real elevation value are used); (b) NAC orthoimage; (c) NAC DTM; (d) The elevation of profiles of (c).

Irregular Mare Patches. Irregular Mare Patches (IMPs) are enigmatic features occurring in the lunar

mare. The formation and age of IMPs are still under debate [14–17]. Typical IMPs (such as Ina and Sosigenes) are one to several kilometers in size and composed of positive-relief mounds surrounding low rough hummocky and/or blocky floor units. The IMPs in Mare Fecunditatis are relatively small (tens to hundreds of meters in size, Fig. 3) and only develop irregular, rough, bright, and pit features. In the western part of Mare Fecunditatis, dozens of IMPs are identified within a length of tens to hundreds of meters. Most of the IMPs are located next to the rim of craters, and a few IMPs are not connected to the crater.

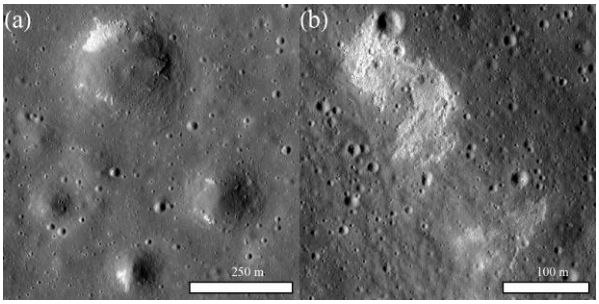

Fig. 3 Two sites of IMP in Mare Fecunditatis. (a) IMPs next to the crater rim (43.31°E, 2.02°S); (b) IMPs on the mare (42.41°E, 0.09°N).

Discussion: After analyzing the geological features in Mare Fecunditatis, several targets are selected with high scientific values: (1) pit crater wall expose in-situ lava strata and covering regolith profile. It may connect vast underground void space, which is an ideal place to build a research station; (2) young basalts (2.2-2.9 Ga) and impact melts of Messier Crater may be used to test the chronology functions; (3) young basalts and potential very young volcanism (IMP and RMDS) are key to the thermal evolution history of the Moon; (4) basalts in the southern Fecunditatis may be a type of high-Al basalt different from previous samples; (5) pyroclastic deposits are windows to understanding the composition of deep mantle; (6) swirls and magnetic anomalies are important to the history of lunar core dynamo and space weathering effects; (7) ray system of the fresh crater may disclose the mixing of local and ejecta material process. Here we summarize their scientific significance first and then design a traverse to detect all these targets for a ~1408 km traverse for a long-distance mission (Fig. 4).

Conclusion: A long-distance lunar traverse could solve times of fundamental scientific questions compared with a nominal short distance mission. The geology and topography of Mare Fecunditatis have been analyzed because the high scientific value of this mare plain to study the lunar impact and thermal histories. In total, eight high-value features (pit crater, IMP, RMDS, High-Al basalts, young basalts, pyroclastic deposits, swirls, and fresh craters) are selected Based on which a ~1408 km traverse has been proposed to explore this basin which may help future planning of this class of long-distance mission on the lunar surface.

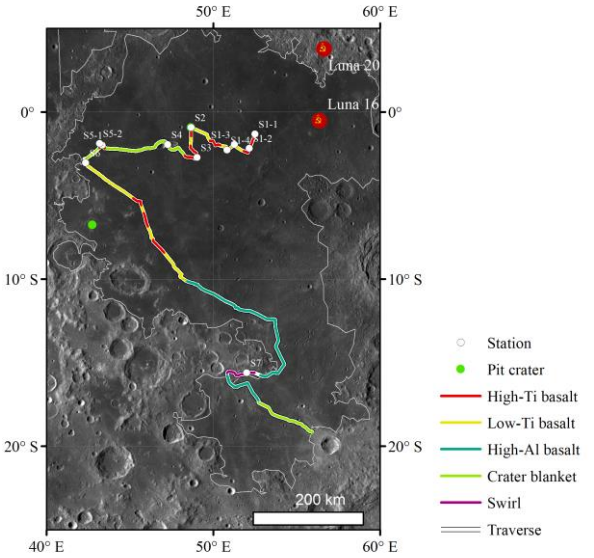

Fig. 4 Long-distance detection traverse in Mare Fecunditatis.

Acknowledgments: LROC WAC images and NAC images are available at PDS Geosciences Node (https://pds-geosciences.wustl.edu/).

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