Geomorphological map of Tianwen-1 landing area in the southern Utopia Planitia. Yuzhou Zhu[1], Bo Li[1*], Xiaohui Fu[1]. Shandong Provincial Key Laboratory of Optical Astronomy and Solar Terrestrial Environment, Institute of Space Sciences, Shandong University, Weihai, China.

Introduction: Tianwen-1, China's first Mars exploration mission, successfully landed in the southern Utopia Planitia on May 15, 2021 at 109.9°E, 25.1°N (Fig.1). Utopia Planitia has complex geological history of, including volcanic, glacial, fluvial, sedimentary, and weathering effects, which have produced rich and representative geomorphic features [1]. In Utopia Planitia, the evolution of the water/ice environment is a research hotspot, and based on it, a large number of related geomorphic features have been studied, such as Giant Polygon [2], Ghost Crater, pitted cone [3], Mesa, Ridge, Concentric crater fill and so on. Previous research has mapped the topography of both small-scale areas of the landing site and larger areas of SW Utopia Planitia [4,5], but there is a lack of research on the possible influence of dichotomous boundaries' topographic factors on the landing site.

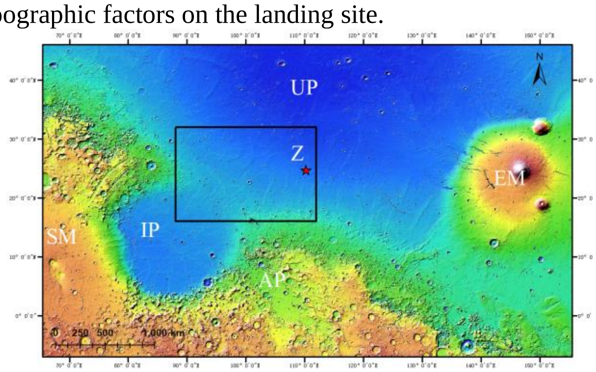


Fig.1. An overview of our study area (Black solid-line rectangle, details shown in Fig.2) which is also a part of the Tianwen-1 pre-selected landing area in regional context using the global Mars Orbital Laser Altimeter data set.

This paper focuses on studying the spatial distribution of geomorphic features in the southwestern Utopia Planitia, which contains dichotomous boundaries; divides geomorphic units based on the identification and characterization of geomorphic features, and draws a geomorphic map; analyzes the spatial correlation of sinuous ridges and mounds; and discusses the possible local geological history.

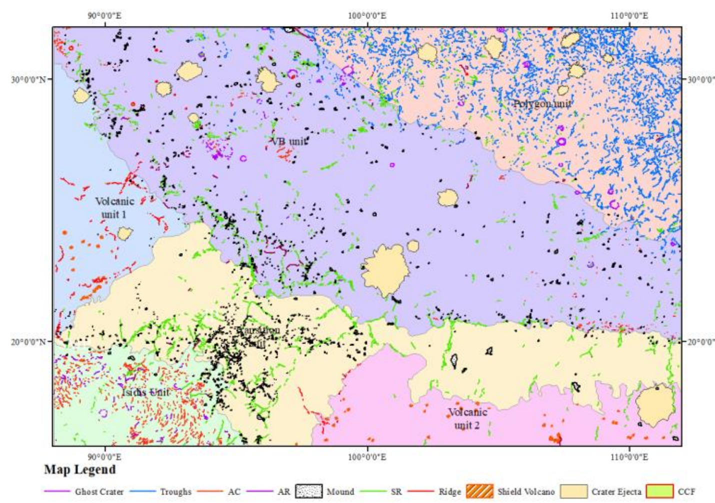
Data and Methods: The NASA Mars Reconnaissance Orbiter (MRO) Context Camera (CTX, ~7 m/pixel) and the Mars Odyssey Thermal Emission Imaging System (THEMIS, ~100 m/pixel) were applied to identify and represent geomorphic features and divide the boundaries of all geomorphic units. The global Mars Orbiter Laser Altimeter (MOLA) data set was used to resolve the mismatch of partial image boundaries between CTX and THEMIS, analyze the topographic information in the study area and find the relationship between the spatial distribution of geomorphic features and topographic factors.

On the other hand, we also used impact crater counts to obtain the age information of each unit. This process mainly performed on CTX images with high resolution, measuring the impact crater size-frequency distribution and obtaining absolute age models for age analysis by using impact crater statistics, Martian production and chronology functions [6].

All the work were performed in GIS software with projections of Equidistant Cylindrical and datum of Mars 2000.

Results: A 16×24 degree (948.4 km by 1422.6 km, ranging from 16°-32°N and 88°-112°E) area geomorphological map (Fig.2) was drafted, which covers at least 10 geomorphological features and 6 geomorphological units. Absolute model ages for each unit were calculated and graphed (Fig.4) to analyze the stratigraphic relationships between them and order information of possible geological activities.

Fig.2. Geomorphologic map of the southwestern Utopia



Planitia. The map is in simple cylindrical projection.

Discussion: In order to quantify the distribution scale of Sinuous Ridges (SRs) and Mounds on the surface, we selected Length sum of SRs and Area sum of Mounds in the step length interval of 50 km as the measurement index. Then, the graph of Length sum of SRs and Area sum of Mounds for Distance from Utopia's center distribution (Fig.3a) was made, and both distribution patterns showed a class-normal distribution. At the distances of ~1200km, ~1600km, and ~1850km from Utopia's center, both of them have their own distribution concentrations and form three "peaks" on the graphs Among them, the distance of 1600km corresponds to the dichotomous boundary in the study area. The substantial concentration at the dichotomous boundary suggests that the spatial distribution of them is influenced by topographic factors, which points to a large flood or glacial advancing or retreating event from the highlands to the lowlands. In addition, to investigate the spatial correlation between Sinuous Ridges and Mounds, a linear fit plot of Length sum of SRs versus Area sum of Mounds (Fig. 3b) was drafted by taking the distance from Utopia's center as the reference axis. Two of them show a good linear correlation with the correlation coefficient R^2=0.8283 and Pearson correlation coefficient of 0.9145, which all indicate a strong spatial distribution correlation between them, suggesting that SRs and Mounds may originate from related or even the same geological activity.

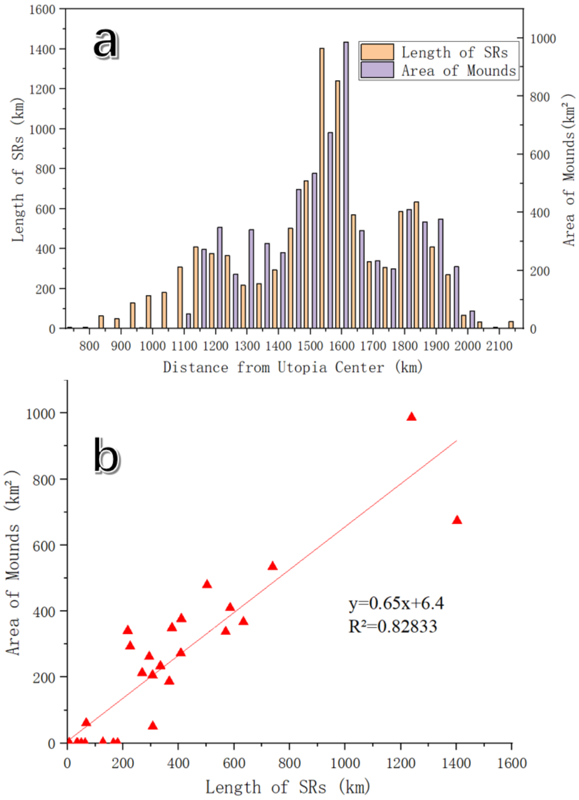


Fig.3. a) Length of SRs and area of Mounds versus distance from the center of Utopia. Both of them show a distribution pattern similar to the normal distribution and have the peaks distributing concentratedly at the similar distance (~1200km, ~1600km, ~1850km). Among them, the distance at ~1600km corresponds to the dichotomous boundary in the study area. b) Length of SRs versus Area of Mounds correlation plot. The linear fitting correlation coefficient is R^2=0.8283 and Pearson correlation coefficient is 0.9145, which all indicate a strong spatial distribution correlation between the two.

The comparison diagram of each unit's absolute age module is drawn (Fig.4) to analyze and study the stratigraphic information in the study area. The Isidis unit, the Volcanic unit 1&2, and the Transition unit all lie near the dichotomous boundary on Mars, and all originate from the earliest Late Hesperian, which correspond to the local Western Ridge volcanic plain [7]. Subsequently, the Vastitas Borealis unit formed and overlaid the surface of the oldest Utopia Planitia. Large-scale catastrophic floods or glacial advancing and retreating occurred in the southern highlands, resulting in the transport of large amounts of upland materials and water/ice to the southern Utopia Planitia and their placement on the surface of the Vastitas Borealis unit, which became the source of the large water body and water/ice environment of the Utopia basin. As the thickness of the cover on the surface of the VB unit increased, the surface pressure of the VB unit increased and bulk compaction occurred, forming Giant Polygons, which are observed in the northern part of the study area and corresponds to the thicker surface covering layer of the VB unit with stronger intense compaction. Eventually, continuously active Elysium volcanic lava flows [8] covered the central area of Utopia where Giant Polygon had been generated, burying a large number of original geomorphic features.

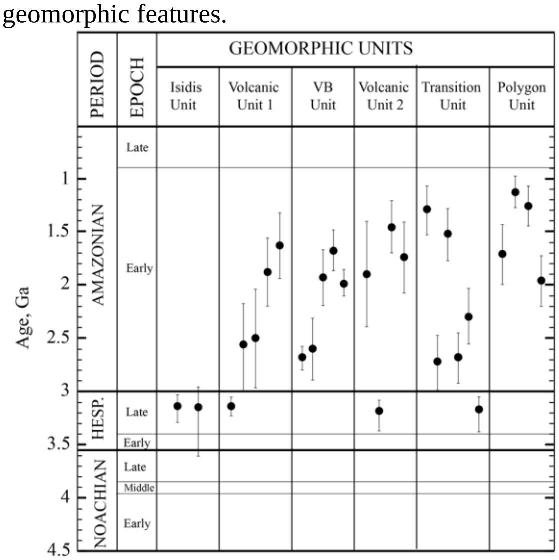


Fig.4. Correlation chart of the major geomorphic units in the southern Utopia Planitia.

References: [1] Tanaka, K. L. et al., (2005) scientific investigations map. [2] Buczkowski et al., (2012) JGR, 117.E8. [3] Guidat et al., (2015) EPSL 411, 253–267. [4] Ivanov et al., (2012) Icarus 218, 24–46. [5] Wu et al., (2021) Icarus 370, 114657. [6] Hartmann, Neukum, (2001). Springer, pp. 165–194. [7] Ivanov et al., (2014). Icarus 228, 121–140. [8] Platz et al., (2011). EPSL 312, 140–151.