

Estimation of Martian middle-latitude subsurface ice distribution using periglacial polygonal landforms

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Revealing the detailed distribution of subsurface ice on present Mars is important because it will be a useful water resource for human exploration in the near future. The Mars Subsurface Water Ice Mapping (SWIM) project recently provided a probable ice consistency map across middle-latitude on Mars, through the integration of orbital datasets based on the neutron spectroscopy, thermal analysis, geomorphological mapping, and radar surface/subsurface analysis (Morgan et al., 2021). NASA and its international partners are considering the Mars Ice Mapper (MIM) mission, which could help to identify abundant, accessible ice for future candidate landing sites on Mars. Some previous studies focused on periglacial polygonal landforms on Earth and Mars (e.g., Marchant & Head., 2007; Levy et al., 2009) to assess the Martian subsurface ice distribution.

Periglacial polygonal landforms are widely recognized in the surface of permafrost areas in polar regions on Earth (e.g., Alaska, Canada, Siberia and Antarctica). These landforms are developed by repetitive frost cracking and ice vein growth over hundreds to thousands of years. Repetition of such process results in the formation of elevated ridges by wedge-shaped ice, with lowered relief of ca. 10-20 m in width (which is named as, low-centered polygon; LCPs). There are areas with inverse topography and they are identified as high-centered polygon (HCPs), where well-drained mounds are surrounded by troughs above degraded ice wedges (Liljedahl et al., 2016). Polygonal landforms are extensively recognized on Mars within 30° to 80° in both northern and southern hemispheres by using High-Resolution Imaging Science Experiment (HiRISE) image data. Based on morphological characteristics, Levy et al. (2009) classified seven groups of polygonal terrain and proposed their different latitudinal distributions on Mars. However, geographical distribution patterns of various shapes of polygonal terrain remain uncertain on Earth, and their relationship with subsurface ice depth is a scientific topic still underexplored.

In this study, we first investigate the distribution of various shapes of polygonal terrain on Earth by using remotely sensed images through Google Earth. Following the classification of Levy et al. (2009), we classified four morphologically different types of polygonal terrains, identified as, “Flat-top polygons”, “Subdued polygons”, “Mixed-center polygons”, and “Peak-top polygons”. An opposite trend in latitudinal distribution was observed for the “Peak-top polygons”, as they are located at the higher latitude range on Earth, while this is the case at lower latitudes on Mars. It is noteworthy that the “Peak-top polygons” are resembling sublimation-type polygons observed in the Dry Valleys of Antarctica (Marchant & Head., 2007). Thus, we suggest that cold and dry environments where sublimation is predominant may have been a controlling factor in the development of this polygonal terrain, although further investigation is required to confirm this inference.

We then investigated the distributional pattern of periglacial polygonal terrains from 25°N to 40°N and from 0°E to 130°E on Mars. This latitudinal area was chosen since this area is a priority observation target for MIM. In addition, the longitudinal area was chosen since this region is located in various elevations, topographic reliefs, and geologic settings (between Utopia Planitia and Arabia Terra). Observing over 1450 HiRISE images, we marked the distributional patterns and found the longitudinal control over the different types of morphological patterns of polygonal terrains. The possible cause of their unique

distributions will be discussed in the presentation.

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