Reconstruction of subsurface ice distribution and surface environment on Mars by comparison of terrestrial analog sites

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About 4 billion years ago, Mars had a warm and humid environment with a thick atmosphere and oceans, and a habitable environment similar to that of the present-day Earth. On the other hand, after the atmospheric dispersal about 3.5 billion years, Mars became extremely cold and dry environment with no liquid water on the surface. However, some of the liquid water that existed in the ancient Martian surface is thought to be present in the polar ice sheets and subsurface ice in mid- to high-latitude regions (Head et al., 2003). In addition, recent studies have pointed to the possibility of subglacial lakes in Martian polar ice-caps (Orosei et al., 2018) and the (meta)stable brines at high latitudes (Rivera-Valentin et al., 2020), suggesting the possible existence of habitable environment on the present-day Mars. In this presentation, we will introduce some of our research results regarding the estimation of the subsurface ice distribution and surface environment on Mars, based on the field survey of terrestrial analog sites (Mongolia), where the environment is similar to that on Mars. We also present our findings that have led to the reconstruction of the past surface environmental change on Earth through studies conducted in comparison with Mars.

One of the research targets is a periglacial landform of “Thermal contraction polygon”, which are polygonal fracture landforms with diameters ranging from several meters to decimeters, and formed by repeated freezing and thawing of frozen soil in permafrost areas due to the presence of ground ice (Marchant & Head, 2007; Levy et al., 2009). On Earth, it has also been observed that shape of thermal contraction polygon in Alaska changes from “Low centered polygon” to “High centered polygon” as a results of the permafrost thawing (Liljedahl et al., 2016). On the other hand, the distributional pattern of the shape of the thermal contraction polygon on mid-latitude of Mars has not been fully investigated. Estimating the distribution and amount of subsurface ice on present-day Mars is important because it will provide water resources for NASA's future human mission to Mars in the 2040’s. In this study, we conducted field survey of thermal contraction polygons in northern Mongolia, where located at the southern limit of permafrost and/so analog site in the mid-latitude of Mars, and examined the causal mechanism of the shape of the thermal contraction polygon. We then visually investigated periglacial landforms using high-resolution satellite images (HiRISE: 1 pixl 30 cm spatial resolution) in the mid-latitude (30°-42°N), where a candidate landing site of human exploration of Mars, to estimate the distribution of existing subsurface ice. Furthermore, we estimated how the subsurface ice distribution has changed from the past high-obliquity period to the present by comparing the Martian GCM results (Madeleine et al., 2009).

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