論文の内容の要旨

論文題目 Topography, distribution, and constituent materials of rootless cones in Myvatn, Iceland, as terrestrial analog cones of Athabasca Valles, Mars

(アイスランドのミーヴァトンにおけるルートレスコーンと火星上類似地形の比較惑星科学的研究)

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Mars is characterized by strong similarities to the Earth in various aspects such as the surface environments, the internal dynamics and the geological evolution. Martian volcanism has been one of the such highlighted research subjects and extensive comparative researches have been conducted between Mars and the Earth. Since the size of Mars is about a half of that of the Earth, the interior has been expected to be evolved further so that the volcanic activity is suspected to have been already declined. In this context, the young volcanic activities reported so far have drawn special attentions with respect to their reality and distinctions from the older ones. In this thesis, I focus on the geological settings of Central Elysium Planitia (CEP), which is suspected as a site of the latest magmatism on Mars. About the origin of extremely flat plain in this area, hot debate has grown: lava flows or water floods, which would lead to completely different contexts in the evolution of Mars. Conical mounds pervasively exist in CEP (hereafter CEP cones) are a key to resolve this controversy. The origin of CEP cones is the main theme in this PhD study.

This study focuses on unique morphological features of CEP cones. In Athabasca Valles, there exist specific types of cones: double cones (DCs) and lotus fruit cones (LCs). In general, CEP cones have a simple structure: a conical edifice with a summit crater. However, DCs and LCs have (an) inner cone(s) inside the summit crater. These morphological features would be a key to identify CEP cones whether volcanic rootless cones or periglacial pingos. To fill shortage of the data inherently existed in planetary data, I have explored the terrestrial analogues. Among the terrestrial cone fields, there exist DCs- and LCs-like cones in Myvatn, Iceland. Cones in Myvatn are rootless cones, which were formed by an interaction between lava and waterlogged sediments (rootless eruptions) in 2300 years ago. Though previous studies mentioned the existence of Myvatn DCs, there is no quantitative morphological data, which could help interpretation of CEP cones through comparison. Furthermore, its formation mechanism has not been clarified. The formation of DCs and LCs seems to be inconsistent with the conventional model. These types of rootless cones have been paid less attention even in the terrestrial volcanology.

In order to overcome this issue, a field campaign in Myvatn was performed focusing on the topography, the distribution and the constituent materials of rootless cones. To know high-resolution topography, this study adopts kinematic GPS (Global Positioning System). Collected tephra samples of the rootless cones were analyzed in terms of grain size distribution, bulk density, vesicularity, and chemical composition. DCs and LCs are concentrated in the specific area in Myvatn. They are located in lake area (Lake Myvatn) within 15 km from the fissure vent; they do

not exist on the paleo-riverbed. In the outcrops of cross sections of DCs in Geitey Island, a structural boundary between the outer cone and the inner cone is clearly recognized, which shows the inner cone was formed by a subsequent separate explosion episode.

For comparison, topographies and distributions of CEP cones were analyzed using several Martian remote sensing data such as the high-resolution visible images and the topographic data. The topography of DCs and LCs resembles to Myvatn ones. The area with high population of DCs and LCs meet the following requirements; 1) the place in flow center of Athabasca Valles (smooth, the regional slope is about 0.02◦), and 2) the place in front of streamlined islands against the CEP flowed materials, where the deposition is expected by these obstacles.

Rootless eruptions have unique characteristic among pyroclastic cone eruptions. They fall into intermediate between phreatomagmatic and magmatic by the crater diameter/volume study. The analysis on the constituent material reveals the explosivity/fragmentation of rootless eruptions decreases with time. The explosivity/fragmentation in the formation of the inner cone was weaker than that in the formation of the outer cone. Morphometrical analysis and the distribution pattern indicates that the geomorphological diversity of rootless cones is related to the availability of water during the formation. Based on the descriptions of Myvatn cones, this study proposes a consistent scenario of DCs formation; the inner cone of DCs is formed by delayed explosions due to percolation of water through the waterlogged sediments. Since this scenario is consistent with the topography of Athabasca Valles, CEP cones can be concluded they are rootless cones, which are formed by interaction between lava-icelogged sediments. Considering this scenario, CEP was abundant in water/ice during the rootless cone formation, which is thought to occur in recent 2 million years.