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Morphometric similarities between Elysium Mons and Mauna Kea

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Abstract

One of the major martian volcano,Elysium Mons has a unique volcanic morphology;an existence of high-sloped top. We focus on the morphological resemblance between Elysium Mons and Mauna Kea in Hawaii and interpret the morphology in terms of the evolution of hotspot volcanism.

1. Introduction

Morphometric characteristics of volcanic edifice contain a lot of information about the evolution of volcano. Generally two distinct processes are tangled up to construct the morphology;original process associated with the growing stage of the volcano and afterward modification process such as erosional process. To separate these two is a prime target in the research of volcanic morphology. Recently backed up with advancements of high quality,homogeneous DEM the morphometric characteristics have been recognized as good parameters to inspect volcanic activity and style of volcanism([1]). For example, Grosse et al([2]) presented a comprehensive database for the morphometry of terrestrial composite volcanoes based on SRTM-DEM. Keryvn et al([3])conducted morphometrical study on terrestrial monogenetic cones and summarized general features of the cones. Karatson et al ([4]) calculate morphometrical parameters for stratovolcanoes. In these studies the average edifice slope as a function of the fractional height is proposed as a useful relationship to characterize volcanoes. Using these data as references Higuchi and Kurita recently classified 18 martian large volcanoes into 5 types by using gridded MOLA data:MEGDR-128(in preparation). Fig.1 shows typical examples of these 5 types. We divided the edifice into 20 sections from top to bottom and estimated the average slope in each section. X axis represents the average slope and Y axis represents the fractional height. Among 5 types Olympus Mons type represents a convex morphology, which is similar to the shield volcanoes such as Mauna Loa,Hawaii and Ceraunius type represents a constant slope edifice, which is similar to the scoria cone. Elysium Mons is quite unique in this diagram and there are no other martian volcanoes having similar relation between height and the slope. To explore the origin of Elysium Mons and the style of volcanism from morphometrical data is our target in this presentation.

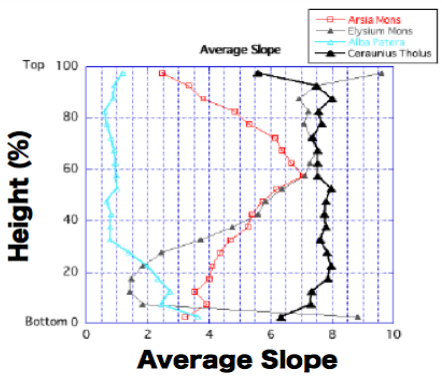

Figure 1: Average slope vs fractional height for 5 types

2. Morphological comparison between Elysium Mons and Mauna Kea

To further characterize the morphometry of Elysium Mons we calculate slope value as a function of the height using two DEM;gridded MOLA-DEM(463m/pixel) and HRSC DEM(100m/pixel). Figure 2 shows the absolute values of the slope are systematically different between two but overall trend is quite similar; the slope increases reaching the max. at around 60 percent of the height,then decreases and

reaches the minimum around 80 percent,then increases to the top. The systematic difference may reflect the difference in the pixel size. Up to 80 percent of the height the trend is similar to that of the Olympus Mons type,a typical shield volcano. This suggests Elysium Mons also started as a shield volcano but at later stage it transformed to another style. The difference is an existence of high-sloped top. Typical shield volcanoes such as Mauna Loa in Hawaii has a flat top,a decreasing slope towards top. The main edifice of Mauna Loa is composed of low viscosity basalt lava flows and the morphology is mainly controlled by low viscosity. The existence of high-sloped top in Elysium Mons indicates change of eruption style or change of magmatic composition. If the eruption style changes from effusive lava flow to explosive one the slope should be controlled by the repose angle of pyroclasts, which is usually much higher value than the viscosity-controlled slope. There is no positive evidence to support the existence of explosive eruptions at Elysium Mons. If the magmatic composition changed and the viscosity increased high-sloped edifice may be formed.

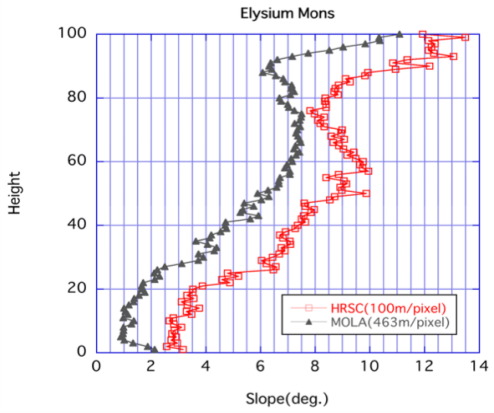

Figure 2: Average slope vs fractional height of Elysium Mons for two DEM

Looking for the terrestrial similar objects we calculate slope-heigh relationship for various types of volcanoes by global SRTM-DEM. We found Mauna Kea in Hawaii Is. has a similar morphometry. Figure 3 compares the average slope as a function of the fractional height for two volcanoes.

In Mauna Kea the high-sloped top is attributed to the different magmatic composition and the glacial activity([5]). Typical Hawaiian style hotspot volcanism

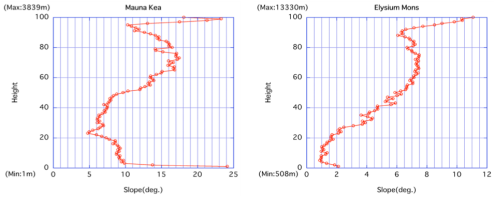

Figure 3: Average slope vs fractional height for Mauna Kea(left) and Elysium Mons(right)

follows three stages;pre-shield,shield and post-shield stages and the chemical composition of the post-shield stage shifted to be silica-rich, which indicates more viscous magma.

Elysium Mons is estimated to have longer activity than large shield volcanoes of Tharsis(Olympus Mons, Arsia Mons,Pavonis Mons,,,) by [6]. This suggests Elysium Mons has evolved further and possibly to the post-shield stage, while other Tharsis volcanoes still have remained at main shield stage. Estimate of the chemical composition of the constituent lava by remote sensing spectroscopy can resolve this hypothesis.

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