Analysis of volcanic surface morphology on Mars by MOLA data

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Mars has strong similarity to the terrestrial geological features. Like Earth, its surface has been subjected to exogenic processes, such as impact cratering, erosion by water and wind and endogenic processes including tectonics deformation of the crust and volcanism. These processes have provided various features of the surface morphology.

The investigation and comparison of the surfaces of Earth and the other silicate planets have revealed importance of volcanism, especially universal existence of basaltic volcanism in the formation and evolution of the crusts. While there are many similarities between the styles of volcanic activity which are presently observed or occurred in the past on Earth and Mars, there are also significant differences. It is because that eruption style is controlled by a combination of factors such as magma composition and temperature, volatile content in the magma, tectonic setting and external environment (ex. gravity and atmospheric pressure). To study volcanoes of the other planets provides a clue to know the generality and peculiarity of volcanic eruption on Earth.

Here, in this presentation, we will focus our attention on the slope of volcanoes. As a description of planetary surfaces, slope is pertinent to the mechanism of formation of physiographic features and is indicative of the style and the duration of subsequent modificational processes. The distribution of flank slopes provides information on volcanic style and constituent magmatic composition. As a step toward quantifying the nature of surface processes of Martian volcano, we analyze slope statistics.

To calculate the slope, highly densed topographical data is necessary. In the previous researches at the Viking era, photogrammetric analysis of the stereo images by the Viking orbiters were widely used. However there are many error sources in this approach. Particularly the errors associated with the position of the spacecraft is significant. Smooth or cloudy regions are poorly suited for this technique. The resultant vertical errors in the maps of Mars were as large as a few kilometers. The data supplied by Mars Global Surveyor (MGS) has completely changed this situation. The Mars Orbiter Laser Altimeter (MOLA) is one of the instrument onboard MGS spacecraft. The MOLA can determine the surface elevation with accuracy of less than 1 m and shot spacing of about 0.3 km. The MOLA data have provided accurate three-dimensional description of volcanic edifice and flow. We analyze slope of Martian volcano quantitatively by MOLA data and reveal features that can not be detected by the conventional photogrammetric analysis.

It is more suitable to use grid data than line profile data for determine the average slopes of volcanoes. Because the result of the analysis along profiles didn't give the absolute slope since the measurement is restricted to the ground-track direction (usually north-south) which may not follow the gradient direction.

From these analysis about twelve Martian volcanoes, we classified these volcanoes into three types by trend of average the slope as a function of its elevation and investigated main component of volcanoes from slope of flank; 1) erosion-dominant type [ex. Tyrrhenum patera], 2) strato volcano (broad range slope) type [ex. Olympus Mons], 3) constant slope type [ex. Ceraunius Tholus].

The first type of volcanoes is highly eroded and histogram of the slope has power-low type distribution. The second type of volcanoes is mainly constructed by lava and average slope is 4-6 (deg.). At the low elevation the average slope is 0-4 (deg.). The third type of volcanoes is mainly constructed by pyroclastic fall and the average slope is constant and higher than others [Ceraunius Tholus : 9 (deg.), Uranius Tholus : 9 (deg.), Tharsis Tholus : 18 (deg.)].