

Geomorphic Comparison of Volcanoes on Earth and Mars: Implications for Plate

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Introduction: Many volcanoes on Earth are asymmetric in shape in map view. This research examined volcanoes in different tectonic settings to assess possible influences of tectonics on terrestrial volcanoes. Volcanic regions studied are the Galapagos Islands (a hot spot), the Caribbean, the Philippines, and Java, Indonesia, all of which are ocean-ocean plate subduction zones. The geomorphology of the volcanoes in these regions may be compared to the volcanoes on Mars to assess possible tectonic control on edifice evolution.

Background: Conventional models depict volcanoes as radially symmetric in map view with a conical shape in profile. Not all volcanoes around the world are symmetric in shape. Volcanic asymmetry can be caused by various processes, including sector collapse, regional extension, and differential erosion.

Methodology: The geomorphology of volcanoes was examined through remote sensing. The volcanoes studied in this research are: Soufriere in St. Vincent, Alcedo, Cerro Azul, and Sierra Negra in the Galapagos Islands, Patuha and Tangkubanparahu in Java, Indonesia, and Ragang and Kalatungan in the Philippines. The images are from shuttle imaging radar (SIR-A). An example of a SIR-A image can be seen in Figure 1. Matutum Volcano in the Philippines was also studied but the image used was from the airborne Sea Ice and Terrain Assessment (STAR-1) Inter X-band synthetic aperture radar (SAR) system [1]. We investigated the feasibility of using Seasat SAR imagery, but its limited resolution and problematic effects from foreshortening prevented us from obtaining meaningful results.

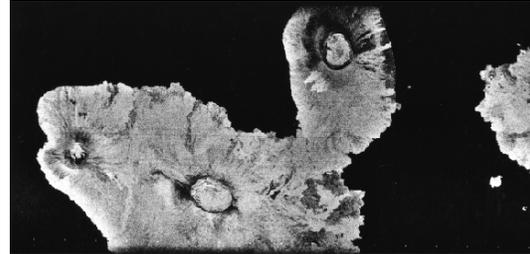


Figure 1: Image of Isabela Island of the Galapagos Islands taken by SIR-A. In this image, from west to east, Cerro Azul, Sierra Negra, and Alcedo Volcanoes can be seen [2].

A quantitative analysis of volcano asymmetry was done by measuring the dimension of the long axis of the edifice and that of the axis normal to that. A percentage of circular symmetry was then calculated between these two values. The length of the axes parallel and normal to the flight path were also determined and a percentage of circular symmetry was calculated for these values as well. Examples of axes measurements are in Figure 2. A ratio between the two sets of circular symmetry data was then calculated to determine a more robust circular symmetry percentage of the volcanic edifice. Ratios are listed in Table 1.

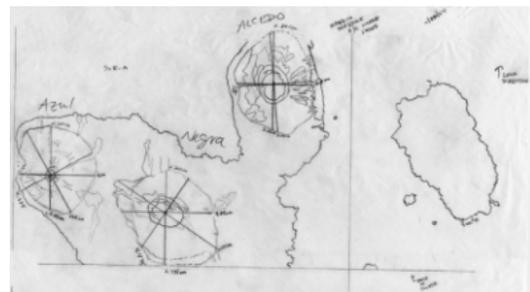


Figure 2: Sample of measurements taken from the volcanoes in the Galapagos Islands.

The percentages found are then compared to relative plate motions along the subduction zone where the volcanoes are located. Arc normal and arc parallel components of relative plate convergence

were calculated to examine correlations between inferred extension directions and volcano asymmetry.

Our goal is to create a database of the Earth volcanoes for comparison to those on other solar system bodies, such as Mars, Venus, and Io. Martian and terrestrial volcanoes may be compared to identify similar volcanic geomorphologies that may have implications for tectonic influence on volcano evolution on Mars.

Results and Conclusions: The preliminary results show that the percent circular symmetries calculated correlate with an observed analysis of the volcanic symmetries.

Table 1: Volcanoes measured and their percent symmetries calculated.

Volcano	Location	Tectonic Setting	Symmetry %
Alcedo	Galapagos Is.	S	94.43
Cerro Azul	Galapagos Is.	S	96.66
Sierra Negra	Galapagos Is.	S	71.72
Soufriere	St. Vincent	CM	85.95
Patuha	Java, Indonesia	CM	53.04
Tangkubanparahu	Java, Indonesia	CM	76.65
Ragang	Philippines	CM	84.09
Kalatungan	Philippines	CM	44.63
Matutum	Philippines	CM	56.57

S = Shield, CM = Convergent Margin

The shield volcanoes in the Galapagos Islands are more symmetric than the stratovolcanoes studied in the other three areas. Stratovolcanoes in convergent margins are effected more because the source of the magma is not in a fixed position relative to the overriding plate, whereas for shield volcanoes the magma source, or hot spot, is in a fixed position. It should also be noted that Martian volcanoes are nominally more similar to terrestrial shield volcanoes. It is too early to conclude that convergent margin volcanoes would

therefore have a preferential extension in a given direction due to the magma source not being in a relative fixed position while plate subduction occurs. It is also too early to determine if there are any correlations between plate tectonics and the geomorphologies of these volcanoes. Ideally a global database of the volcanoes on Earth would be needed before any robust conclusions could be made. A global database would also be more beneficial when comparing terrestrial volcanoes to Martian volcanoes.

References:

[1] Airborne and Spaceborne Radar Systems
http://www.ccrs.nrcan.gc.ca/ccrs/learn/tutorials/fundam/chapter3/chapter3_10_e.html

[2] Radar and Microwave Remote Sensing
http://www.sbg.ac.at/geo/idrisi/remote_sensing_tutorial/rst.gsfc.nasa.gov/sect8/sect8_7.html

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