LOW-SHIELD VOLCANISM: A COMPARISON OF VOLCANOES ON SYRIA PLANUM, MARS AND SNAKE RIVER PLAIN, IDAHO.

A. O. Henderson[1], E. H. Christiansen[2], and J. Radebaugh[3] [1]Brigham Young University, S389 ESC Provo, UT 84602, [1]amhendu05@gmail.com, [2]e_christiansen@byu.edu, [3]janirad@byu.edu.

Introduction: Volcanoes are key indicators of a planet's internal structure, mechanics, and evolutionary history. The very shape of the volcanic landform divulges information about the composition of the magma and eruption mechanisms, as well as the tectonic setting in which the volcano formed. Low-shield volcanoes form on Earth and Mars in specific tectonic settings. Low-shield volcanoes typically have a volume between 0.1-15 km^3 and slopes of less than 15° [1,2]. Low-shield volcanism on Mars appears to be most prevalent in the Tharsis region, the largest volcanic province on Mars. Similar volcanoes have formed in a few locations on Earth. For example, Hawaii and Iceland have volcanoes and vents that possess similar characteristic to low-shield volcanoes. However, the Snake River Plain of southern Idaho remains the most appropriate area for an analog study of volcanism on Syria Planum.

The purpose of this study is to complete a detailed analysis of the morphometry and similarities of volcanoes from Syria Planum and the Snake River Plain. The major questions we address are: (1) How similar are the volcanoes of Syria Planum and the Snake River Plain? (2) Using an understanding of the eruptive history of the Snake River Plain low-shield volcanoes, what does the similarity or dissimilarity of the volcanoes imply about the eruptive histories and mechanisms of Syria Planum volcanoes?

Methods: We used a 10 m DEM for the Snake River Plain produced by the U.S. Geological Survey, a MOLA DEM with an approximate resolution of 462 m per pixel, and an HRSC da4 DEM with an approximate resolution of 75 m per pixel. The use of two different DEMs for Mars was to see if higher resolution data gave better correlation between Syria Planum and the Snake River Plain volcanoes. Shields were defined by draping a colorized DEM over a vertically exaggerated shaded relief map of each area and defining the base of the shield at an identifiable break in slope. These boundaries were checked against available imagery and geologic maps. For this study flow aprons were excluded. Measurements were made in ArcGIS. Height was defined by taking the difference between the highest and lowest elevation points of each shield. The mean flank slope was determined by creating a slope map of each shield and then averaging the values of all cells within the map. Volume was calculated using the Surface Volume tool in ArcGIS, and diameter is that of a circle with the same area as the shield.

Observations: The Snake River Plain is a topographic depression bounded by Basin and Range fault systems and runs west to east in southern Idaho marking the Yellowstone hot-spot trace. The low-shield volcanoes that are typical of this area consist of monogenetic Pleistocene and Holocene basaltic lavas [1] emplaced as compound, tube-fed lava flows. The shields are clustered along the central axis of the plain. However, there are also several locations where the clusters align with the Basin and Range faults that bound the plain. The average, minimum, maximum, and standard deviations for height, mean flank slope, diameter, and volume of the studied shields are reported in Table 1; 229 shields were studied on the Snake River Plain, 81 of which were unburied by neighboring flows. Approximately 48% of the shields studied do not have preserved craters: nonetheless, radial flows and general morphology reveal summit vent locations. Approximately 11% have both a point type summit vent and off-summit pit craters and 77% of pit craters are elongated. About 27% of the shields have multiple vents. The steepest shields are marked by near vent spatter ramparts.

Table 1. Morphometric parameters for all low-shields on Snake River Plain and for those shields on Syria Planum that have both MOLA and HRSC data.

	Height (m)	Mean Flank Slope (°)	Diameter (km)	Volume (km^3)
	Snake River Plain (229 Shields)			
Avg	80	2.4	4	1
Min	13	1.0	0.4	0.001
Max	250	9.7	14	13
STD	44	1.2	3	2
	Syria Planum MOLA (160 Shields)			
Avg	109	0.7	12	11
Min	22	0.2	3	0.1
Max	451	2.8	40	199
STD	69	0.4	6	23
	Syria Planum HRSC (160 Shields)			
Avg	191	1.7	12	16
Min	61	0.6	3	0.3
Max	542	6.5	41	241
STD	89	0.8	6	28

Syria Planum is on the southeastern margin of the Tharsis province of Mars. It is bounded by three distinct tectonic provinces and forms a high plateau with a regional slope to the southeast. The volcanoes in this area range in age from early Hesperian to early Amazonian representing nearly 900 m.y. of Martian history [3,4]. The shields appear to cluster along preexisting fault systems. 261 shields were studied on Syria Planum, 160 of which have HRSC and MOLA data. Approximately half the studied low-shields in Syria Planum have recognizable pit craters. Approximately 87% of these pit craters are elongated or form chains along the ridge axis of the shield, and 15% have multiple pit craters.

Measurements taken from HRSC DEMs consistently give significantly greater mean heights, steeper flank slopes, and greater volumes than measured with MOLA data. The larger heights for the same diameter shields forces a steeper mean flank slope and greater volume for the HRSC measurements.

When buried shields are excluded, the heights of Snake River Plain shields vary little from the heights of volcanoes on Syria Planum measured using MOLA data (Figure 1). Because measured diameters for MOLA and HRSC are the same, the greater similarity between SRP and SPHRSC trends for slope v. height, diameter v. height, and diameter v. slope can be attributed to the larger heights measured from HRSC data. Snake River Plain shields are similar in morphology to Syria Planum shields but they are systematically smaller in diameter, area, and volume with steeper mean slopes.

Conclusions: This study quantitatively reinforces previous qualitative conclusions that the low-shield volcanoes of Syria Planum and the Snake River Plain are similar. We also show that higher resolution topographic data (HRSC) show greater similarities in morphometric trends defined by the volcanoes of the Snake River Plain. Consequently, the volcanoes probably have similar eruption mechanisms and lavas with similar viscosities and compositions.

The larger sizes of the shields on Syria Planum than on the Snake River Plain may be linked to the smaller size of Mars. Because it is smaller, it has a lower gravitational force, which also results in lower buoyancy requirements for batches of magma rising through the lithosphere. The forces required for breaking through the crust is probably about the same on Earth and on Mars. Since the buoyancy force for a given volume of magma is smaller on Mars, the total volume of rising magma must be greater than on Earth to overcome the strength of the brittle crust [5]. The resultant larger magma batches could lead to higher eruptive rates and longer lava flows. This could then explain the larger diameters of the Syria Planum shields, their lower profiles, and larger sizes. In addition, greater bubble nucleation depths and lower gravity lead to wider dispersal of spatter and spatter fed flows on Mars.

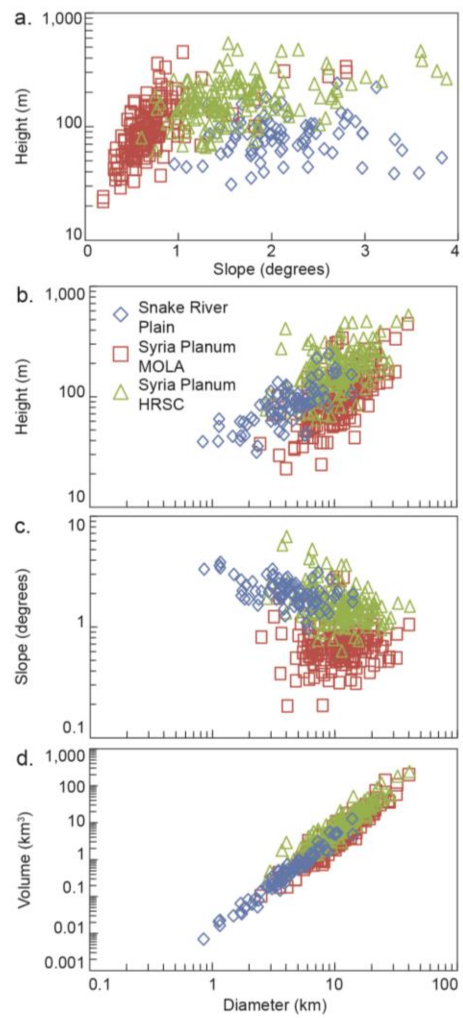

Figure 1. a: Mean slope v. height of low-shield volcanoes on Earth and Mars. b: Trends for height v. diameter are similar for SRP and SP-HRSC. c:Trends for slope v. diameter are also similar for SRP and SP-HRSC. d: Trends for volume v. diameter are similar for all data sets and show SRP shields are smaller but follow same trend as SP shields.

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