TOPOGRAPHIC EVIDENCE FOR ERUPTIVE STYLE CHANGES AND MAGMA EVOLUTION OF SMALL PLAINS-STYLE VOLCANOES ON EARTH AND MARS. S. S. Hughes[1], S. E. H. Sakimoto[2], T. K. P. Gregg[3], D. J. Chadwick[1], S. B. Brady[1], M. A. Farley[3], A. A. J. Holmes[1], A. M. Semple[3] and S. L. Weren[4], [1]Dept. of Geosciences, Idaho State University, Pocatello, ID 83209, hughscot@isu.edu; [2]Geodynamics Branch NASA/GSFC, Greenbelt, MD 20771; [3]Dept. of Geology, University at Buffalo, 876 Natural Science Complex, Buffalo, NY 14260; [4]Dept. of Geoscience, Franklin and Marshall College, PO Box 3003, Lancaster, PA 17604.

Introduction: Topographic profiles and surface characteristics of small (5 – 25 km diameter) plains-style shield volcanoes on the eastern Snake River Plain (ESRP) [1-3] provide a method to evaluate eruptive processes and magmatic evolution on Martian volcanic plains [4, 5]. The ESRP is an ideal place to observe Mars-like volcanic features where hundreds of small monogenetic basaltic shields dominate the volcanic-sedimentary depositional sequence, and numerous planetary analogues are evident [1, 3]: coalescent mafic shields, hydromagmatic explosive eruptions, the interaction of lava flows with surficial water and glacial ice, and abundant eolian sand and loess. Single flows cannot be correlated over great distances, and are spatially restricted. These relations are useful for planetary exploration when inferring volcanic evolutionary patterns in lava plains represented by numerous eruptive vents.

High spatial resolution imagery and digital topographic data for Mars from MOC, MOLA, and THEMIS is allowing for improvements in the level of detail of stratigraphic mapping of fields of small (< 25 km in diameter) volcanoes as well as studies of the morphological characteristics of individual volcanoes [5, 6, 7]. In order to compare Mars and Earth volcanic features, elevation data from U.S.G.S. 10-meter digital elevation models (DEMs) and high-precision GPS field measurements are used in this study to generate ~20m spacing topographic profiles from which slope and surface morphology can be extracted. Average ESRP flank and crater slopes are calculated using 100 – 200 m spacing for optimum comparison to MOLA data, and to reduce the effects of surface irregularities.

Slope Parameters: ESRP plains-style volcanoes (Fig. 1) have gently sloping lower flanks and distal "outflow" regions with ~2 – 5m surface irregularity (Fig. 2). Distal slopes generally represent the original topography on which lava flowed, which is usually less than 1°. Characteristic types of non-explosive volcanoes are either shields with low overall profiles and only slightly elevated summit regions, or shields with steeper flanks near vents and an elevated topographic crown at the summit. Both types may also have broad flat areas on the flanks indicating possible lava lake impoundment, or collapse pits in vent regions due to magma drainout through lava tubes. Average slopes in distal regions are typically <1°. For example, Pillar Butte, a Holocene ESRP shield (Wapi lava field) of the first type has an average distal outflow slope of ~0.74°, and the maximum local slope around the vent region is 8°. Table Legs Butte, a mid-Pleistocene shield of the second type has distal slopes of ~1.3°, a topographic shield with slopes of ~1.9°, and an elevated crown at the summit with local slopes up to 17°.

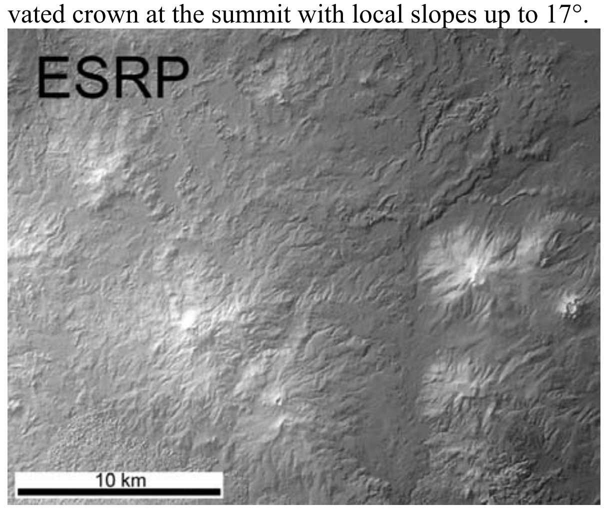

Figure 1. Digital elevation model of representative ESRP region on Earth depicting the coalescence and variability in size and shape of mafic shields.

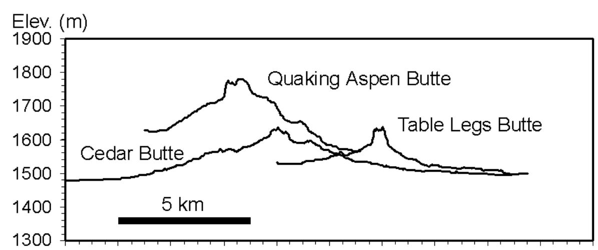

Figure 2. Topographic profiles of ESRP shield volcanoes with distinctive topographic crowns.

The small volcanoes in the Tempe Terra region (Fig. 3) have geomorphologies similar to the crowned shields on the ESRP. Although the average slopes of large shield volcanoes on Mars (except Alba Patera) typically range ~1–7° [8], plains-style Tempe Terra volcanoes and their distal lava flows have characteristically much lower slopes. They are thus typical of Martian small shields that have average flank slopes of ~0.25°–1° and bimodal slopes with steeper summit slopes of ~1°–2° [6]. Profiles of Tempe Terra shields (Fig. 4) indicate lower distal slopes of ~0.26° and flank slopes of 0.7°–0.9°. The profiles suggest that, although the slopes are different from ESRP volcanoes, their overall volumes are similar and a definitive change in eruption style is reflected in slope change and the construction of a summit crown.

Shields with summit crowns thus produce characteristic profiles, regardless of total size and volume of the volcano, that can be used to infer late-stage changes in eruptive style that is not manifested in shields without summit crowns. Bimodal slopes indicate likely changes in eruptive style with time. Construction of a steeper summit region may simply reflect waning magma supply and the allowance for each pulse of magma to cool in place rather than congeal into flank flows. Spatter ramparts and spatter-fed flows are evident in shields of both types on the ESRP and indicate control by magma supply rate. More importantly however, lava flows and spatter deposits in the ESRP shields with the most prominent summits have coarsely diktytaxitic textures characterized by a frothy meshwork of abundant large plagioclase laths embedded in interstitial fine groundmass (see abstract by Brady et al., this meeting) that may increase the viscosity and explosive potential. This suggests that intrinsic magmatic properties of temperature, composition, crystal content, and viscosity are different between shields of the first and second types [5].

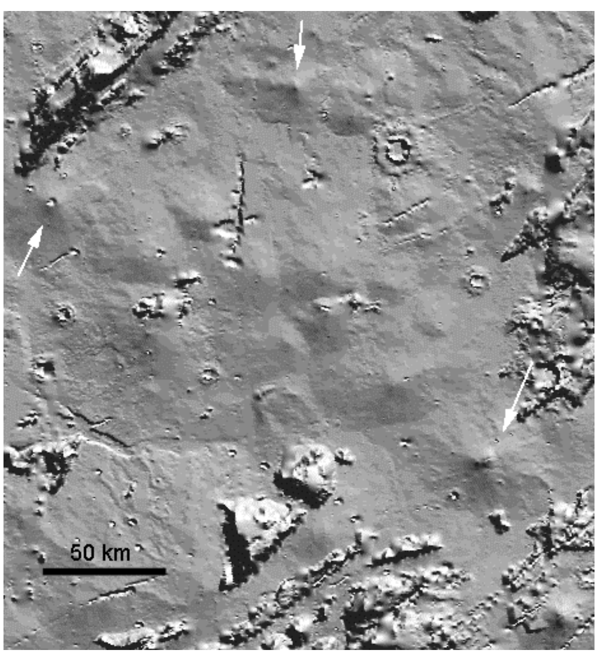

Figure 3. MOLA digital elevation model of small shield volcanoes in the Tempe Terra region of Mars.

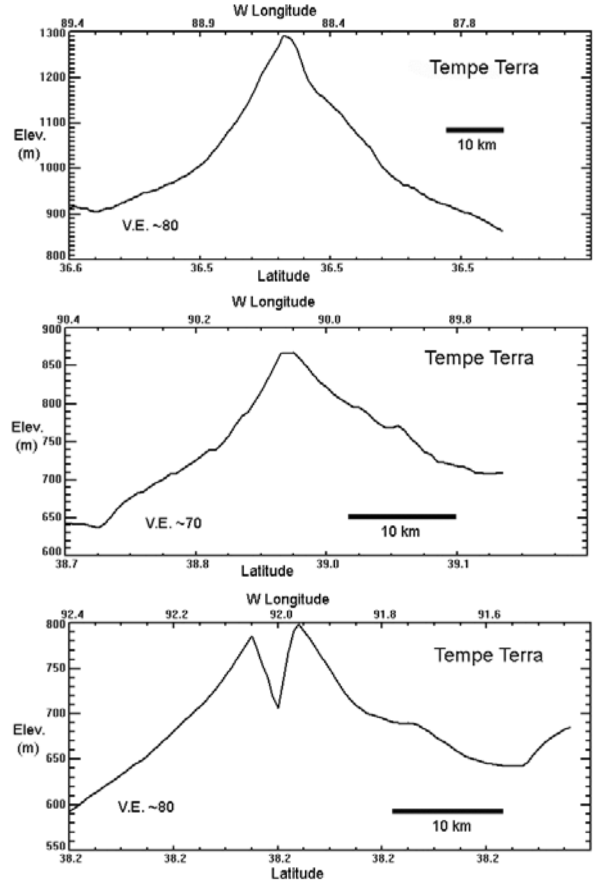

Figure 4. Topographic profiles of Tempe Terra shield volcanoes depicted by arrows in Fig. 3.

Conclusions: Previous geochemical, isotopic, and field studies of ESRP volcanoes [9] suggest that, for each shield, a small inhomogeneous batch of magma was responsible. Petrological models (in prep) suggest that some ESRP basaltic magmas must commingle with and partially assimilate previously intruded mafic magmas, which had already begun to differentiate as small layered intrusions in the lithosphere. We propose that small Martian shields likewise are derived from small batches of magma in the lithosphere that rapidly diminish as the supply is tapped, thus shutting down the eruption.

References: [1] Greeley R. (1982) *JGR 87*, 2705-2712. [2] Kuntz, M.A., et al. (1992) *GSA Memoir 179*, 227-267. [3] Hughes, S.S. et al. (2002) *Idaho Geol. Surv. Bull. 30*. [4] Meyer B. R. and Gregg T. K. P. (2001) *LPS XXXII*, #1849. [5] Sakimoto et al. (2003) *6th Int. Mars Conf.*, #3197. [6] Wong et al. (2001) *LPS XXXII*, #1563. [7] Hughes S. S. (2001) *LPS XXXII*, #2147. [8] Kallianpur K. and Mouginis-Mark P. J. (2001) *LPS XXXII*, #1258. [9] Hughes S.S. et al. (2002) *GSA Sp. Pap. 353*, 151-173.