VOLCANIC GEOLOGY OF TYRRHENA PATERA: MORPHOLOGIC SIMILARITIES TO TERRESTRIAL ASH SHIELDS; *Ronald Greeley and David A. Crown, Department of Geology, Arizona State University, Tempe, Arizona 85287*

The Mariner 9 mission provided the first clues to the volcanic diversity of Mars [1, 2]. In addition to shield volcanoes and lava plains, a new category of suspected volcanic feature was identified. Termed "patera", this class was characterized by a circular to elliptical planform, low topographic relief, and channel-like structures which radiate from a central depression. Early photogeologic mapping suggested that the paterae were shield volcanoes formed by eruptions of fluid lavas [3-6]. Viking data provided additional information [7, 8] and enabled classification of the paterae [9], with Amphitrites, Hadriaca, Tyrrhena, and Tempe Paterae designated *highland patera* [8, 10]. Highland paterae apparently formed contemporaneously, with activity occurring between 3.1 and 3.7 billion years ago [11]. The oldest materials comprising the highland paterae are middle Hesperian [12], making them the oldest central-vent volcanoes on Mars. Highland paterae are also of interest because they present evidence for the earliest explosive eruptions on Mars. Morphometric comparison of volcanoes on terrestrial planets indicates similarities between highland paterae and large ash sheets [13]. From analysis of their morphology and erosional characteristics, Greeley and Spudis [8] proposed that highland paterae are composed partly of ash resulting from phreatomagmatic eruptions. Recently, studies have shown that the morphometry of these volcanoes is consistent with an origin by the emplacement of gravity-driven pyroclastic flows generated by hydromagmatic eruptions [14-16]. The formation of the highland paterae by eruptions due to the interaction of magma with water contained in the megaregolith is consistent with suggested global changes on Mars [17] and could explain the absence of this style of volcanism in later eras.

High resolution Viking images provide an opportunity for a detailed study of Tyrrhena Patera (Figure 1). Centered at 22.5° S, 253.5° W, the caldera complex may be associated with the inferred outer ring of the Hellas basin [5, 18]. The construct is composed of four, or possibly five, principal units. The basal shield extends as far as 340 km to the S from the caldera and on the eastern side of the volcano is presumably buried by younger materials. The distal margins of the unit are highly dissected and form isolated, erosional remnant mesas. The upper shield is similar in morphology but is less extensive. The generally higher albedo of these units distinguishes them from the surrounding plains. The morphology and erosional style are consistent with a pyroclastic composition [8, 13], and the erosional scarps and layering seen in high resolution suggest multiple cooling and/or flow units. The SW flank appears to be composed of many individual flow lobes which form a fan-shaped deposit extending ~430 km where it embays older terrain or merges with Hesperia Planum materials. Short, local scarps appear to be flow or channel margins. Smooth plains extend W and NW from the basal shield and are generally featureless with the exception of a few erosional scarps and small, mare-type ridges. The distal margins either embay cratered terrain or are "etched" and diffuse. To the N the smooth plains merge imperceptibly with Hesperia Planum materials and thus, may be a facies unit of the ridged plains; alternatively, the smooth plains may be an eruption unit associated with Tyrrhena Patera which underlies the basal shield materials and represents the earliest exposed deposits erupted from the volcano. The summit of Tyrrhena Patera consists of a caldera-filling unit which is apparently composed of lava flows and contains several small, mare-type ridges. Two sets of ring fractures and 3 rille-like channels can be identified. Inner ring fractures are composed of discontinuous grabens that define a region approximately 50 km across. The outer fracture set, which occurs only on the north side of Tyrrhena Patera, consists of a series of inferred graben segments that are ~ concentric to the summit region and appear to have locally controlled the erosion of the basal shield unit. Three major volcano-tectonic channels extend from the summit area. The "headward" portion of the SW channel was clearly controlled by the structure of the inner ring fractures; images show small mare ridges and volcanic flows [8] which suggest it may have been a "feeder" to the plains and SW flank flow unit. The non-sinuosity of the NE channel indicates tectonic influence, but unlike the SW channel it may be not be associated with the emplacement of lava flows. The NW channel is interpreted to be a volcano-tectonic feature similar to the SW channel with its upper region buried by flows associated with the large SW channel. Alternatively, it may be an erosional feature.

The following model is given for the evolution of Tyrrhena Patera [8]. During initial stages of volcanism, magma rising along Hellas fractures encountered the impact-generated, water- and/or ice-rich megaregolith causing phreatomagmatic eruptions. Continued eruption of ash built extensive ash sheets and shields around the most active vents. Ash emplacement was followed by partial collapse, perhaps due to withdrawal of support resulting from eruption, and the formation of quasi-concentric fractures. Erosion by wind, water, and mass wasting produced the observed radial texture, "etched" signatures, and remnant mesas. The final stage of development of Tyrrhena Patera involved the formation of the volcano-tectonic channels and caldera-filling unit associated with the summit region and the emplacement of the flood lavas of Hesperia Planum which partly buried the flanks of the volcano.

The interpretation of the basal and summit shields and possibly the smooth plains of Tyrrhena Patera as consisting of ash is supported by remote sensing studies of ignimbrites in the Central Andes. The following morphologic properties characterize the Frailes Formation of Bolivia [19] and suggest that the martian highland paterae have similar eruptive histories: a) ash-flow sheets emanate from topographically high regions composed of late-stage lavas, b) ash flows form low-relief shields which are dissected radially from their sources, primarily by fluvial processes, c) steep-sided walls bound the margins of eroded ash-flow sheets, and d) erosional outliers of ash flows are evident on the margins of eruptive complexes.

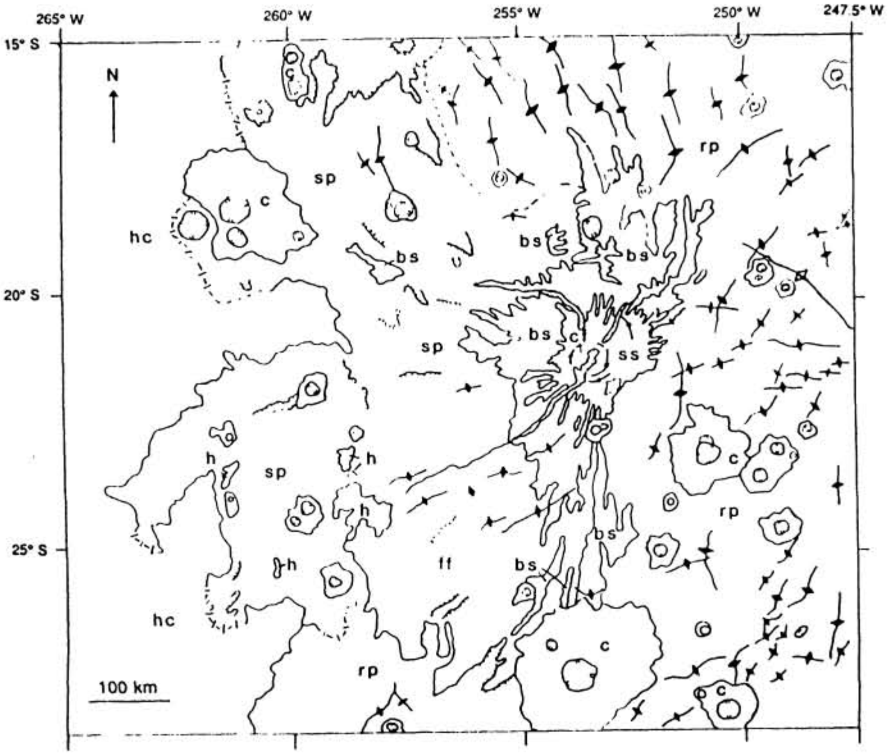

Figure 1. Preliminary geologic sketch map of Tyrrhena Patera.

Units		c	crater materials		scarp
bs	basal shield materials	h	highland materials		graben
ss	summit shield materials	hc	hilly and cratered materials		ridge
ff	flank flow materials				basin-related ridge
cf	caldera-filling materials	**Map**	**Symbols**		crater rim crest
sp	smooth plains	——	contact, observed		volcano-tectonic channel
rp	ridged plains	– – –	contact, inferred	–|–|–	eroded unit margin

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