TECTONIC ENVIRONMENTS OF MARTIAN FLOOD LAVAS, A. W. Ward and P. D. Spudis, U.S. Geological Survey, 2255 North Gemini Drive, Flagstaff, AZ 86001

Approximately 60 percent of the surface of Mars is covered by volcanic flows of varied ages and emplacement styles [1]. On the basis of lava rheology, morphology of landforms, and theoretical models the majority of these volcanic lavas are considered to be basaltic (2,3,4] In four volcanic provinces on Mars, most of which are considered to be basaltic lavas associated with central constructs, we have found evidence of of major and minor eruptions from fissures. We have examined the orientation of these fissures to determine if they are related to surface or near-surface features (volcanic shields, impact basins) or controlled by deeper subcrustal stresses.

Terrestrial basaltic lavas have three dominant modes of occurrence: 1) interplate eruptions at mid-ocean ridges, 2) discrete constructs and associated flows above presumed mantle intraplate "hot spots", and 3) fissure-fed continental plateau or "flood" basalts and continental rift basalts. Basaltic magmas also occur in shallow intrusive rocks as diabase or dolerite dike swarms [5].

Basaltic magmas are considered to be derived by partial melting in the so-called low-velocity zone of the upper mantle. They reach the surface through tension cracks that range in size from narrow conduits to broad dikes. Volcanic activity associated with narrow conduits tends to form volcanoes, whereas that associated with fissures tends to form flood basalts. Examples of the former are the Hawaiian Islands, Tristan da Cunha, and many other volcanic islands, as well as continental volcanoes such as some in central Australia. Examples of fissure eruptions include the mid-ocean ridges, Iceland, continental flood basalts such as the Columbia River, Parana, and Karoo basalts, and also diabase-dike swarms such as those in the Appalachian-Piedmont province of North America and in northern England and western Scotland.

The regional tectonic setting greatly affects the nature of the eruption, be it oceanic or continental, rift or point source ("hot spot") volcanism. These terrestrial basaltic provinces and tectonic environments are well defined and fairly well understood.

The four Martian volcanic provinces under study are those in the Tharsis and Elysium regions, the smooth plains within the cratered highlands, and the plateau plains [6,7]. Preliminary examination of all four provinces and detailed examination of the first two has revealed approximately two dozen linear features that we consider feeder fissures. Most of their associated flows seem to be of moderately large area (tens of thousands of square kilometers; fig. 1) except for those from a partly covered, ENE-trending, probable fissure in Memnonia Fossae (lat 20°N., long 149° to lat 16°N., long 139°; fig. 2). Fissure/flow-front relations indicate that this presumed vent extruded lavas of intermediate age that were later partly covered by younger lavas from Arsia Mons [8].

Radial feeder fissures in the Tharsis region apparently are related to the Tharsis uplift; fissures in Memnonia Fossae trend NE in a direct line from Arsia Mons; fissures in Syria Planum trend NW, in a direct line from Pavonis Mons; other local fissures are radial or circumferential to Olympus Mons or Alba Patera. The fissures of Ceraunius Fossae have extruded voluminous flows [9]. We have found no fissure/flow relations in that region, but regard their presence as very likely.

The two other Martian provinces are yet to be examined in detail. The first is comprised of several plains units of widely varied ages within the Martian cratered terrain [10]. Many of these units are flood lavas, some as well preserved as the Tharsis lavas, but older. Their general tectonic setting is somewhat different from that of other volcanic units in the Tharsis region; they typically embayed impact basins and craters. In particular, several of these plains units are associated with old, nearly obliterated multi-ring basins [11], analogous to the lunar maria. The second province, another extensive plains unit in the cratered terrain, is the plateau plains units [1, 6]. They display an abundance of wrinkle ridges and flow fronts in some areas. They are not concentrated within multi-ring basins, but form an intercrater plains unit within the Martian highlands. Thus, the tectonic setting of these plains is distinctly different from those of both the volcanic-center and the basin-related settings described above.

Further study of the plateau plains material and other presumed volcanics of unrecognized origin in the old cratered terrain may reveal fissures and fissure/flow relations. Dike/flow contacts are rare on Earth [12]; fissure/flow relations were difficult to find in the younger volcanic provinces of Mars and may be impossible to resolve with available imagery of the old cratered terrain. Nevertheless, an understanding of the origin and ages of presumed lavas in these older regions and a study of the orientation of any recognized vents will give insight into pre- and post-Tharsis structural regimes on Mars.

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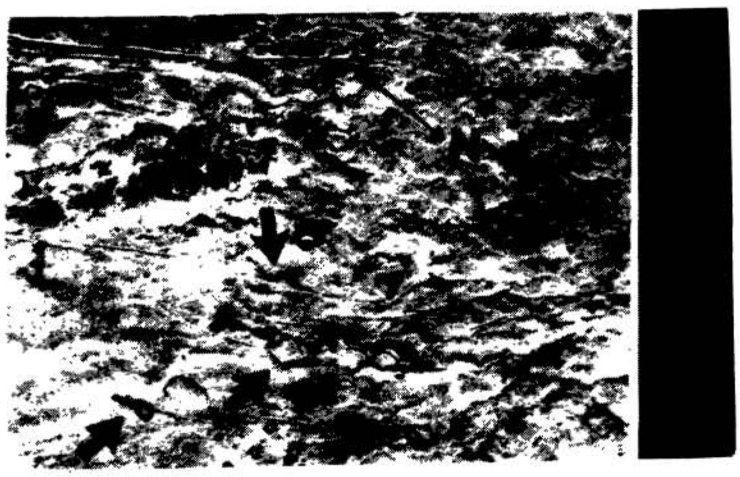

Figure 1. Fissure-fed lava flows (arrows) in the southeastern part of the Phoenicis Lacus quadrangle. Viking 643A64; lat 20°S., long 100°.

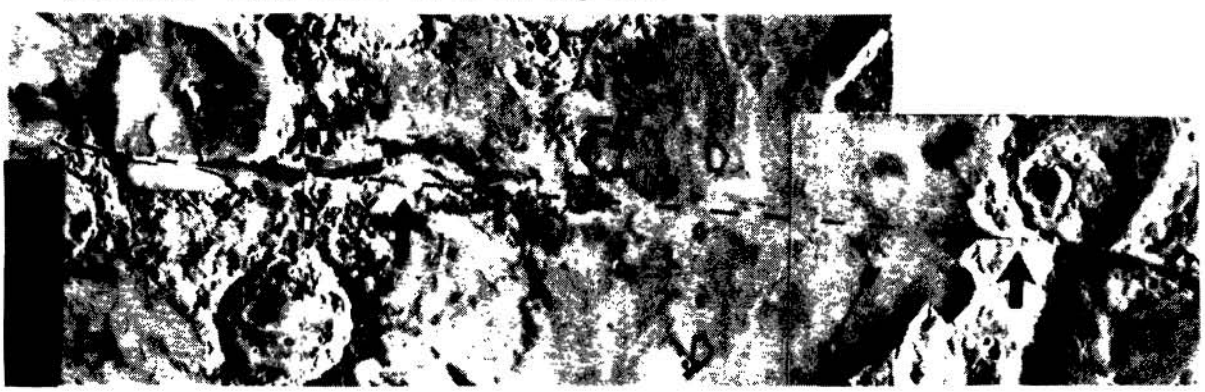

Figure 2. Probable large fissure vent in Memnonia Fossae, (solid arrow; dashed line) partly covered by late-stage local flows (open arrows) and young flows from Arsia Mons to the northeast (FA). Viking 639A11, A14, A35; lat 17°S., long 145°.