GEOLOGIC HISTORY OF THE SMOOTHEST PLAINS ON MARS (AMAZONIS PLANITIA) AND ASTROBIOLOGICAL IMPLICATIONS.

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Abstract: MOLA data show that the extreme smoothness of Amazonis Planitia is a product of repeated resurfacing continuing to the geologic present. A model is presented to explain the common sources of fluvial and volcanic material in Marte Vallis.

Introduction: Amazonis Planitia, located between the Tharsis and Elysium volcanic provinces, is characterized by topography that is extremely smooth at several scale lengths [1]: as smooth as oceanic abyssal plains on Earth [2]. We have examined MGS data, primarily MOLA topography, to examine the surface morphology of Amazonis Planitia and determine stratigraphic relationships. These new data provide evidence for a 1300 km diameter Noachian impact basin in northwest Amazonis Planitia and an Upper Hesperian lava flow that appears to have originated at Olympus Mons, prior to the emplacement of the aureole. This previously unmapped flow unit strongly suggests that Olympus Mons was active at least as early as the Hesperian. In the Amazonian, the degraded Noachian crater rim, the pre-aureole lava flow and the Olympus Mons aureole served as topographic barriers that created a cachement basin for subsequent lava flows and outflow channel effluents. Extensive study of the geologic history of Amazonis Planitia and the resurfacing events that have led to its extreme smoothness have resulted in the production of a revised map of the region (Figure 1).

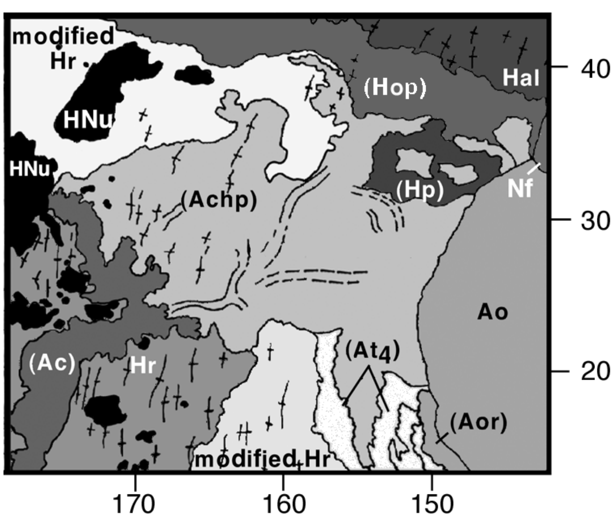

Figure 1: New geologic map of the Amazonis Planitia region, after [3]; units not present in [3] in parentheses, and follow their mapping conventions. See discussion of units in text.

Geologic map units: The **Cerberus Formation**, designated unit **Ac**, was first mapped by [6]. **Achp** is sediments from the most recent Marte Vallis fluvial outflow event, and is the uppermost surface of the central smooth unit of Amazonis Planitia; within the unit, wrinkle ridges and small hyperpycnal channels are mapped. Lava flow units that post-date the Olympus Mons aureole and appear to originate from Tharsis are designated **At_4**. **Hr**, the wrinkle ridged plains unit, resurfaced the region in the early Hesperian. To the north and south, **Hr** has been **modified** by outflow effluvium from Marte Vallis and Mangala Vallis, respectively. **Hop** is a series of Hesperian lava flow units from the pre-aureole Olympus Mons volcanic structure. They curve around rectilinear basins in northwestern Amazonis Planitia that appear to be volcanic in origin, **Hp**, but have a geometry unlike any other plains unit in the region. Alba Patera, a large volcanic edifice northeast of Amazonis Planitia, produced lava (**Hal)** from the early Hesperian into the early Amazonian. Discontinuous knobs of **HNu**, a catch-all designation for ancient material of unspecified origin, we interpret to be the rim of a proposed ancient impact basin. **Nf** is exposed in the region as a tip of Acheron Fossae.

Resurfacing History of Amazonis Planitia: The first of the resurfacing events was the emplacement and deformation of volcanic plains in the Hesperian, creating the ridged plains unit (Hr of [3]). This unit resurfaced most of the martian surface [4], and is marked by asymmetrical wrinkle ridges that rise 80-150 m above the surrounding terrain. In Amazonis Planitia, however, the ridges typically stand only 25-40 m above the plain, showing that the ridged plains unit has been mantled by 40-125 m of material.

A large fraction of that material is likely Vastitas Borealis Formation (Hv). Though it does not crop out within Amazonis Planitia, Hv blankets the landscape north of the region. The southern boundary of Hv correlates closely with the pre-aureole flow from Olympus Mons, supporting the idea that this flow unit served as a barrier to subsequent effluent from the south. One or more outflow events from Mangala Valles likely ponded within Amazonis Planitia during the late Hesperian, and at least two outflows from Elysium Planitia flowed into Amazonis Planitia (through Marte Vallis) during the Amazonian. The first Elysium Planitia outflow event carved the major channel structures visible within Marte Vallis and debouched into Amazonis Planitia, depositing the eroded material. This was followed by a lava flow that utilized and resurfaced the fluvial channels, ultimately terminating in digitate lobes in central Amazonis Planitia. There may have been regularly alternating fluvial and volcanic flows, as suggested by [5], but we have clear evidence for at least two. The second outflow event carved channels within the lava flow, and was followed by the volcanism of the Cerberus Formation [6], which pirated these younger channels, resulting in the presently visible inverted topography. The Cerberus Formation terminates along the western margin of Amazonis Planitia (Figure 2).

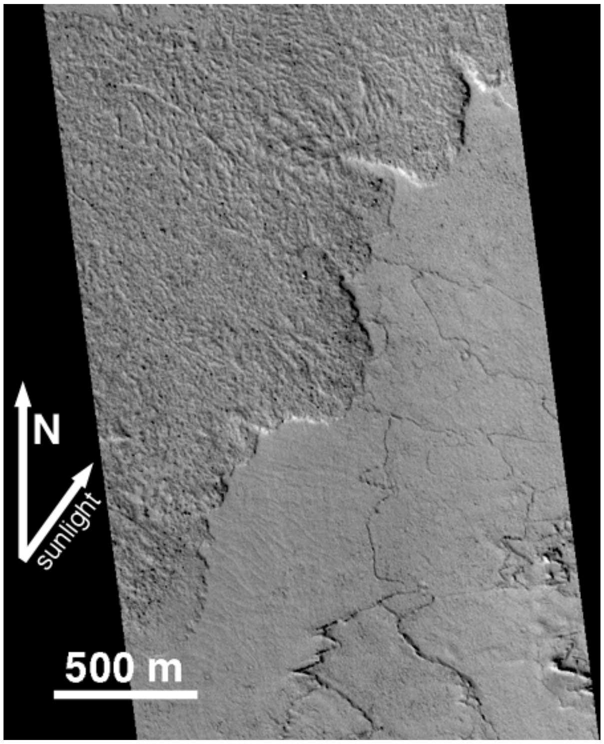

Figure 2: MOC image M0903597, showing the digitate margin of the Cerberus Formation lava flow. The younger lava flow (top) shows the rafted plate morphology typical of young Marte Vallis flows, while the older lava flow (bottom) shows only the pressure ridges, not the down-dropped areas between the lava surface rafts. The older flow has been mantled by effluvium from the intervening fluvial outflow.

Model for volcano/fluvial genetic relationship in Marte Vallis: To explain the phenomenon of fluvial and volcanic features apparently originating from common rift sources in the Cerberus region [e.g., 5], we propose the following model (similar to that proposed in other regions by other researchers [e.g. 7, 8]) that shows a genetic relationship between the fluvial and volcanic events: A dike feeding Elysium Planitia propagates laterally and upwards, generating a stress field that propagates a fracture. The fracture ultimately breaches the cryosphere, forming a graben. The cryosphere, a frozen layer of ice and regolith, has been acting as a global aquitard to the groundwater system below [e.g., 9]. Once the cryosphere is breached, the water, under hydrostatic pressure, emerges with very high flow rates, and continues flowing until pressure equilibrium is reached. This water flowed through Marte Vallis, eroding channels and debouching into Amazonis Planitia. This catastrophic outflow was shortly followed by lava outflow; the magma flowed through the fracture and released flood lavas onto the surface. This lava followed the path of the water, resurfacing Marte Vallis and pouring into Amazonis Planitia. As it flowed over the water-saturated surface, the phreatomagmatic interactions created rootless cone structures [see also discussion in 10].

Astrobiological implications: The lava flows associated with the emplacement of these plains have been dated as extremely young geologically (less than 10 million years old [11]). If fossil or extant life existed at depth in the subsurface groundwater system at this time (a troglodytic fauna), it is highly likely that they would be among the material erupted to the surface, and washed down into Elysium Planitia and Amazonis Planitia. The fate of such effluents under current martian conditions has recently been modeled [12] and it has been shown that standing bodies of water at this scale would quickly freeze over and sublimate, leaving a sedimentary sublimation residue. Thus, Elysium and Amazonis Planitiae would be excellent locations to sample recently emplaced freeze-dried troglodytic faunal remains.

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