DARK MATERIALS IN VALLES MARINERIS: INDICATIONS OF THE STYLE OF VOLCANISM AND MAGMATISM ON MARS

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Rifting on the equatorial canyon system of Valles Marineris provides a unique view of the interior of the martian crust to depths reaching 7 kilometers, exposing several in-situ bedrock units which testify to past volcanic and magmatic processes on Mars. Dark, relatively gray materials, believed to be among the least altered of martian crustal components, are found in a variety of geologic settings in Valles Marineris. These include in-situ wall-rock layers exposed during the formation of the canyon system, canyon floor covering deposits such as eolian dunes, and volcanic materials, possibly indicating relatively recent volcanism in the Valles [1]. Using Viking Orbiter apoapsis color images, we have studied the spectral reflectance and spatial distribution of these materials in an attempt to understand their relation to past episodes of volcanism, tectonism, igneous intrusion, and eolian redistribution in the canyon system.

A series of cliffs in the Ophir Chasma wallrock is interpreted to be exposures of resistant bedrock; the spectral signature of this massive and uniform unit most closely resembles that of terrestrial mafic rocks altered to or coated by crystalline hematite. These Ophir Chasma cliffs may be erosional scars exposing fresh bedrock beneath more weathered wallrock of a similar composition, or they could be a physically and compositionally distinct unit, produced, for example, by igneous intrusion prior to the formation of the Valles.

Application of multispectral mapping techniques to probable young volcanic materials in the Central Troughs yields an inferred distribution of volcanic activity consistent with an interpretation of extrusion along faults near the margins of the canyon floors. Terrestrial examples of similar relationships between tectonism and volcanism include the African Rift Valleys and the Basin and Range Province in the southwest of the U.S., both areas of crustal extension. Since there is no a-priori reason to expect this relationship to occur if the Valles were generated by fluvial erosion or by subsidence of karst or thermokarst, the inferred distribution of volcanism appears to support the hypothesis [2] that the Valles originated through tectonic extension and graben subsidence. While the age of this volcanism is at present poorly constrained, photogeologic indications that it may be relatively recent [1] could suggest that tensional rifting and canyon formation may be ongoing processes.

A thick, regionally extensive deposit observed in outcrops in Juventae Chasma and in a wallrock layer in Coprates is interpreted to be composed of mafic glass on the basis of spectral reflectance, incompetent erosional morphology and marked tendency for eolian redistribution, indicating that the material is easily broken down into sand-sized grains capable of saltation. Multispectral mapping suggests that the eolian floor-covering materials in the lower canyons several hundred kilometers to the east are derived from sources in Juventae and

Coprates Chasmata. The interpretation of this unit as volcanic ash requires that the deposits were produced in pyroclastic eruptions at what was once the surface of the planet, and later buried by almost 3 kilometers of plains materials including the 400 to 600 meters of Hesperian lavas believed to resurface the Lunae-Sinai Planum region. The deposits in Coprates and Juventae Chasmata are thus probably among the oldest of martian volcanic materials.

Voluminous regional deposits of basaltic ash have no terrestrial analogue, although they are common on the Moon [3-8] and may be present on Mercury as well [9]. If we tentatively accept the identification of massive mafic ash deposits on Mars, the Moon and Mercury, then the absence of such deposits from the inventory of present day crustal materials on Earth requires explanation. One possibility is that the processes which produce large pyroclastic eruptions from mafic magmas are confined to smaller terrestrial planets, perhaps because of their reduced gravitational acceleration and atmospheric pressure [10]. Another possibility is that these processes could be confined to the early stages of planetary evolution. By analogy with the lunar mantling deposits, the materials exposed in the layer in Coprates Chasma and in Juventae may represent a relatively volatile-rich phase of volcanism early in the history of Mars, possibly even the late stages of planetary outgassing. The absence of extensive deposits of mafic glass associated with more recent volcanism on Mars and the Moon (and, perhaps, the Earth) might then be due to a diminishing supply of juvenile volatiles. It is interesting to speculate that massive basaltic ash deposits might once have been common on Earth, and later obliterated from the geologic record along with the evidence for an early period of heavy bombardment by impactors.

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