WHERE IS THE GEOCHEMICAL EVIDENCE FOR A WARM WET MARS? D. L. Blaney[1] , NASA Jet Propulsion Laboratory, MS 183-501, 4800 Oak Grove Drive, Pasadena, CA 91009, email: blaney@scn1.jpl.nasa.gov

Introduction: Groundbased and spacecraft data continue to tell contradictory stories of how the surface of Mars evolved. On one hand, there is clear evidence for the important role water has had shaping the geomorphology of the Martian surface [see 1 and references therein]. On the other hand, the geochemical signature of extended liquid water – rock interactions has not been detected. Reconciling these data is critical to understanding the biological potential of Mars and to developing an effective approach to search for evidence of life on Mars.

The Search for Geochemical Evidence of a Warm Wet Mars. Searching for carbonates, clays, and hydrated iron oxides on Mars has been a major focus of the Martian remote sensing community for almost 30 years. Yet a similar picture continues to emerge even as we get a data globally and at higher spatial resolution.

The Martian Crust: There is ample spectroscopic evidence that the most of the dark regions on Mars are composed of basalt [e.g. 2,3,4,5]. The clear signature of basalt over much of the surface implies that global ambient weathering rates are relatively slow and do not contribute significantly to global soils. To date, there has just been one region detected where there is clear, unambiguous evidence of crustal alteration, the hematite region detected by TES [5]. The origin of this deposit is still unknown. Regions with carbonates, clays, or iron oxyhydroxides have not been seen. Thus the soils of Mars may preserve the best evidence for Martian climate evolution.

Martian Soils: A detailed review of the characteristics of Martian soil is presented by Bell [6,7]. Martian soil mineralogy and formation is actively debated. Some of the mechanisms that are currently thought to be consistent with Martian soil formation include: generation during impact events [e.g. 8, 9], palagnization [e.g. 7, 10, 11, 12,], freeze-drying of iron rich aqueous solutions [13], acid-fog weathering [14, 15], and hydrothermal alteration [e.g. 16, 17, 18, 19]. Regardless of what your favorite mechanism for soil formation on Mars is, none invoke a prolonged warm, wet climate. These formation mechanisms in fact tend to exclude widespread abundant liquid water due to a warmer climate.

If the soils of Mars are a primary weathering product, they are do not seem to be associated with any prolonged period of warm and wet climate. Either early Mars was never warm and wet or the Martian soil formation process is volumetrically larger than weathering under wet and warm conditions so it dilutes the signature of an early clement period on Mars. Soil formation models therefore need to begin investigating not only the chemistry produced but also the rate and volume of soil produced. Comparing these rates with the rates expected from weathering during a warm, wet period will allow us to better determine if Mars was ever warm.

Secondary Alteration? If Mars had a warmer, wetter period, perhaps the weathering products have been altered by secondary weathering into the current Martian soils. Therefore, the stability of carbonates, clays, and hydroxylated minerals which may have been produced by a warm, wet Mars needs to be considered.

Carbonate minerals seem to be the most susceptible to destruction on the Martian surface. Volcanic sulfuric acid aerosols could easily decompose carbonates. Volcanic sulfate aerosol deposition is a leading formation mechanism of the sulfates at both the Viking and Pathfinder landing sites [e.g. 7, 14, 20, 21, 22, 23, 24].

Additionally, laboratory experiments have shown the carbonates can be destroyed from exposure to UV radiation[25]. These results indicate that over geologic time a several hundred meters of carbonates could have been photoreleased.

The lack of carbonates in the Martian soils can thus be explained by either volcanic aerosols, UV breakdown, or a combination of both. Strategies for sample selection or bio-marker identification that focus on carbonate detection are problematic with non-unique interpretations.

Hydroxylated minerals seem to be more stable. Early work [26] and more recent work by Yen et al [27] do not find evidence for ultra-violet dehydrxylation of iron minerals. Yen et al. concluded that if iron oxyhydroxides formed during an earlier warm, water rich environment they should be found on Mars today.

Much more work on the stability of minerals on Mars needs be carried out before secondary alteration can be either proved or disproved. Exploration strategies and instrument design should focus on minerals which are stable on Mars.

Conclusions. The global mineralogy of Mars does not as yet provide any evidence for extensive water – rock interactions that would be expected by an early warm, wet Mars. Three possible explanations exist:

1) Mars was never warm and wet for an extended period. Liquid water on the surface which formed the valley networks and other fluvial features, was not present long enough to weather significant amounts of material.
2) Other mechanism of soil formation are volumetrically more significant than weathering by a warm wet Mars. These mobile materials dilute the geochemical signature of a warm, wet Mars.
3) The geochemical signature of a warm, wet Mars has been erased by secondary weathering processes. These processes include reaction with volcanic aerosols and ultra-violet decomposition.

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