CLOSED SYSTEM CHEMISTRY INSIDE MASSIVE ICE DEPOSITS AT MERIDIANI PLANUM. P. B. Niles[1], J. Michalski[2], [1]Astromaterials Research and Exploration Science, NASA Johnson Space Center, Houston, TX 77058; [2]Institut d'Astrophysique Spatiale, Université Paris Sud, Orsay, 91405, France. (*paul.b.niles@nasa.gov)*

Introduction: The discoveries made by the Opportunity rover at Meridiani Planum have provided a new view of the chemistry of the martian surface. These results have also spawned a number of different interpretations. These different interpretations of the chemistry of the Meridiani sulphate-bearing rocks can be categorized into two main groups. The first model suggests that the rocks are sedimentary and composed of a mixture of two components – a heavily weathered silicate component and an evaporite salt component [1]. The second model suggests the rocks are volcanoclastic and were weathered in place by sulphur rich gases [2].

We propose a third model [3] which suggests that individual grains or agglomerates of grains were weathered inside of a large dust/ice deposit, and were redeposited into eolian sediments after the ice had been removed by sublimation. This hypothesis explains the available data better than the others for the following reasons: 1) The Meridiani sediments have basaltic cation compositions despite the fact that many of the cations are now associated with secondary weathering products such as sulfate[4]; 2) Only small variations in chemical composition are observed in the Meridiani sediments across the 16 km traverse of the Opportunity rover, and these changes are in $MgSO_4$ content alone, with little or no change in Fe, Ca, Na, or K [4]; 3) The cation composition of the Meridiani sediments shows a strong resemblance to the composition of the bright soils observed at the Pathfinder, Spirit, and Opportunity landing sites [4].

Model Description: This new model [3] for the provenance of the sediments at Meridiani Planum is based in principal on geochemical ideas pioneered by Burns [5], and sedimentological ideas proposed by Tanaka [6]. In our model, the sediments now located at Meridiani Planum were sourced from a nearby, massive dust/ice deposit that was located adjacent to Meridiani Planum. This massive dust/ice deposit formed through precipitation of ice around dust grains and aerosols during a period of high obliquity, and resembled the polar layer deposits that exist today in the martian north and south polar regions. Suspended dust in a Noachian atmosphere provided nucleation points for ice crystals to form which is an important driver for the precipitation of water ice in the present day polar caps [7] and would have been more prevalent on ancient Mars.

Exposure of the ice deposits to sunlight during the summer seasons allowed for radiant heating of dark grains within the water ice matrix. A similar effect has been observed where radiant heating of soil grains, trapped in ice deposits in Antarctica, causes melting and migration resulting in the formation of aggregates [8]. The radiant heating led to the formation of thin water films sufficient to allow for reaction with the volcanic aerosols or sulphide minerals to create acidic solutions. The ice matrix provided a physical barrier enclosing each grain or aggregate of grains within a closed system environment at low temperatures with low water/rock ratios. The acidic solutions weathered silicate grains to form poorly crystalline aluminosilicates and sulphates [5]. The cold temperatures of the polar environment provided a mechanism for limiting water/rock ratios while simultaneously forming more concentrated solutions through freezing of excess solution.

A climactic shift (due to polar wander or obliquity changes) then led to conditions which favoured net sublimation of the massive ice deposit rather than deposition. The sublimation residue was made up of sand sized agglomerates of fine-grained, chemically weathered, and highly hydrated siliciclastic material mixed with sulfate salts. This material was reworked by eolian or impact activity. Burial of these highly hydrated phases caused the release of structural water that allowed limited diagenesis and blueberry formation to occur, but also prevented wholesale re-equilibration of the deposit and complete conversion of jarosite to hematite [9]. Small amounts of additional water may also have been supplied by brief ice melting events allowing for the possibility for surface runoff [1].

Implications: The weathering model proposed here could potentially explain the origin of many layered sulfate deposits on Mars, which share common characteristics: they are layered, occur in mounds and ridges, and lack an obvious provenance [10]. The sulfates are all exposed in spectrally detectable layered deposits that may have formed through eolian or impact reworking and transport of sublimation residue, or through episodic fluvial processes driven by limited melting of ice, or may reflect the original morphology of layered ice deposits.

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