**LAYERING DUE TO PEDOGENIC PROCESSES IN MARTIAN SOIL**. John F. Mustard, and Christopher D. Cooper, Dept. Geol. Sci., Box 1846, Brown University, Providence RI, 02912 (John_Mustard@brown.edu).

**Introduction:** Malin and Edgett [1] note that Mars is layered on a variety of scales, indicating that mechanisms that deposit and indurate have played a significant role in the evolution of at least the near surface (1-5 km) of the planet. We have been investigating processes that have may occur in the regolith of Mars (which we refer to as soil), and have focused on those processes likely to have resulted in induration and layering. In this abstract we outline the basic classes of pedogenic processes that would lead to induration and layering, and discuss implications of the processes for testable observations from existing and planned spacecraft.

The very presence of a layer indicates a material whose strength is distinct from the surrounding materials. In soils, this contrast in strength is due to the presence of a cementing agent or from a textural difference (e.g. compacted vs. loose dust). In general, pedogenic processes leading to induration and layering can be divided into top-down, bottom-up, and cyclic. Top-down processes are those where the mechanism leading to induration is driven by a surface-atmosphere interaction. In bottom-up processes, the mechanism is driven by subsurface transport. Cyclic processes are those where materials are eroded and deposited on long time scales leading to sorting or burial.

**Top-Down Processes:** Near-surface induration requires a mechanism for cementation. On Earth, such mechanisms are a function of available water, and in arid regions solute transport due to water as thin layers bound to grains can lead to substantial cementation of soils into calcrete, hardpans, ferricrete, etc. Water is typically deposited into the soils through rainfall or other atmospheric means, and vertical transport is accomplished through evaporation. Water is not likely to have been deposited into Martian soils through rain or other atmospheric deposition. However, surface-atmosphere exchange of water is an active mechanism on Mars, and capable of significant transport over time. [2, 3]. Models that describe the exchange of water between volatile reservoirs, including adsorbed water in soils, show that significant fluxes of water in and out of surface soils are expected (mg•$H_2O/cm^3$/day) and these operate on diurnal, seasonal, and millennial time scales [2, 3].

Surface-atmosphere exchange of volatiles and transport of soluble ions to the surface is a viable mechanism to explain the formation of duricrust on Mars [e.g. 4]. Duricrust refers to the case-hardened crusts observed at both Viking landing sites [5]. At the Mutch Memorial Station (MMS), a thick crust with fractures and planar features was exposed by the erosion of loose material by the engine exhaust of the lander during landing. Thin and apparently weak surface crusts were also observed: a small slump in a dune of drift material was observed at the MMS station that appeared to be due to failure in a weakly cemented surface layer, and at VL 2, one of the rocks displaced by the sampling arm had a thin layer of weakly cemented soil that adhered to the rock and apparently had formed at the interface between the soil and the atmosphere.

Several key features would be expected for soils indurated due to surface-atmosphere exchange of volatiles and solute transport. They would contain small amounts of a highly soluble salt as a cementing agent (e.g. $MgSO_4$), they would have a slightly enhanced strength over the unconsolidated soils, and because the layers form at the surface-atmosphere interface, they would follow the terrain (i.e. not necessarily a horizontal surface).

**Bottom-up Processes**: Roger Burns [6] considered the implications of the weathering of sulpher-rich volcanic rocks due to groundwater. In that analysis, ferrous-rich groundwaters were produced that could easily transport iron and sulpher large distances. Where these fluids encountered oxidizing conditions, the ferrous iron would rapidly oxidize to ferric iron, resulting in induration and lithification of the soils.

As a pedogenic process, groundwater oxidation could occur in a number of environments. At the boundary between the saturated and unsaturated soil, the groundwater could be oxidized through contact with the atmosphere. In addition, transport of groundwater through highly permeable layers in the subsurface could encounter oxidizing conditions. In both cases, the resulting cemented soils would be expected to have a somewhat irregular surface, thickness, and extent, largely controlled by the permeability of the soils and the nature of the oxidizing environment. Regardless, the mineralogy may be expected to be somewhat unique, dominated by hydrated iron oxides and hematite.

**Cyclic Processes:** Aeolian erosion and deposition is a well recognized process on Mars leading to the transport of material [7]. Cycles of deposition and erosion can lead to textural sorting and thus layers. In addition, burial can lead to compaction. If such cyclic processes are also accompanied by periodic deposition of volcanic ash [8, 9] or impact glass [10, 11], then compositional layering is also possible. These types of deposits are expected to be layered on a variety of thickness and horizontal scales, but are expected to have irregular properties.

**Summary**: Layered deposits formed in standing bodies of water can be expected to be relatively flat and homogenous at their time of formation. In contrast, the pedogenic processes discussed in this abstract lead to layers with a variety of textures, compositions, and properties. These deposits are typically not horizontal at their time of formation and can be recognized by their unique textural, chemical, and mineralogical properties.

Remote sensing using Viking, Phobos, MGS and other future Mars data can distinguish among potential modes of origin of these deposits on the basis of their unique properties.

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