GEOCHEMICAL EVIDENCE FOR SEDIMENTARY SILICA ON MARS. Scott M. McLennan, Department of Geosciences, State University of New York at Stony Brook, Stony Brook, NY, 11794-2100, U.S.A. (Scott.McLennan@sunysb.edu)

Introduction: There is abundant evidence from imaging, spectroscopy, magnetics, thermodynamic considerations, and chemical analyses that a variety of sedimentary processes have affected the Martian surface. Among those processes that have been identified or proposed are conversion of basalt to palagonite and clays during low temperature alteration [1], oxidation of igneous minerals to form hematite and other iron-oxides [1,2] possibly including a magnetic iron oxide mineral [3], chemical evidence consistent with heavy mineral fractionation during sedimentary transport [4], and evidence for magnesium (and possibly iron) sulfates and chlorides in Martian soils [2,4,5].

Analyses of SNC meteorites and Martian rocks and soils also indicate that the Martian surface is dominated by mafic to ultramafic rocks [6]. During weathering and low temperature alteration of basalt on Earth, large amounts of SiO$_2$ may be liberated and under certain near-surface conditions silica is highly mobile. Accordingly, an important question is whether or not similar processes take place on Mars and if so, what role does sedimentary silica play? A variety of workers have recognized that silica may play a role during alteration processes (e.g., [1,5]) and Burns [1] alluded to “hydrus iron oxide - silica deposits” in the Argyre and Hellas basins. However, the possibility of extensive silica deposits at or near the Martian surface has been inadequately explored.

Low Temperature Alteration of Terrestrial Basalt: Alteration of terrestrial basalt across a broad range of conditions from weathering to hydrothermal is commonly accompanied by loss of up to >50% of SiO$_2$ due to the dissolution of unstable mafic minerals and glass [e.g. 7,8]. Examples of idealized dissolution reactions for olivine and pyroxene include:

- Fayalite: $\text{Fe}_2\text{SiO}_4 + 4\text{H}^+ = 2\text{Fe}^{2+} + \text{H}_2\text{SiO}_4$
- Forsterite: $\text{Mg}_2\text{SiO}_4 + 4\text{H}^+ = 2\text{Mg}^{2+} + \text{H}_2\text{SiO}_4$
- Diopside: $\text{CaMgSi}_2\text{O}_6 + 4\text{H}^+ + 2\text{H}_2\text{O}$

$= \text{Mg}^{2+} + \text{Ca}^{2+} + 2\text{H}_2\text{SiO}_4$

On Earth weathering processes often proceed under largely open system conditions and much of the silica is either transported to less altered portions of the weathering zone where it may be involved in other weathering reactions or is lost entirely from the weathering zone to streams and groundwater.

Evidence for Low Temperature Alteration of Martian Basalt: Among the most surprising results of the chemical analyses of Martian soils and rocks are the high abundances of sulfur and chlorine [9,10]. At the Pathfinder site, only MgO (and possibly FeO$_2$) correlate positively with SO$_2$ and Cl, suggesting that a significant fraction, if not all, of the Mg in soils is present as sulfide and chloride minerals [4,5,11]. It is also generally agreed that much of the iron in Martian surficial deposits is present as secondary oxide minerals such as hematite [1,2]. Chemical data are also consistent with fractionation of iron rich phases (e.g., hematite, Fe-sulfate) in Martian soils and rocks, likely during sedimentary transport [4].

The significance of these relationships is that much of the Mg and Fe derived from alteration of mafic minerals reacted to form non-silicate minerals. Accordingly, there is a likelihood that substantial amounts of SiO$_2$, also derived from alteration processes, would be available to form discrete sedimentary silica phases, including non-crystalline or crystalline opals, microcrystalline quartz (e.g., chaledony) or quartz.

Fate of Sedimentary Silica: The ultimate fate of silica is difficult to constrain because little is known about the nature of the Martian hydrosphere over geological history. Near alteration zones, silicon may combine with aluminum (from plagioclase) and various cations to form palagonite and a variety of clays (e.g., saponite, nontronite, sepiolite, montmorillonite, etc.). However silica that is lost to near-surface waters could be transported considerable distance and precipitated as a separate silica phase. Thus silica could be found in a variety of geological settings, including sedimentary chert deposits (iron formations of Burns [1]), veins, fracture fillings, mineral overgrowths, encrustations on rock surfaces, authigenic mineral grains, or dust coatings. The presence of abundant silica would have important implications for interpreting imaging, remote sensing and chemical data that have been returned from Mars.