Effects of weathering a volcanic rock on Mars 3.7 billion years ago

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The Sheepbed mudstone in Gale Crater on Mars has been gimaged at various scales & examined mineralogically & chemically by NASA's Curiosity rover [1, 2]. We re-examined the available information & produced an integrated interpretation of the depositional environment, weathering processes that produced the sediment, & its burial diagenesis history [3]. We show that the source material was of basaltic composition (primary or an impact melt), probably weathered in situ &/or or while being transported to a lacustrine basin, & which produced secondary clay minerals. The same chemical reactions active in weathering continued during burial diagenesis & involved the most labile components, either volcanic glass &/or olivine (ferroan forsterite). Equilibrium thermodynamic geochemical modeling of the successive stages of reaction indicated formation of product minerals compatible with the observed assemblage.

The striking textural features of the Sheepbed mudstone resulted from the minerals & evolving porefluids from the water-rock reaction. We explain how the following formed successively in the sediment: a) mm-size nodules; b) slightly larger mm-size hollow nodules; c) raised ridges, cemented shrinkage cracks; d) stratiform cementation. The nodules formed by centrifugal & counter diffusion of dissolved species, while increased diagenetic solute concentration deflocculated clays producing synaeresis cracks. Cracks & some layers of the matrix porosity filled with cement. Most importantly, the diffusion reactions can be modeled temporally [4] to give the duration of growth of the nodules.

These processes probably had little effect on Mars climate at the time, more likely controlled then by loss of atmosphere, a result of significant reduction of magnetosphere protection.

[1] Grotzinger *et al*. (2014) *Science* **343**, 1242777. [2] McLennan *et al*. (2014) *Science* **343** 1244734. [3] Schieber *et al*. (2017) *Sedimentology* **64** 311-358. [4] Coleman & Raiswell (1993) *Phil Trans R Soc Lond A* **344**, 69-87.