Emerging views of the role of water during early Mars history

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The emerging view of Mars from recent orbital and rover-based observations is one where evidence is mounting that older rocks have in some cases formed in or been strongly modified by surface and/or subsurface aqueous environments. Specifically, the Spirit rover reached the Columbia Hills after traversing across volcanic plains to find older rocks that have been altered by salty ground water [1]. The Opportunity rover, traversing across the plains of Meridiani, has found evidence for cross-bedded sulfate evaporite deposits that formed in shallow, open water, with subsequent modification by wind and corrosive ground waters [2]. The deposits are at the top of a $\sim$300 m layer of sedimentary rock that covers the dissected, channeled cratered terrain. This means that a water-rich environment existed at or near the surface even after deposition of the $\sim$300 m section, i.e., after burial of the channel systems within the cratered terrains. Mars Express OMEGA data show that hydrated sulfate minerals are found in equatorial to mid-latitude layered deposits, including those explored in Meridiani Planum by Opportunity, and extensive deposits found within Valles Marineris [3]. These systems were dominated by acid-sulfate aqueous waters. The acidic conditions would have precluded formation of carbonate deposits. OMEGA data also show that clay minerals occur, but only in the older cratered terrains, consistent with a warm, wet early Mars with more neutral pH conditions [4]. The growing evidence for surface and subsurface water early in Mars history is an encouraging sign that Mars may have supported habitable zones and perhaps life. Searching for the evidence for habitable conditions and life is an exciting theme that will carry Mars exploration through its robotic period and into a time when humans explore the red planet.

[1] Arvidson, R. E. et al. (2006), Overview of the Spirit Mars Exploration Rover Mission to Gusev Crater: Landing site to Backstay Rock in the Columbia Hills, *J. Geophys. Res.*, *111*(E2), doi: 10.1029/2005JE002499. [2] Squyres, S. et al. (2004), The Opportunity Rover's Athena Science Investigation at Meridiani Planum, Mars, *Science, 306*, 1698-1703, doi: 10.1126/science.1106171. [3] Gendrin, A. et al. (2005), Sulfates in Martian Layered Terrains: The OMEGA/Mars Express View, *Science, 307*, 1587-1591, doi: 10.1126/science.1109087. [4] Poulet, F. et al. (2005), Phyllosilicates on Mars and implications for early martian climate, *Nature, 438*, 623-627, doi:10.1038/nature04274.