Depth of Burial for Lithification and Diagenesis of Muds and Sands on Early Mars

Kenneth S. Edgett[1], Juergen Schieber[2], John P. Grotzinger[3], Kirsten L. Siebach[3], Kathryn M. Stack[4], Lauren A. Edgar[5], Patrick J. Gasda[6], Jens Frydenvang[6], Sanjeev Gupta[7], Rachel E. Kronyak[8], and Linda C. Kah[8]

[1]Malin Space Science Systems, San Diego, California, USA
[2]Indiana University, Bloomington, Indiana, USA
[3]California Institute of Technology, Pasadena, California, USA
[4]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA
[5]U.S. Geological Survey, Flagstaff, Arizona, USA
[6]Los Alamos National Laboratory, Los Alamos, New Mexico, USA
[7]Imperial College, London, UK
[8]University of Tennessee, Knoxville, Tennessee, USA

ABSTRACT

Until discovery in 2013, finding and investigating a mudstone was one of the holy grails of Mars science. Well-preserved mudstones on a neighboring terrestrial world-particularly those deposited co-temporally with Earth's Hadean and early Archean Eons-were considered to have the highest potential for long-term preservation of organics and potential extraterrestrial biosignatures. Since landing in Gale crater (5.2°S, 222.2°W) in 2012, the Curiosity rover has traversed > 12 km and the team has investigated > 100 m of stratigraphy. Nearly half of the strata examined are mudstones. On the basis of orbiter images, at least 200m of additional mudstone strata are expected to be examined over the next one to two years.

Mars has an extensive, ancient sedimentary rock record with a diversity of lithologies and sedimentary facies. Sedimentary rock bodies are exposed in a wide range of settings. Some of the coarser clastic rocks (e.g., sandstones) are quite resistant to erosion-so much so that, until recently, some were presumed to be lava fields because they resist wind erosion as well as do mafic lavas. Thus, Martian sedimentary rocks present a puzzle: How deeply were they buried so as to become so well cemented, and how were they subsequently exhumed to the surface? The Martian crust has not experienced the same style and intensity of tectonic modification as is typical for Earth's crust. Sedimentary basins (excepting the northern lowlands) are largely impact craters and intercrater lows. The planet has no convergent plate boundaries and thus there has been no attendant metamorphism and mountain-building to strongly alter sedimentary rocks and return them to the surface.
To date, the processes that control lithification and diagenesis of clastic sediment on Mars, and the depth that these occur, are poorly constrained. Our objective here is to explore observations regarding burial and diagenesis of sedimentary rocks exposed at the Martian surface in Gale crater, a 155 km diameter impact- generated basin that includes the Curiosity rover field site.