Exploring Mars for Evidence of Habitable Environments and Life

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The climate of Mars has been more similar to Earth's climate than to that of any other planet in our Solar System. Still, Mars represents a different example of how planetary environments and processes might affect the presence of life. For example, although Mars also differentiated to form a core, mantle and crust, it evolved mostly if not completely without plate tectonics and it lost most of its early atmosphere. The Martian crust has been more stable than Earth's crust and so it has probably preserved a more complete record of its early history.

Orbital observations revealed that near-surface water was once pervasive. Orbiters acquired evidence of ancient diverse aqueous deposits: layered phyllosilicates, phyllosilicates in intracrater fans, evaporites, deep phyllosilicates, carbonates, intracrater clay-sulfate deposits, Meridiani-type layered deposits, valles-type layered deposits, hydrated silica-bearing deposits, and gypsum plains. These features indicate that early climates were wetter and perhaps also somewhat warmer. The denser atmosphere that sustained liquid water at the surface also provided protection from radiation.

Ancient climates might have favored habitable environments at least in some localities, but since then the Martian surface has been markedly less favorable for life. Dry and oxidizing conditions, together with typically low rates of sedimentation, were not conducive to the preservation of evidence about ancient environments and any life. Candidate sites must be characterized for their potential to preserve evidence of past conditions. Then rovers should explore the most promising sites.

The Mars Exploration Rover (MER) Opportunity revealed sediments that formed in ancient saline lakes whose waters were stirred by ancient winds that also sculptured their salt deposits into sand dunes. Opportunity subsequently explored even older deposits on a crater rim. MER Spirit found evidence that thermal waters, heated perhaps by volcanism or impacts, altered rocks to create sulfate salts and siliceous sinters.

The main objective of the Mars Science Laboratory (MSL) Curiosity rover has been to determine the extent to which Gale crater hosted environments capable of supporting microbial life. The rover has already found stream gravels and sediments that were deposited in an ancient lake. The rover is now traversing to Mt. Sharp, a 5 km-high mound that exhibits layered sedimentary rocks with diverse minerals. These include sulfates and phyllosilicates that formed in the presence of liquid water. This rock sequence was deposited over an extended time period in diverse potentially habitable aqueous environments. Curiosity is poised to characterize a a well-preserved rock record of hundreds of millions of years of habitable environments and profound climate change.

An early hydrological cycle apparently sustained precipitation, streams and lakes. Liquid water participated in rock-weathering reactions, including iron and sulfur oxidation. Volcanism, impacts, groundwater and ice interacted at least locally. Redox chemical energy from volcanism, hydrothermal activity and weathering of crustal materials would have been available for any life. Thus conditions on early Mars could have supported any life, at least locally.