Climate change from wet to dry at the Mars Exploration Rover landing sites

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Sedimentary "dirty" evaporites in Meridiani Planum were deposited in salt-water playas or sabkhas in the Noachian and highly water altered rocks in the Columbia Hills of Gusev crater formed at a time when a variety of geomorphic indicators on Mars (valley networks, degraded craters, highly eroded terrain, and layered sedimentary deposits) indicate a possible early warmer and wetter environment. In contrast, the cratered plains of Gusev that Spirit has traversed (exclusive of the Columbia Hills) have been dominated by impact and eolian processes and a gradation history that argues for a dry and desiccating environment since the Late Hesperian. The Late Hesperian/Early Amazonian cratered plains of Gusev crater are generally low relief moderately rocky plains dominated by hollows, which appear to be craters filled with soil. Rocks are generally angular basalt fragments in an unconsolidated $>$10 m thick regolith of likely impact origin. Eolian bedforms appear to be presently inactive ripples and no active sand dunes have been identified. Moderate localized surface deflation of 5 to 25 cm is indicated by two-toned rocks with a redder patination along the base, ventifacts that originate from a common horizon above the soil (suggesting that the lower part of the rock was shielded), rocks that appear to be perched on top of other rocks, and some undercut rocks, in which the soil has been removed from their bases. The observed gradation and deflation of ejected fines and deposition in craters to form hollows thus provides a measure of the rate of erosion (average vertical removal of material per unit time), which yields extremely slow erosion rates of $\sim$0.03 nm/yr comparable to those estimated at the Mars Pathfinder ($\sim$0.01 nm/yr) and Viking Lander 1 ($\sim$1 nm/yr) sites and argues that a dry and desiccating environment similar to today's has been active throughout the Hesperian and Amazonian (since $\sim$3.7 Ga). By comparison, erosion rates estimated from changes in Noachian age crater distributions and shapes are 3-5 orders of magnitude higher and comparable to slow denudation rates on the Earth ($>$5 micron/yr) that are dominated by liquid water. The erosion rates from Gusev as well as those from Viking 1 and Pathfinder strongly limit this warmer and wetter period (recorded in the Meridiani evaporites and Columbia Hills) to the Noachian, pre-3.7 Ga and a dry and desiccating climate since.