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by ***Stephen M. Clifford,***
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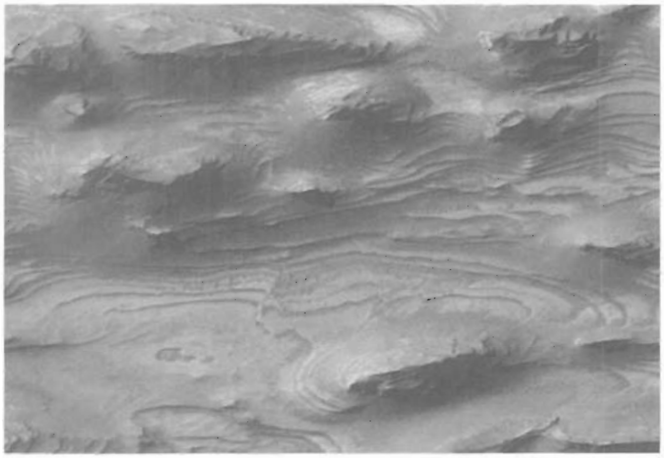

The History of Water on Mars:

Insights Provided by 35 Years of Robotic Exploration

The presence of numerous kilometer (km)-deep channels, up to several hundred of kilometers wide and thousands of kilometers long, provides persuasive evidence that Mars was (and likely remains) water-rich. The elevation of channel source regions (which average several km above the planet's low-lying northern plains) also indicates that, at the time the channels formed, much of this inventory of water was stored in the subsurface in disequilibrium with the global topography. The preservation of a reservoir of groundwater under disequilibrium conditions can be explained if it is confined beneath a thick layer of frozen ground, a hydraulic barrier whose existence is consistent with the extremely cold climatic conditions that are thought to have characterized the planet at the time the channels formed (~2–3 billion years ago).

However, earlier in the planet's history, a higher geothermal heat flux would have resulted in a thickness of frozen ground that was too thin to confine an elevated water table, implying that the initial distribution of water on Mars was in a state of hydrostatic equilibrium. If so, then it suggests that an ice-covered ocean, as much as several kilometers deep, may have occupied the northern third of the planet, with numerous lakes and seas residing in other low-lying elevations.

The progressive crustal assimilation of these early surface reservoirs of water appears to have been a natural consequence of the planet's subsequent climatic and geothermal evolution. Given the plausible range and likely heterogeneity of the planet's crustal properties (as well as regional differences in climatic and geologic evolution), and the evidence provided by the available geomorphic examples, the distribution and state of subsurface water on Mars is thought to be quite complex.

The abundance and distribution of subsurface water on Mars has important implications for understanding the geologic, hydrologic, and climatic evolution of the planet; the potential origin and continued survival of life; and the accessibility of a critical in-situ resource for sustaining future human explorers. For this reason, a principal goal of the international Mars exploration program is to determine the 3-D distribution and state of subsurface water at a resolution sufficient to permit reaching any desired volatile target by drilling.

Instruments designed to sound the Martian subsurface are planned as part of several missions between now and 2007. These initial efforts will provide invaluable data for the design of more comprehensive and ambitious investigations that are most likely to be flown in 2009 and beyond.

Biographical Sketch

STEPHEN CLIFFORD is a staff scientist at the Lunar and Planetary Institute in Clear Lake, where he conducts research on the distribution and dynamic behavior of water on Mars. He received his PhD in astronomy and MS in physics from the University of Massachusetts and did his undergraduate work in math and physics at Windham College in Putney, Vermont. □