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Climate Change and the Evolution of the Martian Water Cycle

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Despite the obvious visual differences, there are striking similarities between the water cycles of Earth and Mars. Both planets have surface polar caps, water ice clouds and an active atmospheric water vapor cycle. Although the martian water cycle is orders of magnitude less "intense" than the terrestrial cycle (annually, the martian atmosphere contains no more than 1-100 pr-µm of water depending on season and location), there is still a vigorous interaction between the surface polar caps, atmosphere and subsurface. Recent observations by the Mars Odyssey Gamma Ray Spectrometer have revealed substantial deposits of buried water ice poleward of 60° latitude in both hemispheres [1,2,3]. Although the full extent of these deposits is unknown, they represent the greatest reservoir of water on Mars observed to date.

The presence of these subsurface ice reservoirs, in locations where ice is not stable on the surface, suggests that the martian climate changes through time, and that at some point in the past, surface ice must have been resident at more equatorward locations than present. The mechanism responsible for this climate change is believed to be changes in the martian obliquity (predominantly), eccentricity, and argument of perihelion. The magnitude of these orbital and spin axis cycles is substantially greater on Mars than on Earth; martian obliquity, for example, has varied by up to 40° in the past 6 million years, reaching a value as high as 45° [4]. Under such extreme conditions on Mars, it becomes possible (and preferable) for ice deposits to form at tropical latitudes, establishing a tropical ice "belt" at the expense of the polar caps [5].

There is substantial visual, remote sensing and modeling evidence to support this behavior. The presence of glacially deposited moraines and eskers [6] suggest that glaciers once existed on the flanks of the large mountains atop the Tharsis rise. Currently, the presence of glacial landforms [7] on the sides of crater and valley walls in the mid-latitudes indicates that ice was recently stable (on geologic timescales) in such locations.

References

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