

Evolution of three distinct water reservoirs through the history of Mars

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The surface geology and geomorphology of Mars indicate that it was once warm enough to maintain a large body of liquid water on its surface, though such a warm environment might have been transient. The transition to the present cold and dry Mars is closely linked to the history of surface water, yet the evolution of surficial water is poorly constrained. This study identifies three distinct Martian water reservoirs based on the analyses of Martian meteorites, telescopic observations, and Curiosity measurements. One is mantle-derived water that has a D/H ratio similar to those seen in planetary building blocks (i.e., chondrites) and in the Earth's ocean water. The second reservoir is atmospheric water with a mean D/H ratio of ~6 times the terrestrial value. The third, subsurface-ice reservoir, has been recently detected based on analyses of Martian near-surface materials. This reservoir has a relatively restricted range of D/H ratios (2-3 times Earth's ocean water), which is distinct from the low-D/H primordial and the high-D/H atmospheric water reservoirs. This subsurface-ice reservoir could have possibly acquired its intermediate-D/H composition from the ancient surface water before the rise of the atmospheric D/H ratio to the present level. During ancient times, the atmosphere and hydrosphere could have approached isotopic equilibrium due to the high water activity relative to the recent dry Mars.

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