Warmer Wetter Mars in the Past?

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The isotopes of CO_2 ($^{13}C/^{12}C$, $^{18}O/^{16}O$), H_2O (D/H), N_2 ($^{15}N/^{14}N$), Ar (^{38},$^{40}Ar/^{36}Ar$), Kr and Xe are excellent indicators of climate change in the atmosphere of Mars. Recent high precision measurements of those isotopes with the quadrupole mass spectrometer and the tunable laser spectrometer of the Sample Analysis (SAM) suite of instruments on the Curiosity Rover clearly show that the atmosphere of Mars has been substantially depleted over the past four billion years. At the same time, both geological evidence and a comparison of the D/H isotope ratios in water vapor in the atmosphere with the Hesperian-era Gale Crater smectite rock fines, and even older Mars meteorites suggest a relatively large abundance of (liquid) water on the surface of Mars in the past. With the exception of xenon, the above isotopes inform about the change since roughly 4 Ga. The isotopic fractionations in xenon suggest, in addition, a massive H_2-driven hydrodynamic escape very early in the geologic history of Mars. Employing the isotopic record in the atmosphere and rock fines, we investigate a scenario of Mars where atmospheric composition and relatively high atmospheric pressure resulted in warmer conditions necessary for maintaining surface liquid water at least intermittently through late Noachian/early Hesperian, followed by a gradual loss of the atmosphere by escape since then, hence warmer and wetter conditions in the past compared to Mars' present cold and arid state.

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