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Evidence for the Survival of Subsurface H2O in the Martian Equatorial Region to the Present Day.

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Based on the geomorphic interpretation of a wide variety of Martian landforms, and a conservative estimate of the volume of water required to erode the outflow channels, Carr [1, 2] has estimated that, at the time of peak outflow channel activity (∼2-3 Ga), Mars possessed a planetary inventory of water equivalent to a global equivalent layer ∼0.5–1 km deep. As the outflow channels significantly post-date the period when the most efficient mechanisms of water loss (impact erosion and hydrodynamic escape) were thought to be active (>4 Gya) [3], it is expected that the bulk of this water still survives on Mars today, 90-95% of which is believed to be stored in the subsurface, as either ground ice or groundwater [2, 4].

However, a recent theoretical investigation of the evolution of subsurface H_2O on Mars [5] suggests that the equatorial regolith should have been completely desiccated, just a few hundred million years following the inferred transition from a warm to cold early climate, ∼ 3.7-3.9 Ga.

Yet there is evidence of significant, and geologically recent, outflow channel activity at several equatorial locations, including: Mangala Valles (∼0. 2-1 Ga [7], Kasei and Echus Chasma (∼0.07 – 1 Ga [8, 9], and Cerberus/Athabasca Valles (∼2 Ma [10-12]).

Recent atmospheric methane observations also appear to indicate a low-latitude subsurface source [13, 14]. Since there is no obvious evidence of local volcanism, the most plausible origins of this methane appear to be either the serpentization of olivine or the presence of methanogenic bacteria – both of which require the presence of a significant subsurface reservoir of liquid water. Thus, if the methane is recent, that reservoir of liquid water should still exist.

However, if the methane is old (i.e., formed during the Noachian and preserved to the present day as gas hydrate by the diffusion limiting properties of the regolith) then it implies that the vast majority of the H_2O that existed in the equatorial subsurface at the time of peak outflow channel activity should still be there (either as ground ice or groundwater). This follows because the diffusion coefficient of methane is similar to that of H_2O – implying more restrictive subsurface diffusive conditions than generally assumed by most theoretical models.

Thus, the prediction that equatorial subsurface H_2O should have experienced rapid desiccation is in conflict with several independent lines of observational evidence, including the occurrence of Mid- to Late Amazonian outflow channel activity and recent emissions of methane, which can only be explained by the survival of an equatorial reservoir of H_2O to the present day.

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