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Gullies, gullies everywhere (on Mars), but not a drop to drink?

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Gullies on Mars are kilometre-scale erosion-deposition systems found commonly on steep slopes predominantly in the mid-latitudes (30-50°N and S). Upon their discovery [1] they were hypothesised to originate from flowing liquid water, because of their resemblance to terrestrial gully systems. These include: tributary headwaters, incised and often braided or leveed channels, and fan/digitate depositional forms. Combining the facts that liquid water is unstable under present-day martian conditions and that martian gullies show latitudinal trends in both orientation and density, led researchers to propose that gullies were formed during periods of high axial tilt in the last ∼10Ma [2]. It is hypothesised that at axial tilts >35° (as opposed to ∼23° today), greater insolation at the poles causes sublimation of the polar caps, an increase in atmospheric density and humidity, thus a greater probability of forming liquid water. At axial tilts >35° pole-facing slopes in the mid-latitudes receive more insolation than equator-facing ones [3], which provides an explanation of the orientation preference of martian gullies. However, recent observations have revealed that many gullies are actually active at the present-day, during the season when CO_2 frost deposited each winter is sublimating from the surface [4]. This shift in formation process is supported by the observation that the present-day latitudinal distribution of seasonal CO_2 frost follows the orientation trends of gullies. Here we use a 1D climate model to assess whether the CO_2 model of gully formation can also be applied in the past, as gully systems are known to have been sporadically active for at least the last 5Ma [5,6]. We use the most up to date global data on density and orientation, which take into account the latitudinal variation in the availability of steep slopes on Mars [7] and a 1D version of the LMD Mars climate model physics [8,9] to simulate surface temperature on slopes up to 35°, oriented to face north or south, for all latitudes (5° spacing), and for orbital obliquities of 5-55°. We will use this model to determine the distribution of CO_2 frost with latitude, slope and orientation to compare with that of martian gullies.

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