The Case for A Wet, Warm Climate on Early Mars
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The theoretical arguments are presented in support of the idea that Mars
possessed a dense CO₂ atmosphere and a wet, warm climate early in its
history. Calculations with a 1-D radiative-convective climate model
indicate that CO₂ pressures between 1 and 5 bars would have been
required to keep the surface temperature above the freezing point of
water early in the planet's history. The higher value corresponds to
globally and orbitally-averaged conditions and a 30% reduction in solar
luminosity; the lower value corresponds to conditions at the equator
during perihelion at times of high orbital eccentricity and the same
reduced solar luminosity.

The plausibility of such a CO₂ greenhouse is tested by formulating a
simple model of the CO₂ geochemical cycle on early Mars. By
appropriately scaling the rate of silicate weathering on present Earth,
we estimate a weathering time constant of the order of several times 10⁷
years for early Mars. Thus, a dense atmosphere could have persisted for
a geologically significant time period (~ 10⁹ years) only if atmospheric
CO₂ was being continuously resupplied. The most likely mechanism by
which this might have been accomplished is the thermal decomposition of
carbonate rocks induced directly and indirectly (through burial) by
intense, global scale volcanism. For plausible values of the early heat
flux, the recycling time constant is also of the order of several times
10⁷ years. The amount of CO₂ dissolved in standing bodies of water was
probably small; thus, the total surficial CO₂ inventory required to
maintain these conditions was approximately 2 to 10 bars. The amount of
CO₂ in Mars' atmosphere would eventually have dwindled, and the climate
cooled, as the planet's internal heat engine ran down. A test for this
theory will be provided by spectroscopic searches for carbonates in
Mars' crust.