**$O_2$ SOLUBILITY IN MARTIAN NEAR-SURFACE ENVIRONMENTS AND IMPLICATIONS FOR AEROBIC LIFE ON MARS:** V. Stamenković[1], L. M. Ward[2], M. Mischna[1] & W. W. Fischer[3]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 USA. [2]Harvard University, Cambridge, MA 02139 USA. [3]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125 USA.

**Introduction:** Due to the scarcity of $O_2$ in the modern Martian atmosphere, Mars has been assumed incapable of producing environments with sufficiently large concentrations of $O_2$ to support aerobic respiration. Here we present a thermodynamic framework for the solubility of $O_2$ in brines under Martian near-surface conditions. We find that modern Mars can support liquid environments with dissolved $O_2$ values ranging from ~$2.5 \cdot 10^{-6}$ mol m$^{-3}$ to 2 mol m$^{-3}$ across the planet, with particularly high concentrations in polar regions because of lower temperatures at higher latitudes promoting $O_2$ entry into brines. General circulation model simulations show that $O_2$ concentrations in near-surface environments vary both spatially and with time — the latter associated with secular changes in obliquity. Even at the limits of the uncertainties, our findings suggest that there can be near-surface environments on Mars with sufficient $O_2$ available for extant aerobic microbes to breathe [1].

**Methods:** We develop a new comprehensive thermodynamic framework applicable to Martian conditions that calculates the solubility of $O_2$ in liquid brines. The supply of $O_2$ for our calculation is the atmosphere and, hence, our approach is valid for the surface and shallow subsurface ("near-surface") only, where brines are assumed to communicate with the atmosphere. We then couple this solubility framework to a Mars general circulation model (GCM) [2, 3] to compute the solubility of $O_2$ as a function of annually averaged values of pressure and temperature varying with location on Mars today (for an obliquity of ~25°). Using annual average climate values precludes the specifics of diurnal and seasonal variations of these aerobic environments but gives a concise first look into the regions that are most or least likely to sustain high dissolved $O_2$ solubilities. Last, we examine how the distribution of aerobic environments evolved over the past 20 Ma and how it may change in the next 10 Myr. To achieve this, we extend the modern-day Mars climate model [2, 3] using different values of obliquity to obtain annually averaged climate maps for each obliquity, and use calculations of Mars' obliquity changes over the past ~20 Ma and the next ~10 Myr [4] to identify those epochs in time with different axial tilts.

**Results:** We find that, on modern Mars—accounting for all uncertainties—the solubility of $O_2$ in various fluids can exceed the level required for aerobic respiration of ~$10^{-6}$ mol m$^{-3}$ for microbes [5, 6] by ~1-6 orders of magnitude. Thus, in principle, Mars could offer today a wide range of near-surface environments with enough dissolved $O_2$ for aerobic respiration like that seen in diverse groups of terrestrial microorganisms. Moreover, for supercooled Ca- and Mg-perchlorate brines on Mars today, ~6.5% of the total Martian surface area could support far higher dissolved $O_2$ concentrations—enabling aerobic oases at levels of $[O_2]_{aq}$>$2 \cdot 10^{-3}$ mol m$^{-3}$ sufficient to sustain respiration demands of more complex multicellular organisms like sponges [7]. Such aerobic oases are common today at latitudes poleward of ~67.5°N and ~72.5°S. Other aerobic environments with intermediate $[O_2]_{aq}$ values of ~ $10^{-4}$-$10^{-3}$ mol m$^{-3}$ can occur today closer to the equator in areas of lower topography like Hellas, Arabia Terra, Amazonis Planitia, and Tempe Terra, with larger mean surface pressures. The trends we show here are robust, as they can be tracked back to model-independent findings: (1) higher solubility for lower temperature and higher pressure, (2) temperature as the main control factor for solubility, (3) the poles being colder than the equator for modern Mars, and (4) the poles warming at higher obliquities.

Our study focused on near-surface environments. Recent results have indicated the potential existence of Ca- and Mg-perchlorate-rich subsurface brines at a temperature of ~205 K and a depth of 1.5 km [8]. Our results imply that the $O_2$ solubility in such a reservoir would be high, raising the possibility that they could be rich in $O_2$ if the supply either from intermittent communication with the atmosphere or from the radiolysis of water is sufficiently large. On Earth, aerobic respiration appears to have followed in the evolutionary footsteps of oxygenic photosynthesis, reflecting the scarcity of $O_2$ on Earth before photosynthesis. However, by sourcing $O_2$ in a different way, Mars shows us this need not be the case, broadening our view of the opportunities for extant aerobic life on Mars.

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