The evolution of redox gradients on Mars in space and time

*Vlada Stamenkovic[1,2], Lewis Ward[1], Woodward Fischer[1], Michael Mischna[2], Michael Russell[2]

1. California Institute of Technology, 2. Jet Propulsion Laboratory

From its deep interior to its atmosphere, a rocky planet can generate nutrients and redox gradients critical for the emergence and the evolution of life. We focus on the implications for life on modern Mars and potential changes in the last 20 Myr and the next 10 Myr from a 3D time-dependent perspective - by studying the spatial and temporal evolution of oxygen- and hydrogen-rich planetary niches.

We use time-dependent geodynamic models, capable of computing the 3D temperature profile and self-consistently accounting for serpentinization and radiolysis reactions as a function of subsurface temperature, pressure, and chemistry throughout the last 4.5 billion years (based on [1]-[4]). Additionally, we couple a parameterized climate model, which computes the local average annual surface temperature and pressure varying with obliquity and has been gauged with the Mars Weather Research and Forecasting (MarsWRF) GCM. MarsWRF is a global model based on the terrestrial mesoscale WRF model (see [5]-[7]) and is a Mars-specific implementation of the PlanetWRF GCM [8].

Geodynamic and climate models combined allow us to compute for Mars the time-dependent 3D distribution of 1) hydrogen-rich reducing subsurface environments, driven by serpentinization and radiolysis of water, and 2) oxygen-rich regions as a product of atmosphere-brine interactions governed by climate and surface chemistry. We will show spatial maps of such zones and results on their variability in the last 20 Myr and discuss implications for life, planetary protection, and landing site selection on Mars.

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