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Impact of oxygen fugacity on mid-infrared atmospheric spectral features of ultra-hot rocky exoplanets.

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With the advent of exoplanet characterization by next-generation telescopes such as the James Webb Space Telescope (JWST), attention has been drawn to the population of rocky, roughly "Earth-like" worlds orbiting other stars. However, the bulk compositions of these planets are poorly known. Existing estimates use the masses and radii of these bodies, as well as the abundances of refractory elements in their host stars, as proxies for terrestrial planet compositions [1], yet direct estimates are lacking. One of the major uncertainties lies in the abundance of oxygen, which dictates the share of Fe and Si between mantle and core, yet cannot be constrained from stellar abundances because it behaves both as a volatile and a refractory element during nebular condensation. Here, we investigate the effect of oxygen fugacity (fO_2) on the formation of silicate atmospheres on extremely hot, ultra-short period rocky planets. We use a thermodynamically self-consistent approach to model both the vaporization of the surface melt [2] as well as the atmospheric gas speciation excluding major volatiles [3], followed by a radiative transfer model with up-to-date opacities [4-5]. Oxygen fugacity was treated as a free parameter. Contrary to previous studies, we find that the pressures at the magma-atmosphere interface are not low by default [6], and can span a range of 0.1-100 bar, depending on the fO_2. We conclude that prospective lava ocean planets can possess thick atmospheres even in the absence of volatiles such as H, C and N. We show how such differences may manifest themselves in the emission spectra of the currently best characterized lava world, 55-Cancri-e, and how the JWST is capable of distinguishing between various oxidation states, thus providing the first independent constraints on rocky exoplanet chemistry.

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