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Strongly oxidizing surface conditions that are unfavorable for prebiotic chemistry might be a frequent outcome of lifeless planetary evolution

JOSHUA KRISSANSEN-TOTTON

University of Washington

Presenting Author: joshkt@uw.edu

Abundant molecular oxygen in planetary atmospheres is a promising exoplanet biosignature due to the evolutionary advantages conferred by oxygenic photosynthesis and the purported implausibility of oxygen-rich atmospheres on lifeless worlds in the habitable zone. But could the apparent implausibility of abiotic oxygen be an illusion? The extended, super-luminous pre-main sequence of M-type stars provides ample opportunity for excessive water photodissociation and subsequent hydrogen loss, potentially leaving behind sufficient atmospheric oxygen to overwhelm crustal sinks. Indeed, several independent modeling efforts have predicted abundant abiotic oxygen as a plausible outcome on habitable zone terrestrial planets around M-type stars [1-3]. And even on sun-like, G-type stars, the pressure overburden of large surface water inventories may suppress crustal sinks of oxygen, thereby permitting atmospheric oxygen to build up given relatively modest hydrogen escape rates [4]. Fully coupled atmosphere-interior evolutionary model results will be presented to show why these non-biological oxygen scenarios may be widespread. In particular, initial water inventories in excess of 10-100 Earth oceans frequently result in abundant abiotic oxygen, whereas planets near the inner edge of the habitable zone frequently attain oxygen-rich atmospheres given plausible C:H endowments and cloud feedbacks. In addition to being a potential "false positive" for life, strongly oxidizing surface conditions could preclude the emergence of life by inhibiting prebiotic chemistry involving organic carbon [1]. Notably, Venus provides a potential counterexample against a universe filled with oxygen-rich atmospheres due to hydrogen loss, and so the implications of Venus's uncertain atmospheric evolution will be discussed [5]. Abiotic oxygen-rich atmospheres are probably detectable with the James Webb Space Telescope, and so the prevalence of oxygen "false positives" planets and the implications for prebiotic chemistry may soon be empirically constrained.

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