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# A Venus-like atmosphere on the early Earth from magma ocean outgassing

**Paolo Sossi**[1,2], Antony Burnham[3], James Badro[2], Antonio Lanzirotti[4], Matt Newville[4], and Hugh O'Neill[3]

[1]ETH Zurich, Institute of Geochemistry and Petrology, Earth Sciences, Zurich, Switzerland (paolo.sossi@erdw.ethz.ch)
[2]Institut de Physique du Globe de Paris, Universite de Paris, Paris, France
[3]Research School of Earth Sciences, Australian National University, Canberra, Australia
[4]Center for Advanced Radiation Sources, University of Chicago, Chicago, USA

Outgassing of an early magma ocean on Earth plays a dominant role in determining the composition of its secondary atmosphere, and hence bears on the potential for the emergence of life. The stability of gaseous species in such an atmosphere reflects the redox state of the magma ocean. However, the relationship between oxygen fugacity ($fO_2$) and the oxidation state of the most abundant polyvalent element, Fe, in likely magma ocean compositions is poorly constrained. Here we determine $Fe^{2+}/Fe^{3+}$ ratios as a function of $fO_2$ in peridotite liquids, experimentally synthesised by aerodynamic laser levitation at 1 bar and 2173 K. We show that a magma ocean with $Fe^{3+}/\sum Fe$ akin to that of contemporary upper mantle peridotite (0.037) would have had $fO_2$ 0.5 log units higher than the Fe-"FeO" equilibrium. At this relative $fO_2$, a neutral $CO_2$-$H_2O$-dominated atmosphere of ~ 150 bar would have developed on the early Earth, taking into account the solubilities of the major volatiles, H, C, N and O in the magma ocean. Upon cooling, the Earth's prebiotic atmosphere was likely comprised of $CO_2$-$N_2$, in proportions and at pressures akin to that on presently found on Venus.