Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5633

Milankovitch climate control on redox cyclicity at the onset of the Great Oxidation Event

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The oxygenation of Earth's oceans and atmosphere is increasingly viewed as a dynamic transition [1], with geochemical evidence from multiple intervals within the Mesoarchean-Paleoproterozoic sedimentary record arguing for localised shallow-marine O_2 availability and transient surface oxygenation events [2,3] prior to the Great Oxidation Event (the GOE at ~2.4 – 2.3 Ga). However, proposed models for observed non-linearity or "whiffs" of oxygen (biogeochemical feedbacks; tectonic processes) and their estimated timescales (tens of millions of years [2,3]) thus far seem to exclude potential climate influences driven by Earth's orbital and inclination cycles (Milankovitch forcing) which occur at much shorter timescales (thousand- to million-year scale). This is remarkable because (1) regular alternations reminiscent of Milankovitch forcing have been described from the stratigraphic record [4-6] and (2) such orbitally-induced insolation changes may affect the dynamics of oxygen production and marine redox variability [7,8]. Here we present high-resolution X-ray fluorescence core scan and chemical abrasion (CA)-ID-TIMS U-Pb zircon data of early Paleoproterozoic banded iron formations from the Hamersley Basin, Western Australian, which suggest the presence of cyclical redox variations induced by astronomical forcing. Combined with reactive transport modelling, we explore their possible diagenetic, depositional and climatic origin, and the implications for the dynamics of early Earth's oxygenation history.

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