Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24592

# Dynamics of Neoproterozoic to early Paleozoic atmospheric and ocean oxygen

**STUART DAINES**[1] AND ZIHENG LI[2]

[1]University of Exeter

[2]China University of Geosciences

Presenting Author: s.daines@exeter.ac.uk

The geochemical carbon isotope and redox proxy record shows that the progressive oxygenation of the Earth surface includes a protracted interval of extreme variability in atmosphere and ocean oxygen, extending from the early Neoproterozoic (since ~900 Ma) and ending with a rise to near modern levels in the early Paleozoic (at 450 - 400 Ma). Previous work has linked this variability to both external tectonic and evolutionary forcings, and to internal nonlinear feedbacks generated by the redox-sensitivity of marine phosphorus burial.

We introduce a multi-timescale dynamical systems framework, and use it to reveal the controls on global and local stability of the coupled biogeochemical cycles of marine phosphorus and atmosphere-ocean carbon and oxygen, and to assess the relative contributions of external forcings and amplifying internal feedbacks. We derive the criteria for the atmosphere-ocean system to show stable or oscillatory behaviours, and show that it may also be in a highly nonlinear "excitable" regime. In this regime stochastic forcing by small tectonic events can produce a large transient response, and the system is also sensitive to the rate at which forcings change.

We suggest that secular evolution through stable, excitable and unstable regimes can explain the patterns and trends in the Neoproterozoic to Paleozoic record, where rate-dependent changes in degassing fluxes may drive both ocean oxygenation events (OOE) and anoxic events (OAE). Diversity and secular trends in later Phanerozoic OAE can also be understood as a result of changes in the susceptibility to excitation by tectonic perturbations. Internal feedbacks and instability, not (just) tectonic forcings may then drive extinctions and biodiversity.