Stepwise oxygenation of the Paleozoic atmosphere

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Geochemical proxies have been instrumental in determining the broad evolutionary history of oxygen on Earth, but much of our insight into the temporal variability of atmospheric oxygen levels over the Phanerozoic comes from biogeochemical modelling. However, there are fundamental disagreements amongst the different models, and between models and geochemical proxies, particularly during the early Paleozoic.

Here, we revisit the the GEOCARBSULF model [1], which calculates atmospheric oxygen by estimating the burial and weathering rates of organic carbon and reduced sulphur, from the sedimentary records of $\delta^{34}S$ and $\delta^{13}C$. The model estimates near present day levels of oxygen in the Paleozoic, but is restrained from predicting much lower levels by its simplified treatment of a complex geochemical process: sulphur isotope fractionation, which is used to calculate pyrite burial. We update the model by replacing the sulphur cycle equations with ones which eliminate the requirement for sulphur isotope fractionation values to calculate pyrite burial [2], thus lifting this constraint on its calculation of atmospheric oxygen levels.

Our new model produces a new history of atmospheric oxygen levels over the Phanerozoic. Crucially, our results are compatible with both geochemical indices and previous biosphere-driven modelling, and support the hypothesis that the evolution of land plants caused a stepwise change in Earth's oxygen levels.

[1] Berner (2006) *Geochim. Cosmochim. Acta* **70**, 5653-5664. [2] Lenton *et al*. (2018) *Earth-Sci. Rev.* **178**, 1-28.