Stable isotope investigation of palaeo-CO_2 levels: Neoproterozoic climatic extremes as a test study

S.A. KASEMANN[1], A.R. PRAVE[2], C.J. HAWKESWORTH[3] AND A.E. FALLICK[4]

[1] Grant Institute of Earth Science, University of Edinburgh, Edinburgh, U.K.; simone.Kasemann@ed.ac.uk
[2] School of Geography & Geosciences, University of St Andrews, Fife, U.K.; ap13@st-andrews.ac.
[3] Department of Earth Sciences, University of Bristol, Bristol, U.K.; C.J.Hawkesworth@bristol.ac.
[4] Scottish Universities Environmental Research Centre, Glasgow, U.K.; T.Fallick@suerc.gla.ac.

The abundance of atmospheric carbon dioxide throughout Earth's history is key issue for palaeoclimate reconstructions, especially during times of extreme climate change such as those that marked the Neoproterozoic. The prevalent explanation for significant climate changes in the Neporterozoic is based on carbon isotope anomalies and invokes the build up of a global ice cover. During this time atmospheric CO_2 levels rose to ~ 350 times those at the present day, leading to rapid melt back under ultra-greenhouse conditions [1]. However, there is considerable uncertainty about the source and the timing of carbon isotope anomalies and the levels of inferred pCO_2. To investigate the extent to which atmospheric CO_2 determined climate change in the Neoproterozoic, multi-proxy isotope analyses of boron, calcium, carbon and oxygen are applied to carbonate rocks from Namibia to isotopically fingerprint ancient seawater and use them as proxies to document variations in the palaeo-environment and to quantify palaeo-CO_2 changes.

Neproterozoic cap carbonate profiles from different palaeo-environmental settings show systematic and facies independent stable isotope variation demonstrating the reproducibility and validity of the isotopic trends and patterns. The B-isotopes in the postglacial carbonate rocks show a systematic negative excursion (~9‰), attributed to a decrease in the pH of the ocean water. Variations in Ca-isotopes (~0.8‰) reflect temporary fluctuations in the rate of continental weathering and the Ca concentration of the ocean. The Ca variation is linearly coupled with the C-isotope anomaly (-6‰) indicating a concomitant delivery of Ca and CO_2 to the ocean via enhanced weathering rate. The reconstructed seawater pH and weathering profiles indicate that high atmospheric CO_2 concentrations (90000 ppm) are possible during the meltback of the Neoproterozoic glaciations and carbonate deposition. However, the B-isotope trend suggests that such elevated CO_2 concentrations rapidly declined and does not correlate with C-isotopes.

References

[1] Hoffman, P.F., Kaufman A.J., Halverson G.P. and Schrag D.P. (1998). *Science* **281**, 1342–1346.