Crustal growth and recycling during supercontinent cycles: evidence from detrital zircon Hf-isotope data from the Damara Orogen

DAVID A. FOSTER* AND PAUL A. MUELLER

Department of Geological Science, University of Florida, Gainesville, Florida 32605 USA (*correspondence: dafoster@ufl.edu)

Orogenic belts formed during the Rodinia to Gondwana supercontinent cycle harbor information about the construction and recycling of continental crust. U-Pb ages and Hf-isotopic compositions of detrital zircons reflect contributions from recycled and juvenile crust within the orogenic belts. Neoproteorozoic strata of the Damara Sequence, which was deposited along the southern and western margins of the Congo Craton, give populations of detrital zircons with distinctive age components derived from the craton. The major age populations in these metasedimentary rocks are 2050-1900 Ma, ca. 1700 Ma, 1100-950 Ma, and 800-700 Ma. In addition to the Proterozoic zircons, there is a smaller number of late Archean grains. Initial epsilon Hf values for zircons from each of these age populations range from strongly negative to positive values approaching depleted mantle values at the respective times. The majority of the zircons give initial epsilon Hf values between +10 and -10, with notable exceptions for ca. 1100-1000 Ma grains (values as low as -20) and the 800-700 Ma grains, which are dominated by positive values. Each of the Paleoproterozoic to early Neoproterozoic orogenic cycles represented in the populations from the Damara sequence, therefore, includes a mixture of juvenile and ancient crustal materials. A relatively larger fraction of juvenile material is represented in the detritus derived from syn-rift magmatism associated with opening of the Khamos Ocean. Results from latest Neoproterozoic to Cambrian Nama Group strata deposited in the foreland basin to the Damara Orogen mirror the zircon populations in the Damara Sequence. The Nama Group also contains ca. 570-530 Ma zircon with negative epsilon Hf. These data suggest that most of the material involved in the Damara Orogen was recycled from the earlier Proterozoic events and syn-rift magmatism. Our results suggest that the Grenvillian-Kilbaran and Pan-African events in the Damara-Zambezi Orogen recycled large fractions of older crust along with some juvenile crust, and that significant juvenile crust formed during Neoproterozoic rifting of Rodinia, which was subsequently cratonized during the accretion of Gondwana.

pCO_2 and climate; Evidence from boron based proxies of pH and *p*CO_2

GAVIN L. FOSTER[1]* OSAMU SEKI[2,3], RICHARD D. PANCOST[3] AND DANIELA N. SCHIMDT[1]

[1]Department of Earth Sciences, University of Bristol, Bristol, BS8 1RJ, UK (*correspondence: g.l.foster@bristol.ac.uk)
[2]Faculty of Environmental Earth Science, Hokkaido University, Hokkaido, Japan
[3]School of Chemistry, University of Bristol, BS8 1TS, UK

Identifying the role of atmospheric CO_2 in determing the climate of the past, particularly during time periods when the Earth was warmer than today, has been recognised as a key way in which to better predict the climate of our warming future. However, accurate reconstructions of *p*CO_2 beyond the reach of the ice cores is a notouriously difficult task. What is needed is a robust proxy that can be easily correlated with other climatic archives and can be applied at a suitable temporal resolution. The isotopic composition of boron ($\delta^{11}B$) and its concentration (B/Ca) in foraminifera recovered from ocean sediments however have the potential to fullfil this role.

The boron isotope palaeo-pH proxy has a firm theoretical basis and is dependant on the known pH dependant speciation of boron in seawater and the isotopic fractiation that exists between the two aqueous boron species [1]. Accurate determination of $\delta^{11}B$ is however hampered by a number of analytical difficulties. A new measurement protocol using multi-collector inductively coupled mass spectrometry (MC-ICPMS), overcomes many of the problems that plague traditional $\delta^{11}B$ measurement approaches [2]. This advance is particularly timely since it has also been recently recognised that the B/Ca ratio of foraminifera is a proxy for $[CO_3^{2-}]$ [2] and so combining these two proxies allows a complete reconstruction of the carbonate system (including *p*CO_2) without recourse to further assumptions.

The utility of the combined $\delta^{11}B$ and B/Ca approach will be illustrated here with examples from key time periods throughout the Cenozoic, with a focus on the Mid Pliocene. Particular attention will be placed on how the boron based proxies compare to other *p*CO_2 proxies (e.g. $\delta^{13}C$ of alkenones), the limitations of the approach used, and what can be learnt from these multi-proxies records about how *p*CO_2 controls climate in the geological past.

[1] Klochko *et al.* (2006) *Earth Plant. Science Lett.* **248**, 261-270. [2] Foster (2008) *Earth Plant. Science Lett.* **271**, 254-266.