Eocene pCO_2 reconstructions using boron isotopes in "glassy" planktonic foraminifera

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The Cenozoic climate transition marks the most recent climatic shift in Earth's history from a greenhouse to an icehouse world (~53-33 Ma). This interval is characterized by a gradual deep-sea [1] and high-latitude [2] cooling of ~10ºC and only moderate cooling of the tropics [2], culminating in Antarctic glaciation at the Eocene/Oligocene transition (EOT).

Although a decline in the CO_2 content of the atmosphere (pCO_2) has been suggested as the trigger for final transition into the ice house [3], currently available early Eocene pCO_2 records are rather variable and appear only weakly correlated with climate variations for this interval. For this reason, using multicollector ICPMS, we generated a new record of boron isotopes ($\delta^{11}B$) in planktonic foraminifera, a proven proxy of seawater pH [e.g. 4]. We utilised multi-species depth profiles from very well preserved "glassy" planktonic foraminifera recovered by the Tanzanian Drilling Project from five time slices spanning 53-37 Ma. We discuss our new reconstructions of seawater pH and derived pCO_2 concentrations, in view of estimates of seawater $\delta^{11}B$ composition and alkalinity.

[1] Zachos *et al* (2001) *Science* **292**. [2] Bijl *et al* (2009) *Nature* **461**. [3] Pearson *et al* (2009) *Nature* **461**. [4] Sanyal *et al* (1996) *Paleoceanography* **11**.

A common origin for terrestrial and lunar indigeneous water

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Variable but significant amounts of "water" have been measured in samples derived from the lunar interior [1-7], challenging the long-standing paradigm of a bone-dry Moon. Based on elevated D/H ratios measured in mare basalt apatites (> 500 ‰), lunar "water" has been inferred to be of cometary origin [3]. In contrast, it has been argued that CI-chondrites (δD ~ 100 ‰) are also a viable source for lunar H, and that the elevated apatite δD values reflect intense H_2 degassing during magma ascent and emplacement [8].

New OH and D/H analyses in apatites from Apollo basalts and basaltic meteorites, carried out at The Open University using the NanoSIMS 50L, confirm that apatite in Apollo mare basalts have elevated δD values > 400 ‰ and a wide range of OH contents (300-7300 ppm). Apatites in meteorites MIL 05035 and LAP 04841 expand our range for mare basalt δD values down to ~ 200 ‰. These δD variations are consistent with ~ 85 to 99 % degassing of H_2, starting from a CI chondrite-type δD value of 100 ‰. In the ~ 4.3 Ga basaltic lunar meteorite Kalahari 009, 8 out of 9 analyses define an average δD value of -15 ± 47 ‰ for corresponding OH contents of 500 to ~ 4000 ppm. We interpret this D/H ratio as that of an undegassed basalt, directly reflecting the H isotope composition of the lunar mantle. This is in good agreement with recent analyses carried out in melt inclusions in Apollo 17 orange glasses [9]. As this D/H ratio is similar to that of the bulk Earth [10], these new data suggest that terrestrial and lunar hydrogen share a common origin.

[1] Barnes *et al* (2013) *Chem. Geol.* **337-338**, 48-55. [2] Boyce *et al* (2010) *Nature* **466**, 466-469. [3] Greenwood *et al* (2011) *Nature Geosci.* **4**, 79-82. [4] Hauri *et al* (2011) *Science* **333**, 213-215. [5] Hui *et al* (2013) *Nature Geosci.* **6**, 177-180. [6] McCubbin *et al* (2010a) *PNAS* **27**, 11223-11228. [7] Saal *et al* (2008) *Nature* **454**, 192-196. [8] Tartèse & Anand (2013) *EPSL* **361**, 480-486. [9] Füri *et al* (2013) *LPS XLIV*, Abstract #2108. [10] Lécuyer *et al* (1998) *Chem. Geol.* **145**, 249-261.

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