Subantarctic Pacific stable isotope evidence for a CO_2 sink in the abyssal Southern Ocean during the Late Pliocene

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We present new benthic stable isotope records from subantarctic southeast Pacific cores MV0502-4JC (50°20'S, 148°08'W, 4286m) and ELT 25-11 (50°02'S, 127°31'W, 3969m) which indicate that the abyssal Southern Ocean response to the late Pliocene climate transition (LPCT) at ~2.75 Ma was more extreme than previously thought based on benthic stable isotope records from ODP Sites 704 (46°52'S, 7°5'E, 2532 m) and 1090 (42°55', 8°54'E, 3702 m) in the South Atlantic. In MV0502-4JC $\delta^{13}C$ and $\delta^{18}O$ values appear to shift by -1.05‰ and +1.1‰, respectively, over the period ~2.7 to 1.9 Ma (9.6-7.3 MBSF) and are followed by a dramatic return of the benthic $\delta^{13}C$ values to pre-LPCT values after ~1.7 Ma that is also recorded in the planktonic record. These benthic $\delta^{13}C$ and $\delta^{18}O$ shifts indicate the accumulation of an ever-larger percentage of cold, poorly-ventilated AABW in the abyssal Southern Ocean during the late Pliocene, in response to processes such as sea ice formation, and perhaps reduced upwelling of abyssal Southern Ocean waters. Overall we infer that the pool of cold, poorly-ventilated water was at least sizeable enough to fill the Pacific sector of the Southern Ocean below a depth of 4000 m. Such a large, isolated water mass would have been capable of sequestering large amounts of respired CO_2 within the abyssal Southern Ocean, and thus could potentially have played an important role in the amplification of Northern Hemisphere Glaciation during the late Pliocene.

Enstatite chondrite and related Earth models

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Geochemical models of the Earth have traditionally been based on CI chondrite bulk compositions even though such models are a poor ‘fit’ for the isotopic composition of the planet, which means that a better Earth model is required.

In contrast to CI chondrites, Enstatite chondrites have oxygen isotopic compositions in agreement with those BSE [1] and recent results for Cr, Ni and Ti confirm the close relationship between Earth and this meteorite class. Furthermore, the earliest stages of core segregation on Earth appear to have taken place under strongly reducing conditions [2], similar to those produced by re-equilibrating E-chondrites. Despite these lines of support for the Enstatite-chondrite Earth model, we can find no way to reconcile the bulk compositions of E-chondrites with those of the bulk Earth even if the most extreme compositions are taken as a starting point. The Earth’s mantle would have to have a marked layering in Si [1] which is virtually impossible to reconcile with seismological observations.

Our approach, starting with the enstatite chondrite model, has been to consider mixtures of meteoritic components which generate the right O, Cr, Ni and Ti isotopic composition of the Earth, together with the ‘right’ balance of siderophile and volatile element concentrations. We find that various combinations of ordinary and carbonaceous chondrites can satisfy the isotopic and refractory element constraints, and that we need to apply a volatile element balance in order to derive tighter constraints. We will argue that significant volatile loss from the Earth has not occurred so that a volatile mass balance constraint is reasonable.

[1] Javoy (1995) *Geophysical Research Letters* **22**(16), 2219-2222. [2] Wade & Wood (2005) *Earth And Planetary Science Letters* **236**, 78-95.