

Towards an improved understanding of Paleoceanographic proxies for Antarctic Intermediate Water Circulation: A core-top perspective

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Abstract

The Atlantic Meridional Overturning Circulation has been recognized as a major component of the climate system and is important for oceanic heat transport on millennial and glacial-interglacial timescales (Burton et al., 1997; Rutberg et al., 2000; Piotrowski et al., 2005; Roberts et al., 2010). The records for an important component of this circulation - Antarctic Intermediate Water - are ambiguous, giving rise to conflicting interpretations about the long-term history of AAIW flow into the North Atlantic (Came et al., 2008; Pahnke et al., 2008). To further constrain the past AAIW variability, we systematically examine water mass proxies, such as nutrient tracers (Cd/Ca and $\delta^{13}\text{C}$) in benthic foraminifera and the Nd isotopes in uncleaned planktonic foraminifera using a set of multicore tops (KNR197-3, spanning depths of 380 to 3300 m) and measured seawater chemistry from the Demerara Rise in the western tropical Atlantic. AAIW and NADW overlie the Demerara Rise sediments at these water depths.

Both seawater Cd and $\delta^{13}\text{C}$ at Demerara Rise closely mimic salinity. Cd/Ca of the three benthic foraminifera (*C. pachyderma*, *C. wuellerstorfi* and *Uvi. spp.*) capture the regional seawater Cd profiles and are best explained by a single partition coefficient $D_{\text{Cd}} = 2.7$, similar to values typically found below 2000 m. $\delta^{13}\text{C}$ of individual specimens (*C. pachyderma* and *C. wuellerstorfi*) from multicore tops also reflect the different water mass isotopic compositions. Our seawater Nd isotope data follows the distribution of salinity, demonstrating conservative mixing of Nd in the water column at Demerara Rise. Furthermore, ϵ_{Nd} in uncleaned planktonic foraminifera faithfully record the seawater ϵ_{Nd} , suggesting that we will be able to reconstruct changes in the shape of bathymetric profile of ϵ_{Nd} through time and downcore ϵ_{Nd} changes at a single site in our study area. Preliminary downcore work will be presented.

[1] Burton et al. (1997) *Nature* **386**, 382-385. [2] Rutberg et al. (2000) *Nature* **405**, 935-938. [3] Piotrowski et al. (2005) *Science* **307**, 1933-1938. [4] Roberts et al. (2010) *Science* **327**, 75-78. [5] Came et al. (2008) *Paleoceanography* **23**, PA1217. [6] Pahnke et al. (2008) *Nat. Geosci.* **1**, 870-874.

Relationship between the Isotopic Compositions of Earth and Chondrites: Constraints from Calcium Isotopes

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Chondritic meteorites have been used to estimate the elemental and isotopic compositions for refractory lithophile elements of the bulk Earth. Recent studies reported both mass-dependent and mass-independent isotopic differences between terrestrial rocks and chondrites. Such isotopic differences have been used to argue for (i) a hidden reservoir buried deep at the bottom of the mantle; (ii) certain elements partitioning into the Earth's core; or (iii) that the bulk Earth does not have a chondritic composition for the refractory lithophile elements.

Here we present Ca isotopic measurements of three groups of chondrites (carbonaceous, ordinary and enstatite chondrites). Our results show that Ca is the only major element in addition to O that show both mass-dependent (δ -values) and mass-independent (ϵ -values) isotopic variations among chondrite groups. In contrast, all chondrite groups have essentially the same Mg, Si and Fe isotopic compositions. Our results show that $\delta^{44/40}\text{Ca}$ decreases in the order of enstatite chondrites > ordinary chondrites > carbonaceous chondrites, with enstatite chondrites having the same $\delta^{44/40}\text{Ca}$ as the estimated bulk Earth value. Carbonaceous chondrites also have up to 3 ϵ units of ^{48}Ca excess compared to the Earth. In contrast, such ^{48}Ca excess is not observed in ordinary or enstatite chondrites.

Enstatite chondrites and the Earth have the same isotopic compositions for all major and minor elements (O, Ca, Ti, Cr) which exhibit substantial isotopic variations among different chondrite groups, with Si being the only exception. Available data show that enstatite chondrites have lower $\delta^{30}\text{Si}$ compared to the Earth's mantle. Since only EH chondrites, which have high metal contents and whose metals have very different Si isotopic composition, have been analyzed for Si isotopes, the measured Si isotopic compositions in EH chondrites may not represent the isotopic composition of their parental nebular reservoir.

The identical isotopic compositions of the Earth and enstatite chondrites and their very different chemical compositions imply that they are derived from the same parental nebular reservoir, but experienced different formation processes.