Millennial-scale influence of southern intermediate component water into the North-east Atlantic during the last 40kyr

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Abstract: *The advection of Antarctic Intermediate Water (AAIW) is important for the distribution of heat, salt, nutrients and carbon to the North Atlantic. However little is known about the links between intermediate water circulation and abrupt climate events such as Heinrich events. Here, we have investigated εNd of seawater and cold-water corals located to the Alboran Sea and to the SE of the Gulf of Cadiz to constrain the present day seawater εNd and to reconstruct the past water mass mixing during the last 37kyr. The coral εNd values range from -8 to -10.4, most likely indicating changes of the dominant water mass provenance. Glacial cold-water corals (from 19 to 37kyr) are characterized by more radiogenic εNd values (> -9.5) compared to the ones from the Holocene demonstrating a decreasing contribution of MOW and/or AAIW in the SE Gulf of Cadiz during climate warming. Strikingly, Heinrich events H2 and H3 reveal even more radiogenic εNd values (~-8). In addition, deep-sea corals from the Alboran Sea indicate that εNd of the MOW do not change significantly trough time. These results points to significant advance of southern component water at 500m depth in the eastern temperate Atlantic.*

Key words: *AAIW, Nd isotopes, deep-sea corals, north Atlantic cold events.*

INTRODUCTION

Throughout the last glacial-interglacial cycle, major reorganizations of water masses in the North Atlantic occurred. Nutrient-proxies ($\delta^{13}C$ and Cd/Ca) provide evidence that deep-water production in North Atlantic was shallower and thus the deep basin was occupied by southern water (Antarctic Intermediate Water = AAIW and Antarctic Bottom Water = AABW; Duplessy et al., 1988). However little is known about the hydrological parameters of the intermediate water masses.

Antarctic Intermediate Water (AAIW) is an important water masse of the general ocean circulation because its production and advection influence interhemispheric heat exchange as well as the distribution of salinity, nutrients and carbon. Recently it has been shown a decrease in the AAIW fraction in the North Atlantic during cold events (Heinrich events and Younger Dryas; Kuo-Fang et al., 2014). Nevertheless, deglacial variability of Atlantic AAIW is still unclear, other studies arguing for a greater fraction (e.g. Pahnke et al., 2008). Furthermore Mediterranean Outflow Water (MOW), being an important source of saline and warm intermediate water, has been modulated regarding its strength and mean depth (Voelker et al., 2006; Toucanne et al., 2007).

In order to constrain the hydrology of these water masses in the NE Atlantic, we have investigated εNd that constitute a reliable proxy to trace water mass provenance in oceans. The residence time of the dissolved Nd in the ocean (about 800yrs, Tachickawa et al., 1999) is shorter than the global turnover time of the ocean (about 1000yrs). Consequently, intermediate and deep-water masses acquire εNd signature from downwelling surface water though lithogenic input.

Here, we have investigated εNd of seawater and cold-water corals (L. *pertusa*, M. *oculata* and D. *dianthus*) located to the Alboran Sea and the SE of the Gulf of Cadiz (between 550 and 850m) to constrain the present day seawater εNd and to reconstruct past water mass mixing during the last 37kyr.

HYDROLOGICAL SETTINGS

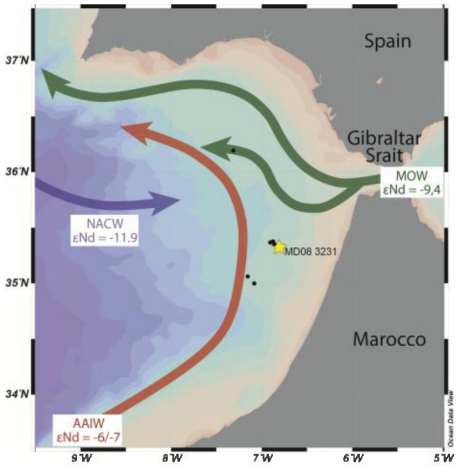

FIGURE 1. Simplified distribution of intermediate water masses in the Gulf of Cadiz. εNd values are also reported. The yellow star indicate the location of the studied core and black dots indicate other sampling sites used in this study.

The Gulf of Cadiz near the Strait of Gibraltar is located in a region influenced by the 3 major temperate

Atlantic mid-depth water masses (Fig. 1) : (1) MOW flows out the Mediterranean Sea along the Southern Iberian slope into two main cores — the upper and lower Mediterranean Sea Water (MSW) at depths of 500 to 800m and 800 to 1200m respectively; (2) North Atlantic Central Water (NACW) formed in the western Atlantic basin, flows from west to east in the Gulf of Cadiz at 100-600m depth; (3) AAIW has been identified in the Gulf of Cadiz in several studies (e.g. Louarn & Morin, 2011). It is formed at the polar front in the south-west Pacific and is characterized by low oxygen and high silicate values.

Those water masses are today characterized by contrasted Nd εNd : NACW εNd = -11.9; MOW εNd= -9.4; AAIW εNd= -6 to -7 (Fig. 1).

MATERIAL AND METHODS

εNd values have been analyzed on seawater and fossil deep-sea corals from a sediment core MD08-3231 (35°18.90'N, 06°48.19'W; Fig. 1) recovered at 550m water depth on the Gamma Mound from the Pen Duick Escarpment (PDE) during the MD 169 MiCROSYSTEMS Cruise.

Corals have been dated using U-Th method. Nd has been separated following the procedure described in details by Copard et al. (2010). A Nd-oxide technique for thermal ionization mass spectrometry (TIMS) was used to determine the Nd isotopic composition.

RESULTS AND DISCUSSION

Seawater εNd value of -11.6 indicates that the NACW is today the predominant water mass at the position of the studied site (core MD08-3231).

The coral εNd values range from -8 to -10.4 during the last 37kyr, most likely indicating changes of the dominant water mass provenance. Glacial cold-water corals (from 19 to 37kyr) are characterized by more radiogenic εNd values (> -9.5) compared to the ones from the Holocene. At this time, the weaker southward export of Atlantic water results in more radiogenic and less diluted AAIW.

Strikingly, Heinrich events H2 and H3 reveal even more radiogenic εNd values (~ -8). In addition, deep-sea corals from the Alboran Sea indicate that εNd of the MOW do not change significantly trough time. These results imply a higher contribution of AAIW linked to an increase in AAIW formation and a collapse of the AMOC.

The incursion of southern source water into the Gulf of Cadiz at 19kyr ago is also described in a core of the western basin (Pahnke et al., 2008). This event is not associated with an increase in AAIW production. However, it is coeval with the southwards flow of the Fennoscandian ice sheet derived meltwater as seen in a core of the Fleuve Manche and several cores of the Bay of Biscay (Toucanne et al., 2010) that could have weakened the GNAIW convection.

CONCLUSION

We report for the first time past seawater εNd record obtained from cold-water corals of the intermediate water of the Gulf of Cadiz. Glacial time is characterized by more radiogenic εNd values than the Holocene implying the presence of a higher contribution of AAIW in the Gulf of Cadiz. Our results indicate an advance of southern component water (AAIW) at shallow depth into the NE Atlantic during the cold events H2 and H3 and at 19kyr.

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