Nd isotopic composition of present and Holocene water masses from the Gulf of Cadiz and the Alboran Sea

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Abstract: *Six depth-profiles of dissolved Nd concentrations and isotopic ratios (εNd) were obtained in the Gulf of Cadiz and the Alboran Sea to answer the lack of data in these areas. εNd are analyzed on a multi-collector inductively coupled plasma mass spectrometer. Seawater εNd will be compared with εNd values of deep-sea corals from Alboran Sea dated between 13.5-12.8ka, 11.2-9.8ka and 5.4-0.3ka. εNd from deep-sea corals remained unchanged during these periods and present a narrow range from -8.5 to -9.2 ± 0.2.*

Key words: *Nd isotopes, seawater, Gulf of Cadiz, Alboran Sea*

INTRODUCTION

Nd isotopic composition is expressed as εNd = $[(143Nd144Nd)_{Sample}/ 143Nd144Nd)_{CHUR} - 1] \times 10{,}000$, where CHUR stands for chondritic uniform reservoir and represents the present-day average earth value; $(143Nd/144Nd)_{CHUR} = 0.512638$ (Jacobsen and Wasserburg, 1980). The residence time of Nd, recently re-assessed to about 800 yrs (Tachikawa et al., 1999), is shorter than the global turnover time of the ocean (about 1000 yrs. Consequently, through lithogenic inputs of material with various ages and boundary-exchange processes that occur at the continental margin (Lacan and Jeandel, 2005), intermediate- and deep-water masses acquire εNd from downwelling surface water (Goldstein and Jacobsen, 1988).

In the ocean, the only way to alter the initial isotopic composition of one water masse is to add Nd with a different isotopic composition through riverine or eolian inputs or by mixing with other water masses. In areas where the relative influence of exchange is small, Nd isotopes can be used as a tracer of water circulation. This proxy is used in paleo-oceanographic studies using the dispersed authigenic ferromanganese oxide precipitates in sediments, planktonic foraminifera or deep-sea corals to track changes in water mass provenance and mixing on a glacial/interglacial time scale.

The Mediterranean Sea communicates with the North-eastern Atlantic Ocean through the Strait of Gibraltar. At the surface, the Atlantic Inflow enters the Mediterranean Sea, while, at greater depth, the Mediterranean Outflow enters the Atlantic Ocean. Furthermore, the εNd value of the Mediterranean Outflow (εNd=-9.5; Henry et al., 1994) is higher than that of the Atlantic inflow (εNd=-11.8; Spivack and Wasserburg, 1988)

Despite being highly studied areas, εNd of the water masses from the western Mediterranean basin and the Gulf of Cadiz are poorly constrained. In this study, we present six new depth-profiles of Nd concentrations and seawater εNd collected in the Gulf of Cadiz and the Alboran Sea.

SAMPLES AND HYDROLOGICAL SETTINGS

Ten litters of filtered seawater samples were collected at six stations in the Gulf of Cadiz and the Alboran Sea (Fig. 1) during MD-194 EuroFLEETS-GATEWAY cruise in June 2013.

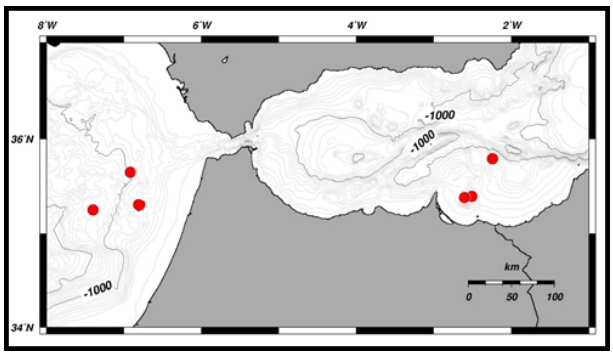

FIGURE 1. Sampling locations of seawaters (red dots).

Three CTD have been made in the Gulf of Cadiz (MD194-MOW1, 35°39.04'N 6°55.10'W, 988m; MD194-MOW2, 35°13.11'N 7°10.56'W, 1050m; MD194-BETA1, 35°17.80'N 6°47.31'W, 520m).

Five water masses are usually observed in the Gulf of Cadiz. The North Atlantic Central Water (NACW) is situated between 100 and 600m. The Antarctic Intermediate Water (AAIW) enters the gulf in the south-western part of the basin and spreads cyclonically at about 800-900m. The salty, dense Mediterranean Sea Water (MSW) flows out of the Mediterranean Sea between 800 and 1400m. In the lowest level lie the deep

water masses of the North Atlantic: the Labrador Sea Water (LSW) and the Lower Deep Water (LDW).

Three CTD have been made in the Alboran Sea (MD194-OMS, 35°24.707'N 2°33.379'W, 340m; MD194-BR1, 35°26.075'N 2°30.822'W, 310m; MD194-CAB1, 35°47.736'N 2°15.669'W, 520m).

The Alboran Sea acts as transition area between the Atlantic Ocean and the Mediterranean Sea. Three water masses are identified in the Alboran Sea. In the upper ~150–200m, Modified Atlantic Water (MAW) flows through the Strait of Gibraltar eastward. In water depths of 200–600m, Levantine Intermediate Water (LIW), formed in the eastern Mediterranean Sea, flows westward towards the Atlantic. Below the LIW flows the Western Mediterranean Deep Water (WMDW) which is formed in the Gulf of Lions in the northern part of the western Mediterranean Sea.

METHODS AND RESULTS

Seawater samples were acidified to pH 2 and stored in precleaned plastic bottles for analysis on land. Dissolved Nd in seawater was preconcentrated using the C18 cartridge-HDEHP/H2MEHP complexation method (Shabani et al., 1992). Nd has been separated by using AG50X8 and Ln-Spec resins.

Nd isotopes were analysed on a multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS) at the Laboratoire du Climat et de l'Environnement (LSCE). Nd aliquots from column chemistry were dried and redissolved in 1N HNO_3 before aspiration using a nebulizer. All $^{143}Nd/^{144}Nd$ ratios were corrected for mass fractionation using $^{146}Nd/^{144}Nd=0.7219$.

Deep-sea corals from the Alboran Sea (Fink et al., 2013), collected between 280 and 440m, have been investigated in this study to establish past changes of the LIW. These deep-sea corals have been dated between 13.5 and 12.8ka, between 11.2 and 9.8ka and between 5.4 and 0.3ka permitting us to investigate past changes of the hydrology of the early and late Holocene and the Bølling-Allerød interstadial. εNd from deep-sea corals remained unchanged during these periods and present a narrow range from -8.5 to -9.2 ± 0.2. Such values are consistent with two εNd seawater profiles further west (between -8.9 and -9.6; Tachikawa et al., 2004). This suggests no major changes of the hydrology of the LIW during the late and early Holocene and the Bølling-Allerød which are characterized by rapid growth of the deep-sea corals in the Alboran Sea (Fink et al., 2013). Foraminifera of one core located close to this studied site will be investigated to complete the seawater εNd record of the Holocene in order to test if the beginning of the Holocene is associated with major reorganisation of the Mediterranean hydrology.

In addition, analyses of Nd isotopic composition in seawater are being acquired and will be presented in comparison with deep-sea corals preliminary results.

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