Conservative behaviour of dissolved Nd isotopes in the South Pacific, reliable extraction of the deep water ε_{Nd} signatures from the sediments and first Late Quaternary reconstruction of deep circulation.

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1) MOTIVATION

The South Pacific and the Southern Ocean have played an important role in the climatic evolution of the Earth. Despite its enormous extent the South Pacific has been poorly investigated in comparison to other regions with respect to chemical oceanography and paleoceanography.

Therefore, one of the main targets of the SOPATRA Project has been the reconstruction of the present and past deep water circulation of the South Pacific using radiogenic Nd isotopes.

Here we present the first analysis of dissolved Nd isotopes (ε_{Nd}) and REE compositions in intermediate and deep water masses of the mid-latitude South Pacific; as well as ε_{Nd} signatures from core-top sediment samples in order to confirm the applicability of Nd isotopes for the reconstruction of past deep circulation regimes. In addition, we present the first results obtained from a sediment record covering the past 240 ka.

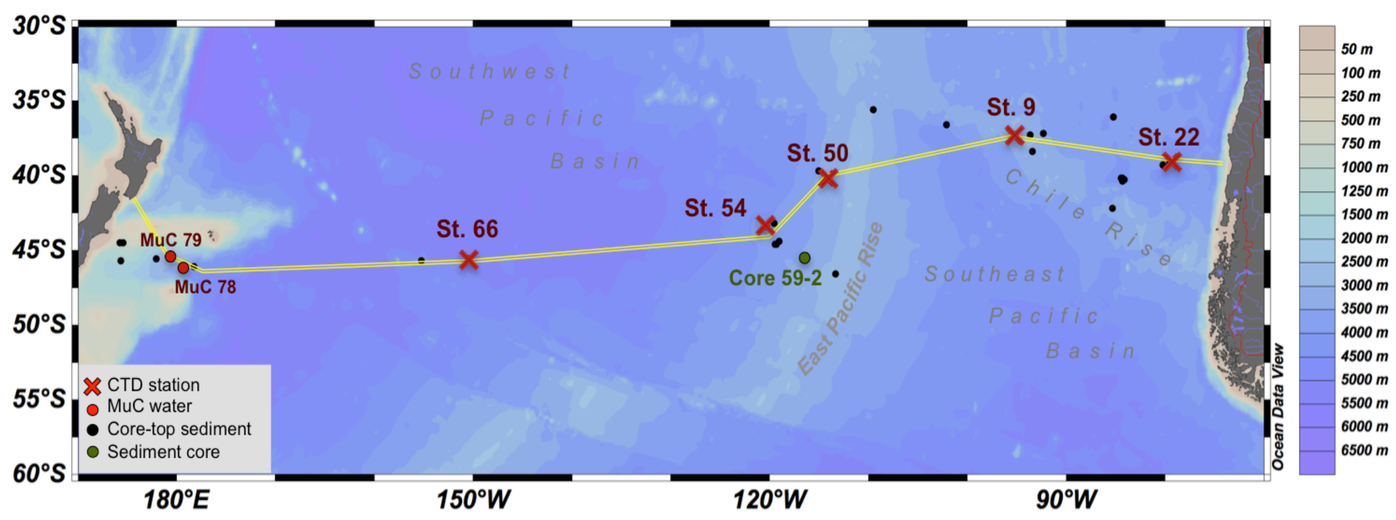
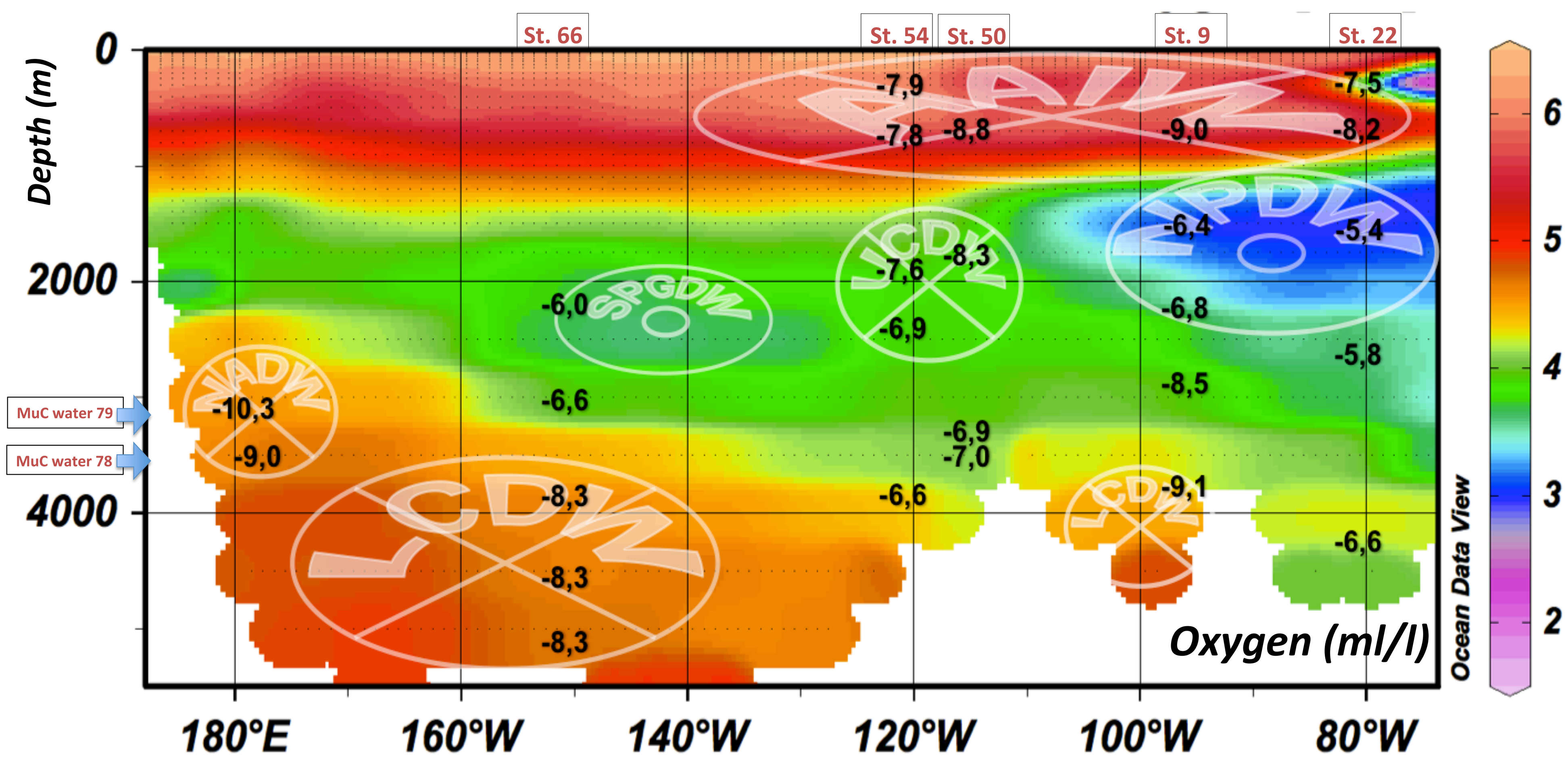


Fig. 1. Cruise track and locations of water and sediment sampling sites of expedition SO213.

Fig. 2. Cross section (yellow line on fig.1) of the study area showing oxygen concentrations (ml/l) and ε_{Nd} signatures (black numbers) in the water column.



2) DISSOLVED Nd ISOTOPE COMPOSITIONS OF INTERMEDIATE AND DEEP WATER MASSES.

The first analysis of the behaviour of Nd isotopes in the intermediate to deep-water column of the open mid-latitude South Pacific overall **confirm the reliability of Nd isotopes as water mass tracer in this region, given that their variations closely reflect changes in the different hydrographic parameters of the water column**. This is particularly true oxygen concentrations, which in the Pacific generally better track the advection of different water masses: Pure circumpolar waters (AAIW and LCDW), occupying the shallowest and deepest areas of the analyzed depth range respectively, reveal a ε_{Nd} signature of -8,3, consistent with previous observations in the Atlantic and Pacific sectors of the Southern Ocean. Pacific derived waters exert their maximum influence at middepths, coinciding with the lowest oxygen concentrations, especially at the eastern part of the study area, as well as in the Southwest Pacific basin, where the main cores of NPDW and South Pacific Gyre derived Deep Water (SPGDW) are located: They Represent the most radiogenic ε_{Nd} values of this study of -5,9 and -6,0; respectively, masking the presence of UCDW except in isolated cases of major presence of this water mass, such as above the East Pacific Rise. The influence of NADW in the western South Pacific, represented by low nutrient concentrations and high salinities (not shown here), is also clearly reflected in the Nd isotopic signatures (ε_{Nd} = -9,7)

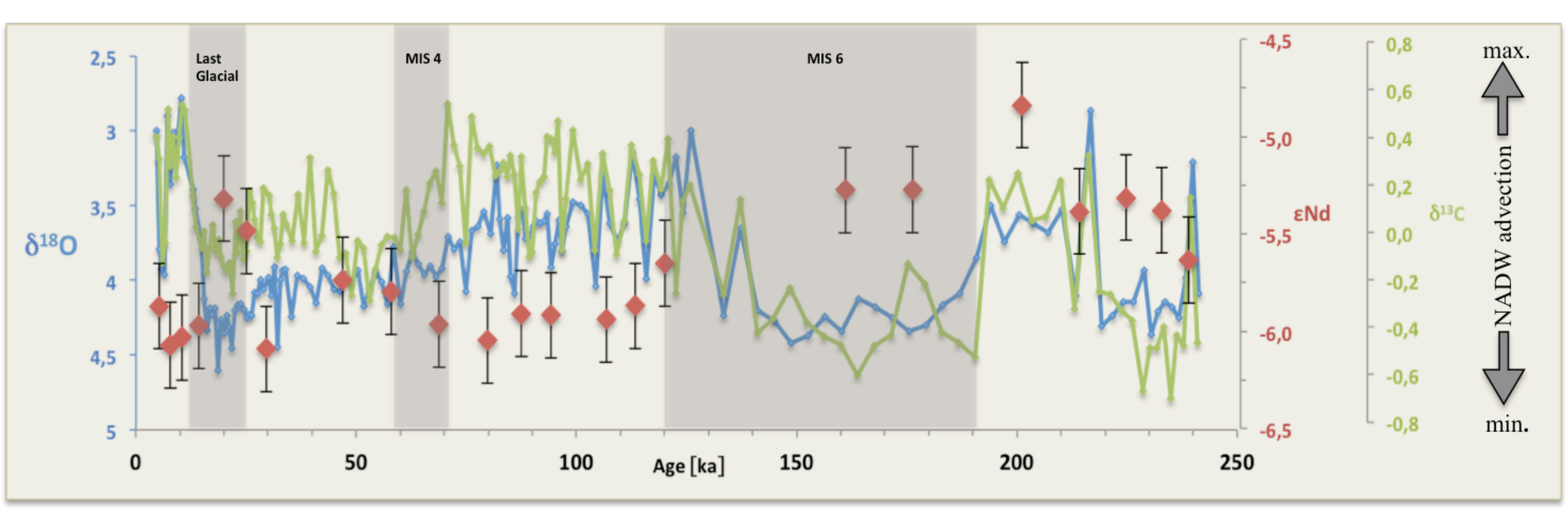


Fig. 5. 240 ka record of Nd, carbon and oxygen isotopes from core SO213-59-2.

5) PRELIMINARY LATE QUATERANRY RECONSTRUCTION OF CIRCULATION FROM Nd ISOTOPES

A first Nd isotope data set obtained from mixed planktonic foraminifera of core SO213-59-2 covering the last 240 ka, reveal systematic changes of the Nd isotope signatures following the major climatic cycles: **The Nd isotope signal was more radiogenic during glacial periods documenting a diminished contribution of unradiogenic NADW to circumpolar deep water during glacials.** Those preliminary results confirm the hypothesis of reduced NADW production during cold climatic stages documented in sediment records from the Atlantic sector of the Southern Ocean (Rutberg et al., 2000, Piotrowski et al., 2005): while in the South Atlantic the signature varied by 2 to 3 ε_{Nd} units between glacials and interglacials, in our study area, less influenced by Atlantic derived waters due to higher dilution, the ε_{Nd} difference was 1 to 2 units. Future Nd isotope analysis planed in this and in a second neighboring core will test this hypothesis.

References.

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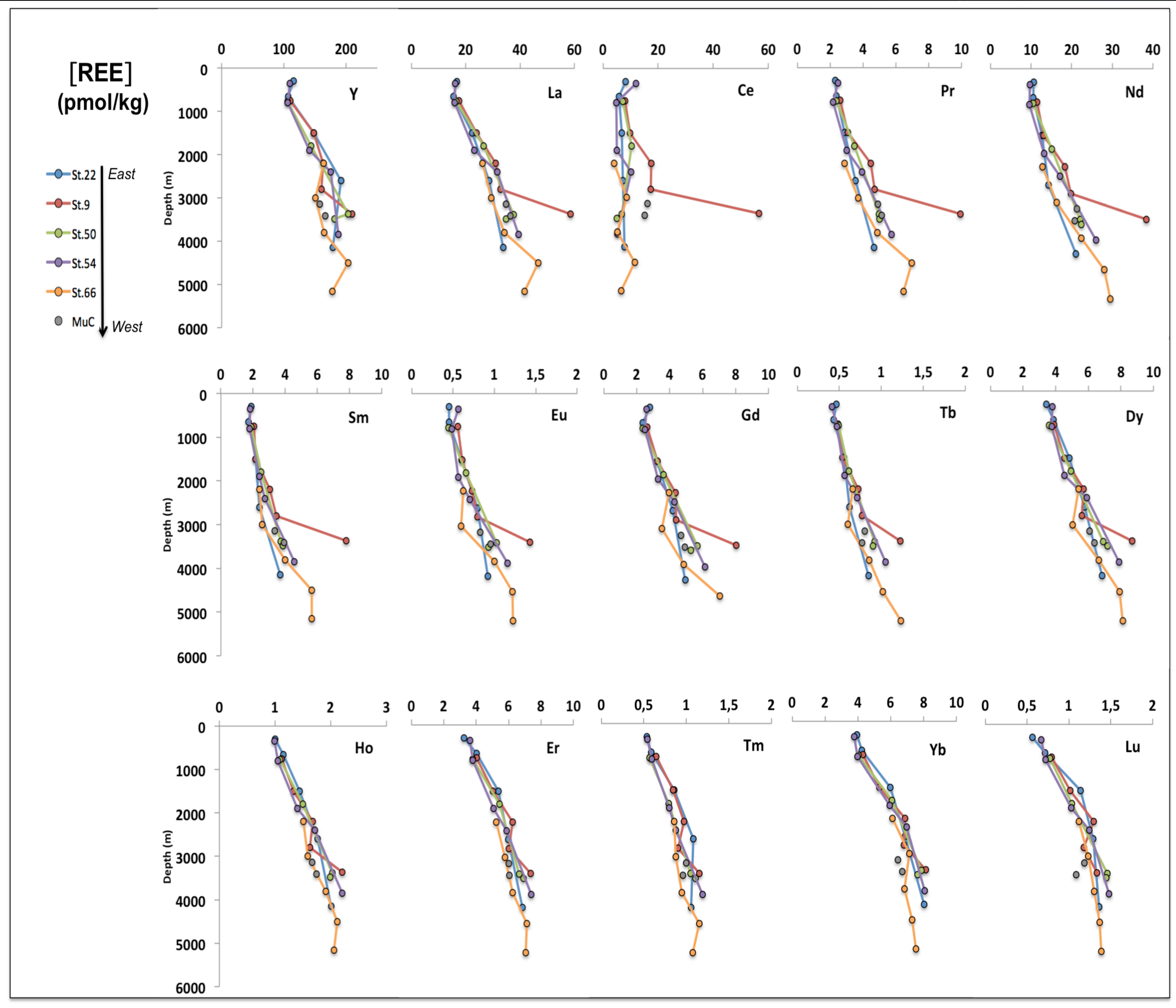

Fig. 3. Dissolved REE concentrations from the water samples obtained during expedition SO213.

3) DISSOLVED REE CONCENTRATIONS.

With the exception of Ce, the REE concentrations of all profiles show a general increase with water depth, as expected for open ocean waters, reflecting **the important role that biogeochemical processes, such as scavenging and dissolution of sinking particles, play in controlling the distribution of dissolved REE. Nevertheless, our vertical [Nd] gradients** are less pronounced than in other regions such as the north Pacific (see Lacan et al. 2012), reflecting a more efficient vertical mixing in the water column of the Antarctic Circumpolar Current and **confirm a major role of advection for the distribution of REEs.**

Nevertheless, biogeochemical processes affect the distribution of REES in two specific cases within the study area, in particular the more particle reactive LREE: 1) Bottom waters of the Southeast Pacific basin (sample 9-3771m), where the sluggish circulation in an enclosed area probably produced an accumulation of LREE derived from dissolution of diatom frustules. 2) Mid-depth waters originating from the north and equatorial Pacific (profiles 22 and 66) supposed to carry concentrations of around 40 pmol/kg of Nd (Lacan et al. 2012) show a slight LREE depletion as a consequence of strong scavenging processes that probably occurred near the equator.

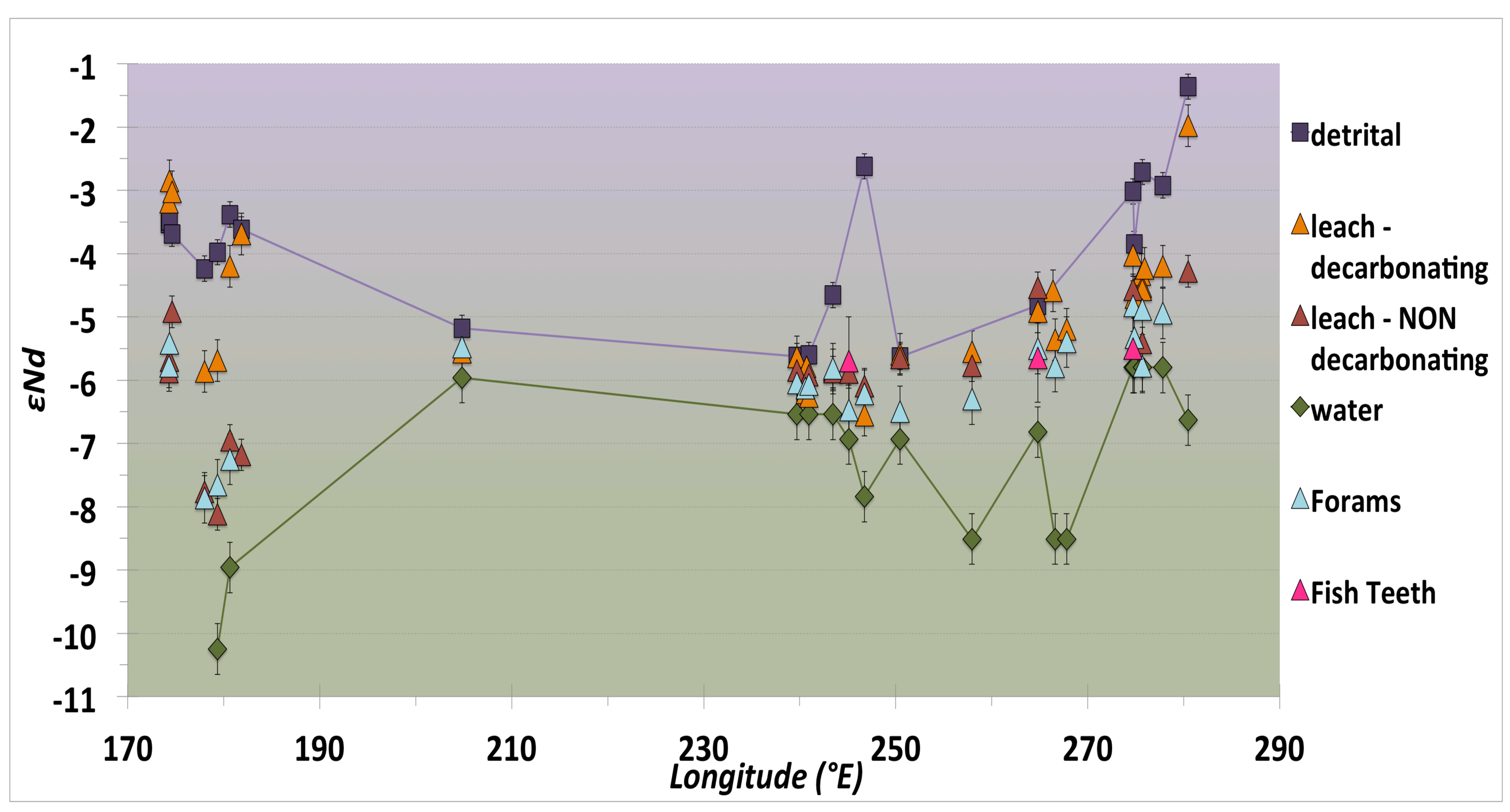

Fig. 4. Comparison of ε_{Nd} signatures obtained from bottom water, detritus and different sediment fractions.

4) RELIABLE EXTRACTION OF ε_{Nd} SIGNATURES FROM THE SEDIMENTS.

We compared four different methods for the acquisition of deep water Nd isotope compositions incorporated into different sediment fractions in order to define the most reliable method to extract deep water signatures for later paleoceanographic studies in this region. Three of those consisted in the extraction of early diagenetic ferromanganese oxide coatings that precipitate on detrital, as well as on biogenic particles in the deep sea incorporating high concentrations of Nd and the last one obtaining the ε_{Nd} signal from fossil fish teeth and debris that incorporate Nd from deep water into biogenic apatite.

We compared the results obtained trough decarbonated and non decarbonated bulk sediment leaching, dissolution of planktonic foraminifera and dissolution of fossil fish teeth and debris to those ε_{Nd} signatures obtained from the two end-members that influence the authigenic sediment Nd isotope composition: The detrital fraction of the sediment and the dissolved Nd in seawater.

Based on the robustness of the results presented in figure 4 **we conclude that the dissolution of detrital particle free hand-picked foraminifera and fish teeth is a reliable method to extract authigenic Nd isotopic compositions from the sediments in this region.**

In carbonate free regions, the leaching of bulk sediment without previous carbonate removal is a most reliable method to extract Nd isotopic compositions from the sediment than the common bulk leaching procedure (Gutjahr et al., 2007).

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