Late Quaternary reconstruction of the deep-water circulation in the South Pacific Ocean using radiogenic Nd and Pb isotopes.

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1) INTRODUCTION

The South Pacific and the Southern Ocean have played an important role for the global climatic evolution. Despite its enormous extent the Late Quaternary paleoceanography of the South Pacific has been poorly investigated in comparison to other regions, which is partly due to its limited accessibility.

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

Here we present Nd and Pb isotope time series of past deep waters obtained from two sediment cores recovered near the East Pacific Rise at 45°S covering the past 250 ka. Additionally, the Nd isotope composition of the water column of the South Pacific is shown for calibration of the downcore record.

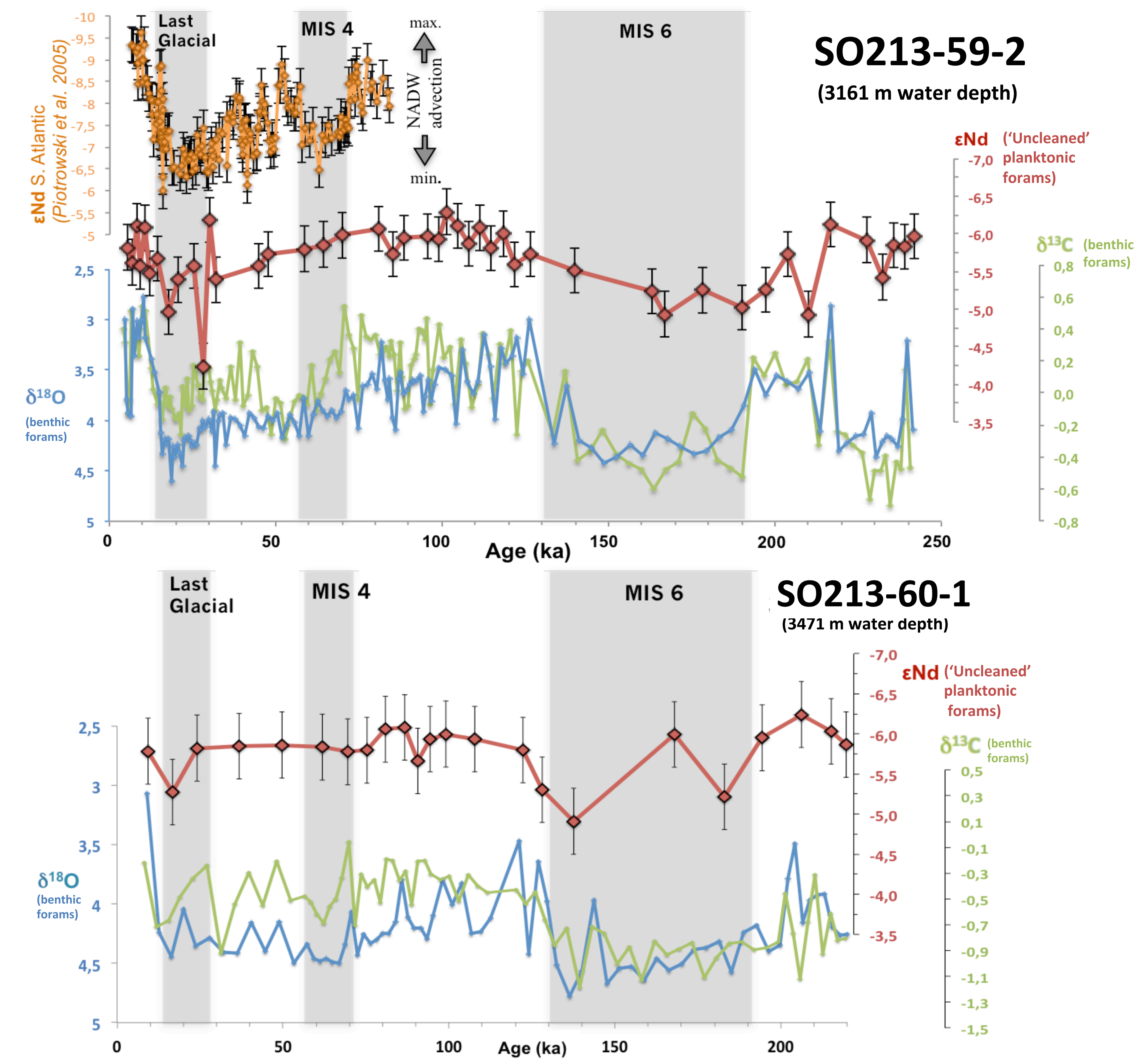

Fig. 3. ε_{Nd}, $\delta^{13}C$ and $\delta^{18}O$ signatures from cores SO-213-59-2 and SO213-60-1 obtained from the last ~ 240 and ~ 220 Kyr respectively.

3) LATE QUATERNARY RECONSTRUCTION OF CIRCULATION FROM Nd AND Pb ISOTOPES

The Nd isotope data set obtained from dissolved 'uncleaned' foraminifera for core SO213-59-2 (fig.3), reveals systematic changes of the deep water Nd isotope signatures following major glacial/interglacial cycles: The Nd isotope signal varied between interglacial ε_{Nd} values near -6 and more radiogenic ε_{Nd} values near -5 during glacial periods documenting a diminished contribution of unradiogenic NADW to Circumpolar Deep Water. These preliminary results support reduced NADW production during cold climatic stages documented in sediment records from the Atlantic sector of the Southern Ocean (Piotrowski et al., 2005). While the εNd signature in the Atlantic sector of the Southern Ocean varied by 2 to 3 ε_{Nd} units between glacials and interglacials, our record reveals amplitudes near 1 ε_{Nd} unit, consistent with higher dilution of the Atlantic-derived waters during advection.

Although the ε_{Nd} and variations are even less pronounced for core SO213-60-2(fig.3), due to its low sedimentation rate of this core (0,66 cm/kyr), it is still possible to identify variations similar to core 59 at the isotopic stage transitions 7 to 6 and 6 to 5.

The ε_{Nd} changes are supported by similar variations of the $\delta^{13}C$ signal, which show more negative values during cold periods, indicating larger contributions of old, nutrient-rich water masses from the deep Pacific to circumpolar waters, while during the interglacials, younger and nutrient-depleted water masses, such as NADW, played a more important role for the mixture of waters of the Antarctic Circumpolar Current (ACC).

On fig. 5, Pb isotopes obtained from sediment leachates of cores 59 and 60, also show variations between glacial and interglacial cycles. Although small, the variations occurred in accordance with the ε_{Nd} variations, with lower $^{206}Pb/^{204}Pb$ and higher $^{207}Pb/^{206}Pb$ values during glacial periods, and thus higher contributions of Pacific Water.

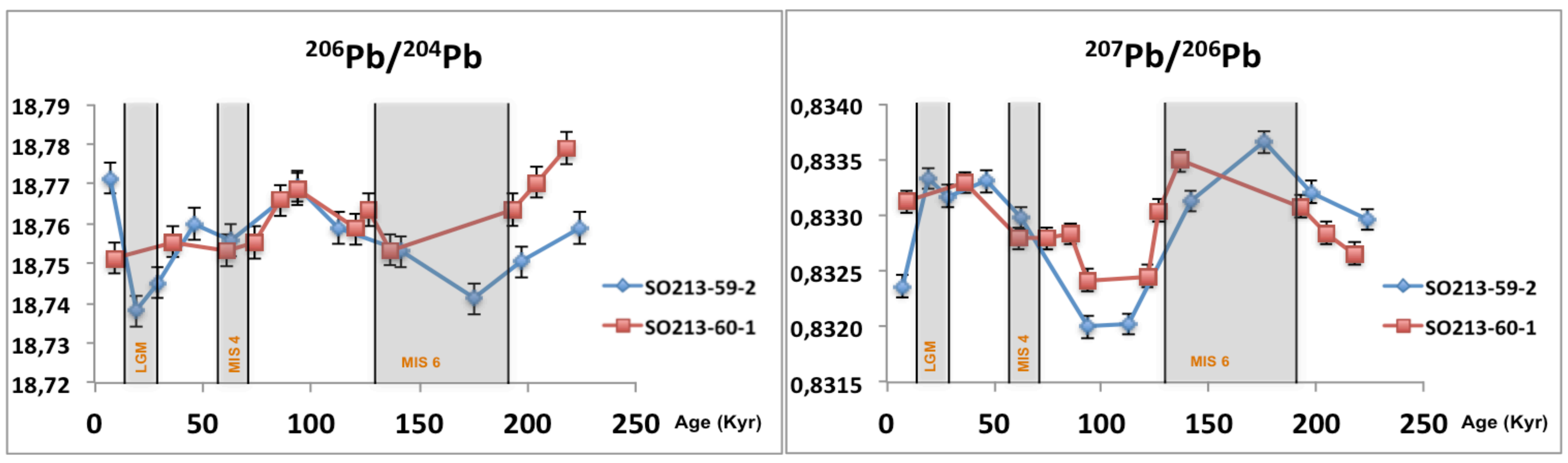

Fig. 5. ~ 240 Kyr record of Pb isotopes obtained from non-decarbonated bulk sediment leachates of cores SO213-59-2 and SO213-59-2.

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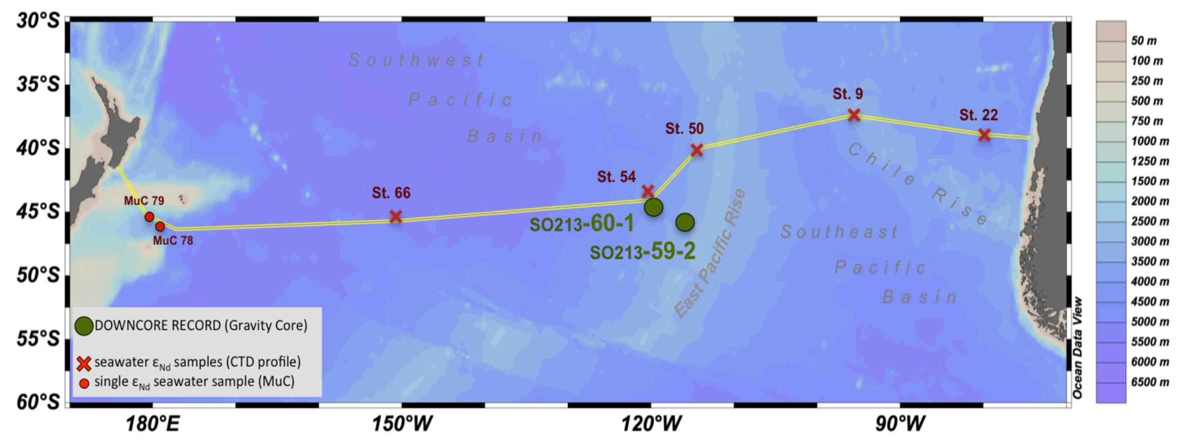
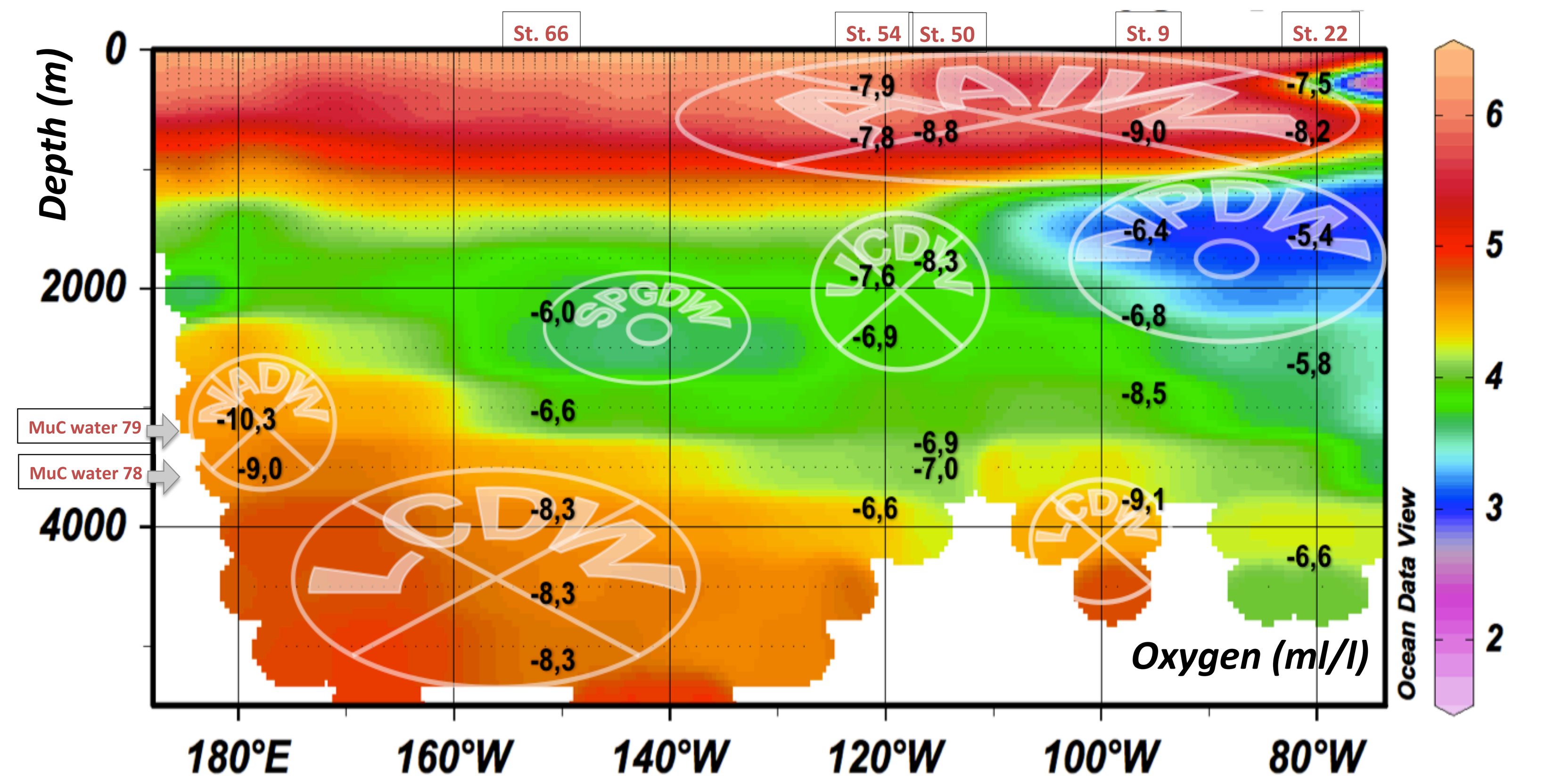


Fig. 1. Cruise track and locations of water and sediment sampling sites of expedition SO213.

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



2) PRESENT DAY DISSOLVED Nd ISOTOPE COMPOSITIONS *(submitted to GCA)*

Dissolved Nd isotopes (fig.2) 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 oxygen concentrations, which in the Pacific generally better track the advection of different water masses: Pure circumpolar waters (AAIW and LCDW), ε_{Nd} =-8,3, occupy the shallowest and deeper areas. Pacific-derived waters dominate middepths with North Pacific Deep Water (NPDW) and South Pacific Gyre derived Deep Water (SPGDW), reflected by ε_{Nd} signatures of -5,9 (average) and -6,0; respectively, and thus replace Upper Circumpolar Deep Water (UCDW) except 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 (average ε_{Nd} = -9,7).

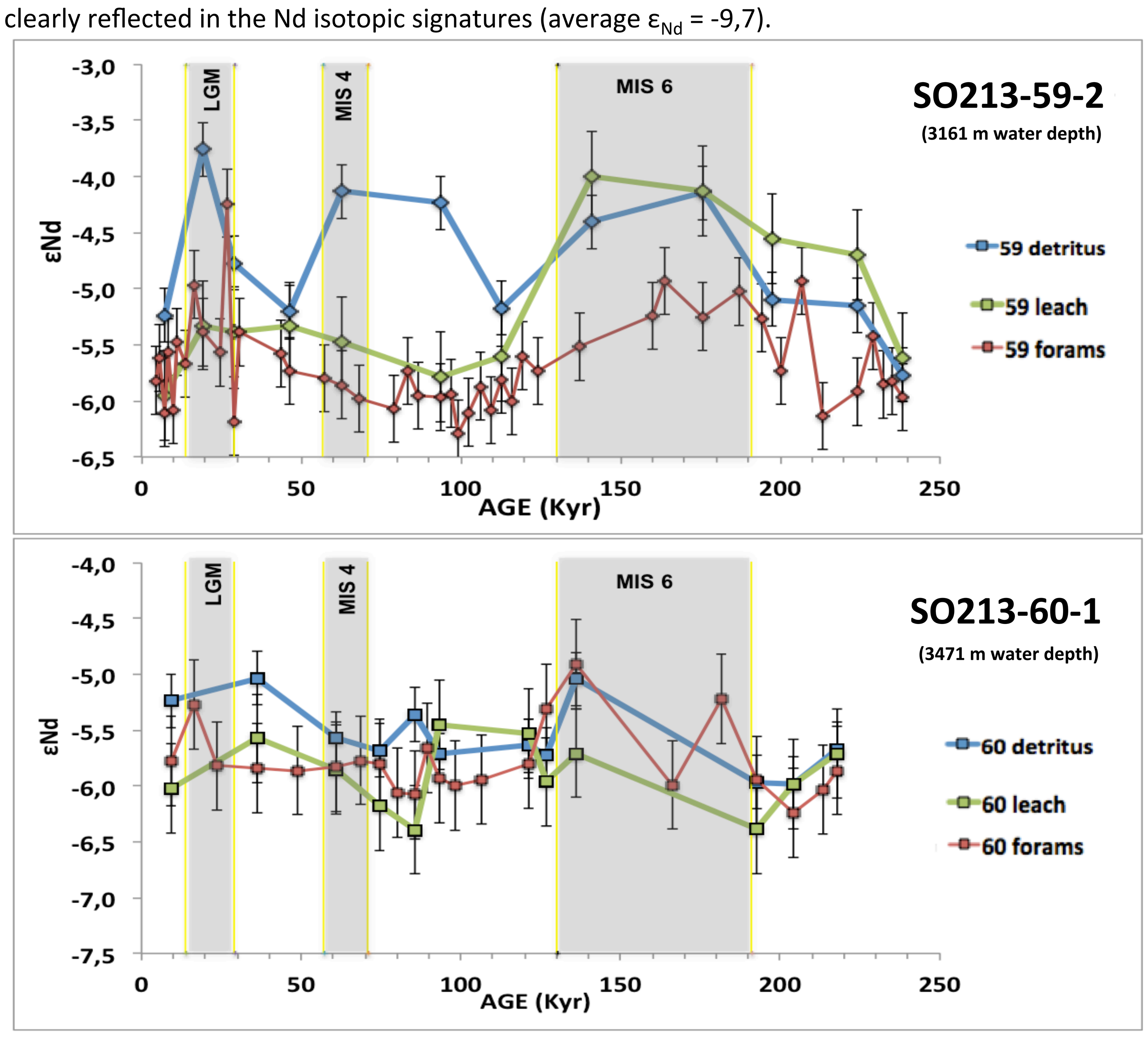


Fig. 4. ε_{Nd} signatures obtained from detritus, non-decarbonated leachates and 'uncleaned' planktonic forams.

4) RELIABLE EXTRACTION OF ε_{Nd} SIGNATURES FROM THE SEDIMENTS AND DETRITUS PROVENANCE VARIATIONS.

We compared the results obtained from non-decarbonated bulk sediment leaching (see Wilson et al. 2012) and 'uncleaned' planktonic foraminifera (after Roberts et al. 2010) to ε_{Nd} signatures from the detrital fraction of the sediment (after Gutjahr et al. 2007) (fig. 4) to verify the reliability of the Nd isotope composition obtained from Fe-Mn coatings, which carry the authigenic deep water circulation signal in the leachates of the authigenic fraction of the bulk sediments as well as of the 'uncleaned' planktonic foraminifera.

Core 60 does not show significant differences between the three phases, presenting similar values to present day bottom waters at the sediment surface. On the other hand, on core 59, the detrital signatures present more radiogenic values with respect to 'uncleaned foraminifera' along the entire record.

By comparison to the more reliable results of 'uncleaned' foraminifera, non-decarbonated leachates from core 59, show similar values between 0 and 120 kyr, while in the interval from 120 to 240 kyr, the signatures are shifted towards more radiogenic values, similar to those of the lithogenic fraction, indicating detrital contamination of the older samples during the extraction of the Fe-Mn coatings.

The analysis of the detrital fraction also allows to track changes in the provenance of lithogenic material to the South Pacific. Detrital ε_{Nd} signatures on core 59, are generally more negative during glacial periods, therefore, a major dust contribution to central South Pacific during glacial stages can not be confirmed, as the shift in the Nd IC's should thereby occur in the opposite direction, which should indicate less radiogenic values originating from dust particles transported from Australia and New Zealand by the dominating Westerlies. The variations towards more radiogenic values in this case could be produced by increased particle transport from Antarctica during cold periods, either by ice rafted debris or via enhanced Antarctic Bottom water (AABW) flow.