PP23C-1487

Contributions from compound-specific radiocarbon and size fraction-specific $^{230}Th_{xs}$ data towards understanding of sediment redistribution processes in the Panama Basin

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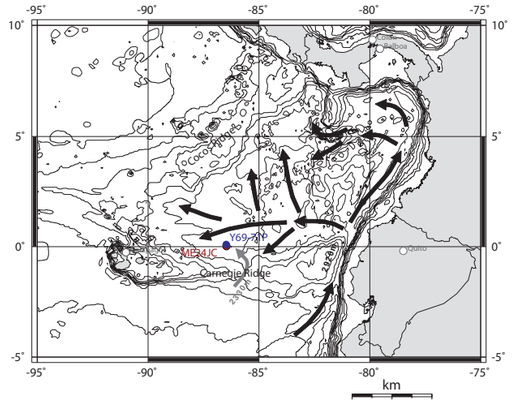

Figure 1: Core sites in the Panama Basin, Eastern Equatorial Pacific. Arrows mark pathways of deep water circulation. Episodic overspill is reported from the Carnegie Ridge close to our core sites.

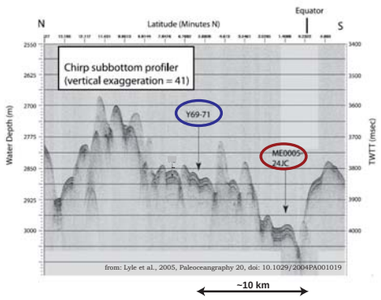

Figure 2: Chirp Echosounder profile across core sites. Note higher accumulation rates at ME24-JC.

Motivation

Despite numerous studies performed in the Panama Basin, the occurrence of lateral sediment redistribution remains a subject of much debate. $^{230}Th_{xs}$ measurements performed on bulk samples imply strong sediment focusing, and 8-fold higher accumulation than vertical flux rates (Kienast et al., 2007, Paleoceanography 22, doi: 10.1029/2006PA001357).

Sediment redistribution predominantly affects the smaller grain size fractions, including organic matter, and may involve lateral supply of pre-aged organic matter.

We therefore determined $^{230}Th_{xs}$ values of individual grain size fractions as well as radiocarbon ages of several sediment constituents , i.e. planktic foraminifera (*N. dutertrei*), total organic carbon (TOC), and phytoplankton-derived biomarkers (alkenones), representative of coarse and fine sediment, respectively.

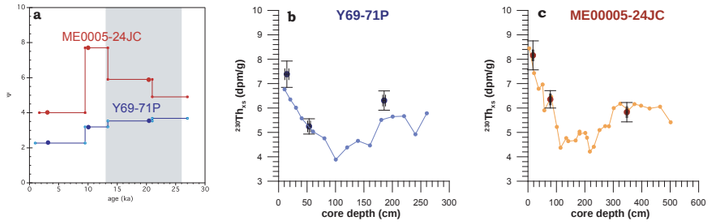

Figure 3: a) Focusing factors from Kienast et al., (2007,); dots mark core depths from which samples were selected for $^{230}Th_{xs}$ measurements in this study (3 kyr, 10 kyr, and 20 kyr); b and c) comparison of bulk $^{230}Th_{xs}$ values obtained in this study (dark large symbols) with values measured by Kienast et al., (2007) (light coloured small symbols).

Results

I. Radiocarbon

In core ME24JC, ^{14}C ages of *N. dutertrei* and alkenones are identical within 1 s error margins (3 out of 4 samples). TOC ages agree with foram ages within 1 s (4 of 6 dated depths).

In core Y69-71P, age differences between *N. dutertrei* and alkenones and *N. dutertrei* and TOC average 360 yr and 140 yr, respectively. Larger deviations between foram and alkenone ages near the top of the core are ascribed to larger uncertainties due to very small (<30µg C) alkenone sample sizes.

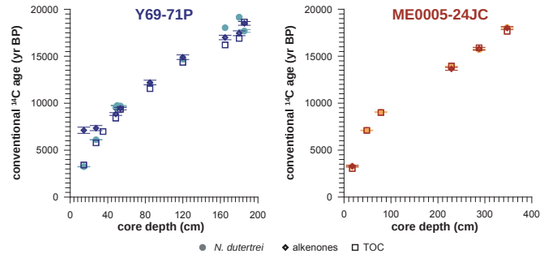

Figure 4: Results of radiocarbon analyses presented as conventional radiocarbon ages. TOC age error bars are left out for better visibilty of symbols.

Unlike at other locations influenced by sediment redistribution (e.g., Bermuda Rise; Ohkouchi et al., 2002, Science 298, 1224-1227) we observe good agreement of radiocarbon ages of coarse grained sediment constituents (forams) and those associated with the fine fraction (alkenones, TOC).

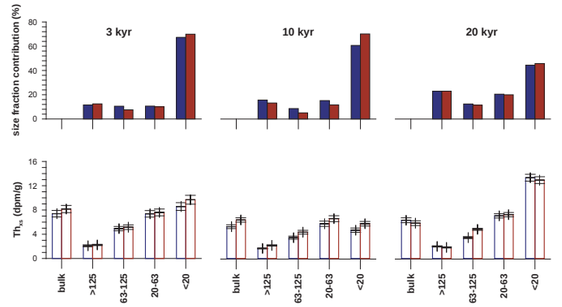

Figure 5: Size-fraction specific $^{230}Th_{xs}$ values and grain-size distribution for Y69-71 (blue) and ME24JC (red). Note low relative abundance of fine fraction in oldest samples.

II. $^{230}Th_{xs}$

Bulk $^{230}Th_{xs}$ values from Kienast et al. (2007) could be reproduced.

Systematic differences between size-fractions were observed, with highest $^{230}Th_{xs}$ values in the smallest grain-size fraction.

Samples from both cores corresponding to the individual time slices yielded very comparable results.

Recovery of small grain-size fractions, particularly for 20kyr samples, was low, indicating substantial sample loss during wet-sieving.

Methodology

TOC radiocarbon dates were obtained from bulk samples using standard procedures. Up to 40g of dried sediment were solvent extracted using standard methods (ASE; Soxhlet). Alkenones were purified using a procedure described by Ohkouchi et al. (2005; Radiocarbon 47, p. 425 ff), and radiocarbon dated using dedicated techniques for small samples. Planktic foraminfera (*N. dutertrei*) were hand-picked from a wet-sieved (>125 µm) sub-sample and radiocarbon dated using standard methodology.

$^{230}Th_{xs}$ measurements were performed on a set of subsamples of the solvent-extracted sediment residues. Sediment samples were disaggregated in de-ionized water by ultrasonic treatment and size fractionated by wet-sieving. Grain-size fractions were freeze-dried, weighed and acid digested in aqua regia and hydrofluoric acid. U and Th isotopes were measured by isotope dilution using a Thermo Finnigan SF-ICP-MS “ELEMENT 2”.

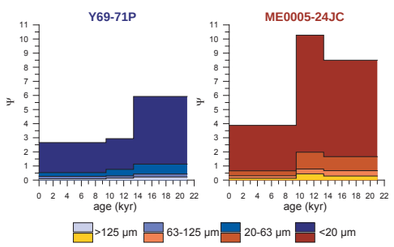

Figure 6: Contributions of grain size classes to total $^{230}Th_{xs}$ inventories expressed as focusing factors Ψ calculated for the intervals core-top to 9.5 kyr, 9.5 to 13.4 kyr, and 13.4 to 21 kyr. Calculations are based on bulk densities multiplied by relative mass contributions (in %) of individual size classes.

Conclusions

Compound-specific radiocarbon ages do not suggest lateral supply of pre-aged organic material to the core sites. Together with the evidence for sediment focusing this implies that lateral redistribution happens shortly after particle formation without long-term intermediate storage.

Thorium is not evenly distributed between the different size-classes. Fine fractions contribute most to the $^{230}Th_{xs}$ inventories. Variable concentrations of fine-grained material may thus partly explain $^{230}Th_{xs}$ inventories.

The heterogeneous distribution of $^{230}Th_{xs}$ in the individual size classes may in part be due to different mineral-predominance in the size classes (e.g., foraminiferal calcite in the sand fraction, clays in the fine fraction). Interestingly, 20-63µm $^{230}Th_{xs}$ values are very similar to bulk values, but the largest size-fraction is <20µm, which is characterized by higher $^{230}Th_{xs}$.

Measured $^{230}Th_{xs}$ values of fine fractions are likely overestimating the true contributions to the total Th inventories due to loss of material during wet-sieving, likely affecting carbonates. Lower $^{230}Th_{xs}$ values for <20µm fractions are calculated if contributions from coarser fractions are subtracted vom bulk values.