$^{230}Th_{xs}$ in size-fractionated calcareous near-surface sediments from Walvis Ridge

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Introduction

Deep-sea sediments often contain significant portions of laterally advected material. This material contribute considerably to the total sediment accumulation. However, its deposition does not correspond to vertical particle fluxes through the overlying water column. ^{230}Th, produced in sea-water at a constant and well-known rate, provides a measure for the vertically received component. Thus, with $^{230}Th_{xs}$-normalization of particle fluxes, it is possible to quantify this advective sediment supply. Bottom currents are likely to sort sediment particles according to grain size and sinking velocity. To study the effects of particle composition on $^{230}Th_{xs}$ calculations, the objective of this study is to perform Th- and U-isotope measurements on grain size fractionated sediments.

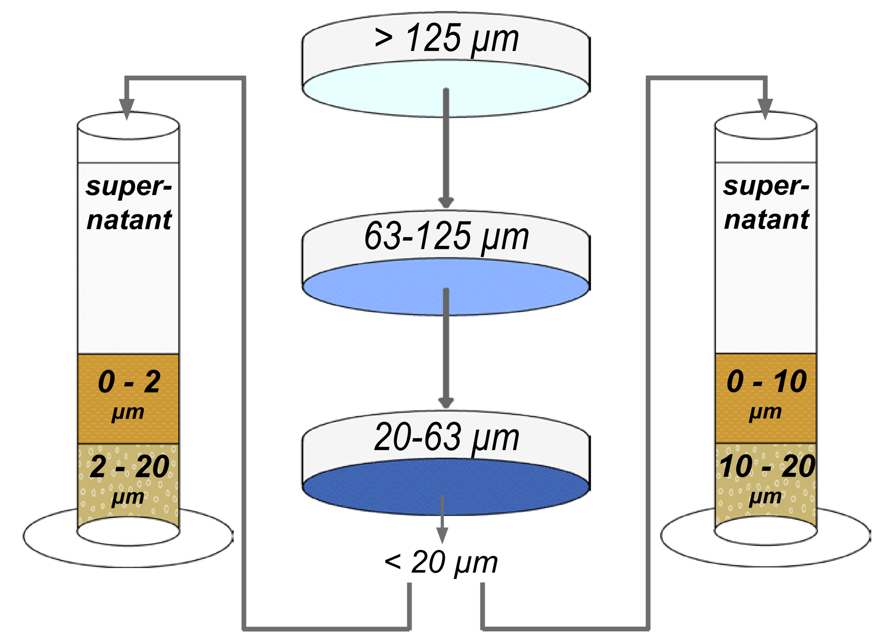

Figure 1: Procedure of particle size class fractionation.
Sieving fractions: 20-63, 63-125, >125 µm.
Settling fractions in MilliQ water (left): 0-2, 2-20 µm.
Settling in seawater (right) resulted in other size classifications than in MilliQ water, due to particle aggregation: 0-10, 10-20 µm.

Methods

Two samples from calcareous near-surface sediments from two sites at Walvis Ridge were grain size fractionated by wet sieving and settling (near 9°E 20°S, water-depths 2200 m and 2700 m, $CaCO_3$ content 93 % resp. 83 %).

Size fractionation was performed with two different methods (fig. 1):

(a) harsh sediment treatment with purified water (desalinization) and ultrasound (disaggregation), left panel.

(b) gentle sediment sieving with natural seawater (without disaggregation), right panel

Each fractionation produced five solid sediment subsamples and one liquid fraction (= supernatant after settling and centrifugation). After acid digestion, subsequent cleaning and separation steps (Fe-precipitation, UTEVA resin) the isotopes of U and Th were measured by isotope dilution on a SF-ICP-MS (Element2, Thermo). $^{230}Th_{excess}$ was calculated following Francois et al. (2004) with modifications.

Fractionation with MilliQ-purified water

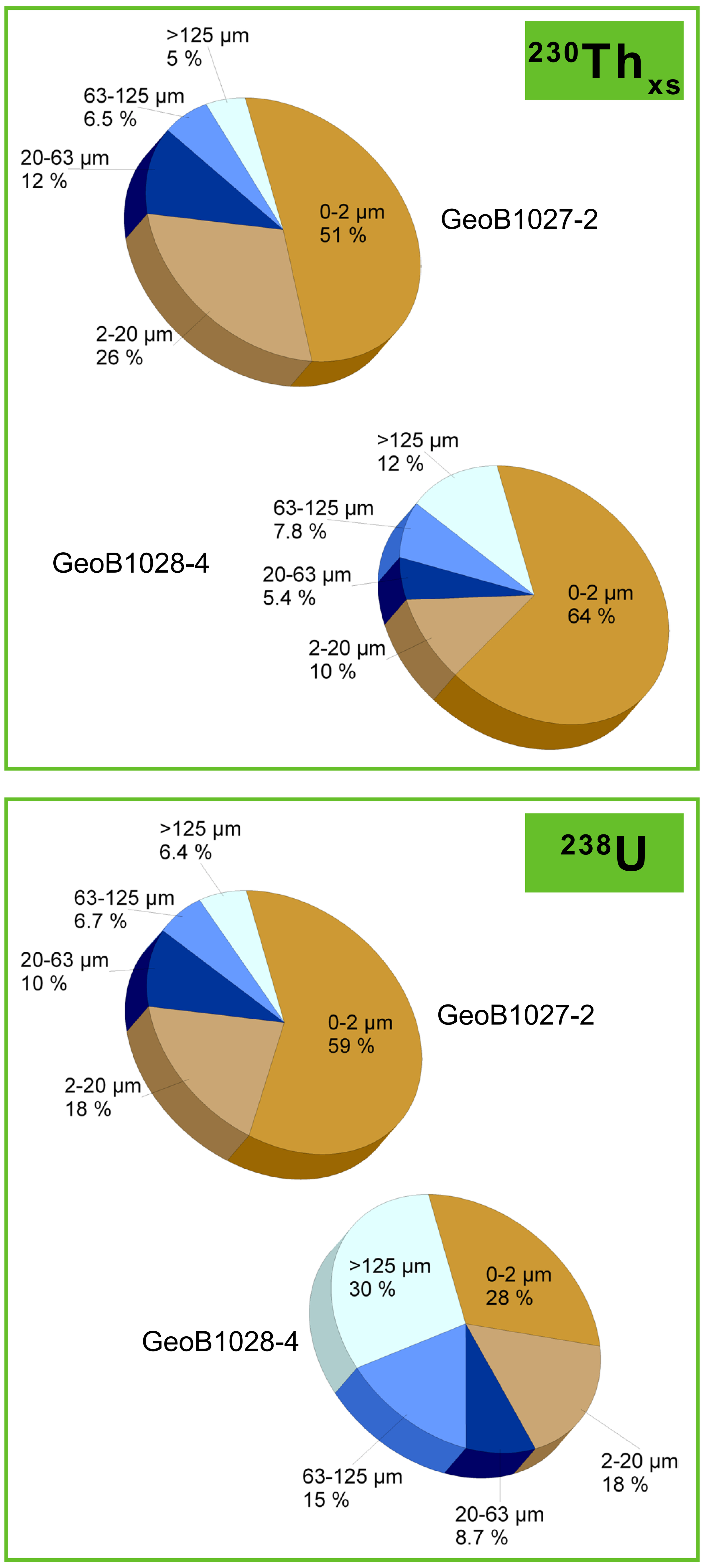

Figure 3: Relative distribution of ^{230}Th and ^{238}U in different grain size classes. Size classes were separated with MilliQ-Water.

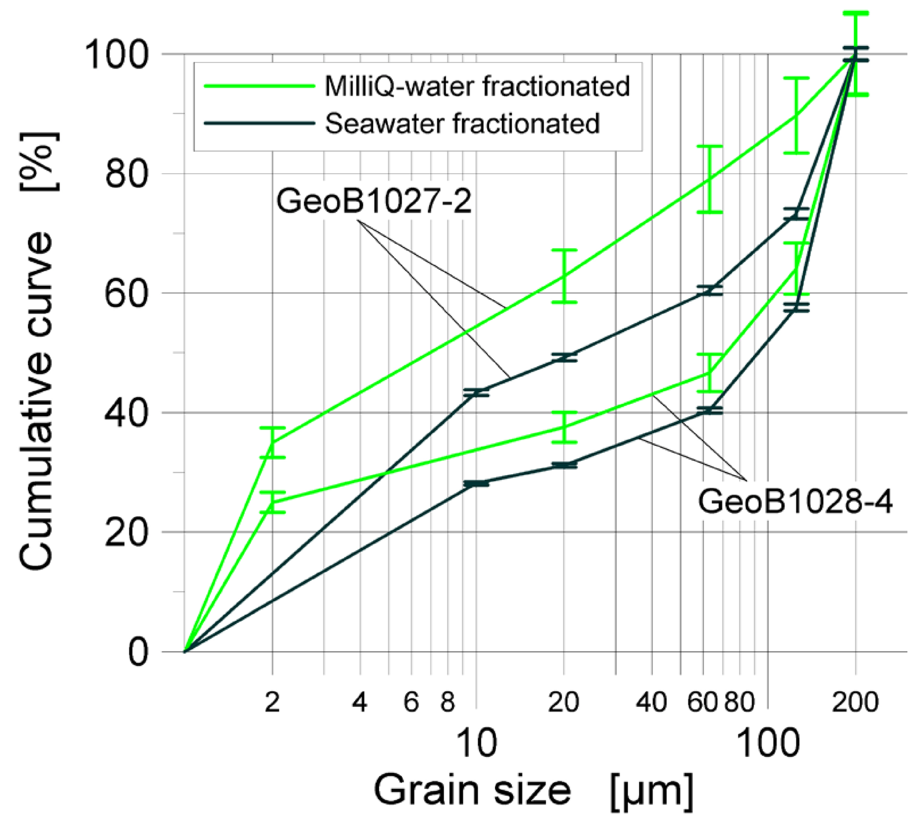

Figure 2: Cumulative curve of grain size classes.

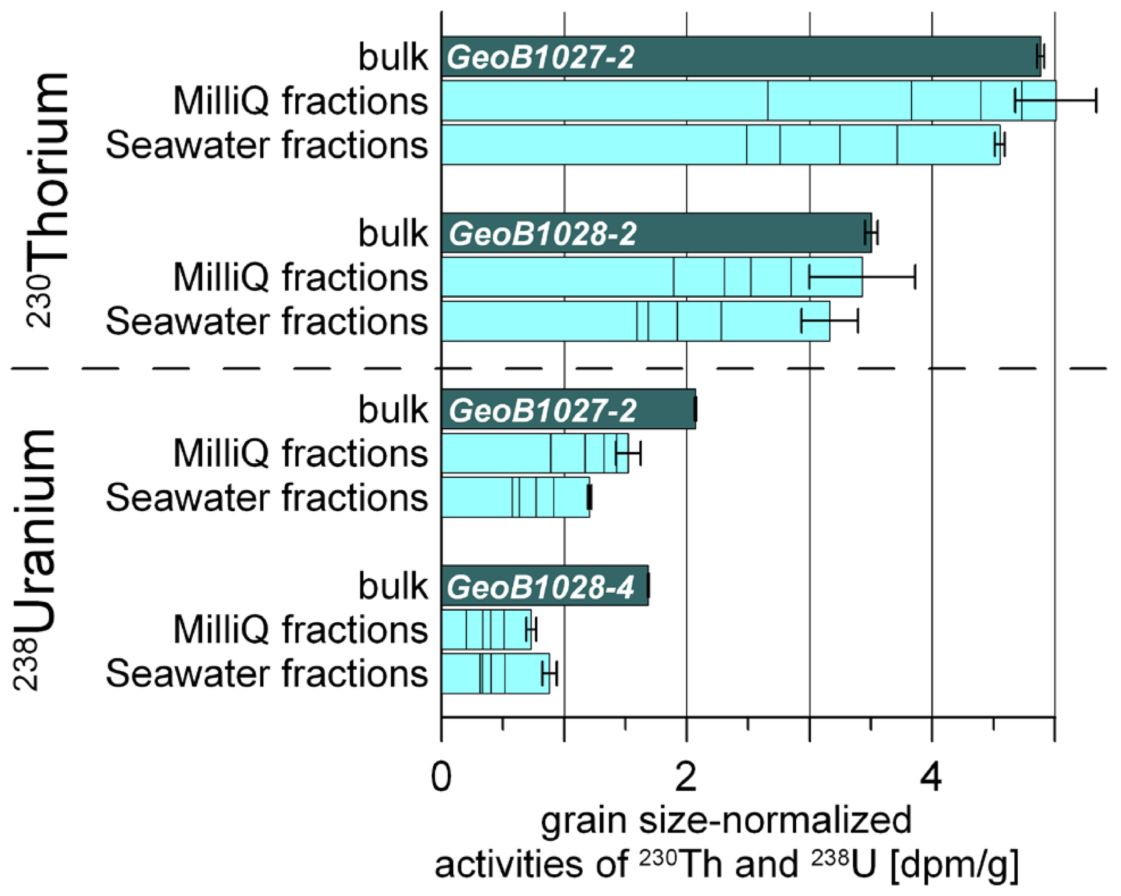

Figure 5: Comparison of ^{230}Th and ^{238}U activity in bulk samples with the summarized ^{230}Th and ^{238}U activities in fractionated samples. Recovery of ^{230}Th is close to the bulk samples. ^{238}U recovery in sediment fractions is low due to dissolved U loss during fractionation.

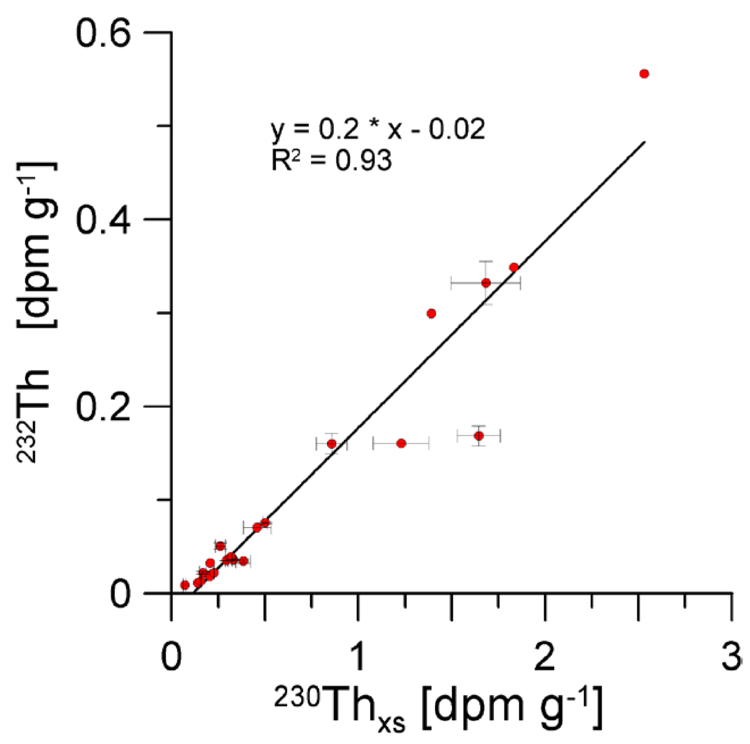

Figure 6: Correlation between grain size normalized $^{230}Th_{xs}$ and ^{232}Th.

Fractionation with natural seawater

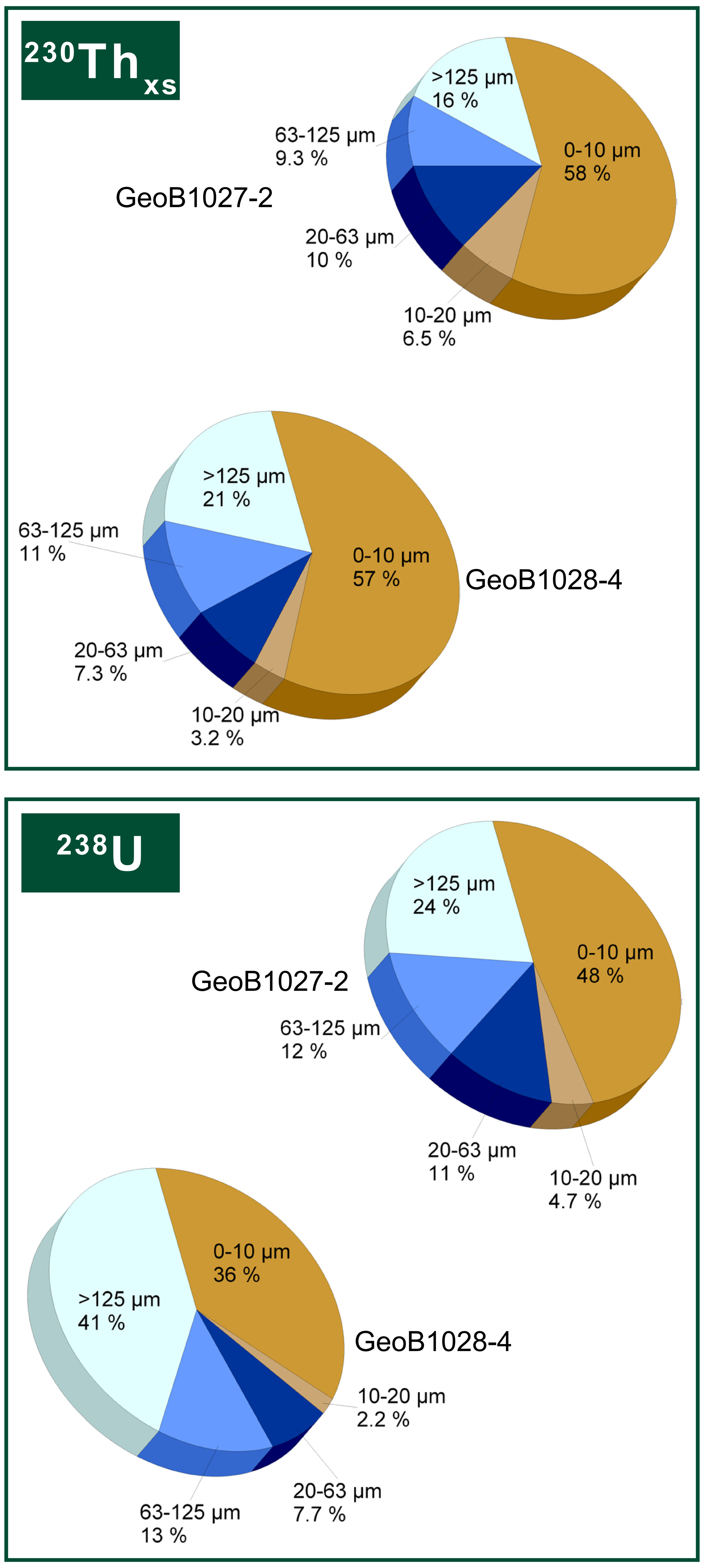

Figure 4: Relative distribution of ^{230}Th and ^{238}U in different grain size classes. Size classes were separated with Seawater.

Results

The sediment is composed of 31-63 % clay- and silt-sized particles (0-20 µm), 37-69 % silt-sized and sand particles (>125-20 µm, mostly foraminifera shell) (fig. 2). In contrast, 60-77 % of $^{230}Th_{xs}$ is contributed solely by the 0-20 µm-classes. Coarse silt and sand contributes to $^{230}Th_{xs}$ in a range of 23-39 %. ^{238}U distribution shows more variability: e.g. sand fractions > 125 µm can supply between 6 % and 41 % of ^{238}U activity (fig. 3 + 4).

Treatment with MilliQ-water and ultrasound is destructive and shifts parts of coarse size fractions towards smaller ones, when comparing with the gentle treatment. On the other hand, during seawater fractionation particle aggregation occurs. This results in higher Th and U contents in the coarse sieving fractions (>125-20 µm, fig. 3 + 4).

Comparison of fractionated ^{230}Th to bulk ^{230}Th indicates a high recovery (fig. 5). In contrast ^{238}U recoveries are very low. There is a considerable „loss" of soluble U during separation procedure. Measurement of supernatant reveals that at least 14-18 % from bulk ^{238}U were dissolved during fractionation.

Fractionation methods involve large uncertainties due to imprecise grain size measurements (fig. 2). The propagation of uncertainty results in high relative errors between 1 and 13 % (fig. 5).

There is a correlation of grain size normalized activities of $^{230}Th_{xs}$ with ^{232}Th (fig. 6) indicating that lithogenic particle fluxes can be normalized by $^{230}Th_{xs}$.

Discussion

The results confirm the findings of previous studies (e.g. Thomson et al., 1993) that ^{230}Th is mainly supplied by the fine sediment fractions. However, the choice of fractionation methods (seawater, MilliQ, ultrasound) can result in severe artefacts within the separated size fractions.

The distribution of Th within distinct particle classes is not equivalent to the distribution of U. Therefore the sorting of particles by bottom currents has potential to induce a decoupling of Th- and U-records. This causes difficulties in calculations of grain size specific $^{230}Th_{xs}$.

Conclusions

The results indicate that scavenging of Th is more selective for smaller size classes.

Grain size effects must be taken into account for $^{230}Th_{xs}$-normalized flux studies, especially in areas with lateral sediment transport.

Methods of calculations of grain size specific $^{230}Th_{xs}$ need further development.

These results highlight the potential of miscalculating $^{230}Th_{xs}$-normalized fluxes of certain sediment consitutents, e.g., of foraminifera using bulk radioisotope measurements.

References

Thomson, J., S. Colley, et al. (1993). Holocene sediment fluxes in the northeast Atlantic from $^{230}Th_{excess}$ and radiocarbon measurements. Paleoceanography 8(5): 631-650.

François, R., M. Frank, et al. (2004). ^{230}Th normalization: An essential tool for interpreting sedimentary fluxes during the late Quaternary. Paleoceanography 19: PA1018, doi:10.1029/2003PA000939.

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