^{231}Pa and ^{230}Th in the Mediterranean Sea

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Introduction

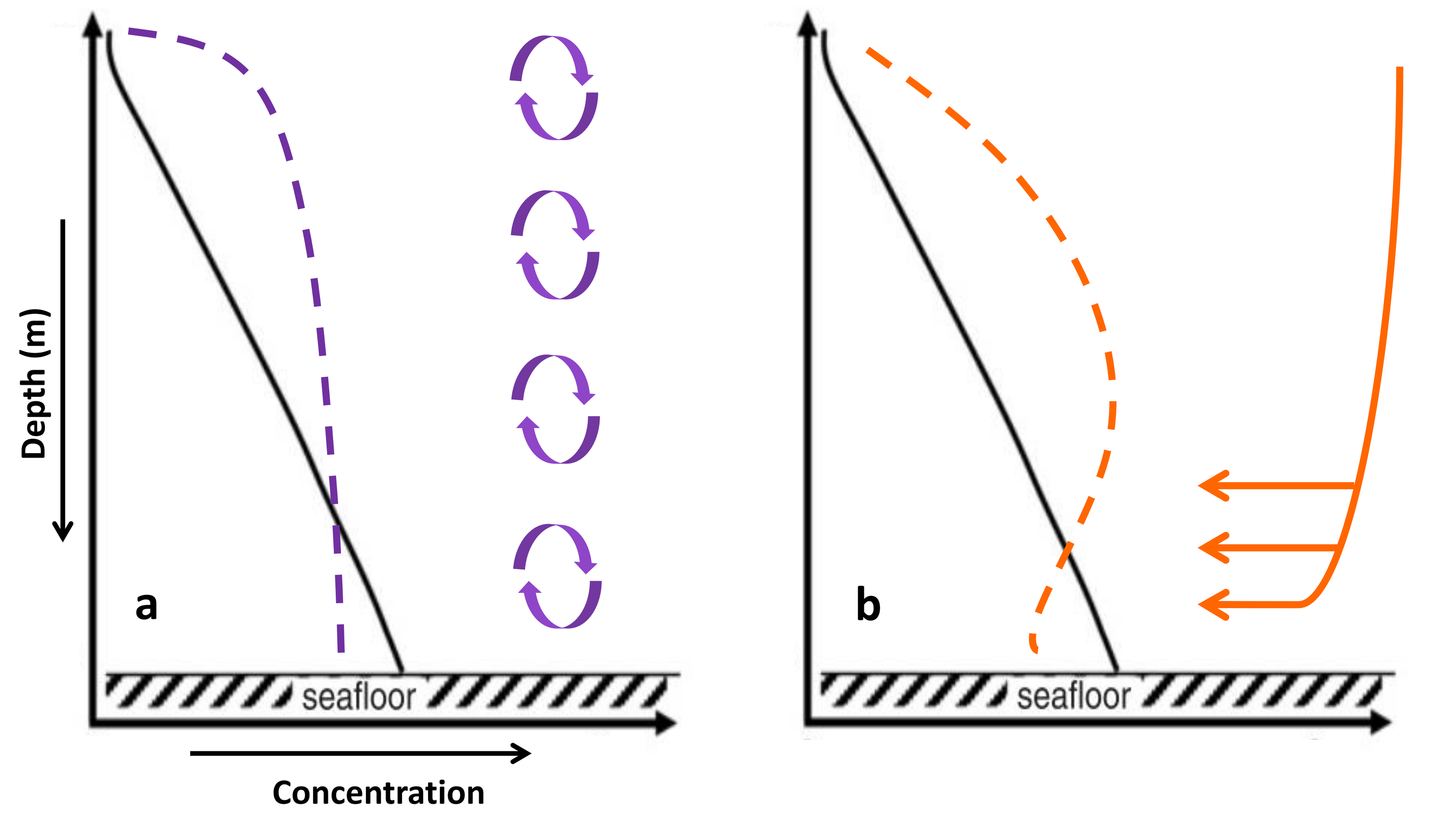


Figure 1. Examples of how advection and ventilation might affect depth profiles of Pa and Th. Black lines represent the distribution of Pa-Th in absence of lateral transport by currents. **(a)** convection will homogenize the water column and produce a vertical slope of the profile due to horizontal mixing. **(b)** during ventilation, an intrusion of deep water with lower Pa-Th concentrations will produce a concave shaped profile.

^{231}Pa and ^{230}Th are particle reactive radionuclides used as tracers of processes such as boundary scavenging, particle transport and ocean circulation. In seawater, ^{231}Pa and ^{230}Th are produced from the radioactive decay of their uniformly distributed uranium parents (^{235}U and ^{234}U)[1]. After production, ^{231}Pa and ^{230}Th are removed by adsorption onto settling particles and buried in marine sediments.

In the absence of lateral transport by currents, the **vertical distribution of ^{231}Pa and ^{230}Th in the water column is expected to increase linearly with depth (Fig. 1).** Deviations from a linear depth profile indicate that **currents transport ^{231}Pa and ^{230}Th away from the location where they were produced**[2] **(Fig. 1)**. The study of ^{231}Pa and ^{230}Th in the Mediterranean Sea has important implications for our understanding of processes that control their water column distributions and how their behavior can be utilized to trace chemical flux in modern and past ocean environments.

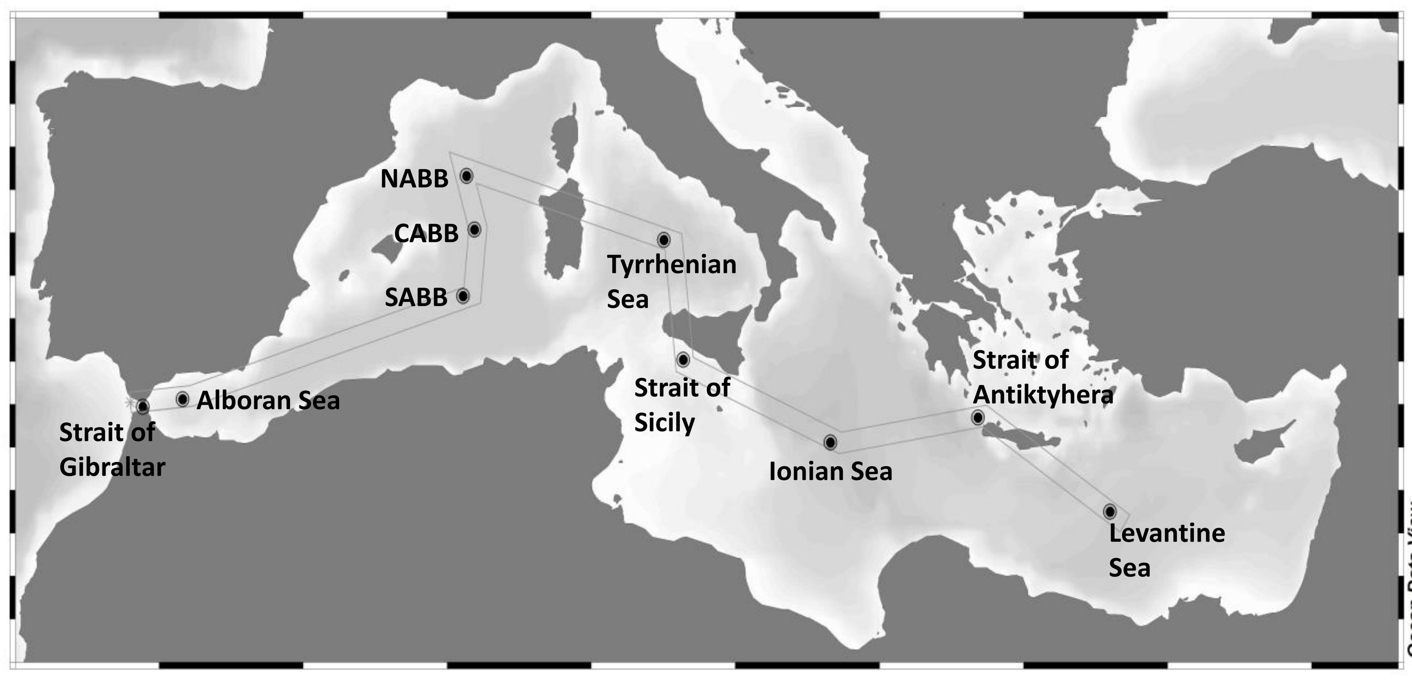


Figure 2. Station Map. ^{231}Pa, and ^{230}Th were analyzed in unfiltered seawater (n = 66) and suspended particles (n = 19) collected in the Mediterranean Sea during the MedSeA-GA04-S cruise along the GEOTRACES section GA04S.

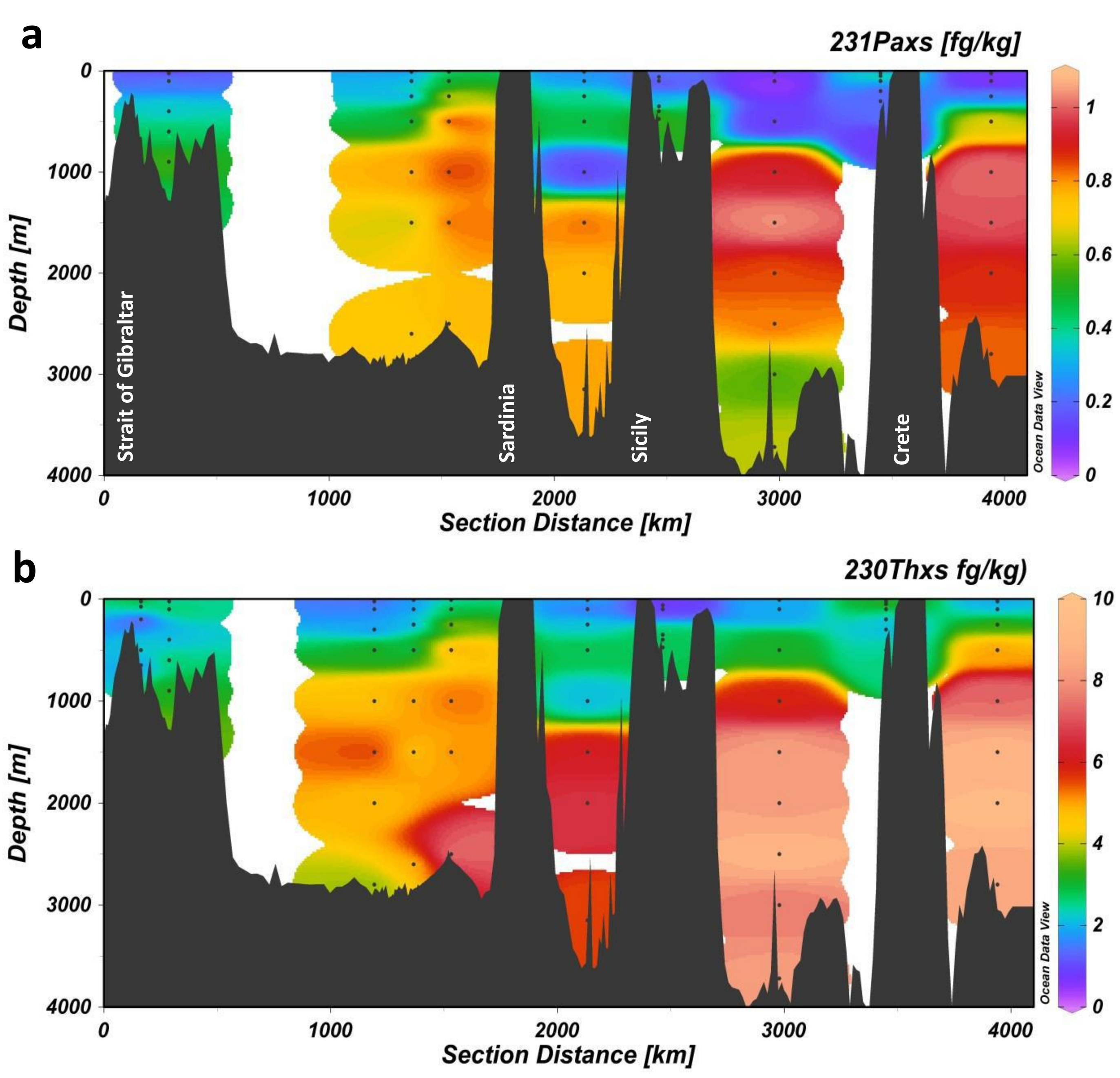


Figure 3. Cross section plots of (a) ^{231}Pa$_{xs}$ and (b) ^{230}Th$_{xs}$ measured in unfiltered seawater

Deep water convection in the Western Basin

Total ^{231}Pa$_{xs}$ and ^{230}Th$_{xs}$ distributions show a clear impact of **convective mixing** with relatively high concentrations in the shallow water, followed by lower concentrations in the deep water due to homogenization by convection **(Fig. 1a and 4a-b).**

In the NABB, an enrichment of ^{230}Th$_{xs}$ was observed at 2500 m depth, due to **particle resuspension** created by deep water cascading along the slopes of the continental shelf **(Fig. 4a).**

Deep water ventilation in the Eastern Basin

During the Eastern Mediterranean Transient, the deep water formation area shifted from the Adriatic Sea to the Aegean Sea[3]. The distribution of ^{231}Pa$_{xs}$ and ^{230}Th$_{xs}$ in the Eastern Basin indicates the presence **of younger but denser Aegean deep water** (2500-3700 m depth), while elevated concentrations indicate the **presence of older uplifted Adriatic water** (500-2500 m depth) **(Fig. 1b and 4c-d).**

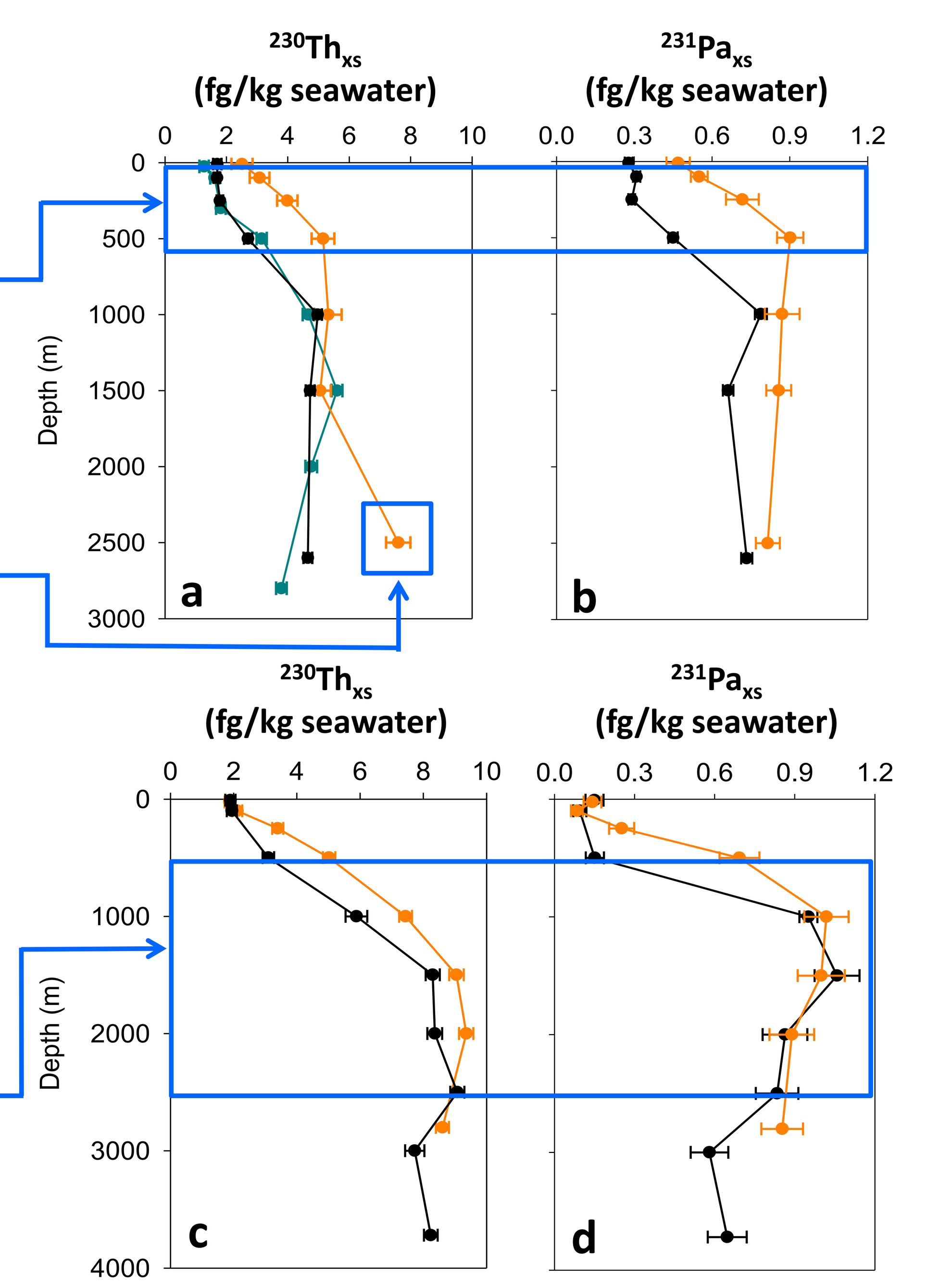


Figure 4. Depth profiles of (a and c) ^{230}Th$_{xs}$ and (b and d) ^{231}Pa$_{xs}$ for the Western and Eastern Basin.

The influence of particle composition during scavenging

$$F(Th/Pa) = \frac{^{230}Th/^{231}Pa\ particles}{^{230}Th/^{231}Pa\ dissolved}$$

- $F_{Th/Pa}$ **≈ 10** for open ocean SPM
- $F_{Th/Pa}$ **≈ 1-2** for biogenic opal and Fe/Mn-oxides
- $F_{Th/Pa}$ **≈ 10-20** for $CaCO_3$

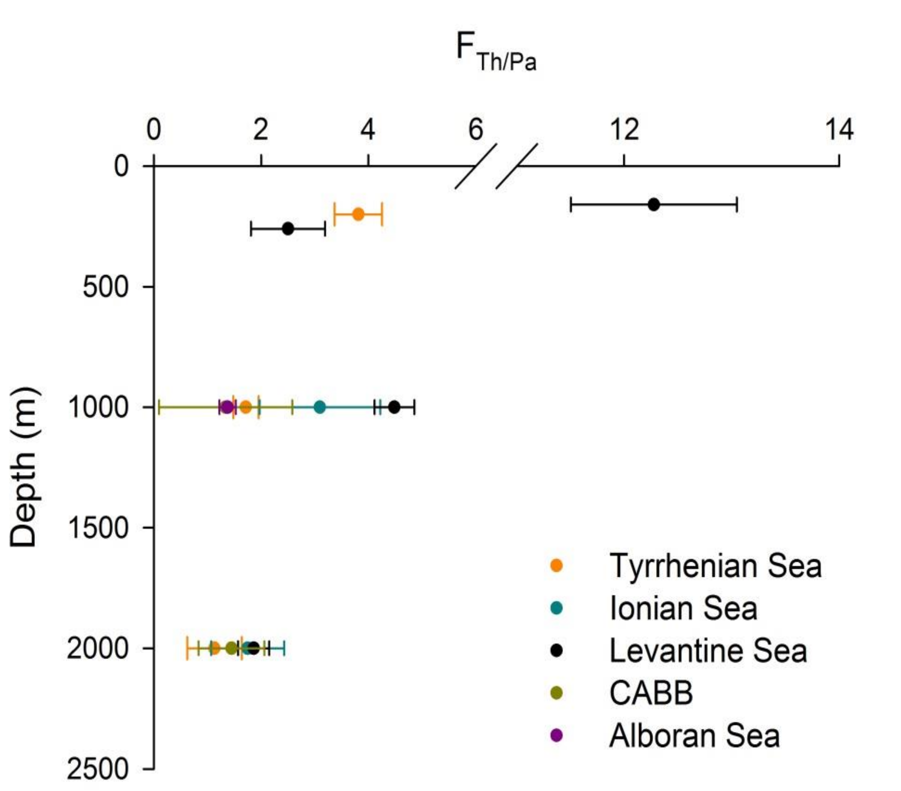
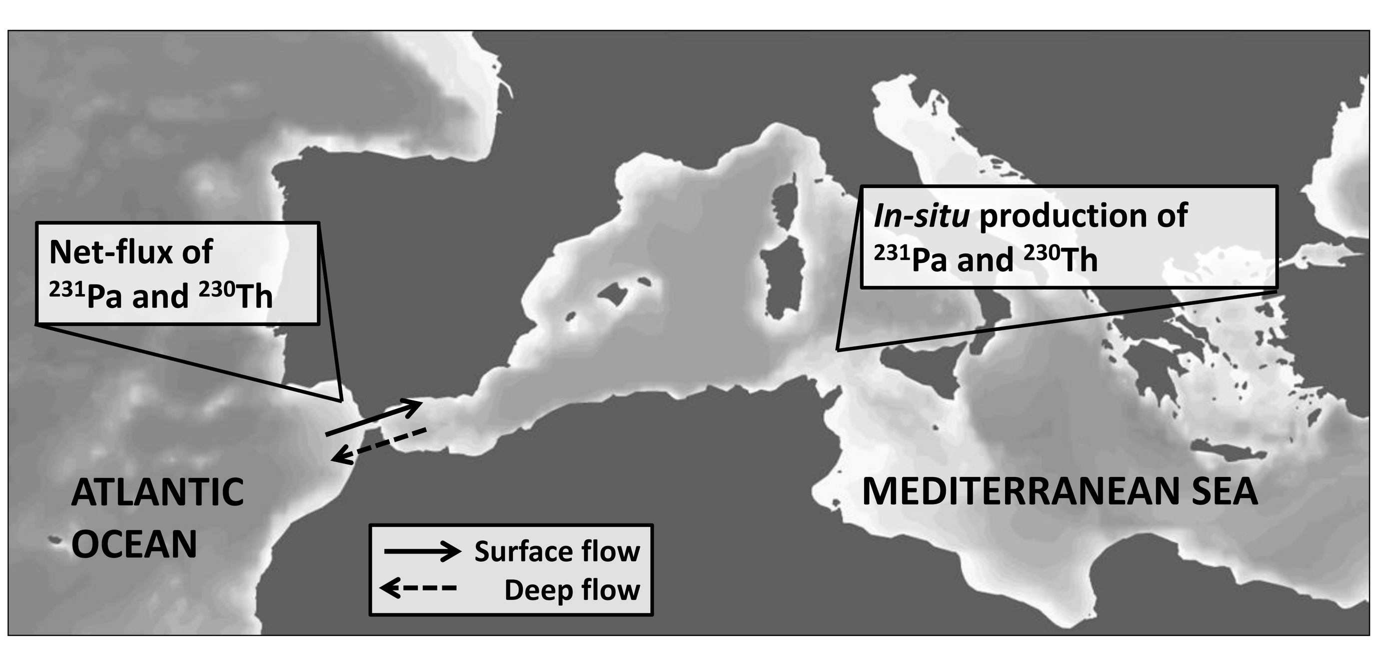


Figure 5. $F_{Th/Pa}$ calculated between seawater and suspended particles in the water column

^{231}Pa and ^{230}Th budgets for the Mediterranean Sea

In order to estimate the amount of **^{231}Pa and ^{230}Th that is scavenged within the Mediterranean Sea or transported to the Atlantic**, a box-model was used to constrain ^{231}Pa$_{xs}$ and ^{230}Th$_{xs}$ budgets.

Any disequilibrium between the ***in-situ* production** and the **net-fluxes** indicate removal of ^{231}Pa and ^{230}Th by sedimentation:



Transport to the Atlantic
- **0.1 % of the ^{230}Th**
- **6 % of the ^{231}Pa**

Sedimentation within the MedSea
- **~100 % of ^{230}Th**
- **~94 % of ^{231}Pa**

Conclusions

- The water column distribution of ^{230}Th and ^{231}Pa is greatly influenced by deep water circulation
- **All *in-situ* produced ^{230}Th (99.9 %) is deposited within Mediterranean sediments**
- Most ***in-situ* produced ^{231}Pa (94 %) is also deposited within the Mediterranean Sea**
- The efficient scavenging of ^{231}Pa **produces low $F_{Th/Pa}$**
- Possible presence of a particulate phase with higher affinity for ^{231}Pa relative to ^{230}Th

Acknowledgements

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GEOTRACES

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