Outflow of the western boundary undercurrent *vs* ^{230}Th-excesses in the late Quaternary sediments of the NW Atlantic marginal basins

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Late Quaternary sedimentary sequences collected during two campaigns of the CSS Hudson (90-013 and 91-045) in the North Atlantic marginal basins (30–60°W; 50–60°N) were analysed for their Th and U isotope contents. They include 21 box cores selected along three transects: i) in the Labrador Sea, from Hamilton Inlet on the Labrador coast, to Cape Farewell, south Greenland, ii) in the Irminger and western Iceland basins, along the 60th parallel, and iii) along the northern edge of the Charlie Gibbs Fracture zone. Five long cores spanning at least the Last Glacial Maximum (LGM)-Present, were also used. They were raised respectively, from the Greenland lower slope (PC-012) and upper rise (PC-013), the Orphan Knoll area (PC-094) and the Iceland basin (P-072; TWC-074). Sedimentological, geochemical, and isotopic studies provided independent chronologies. During the Holocene, very low Holocene sedimentological rates (2 to 5 cm/ka) are observed on the lower slope, i.e. along the high velocity core of the Western Boundary Undercurrent (WBUC) as well as in central parts of the major gyres. They contrast with the much higher rates observed below, on the rise ($\geqslant$ 20 cm/ka) (Hillaire-Marcel *et al.*, 1994). A reverse situation prevailed during the Last Glacial Maximum (LGM), when a weaker WBUC resulted in higher sedimentation rates on the lower slope and central gyres ($\geqslant$15 cm/ka) than on the rise (~ 10 cm/ka).

TABLE 1. Mean composition of the studied sediments

	Th dpm/g*	^{238}U/^{232}Th
Rekjanes Ridge	1.53 ± 0.76	1.02 ± 0.44
Greenland margin	1.04 ± 0.25	0.74 ± 0.13
Labrador margin	1.82 ± 0.48	0.50 ± 0.07

* *vs* $CaCO_3$-free sediment
\# activity ratios

Th-U systematics in modern sediments

The surface sediments from the Reykjanes Ridge, Greenland margin and Labrador margin show distinct U-Th signatures (Table 1). The large spread of values of the Reykjanes Ridge area seems due to mixing between a Th-rich-U-poor, and a Th-poor-U-rich source associated with smectites originating from MORB alteration. Elsewhere, U-Th systematics as well as Nd-isotope values and smectites/illites ratios (Innocent *et al.*, 1997) suggest mixing between two end members (an 'Irminger' and a 'Labrador' component).

In the surface sediments, ^{230}Th-excess fluxes (F-^{230}Thxs) are likely linked to those of biogenic carbonates (F-$CaCO_3$). They vary from ~ 1.5 to 45 dpm/cm^2.ka, and from ~ 0.4 to 9 10^{-2} mole/cm^2.ka, respectively. They are primarily controlled by the site situation with respect to the WBUC pathway. In the high velocity core of the current, low geochemical fluxes are observed (~2.3 dpm/cm^2.ka and ~0.5 10^{-2} mol/cm^2.ka, respectively). Below, on the continental rise, enhanced supplies are observed (~10 dpm/cm^2.ka; ~3.2 10^{-2} mole/cm^2.ka, respectively). F-$CaCO_3$ and F-^{230}Thxs are positively correlated (R^2 $\geqslant$ 0.68) even at low sedimentation rate sites ($\leqslant$ 5 cm/ka). On the contrary, detrital silicate fluxes (F-sil.) and F-^{230}Thxs seem independent (R^2 ~ 0.15) at such sites. The influence of the WBUC is illustrated on Fig. 1, by the distribution of the lateral ^{230}Thxs fluxes. Worth of mention is the negative value observed in the central part of the basin (see NAMOC value), i.e. at a site where Moran *et al.* (1997) observed a downward decreasing trend in ^{230}Th concentrations of the overlying deep water column (NADW water masses).

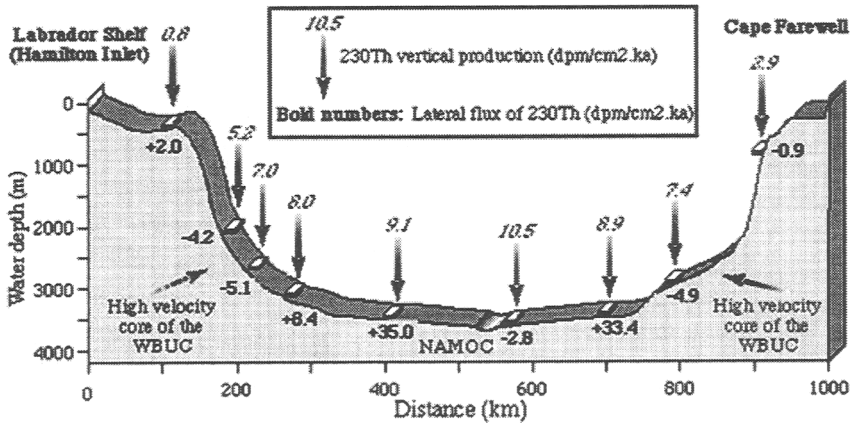

FIG. 1. The Labrador Sea transect with negative ^{230}Thxs lateral fluxes along the WBUC pathway and at the NW Mid-Ocean Channel – NAMOC- implacement – Lateral fluxes are calculated by subtracting the vertical production to the total ^{230}Thxs flux.

Th-U systematics in LGM and deglacial sediments

Compared with the modern situation, the LGM lower slope sediments (P-012) show a lesser influence WBUC supplies, and an enhanced influence of proximal Greenland sources. At all sites, lateral ^{230}Thxs fluxes are strongly reduced as well as smectites/illites ratios in the clay fraction. Biogenic carbonate fluxes are almost null. All these features suggest a very weak LGM WBUC.

During deglaciation, and at sites under direct influence of the WBUC, the ratio F-CaCO3/ F-^{230}Thxs increased slightly in response to the increasing outflow of the current. This ratio then stabilized during the middle and late Holocene. In opposition, the F-sil./F-^{230}Thxs ratio shows much larger variations with values decreasing by 3 to 5 folds between deglacial and post-glacial times. The strong correlation between F-^{230}Thxs and F-CaCO3 suggests that the organo-mineral compounds produced by coccolithophorids at the origin of the biogenic carbonates are more efficient scavengers than the relatively coarse terrigenous particles, and are partly responsible for the enhanced Holocene fluxes ^{230}Thxs fluxes, adding to the influence of increasing outflow of the WBUC.

Based on the above observations, it is concluded that a quantitative linkage of ^{230}Thxs fluxes in the NW Atlantic basins, with WBUC outflow rates, requires to better constrain the differences in specific scavenging rates of biogenic carbonates and of terrigenious supplies.

References

Hillaire-Marcel, C., de Vernal, A., Bilodeau, G. and Wu, G. (1994) *Can. J. Earth Sci.*, **31**, 63–16.

Innocent, C., Fagel, N., Stevenson, R. and Hillaire-Marcel, C. (1997) *Earth Planet. Sci. Lett.*, **146**, 607–18.

Moran, S.B., Charette, M.A., Hoff, J.A., Edwards, R.L. and Landing, W.M. (1997) *Earth Planet. Sci. Lett.*, **150**, 151–9.