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Calcification depth of deep-dwelling planktonic foraminifera from eastern North Atlantic: evidence from stable oxygen isotope ratios of shells from plankton tows

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Stable oxygen isotopes ($\delta^{18}O$) of planktonic foraminifera are one of the most used tools to reconstruct environmental conditions of the water column. Since different species live and calcify at different depths in the water column, the $\delta^{18}O$ of sedimentary foraminifera reflects to a large degree the vertical habitat and interspecies $\delta^{18}O$ differences and can thus potentially provide information on the vertical structure of the water column. To fully unlock the potential of foraminifera as recorders of past surface water properties, it is necessary to understand how and under what conditions the environmental signal is incorporated into the calcite shells of individual species. Deep-dwelling species play a particularly important role in this context, since their calcification depth reaches below the surface mixed layer. Here we report $\delta^{18}O$ measurements made on four deep-dwelling Globorotalia species collected with stratified plankton tows in the Eastern North Atlantic. Size and crust effects on the $\delta^{18}O$ signal were evaluated showing that a larger size increases the $\delta^{18}O$ of *Globorotalia inflata* and *Globorotalia hirsuta*, and a crust effect is reflected in a higher $\delta^{18}O$ in *Globorotalia truncatulinoides*. The great majority of the $\delta^{18}O$ values can be explained without invoking disequilibrium calcification. When interpreted in this way the data imply depth-integrated calcification with progressive addition of calcite with depth to about 300 m for *G. inflata* and to about 500 m for *G. hirsuta*. In *Globorotalia scitula*, despite a strong subsurface maximum in abundance, the vertical $\delta^{18}O$ profile is flat and appears dominated by a surface layer signal. In *G. truncatulinoides*, the $\delta^{18}O$ profile follows equilibrium for each depth, implying a constant habitat during growth at each depth layer. The $\delta^{18}O$ values are more consistent with the predictions of the Shackleton (1974) paleotemperature equation, except in *G. scitula*, which shows values more consistent with the Kim and O'Neil (1997) prediction. In all cases, we observe a difference between the level where most of the specimens were present and the depth where most of their shell appears to calcify.