Quantification of deep-ocean carbon sequestration during millennial-scale variations in atmospheric CO_2

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Explanations for atmospheric CO_2 ($CO_{2,atm}$) variations over glacial-interglacial and millennial time scales change invoke significant changes in the sequestration of carbon in the deep ocean. Despite observational evidence for variations in the (surface) ocean-atmosphere exchange of CO_2 and varying carbon export into the abyssal ocean that suggest the partitioning of carbon among the oceanic and atmosperic reservoirs, changes in deep-ocean carbon sequestration remain qualitatively and quantitatively poorly constrained.

Here, we reconstruct changes in respired dissolved inorganic carbon (DIC) in the deep sub-Antarctic Atlantic during the last deglacial and mid-glacial periods based on bottom water $[O_2]$ estimates via the offset of pore water, i.e. *G. affinis*, $\delta^{13}C$ from bottom water, i.e. *C. kullenbergi*, $\delta^{13}C$ in sediment core MD07-3076Q (44°9.2'S, 14°13.7'W, 3770 m water depth). We complement these analyses with qualitative estimates of past variations in sedimentary redox-conditions by determining the authigenic accumulation of redox-sensitive trace elements, i.e. uranium and manganese, in authigenic coatings of planktonic and benthic foraminifera.

We find that bottom water $[O_2]$ variations in the deep sub-Antarctic Atlantic strikingly co-varied with $CO_{2,atm}$ variations during the last deglacial and mid-glacial periods. When extrapolated to the global deep ocean below 3 km water depth (i.e. below the putative 'chemical divide'), these changes translate into a respired carbon change of 509±68 Gt C (early deglaciation) and 292±111 Gt C (mid-glacial period), which greatly exceed the carbon mass gain by the atmosphere implied by Antarctic ice-core $CO_{2,atm}$ records. We discuss possible pathways of respired carbon from the deep ocean to the atmosphere by considering the ocean DIC buffer (i.e. Revelle) effect. We further assess the influence of variations in the Redfield ratio and the ocean volume on our deep ocean carbon storage estimates, and compare these with other available calculations based on ^{14}C ventilation ages.