

The fate of carbon in upper and intermediate waters in the South Atlantic during rapid climate change of the late Pleistocene

KARL J.F. MEIER¹, ELEN ANAGNOSTOU², OLIVER FRIEDRICH³, CRISTIANO M. CHIESSI⁴, ANDRÉ BAHR¹
AND JÖRG LIPPOLD³

¹Heidelberg University, Heidelberg, Germany

²GEOMAR Helmholtz Centre for Ocean Research Kiel

³Heidelberg University

⁴University of São Paulo

Antarctic Intermediate Water (AAIW) plays a crucial role in the return flow of the Atlantic Meridional Overturning Circulation (AMOC). Today, AAIW formation acts as a sink for atmospheric CO₂. Yet, as (anthropogenic) carbon accumulates in AAIW and is transported northwards, eventually reaching equatorial upwelling regions, where a higher oceanic-to-atmospheric pCO₂ gradient may be expected, implying more efficient oceanic CO₂ outgassing. This suggests that AAIW could evolve from a CO₂ sink to a potential source, highlighting its ambiguous role in the global carbon cycle during climate transitions.

To assess whether AAIW acts as either a source or sink of CO₂ during periods of rapid climate change, we generated a multiproxy record from sediment core M125-25-4 (SE Brazilian margin), comprising the last glacial and deglacial periods of the late Pleistocene, with a focus on $\delta^{11}\text{B}$ as a seawater pH/pCO₂ proxy. The examined intervals are characterized by abrupt climate variations (such as Dansgaard/Oeschger cycles and Heinrich Stadials), which are associated with AMOC perturbations and pronounced atmospheric CO₂ variability, arguably comparable to recent climate change.

Using Mg/Ca, stable isotopes ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$, $\delta^{11}\text{B}$) of both planktic and benthic foraminifera and additionally B/Ca and Cd/Ca obtained from benthic foraminifera, we aim to reconstruct the properties of AAIW and further examine the role of the South Atlantic Subtropical Gyre (SASG) to carbon dynamics. First, we estimate the oceanic-to-atmospheric pCO₂ gradient to evaluate CO₂ exchange, considering variations in physical properties (e.g., sea surface temperature) and biological productivity affecting carbon fixation. Second, given the SASG's connection to AAIW via the downwelling limb of the shallow overturning in the Southern Ocean, we discuss whether preformed SASG waters contribute to AAIW's carbon budget.