Paleoceanographic changes in the Southern Ocean during Pleistocene glacial-interglacial cycles: Biomarker and dinocyst-based reconstructions

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Expected Antarctic Circumpolar Current (ACC) and sea-ice dynamics on Pleistocene glacial-interglacials

- Dynamics of the ACC play a crucial role in the delivery of heat to the marine-terminating Antarctic ice sheets, yet large uncertainties in this relationship hamper projections of future sea level rise.
- Due to the penetration of relatively warm Circumpolar Deep Water (CDW) onto the Antarctic margin Antarctic ice shelves melt from below (basal melt), contributing to far more melting than at the surface due to atmospheric warming¹.

Figure 1: Conceptual cross-section of the Southern Ocean oceanography with and without sea ice.

- A better understanding of changes in the strength and/or position of the ACC may help to better estimate upwelling intensities of CDW and thus its influence on sea-ice and ice shelves.

Southern Ocean oceanography during late Pleistocene Glacial-Interglacials

- We aim to reconstruct Southern Ocean latitudinal SST gradients, upwelling intensities and Antarctic sea-ice behavior over late Pleistocene glacial-interglacial cycles.
- Although boundary conditions and climate forcing are well-constrained for this time period, large uncertainties remain about latitudinal migration of ocean fronts, the amplitude of sea-ice extent and ice-proximal ocean conditions offshore marine-terminating ice sheets.
- A main focus will lie on terminations into interglacials and their intrinsic dynamics. Marine isotope stages (MIS) 5e and 11 are outstanding time intervals to be investigated and to be compared, given the different orbital forcing and behaviors of MIS 5e and 11².

Figure 2: Key paleoclimatic records over the past 450 ka.

Methods

- We apply quantitative dinocyst assemblage-based as well as organic geochemical proxies to reconstruct SST, upwelling and sea-ice.
- This will allow for proxy-proxy comparison of SST reconstructions, thus confirming results and/or identifying possible shortcomings and biases towards the interpretation of a single proxy.

- Dinocyst assemblages have proven to show a strong affiliation to ACC-associated fronts, sea-ice proximity and nutrient conditions.

- Additional GDGT-based indices such as the BIT help to further corroborate TEX86-based SST results or recognize enhanced terrestrial input².

Figure 3: Modern dinocyst assemblages in the Pacific sector of the Southern Ocean².

Challenges and Outlook

- We are confident that in open ocean conditions both of our intended proxies will lead to reliable results.
- Future projects include looking into dynamics at Totten Glacier and the South Atlantic (IODP Cruise 382).

The “OceaNice” project

This ERC project aims at contributing to a better understanding of past ice-proximal ocean conditions in order to elucidate the interactions of ocean circulation dynamics and Antarctic ice loss and to anticipate potential sea level rise under current and future climate change conditions.

Applying proxy-proxy calibrations for late Pleistocene surface ocean dynamics SST, upwelling intensities and sea-ice

These findings will be integrated in ocean circulation model simulations are you a modeler? Go talk to Peter Bijl for a possible PostDoc position

Application to deeper time scales that show relevance for future atmospheric CO₂ concentrations go see posters by Suning Hou and Frida Holm

Figure 4: Core locations of ODP Leg 189.

Dynamics in the Tasmanian Gateway

- We revisit ODP Site 1172 at the East Tasman Plateau north of the subtropical front and ODP Sites 1170 and 1171 at the Tasman rise in the Subantarctic Zone.
- Previous studies proposed a very dynamic frontal system over glacial-interglacials, with a general equatorward shifts during glacialis, but distinctly different responses² during MIS 11, 9 and 5.
- As an ice-proximal location along this transect, we look at IODP Site U1361 from the continental rise offshore of the Wilkes Subglacial Basin. We aim at further expanding on a recent study indicating ice margin retreat and thinning during past interglacials³.

References:


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