

# Invigoration of Southern Ocean surface circulation during Late Eocene cooling

Sander Houben<sup>1,2</sup>, Peter Bijl<sup>1</sup>, Appy Sluijs<sup>1</sup>, Stefan Schouten<sup>3</sup>, Henk Brinkhuis<sup>3</sup>

<sup>1</sup> MPP, Utrecht University, Utrecht, the Netherlands; <sup>2</sup> Geological Survey of the Netherlands, Utrecht, the Netherlands; <sup>3</sup> Royal NIOZ, and Utrecht University, Texel, the Netherlands

## Abstract

The Late Eocene (37-34 Ma), progressive cooling preconditioned Antarctica for glaciation. Questions remain about the exact oceanic reorganisations that occurred in the Southern Ocean, as a result of tectonic gateway opening, and the consequences for regional temperature. We have reviewed the available sediments covering the Late Eocene, which we could accurately correlate stratigraphically. We reconstruct profound ocean current invigoration leading up to Antarctic glaciation, which had major consequences for regional distribution of heat particularly in the southwest Pacific Sector.

## Tools

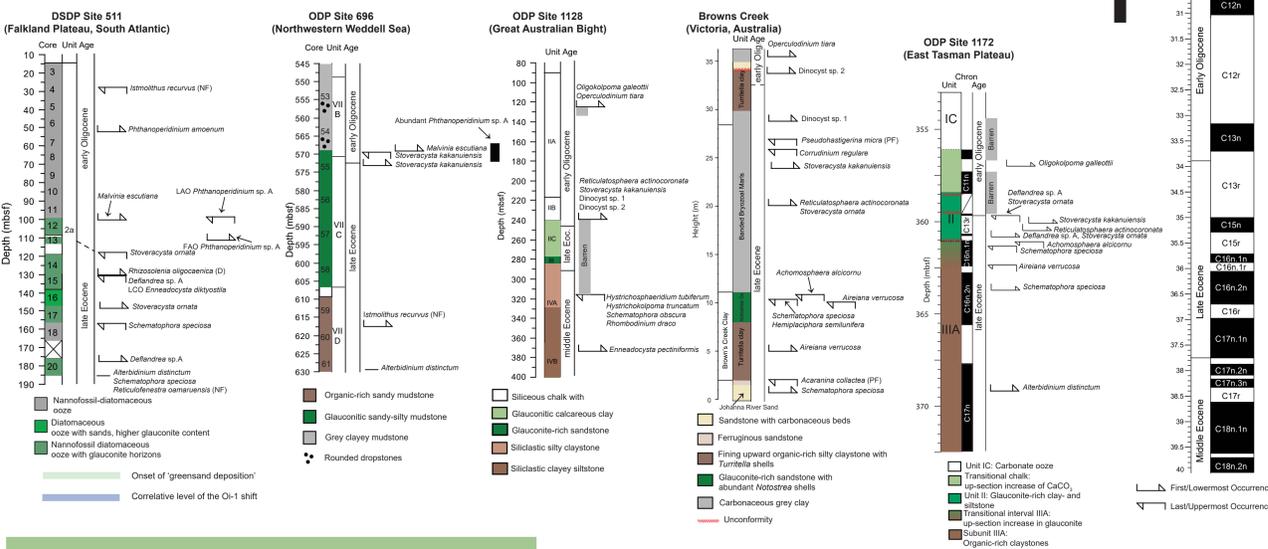
We use dinoflagellate cysts preserved in a number of sedimentary archives in the Southern Ocean. Eocene dinocyst assemblages are dominated by an Antarctic endemic community in sediments underlying Antarctic-derived surface currents (Bijl et al., 2011).

In 2 key sectors, the southwest Pacific (Site 1172) and sw Atlantic Ocean (Site 511), we pair our dinocyst analyses with organic geochemical biomarker analyses ( $TEX_{86}$  and  $U^K_{37}$ ) for quantitative sea surface paleotemperature reconstructions.

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## Stratigraphy and lithology

Using particularly dinoflagellate cysts, we could stratigraphically correlate coarse-grained green-sand deposits around the Antarctic Margin and on the South Australian Margin. This suggests throughout the Southern Ocean, surface currents invigorated, probably as a result of stronger atmospheric circulation forced by progressive cooling, and possible some glaciations on Antarctica. Not only the Antarctic Counter Current invigorated in this process, but also the Proto-Leeuwin Current, flowing south of Australia.



## Absolute SST

Site 1172 in the sw Pacific Ocean, shows the onset of throughflow of the proto-leeuwin current in the diminishing abundance of endemic-antarctic dinocysts. The surface water warming as documented in  $TEX_{86}$  suggest that the incoming proto-leeuwin water was significantly warmer than the Antarctic-derived Tasman Current water.

SSTs at Site 511 in the sw Atlantic Ocean show a much more 'classic' cooling pattern across the Eocene-Oligocene boundary, suggesting no changes in Drake Passage throughflow.

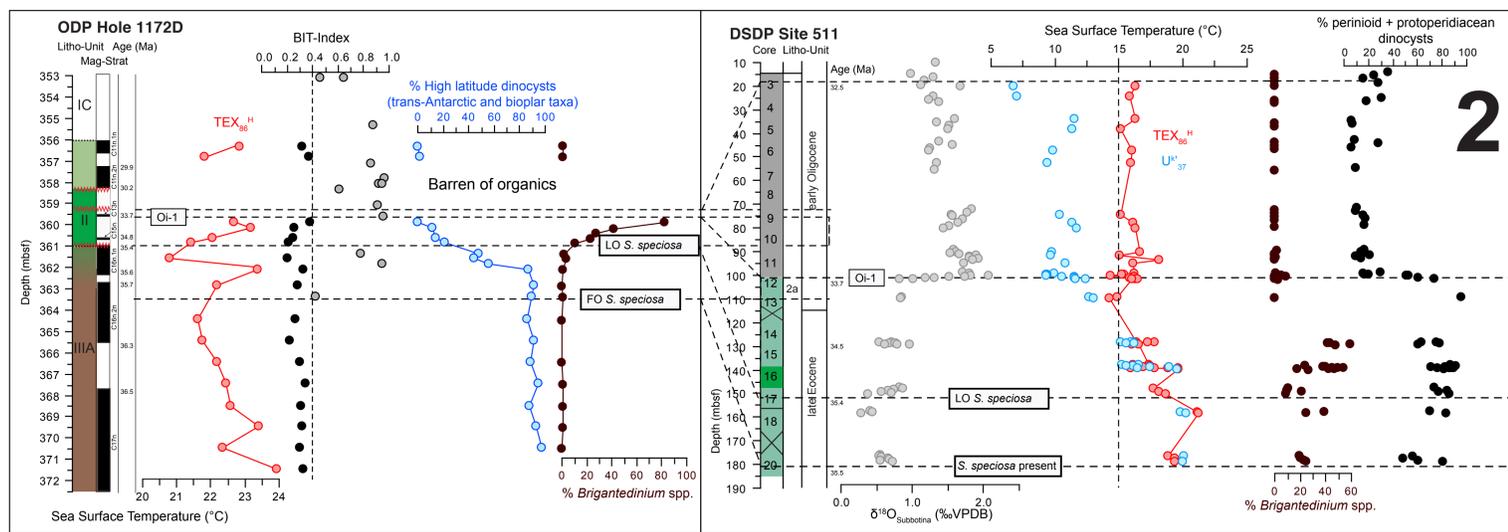


Fig. 1. Lithologies and stratigraphic correlation of sedimentary records around Antarctica.

Fig. 2. biomarkers and dinocyst assemblages of 2 key sites: 1172 in the sw Pacific Ocean and Site 511 in the sw Atlantic Ocean.

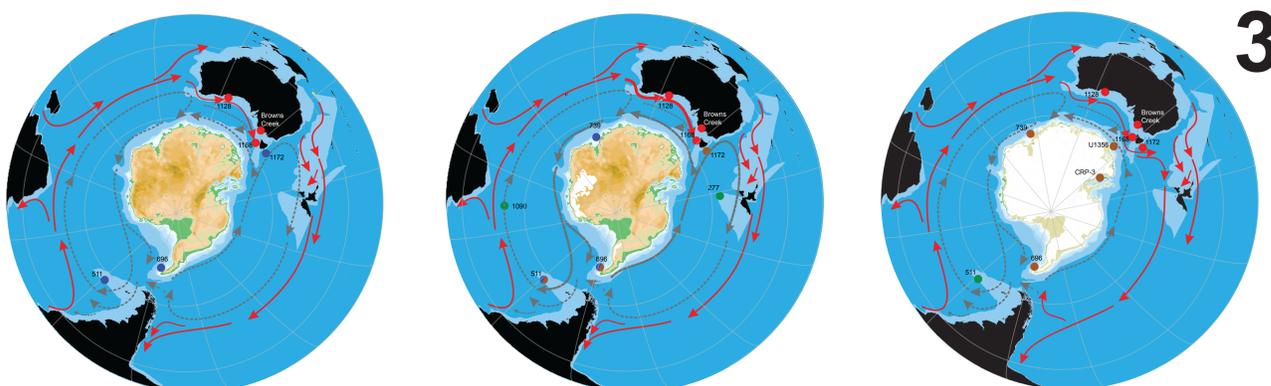
Fig. 3. Synthesis of oceanographic changes in the Southern Ocean across the Eocene-Oligocene boundary

## Synthesis and conclusions

The late Eocene Southern Ocean saw a series of powerful positive climate feedbacks: gateway deepening, climatic cooling, atmospheric circulation, thermal isolation and biological productivity.

These may have been a preconditioning factor in the nature and timing of ice-sheet expansion across the Oi-1, which is considered to be ultimately forced by decreasing atmospheric CO<sub>2</sub> concentrations and orbital forcing of summer insolation.

Intensification of the Antarctic Counter Current and its feedbacks may have contributed to setting the stage of minor scale, ephemeral Antarctic glaciations prior to the EOT.



early late Eocene (36 Ma)

latest Eocene (34 Ma)

early Oligocene (32 Ma)

- Cosmopolitan and high-latitude autotrophic dinocysts dominant
- High-latitude endemic dinocysts dominant
- Abundant high-latitude dinocysts and protoperidiniacean dinocysts
- Protoperidiniacean dinocysts dominant
- Diverse, autotrophic dinocyst assemblage

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