Geophysical Research Abstracts
Vol. 16, EGU2014-16490, 2014
EGU General Assembly 2014

The oceanographic and climatic evolution of the Paleogene Southern Ocean (Arne Richter Award for Outstanding Young Scientists Lecture)

Peter Bijl (1), Alexander J.P. Houben (2), and the PSO Team

(1) Faculty of Geoscience, Utrecht University. Laboratory of palaeobotany and palynology, Budapestlaan 4, 3584 CD Utrecht, the Netherlands. p.k.bijl@uu.nl, (2) Netherlands Organization for Applied Scientific Research (TNO), Princetonlaan 6, 3584 CB Utrecht, Netherlands. alexander.houben@tno.nl

Continental-scale ice sheets first appeared in Antarctica following long-term cooling through the Eocene Epoch (56-34 Ma) within the Paleogene Period (65.5-23 Ma). Both the long-term cooling following early Eocene hot-house climates and the onset of large-scale glaciation itself has been related to the gradual decline of atmospheric greenhouse gas concentrations. Although much work is now centered in improving techniques for reconstructing past atmospheric pCO_2, at present proxy-based reconstructions of atmospheric greenhouse gases for the Paleogene are of low temporal resolution and subject to a large degree of uncertainty. Furthermore, long-term mid-Eocene surface water cooling appears to have been confined to high- and mid-latitudes only, with little to no cooling in the tropical regions. This observation questions the role of atmospheric greenhouse gas (notably CO_2) decline as a primary cause of Eocene climate cooling. Furthermore, the greenhouse-gas hypothesis has now superceded long-held hypothesis that the opening of southern ocean tectonic gateways cooled Antarctica. A direct relationship between the deepening of the Tasmanian Gateway and Antarctic glaciation has been refuted by accurate dating of this tectonic event, indicating that the Tasmanian Gateway deepened 2 million years prior to Antarctic glaciation. However, the precise secondary role of gateway evolution on Antarctic climate change is not well constrained. On the other hand, it is increasingly apparent that the Southern Ocean was the main region for intermediate-deep water formation in the Paleogene, which implies that even environmental change with regional effects may have had direct implications for global climate change.

While the forcing mechanism that pushed Antarctica towards fully glaciated conditions is likely atmospheric pCO_2 decline across a critical threshold, the regional environmental responses are not well constrained. Numerical modeling studies suggest that in conjunction with the buildup of continental ice on Antarctica, sea-ice may have first developed along the margin of East Antarctica Margin, but this conclusion lacks support from field evidence. Other numerical models predict that hysteresis effects within the ice sheet render a continental-size Antarctic ice sheet rather insensitive to warming. In contrast, deep-water benthic foraminiferal oxygen isotope records across the Oligocene suggest dramatic waxing and waning of Antarctic ice sheets.

In summary, the complex interaction of climate forcings and responses following the opening and subsequent deepening of the Southern Ocean gateways, as well as the precise relationship between Southern Ocean oceanographic change, sea ice formation and continental ice dynamics are as yet poorly understood. In my presentation, I will provide an overview of our recent palynological and organic geochemical studies on Eocene sediments from the Southern Ocean that addresses some of these uncertainties. The presented studies were only possible through access to ocean sediments collected and curated by the several scientific ocean drilling programs (DSDP, ODP, IODP). IODP Expedition 318 drilled the Antarctic Margin in 2010, and recovered sediments from both pre-glacial and early glacial phases of Antarctic climate evolution. Using these drill cores together with sediments retrieved during previous expeditions we can now evaluate the robustness of the results of numerical models with field data. Strata sampled at IODP Site U1356 represent a thick and relatively complete (albeit compromised by core gaps) Eocene- Oligocene succession that is chronostratigraphically well-calibrated in the context of of nannoplankton- dinoflagellate cyst (dinocyst) and paleomagnetism. Notably, this record yields diverse dinocysts assemblages and organic molecular biomarkers, which we can use to investigate changes in surface-water paleoenvironmental changes through the Eocene and Oligocene to provide answers to these outstanding questions.