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Late Eocene sea surface cooling of the western North Atlantic (ODP Site 647A)

Kasia K. Sliwinska (1), Helen K. Coxall (2), and Stefan Schouten (3)

(1) Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, DK-1350 Copenhagen K, Denmark (kksl@geus.dk), (2) Department of Geological Sciences, Stockholm University, SE-106 91 Stockholm, Sweden, (3) Royal Netherlands Institute for Sea Research (NIOZ), Department of Marine Organic Biogeochemistry, P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands

The initial shift out of the early Cenozoic *greenhouse* and into a glacial *icehouse* climate occurred during the middle to late Eocene and culminated in the abrupt growth of a continental-scale ice cap on Antarctica, during an episode known as the Oligocene Isotope Event 1 (Oi-1) ~33.7 Ma. Documenting the patterns of global and regional cooling prior to Oi-1 is crucial for understanding the driving force and feedback behind the switch in climate mode. Well-dated high-resolution temperature records, however, remain sparse and the climatic response in some of the most climatically sensitive regions of the Earth, including the high latitude North Atlantic (NA), where today large amounts of ocean heat are exchanged, are poorly known.

Here we present a sea surface palaeotemperature record from the late Eocene to the early Oligocene (32.5 Ma to 35 Ma) of ODP Hole 647A based on archaeal tetraether lipids (TEX_{86}^{H}). The site is located in the western North Atlantic (Southern Labrador Sea) and is the most northerly located (53˚N) open ocean site with a complete Eocene-Oligocene sequence which yields both calcareous and organic microfossils suitable for detailed proxy reconstructions. Our record agrees with the magnitude of temperature decrease (~3 ˚C sea surface cooling) recorded by alkenones and pollen data from the Greenland Sea, but our higher resolution study reveals that the high latitude NA cooling step occurred about 500 kyrs prior to the Oi-1 Antarctic glaciation, at around ~34.4 Ma. This cooling can be explained by regional effects related to local NA tectonics including ocean gateways, known to have changed at the time, with potential to effect NA overturning circulation due to adjustments in the thermohaline density balance. Alternatively, the cooling itself may be due to changes in NA circulation, suggesting that global ocean circulation played a role in pre-conditioning the Earth for Antarctic glaciation.