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Orbitally resolved records of Oligocene ice-sheet dynamics and deep-water chemistry from ODP Site 689 (Maud Rise, Weddell Sea)

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The early stages of the modern 'Icehouse' climate state first developed in the Oligocene following rapid global cooling and the onset of Antarctic glaciation at the Eocene-Oligocene Transition (34 Ma). However, the size and stability of the early Antarctic ice sheets that existed during the Oligocene under atmospheric CO_2 levels higher than present day are poorly known. Here we report on an ongoing investigation of Oligocene (hemi)pelagic drillcores recovered at Ocean Drilling Program (ODP) Site 689, drilled on Maud Rise in the eastern Weddell Sea in late 1980s (Leg 113). Shipboard physical properties data were not routinely collected from pre-Quaternary cores at this site, and the lack of continuous composite sections and supporting data has previously been a considerable hindrance to high-resolution paleoceanographic studies. New high-resolution XRF scanning, discrete magnetic susceptibility, and benthic foraminiferal stable isotope records were collected from the upper Eocene–upper Oligocene interval of ODP Sites 689. The XRF datasets allow compositing of Holes 689B and 689D, which fortuitously contain offset cores throughout the sequence. Although condensed in two intervals, Site 689 contains a complete ∼12-Myr record spanning Chron C17n.1n to Chron C8n.1n (∼37 to 25 Ma).

The composited records from Sites 689 exhibit prominent orbital-scale cyclicity in XRF-derived iron/calcium ratios, enabling development of an astronomical age model and detailed reconstruction of carbonate dissolution intensity of South Atlantic deep waters. These composited and well-dated records from Site 689 will, for the first-time, provide an Oligocene pelagic reference section for the Southern Ocean and serve as stratigraphic stepping stone between proximal Antarctic shelf records and high-resolution proxy records from lower latitude locations. Further development of high-resolution benthic foraminiferal and detrital neodymium isotope records at Site 689 will address the timing and frequency of East Antarctic ice-sheet advance and retreat events during cool intervals of the mid Oligocene and the onset of warming in the latest Oligocene. These data will both inform and test model results of ice-sheet behaviour and stability during different climatic phases of the Oligocene.