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The role of vigorous current systems in the Southeast Indian Ocean in redistributing deep-sea sediments

Adriana Dutkiewicz (1), Dietmar Müller (1), Andrew Hogg (2), and Paul Spence (3)

(1) School of Geosciences, Univ. of Sydney, Sydney, Australia (dietmar.muller@sydney.edu.au), (2) Research School of Earth Sciences, Australian National University, Canberra, Australia, (3) ARC Centre of Excellence for Climate System Science, University of New South Wales, Australia

Understanding the transport of modern deep-sea sediment is critical for accurate models of climate-ocean history and the widespread use of the sedimentological record as a proxy for productivity where the connection between biogenic seafloor lithologies and sea-surface is tenuous. The Southern Ocean, where diatoms contribute the bulk of pelagic material to the seafloor forming an extensive belt of diatom ooze, is an exemplar. However, most of the key studies on large-scale sediment reworking in the Southern Ocean were conducted in the 1970s when relatively little was known about the oceanography of this region. At this time even our knowledge of the bathymetry and tectonic fabric, which underpin the distribution of deep-sea currents, were fairly general. The record of widespread regional disconformities in the abyssal plains of the Southern Ocean is well-established and indicates extensive erosion of deep-sea sediments throughout the Quaternary. Here we combine a high-resolution numerical model of bottom currents with sedimentological data to constrain the redistribution of sediment across the abyssal plains and adjacent mid-ocean ridges in the Southern Ocean. We use the global ocean-sea ice model (GFDL-MOM01) to simulate ocean circulation at a resolution that results in realistic velocities throughout the water column, and is ideal for estimating interaction between time-dependent bottom currents and ocean bathymetry. 230Th-normalized vertical sediment rain rates for 63 sites in the Southeast Indian Ocean, combined with satellite data-derived surface productivity, demonstrate that a wide belt of fast sedimentation rates (> 5.5 cm/kyr) along the Southeast Indian Ridge (SEIR) occurs in a region of low surface productivity bounded by two major disconformity fields associated with the Kerguelen Plateau to the east and the Macquarie Ridge to the west. Our ocean circulation model illustrates that the disconformity fields occur in regions of intense bottom current activity where current speeds reach 0.2 m/s and are favorable for generating intense nepheloid layers. These currents transport sediment towards and along the SEIR and through leaky fracture zones to regions where bottom currents speeds drop to < 0.03 m/s and fine particles settle out of suspension. We suggest that the anomalously high sedimentation rates along an 8,000 km-long segment of the SEIR represent a giant Pliocene-Holocene succession of contourite drifts. It is a major extension of the much smaller contourite east of Kerguelen and has accumulated since 3-5 Ma based on the age of the oldest crust underlying the deposit. These inferred contourite drifts provide exceptionally valuable drilling targets for high-resolution climatic investigations of the Southern Ocean. Understanding and quantifying the link between bottom current activity and sediment transport is critical for paleooceanographic and palaeoclimatic reconstructions and for understanding the history of current flow.

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