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Pleistocene ice-rafted debris events recorded at the Agulhas Plateau - indicators of intermittent Indian-Atlantic gateway closure

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Interocean exchange of heat and salt around South Africa - the so called 'Agulhas Leakage' - is thought to be a key link in the maintenance of the Atlantic meridional overturning circulation (AMOC). It takes place at the Agulhas Retroflection, largely by the intermittent shedding of enormous rings that penetrate into the South Atlantic Ocean (Lutjeharms, 1996, Biastoch et al., 2008; Beal et al., 2011). Recent palaeoceanographic studies suggest that variability in the latitudinal position of the subtropical front (STF) in the Southern Ocean, act as a gatekeeper for the Agulhas retroflection and moreover, that a variable northward migration of the STF potentially modulated the severity of glacial periods by altering the amount of Agulhas leakage with consequences for the AMOC (Bard and Rickaby, 2009).

Here we present a high-resolution record of ice rafted debris (IRD) from the southern Agulhas Plateau (sediment core MD02-2588, 41°19,90 S and 25°49,70 E, 2907 m water depth) covering the last 350,000 years. We find distinct millennial scale events with high abundances of IRD in the sediments. Scanning-electron microscope analysis of individual grains shows a wide range of morphologies, with a high degree of angularity being a dominant feature, with surface microfeatures (linear fractures, grooves and troughs) that are typical for glacial origin and transport.

We interpret these IRD events as indicators for a northward shift of the Southern Ocean frontal system, thereby allowing sufficient cooling and iceberg survivability as far north as the Agulhas Plateau. Our proxy record suggests significant millennial scale variability of the frontal movements throughout the last three glacial cycles. Largest IRD peaks occur during marine isotope stage 8 ($\sim$300 ka BP) and hence during a period for which an extreme northward shift in the STF has been identified previously (Bard and Rickaby, 2009). We compare our IRD record with records of millennial scale climate variability in the North Atlantic (McManus et al., 1999, Martrat et al., 2009) after careful synchronization of individual age models using benthic oxygen isotopes. In general, IRD peaks recorded on the Agulhas Plateau occur during globally cold conditions but in anti-phase with coldest events (Heinrich events) in the North Atlantic, which systematically occur at the culmination of large reductions in AMOC. This observation is in line with the concept of a bipolar seesaw behaviour of the glacial Atlantic. As IRD peaks recorded in MD02-2588 tend to precede IRD peaks in the North Atlantic we speculate that the events in the South may have been active in triggering the episodic ice rafting events in the North. A reduced salt export into the Atlantic ocean associated with the southern IRD events may have augmented the destabilization of AMOC activity in the North Atlantic triggering feedbacks in that region, such as basin-wide subsurface warming, increased basal melt rates under an ice shelves fronting the Laurentide Ice Sheet, subsequent collapse allowing ice flow surges and eventually iceberg and freshwater discharge into the Labrador Sea that further amplified weakening of the AMOC (e.g. Alvares-Solas et al., 2010 , Marcott et al., 2011). Ongoing coupled climate and ocean modelling studies will test the feasibility of such a sequence of events.

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