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A more alkaline Glacial Southern Ocean? Evidence from an 800 kyr record of foraminiferal trace metals in the Weddell Sea

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The Southern Ocean has long been recognised as the major player in driving the climate oscillations of the Pleistocene. Reconstructing the biogeochemistry of the past Southern Ocean is crucial for understanding the partitioning of atmospheric carbon dioxide between the atmosphere and the ocean. Hypotheses to account for glacially reduced atmospheric carbon dioxide (pCO_2) have focussed on increased stratification of the water column or enhanced efficiency of nutrient utilisation in the surface waters of the Southern Ocean. But this region, and the Weddell Sea in particular, is also responsible for the formation of the major carbon and nutrient rich deepwater mass of the global oceans, Antarctic Bottom Water (AABW), which ultimately determines the carbonate chemistry of the deep ocean. An alternative means of titrating pCO_2 into the ocean during glacial times could be to increase the alkalinity of the global deep ocean. The lack of carbonate preservation in the Southern Ocean area, however, has largely prevented probing of the past palaeochemistry of the Southern Ocean with traditional foraminiferal proxies. Here we present an 800 kyr record of trace metal contents from benthic foraminifera from PS1506 (67.8°S 5.8°W, 2426m, Weddell Sea) to investigate how the biogeochemistry of Southern Ocean has evolved during Pleistocene glacial-interglacial cycles. Our results indicate that at the extreme

low temperatures of the high latitude Southern Ocean, the downcore variability in all trace metals in foraminifera is largely controlled by variations in the carbonate ion content of the ambient water. For instance, benthic B/Ca and Mg/Ca correlate closely and show a strong 100 kyr cyclicity but with higher values during the glacial periods. Our glacial increase in trace metal content of the benthic foraminifera is paralleled by an increase in the %carbonate content of PS1506; a pattern which is reproduced in a number of cores from around the Antarctic margin and for all glacial periods of the last 800 kyrs. Using existing calibrations, our trace metal values correspond to elevated carbonate ion concentrations in glacial southern sourced deepwaters of 10-20 μmol/mol. This elevated alkalinity may derive from a glacial decrease in the flux of low alkalinity northern sourced water to the Weddell Sea, but could also be due to local changes in the carbonate cycle associated with sea ice and polynyas of the glacial Weddell Sea. We propose that an increase in the carbonate ion of southern sourced deepwaters is responsible for the "Pacific-style" carbonate cycles, and accounts for at least part of the 90 ppmv drawdown of pCO_2 during glacial periods.