Surface Changes in Southern Ocean and the Link to Deep Carbon Reservoir Expansion During 2.7 Ma

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The Southern Ocean plays a vital role in the global carbon cycle due to its extensive stores of deep carbon and its capacity to absorb atmospheric CO2 through vigorous vertical circulation between the atmosphere and deep waters. However, our comprehension of the Southern Ocean's dynamic evolution is hindered by a lack of long-term observations, impeding our ability to gain timely insights into its role in future warming trends. This study utilizes deep-sea sedimentary cores to offer new insights into the connection between the Southern Ocean's deep-sea carbon reservoir, surface physical oceanography, and its role during a global cooling phase known as the Northern Hemisphere Glaciation (NHG) around 3 million years ago (Ma). Analysis of planktonic foraminifera fauna assemblages and sedimentary geochemical records from International Ocean Discovery Program (IODP) Site U1541 during 2.8-2.4 Ma reveals significant changes. The dominance of Neogloboquadrina pachyderma (a polar species) after 2.5 Ma suggests sea ice expansion and reduced sea temperatures, while the decrease in Globoconella spp. before 2.5 Ma implies surface ocean destratification. Moreover, a long-term increase in total organic carbon during this period indicates poorly ventilated bottom water and an expanded deep carbon reservoir, possibly triggered by sea ice expansion inhibiting deep ocean upwelling. This proposed mechanism sheds light on the decrease in atmospheric CO2 levels resulting from the dynamic interaction between the ocean and atmosphere during the gradual cooling trend of the Plio-Pleistocene transition.

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