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Southern Ocean CO_2 draw down and release on glacial-interglacial timescales

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Vertical and lateral exchanges of heat and carbon make the Southern Ocean a key player in regulating global climate, yet its role in future climate change remains uncertain. To address this knowledge gap, paleoceanographers study the state of the Southern Ocean under past climate states to better understand the processes governing its role in global climate. For instance, the Southern Ocean is widely thought to play a driving role in the atmospheric CO_2 fluctuations of the ice ages, ventilating carbon-rich deep waters to the atmosphere during interglacial periods and limiting this deep-surface exchange during glacial periods. However, direct evidence of these dynamics and of the Southern Ocean's overall role in glacial CO_2 draw down remains limited.

Here we present a suite of geochemical data that provides new insights into Southern Ocean carbon cycling and circulation, evincing deep-ocean carbon storage over the last glacial cycle. Trace element and stable isotope ($\delta^{13}C$, $\delta^{18}O$) compositions of foraminiferal calcite from the high-latitude Indian Ocean demonstrate how carbon was sequestered in the deep ocean during glacial intensification and subsequently released to surface waters during deglaciation. These dynamics are captured by geochemical records reflecting temperature, pH, and circulation changes, providing key insights into the processes responsible for this carbon cycling. This observational data provides the foundation for developing a better mechanistic understanding of the Southern Ocean's role in past and future climate change, including processes such as advection and mixing, ocean-ice interactions, and productivity.