Covariation of deep Southern Ocean oxygenation and atmospheric CO_2 through the last ice age

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No single mechanism can account for the full amplitude of past atmospheric carbon dioxide (CO_2) variability over glacial-interglacial cycles. Among the possible candidates, a build-up of carbon in the deep ocean has emerged as a central mechanism for lowering atmospheric CO_2 concentrations during the Last Glacial Maximum (LGM). However, the mechanisms responsible for the release of the deeply sequestered carbon to the atmosphere at deglaciation, and the relative importance each played in controlling variations in atmospheric CO_2 concentrations prior to the LGM, have remained subjects of debate. Here we present sedimentary redox-sensitive trace metal records from the Antarctic Zone of the Southern Ocean that provide a reconstruction of transient changes in deep ocean oxygenation and, by inference, respired carbon storage throughout the last glacial cycle. Our data suggest that respired carbon was removed from the abyssal Southern Ocean during the northern hemisphere cold phases of the deglaciation, when atmospheric CO_2 concentrations increased rapidly, reflecting - at least in part - a combination of dwindling iron fertilization by dust and enhanced deep ocean ventilation. Furthermore, our records show that the observed correlation between atmospheric CO_2 concentrations and abyssal Southern Ocean oxygenation was maintained throughout most of the past 80 kyrs. This suggests that on millennial timescales deep ocean circulation and iron fertilization in the Southern Ocean played a consistent role in controlling atmospheric CO_2 concentrations.