Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7917

CO_2 storage and release in the North Atlantic Ocean during the last glacial period

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The striking similarity between atmospheric CO_2 and Antarctic temperature on millennial timescales have led many to credit the dominance of Southern Ocean processes as the primary source of CO_2 to the atmosphere during the last glacial period. However, closer examination of the phasing of these records has revealed that the peak of atmospheric CO_2 lagged Antarctic temperatures by more than 500 years. This raises the possibility that another process operating on these timescales may be acting to maintain high CO_2 and slow the pace of recovery. Here we present a high resolution boron isotope record of surface pCO_2 from the high latitude North Atlantic Ocean. Transient pulses of CO_2 >70 ppm above pre-event levels are associated with the abrupt transition from Heinrich stadials into an interstadial climate and correspond with peaks of atmospheric CO_2. Supported by model analysis, we attribute these to the sudden onset of vigorous deep overturning and suggest that this upwelled CO_2-rich deep water, accumulated at depth during stadials, into the surface ocean. In combination with warming atmospheric temperatures, which decreased the solubility of CO_2 in the surface ocean, these pulse events likely weakened the North Atlantic carbon sink and prevented atmospheric CO_2 levels from falling despite Southern Hemisphere cooling. In the deep ocean, we link these major upwelling events to a sudden increase in export productivity. Interstadial peaks of redox sensitive elements in authigenic coatings of foraminifera indicate a sudden change in sediment conditions that cannot be associated with poor deep ocean ventilation. Simulations in a biogeochemical model of the sediment column suggest that these changes may reflect a change in organic carbon delivery.