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Enhanced shelf sediment weathering during glacial periods damps pCO2 reduction: A negative feedback

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In the past million years and before industrialization, the largest variations in atmospheric CO_2 occurred in connection with the glacial cycles that characterized Earth's climate over this period. The mechanisms responsible for the glacial-interglacial CO_2 changes have remained unresolved. One curios feature of at least the last four glacial-interglacial cycles is that pCO_2 reached about the same upper limit of 280 ppm during peak interglacial periods and about the same lower limit of 180 ppm during peak glacial periods. Here, we show using a numerical model of earth system that enhanced shelf sediment weathering during glacial sea-level low stand will tend to raise pCO_2 and thus stabilize it from further reduction. This is contrary to the so-called shelf nutrient hypothesis (Broecker, 1982), which proposed that increased weathering of nutrients (e.g., phosphate) would enhance the organic carbon pump of the ocean and thus reduce atmospheric pCO_2. We demonstrate that weathering of exposed continental shelves would in fact raise pCO_2 because not all nutrients from weathering will be utilized by biology but more importantly because the spatial distributions of carbon and phosphate from weathering become decoupled in such a way that carbon is preferentially stored in the upper ocean and phosphate in the deep ocean. An extension of this finding suggests that the preferential dissolution of phosphate in shelf sediments during interglacial high stand would tend to enhance biological production and thus stabilize atmospheric pCO_2 from further increase. The impact of sea level-driven continental shelf exposure and submersion on atmospheric CO_2 is therefore a negative feedback that helps explain both the upper and lower limits of atmospheric CO_2 over the Pleistocene.

Keywords: Glacial-Interglacial Cycles, pCO2, Earth system model