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Dissolution of Antarctic shelf carbonates: an insignificant feedback to acidification

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Dissolution of calcium carbonate neutralizes anthropogenic CO_2. An upward shift of the calcite and aragonite saturation horizons exposes carbonate deposits to dissolution which is an important carbon sink reaction on a time scale of several thousand years for the world oceans.

In the Southern Ocean, the surface calcite and aragonite saturation states are naturally low due to cold temperatures. They are further reduced by the uptake of anthropogenic carbon which is strongest in the top 1000 m. Undersaturation at the surface might occur even before the underlying water column is completely undersaturated. Therefore, carbonate sediments on Antarctic shelves are likely to be be among the first to dissolve due to man-made acidification.

Obviously, we need to know the inventory of $CaCO_3$ in the bioturbated layer of the Antarctic shelf sediments to quantify the capacity of this negative feedback mechanism. Here, we present a technique that allows us to spatially interpolate $CaCO_3$ data on the Antarctic shelves. We derive quantitative relationships between nearly 400 measurements of $CaCO_3$ on the Antarctic shelves, water depth and satellite-derived primary production in the overlying water column. This confirms that primary production mainly determines the $CaCO_3$ distribution on the Antarctic shelves: On the one hand, there is hardly any $CaCO_3$ production when primary production is low. On the other hand, dissolution due to CO_2 produced by remineralization of organic matter dominates in high primary production regions; this constrains $CaCO_3$ accumulation and preservation to regions with an optimum primary production level.

These relationships between sedimentary $CaCO_3$, primary production, and water depth are then applied to produce a map of $CaCO_3$ on all Antarctic shelves. The inventory, calculated from this interpolated map of $CaCO_3$, amounts to 4 Pg $CaCO_3$, capable to neutralize about 0.5 Pg C. This, however, is in the same range as estimates of the annual anthropogenic CO_2 uptake in the Southern Ocean. The dissolution of $CaCO_3$ is limited by slow reaction kinetics, otherwise $CaCO_3$ could disappear from the Antarctic shelves in only one to a few years. Our analysis suggests that deposits of $CaCO_3$ will dissolve without releasing a significant buffering signal and that Antarctic acidification will proceed without being slowed down by dissolution of carbonates from Antarctic shelves.