Carbon mineralization pathways in Antarctic shelf sediments, East Antarctic Peninsula

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The Antarctic continental shelf represents roughly 11% of the world's continental-shelf area and exhibits the highest area-based primary production rates in the Southern Ocean. On the shelf, primary production strongly varies depending on light conditions, sea ice cover, mixing depth and nutrient availability. In regions impacted by global warming, such as the Antarctic Peninsula, these conditions are changing. The retreat of sea ice and the availability of previously ice-covered areas for marine primary production has important repercussions on nutrient and carbon fluxes. In this study, we investigated benthic remineralization processes along a cryo-pelagic productivity gradient from year-round heavy ice conditions through the marginal ice zone to mainly ice-free conditions at the Western shelf of the Weddell Sea (East Antarctic Peninsula). Carbon mineralization rates were derived from pore-water profiles of oxygen, nitrate, ammonium, dissolved manganese and dissolved iron. Pore water samples were obtained from sediment cores retrieved by multi-coring at water depths between 330 to 455 m. Two deep stations (3000 m depth) were sampled for comparison. While yearly sea ice cover decreased from 80 to 30% between the stations, benthic carbon oxidation rates increased from 1.0 to 7.6 mmol C m^{-2} d^{-1} and the total organic carbon contents ranged from 0.15 to 1.5 wt.%. The low rates at heavy ice covered shelf stations were comparable to those of deep sea stations further north. Carbon mineralization rates showed that aerobic respiration accounted for 60-95% of the total carbon degradation. Anaerobic degradation was dominated by denitrification and iron reduction at stations with high sea ice cover, while sulfate reduction was present only at stations with less sea ice cover. Pore water Fe^{2+} concentrations reached up to 50 µmol/L near the sediment surface and up to 670 µmol/L at about 4 cm depth, which can lead to a substantial release of Fe^{2+} to the water column and to a subsequent increase of the iron limited primary production. In summary, the results indicate that future sea ice retreat may lead to a significant increase of benthic carbon mineralization with a subsequent enhancement of the benthic iron efflux.