Benthic element cycling on the Antarctic shelf and its potential control by sea ice cover

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Antarctic shelf regions are potential carbon and nutrient cycling hotspots where rapid climatic changes are projected to affect seasonal sea ice cover, water column stratification, and thus surface primary production and associated fluxes of organic carbon to the seafloor. Here, we report on surface sediment oxygen profiles and respective fluxes in combination with pore water profiles of dissolved iron (DFe) and phosphate (PO_4^{3-}) from 7 stations along a 400 mile transect with variable sea ice cover and water column stratification from the East Antarctic Peninsula to the west of South Orkney Islands. Our results show that sea ice concentrations and stratification of the upper water column decreased across the transect. We defined a marginal sea ice index of 5-35% sea ice cover which was positively correlated with the benthic carbon mineralization rate. C-mineralization rates increased gradually between the heavy ice-covered station and the marginal sea ice stations from 1.1 to 7.3 mmol C m^{-2} d^{-1}, respectively. The rates decreased again to 1.8 mmol C m^{-2} d^{-1} at the ice-free station, likely attributed to a deeper water column mixed layer depth, which decreases primary production and thus organic carbon export to the sediment. Iron cycling in the sediment was elevated at the marginal sea ice stations where Fe-reduction led to DFe fluxes in the pore water of up to 0.379 mmol DFe m^{-2} d^{-1}, while moderate (0.068 mmol DFe m^{-2} d^{-1}) and negligible fluxes were observed at ice-free and ice-covered stations, respectively. In pore waters, concentrations of DFe and PO_4^{3-} were significantly correlated with almost identical flux ratios of 0.33 mol PO_4^{3-} per mol DFe for most of the stations, indicating a strong control of the iron cycling on the phosphate release to the water column. The high benthic DFe and PO_4^{3-} fluxes highlight the importance of sediments underlying the marginal ice zone as source for limiting nutrients to the shelf waters.

Keywords: East Antarctic Peninsula, marginal ice zone, carbon oxidation rate, iron flux, phosphate flux