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Constraining Glacial input of phosphorus to the oceans based on Greenland ice core evidence

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Ice cores provide insight to past environmental conditions and Greenland ice cores can cover continuous records back to the previous interglacial period. Phosphorus is believed to have been the limiting nutrient for the ocean primary production in the past. Not much is known, however, about the atmospheric delivery of phosphorus to the oceans over time.

In this study phosphate concentrations have been measured in the North Greenland Eemian Ice Drilling (NEEM) ice core for the period 35.6 to 25.2 kyr b2k. Phosphate was determined continuously in selected ice core sections using a molybdenum blue method and discretely by ion chromatography (IC). 20th century phosphate concentrations have recently been reported for a firn core from the North East Greenland Ice Stream (NEGIS), showing a fairly constant level, with a mean value of 2.7 nM.

For the last glacial period, the molybdenum blue method indicated concentrations between 3 and 32 nM, whereas the IC method indicated higher concentrations. The deviation between the methods is strongly correlated (corr=0.9) to the dust content in the sample, suggesting that part of the phosphorus attached to dust particles does not instantly become labile after melting, but slowly (within hours) dissolves in the water. Both methods show higher concentrations during colder periods (stadials). The concentration differences between glacial mild and cold periods correlate positively to the dust variability suggesting that changes are linked to transport, however for very high phosphate loads (last glacial maximum) the relationship between phosphate and dust is weaker, suggesting secondary phosphate sources.

We estimate that glacial atmospheric fluxes of phosphorus to the northern Hemisphere high latitude open oceans were 4 to 11 times higher during the glacial period as compared to recent Holocene, with the highest input during the stadials.

For the recent century we find that between 4 and 100 % of the dissolved reactive phosphorus has a dust source, and between 4 and 38 % is of biogenic origin. We find no correlation with sea salt and no evidence of recent anthropogenic changes of the phosphate concentration.