Subarctic Pacific Paleoproductivity over the last 500 ka

Jaccard, S.[1], Haug, G.[2], Sigman, D.[3], Thierstein, H.[4], Röhl, U.[5]
[1]Geological Institute, ETHZ, Zurich. jaccard@erdw.ethz.ch; [2]GFZ Potsdam, Potsdam, Germany; [3]Departement of Geoscience, Princeton University, Princeton, USA; [4]Geological Institute, ETHZ, Zurich; [5]RCOM, Bremen University, Bremen, Germany.

The available paleoceanographic data indicate that export production in the Antarctic was lower during glacial times. What this signifies for local conditions and for the effect of the polar ocean on atmospheric CO_2 depends on the cause of this productivity decrease. If it was driven by increased light limitation during glacial times because of nearly year-round ice coverage, then one would expect Antarctic surface pCO_2 to have been higher during glacial times. In this case, the region could not be taken as a driver of lower CO_2 during glacial times, unless sea ice coverage was so pervasive as to prevent gas exchange between the surface ocean and atmosphere. In contrast, if this decrease in productivity was due to decreased vertical exchange lowering the nutrient supply from below (iron likely being most critical), then the region may indeed have been a driver of lower glacial CO_2, even without limitation of gas exchange by sea ice coverage. Proxies for nutrient status and surface ocean pCO_2 remain uncertain and so have not yet convincingly distinguished between these two different scenarios.

At subarctic Pacific ODP Site 882 (50°21'N, 167°35'E, 3,244 m water depth) we investigated sedimentary biogenic barium as a proxy of export production over the past 500 ka. Analysis was performed at submillennial resolution using the XRF core-scanner at Bremen University. The Ba/Al record shows a strong climate-related signal, with high values during interglacials and lower values during cold stages. Ba/Al maxima during peak interglacials in isotope stages 1, 5e, 7e, 9e and 11 are accompanied by Ca/Al maxima which contain up to 30% $CaCO_3$ in these otherwise carbonate free sediments. These data confirm previous data from the Okhotsk Sea that the export production in the subarctic Pacific is similar to the Antarctic in its response to glacial conditions. However, ODP Site 882 is located eastward of the maximum perennial sea-ice extent, so that these changes cannot be explained by sea ice-driven light limitation, leaving stratification as the only reasonable explanation. We argue that, by analogy with the Antarctic and to the degree that the subarctic Pacific itself affects atmospheric CO_2, these data make a strong case for the occurrence of polar ocean stratification during glacial times and for a significant role of this process on glacial CO_2 levels.

The most striking feature of the dataset is the strong correlation between the subarctic Pacific Ba/Al record and the Vostok deuterium record [3]. The close coupling of the North Pacific with Southern Hemisphere climate fits well with our previous suggestion of low global ocean temperature as a driver of polar ocean stratification [2].

References

[1] Narita et al. (2002), GRL, 29, 10.1029/2001GL0114320
[2] Sigman et al. (2004), Nature, 428, p 59-63
[3] Petit et al. (1999), Nature, 399, p 429-436