Polar twins? Deglacial carbon and circulation records from the deep North Pacific and Southern oceans

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The cause of glacial – interglacial CO_2 transfer between the deep ocean and the atmosphere is one of the oldest puzzles in palaeoclimatology. The regularity of these cycles, and their strong coupling to a range of climate proxies, suggests a well-ordered set of controlling mechanisms [1]. The Southern Ocean is thought to play a key role by providing a (stemable) link for carbon and nutrients between the deep ocean and the atmosphere [2]. The North Pacific shares some of these nutrient and mixing characteristics; records from both locations may thus help us understand the fundamental processes driving glacial deep ocean CO_2 storage and release [3].

We present novel proxy data from the deep North Pacific and Southern oceans that provide new constraints on deep ocean chemistry and circulation changes during deglacial pCO_2 rise. Boron isotopes ($\delta^{11}B$) from benthic foraminifera are used to record the state of the deep ocean carbonate system, and are coupled with neodymium isotopes (ε_{Nd}) and benthic-planktic radiocarbon ($\Delta^{14}C$; [4]) to explore the influences of water mass mixing and ventilation age changes. Our $\delta^{11}B$ data show a pronounced pattern of millennial carbonate system variations that is consistent between two cores in the Southern Ocean and one in the North Pacific. In contrast, Southern Ocean ε_{Nd} shows a relatively smooth deglacial transition, suggesting that mixing of differently sourced water masses has minimal control on our millennial carbonate system variations. Rather, the $\delta^{11}B$ and $\Delta^{14}C$ data are best explained by increases in vertical mixing, consistent with the breakdown of glacial stratification in these high latitude oceans during the Heinrich Stadial 1 and Younger Dryas intervals of atmospheric CO_2 rise.

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Response of coralline alga *Lithothamnion glaciale* Kjellman to ocean acidification

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Since the industrial revolution, the partial pressure of carbon dioxide in the atmosphere has been rising. The increase of carbon dioxide in the atmosphere and the related uptake by the oceans [1] will result in a decrease in ocean pH by 0.2-0.4 units over the next century [2] and in a decline of calcium carbonate saturation states in the seawater surface. The potential for marine life to adapt to increasing CO_2 concentration are not well known, especially for the organisms living at high latitudes in waters which have naturally low saturation levels.

The effects of elevated pCO_2 were investigated in the high latitude coralline alga *L. glaciale*, an high Mg-Calcite calcifier. The algae were kept in the aquaria for 3 months at 8 ± 0.5 °C with 20 µmol photons m^{-2} sec^{-1} in 12 hours light/ dark cycle at four different CO_2 concentrations: 410 ppm (control), 563 ppm, 838 ppm and 1120 ppm according to the IPCC prediction.

During this incubation period, *L. glaciale* showed a significant linear trend towards lower 'apical tip' growth rates (from 1.0 mm $year^{-1}$ to 0.8 mm $year^{-1}$) with increasing pCO_2 in the water. In water undersaturated with respect to aragonite (pCO_2 1120 ppm- $\Omega Ar = 0.9$), the cell density of the newly grown thallus was 68 % less compared to the control together with a 56 % decrease in the cell walls thickness. Reduced growth rates and the weakening of the coralline thallus could have severe consequences for the biodiversity, growth and stabilization of carbonate reefs.

[1] Sabine *et al.* (2004) *Science* **305**, 367–371. [2] Caldeira & Wickett (2003) *Nature* **425**, 365.