The ocean's great deglacial CO_2 release: Evidence from deep sea $CaCO_3$ preservation and intermediate water ^{14}C activity

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Benthic foraminiferal $\delta^{13}C$ suggests that dissolved inorganic carbon (DIC) was preferentially sequestered in the deep ocean during the last glaciation. Return of this carbon to the upper ocean during early deglaciation was likely an important driver of the deglacial atmospheric CO_2 rise. It should also have resulted in a transient deep sea carbonate ion (CO_3^{2-}) rise that was eventually reversed by excess burial of $CaCO_3$. The '$CaCO_3$ compensation' hypothesis calls for a corresponding decrease in whole-ocean pH, compounding the the deglacial atmospheric CO_2 rise. $CaCO_3$ preservation proxies and benthic foraminiferal Zn/Ca from the deep tropical Pacific are consistent with a deglacial CO_3^{2-} spike of ~25-30 µmol kg^{-1}, and comparison to model results suggests that compensation alone may account for more than one third of the atmospheric CO_2 rise.

Coincident with the deglacial atmospheric CO_2 rise was a sharp drop in atmospheric ^{14}C activity. One possible explanation for the ^{14}C drop is that the DIC released from the deep ocean was extremely depleted in ^{14}C due to strong glacial stratification (poor ventilation), particulary in the deep Southern Ocean. However, convincing evidence for such a low-^{14}C deep water mass during the last glaciation has been elusive. We show that very low-activity intermediate waters were present off of southern Baja California during the last deglaciation. The spectral reflectance record from our sediment core bears a remarkable resemblance to Greenland ice $\delta^{18}O$, allowing us to assign calendar ages to our samples. Radiocarbon activity of paleo-waters is then calculated by age correcting our benthic foraminiferal ^{14}C measurements. During most of the 40,000 year record, intermediate water activity was ~100-200‰ lower than the atmosphere (like today), but during deglaciation this depletion increased to as much as 400‰. We suggest that this transient drop represents the return of 'old' DIC to the upper ocean, with spreading to the North Pacific via Antarctic Intermediate Water. This route was previously proposed to explain the widespread $\delta^{13}C$ minimum in planktonic foraminifera, and it is possible that a deglacial $\Delta^{14}C$ minimum is similarly ubiquitous.