Influence of Hydrothermal Carbon Fluxes on Glacial/Interglacial Atmospheric pCO_2

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During the past 1 million years glacial cycles were accompanied by a gradual drop in atmospheric pCO_2 of ~80ppm and more rapid rise in pCO_2 upon deglaciation. Attempts to explain this CO_2 behavior via ocean-only mechanisms have been unsuccessful or inconclusive. Stott and Timmermann [1] set forth a new hypothesis that proposes marine hydrothermal CO_2 fluxes decreased during glaciations as the ocean cooled and CO_2 hydrate expanded, trapping CO_2-rich fluids in sediments that blanket active vents. As the ocean warmed during deglaciation hydrate was lost and the CO_2 fluxes increased. We present observational and modeling results to further test the Stott and Timmermann hypothesis.

At intermediate water depths in the equatorial eastern Pacific (EEP) and Arabian Sea the deglacial $\Delta^{14}C$ record derived from benthic foraminiferal carbonate documents a negative excursion too large to be explained by ventilation of a formally isolated water mass and thus requires an input of ^{14}C-dead geologic carbon. Simulations with an Earth system model of intermediate complexity (cGENIE) estimate the amount of ^{14}C-dead carbon that must be added to the ocean to cause such $\Delta^{14}C$ values is ~ 1400Gt. In the EEP deglacial sediments that contain anomalous $\Delta^{14}C$ values have elevated Pb/Ca, Zn/Ca and Cu/Ca, element associations indicative of a hydrothermal source. The $\Delta^{14}C$ and trace element anomalies are also associated with a negative $\delta^{13}C$ excursion in pelagic carbonates as well as carbonate dissolution and decreased calcification of foraminifers that indicate $[CO_3^{=}]$ also decreased. Taken together these observations are best explained by a release of CO_2-rich hydrothermal fluids to intermediate waters as proposed by Stott and Timmerman[1]. The Earth System model also simulates how atmospheric pCO_2 changes from such a release. In our simulations a release of 1400Gt of carbon to intermediate waters causes a ~ 60ppm rise in atmospheric pCO_2 that closely approximates the ice core record from the last deglaciation. If validated this hypothesis means that hydrothermal carbon fluxes play a much larger role in regulating atmospheric pCO_2 on sub-million year time scales than previously thought.

[1] Stott & Timmermann (2011) Geophysical Monograph Series: Understanding the Causes, Mechanisms and Extent of the Abrupt Climate Change., American Geophysical Union.