

The joint impact of ocean circulation and plate tectonics on the glacial South Pacific carbon pool

Thomas A. Ronge¹, Peter Köhler¹, Ralf Tiedemann¹, Frank Lamy¹, Brent V. Alloway², Ricardo de Pol-Holz³, Katharina Pahnke⁴, John Southon⁵, Lukas Wacker⁶

¹ Alfred Wegener Institut Helmholtz Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany

² School of Geography, Environment and Earth Sciences, Victoria University of Wellington, New Zealand

³ Departamento de Oceanografía, Universidad de Concepción, Chile

⁴ Max Planck Institut & Institut für Chemie und Biologie des Meeres, Universität Oldenburg, Germany

⁵ School of Physical Science, University of California, Irvine, USA

⁶ Laboratory for Ion Beam Physics, Eidgenössische Technische Hochschule, Zurich, Switzerland

To understand the whereabouts of CO₂ during glacial and its pathways during deglacial transitions is one of the main priorities in paleoclimate research. The opposing patterns of atmospheric CO₂ and $\Delta^{14}\text{C}$ suggest that the bulk of CO₂ was released from an old and therefore ¹⁴C-depleted carbon reservoir. As the modern deep ocean, below ~2000 m, stores up to 60-times more carbon than the entire atmosphere, it is considered to be a major driver of the atmospheric CO₂ pattern, storing CO₂ during glacial, releasing it during deglacial transitions.

We use a South Pacific transect of sediment cores, covering the Antarctic Intermediate Water (AAIW), the Upper Circumpolar Deep Water (UCDW) and the Lower Circumpolar Deep Water (LCDW), to reconstruct the spatio-temporal evolution of oceanic $\Delta^{14}\text{C}$ over the last 30,000 years.

During the last glacial, we find significantly ¹⁴C-depleted waters between 2000 and 4300 m water depth, indicating a strong stratification and the storage of carbon in these water masses. However, two sediment cores from 2500 m and 3600 m water depth reveal an extreme glacial atmosphere-to-deep-water $\Delta^{14}\text{C}$ offset of up to -1000‰ and ventilation ages (deep-water to atmosphere ¹⁴C-age difference) of ~8000 years. Such old water masses are expected to be anoxic, yet there is no evidence of anoxia in the glacial S-Pacific.

Recent studies showed an increase of Mid Ocean Ridge (MOR) volcanism during glacial due to the low stand of global sea level. For this reason, we hypothesize that the admixture of ¹⁴C-dead carbon via tectonic activity along MORs might have contributed to these extremely low radiocarbon values. With a simple 1-box model, we calculated if the admixture of hydrothermal CO₂ has the potential to lower the deep Pacific $\Delta^{14}\text{C}$ signal.

We show that if the oceanic turnover time is at least 2700 years, an increased hydrothermal flux of 1.2 $\mu\text{mol kg}^{-1} \text{yr}^{-1}$ has the potential to reproduce the extreme radiocarbon values observed in our records.