The forensics of diatoms: modelling approaches to reconstruct seasonal silicon cycling from deep sediment trap data

IVIA CLOSSET[1*], DAMIEN CARDINAL[2], FRANCOIS FRIPIAT[3]

[1]MSI, University of California Santa Barbara, Santa Barbara CA 93106-6150. [ivia.closset@lifesci.ucsb.edu]
[2]LOCEAN, Universite Pierre et Marie Curie, UMR 7159 CNRS/UPMC/IRD/MNHN, 4 place Jussieu – boite 100, F-75252 Paris, France. [damien.cardinal@locean-ipsl.upmc.fr]
[3] Max Plank Institute for Chemistry, Hahn-Meitner-Weg 1, 55128 Mainz, Germany. [f.fripiat@mpic.de]
*correspondence: ivia.closset@lifesci.ucsb.edu

In the Southern Ocean, the silicon (Si) biogeochemical cycle is dominated by processes such as diatom uptake and dissolution, and physical export and mixing. The Si isotopic composition (δ^{30}Si) of biogenic silica (BSi) is closely linked to the degree of Si utilization in the mixed layer (ML) because diatoms fractionate Si isotopes during production.

We used the δ^{30}Si of sinking BSi collected by sediment traps in the Antarctic, Polar Front and Sub-Antarctic Zones (AZ, PFZ and SAZ, respectively) to identify and quantify the seasonal evolution of Si fluxes and Si-isotopic balance in the ML in the Southern Ocean. Using this dataset, we estimate that the production of BSi consumed approximately 30% of the winter silicic acid stock supplied to the ML both in the AZ and PFZ, leaving 8.7 μmol.L^{-1} and 3.86 μmol.L^{-1}, respectively at the end of summer.

South of the subantarctic front and during the productive period, the system is better described by a Rayleigh model with a fractionation factor ($^{30}\varepsilon$) close to the expected -1.2‰. North of the front, the system follows a steady state model with a lower $^{30}\varepsilon$ (from -0.42 to -0.89 ‰). However, these two conceptual models can not satisfactorily describe the seasonal evolution of δ^{30}Si of exported BSi.

To better characterize the seasonality in systerm we implemented a box-model that simulates the Si isotopes in silicic acid and BSi (production and export) over the full year and takes into account seasonal variations in ML depth and the sinking velocities of particles. Model results suggest that fractionation during dissolution does not occur and agree well with the seasonal evolution of δ^{30}Si measured in the traps.