Spatial pattern of BSi-Dissolution-Index in the Southern Ocean

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1 Introduction

Biogenic silica (BSi) is a major component in marine geochemical cycles and a suitable proxy for paleoproductivity. The Southern Ocean plays a key role in the biogeochemical cycle of silicon. To understand opal preservation mechanisms and to assess the global biogenic silica cycle it is important to study the processes controlling BSi dissolution kinetics. Common techniques for the assessment of dissolution kinetics are flow-through and batch experiments. In this study, information on BSi dissolution kinetics will be considered in a regional context.

The combination of results from laboratory measurements and regional distribution of parameters affecting the benthic silica cycle can be used to decipher processes regulating the BSi burial. In addition a more detailed understanding of the dissolution of BSi in surface sediments within certain regions of the Southern Ocean is provided.

2 Material and Procedures

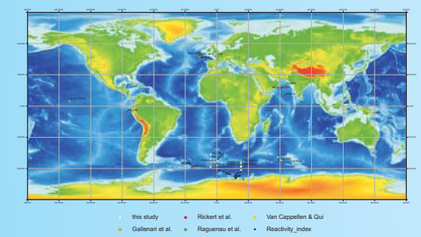


Fig. 1: Published and new sites for investigation of BSi dissolution in the Southern Ocean.

Wet Alkaline Extraction

Digital recorded data of leaching curves from wet alkaline extraction experiments after Müller & Schneider (1993), were run through a fitting procedure after Koning et al. (2002) to obtain BSi content and an estimate of the reactivity of biogenic silica in sediments.

Fig. 2: An autoanalyser system wet alkaline extraction line, for opal content measurement. Water bath, sample vessels and stirrer on the left. A flow through photometer on the right.

Wet-alkaline-extraction experiments were carried out on surface sediment samples to determine the distribution of biogenic silica content and to identify spatial patterns of a BSi-Dissolution-Index in the Southern Ocean.

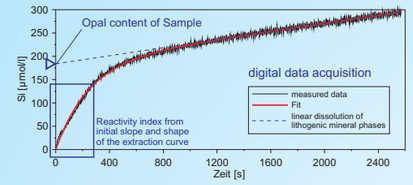


Fig. 3: Wet alkaline leaching curve with a fitted curve.

During RV Polarstern cruises ANT-XX/2, ANT-IX/4 and ANT-X/4 multicorer and minicorer samples were retrieved. The opal content of 65 selected surface samples (typically 0-0.5 cm depth) were determined and a reactivity index were obtained by a fitting procedure of the leaching curves.

$$Si_{eq} = [Si_{eqv}]_0 \cdot (1 - e^{-kt}) + bt$$

Equation 1: Model to fit leaching curves from Koning et al. (2002).

Flow Trough Experiments

To get detailed information on kinetics and solubility of biogenic silica, continuously stirred flow-through experiments were performed (Van Cappellen 1997, Rickert 2002).

Use of flow through reactors allows quantification of dissolution rates and saturation concentrations under well defined conditions. Dissolution rates of sediment samples in stirred flow-through reactors were measured as a function of the degree of undersaturation by varying the silica acid concentrations or the flow rate of the inflow solution.

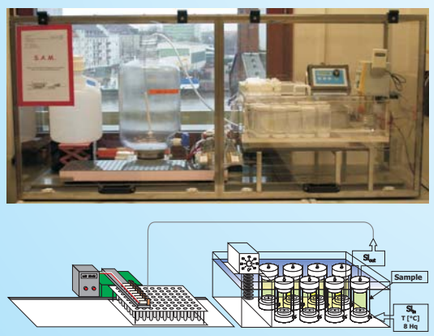


Fig. 4: Photo & schematic illustration of stirred continuous flow-through (CFT) reactor technique coupled with a time-controlled microvalve fraction collector. Inflow solution is added to the reactors with a peristaltic pump. Tygon tubing is used for interconnecting all parts of the system.

3 Results

Wet Alkaline Extraction

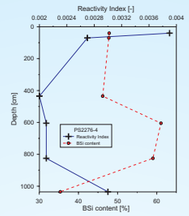


Fig.5: Downcore change of BSi reactivity and BSi content in the piston core PS2276-4 (Scotia Sea).

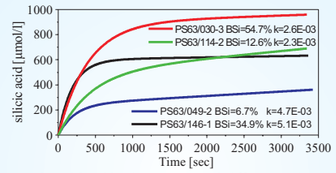


Fig. 6: Four selected fitted leaching curves, with different opal content and reactivety index.

Flow Trough Experiments

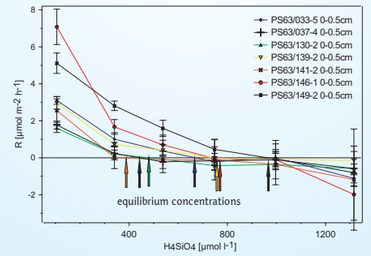


Fig. 7: Steady state dissolution rates as function of silicic acid concentrations show solubilities between 380 and 970 µmol.

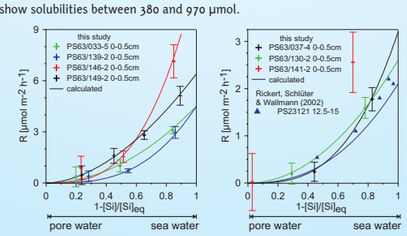
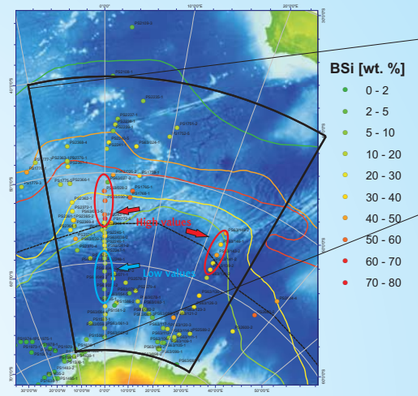


Fig. 8: Dependence of silica dissolution rate on the degree of undersaturation obtained by flow through experiments.

Biogenic silica in surface sediments [%]



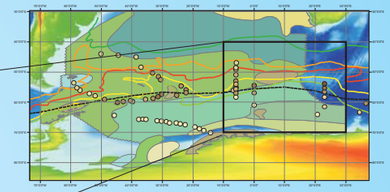
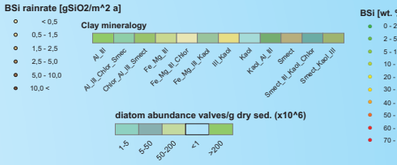


Fig. 11: Map of Clay provinces after Petschick et al. (1996) and preserved vertical opal rainrates after Geibert et al. (Subm.)



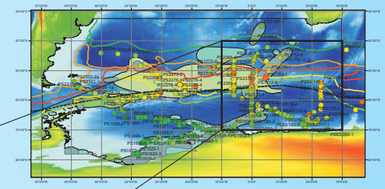


Fig. 11: Map of Bsi content and diatom abundance after Zielinski & Gersonde (1997)

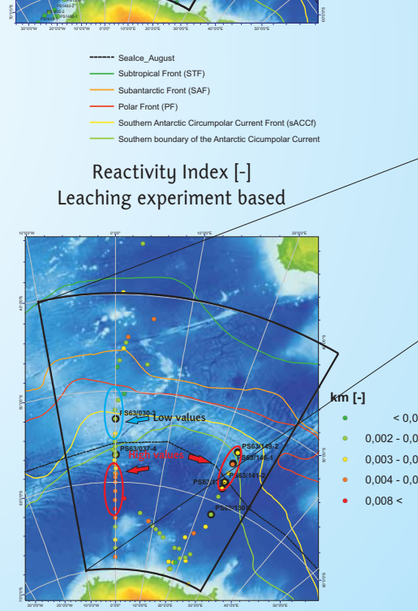


Fig. 9 & 10: Maps of BSi content and reactivity index in surface sediments in the eastern sector of South Atlantic values were obtained by leaching experiments and fitting the leaching curves. Reactivity values differ by a factor of three.

4 Conclusion

The flow through technique provide very precise results of dissolution kinetics, but it is time consuming. With the wet alkaline leaching technique it is possible to measure semi-quantitative differences in reactivity. This allows us to decipher regional patterns of BSi dissolution kinetics. In the investigated area the reactivity of BSi differs by a factor of three .

Equlibrium concentrations between 380 and 970 µmol/l were found in the eastern sector of the South Atlantic. These values are lower than Rickert (2002) measured in the Scotia Sea (762-1056 µmol/l), but generally higher than equlibrium concentrations from the North Atlantic (107 - 277 µmol/l, Rickert (2002), Gallinari (2002))

Areas with different solubilities and reactivities can be identified in the Southern Ocean. For example, preserved vertical BSi fluxes show that major BSi deposition occurs between the Polar Front and the winter sea ice boundary. BSi-dissolution kinetic studies generally indicate low reactivity in this area. It is characterized by strongest deposition of the diatom *Fragilariopsis kerguelensis* (>100 x 10 valves/g), the most prominent opal carrier in the modern HNLC areas of the Southern Ocean.

References:

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