Sensitivity of boron adsorption on clays to changes in seawater chemistry
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1. Licence

2. Citation

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3. Data Description

The adsorption of boron on detrital particles like clay or metal oxides is thought to be a major mechanism driving changes in the boron isotopic composition of seawater on geologic timescales. However, the sensitivity of adsorption parameters to long-term changes in the seawater concentration of major ions (Mg2+, Ca2+, SO42-) and dissolved inorganic carbon (HCO3-, CO32-) is not known. We conducted multiple sets of adsorption experiments that consist of suspending pretreated clay minerals (either kaolinite, smectite or illite) in artificial seawater with a modified chemical composition. Specifically, we investigate adsorption in seawater with a major ion composition resembling that of the Cretaceous (100 Ma) and the Eocene (50 Ma), as well as modern seawater with either reduced or elevated concentrations of dissolved inorganic carbon. We finally combine the results with modeled values for the mineral assemblage of detrital sediment to constrain boron adsorption fluxes in the past. The dataset consists of two sheets that store (1) the results of our adsorption experiments and (2) the modeled sediment properties.

3.1. Sampling method

Experiments were performed on KGa-1b kaolinite, SWy-3 smectite and IMt-2 illite obtained from the Clay Mineral Society. For each of these clays, a consistent particle size fraction of 2 – 0.2 µm was extracted by repeated centrifugation and decantation. As a result, clay samples used in the experiments have a high mineralogical purity of 95% (in the case of kaolinite and illite) and 50% (in the case of smectite).

Pretreated clays were submerged in one of four different boron-containing artificial seawater solutions. These seawater solutions were prepared by mixing trace element-grade salts with ultrapure water according to the recipe of Millero (2013). Specifically, the amounts of added MgCl2, CaCl2, Na2SO4 and NaHCO3 were varied to produce four different seawater stock solutions that have (i) a major ion concentration similar to Eocene seawater; (ii) a major ion concentration similar to Cretaceous seawater; (iii) a DIC concentration half as high as in modern seawater; (iv) a DIC concentration twice as high as in modern seawater. Clay and seawater were allowed to interact for 48h through continuous agitation, after which solution samples were extracted.

3.2. Analytical procedure:

Laboratory: HELGES – Helmholtz-Laboratory for the Geochemistry of the Earth Surface (GFZ) and Laboratory of the Bristol Isotope Group (BIG), School of Earth Sciences, University of Bristol

Boron concentration before and after adsorption on clay was measured on a single-quadrupole *iCAP* MC-ICP-MS that was calibrated with diluted samples of OSIL standard seawater.

Boron isotopic composition before and after adsorption was measured on a Neptune MC-ICP-MS using 951a (20 ppb) as a bracketing standard and ERM-AE121 (1 – 24 ppb) as a consistency standard.

3.3. Data processing

Adsorption parameters were calculated by comparing the boron content of the fluid before and after adsorption on clays. Specifically, partition coefficients (K_D) were calculated as the ratio between the mass of adsorbed boron and the mass of aqueous boron. Fractionation factors (α_B) were calculated as the ratio between $^{11}B/^{10}B$ of adsorbed boron and the $^{11}B/^{10}B$ of aqueous boron. Uncertainty envelopes were calculated through a Monte-Carlo routine that propagates the instrumental uncertainties of all relevant measurements.

4. File description

The dataset consists of a single excel file (.xlsx) with two sheets.

4.1. Description of the data table 2025-014_Ring-et-al_Data.xlsx

Column header	unit	Description
pH	dimensionless	NBS-scale aqueous pH
Chemistry	dimensionless	chemistry of the
$[B]_{dissolved}$ (µmol/kg)	µmol/kg	dissolved boron concentration following adsorption
±2σ (µmol/kg)	µmol/kg	propagated error
$\delta^{11}B_{dissolved}$ (‰)	‰ wrt. 951a	dissolved boron isotopic composition following adsorption
±2σ (‰)	‰ wrt. 951a	propagated error
K_D	dimensionless	Partition coefficient associated with adsorption
2σ lower CI	dimensionless	propagated error
2σ upper CI	dimensionless	propagated error
α_B	dimensionless	Isotope fractionation associated with adsorption on clay
2σ lower CI	dimensionless	propagated error
2σ upper CI	dimensionless	propagated error
Chemistry	n.a.	Type of seawater stock solution
Time (Ma)	Ma	Model time
Normalized sediment discharge	dimensionless	Sediment discharge at a given time, normalized to the modern sediment discharge
Fe oxide fraction (%)	weight %	Percentage of bulk sediment comprised by Fe oxides
Kaolinite fraction (%)	weight %	Percentage of bulk sediment comprised by kaolinite
Smectite fraction (%)	weight %	Percentage of bulk sediment comprised by smectite
Illite fraction (%)	weight %	Percentage of bulk sediment comprised by illite
Chlorite fraction (%)	weight %	Percentage of bulk sediment comprised by chlorite
Non-adsorbing mineral fraction	weight %	Percentage of bulk sediment comprised by all other minerals
Normalized adsorption capacity	dimensionless	Product of sediment discharge and the bulk sediment partition coefficient, normalized to the modern adsorption capacity
Bulk α_B	dimensionless	Isotope fractionation associated with adsorption on bulk sediment
$[B]_{sw}$ (µmol/kg)	µmol/kg	Modelled boron concentration of seawater
$\delta^{11}B_{sw}$ (‰)	‰	Modelled boron isotope composition of seawater

5. References

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