Barium isotope tracer experiment results from natural and synthetic barite–fluid laboratory equilibration experiments in artificial and filtered seawater

Website: https://www.bco-dmo.org/dataset/1004882
Data Type: experimental
Version: 1
Version Date: 2026-08-12

Project
» The Speed, Signature, and Significance of Barium Transformations in Seawater (The Three S's)

Contributors	Affiliation	Role
Horner, Tristan J.	Woods Hole Oceanographic Institution (WHOI)	Principal Investigator, Contact
Middleton, Julien	Woods Hole Oceanographic Institution (WHOI)	Student
Soenen, Karen	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
These data are from laboratory barite–fluid isotope-tracer experiments conducted with synthetic barite and natural pelagic barite in artificial seawater and filtered seawater. Experiments were performed as a four-condition matrix combining two fluid types and two barite types, and measured the temporal evolution of the 138Ba:136Ba ratio in filtered fluid samples over 174 days. Filtered seawater was collected from Vineyard Sound, Massachusetts, and the natural pelagic barite was isolated from Equatorial Pacific sediments. The dissolved pool in each experiment was amended with 136Ba-enriched solution, and aliquots of 2 milliliters were sampled through time and filtered through 0.22 micrometer polyethersulfone membrane filters prior to analysis. Tracer isotope ratios were measured on a quadrupole inductively coupled plasma mass spectrometer at the Woods Hole Oceanographic Institution Plasma Facility. These data were collected to assess barium ion exchange between barite and fluid under chemical equilibrium conditions and to compare exchange behavior in artificial and natural seawater and in synthetic and pelagic barite. The dataset is likely to be useful to researchers studying barite recrystallization and the preservation of sedimentary geochemical signals.

Table of Contents

Methods & Sampling

Laboratory barite–fluid isotope-tracer experiments were conducted in the NIRVANA Labs at the Woods Hole Oceanographic Institution. A four-condition matrix combined two fluid types, artificial seawater and filtered seawater from Vineyard Sound, Massachusetts, with two barite types, synthetic barium sulfate and natural pelagic barite isolated from Equatorial Pacific sediments. Artificial seawater was prepared following Smith & Chanley (1975) and adjusted to approximately pH 8.1 with concentrated potassium hydroxide. Filtered seawater was collected using the flow-through seawater system at the Environmental Systems Laboratory at the Woods Hole Oceanographic Institution (Huguenin, 1975), collected into 1 liter acid-washed high-density polyethylene bottles, and filtered through a 0.4 micrometer acid-washed polyethersulfone membrane in a clean room. Synthetic barite was Alfa Aesar barium sulfate powder, Lot 24177, and natural pelagic barite was isolated from Equatorial Pacific sediments. Known quantities of barite powder were added to each fluid and

kept under constant agitation for up to six months. In each experiment, the dissolved pool was amended with a 136Ba-enriched solution such that the initial fluid 138Ba:136Ba ratio was approximately 0.35 ± 0.03 (±2 standard error, n = 4). Barium-136 additions were adjusted to achieve an initial barite saturation state of 1.3, calculated using PHREEQC. Aliquots of 2 milliliters were sampled over 174 days and filtered through a 0.22 micrometer polyethersulfone membrane filter prior to analysis of the fluid 138Ba:136Ba ratio.

Data Processing Description

For tracer analyses, a 100 microliter aliquot was taken from each isotope-tracer subsample, diluted with 2 percent nitric acid, and spiked with indium as an internal standard to achieve a final indium concentration of 1 nanogram per milliliter. Samples were measured at a salinity of 1.75 to minimize non-spectral matrix effects. Filtered samples were analyzed for 138Ba:136Ba on a quadrupole inductively coupled plasma mass spectrometer.

Problem Description

A control experiment conducted under the same conditions as the isotope-tracer experiments, but without added barium sulfate, showed no significant adsorption of dissolved barium to bottle walls over 180 days. In experiment ASW1, initial net dissolution of barium sulfate increased the fluid 138Ba:136Ba ratio by 0.27, which is small relative to the final value of 6.34. The solid 138Ba:136Ba ratio was not monitored through time because the maximum possible change in the solid phase was estimated to be 0.04, which was the same magnitude as the analytical uncertainty.

[table of contents | back to top]

Related Publications

Huguenin, J. E. (1975). Development of a marine aquaculture research complex. Aquaculture, 5(2), 135–150. https://doi.org/10.1016/0044-8486(75)90094-0
Methods

Middleton, J. T., Paytan, A., Auro, M., Saito, M. A., & Horner, T. J. (2023). Barium isotope signatures of barite–fluid ion exchange in Equatorial Pacific sediments. Earth and Planetary Science Letters, 612, 118150. https://doi.org/10.1016/j.epsl.2023.118150
Results

Smith, W. L., & Chanley, M. H. (Eds.). (1975). Culture of Marine Invertebrate Animals. Springer US. https://doi.org/10.1007/978-1-4615-8714-9
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Horner, T. J., Middleton, J. (2026) **Barium isotope tracer experiment results from barite–fluid laboratory equilibration experiments.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-08-12 http://lod.bco-dmo.org/id/dataset/1004723 [view at BCO-DMO]
Relationship Description: Same experiment series

Horner, T. J., Middleton, J. (2026) **Mass-dependent barium isotope and dissolved barium concentration results from barite–fluid laboratory equilibration experiments.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-08-13 http://lod.bco-dmo.org/id/dataset/1005137 [view at BCO-DMO]

Relationship Description: Same experiment series

[table of contents | back to top]

Parameters

Parameter	Description	Units
experiment_id	Identifier for the isotope-tracer experiment.	unitless
fluid_type	Type of fluid used in the isotope-tracer experiment.	unitless
barite_type	Type of barite used in the isotope-tracer experiment.	unitless
fluid_mass_g	Mass of fluid in the experiment reactor at initiation.	g
barite_mass_mg	Mass of barite in the experiment reactor at initiation.	mg
initial_ba_nmol_l	Initial dissolved barium concentration in the fluid at experiment initiation.	nmol L-1
initial_ba_2se_nmol_l	Two standard error uncertainty of the initial dissolved barium concentration.	nmol L-1
l_barite_initial	Initial fraction of total barium in the barite-fluid system that was held in barite.	unitless
initial_ba138_ba136_ratio_fluid	Initial 138Ba:136Ba ratio of the fluid at experiment initiation.	unitless
time_hr	Elapsed time since experiment initiation.	hr
ba138_ba136_ratio	Measured 138Ba:136Ba ratio in the filtered fluid sample.	unitless
ba138_ba136_2se	Two standard error uncertainty of the measured 138Ba:136Ba ratio in the filtered fluid sample.	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Thermo Fisher Scientific iCAP Q quadrupole ICP-MS
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Dataset-specific Description	Thermo Fisher Scientific iCAP Q quadrupole inductively coupled plasma mass spectrometer, operated in kinetic energy discrimination mode at the Woods Hole Oceanographic Institution Plasma Facility. This instrument was used for 138Ba:136Ba measurements in filtered fluid samples from the isotope-tracer experiments.
Generic Instrument Description	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

Dataset-specific Instrument Name	New Brunswick Scientific Innova 2100 orbital shaker table
Generic Instrument Name	Shaker
Dataset-specific Description	New Brunswick Scientific Innova 2100 orbital shaker table, used for continuous agitation of reactors.
Generic Instrument Description	A Shaker is a piece of lab equipment used to mix, blend, or to agitate substances in tube(s) or flask(s) by shaking them, which is mainly used in the fields of chemistry and biology. A shaker contains an oscillating board which is used to place the flasks, beakers, test tubes, etc.

[table of contents | back to top]

Project Information

The Speed, Signature, and Significance of Barium Transformations in Seawater (The Three S's)

Coverage: Eastern Tropical Pacific, Subtropical South Pacific, Sub-Antarctic Pacific, and Southern Oceans

NSF Award Abstract:
The biological cycling of carbon in the oceans entrains many other elements, some directly (like nutrients that are essential for life) and some indirectly, as they become chemically involved in the processes that are affecting carbon. One such element is barium (Ba). Particles of the mineral barite (barium sulfate) have been found to form in association with microbial consumption of organic material in the ocean’s “twilight zone.” These particles settle to the ocean floor, and their presence in sediments has been used to infer changes in the conditions in the ocean back in time. Both the amount of barite in sediments and the isotope composition of Ba in barite are potentially sensitive to processes occurring in the twilight zone. However, several long-standing questions remain about Ba cycling in the oceans, which complicates the interpretation of barium-based proxy records. Examples of remaining questions include how much barium enters the oceans at mid-ocean ridge hydrothermal sites, and what controls the precipitation and dissolution of barite in the water column. This project seeks to tackle these questions using new approaches, on three scheduled research expeditions in the Pacific and Southern Oceans. In doing so, this project will support the education, training, and career development of a graduate student, postdoctoral researcher, and junior investigator. Undergraduate students from underrepresented groups will be recruited to conduct complementary shore-based experiments.

This proposal seeks to answer four questions central to the utility of barium-based proxies in oceanography: What are the major inputs of new Ba to the ocean? What are their isotopic compositions? What controls the amount of pelagic barite precipitated during the remineralization of organic matter? What influences its isotopic

composition? These questions will be addressed using a field-centric approach combining: in situ and shipboard tracer-incubation experiments, AUV-led adaptive sampling of Ba cycling ‘hotpots’, and section-based surveying of the surrounding oceanographic features. This multi-pronged approach will be used to investigate: the flux and isotopic composition of Ba released from the largest hydrothermal fields in the ocean, the Southern East Pacific Rise, with a focus on low-temperature venting; rates and signatures of pelagic barite precipitation associated with different phytoplankton assemblages in the Southern Ocean; and, the importance of environmental conditions, such as low ambient oxygen concentrations, in setting the efficiency of barite precipitation in the Eastern Tropical Pacific. The significance of each transformation will be assessed, which may lead to ruling out the importance of certain processes, or identifying new dependencies that could form the basis of new proxies.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023456

[table of contents | back to top]