Boron isotopes and trace elements experimental data of tropical corals

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Project
» A combined boron isotope, pH microelectrode and pH-sensitive dye approach to constraining acid/base chemistry in the calcifying fluids of corals (CoralCalcifyFluid_pH)

Contributors	Affiliation	Role
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Dataset Description

Boron isotopes and trace element data (Li/Ca, B/Ca, Mg/Ca, Sr/Ca) for corals Pocillopora damicornis and Stylophora pistillata cultured under scenarios of ocean acidification and warming temperature. Calculated internal parameters of the calcifying medium (pHcf, [CO32-]cf, DICcf) are also presented.

Methods & Sampling

Boron isotopes were measured at the University of Cambridge (Cambridge, UK) utilizing an MC-ICP-MS Neptune+ equipped with 10^13 ohm amplifiers technology (Lloyd et al., 2018). Boron purification was realized by microdistillation (Wang et al., 2010, Misra et al., 2014b). Uncertainties (2sd) are calculated based on replicates of standard AE121 δ11B measurements for an analytical session.

Trace elements were measured on an Element XR at the IUEM (Plouzané, France), method is detailed in Guillermic et al., in prep (Biogeosciences). Uncertainties (2sd) are calculated based on replicates of an in-house standard CamWuellestorfi (Misra et al.,2014a) for an analytical session.

Data Processing Description

pHcf, DICcf and [CO32-]cf were calculated based on δ11B and B/Ca data utilizing the Matlab© code provided by DeCarlo et al., (2018), adapted for various δ11Bsw and using a KD of McCulloch et al., 2017.

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date

- modified parameter names to conform with BCO-DMO naming conventions
- replaced spaces with undrscores in species names.

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Related Publications

DeCarlo, T. M., Holcomb, M., & McCulloch, M. T. (2018). Reviews and syntheses: Revisiting the boron systematics of aragonite and their application to coral calcification. Biogeosciences, 15(9), 2819–2834. doi:10.5194/bg-15-2819-2018
Methods

Lloyd, N. S., Sadekov, A. Y., & Misra, S. (2017). Application of 1013 ohm Faraday cup current amplifiers for boron isotopic analyses by solution mode and laser ablation multicollector inductively coupled plasma mass spectrometry. Rapid Communications in Mass Spectrometry, 32(1), 9–18. doi:10.1002/rcm.8009
Methods

McCulloch, M. T., D'Olivo, J. P., Falter, J., Holcomb, M., & Trotter, J. A. (2017). Coral calcification in a changing World and the interactive dynamics of pH and DIC upregulation. Nature Communications, 8, 15686. doi:10.1038/ncomms15686
Methods

Misra, S., Greaves, M., Owen, R., Kerr, J., Elmore, A. C., & Elderfield, H. (2014). Determination of B/Ca of natural carbonates by HR-ICP-MS. Geochemistry, Geophysics, Geosystems, 15(4), 1617–1628. doi:10.1002/2013gc005049 https://doi.org/10.1002/2013GC005049
Methods

Misra, S., Owen, R., Kerr, J., Greaves, M., & Elderfield, H. (2014). Determination of δ11B by HR-ICP-MS from mass limited samples: Application to natural carbonates and water samples. Geochimica et Cosmochimica Acta, 140, 531–552. doi:10.1016/j.gca.2014.05.047
Methods

Wang, B.-S., You, C.-F., Huang, K.-F., Wu, S.-F., Aggarwal, S. K., Chung, C.-H., & Lin, P.-Y. (2010). Direct separation of boron from Na- and Ca-rich matrices by sublimation for stable isotope measurement by MC-ICP-MS. Talanta, 82(4), 1378–1384. doi:10.1016/j.talanta.2010.07.010
Methods

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Parameters

Parameter	Description	Units
species	Species	unitless
pco2sw	pCO2sw	parts per million (ppm)
T	temperature	degrees Celsius (C)
pHsw	pHsw on total scale	total scale
Tank	Tank	unitless

delta_11B1	11B1	parts per thousand
delta_11B1_2sd	11B1 2 standard deviations	parts per thousand
delta_11B2	11B2	parts per thousand
delta_11B2_2sd	11B2 2 standard deviations	parts per thousand
delta_11B_avg	11Baverage	parts per thousand
delta_11B_avg_2sd	11Baverage 2 standard deviations	parts per thousand
Li_Ca	Li/Ca	micromole per mole (umol/mol)
Li_Ca_2sd	Li/Ca 2 standard deviations	micromole per mole (umol/mol)
B_Ca	B/Ca	micromole per mole (umol/mol)
B_Ca_2sd	B/Ca 2 standard deviations	micromole per mole (umol/mol)
Mg_Ca	Mg/Ca	millimole per mole (mmol/mol)
Mg_Ca_2sd	Mg/Ca 2 standard deviations	millimole per mole (mmol/mol)
Sr_Ca	Sr/Ca	millimole per mole (mmol/mol)
Sr_Ca_2sd	Sr/Ca 2 standard deviations	millimole per mole (mmol/mol)
pHcf	pHcf	total scale
CO3_2_cf	[CO32-]cf	micromole per kilogram (umol/kg)
CO3_2_cf_2sd	[CO32-]cf 2 standard deviations	micromole per kilogram (umol/kg)
DIC_cf	Dissolved Organic Carbon	micromole per kilogram (umol/kg)
DIC_cf_2sd	Dissolved Organic Carbon	micromole per kilogram (umol/kg)

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Instruments

Dataset-specific Instrument Name	MC-ICP-MS Neptune+
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Boron isotopes were measured at the University of Cambridge (Cambridge, UK) utilizing an MC-ICP-MS Neptune+ equipped with 10^13 ohm amplifiers technology (Lloyd et al., 2018).
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	Element XR
Generic Instrument Name	Mass Spectrometer
Dataset-specific Description	Trace elements were measured on an Element XR at the IUEM (Plouzané, France), method is detailed in Guillermic et al., in prep (Biogeosciences).
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

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Project Information

A combined boron isotope, pH microelectrode and pH-sensitive dye approach to constraining acid/base chemistry in the calcifying fluids of corals (CoralCalcifyFluid_pH)

Website: http://nuweb2.neu.edu/rieslab/

Coverage: Marine Science Center, Northeastern University

Description from NSF award abstract:
The anthropogenic elevation of atmospheric CO2 is causing the oceans to become more acidic, which may make it more challenging for corals to build their skeletons and, ultimately, entire reef structures. How corals respond to future ocean acidification will largely depend on how the pH of the internal fluid from which they produce their skeletons-their so-called calcifying fluid-is impacted by the surrounding seawater. It is therefore essential that current methods are refined to accurately measure the pH of corals' calcifying fluids in order to understand and, ideally, predict their responses to CO2-induced ocean acidification. In this project, a three-pronged approach to measure calcifying fluid pH within three species of reef-forming corals will be used to assess how their calcifying fluid pH responds to experimentally induced ocean acidification. This research will improve our understanding of corals' responses to ocean acidification and thus has the potential to inform the decisions of policy makers and legislators seeking to mitigate the deleterious effects of rising atmospheric CO2 on marine ecosystems. The work will support the development of three early career scientists, a postdoctoral

fellow, graduate students, and undergraduate researcher assistants-several of whom are from underrepresented groups in the earth and ocean sciences. Results will be widely disseminated through publications, conference presentations, the PIs' websites, an educational film, coursework, and outreach activities at area schools, museums, and science centers.

Corals and other types of marine calcifiers are thought to begin the mineralization of their calcium carbonate skeletons by actively elevating pH of their calcifying fluid, thereby converting bicarbonate ions (comprising ~90% of seawater dissolved inorganic carbon) to carbonate ions, the form of carbon used in calcification. This project will compare the combined boron isotope, pH microelectrode, and pH-sensitive dye approach to measure the calcifying fluid pH of three species of scleractinian corals, and to assess how their calcifying fluid pH (a primary factor controlling their calcification) responds to experimentally induced ocean acidification. As a result this multi-pronged approach to measuring calcifying fluid pH of the same coral species under equivalent culturing conditions will permit the first systematic cross-examination of the validity of these independent approaches. The combined approach will also yield values of calcifying fluid pH with uncertainties that can be quantified via inter-comparison and statistical treatment of these independent measurements. Importantly, this multi-pronged approach will be used on three coral species that due to differences in the carbonate chemistry of their native waters possess differing capacities for proton regulation at their site of calcification; a deep, cold-water coral (strong proton-pumper); a shallow, temperate coral (moderate proton-pumper); and a shallow, tropical coral (weak proton-pumper). Target outcomes of this research include (1) cross-examination of the validity of three independent approaches to estimating coral calcifying fluid pH, (2) quantification of uncertainty associated with the three approaches to estimating coral calcifying fluid pH, (3) advancement of our mechanistic understanding of coral calcification, (4) exploration of the mechanism by which ocean acidification impacts coral calcification, (5) elucidation why corals exhibit such varied responses to ocean acidification, (6) identification of coral types most vulnerable to ocean acidification, (7) exploration of so-called "vital effects" that limit the use of corals in paleoceanographic reconstructions, and (8) quantitative constraint of existing models of coral biomineralization.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1437371
NSF Division of Ocean Sciences (NSF OCE)	OCE-1437166

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