

Michael J. Henehan, Ph.D.

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Education

PhD, Geochemistry and Palaeoclimate, University of Southampton 2009 - 2013

Title: "Ground-truthing the boron-based proxies". *Project Supervisors:* Prof. Gavin L. Foster, Prof. Paul A. Wilson, Prof. Jonathan Erez. *Examiners:* Prof. James C. Zachos and Prof. Martin R. Palmer.

M/Sci, Palaeontology and Evolution, University of Bristol 2005-2009

First Class Honours. *Tutor:* Prof. Michael J. Benton.

Research Interests

- The development and application of palaeoclimate proxies (geochemical and micropalaeontological), with a view to better understanding past climate, weathering and carbon-cycle perturbations.
- Understanding biogeochemical and geochemical cycles and feedbacks on Earth's climate.
- The biology, physiology and evolution of foraminifera and other marine calcifiers.

Grants and Awards

BIOS Grant-in-aid

2016

Project title: "Constraining the physiological influences on lithium isotope ratios in Foraminifera"

Awarded a \$6,350 seed grant to take 2 Yale researchers to BIOS, Bermuda for 3 weeks. We set up foraminiferal culturing facilities for future proposals, cultured planktic foraminifera for Li isotope and trace metal geochemistry, and forged lasting collaborative relations with PIs such as Amy Maas at BIOS. *[Co-I: Michael Henehan, Co-Is: Pincelli Hull, Janet Burke, Leanne Elder]*

EU FP7 Assemble Marine Science Grant

2013

Project title: "Investigating controls on boron incorporation and boron isotope fractionation in planktic foraminifera, and the origin of vital effects"

Awarded funding to take 4 University of Southampton researchers to the Interuniversity Institute of Eilat, Israel, for 3 weeks. Led culturing of planktic foraminifera to test the environmental controls on $\delta^{11}\text{B}$ and B/Ca ratios in foraminiferal shells.

[Project Leader and Author: Michael Henehan, PI: Gavin Foster]

2011: Awarded **UK-IODP Student Bursary (€1,000)** to attend the ECORD Urbino Summer School in Palaeoclimatology.

2008: Awarded a **Nuffield Foundation Student Research Bursary (£1,400)** bursary for a summer research project in palaeoceanography at the University of Bristol using IODP sediment core material.

2007: Awarded a **BMSS-funded studentship** to undertake carbon and oxygen isotope analysis of soil and biological samples via GC-IRMS at IGER (now [North Wyke Research](#)).

Research Publications

Zhang, Shuang, **Henehan, Michael J.**, Hull, Pincelli M., Reid, R. Pamela, Hardisty, Dalton S., Hood, Ashleigh and Planavsky, Noah J. (in press) *On the reliability of ocean pH estimates derived from boron isotopes in shallow marine inorganic carbonates*. Earth and Planetary Science Letters.

Henehan, Michael J., Foster, Gavin L., Bostock, Helen C., Greenop, Rosanna, Marshall, Brittney J., and Wilson, Paul A. **2016.** *A new boron isotope-pH calibration for *Orbulina universa*, with implications for understanding and accounting for 'vital effects'*. Earth and Planetary Science Letters, 454, 282-292.

Wang, Xiangli, Planavsky, Noah J., Hull, Pincelli M., Tripathi, Aradhna, Zou, Huijuan, Elder, Leanne and **Henehan, Michael J.** **2016.** *Assessing the utility of foraminifera as an archive of seawater $\delta^{53}\text{Cr}$* . Geobiology, 10.1111/gbi.12198.

Henehan, Michael J., Hull, Pincelli M., Penman, Donald E., Rae, James W. B and Schmidt, Daniela N. **2016.** *Biogeochemical Significance of Pelagic Ecosystem Function: An end-Cretaceous Case Study*. Philosophical Transactions of the Royal Society B, 371: 20150510.

Evans, David, Wade, Bridget S., **Henehan, Michael J.**, Erez, Jonathan and Müller, Wolfgang. **2016.** *Revisiting carbonate chemistry*

controls on planktic foraminifera Mg/Ca: Implications for sea surface temperature and hydrology shifts over the Paleocene-Eocene Thermal Maximum and Eocene-Oligocene Transition. *Climate of the Past*, 12, 819-835.

Martínez-Botí, Miguel. -A., Marino, Gianluca, Foster, Gavin L., Ziveri, Patrizia, **Henehan, Michael J.**, Mortyn, P. Graham, and Vance, Derek, **2015**. *The role of the ocean in deglacial atmospheric CO₂ rise*. *Nature*, 518 (7538) 219-222.

Henehan, Michael J., Foster, Gavin L., Rae, James W.B., Bostock, Helen C., Marshall, Brittney J., Erez, Jonathan, Kucera, Michal, and Wilson, Paul A., **2015** *Evaluating the utility of B/Ca ratios in planktic foraminifera as a proxy for the carbonate system: A case study of Globigerinoides ruber*. *Geochemistry, Geophysics, Geosystems* 16 (4), 1052-1069.

Marshall, Brittney J., Thunell, Robert C., Spero, Howard J. **Henehan, Michael J.** and Astor, Yrene. **2015**. *Morphometric and stable isotopic differentiation in Orbulina universa morphotypes from the Cariaco Basin, Venezuela*. *Marine Micropalaeontology* 120, 46-64.

Henehan, Michael J., Rae, James W.B., Foster, Gavin L., Erez, Jonathan, Prentice, Katherine C., Kucera, Michal, Bostock, Helen C., Martínez-Botí, Miguel A., Milton, J. Andy, Wilson, Paul A., Marshall, Brittney J. and Elliott, Tim. **2013**. *Calibration of the boron isotope proxy in the planktonic foraminifera Globigerinoides ruber for use in palaeo-CO₂ reconstruction*. *Earth and Planetary Science Letters*, 364, 111-122.

Marshall, Brittney J., Thunell, Robert C., **Henehan, Michael J.**, Astor, Yrene and Wejnert, Katherine E. **2013**. *Planktonic foraminiferal area density as a proxy for carbonate ion concentration: A calibration study using the Cariaco Basin Ocean Time Series*. *Paleoceanography*, 28 (2), 363-376.

Selected Publications in Review/Preparation

Henehan, Michael J., Evans, David, Shankle, Madison, Burke, Janet, Foster, Gavin L., Durrant, Joseph, Anagnostou, Eleni, Chalk, Thomas B., Stewart, Joseph A., Alt, Claudia H. S., Erez, Jonathan and Hull, Pincelli M. (in discussion) *Size-dependent response of foraminifera calcification to seawater carbonate chemistry*. *Biogeosciences*.

Pearce, Christopher R., Edgar, Kirsty M., **Henehan, Michael J.**, Li, Gaojun and Foster, Gavin L. *Enhanced basalt weathering response to elevated global temperatures during the middle Eocene*. (submitted, *Science*, November 2016)

Henehan, Michael J., Edgar, Kirsty M. (joint first authors), Foster, Gavin L., Bohaty, Steve M., Anagnostou, E. and Pearson, Paul N. (in. prep.) *Solving the Middle Eocene Carbon Cycle Conundrum*. (intended submission to *Nature Geoscience*, Winter 2016)

Henehan, Michael J., Klein-Gebbinck, Christa, Foster, Gavin L., Clymans, Jill, and Kim, Sang-Tae (in prep). *pH-dependence of boron isotope and trace element composition in inorganically precipitated carbonates*. (intended submission to *Geochimica et Cosmochimica Acta*, Winter 2016)

Recent Conference Abstracts

Henehan, M. J., Zhang, S, Planavsky, N. J., Thomas, E., Huber, B. T. and Hull, P. M. **2016**. *How strange was the Strangelove Ocean?* International Conference on Palaeoceanography, Utrecht (poster).

Henehan, M. J., Hull, P. M., Planavsky, N. J., Thomas, E., and Özen, V. **2015**. *Between a Rock and a Hard Place: The History of Palaeocene Ocean pH*. Goldschmidt, Prague (talk).

Henehan, M. J., Klein-Gebbinck, C., Foster, G. L., Clymans, J., and Kim, S.-T. **2015**. *Spreading the good news: corroborating the inorganic basis of the boron isotope-pH proxy*. Boron Geochemistry Meeting, Goldschmidt, Prague (talk).

Pearce, C., Foster, G. L., Sexton, P., **Henehan, M. J.**, Edgar, K. M. and Parkinson, I. **2015**. *Searching for Silicate Weathering Feedback in the Geological Record*. Goldschmidt, Prague (talk).

Henehan, M. J., Hull, P. M., Planavsky, N. J., Huber, B. and Thomas, E. **2014**. *Investigating Carbonate System Perturbations across the Cretaceous-Palaeogene Transition using Boron Isotopes in Planktonic Foraminifera*. AGU Fall Meeting, San Francisco, Abstract PP51B-1122 (poster, session convenor).

Mikenas, M., Hull, P. M., and **Henehan, M. J.** **2014**. *Morphological Analysis of Cretaceous-Paleogene Boundary Foraminiferal Taxa*. AGU Fall Meeting, San Francisco, Abstract PP51B-1131 (poster).

Henehan, M. J., Edgar, K. M., Foster, G. L., and Hull, P. M. **2014**. *Using boron isotopes to characterise past carbon cycle perturbations: the case of the MECO*. Climatic and Biotic Events of the Palaeogene, Pesarra (talk).

Guest Speaker: BIOS, Lamont-Doherty Earth Observatory, Yale University, University of Tübingen, NIWA, Cardiff University, University of Oviedo, University of Birmingham, University of Southampton and the Interuniversity Institute of Eilat.

Research Experience

Post-Doctoral Research Associate, Yale University

April 2014-Present (PI: Dr. Pincelli Hull)

Currently in my third year of a post-doc at Yale, investigating carbon cycle perturbations around the Cretaceous-Palaeogene boundary. I have successfully set up the infrastructure, procedures and protocols required to generate boron isotope data via MC-ICPMS at Yale, and started producing records of $\delta^{11}\text{B}$ in fossil planktic foraminifera. A low-resolution Palaeocene pCO_2 record is almost complete, and was the subject of one of my two presentations at last year's Goldschmidt Conference in Prague (the other on validating the inorganic basis of the boron isotope proxy). Prior to this project's conclusion, we will extend our initial analyses in the latest Maastrichtian. These investigations extend our record of atmospheric CO_2 levels (as derived from boron isotopes) into the Mesozoic, and will be a crucial resource in understanding late Cretaceous climate, recovery from the Chicxulub impact, and the drivers of long-term warming in the Palaeocene, as the Earth entered a greenhouse climate. Data from this project are yielding new insights into 'vital effects' in extinct foraminiferal species, and their importance in interpreting records of $\delta^{11}\text{B}$.

Post-Doctoral Research Associate, University of Southampton

August 2013 - February 2014 (PI: Dr. Gavin Foster)

Undertook a 6-month post-doc as part of the 'Abrupt Ocean Acidification Events' project (under the NERC/DECC/DEFRA Ocean Acidification programme), working with Prof. Gavin Foster (University of Southampton, CO-I), Dr. Kirsty Edgar (Birmingham University), and Professor Paul Pearson (Cardiff University, PI). During this time, I led a foraminiferal culturing expedition to Eilat, Israel under the EU FP7 ASSEMBLE program, and generated boron isotope and trace elements proxy records (generated via MC-ICPMS and ICPMS) over the enigmatic MECO (Middle-Eocene Climatic Optimum) event, to elucidate the role of atmospheric pCO_2 in driving this event and the strength of earth system feedbacks in prompting recovery. This work, in the later stages of preparation having incorporated carbon cycle modelling at Yale, provides a new record of atmospheric CO_2 levels and ocean temperature during the MECO, incorporating robust quantification of uncertainty. In tandem, we have submitted a new high-precision Sr record across the same interval detailing weathering changes at this time.

Community Contributions

- Reviewer for *Science*, *Geology*, *Nature Scientific Reports*, *Chemical Geology*, *Geophysical Research Letters*, *Marine Micropalaeontology*, *Earth and Planetary Science Letters*, *Mass Spectrometry Reviews*, *Palaeo*³, *Geochimica et Cosmochimica Acta*.
- Co-convened a session at AGU in 2014 titled *Global Climate Events and Ocean Chemistry of the Palaeogene and K-Pg Transition*.

Professional/Academic Development

Courses attended:

- 2016 *PALEOGENiE / ECOGEM modelling summer school* (University of Bristol)
- 2013 *Storytelling in Science* (University of Southampton).
- 2012 *Communicating Climate Change* (Union of Concerned Scientists, San Francisco).
- 2012 *NERC Life and the Planet Spring School* (NERC, Southampton).
- 2012 *Nuts and Bolts of Mass Spectrometry Short Course* (EAG, Bristol University).
- 2011 *ECORD Urbino Summer School in Palaeoclimatology* (ECORD/NSF, University of Urbino).
- 2011 *Media Handling Skills* (University of Southampton).
- 2010 *Postgraduate Introduction to Learning and Teaching* (University of Southampton).
- 2010 *Skills for Postgraduate Researchers* (University of Southampton).

Professional Affiliations:

European Association of Geochemists, American Geophysical Union, The Micropalaeontological Society, The Cushman Foundation.

Teaching and Outreach

Yale University

2014- present

Lectured on Greenhouse and Icehouse Climates, and their relevance to macroevolutionary history, as part of the undergraduate 'History of Life' course, and lectured on the boron isotope proxy as part of the mixed undergraduate and graduate level 'Paleoenvironments' course. I also co-taught in the graduate level course 'Advanced Critiques of Paleooceanographic Methodologies'.

Bestival Science Tent and Bestiversity

2011-2013

At Bestival Music Festival (Isle of Wight, UK) I lectured to festival-goers on the science behind climate change, co-ordinated and staffed the National Oceanography Centre's interactive exhibits in the Science tent. The science tent continues to exhibit at this and other festivals in the UK, including Glastonbury Music Festival and the Cheltenham Science Festival.

Teaching Assistant, University of Southampton

2010-2012

Geochemistry (Level 2), Maths (Level 1), Palaeobiology, including 2 field trips (Level 2).

IUI Eilat

2010

Taught Planktic Foraminifera as a guest lecturer, as part of their *Plankton Ecology* course.

Outreach: Delivered many talks to diverse public audiences on climate science, including: *Lauralton Hall Girl's School* (Milford CT, US), *The Science Café* (Southampton, UK), the *Marine Life* public lecture series (Southampton, UK), *Headford Environment Group* (Galway, Ireland), the *Eco-Schools Initiative* (Southampton, UK), a *Curriculum-building workshop for Teachers* (Yale, USA) and the *Countryside Education Trust* (Beaulieu, UK). I am also a registered participant in the Climate Voices initiative (climatevoices.org), and contributor to the Climate Feedback organisation, that fact-checks climate science in the media (climatefeedback.org).

Student Mentoring

At Yale, I co-supervised four independent research projects involving undergraduates and graduate students: investigating controls on foraminiferal shell weight (*Madison Shankle*, culminating in a manuscript submitted to *Biogeosciences*), foraminiferal diversity and disparity in the run up to the Cretaceous-Palaeogene Boundary (*Megan Mikenas*, culminating in a poster at last year's AGU), and applying paired Li and B isotope measurements in foraminifera (*Rain Tsong*, manuscript in prep.). Supervising graduate student Shuang Zhang at Yale in applying boron isotopes to natural precipitates of inorganic CaCO₃ and to foraminifera over the MECO, with a manuscript currently in press in *EPSL*. At the University of Southampton, I supervised a Masters student (*Joe Durrant*) on a project investigating the drivers of foraminiferal shell weight, whose work has also fed into a manuscript submitted to *Biogeosciences*.

Other Research Skills

- Experienced operator of ICPMS machines, including quadropole, sector field and multicollector ICPMS.
- Skilled geochemical clean lab operator and co-ordinator, incl. trace element cleaning and ion exchange column chemistry.
- Skilled in culturing marine organisms (foraminifera) under controlled laboratory conditions.
- Expertise in statistical methods, including uncertainty propagation and multivariate analysis (using R and Matlab).
- Experienced user of scanning electron and compound-focus light microscopes and image analysis software.
- Taxonomic expertise in identification of a range of planktic and benthic foraminifera from the Cretaceous to the present.
- Experience in undertaking shipboard research, using MOCNESS plankton sampling nets and piston coring apparatus.
- Expertise in aqueous carbonate chemistry and the use of MyAMI, PHREEQC, CO2sys, CO2calc, and Seacarb.

Further references available on request