

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN AUSTRALIA

June 1st, 2015 to April 30th, 2016

New scientific results

New research by PhD student Holly Winton investigating sources of soluble atmospheric iron in the Australian sector of the Southern Hemisphere has shown that variance in the observed fractional iron solubility is due to a combination of different soluble iron sources including mineral dust and biomass burning emissions. The research investigated differences in atmospheric iron solubility over tropical northern Australia, the Southern Ocean and in Antarctic snowfall. These locations were used to investigate iron in aerosols transported over continental and marine areas at different spatial scales relative to sources. The results of the study suggest that aerosol iron derived from mineral dust is relatively insoluble regardless of atmospheric transport time. However, the interaction of mineral dust with biomass burning emission plumes may increase fractional iron solubility episodically. This indicates that fire emissions are not a major source of soluble iron, but that they may indirectly enhance the solubility of iron derived from mineral dust. An inverse hyperbolic relationship was observed between total iron concentration and fractional iron solubility at all the study areas, including tropical continental, marine and remote polar locations. Differences in this relationship were observed with respect to the constant fractional iron solubility at high total iron concentrations. Contrary to expectations, higher constant fractional iron solubility was found in northern tropical Australia and may be due to the presence of higher concentrations of organic acids emitted by biomass burning.

During the HEOBI voyage on *RV Investigator* in early 2016 (see below), micronutrient trace elements including dissolved iron concentrations were measured at sea in the water column on and around the Kerguelen plateau, specifically focussing on nearshore waters close to the volcanic Heard and McDonald Islands, waters that have not been sampled previously for these oceanographic parameters. Along two broadly east-west transects of the northern plateau, dissolved iron was largely depleted (<0.2 nmol/L) in surface waters, with enrichment near the seafloor from sediments, consistent with the results from the KEOPS voyages. Conversely, in the shallow (100-200 m deep) waters near Heard and McDonald Islands, dissolved iron was elevated (up to 3.0 nmol/L) throughout the well-mixed water column. Interestingly, iron(II) was also elevated close to the McDonald Islands, in the vicinity of acoustic plume signals (indicative of bubbles rising from the seafloor and potentially associated with hydrothermalism), accounting for up to 30% of the dissolved iron concentration. This feature was not as evident in the samples collected near acoustic plumes close to Heard Island. Studies are continuing in 2016 to trace the source of the iron, in both reduced, dissolved and particulate forms.

New publications (published or in press)

- Boyd, P.W., R. F. Strzepek, M. J. Ellwood, D. A. Hutchins, S. D. Nodder, B. S. Twining, S. W. Wilhelm (2015) Why are biotic iron pools uniform across high- and low-iron pelagic ecosystems? *Global Biogeochemical Cycles*, 10.1002/2014GB005014
- Hanington, P., Rose, A., & Johnstone, R. (2016). The potential of benthic iron and phosphorus fluxes to support the growth of a bloom forming toxic cyanobacterium *Lyngbya majuscula*, Moreton Bay, Australia. *Marine and Freshwater Research*.

- Lannuzel, D., Grotti, M., Abelloschi, M. L., & Van Der Merwe, P. (2015). Organic ligands control the concentrations of dissolved iron in Antarctic sea ice. *Marine Chemistry*, 174, 120-130.
- Lieser, J. L., Curran, M. A. J., Bowie, A. R., Davidson, A. T., Doust, S. J., Fraser, A. D., Galton-Fenzi, B. K., Massom, R. A., Meiners, K. M., Melbourne-Thomas, J., Reid, P. A., Strutton, P. G., Vance, T. R., Vancoppenolle, M., Westwood, K. J., and Wright, S. W.: Antarctic slush-ice algal accumulation not quantified through conventional satellite imagery: Beware the ice of March, *The Cryosphere Discuss.*, 9, 6187-6222, doi:10.5194/tcd-9-6187-2015, 2015.
- Rajah L., Nicol S., Meinder K., Lannuzel D., Bowie A.R., 2016. A preliminary model of iron fertilization by whales in the Southern Ocean: parameter sensitivity of primary production estimates. *Ecological Modelling* 320 (2016) 203–212, doi:10.1016/j.ecolmodel.2015.10.007.
- Samanta, M., M. J. Ellwood, and G. E. Mortimer (2016), A method for determining the isotopic composition of dissolved zinc in seawater by MC-ICP-MS with a ⁶⁷Zn–⁶⁸Zn double spike, *Microchemical Journal*, 126, 530-537, doi:http://dx.doi.org/10.1016/j.microc.2016.01.014.
- Schneider, L., Maher, W. A., Floyd, J., Potts, J., Batley, G. E., & Gruber, B. (2016). Transport and fate of metal contamination in estuaries: Using a model network to predict the contributions of physical and chemical factors. *Chemosphere*, 153, 227-236.
- Sinoir, M., Bowie, A.R., Mongin, M., Butler, E.C. V., and Hassler, C.S. (2016). Zinc requirement for two phytoplankton strains of the Tasman Sea. *Marine and Freshwater Research* , http://dx.doi.org/10.1071/MF15323
- Sinoir, M., M. J. Ellwood, E. C. V. Butler, A. R. Bowie, M. Mongin, and C. S. Hassler (in press) Zinc cycling in the Tasman Sea: Distribution, speciation and relation to phytoplankton community, *Mar. Chem.*, doi:http://dx.doi.org/10.1016/j.marchem.2016.03.006.
- Winton, V. H. L., R. Edwards, B. Delmonte, A. Ellis, P. S. Andersson, A. Bowie, N. A. N. Bertler, P. Neff, and A. Tuohy, 2016, Multiple sources of soluble atmospheric iron to Antarctic waters, *Global Biogeochemical Cycles*, 30, 421–437, doi:10.1002/2015GB005265
- Winton, H., Bowie, A., Keywood, M., van der Merwe, P., and Edwards, R.: Suitability of high-volume aerosol samplers for ultra-trace aerosol iron measurements in pristine air masses: blanks, recoveries and bugs, *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2016-12, 2016.

Cruises

Three Australian GEOTRACES voyages have taken place in the reporting period:

- HEOBI: “Heard Earth Ocean Biosphere Interaction”, 8 January – 27 February 2016, RV Investigator voyage IN2016_V01, GEOTRACES Process Study. The project tested the hypothesis that hydrothermal activity driven by active submarine magmatism fertilises surface waters with iron thereby enhancing biological productivity around Heard and McDonald Islands, one of the world’s most active hotspot volcanic regions.
- K-Axis: “Assessment of habitats, productivity and food webs on the Kerguelen Axis in the Indian Sector of the Southern Ocean”, 8 January- 12 March 2016, *RSV Aurora Australis*

voyage au15_03, GEOTRACES Process Study. The project examined the principal drivers of ecosystem structure and processes around the southern Kerguelen plateau and included a trace element biogeochemistry component.

- SOTS+CAPRICORN+Eddy: “Linking eddy physics and biogeochemistry in the Antarctic Circumpolar Current south of Tasmania”, 14 March – 16 April 2016, IN2016_02, GEOTRACES Process Study. The goal of this study was to understand how eddy circulation impacts elemental cycling, and how this scales up to the eddy field of the Southern Ocean. Process studies were conducted within two contrasting eddies, one cyclonic and one anti-cyclonic. A number of trace metal and nutrients profiles were collected and will be analysed ashore for their isotopic composition.

New projects and/or funding

- Awarding of shiptime (GEOTRACES PI: Bowie) to support “Detecting Southern Ocean Change From Repeat Hydrography, Deep Argo And Trace Element Biogeochemistry” (Southern Ocean section from Tasmania to Antarctica) voyage in January/February 2018 (45 days). The SR3 section was previously occupied during IPY-GEOTRACES in 2008, and we have the opportunity to expand the GEOTRACES measurements and spatial resolution on the 2018 voyage.
- Awarding of shiptime (GEOTRACES PIs: Boyd, Ellwood, Bowie) to support “Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site” (Subantarctic Southern Ocean south of Tasmania voyage in March 2018 (20 days)
- Philip Boyd was awarded a prestigious Australian Research Council Laureate Fellowship, for the project: “Geoengineering the Southern Ocean? A transdisciplinary assessment”
- Science and Industry Fund (SIEF) John Stocker Postdoctoral Fellowship awarded to Taryn Noble and Zanna Chase for the project “The impact of changing ocean circulation on the Antarctic ice shelf”. This project involves analysis of seawater and surface sediment Nd isotope composition in order to evaluate the potential of Nd to AABW in the Mertz glacier region. The project is also supported by the Antarctic Gateway Partnership, an initiative of the Australian Research Council.

PhD theses

- Fabien Queroue, 2015. “Trace metals distributions in the Southern Ocean: Kerguelen Plateau process study”.
- Holly Winton, 2016. “Impact of biomass burning emissions and dust on soluble iron deposition to Australian waters, the Southern Ocean and Antarctica”.

Meetings

Australian GEOTRACES scientists presented results at the following meetings:

- Goldschmidt 2015 (Prague), August 2015.
- Royal Society meeting (London), “Quantifying fluxes and processes in trace-metal cycling at ocean boundaries”, December 2015.
- PACIFICHEM 2015 (Hawaii), December 2015.

- International Partnerships In Ice Core Sciences, Second Open Science Conference, (Hobart), March 2016

Outreach activities

- HEOBI blog: <https://blog.csiro.au/investigator/>
- K-axis blog: <http://k-axis.voyage/>
- Zanna Chase: Presentation on HEOBI voyage to students at Princes Street Primary School (March 11 and March 17).

Other activities

- Modifications were made to the new trace metal sampling container on R/V Investigator following sea trials in April 2015. The new container was thoroughly tested in early 2016 across two cruises, and performed well. Similarly the trace metal clean rosette and 6 new mark II McLane in situ pumps acquired as part of the ship's new equipment pool performed well in the cold waters and high seas around Heard Island (we didn't lose anything!). The ship's trace metal clean underway sampling system was also tested further in January 2016; results show this system may be suitable for uncontaminated collection of seawater at iron concentrations above 0.2 nmol/L.
- An atmospheric monitoring program for trace elements around Australia is being established at both land-based sites and on the *RV Investigator* (shiptime subject to approval). Contact: Andrew Bowie.
- Results of the joint Australian-New Zealand GEOTRACES GP13 section in the southwest Pacific are being written up.

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