***Australia***

## *Meetings*

- GEOTRACES presentations at the Australian-UK joint Royal Society-Australian Academy of Science 'Frontier of Science' meeting in Perth (Australia), October 2010
- GEOTRACES process study 'PINTS' (voyage ss2010_v01) workshop held in Hobart (Australia), February 2011 (Principal Investigator: Hassler)

## *Cruises*

- GEOTRACES section GP13 leg (voyage ss2011_v02) in Southwest Pacific Ocean completed by Australian scientists, 13 May – 5 June 2011, along approximately 30oS (see report below; Chief Scientist: Bowie). Leg 2 further east to be undertaken by NZ colleagues on RV *Tangaroa* from June 6 to 30 (Chief Scientist: Boyd)
- Australian participation in GEOTRACES approved process study around the Kerguelen Plateau in Oct/Nov 2011 (project: KEOPS-2; PI: Blain). Dissolved and particulate trace element studies in naturally iron-fertilised region of the Southern Ocean region in the Indian Ocean sector
- Preliminary discussion on submission of an Expression of Interest for shiptime for the next Australia GEOTRACES section study in the Pacific (N-S along 170oW GP19) or Indian (Hobart to South Africa GI05 or Fremantle to India GI03) Oceans on the new research vessel *Investigator* in 2014-2015 (feedback from SSC as to which line to focus on; joint study with another nation; which countries have already committed to these sections?)
- In addition, a process study of the Tasman Sea aiming to study TEI, macronutrient and carbon cycling and budgets is under discussion. This project is a follow up of the PINTS voyage (ss2010_v01, GEOTRACES Process study) At this stage, the Australian GEOTRACES participants, researchers from CSIRO, as well as international researchers (e.g. from NIWA, NIOZ, CNRS, NOC Southampton) have shown interest in this project.

## *New funding*

- Funding for GEOTRACES activities in Australia continues to be tight, with most projects carried out using small research grants from the institutions of the major GEOTRACES researchers (University of Tasmania, Australian National University, University Technology Sydney) and some national funding from the Australian Research Council

## *New results*

- Data published from sea ice iron biogeochemistry time-series study undertaken at Casey Station (Antarctica) in November/December 2010 (PI: Lannuzel)
- Participation and sample analyses of GEOTRACES intercalibration exercises for dissolved (Bruland), particulate (Sherrell) and aerosols (Landing) trace elements (Bowie lab)

## *Publications*

- Several manuscripts published with results from GEOTRACES activities, including during the International Polar Year; publication of *Deep-Sea Research* special issue on 'Subantarctic Biogeochemistry' in 2011 (detailed below; pdfs available on request)

***Other activities***

- Exchange of personnel and international training activities under EU-Cost Action ES0801 between laboratories in the UK (University of Plymouth) and Australia (University of Tasmania)
- Design specifications for GEOTRACES sampling requirements continue to be implemented for new Australian oceanographic research vessel, RV *Investigator* (to be commissioned in 2013)

**Brief report on GEOTRACES GP13 section study in the Southwest Pacific**

This project undertook an integrated oceanographic transect and dust monitoring program for iron, other trace elements, and their isotopes (TEIs) along the western end of the GP13 zonal section (~30°S) east of Australia.

Deployment of all equipment required for the GEOTRACES GP13 voyage was successful. The trace metal rosette (TMR), the McLane pumps, CTD and aerosol sampler all performed well. Three types of stations were used to achieve our aims: (i) 29 normal stations (every 1° of longitude), (ii) 3 super stations (every 5°), and (iii) 4 mega stations (every 10°). Deployments at normal stations were typically down to 1500 m, with deployments at super- and mega- stations to the full water column. We also collected samples and data from the TMR and CTD down to 6000 m at station 31 (32.5°S, 177°W) to characterise for the first time trace elements and isotopes in the deep waters passing through the Kermadec Trench.

Over 3000 dissolved water samples were collected from the TMR, over 400 particulate filter samples from the McLane pumps, over 2000 water samples from the CTD, and 7 filter samples from the aerosol sampler. Samples will be analysed in the 6-18 month period following the voyage in the laboratories of the respective Principal Investigator for the following parameters:

- Dissolved trace elements (Fe, Al, Cd, Zn, Co, Mn, Pb, etc, using FIA and ICP-MS techniques).
- Abundance and isotopic composition of trace elements in suspended marine particles
- Particulate organic carbon (POC) and nitrate (PON)
- Iron chemical speciation using an electrochemical approach
- Iron bioavailability
- Large sample volumes (1-2 L) for iron, zinc, cadmium and copper isotopes
- Large sample volumes (5-10 L) for radiogenic isotopes of Pa, Th, Nd
- Trace elements in atmospheric dusts collected on filters from an aerosol sampler
- Nutrients at the nanomolar levels
- Phytoplankton characterisation using microscopy, high-performance liquid chromatography and flow cytommetry

A number of analyses were carried out on-board including dissolved Fe by flow injection analyses, iron chemical speciation by competitive ligand equilibration – cathodic stripping voltammetry, phytoplankton photophysiology and hydrography (major nutrients, salinity, oxygen) by standard techniques. Shipboard data indicate that the TMR was non-contaminating for dissolved Fe, one of the most contamination prone elements. At station

#3, a typical micronutrient-type and oceanographically-consistent profile for dissolved Fe was observed (Figure 3). Surface subsamples for nanonutrients were collected from the TMR at all stations, and these will be analysed on the next leg of the GP13 section by New Zealand colleagues. Ocean colour satellite data (8 day MODIS image, 4 km resolution) and aerosol dust data and forecasts (NAAPS, hysplit forward trajectories) was relayed to the ship by colleagues at University of Technology Sydney (Dr Mark Baird) and Griffith University (Prof. Grant McTainsh and the Australian dustwatch network), respectively, in order to help with sampling strategies during the voyage.

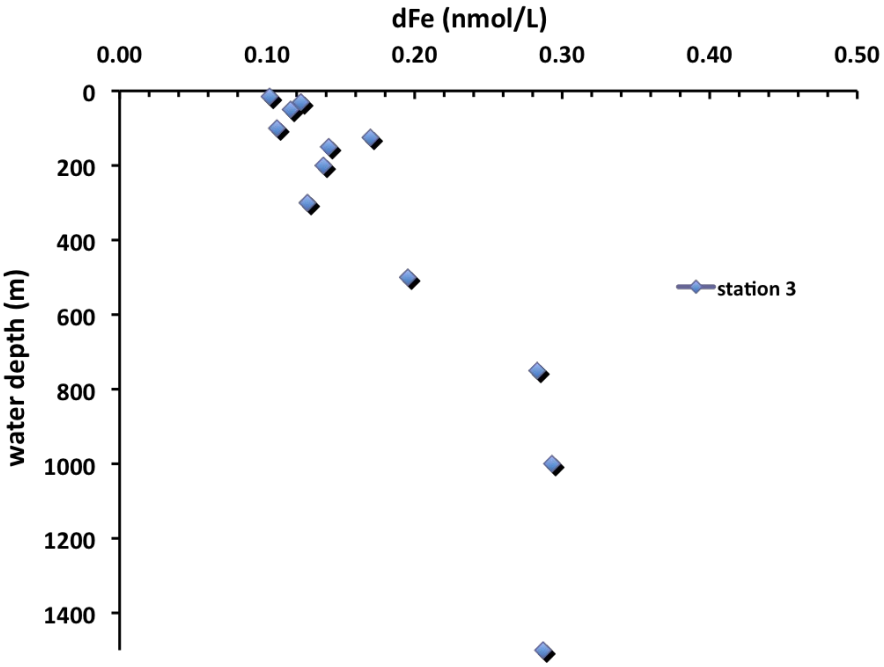


*Figure 3. Dissolved iron (dFe) distribution in the upper 1500 m of the water column at mega-station #3 (30°S, 155°E).*

Two stations were not carried out due to inclement weather (stations 09, and 25 CTD only deployed). Two deployments (station 03 cast 2, and station 04 cast 1) of the TMR were unsuccessful due to a software problem. This was resolved by reverting to an earlier version of the software, which was successfully tested at station 04 cast 2. An intermittent problem was identified with the one of the McLane pumps. This was believed to be due to a faulty communications cable between the electronics housing and the pump head, and the CI is in consultation with the pump manufacturer to resolve this problem.

Operations were carried out in an efficient manner, which resulted in many deployments taking less time than that allocated. This allowed us to add an extra 2 normal stations at the end of the Australian leg of the GP13 section and finish our science at 32.5°S 170°W.

This project is the first time that data on the distribution of many trace elements and their isotopes along the GP13 section in the Tasman Sea and southwest Pacific has been collected, and the 8 deep water deployments (including a 6000 m deployment of the TMR in the Kermadec Trench at 32.5°S 177°W) represent some of the few deep profiles that presently exist in any ocean worldwide. Preliminary results from shipboard analysis of dissolved Fe indicate that the western end of the transect was extremely low concentrations of dissolved Fe, despite the proximity of sampling to the continental shelf and possible dust deposition sources. Upper mixed layer nutrient concentrations were

below macromolar detection limit at all stations along section GP13, with typical increases below the mixed layer. These preliminary hydrography results demonstrate low NOx concentrations in the top 100 m. Based on the maximum quantum yield (Fv/Fm), phytoplankton east of 170 oE were nutrient limited. Complementary studies on the voyage will indicate the degree of iron and nitrogen co-limitation ion these waters. In addition, new EM300 swath bathymetric data was collected along the ocean section from 153.5°E to 170°W along 30°S (diverting to 32.5°S at 177°E), an area of significant topography including ocean ridges and trenches, submerged reefs and seamounts. This data is archived and can be processed and quality controlled after the voyage.

In summary, voyage ss2011_v02 successfully achieved the following objectives:
(1) We carried out an integrated zonal oceanographic transect east of Australia studying the marine biogeochemical cycles of TEIs, as part of Australasia's contribution to the international GEOTRACES program;
(2) Samples were collected to establish the full water column, basin-scale distribution of trace elements and isotopes along GP13 for the first time;
(3) Data from subsequent laboratory analyses will determine the sources, sinks and fluxes of TEIs (focussing on atmospheric dust delivery and biomass burning), as well as their transport, solubility and chemical form in the ocean;
(4) A number of subsamples were collected for later analysis of other GEOTRACES (such as stable, radioactive and radiogenic isotopes) and bioGEOTRACES (marine microbial biogeography and biogeochemistry; i.e., 'omics') key parameters by international colleagues who are not able to participate in the field program.

We were unable to carry-out all our planned analytical tasks on board due to contaminated Milli-Q pure water supply (flow injection analyser) and unstable power supply (cathodic stripping voltammeter) in the ANU 20' clean container. These samples will now be analysed in the home laboratories after the voyage.

Voyage Plan and Summary can be found online at www.marine.csiro.au/nationalfacility/voyagedocs/index.htm. A blog of the cruise is posted at http://www.obs-vlfr.fr/GEOTRACES/index.php/outreach/cruise-blogs/gp13-blog, as part of

**GEOTRACES Outreach activities**. SCOR-sponsored participation of Dr Thato Mtshali from South Africa under GEOTRACES Training and Education activities.

## Outputs from GEOTRACES activities involving Australian researchers (2010-2011):

*Journal articles:*

Lannuzel D., van der Merwe P.C., Townsend A.T., Bowie A.R., 2011. Size fractionation of particulate metals during a time series in East Antarctic fast ice. Geochimica et Cosmochimica Acta, in review (submitted 10 May 2011)

Wake B.D., Hassler C.S., Bowie A.R., Haddad P.R., Butler E.C.V., 2011. Phytoplankton selenium requirements: the case for species isolated from temperate and polar regions of the Southern Hemisphere. Journal of Phycology, in review (submitted 25 January 2011)

Baeyens W., Bowie A.R., Buesseler K., Elskens M., Gao Y., Lamborg C., Leermakers M., Remenyi T.A., Zhang H., 2011. Size-fractionated labile trace elements in the Northwest Pacific and Southern Oceans. Marine Chemistry, doi: 10.1016/j.marchem.2011.04.004, in press (accepted 11

April 2011)
Cossa D., Heimbürger L.-E., Lannuzel D., Rintoul S.R., Butler E.C.V, Bowie A.R., Averty B., Watson R., Remenyi T., 2011. Mercury in the Southern Ocean. Geochimica et Cosmochimica Acta, doi: 10.1016/j.gca.2011.05.001, in press (accepted 24 March 2011)
van der Merwe P., Lannuzel D., Bowie A.R., Meiners K.M., 2011. High temporal resolution observations of spring fast-ice melt and seawater iron enrichment in East Antarctica. Journal of Geophysical Research – Biogeosciences, in press (accepted 15 March 2011)
Lannuzel D., Schoemann V., Pasquer B., van der Merwe P., Bowie A.R., 2011. What controls the distribution of dissolved iron in Antarctic sea ice? Spatial, seasonal and inter-annual variability. Journal of Geophysical Research - Biogeosciences, doi:10.1029/2009JG001031, in press (accepted 14 April 2010)
Bowie A.R., Griffiths F.B, Dehairs F., Trull T.W., 2011. Oceanography of the subantarctic and polar frontal zones south of Australia during summer: setting for the SAZ-Sense study. Deep-Sea Research II, in press (accepted 10 March 2011)
Petrou K.L., Hassler C.S., Doblin M.A., Shelly K., Schoemann V., Ralph P.J., 2011. .Interaction of iron and light on Southern Ocean phytoplankton. Deep-Sea Research II, in press (accepted 07 September 2010)
Lannuzel D., Remenyi T., Lam P., Townsend A., Ibisanmi E., Butler E., Wagener T., Schoemann V., Bowie A.R., 2011. Distributions of dissolved and particulate iron in the sub-Antarctic and polar frontal Southern Ocean (Australian sector). Deep-Sea Research II, in press (accepted 17 December 2009)
Ibisanmi E.B., Hunter K.A., Sander S., Boyd P.W., Bowie A.R., 2011. Vertical distributions of iron-(III) complexing ligands in the Southern Ocean, Deep-Sea Research II, in press (accepted 26 August 2009)
Hassler C.S., Schoemann V., Nichols C.A.M., Butler E.C.V., Boyd P.W., 2011. Saccharides enhance iron bioavailability to Southern Ocean phytoplankton. PNAS, 108: 1076-1081
van der Merwe P., Lannuzel D., Mancuso Nichols C.A., Meiners K., Bowie A.R., 2011. Iron partitioning in pack and fast ice in East Antarctica: temporal decoupling between the release of dissolved and particulate iron during spring melt. Deep-Sea Research II, 58, 1222–1236, doi: 10.1016/j.dsr2.2010.10.036
Lannuzel D., Bowie A.R., van der Merwe P., Townsend A., Schoemann V., 2011. Particulate and dissolved metals distribution in Antarctic sea ice and their role in tracing iron sources. Marine Chemistry, 124 (2011) 134-146, doi:10.1016/j.marchem.2011.01.004
Hassler C.S., Alasonati E., Mancuso-Nichols C.A., Slaveykova V.I., 2011. Exopolysaccharides produced by bacteria isolated from the pelagic Southern Ocean: role in iron binding, chemical reactivity and bioavailability. Marine Chemistry, 123, 88-98
Cassar N., DiFiore P., Barnett B.A., Bender M.L., Bowie A.R., Tilbrook B., Petrou K., Westwood K., Wright S., Wagener T., 2011. The influence of iron and light on net community production in the Subantarctic and Polar Frontal Zones. Biogeosciences, 8, 227-237, doi:10.5194/bg-8-227-2011
Chever F., Sarthou G., Bucciarelli E., Blain S., Bowie A.R., 2010. An iron budget during the natural iron fertilization experiment KEOPS (Kerguelen Island, Southern Ocean). Biogeosciences, 7, 455–468

*Book chapter*

Hassler C.S., Schoemann V., Boye M., Tagliabue A., Rozmarynowycz M., McKay R.M.L., 2011. Iron Bioavailability in the Southern Ocean. In: Southern Ocean: Oceanography, Climatic Impact. Nova Publishers, in review (submitted 10 April 2011).

Prepared by:

Andrew Bowie (Antarctic Climate & Ecosystems CRC, University of Tasmania, Australia)