GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2016/2017

May 1st, 2016 to April 30th, 2017

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1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

Co-Chairs
Ed Boyle, USA
Reiner Schlitzer, Germany

Members
Eric Achterberg, Germany
Adrian Burd, USA
Zanna Chase, Australia
Jay T. Cullen, Canada
Tina van de Flierdt, UK
Vanessa Hatje, Brazil
Tung-Yuan Ho, China-Taipei
Marina Kravishina, Russia
Phoebe Lam, USA
Rob Middag, Netherlands
Hajime Obata, Japan
Katharina Pahnke, Germany
Alakendra Roychoudhury, South Africa
Yeala Shaked, Israel
Géraldine Sarthou, France
Antonio Tovar-Sanchez, Spain
Liping Zhou, China-Beijing

The SSC membership (listed above) contains representatives of 16 different countries with diverse expertise, including marine biogeochemistry of carbon and nutrients; trace elements and isotopes as proxies for past climate conditions; land-sea fluxes of trace elements/sediment-water interactions; trace element effects on organisms; internal cycles of the elements in the oceans; hydrothermal fluxes of trace elements; tracers of ocean circulation; tracers of contaminant transport; controls on distribution and speciation of trace elements; and ocean modelling.

2. Progress on implementation of the project

GEOTRACES continues to progress very successfully. GEOTRACES has now more than 1000 section stations completed (1024) from 95 GEOTRACES cruises (including 11 International Polar Year cruises). Next Intermediate Data Product will be released in summer 2017 including data from the first 5 years of the programme. So far, 818 peer-reviewed publications have been published including 20 publications in Nature journals and 12 in PNAS.

2.1 Status of GEOTRACES field programme

With the completion of the German expedition in the Fram Strait in summer 2016, GEOTRACES successfully completed the international Arctic GEOTRACES Programme (with 4 cruises from USA, Canada and Germany already completed in 2015). In addition, during this reporting period, the Indian GEOTRACES programme completed 2 cruises in the Arabian Sea, Bay of Bengal and Indian Ocean.

In complement to the GEOTRACES Ocean sections cruises, one process study cruise from Netherlands was completed in the Atlantic Ocean.

The GEOTRACES cruise programme for 2017 includes 2 more section cruises, from UK and Japan, in the Atlantic and Pacific Oceans respectively, and 2 process studies: one from France in the Mediterranean Sea and another one from UK in the Atlantic Ocean.

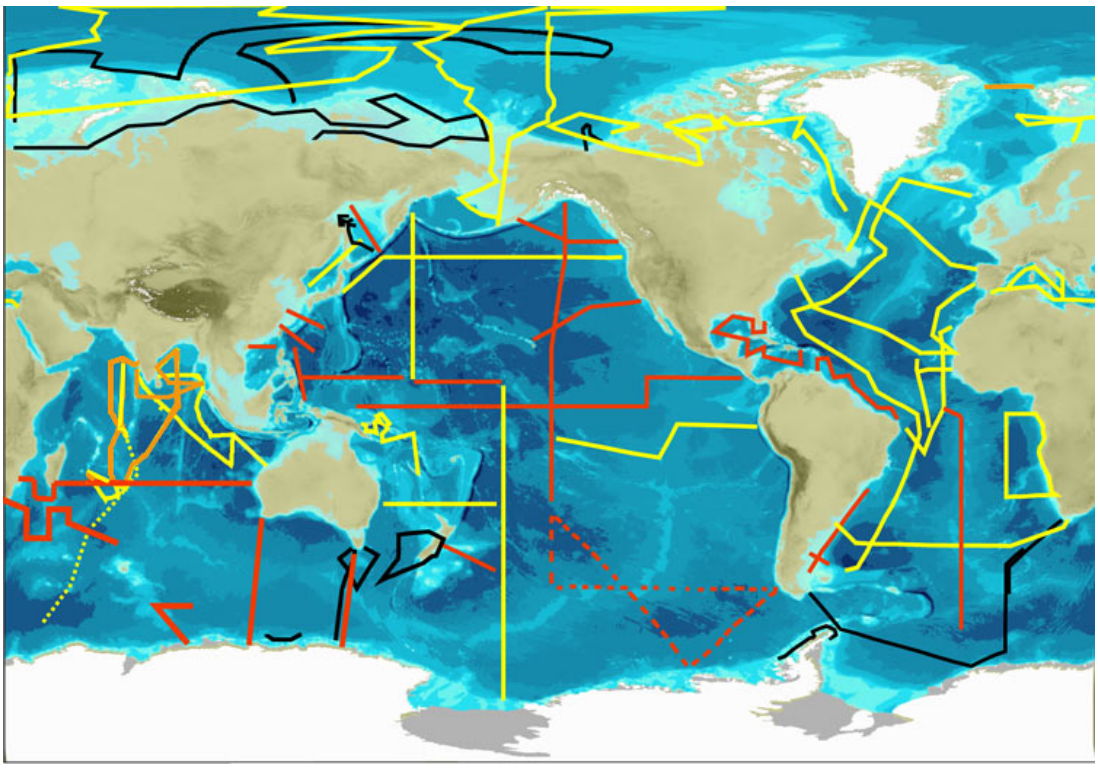


Figure 1. *Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey. In orange: Sections completed during the past year. In red: Planned Sections. An updated version of this map can be found on the GEOTRACES home page <http://www.geotraces.org>.*

2.2 GEOTRACES Intermediate Data Products

Release of the new Intermediate Data Product in summer 2017!

Building on the success of the first Intermediate Data Product (IDP), released in 2014, the next intermediate data product will be delivered at the 2017 Goldschmidt Meeting in Paris, France. A town hall meeting is scheduled on **Wednesday 16 August 2017** at the main venue of the Goldschmidt conference.

The Intermediate Data Product 2017 (IDP2017) will present a remarkable synthesis of data from the Atlantic Ocean and a more complete coverage of data from the Arctic, Indian, Pacific and Southern Oceans and include a larger range of biogeochemical parameters that was included in the IDP2014.

Coming soon!

Intermediate Data Product 2014

A new version of the Intermediate Data Product 2014 (IDP2014) was made available on June 2016. This version is available to download from the following web page: http://www.bodc.ac.uk/geotraces/data/idp2014/ A document describing the changes from previous version is available on the web page indicated above.

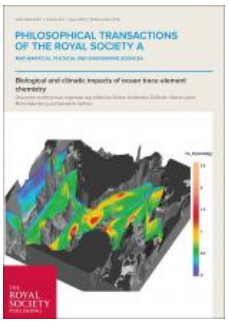
So far, the IDP2014 has been downloaded more than 900 times. In the past year, several events to publicise and promote use of the IDP data with the broader ocean research community were held. Please see section "3.4 GEOTRACES Workshops" below.

2.3 GEOTRACES Publications

During the reporting period, 140 new peer-reviewed papers have been published, including the most prestigious journals such as Nature (with 5 papers published) and PNAS (with 2 papers published). In total the GEOTRACES peer-reviewed papers database includes 818 papers.

It is important to highlight that the special issue from the GEOTRACES-Royal Society coupled meeting and workshop to discuss and synthesis findings from the GEOTRACES programme (7–10 December 2015, UK) was published in November 2016.

The volume includes four synthesis papers, which summarise current knowledge and identify areas for future work relating to chemical fluxes at the four ocean boundaries - with the atmosphere, the continents, sediments, and mid-ocean-ridges. These papers and some other papers are available open access.



Philosophical Transactions of the Royal Society A (28 November 2016; volume 374, issue 2081)

Biological and climatic impacts of ocean trace element chemistry

Edited by Gideon Henderson, Ed Boyle, Maeve Lohan, Micha Rijkenberg and Géraldine Sarthou

Publicity articles to promote GEOTRACES continue to be published nationally and internationally. The complete list of promotional articles is available here: http://www.geotraces.org/outreach/publicity-documents

For complete information about GEOTRACES publications please check the following web pages:

- GEOTRACES peer-reviewed papers database: http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers
- GEOTRACES special issues: http://www.geotraces.org/library-88/scientific-publications/geotraces-special-issues

2.4 GEOTRACES Science highlights

The GEOTRACES International Project Office regularly edits highlights of published articles, which are posted in the website (http://www.geotraces.org/science/science-highlight) and in the electronic newsletter (http://www.geotraces.org/outreach/geotraces-enewsletter). Among the numerous highlights published since last year's report, we selected the following five:

Changing the paradigm on the oceanic iron cycle

Tagliabue and co-workers (2017, see reference below) discuss an extensive review on the recent findings on iron (Fe) cycle in the ocean. They figure out clearly that:

- Fe is a nutrient as essential as nitrogen (N) or phosphorus (P) for the phytoplankton. In other words, the full understanding of any marine ecosystem cannot neglect the analysis of micronutrients anymore.
- Fe oceanic sources are multiple, and supply from continental margins extends far beyond the coastal zone while striking Fe inputs from hydrothermal activity along mid-ocean ridges were observed in all the oceans. This revolutionizes the preceding view of the dust inputs, although those are essential drivers of N2 fixation at low latitude.
- The cycling of organic iron-complexing ligands has also emerged as a crucial component of the ocean iron cycle, ligand concentrations being not as uniform as considered earlier.
- It is also recognized that phytoplankton can exhibit substantial variations in their iron stoichiometry in different environments...

Synthesizing these new insights provides a more refined picture of the ocean iron cycle, challenging the global ocean modelling for testing hypotheses and projections of change. The authors also draw exciting new frontiers for the oceanic Fe cycle...

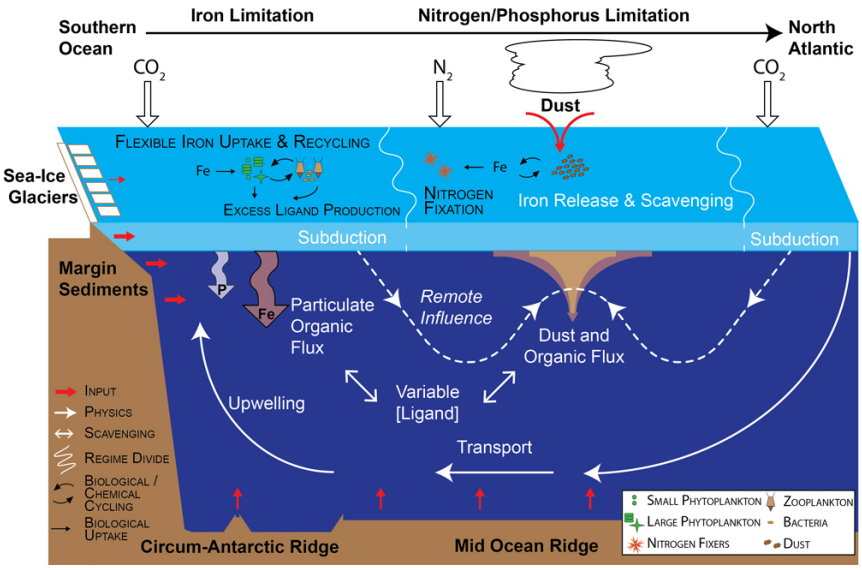


Figure 2. *Revised model of the major processes in the ocean iron cycle, with focus on the Atlantic Ocean. Note that there is a broad meridional contrast between the iron-limited Southern Ocean and the major nutrient-limited low-latitude regimes. Dust remains a dominant source in the low latitudes, but continental margin and upwelled hydrothermal sources are more important in the Southern Ocean. Flexible iron uptake and biological cycling, together with the production of excess iron-binding ligands, dominate the Southern Ocean. Nitrogen fixation occurs in the low latitudes (although this process can also be restricted by lack of iron outside the North Atlantic subtropical gyre). The particulate organic iron flux is decoupled from that of phosphorus at high latitudes and the flux of lithogenic material is important at low latitudes influenced by dust. Subduction of excess organic iron-binding ligands from Southern Ocean has a remote influence on the interior ocean at low latitudes.*

Reference:

Tagliabue, A., Bowie, A. R., Boyd, P. W., Buck, K. N., Johnson, K. S., & Saito, M. A. (2017). The integral role of iron in ocean biogeochemistry. Nature, 543(7643), 51–59. DOI: http://dx.doi.org/10.1038/nature21058

Contrasting lithogenic inputs from North Atlantic to North Pacific Oceans traced by thorium isotopes

Dissolved thorium (Th) isotopes and iron (Fe) are used to document the transfer of lithogenic material to the ocean.
Two contrasting areas are compared: the Atlantic Ocean around Barbados Islands, under the influence of the Amazon plume and dust of Saharan origin, and the remote North East Pacific Ocean, far from dust inputs.
The Amazon is a substantial source of dissolved ^{232}Th and iron (Fe) to the low-latitude Atlantic Ocean, even as far away a 1900 km from the river's mouth. This complicates the use of ^{232}Th as a dust proxy in river-influenced ocean regions.
A striking feature is the similarity in Fe concentrations from the North Pacific to the North Atlantic Oceans, while ^{232}Th reveals a dust flux six fold higher in the later. This supports the idea that dissolved Fe distribution is highly buffered in the ocean.

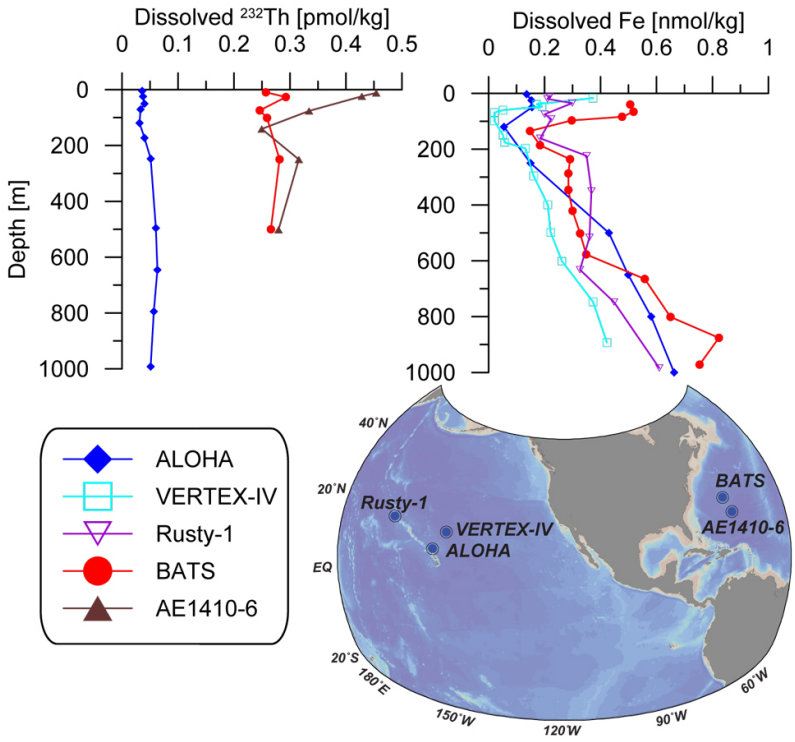


Figure 3. *The North Atlantic Ocean receives a much larger input of mineral dust blown from the continents than does the remote North Pacific. This contrast is seen clearly in the seawater concentrations of dissolved Thorium-232, the isotope of thorium that is enriched in the continental crust (left panel). The distribution of Fe, however, is much more homogeneous between these two ocean basins (right panel), despite that fact that continental dust is the major source of Fe in these areas. We think this is because Fe is highly buffered in the ocean by a combination of biological uptake, adsorption onto particles, and complexation by organic molecules, or ligands.*

Reference:

Hayes, C. T., Rosen, J., McGee, D., & Boyle, E. A. (2017). Thorium distributions in high- and low-dust regions and the significance for iron supply. Global Biogeochemical Cycles, 31, 1–20. DOI: http://dx.doi.org/10.1002/2016GB005511

The coupled zinc-silicon cycle paradox illuminated

The strong similarities between zinc (Zn) and silicon (Si) vertical profiles have led many studies to suggest the uptake of Zn in diatom frustules, followed by simultaneous remineralisation at depth. However, recent lab experiments have demonstrated that Zn, although essential for diatoms, is located in the organic part of the cell. These cells are characterized by particularly high Zn/P ratios in the Southern Ocean (up to 8 times greater than at low latitudes). Such contrasting observations have raised the question as to what processes could lead to such consistent Si-Zn relationship, given that Zn and Si uptake are obviously not controlled by the same biological process. Vance and co-workers (2017, see reference below) infer that the oceanic zinc distribution is the result of the interaction between the specific uptake stoichiometry in Southern Ocean surface waters and the physical circulation through the Southern Ocean hub.

Their approach couples in situ data collected in the different oceanic basins, experimental results from the literature and physical-biogeochemical coupled modelling on a global scale. This work emphasizes how the consideration of 1-D cycling only can bias the understanding of (macro and micro) nutrient behaviours, and therefore their paleo-applications, although 1-D cycling may also play an important role in Zn cycling.

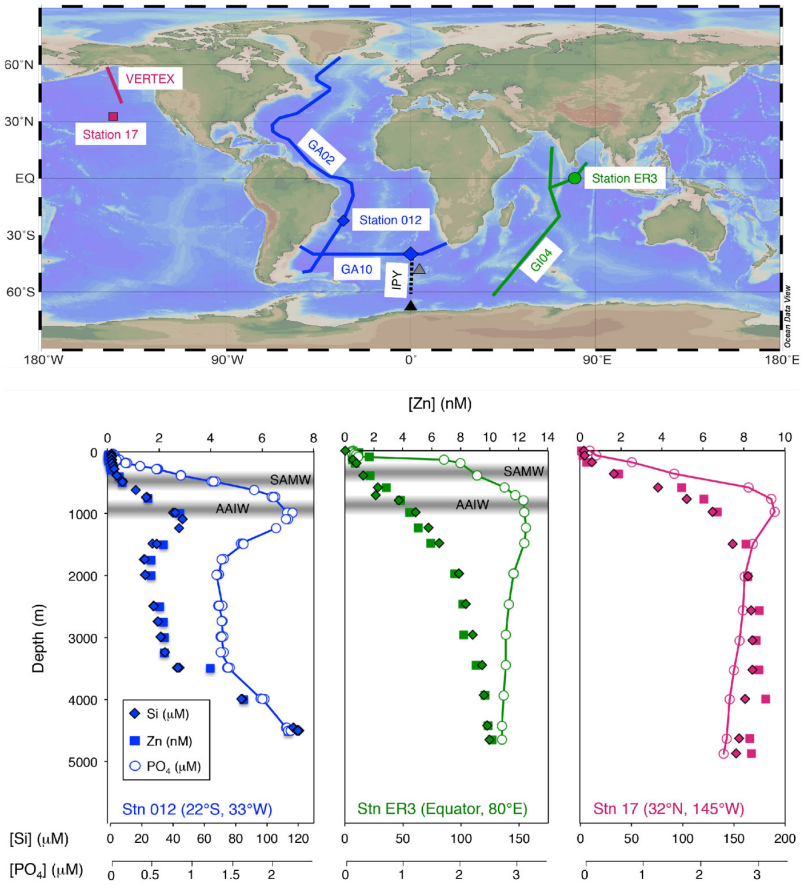


Figure 4. *Depth profiles of dissolved zinc, silica and phosphate in three different ocean basins (bottom), with the locations of each profile shown on the map (top). Both zinc and silicate show deep maxima whereas phosphate has a much shallower maximum, despite the fact that the oceanic biogeochemical cycle of Zn is dominated by uptake into the organic parts of diatom cells with phosphate. Vance et al. explain these features in terms of biological and physical processes in the Southern Ocean.*

Reference:

Vance, D., Little, S. H., de Souza, G. F., Khatiwala, S., Lohan, M. C., & Middag, R. (2017). Silicon and zinc biogeochemical cycles coupled through the Southern Ocean. Nature Geoscience. DOI: http://dx.doi.org/10.1038/ngeo2890

Testament of the efficiency of environmental policies

Human activities, such as the combustion of leaded petrol, emissions from non-ferrous metal smelting, coal combustion and waste incineration constitute major environmental lead (Pb) sources during the past century. This resulted in a considerable increase of anthropogenic Pb in the surface and deep waters of the North Atlantic, large enough to mask the natural lead signal.

Increased usage and then phasing-out of leaded-petrol since the mid-70's yielded a decrease of this contamination. By measuring lead concentrations and isotopes (excellent tracers of the different sources of lead) along the GEOTRACES sections GA02 and GA06, Bridgestock and his co-workers (2016, see reference below) reveal for the first time that natural lead can be detected again in the surface water of the North Atlantic. Indeed, significant proportions of up to 30–50% of natural Pb, derived from mineral dust, are observed in Atlantic surface waters off the Sahara. This clearly reflects the success of the global effort to reduce anthropogenic Pb emissions.

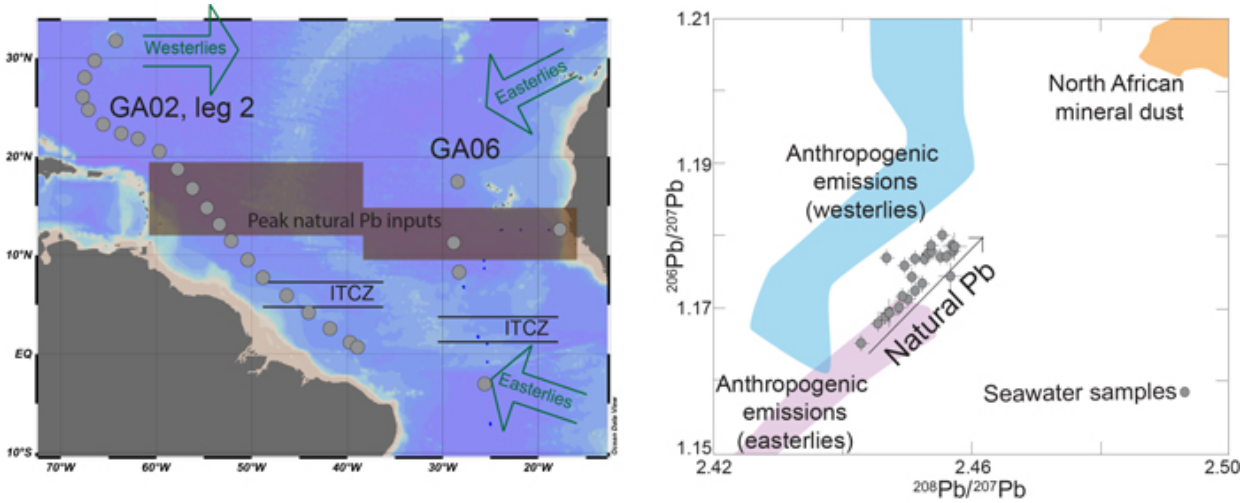


Figure 5. *Locations of the surface seawater samples analyzed in this study (left). The brown shaded box shows the area found to contain the highest amounts of naturally sourced lead (Pb) resulting from the deposition of North African mineral dust. Significant inputs of natural Pb can be identified by higher Pb isotope ratio values ($^{206}Pb/^{207}Pb$ and $^{208}Pb/^{207}Pb$; right).*

Reference:

Bridgestock, L., van de Flierdt, T., Rehkämper, M., Paul, M., Middag, R., Milne, A., Lohan, M.C., Baker, A.R., Chance, R., Khondoker, R., Strekopytov, S., Humphreys-Williams, E., Achterberg, E.P., Rijkenberg, M.J.A., Gerringa, L. J.A., de Baar, H. J. W. (2016). Return of naturally sourced Pb to Atlantic surface waters. Nature Communications, 7, 12921. DOI: http://dx.doi.org/10.1038/ncomms12921

Oxygen biogeochemistry exerts a strong influence on cobalt cycling

This is an important result of the US GEOTRACES East Pacific Zonal Transect (EPZT) cruise (GP16) discussed by Hawco and his co-workers (2016, see reference below). The distribution of dissolved cobalt and labile cobalt along this section is closely tied to the oxygen minimum zone. This work also shows that (1) elevated concentrations of labile cobalt are generated by input from coastal sources and reduced scavenging at low oxygen; (2) atmospheric deposition and hydrothermal vents along the East Pacific Rise are contrastingly minor sources of cobalt; (3) high cobalt waters are further upwelled and advected offshore and; (4) phytoplankton export returns cobalt to low-oxygen water masses underneath. These processes result in covariation of dissolved cobalt with oxygen and phosphates, schematically represented in the Figure below.

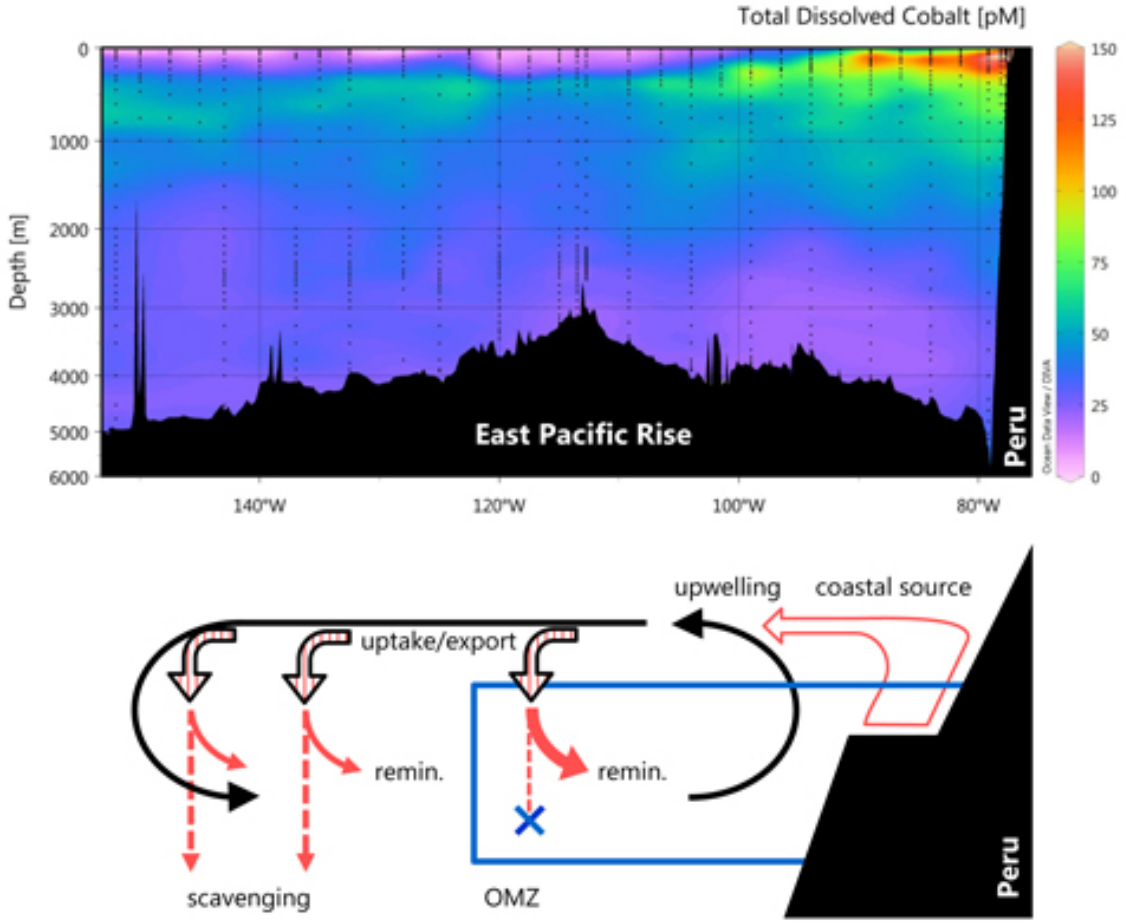


Figure 6. *In the South Pacific Ocean, high levels of cobalt are harbored in waters that are devoid of dissolved oxygen (upper panel, warm colors). This plume of cobalt stems from the Peru coast and is enhanced by degradation of cobalt-bearing phytoplankton in these waters, and by the absence of removal processes (scavenging) when oxygen is low (lower panel).*

Reference:

Hawco, N. J., Ohnemus, D. C., Resing, J. A., Twining, B. S., & Saito, M. A. (2016). A dissolved cobalt plume in the oxygen minimum zone of the eastern tropical South Pacific. Biogeosciences, 13(20), 5697–5717. DOI: http://dx.doi.org/10.5194/bg-13-5697-2016

3. Activities

3.1 GEOTRACES intercalibration activities

The Standards and Intercalibration (S&I) Committee is currently composed of Karen Casciotti, Peter Croot, Tina van de Flierdt, Walter Geibert, Lars-Eric Heimbürger, Maeve Lohan, and Hélène Planquette. Greg Cutter, who has stepped down from the committee last year, is still completing some tasks associated with aerosol intercalibrations. Maeve Lohan and Walter Geibert serve as co-chairs. Since the S&I meeting at Stanford University from 27 to 29 April 2016, the S&I committee held several meetings.

- In person:
  23-26 January 2017 (London Imperial College)

- Virtual meetings (GoToMeeting):
  28 November 2016
  20 March 2017
  24 April 2017

- Virtual S&I-Data Management Committee (DMC) co-chair meetings:
  7 February 2017.
  26 April 2017

In addition, the committee is in constant communication via email and through a shared online resource, and the co-chairs are in regular personal exchange with members of the DMC and BODC at the respective locations.

The main task of the committee in the past year was the continued preparation for IDP2017, which also included the intercalibration of data that were included in IDP2014 but had not been intercalibrated yet. The aim was to have all datasets in IDP2017 seen and evaluated by the S&I committee, according to defined intercalibration criteria. This aim was achieved for all but one dataset on 30th April 2017, and the committee is still working to have all data in IDP2017 assessed.

The submission procedure has been improved by providing a dedicated e-mail address for the S&I committee (sic@geotraces.org) and by reorganizing and updating the content on the GEOTRACES web page, strongly supported by the IPO in Toulouse. The improvements of the submission procedure are working well and we are pleased with the response from the community. The committee has provided details on requirements for different types of cruises and parameters, which made the intercalibration process more transparent for data submitters. In addition, a new flowchart of the intercalibration procedure was designed and put on the website (http://www.geotraces.org/sic/about-s-i/flow-chart-s-i-data-quality-assessment). This is part of the continuous improvements in defining and communicating the procedures that are in place to ensure consistent quality of the GEOTRACES data products. A better description of the process, combined with regular reminders, individual letters, and written instructions for specific parameters, all contributed to receiving a large number of S&I reports from the analysts from the Atlantic and Pacific oceans. All deadlines for data submission for IDP2017 have now passed.

This year we have also produced with the community intercalibration procedures for BioGEOTRACES, which includes the following parameters:

1. HPLC Pigments
2. Single cell trace metals
3. Targeted Metaproteomics

A new committee member responsible for BIOEGOTRACES will join the S&I committee next year.

The S&I Committee received approximately 750 parameters from the Atlantic, 250 parameters from the Pacific, nothing submitted from the Indian Ocean, 32 parameters from past IPY cruises, 44 parameters from process studies and 32 parameters from GEOTRACES-compliant datasets for the final IDP2017 deadline. During the meetings of the S&I Committee, all datasets were introduced by the assigned committee members, and discussed by the full committee. In nearly all cases, questions of the committee about data quality could be easily resolved and only a small and limited number of parameters did not pass intercalibration, mostly due to issues with sampling methods. It is important in this context to refer newly joining contributors to the existence of the GEOTRACES cookbook, for which an updated version (3.0) is in preparation for release in summer 2017. A number of intercalibration reports were of outstanding quality, providing excellent detail on intercalibration procedures. Continuous exchange with submitters and the community clearly results in a better understanding of the requirements for the intercalibration process and benefits data quality and comparability in GEOTRACES.

Coverage in the Atlantic and especially the Pacific is now strongly improved from IDP2014. The first datasets on biochemical parameters (BioGEOTRACES) have been submitted and will be intercalibrated for IDP2017. For some important sections, no data or very little data were submitted for IDP2017, in spite of many attempts to raise awareness of the submission procedure. Progress has been made with including hydrography, DIC, SF_6, CFC's and some sensor datasets, where a defined intercalibration procedure developed by these communities is used, e.g., CLIVAR.

Other Activities

Prof. Jim Moffett is now responsible for GEOTRACES consensus material. In the past year more data has been submitted for this, extending the number of elements that can have consensus material. We hope that next year this will be published on the website. Prof. Eric Actherberg has also collected consensus material from GA08. These samples have now been distributed to laboratories around the world to generate consensus data. We hope in the next year these materials will be available for use by the Community.

A small intercalibration exercise for labile particulate materials was undertaken this year so that labile particulate data could be included in IDP2017. This consisted of groups using s specific leach to apply this to 3 different CRM's. Four different laboratories who routinely carry out this work took part in this exercise resulting in labile particulate material being intercalibrated for IDP2017.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanographic Data Centre (BODC), with the head office located in Liverpool; the GEOTRACES Data Manager (Chris Daniels) is based at the BODC office in Southampton, UK. Regular communication is maintained between the two sites so that support and assistance can be offered to the GEOTRACES Data Manager when required.

GDAC is responsible for the entirety of the GEOTRACES data activities from inception to completion. This takes into account the following components:

- interaction between PIs and national data centres in order to encourage regular and timely data/ metadata submissions
- maintaining and modifying GDAC web pages to include updated ocean basin maps (http://www.bodc.ac.uk/geotraces/cruises/section_maps/) and upcoming cruises on the programme page (http://www.bodc.ac.uk/geotraces/cruises/programme/)
- liaising with the Data Management Committee and Standards and Intercalibration Committee to ensure issues/questions relating to GEOTRACES and its progress can be discussed, and deadlines can be met accordingly.
- input of metadata and data into the BODC database and compilation of documentation to include analysis methodologies
- Collation of data/ metadata for the IDP2017

Chris Daniels is the GEOTRACES Data Manager since January 2017. He took the position of Abigail Bull who left to take a different role. Since Chris started on his role he has focused entirely on processing data to be included in the IDP2017.

Data overview

The data management of the GEOTRACES Project is a large undertaking with a total of 95 cruises (including all cruise legs) associated with the project (this takes into account all section cruises, process studies and compliant data). More than 800 Scientists have taken part in the GEOTRACES cruises, with 15 different nations having run a major GEOTRACES IPY/ section/ process study cruises.

Summary of completed GEOTRACES cruises to date:

Section cruises	IPY cruises	Process studies	Compliant data
35 cruises (including all legs) with 27 sections	11	28 (including all legs) with 24 sections	9

In addition, 2 intercalibration cruises have been completed.

3.3 GEOTRACES International Project Office

The GEOTRACES International Project Office (IPO) is based at the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France. The IPO is staffed by a single person, the IPO Executive Officer, Elena Masferrer Dodas. She works under the scientific supervision of Catherine Jeandel (CNRS, LEGOS, France).

The IPO is responsible for:

- assisting the Scientific Steering Committee (SSC) in implementing the GEOTRACES Science Plan and implementation plans of the programme;
- organising and staffing meetings of the SSC, working groups and task teams;
- liaising with the sponsors and other relevant organisations;
- seeking and managing programme finances;
- representing the project at international meetings;
- maintaining the project website and Facebook and Twitter pages;
- maintaining the project mailing lists;
- preparing GEOTRACES science highlights and the bimonthly GEOTRACES eNewsletter;
- maintaining the GEOTRACES publications database and the GEOTRACES Scientists Analytical Expertise Database;
- assisting the GDAC in securing information about upcoming cruises; and
- interacting with GEOTRACES national committees and groups, as well as other international projects.

From October to December 2016, the IPO has hosted Bob Anderson, US GEOTRACES project office director and past co-chair of the GEOTRACES SSC. The main purpose of his visit was working on the development of the Intermediate Data Product 2017 parameter list.

This year, we want to highlight the following new products:

- GEOTRACES eNewsletter Special Issue – Discovery Digest

  The GEOTRACES IPO has introduced a new type of newsletter, a sort of "discovery digest", which is designed to highlight the progress in a given GEOTRACES-relevant topic. The first one was published in March 2017 and it was devoted to recent discoveries in the oceanic cycle of iron. This issue is available here: http://www.geotraces.org/outreach/geotraces-enewsletter/listid-12/mailid-768-geotraces-discovery-digest

  Following the publication of this special issue, the GEOTRACES IPO has received several spontaneous congratulation and thank you messages from the GEOTRACES community. At the time of writing this report, the issue has received more than 1300 hits.

- New query capability for the GEOTRACES Publications database

  A dynamic querying capability for the GEOTRACES publications database is currently being developed with the help of the Data Service of the Observatoire Midi-Pyrenees (SEDOO) in Toulouse, France. Once available, it will be possible to make advanced searches within the GEOTRACES publication database. This system will also improve the Intermediate Data Product system to link the original publications associated with the given tracer and cruise.

- Video presenting the GEOTRACES Programme

  Short video interviews to SSC members were held during last SSC meeting, which was hosted by the GEOTRACES IPO in Toulouse. The IPO is currently working with Jean-Hugues Babary from Centre for the Development of the Pedagogy at the Université Paul Sabatier and the journalist Jean François Hait editing the videos.

- GEOTRACES website (<http://www.geotraces.org>)

  A new menu devoted to Standards and Intercalibration activities has been added on the GEOTRACES site. Facebook and Twitter feeds will be added on the GEOTRACES homepage in order to give more visibility to all the activity in these two media.

- Publicity articles

  An article introducing GEOTRACES has been published on the Journal of the Atlantic Society of Oceanographers, OKEANOS (Spain) with the aim of promoting GEOTRACES research in Spain. The volume (in Spanish) is available here: http://es.calameo.com/read/0050684378fc854b0db53

From the regular tasks we want to highlight the following:

- Meeting and Workshop organisation

  The IPO hosted the 2016 DMC and SSC meetings in Toulouse (12-16 September 2016) and organised the Workshop "Exploring GEOTRACES Data with ODV" and the GEOTRACES Indian Ocean Planning Workshop which were held in Japan (June 2016). Minor assistance was

also provided to the organisation of the joint GEOTRACES/OCB Workshop: "Biogeochemical cycling of trace elements within the ocean: A synthesis workshop", the "Arctic-GEOTRACES Early Career Researcher Networking Event (ASLO 2017)" and the "IDP2017 Parameter Committee meetings." Please read section "GEOTRACES Workshops" for further information about the workshops.

- Policy advice

  The IPO is actively involved in the G7 Oceans Initiative. It has coordinated the topic « Ocean Chemistry ». The development of a coordinated action plan for research vessels and the need for coordinated programmes coupling physics, chemistry and biology has been the top priorities the IPO has advocated for. SCOR is included as external expert in this process.

  The IPO has assisted Roger François (University British Columbia, Canada) and Peter Croot (NUI-Galway, Ireland) in their initiative of approaching the Arctic Monitoring and Assessment Programme (AMAP) with the objective of establishing a joint Arctic workshop. Unfortunately, AMAP had no funding available to dedicate to this joint workshop.

- Capacity Building

  During Bob Anderson's visit to the GEOTRACES IPO, support was provided to colleagues in Korea who want to initiate a Korean GEOTRACES programme. Korea has a new ship (*RV ISABU*) and has purchased the most-up-to-date clean sampling system so there is high expectation that Korea could successfully carry out GEOTRACES missions. A proposal for funding a Korean GEOTRACES programme has been submitted to the Korea Institute of Marine Science and Technology Promotion (KIMST).

- Some statistics

  30 new highlights published (135 in total)
  5 eNewsletter published, including one special issue (bimonthly 25 in total)
  140 new peer-reviewed papers included in the GEOTRACES Publication Database (818 in total)
  135 new articles published on the GEOTRACES website
  122 announcements sent through the GEOTRACES mailing list
  112 new posts on Facebook and 371 likes (top post reach 1,6K)
  240 tweets and 431 followers (top tweet reach 3,1K)
  94 new subscribers on the GEOTRACES website

The IPO thanks Olivier Boebion (IT system administrator at Observatoire Océanologique de Villefranche sur Mer, France) for all his assistance with the GEOTRACES web site.

3.4 GEOTRACES Workshops

Six GEOTRACES workshops were held in the past reporting year including:

Exploring GEOTRACES data with Ocean Data View (Goldschmidt 2016 Workshop), 26 June 2016, Yokohama, Japan.

46 participants from 13 different nations participated in this hands-on workshop which goal was to teach standard and advanced ODV methods for the exploration and scientific analysis of environmental data. The GEOTRACES Intermediate Data Product 2014 (IDP2014) was used as example dataset. Participants learned how to create publication-ready maps, property-property plots and sections, and how to apply simple or advanced station and sample filters. In addition, an overview of the wide range of derived variables available in ODV was given and a number of variables often needed in geochemical research were described and applied.

The workshop started with presentations of general software concepts and capabilities, followed by hands-on sessions for the creation of specific plot types and scientific discussion rounds explaining the findings.

For further information: http://www.geotraces.org/meetings/geotraces-events/eventdetail/263/-/exploring-geotraces-data-with-ocean-data-view

Figure 7. *Participants of the Workshop "Exploring GEOTRACES with Ocean Data View".*

GEOTRACES Indian Ocean Planning Workshop, 29 June 2016, Yokohama, Japan

35 GEOTRACES scientists met in Yokohama (Japan) to discuss the GEOTRACES Indian Ocean implementation plan. This was an occasional workshop held during the Goldschmidt conference in Japan.

As a result of the Workshop, the following up-coming GEOTRACES cruises in the Indian Ocean were identified: India (2 cruises completed in autumn 2016 and winter 2017), Germany (cruise in 2018) and Australia (cruise in 2018). Other nations (France and South Africa) are currently planning cruises in the Indian Ocean.

Joint GEOTRACES/OCB Workshop: "Biogeochemical cycling of trace elements within the ocean: A synthesis workshop", 1 – 4 August 2016, Lamont-Doherty Earth Observatory, Palisades, New York, USA

More than 100 investigators from 12 nations participated in this workshop focused on setting priorities for exploiting GEOTRACES data to advance scientific objectives at the interface between marine geochemistry and marine ecology. This workshop was the second foundational workshop of the GEOTRACES synthesis of results strategy. It was jointly sponsored by the GEOTRACES programme and the Ocean Carbon and Biochemistry activity of the U.S. Carbon Cycle Science Program.

Workshop activities were organised around three scientific themes:
1) Biological uptake and trace element bioavailability,
2) Abiotic cycling and scavenging, including particulate and dissolved speciation, and
3) Export, recycling and regeneration

Following a series of plenary talks designed to stimulate discussion on these topics, workshop participants spent most of the workshop in smaller groups that identified critical knowledge gaps in each of these areas, as well as strategies to meet those needs. Participants defined six topics to be pursued in greater detail in synthesis papers that combine GEOTRACES data with results from other programmes, such as those involving molecular biology. These activities will inform and improve models used to predict how marine ecosystems are going to respond to future environmental changes, including pollution and global warming.

The plenary presentations (PDF files) from the Workshop can be opened and downloaded directly from the agenda available on the workshop web site: http://web.whoi.edu/geotraces-synthesis/agenda/

Main recommendations and anticipated products from the meeting are listed below:

- Explore Redfieldian concepts of elemental stoichiometry using GEOTRACES TEI data
- Estimate Bioavailability of Fe with oceanographic data using "bioavailability envelope" concept of Lis et al., ISME Journal, 2015
- New hypothesis for light and Fe co-limitation in deep chlorophyll maxima
- A Synthesis Paper on "Paradigms of ligand composition and cycling and the degree of confidence in them" will be produced

- Compare radionuclide-based methods ($^{234}Th/^{238}U$; $^{228}Th/^{228}Ra$; $^{230}Th/^{234}U$; $^{210}Po/^{210}Pb$; Pu/Np) to estimate the downward flux of particulate C, N, P, biogenic Si, ^{232}Th, Al, Cd, Fe, Co, Cu, and Mn
- Combine measured TEI distributions with calculated AOU and preformed TEI concentrations to discriminate among effects of abiotic scavenging, biotic uptake and regeneration, and physical transport

A complete list of products is available in the Appendix II to the National Reports to SCOR.

For further information: http://web.whoi.edu/geotraces-synthesis/

First GEOTRACES-TARA meeting, 5 December 2016, video-conference.

This meeting is one of the first products of the joint GEOTRACES/OCB Workshop described above. TARA is a French non-profit organisation that manages voyages to study and understand the impact of climate change and the ecological crisis facing the world's oceans.

The meeting explored collaborations between GEOTRACES and TARA programmes and start mining through the existing "omic" data of the TARA, in order to link metrics from sequences with the GEOTRACES data.

East Asia GEOTRACES Workshop, Trace Element and Isotope study in the Northwestern Pacific and its marginal seas, 16th - 18th January 2017, Sapporo, Hokkaido, Japan

The East Asia GEOTRACES Workshop was held on 16-18 January 2017 in Sapporo, Japan. The main goals were: to evaluate the current status of trace elements and their isotopes (TEI) studies in the Northwestern Pacific Ocean and its marginal seas, and to identify important scientific questions and directions for future regional collaborative studies. For three days a total of 56 registered scientists from China, Germany, Korea, Russia, Taiwan, United States and Japan, took part in the workshop. The workshop consisted of 5 plenary talks, 17 keynote talks and 25 short topics talks related to GEOTRACES & BioGEOTRACES. Early-career researchers were especially encouraged to give a talk, which was very successful. During the workshop regional scientific results, future cruise plans and possible collaborations were discussed. A succeeding workshop is planned for 2018 in China.

For further information: http://geotraces.jp/EAGW2017/

Figure 8. *Participants of the East Asia GEOTRACES Workshop.*

Arctic-GEOTRACES Early Career Researcher Networking Event (ASLO 2017), 26 February 2017, Honolulu, Hawaii

The U.S., European and Canadian Arctic GEOTRACES cruises in 2015 offered a unique and quasi-synoptic view of the Arctic ocean. Twenty seven early career scientists came together to kick off the ASLO Aquatic Sciences meeting in Honolulu, Hawai'i on 27 February 2017 to discuss emerging areas of international scientific collaboration within the Arctic GEOTRACES programme. The workshop was a special chance for early career scientists to meet their international counterparts and engage initial discussions of interdisciplinary research topics between programmes.

Figure 9. *Participants of the Arctic-GEOTRACES Early Career Researcher Networking Event at ASLO 2017.*

3.5 GEOTRACES Summer School

The first GEOTRACES summer school will be held in Brest, France, from 20th to 26th August 2017. It will bring together over 60 students and 20 world-leading international scientists.

The summer school aims at teaching the skills and knowledge necessary for a good understanding of the biogeochemical cycles of trace metals. It will allow PhD students and early career researchers to see how their work fits within the international community of GEOTRACES.

General lectures will be given by international experts in the field of the GEOTRACES programme and practical workshops in the laboratory will be ran throughout the week.

This summer school is supported by LabexMER (https://www.labexmer.eu/fr) and SCOR. At the time this report is written 110 candidatures to participate in the summer school have been received.

GEOTRACES gratefully acknowledges support from SCOR.

For further information: https://geotracesschool.sciencesconf.org/

3.6 Special sessions at international conferences featuring GEOTRACES findings

Several GEOTRACES special sessions were held in major international conferences including:

2016 Goldschmidt Meeting, 26 June–1 July, 2016, Yokohama, Japan.
For further information: http://goldschmidt.info/2016/

GEOTRACES-sessions:

> *12d: Oceanic Cycling of Trace Elements Using Elemental, Isotopic, and Modeling Approaches: Geotracers and Beyond...
> Convenors: Tim Conway, Tristan Horner, Jessica Fitzsimmons, Hajime Obata, Catherine Jeandel, Andrew Bowie, Phoebe Lam

*12f: Elemental and Isotopic Marine Biogeochemistry at a Range of Scales: The Global Ocean, Marginal Seas, and Polar Atmosphere–Sea Ice–ocean Systems
Convenors: Susan Little, Daiki Nomura, Gregory de Souza, Markus Frey, Delphine Lannuzel, Jun Nishioka, Patrick Rafter, Martin Vancoppenolle

*16d: Models of Life and Geochemistry: Integrating Large-Scale Datasets into Global Climate Models
Convenors: Seth John, Tatiana Ilyina, Andy Ridgwell

Challenger Society 2016 Conference - Oceans and Climate, 5–8 September 2016, Liverpool, UK. For further information: https://www.liverpool.ac.uk/challenger-conference-2016/

GEOTRACES-session:

*Trace element and isotope exchange at ocean boundaries
Convenors: Will Homoky (Oxford), Torben Stichel (Southampton) & Susan Little (Imperial)

VII Congresso Brasileiro de Oceanografia (CBO 2016), 5 - 9 November 2016, Salvador - Bahia, Brazil. For further information: http://www.cbo2016.org/

GEOTRACES-session:

*MS5 – GEOTRACES – Brasil
Coordination: Vanessa Hatje (UFBA)

GEOTRACES-training course:

*MC11 – Ocean Data View para iniciantes (Training Workshop)
Speaker: Leticia C. da Cunha (UERJ)

Third Xiamen Symposium on Marine Environmental Sciences (XMAS), 9-11 January 2017, Xiamen, China. For further information: http://mel.xmu.edu.cn/conference/3xmas

GEOTRACES-session:

*Biogeochemical Cycling of Trace Elements in the Ocean: GEOTRACES and Beyond
Convenors: Martin Frank, Jing Zhang, Zhimian Cao

ASLO 2017, Aquatic Sciences Meeting, 26 February - 3 March 2017, Honolulu, Hawaii, USA. For further information: http://www.sgmeet.com/aslo/honolulu2017/default.asp

GEOTRACES-sessions:

*004 - Biogeochemical Cycling of Trace Elements and Isotopes in the Arctic Ocean
Convenors: Greg Cutter, Roger Francois, David Kadko, William Landing, Michiel Rutgers Van der Loeff

*025 - Linking atmospheric deposition to the biogeochemistry of aquatic and marine systems
Convenors: Clifton Buck and Rachel Shelley

029 - REE marine geochemistry in the 21st century: A tribute to the pioneering research of Henry Elderfield (1943-2016)
Convenors: Karen H. Johannesson and Johan Schijf

PAGES Open Science Meeting, 9-13 May 2017, Zaragoza, Spain.
For further information: http://www.pages-osm.org

GEOTRACES-session:

*12. Trace elements and their isotopes as geochemical proxies of past ocean conditions
Convenors: Catherine Jeandel, Robert Anderson, Susan Little, Thomas Marchitto and Daniel Sigman.

Forthcoming:

IUPAC 2017 - World Chemistry Congress, 9-14 July 2017, Sao Paulo, Brazil.
For further information: http://www.iupac2017.org/

GEOTRACES-session:

*5.8 Trace elements cycling, processes and fluxes across interfaces
Energy, Water and Environmental Sciences (EE)
Symposium Organizers: Roberto M. Torresi and Daniel Belanger.
Co-organizer: Vanessa Hatje

Goldschmidt 2017, 13- 18 August 2017, Paris, France.
For further information: http://goldschmidt.info/2017/

GEOTRACES- sessions:

*10i: Cycles of Trace Elements and Isotopes in the Ocean: GEOTRACES and Beyond
Convenors: Tim Conway, Geraldine Sarthou, Tianyu Chen, Gregory de Souza, Aridane G. González, Kristen Buck, Tina van de Flierdt, Walter Geibert, Zhimian Cao, Catherine Jeandel

*10o: The Role of Scavenging in the Ocean: Chemical Processes, Environmental Controls and Modeling
Convenors: Yves Plancherel, Phoebe Lam

*10g: Submarine Groundwater Discharge: Forms, Delivery, Timing, Processes, Pathways and Scaling of Biogeochemical Fluxes
Convenors: Hans Dürr, Nils Moosdorf, Michael Böttcher, Hannelore Waska, Jing Zhang, Walter Geibert

*10h: Non-Conventional Stable Isotopes in the Ocean: Novel Applications, Technological Advances and Future Applications
Convenors: Horner Tristan, Pearce Christopher, Philip Pogge von Strandmann, Kathleen Scheiderich, Juan Carlos Silva-Tamayo

*10k: Atmosphere-Ocean Interactions and Impacts on Ocean Chemistry and Biology
Convenors: Adi Torfstein, Sophie Bonnet, Eyal Rahav, William Landing

*10m: Insights into Ocean Processes Through the Application of Radioactive Tracers
Convenors: Paul Morris, Guizhi Wang, Virginie Sanial

*17g: Paleoceanographic and Paleoclimate proxies: Their standing on Elderfield's proxy development Curve
Convenors: Marie-Laure Bagard, Marie Boye, Oscar Branson, Sambuddha Misra, Guillaume Paris, Kauzyo Tachikawa

3.7 Capacity building

At-Sea Training GEOTRACES gratefully acknowledges support from SCOR to enable one scientist per year from a developing nation to participate in a GEOTRACES cruise.

Sampling Systems It is a goal of GEOTRACES that every nation carrying out oceanographic research should have access to a trace metal-clean sampling system. GEOTRACES offers guidance based on past experience in the design and construction of sampling systems as well as advice in operating these systems as shared facilities.

An updated status of trace metal-clean sampling systems to support GEOTRACES research is provided in the table below. Scientists interested in developing one of these systems for their own use are encouraged to contact the GEOTRACES IPO or any member of the SSC, who will arrange for contact with an appropriate person to provide technical information about the design, construction and cost of a system.

Nation	Status	System/ Carousel	Bottles	Depth
Australia	Complete	Powder coated aluminium, autonomous 1018 intelligent rosette system	12 x 10-L Teflon-lined Niskin-1010X	6000 m; 6 mm Dynex rope
Australia	2nd system (complete)	Polyurethane powder-coated aluminium autonomous Seabird rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	12 x 12-L Teflon-lined OTE external-spring Niskin-style bottles	1750 m 9mm Dyneema rope or 200 m 6 mm Dyneema rope wth coupling to 6000 m CTD wire
Brazil	Complete	GEOTRACES WATER SAMPLER - 24-bottle sampler for use with modem equipped 911plus CTD	24 X 12-L GO-Flo	3000 m; Kevlar cable
Canada	Complete	Powder coated aluminium with titanium CTD housing, Seabird Rosette	24 X 12-L GO-Flo	5000 m conducting Vectran
China - Beijing	Complete	Towed fish	NA	Surface
China - Taipei	Complete	Teflon coated rosette	Multi- size GO-Flo	3000 m; Kevlar line
France	Complete	Powder coated aluminium with titanium pressure housing for CTD	24 X 12-L GO-Flo	8000 m; conducting Kevlar
Germany	CTD and bottles purchased, winch planned	Powder coated aluminium with titanium pressure housings and fittings	27 x 12-L OTE GO-Flo	8000 m; conducting Kevlar
India	Complete	Powder coated aluminum with titanium pressure housings and fittings	24 X 12-L Niskin-X	8000 m; conducting Kevlar
Israel	Complete	Powder coated aluminium, SeaBird Rosette	12 X 12-L Niskin; 8 X 12-L GO-Flo (Teflon coated)	2000 m, steel conducting cable

Italy	Complete	Go-Flo bottles on Kevlar line	5 x 20-L Go-Flos	Kevlar
Japan	Complete	Powder coated aluminium	12-L Niskin-X	7000 m; Vectran conducting cable
Netherlands	Complete	Titanium frame	24 X 12-liter GO-Flo	10000 m; conducting Kevlar
Netherlands	Complete	Titanium frame	24 X 27-liter ultraclean PVDF	10000 m; conducting Kevlar
New Zealand	Complete	Powder coated aluminium	13 X 5-L Teflon-lined Niskin-X; 13 X 5GO-Flo	4000 m; 8 mm Kevlar line
Norway	In development	Standard 12 positions CTD Rosette GO	5-L Niskin-X	
Poland	Complete* (although the steel cable)	Powder coated aluminum, SeaBird Rosette	8x 10L GoFlo	3000m, steel conducting cable
Poland	Complete	Single bottle	10l G-FLO X Teflon coated	300m Kevlar
Poland	Complete	Teflon pump on-line	Surface water pump	1.5m fixed
Poland	In development	Pump CTD	Teflon hose 10mm	Up to 200m
South Africa	Complete	Powder coated aluminium, titanium housing/fittings	24 X 12-liter GO-Flo	6500 m; Kevlar cable
UK	Complete	2 x Titanium frame, Ti pressure housings	24 10-L OTE 24 10-L OTE	2 x 8000m conducting Kevlar
USA - CLIVAR	Complete	Powder coated aluminium	12 X 12-L GO-Flo	1500 m; conducting Kevlar
USA - GEOTRACES	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L GO-Flo	8000 m; conducting Kevlar
USA- University of Alaska Fairbanks	Complete	Seabird Rosette. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	No Kevlar line available yet.
USA- Old Dominion University	Complete	Seabird Rosette. SBE-19plusV2 CTD unit. Powder coated aluminium with Ti parts and pressure housing.	12 X 5-L Teflon-lined Niskin-X	2000 m 0.5-inch Kevlar wire

		Fires at pre-programmable depths		
USA – Polar Programs	Complete	Powder coated aluminium with titanium pressure housings and fittings	12 X12-L Niskin-X	3000 m; conducting Kevlar

4. Plans for coming year

The release of the **Intermediate Data Product 2017 (IDP2017)** at the Goldschmidt Meeting 2017 (13-18 August 2017, Paris, France) will continue to be the top priority for the first trimester of the next reporting period. After the release of the IDP2017, GEOTRACES will focus on seeking feedback from and promoting the use of the IDP2017 data the broad oceanographic community.

In addition, GEOTRACES will continue to **implement the field programme** and its **GEOTRACES synthesis of results strategy** with the third foundational workshop to be held in 2018 in partnership with Past Global Changes project (PAGES). This workshop will be centred on geochemical tracers used as paleoceanographic proxies.

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