GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2013/2014
June 2014

Table of contents

1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

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The SSC membership (listed above) contains representatives of 14 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; 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

Four years after the launch of GEOTRACES, the programme is enjoying a successful implementation. This is true in terms of implementation of the cruise field programme (with more than 50 cruises, 654 stations completed and about 1,014 data sets identified), data management and intercalibration (with the first Intermediate Data Product released in February 2014) and scientific results published (about 450 papers published).

2.1 Status of GEOTRACES field programme

The field programme is progressing very successfully, with 50 cruises already completed (654 stations sampled). At the time this report is written, two more cruises, one French and one Indian, are at sea completing sections in the Atlantic and Indian Oceans, respectively.

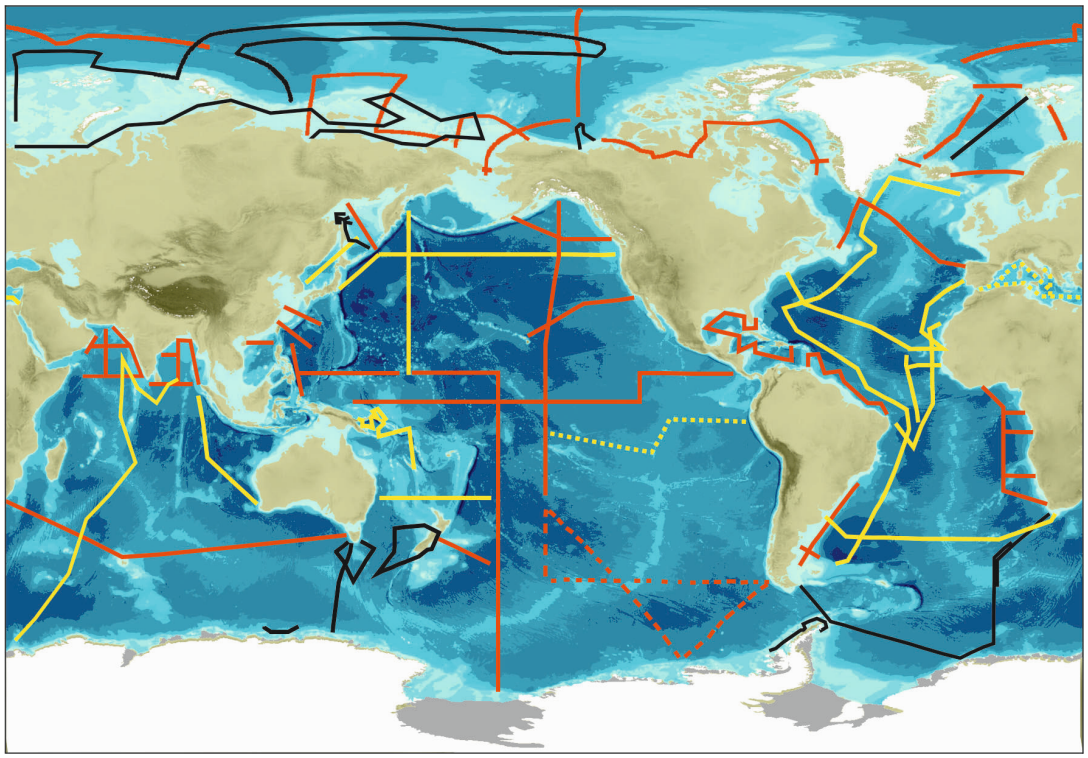

Figure 1. *Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey (dotted yellow, completed during the past year). 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 Product 2014

The GEOTRACES Intermediate Data Product (IDP2014) was successfully released on February 25 at Ocean Sciences Meeting 2014 (Honolulu, Hawaii) during a "town hall" session attended by more than 350 persons. Journals such as *Science* and *Nature* have featured reports describing the release of the product (see later in report).

The IDP2014, containing hydrographical and marine geochemical data acquired during the first three years of the programme, consists of two parts: the **digital data package** and the **eGEOTRACES Electronic Atlas**.

The **digital data package** (available at http://www.bodc.ac.uk/geotraces/data/idp2014/) contains data from 15 cruises and more than 70 hydrographic and geochemical parameters. The data product covers the Arctic, Atlantic and Indian oceans, with data density being the highest in the Atlantic. The growing body of data from the Pacific Ocean will be included in the next data product.

The **eGEOTRACES Electronic Atlas** (available at http://www.egeotraces.org) is based on the digital data package and provides 2D and 3D images of the ocean distribution of many of the parameters, as shown in the figures 2 and 3 below. The 3D images provide geographical context crucial for correctly assessing extent and origin of tracer plumes as well as for inferring processes acting on the tracers and shaping their distribution. The numerous links to other tracers, sections and basins found on section plots and 3D images allow quick switching between parameters and domains to facilitate comparative studies. In addition, eGEOTRACES can help in teaching and outreach activities and can also help convey societally relevant scientific results to interested non-scientists and decision makers.

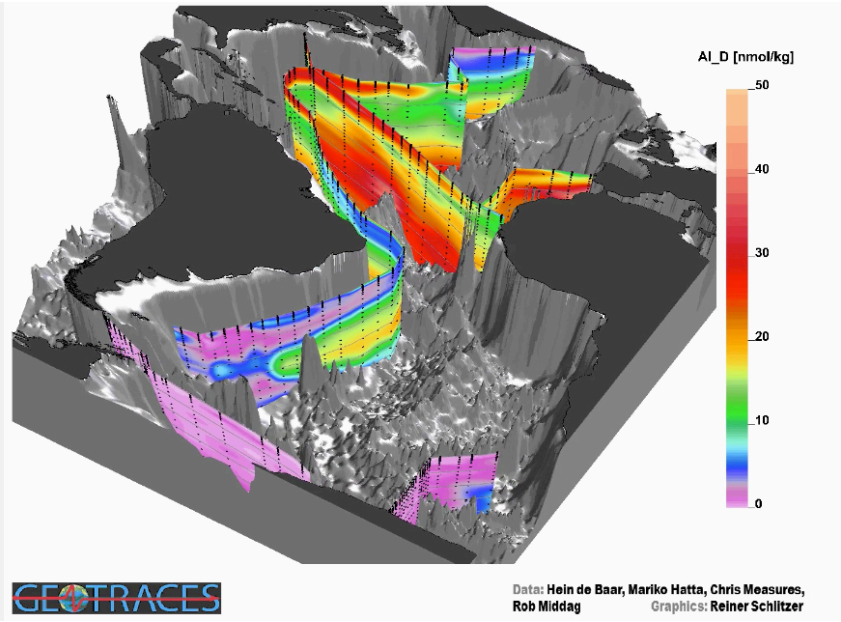

Figure 2. *3D scene showing the distribution of dissolved aluminium (Al) in the Atlantic Ocean. Aluminium is a tracer of terrigeneous inputs: in this image, high surface values are reflecting the dust inputs of Saharan origin between African and U.S. coasts, but there are also high concentrations at depth along the margins, also observed for other tracers, that might reflect Al release from the deposited sediments.*

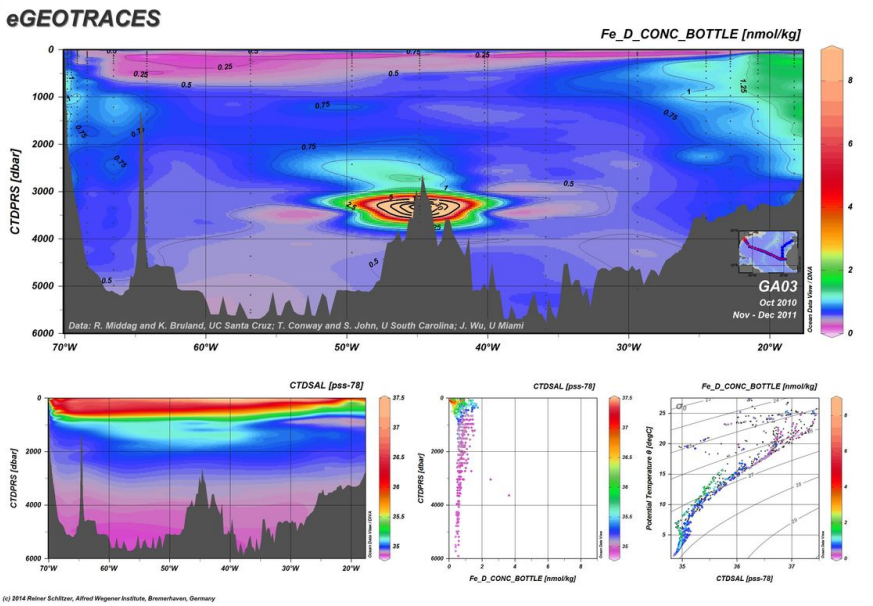

Figure 3. *Full-depth distribution of dissolved iron (Fe) along [GEOTRACES GA03] section in the Atlantic Ocean. Prominent features include the plume of hydrothermal Fe emanating from the Mid-Atlantic Ridge, and high Fe concentrations near the continental margin, especially off NW Africa where margin sediments and Saharan dust both serve as significant sources.*

The IDP2014, as well as other future GEOTRACES data products, will have a digital object identifier (DOI) attached. Users of the data are required to cite the data using the package DOI. Users are also asked to cite all relevant original publications from researchers that made the measurements. Details of publications that should be cited are provided point-by-point in the IDP dataset and are updated on the online database as new papers are published.

Rather than wait until the end of the programme, GEOTRACES sought instead to create and release a product at a time when the programme is very active and actually still expanding, both in terms of the observations as well as scientific analysis of the data produced so far. By releasing and sharing the data now, GEOTRACES intends to strengthen and intensify collaboration within the oceanographic community; specifically, to attract and invite colleagues from other disciplines to join and devote their unique knowledge and skills to marine geochemical problems. At the same time, GEOTRACES is seeking feedback from the ocean research community to improve future data products.

SCOR Booth at Ocean Sciences 2014

In addition of the town hall session, the IDP2014 was also presented in the SCOR Booth at Ocean Sciences Meeting. The booth was equipped with a screen where images from the eGEOTRACES continually displayed, making it possible to make live demonstrations of the product. Interested people were also invited to navigate through eGEOTRACES. In addition, relevant scientific discoveries made in the first three years of the programme were shown in a banner.

Figure 4*. Bob Anderson and Reiner Schlitzer staffing the SCOR Booth at Ocean Science 2014.*

GEOTRACES also handed out USB memory sticks containing the complete *eGEOTRACES* at the town hall event and at the booth. The advantage of the thumb-drive version is that it does not require an Internet connection, so that users can browse the atlas with no download delays.

GEOTRACES is very grateful to SCOR for the opportunity to participate in the SCOR Booth.

2.3 GEOTRACES publications and science highlights

GEOTRACES publications

Since last report, 240 peer-reviewed papers including GEOTRACES scientific results have been added to the GEOTRACES publications database; overall, about 450 GEOTRACES publications have been produced from the beginning of the project. The release of the IDP2014 has been object of broad media coverage, with reports published in printed or on-line versions of newspapers or journals (in Germany alone, reports have been published more than 111 times). Two publications about the IDP2014, one in *Science* and other in *Nature*, merit special mention:

> Malakoff, D. (2014). Oceanography. Chemical atlas shows where seas are tainted--and where they can bloom. *Science* (New York, N.Y.), 343(6175), 1070. doi: 10.1126/science.343.6175.1070
>
> Morrison, J. (2014). Digital atlas shows oceans' iron levels. *Nature*, News. doi: 10.1038/nature.2014.14774

The official magazine of The Oceanography Society, *Oceanography*, has devoted a special issue to the topic of changing ocean chemistry. One paper of this issue is dedicated to the GEOTRACES Programme:

> Anderson, R. F., Mawji, E., Cutter, G. A., Measures, C. I., & Jeandel, C. (2014). GEOTRACES: Changing the way we explore ocean chemistry. *Oceanography*, 27(1), 50–61. doi:10.5670/oceanog.2014.07

In addition, the *Limnology and Oceanography: Methods* special issue devoted to the topic of GEOTRACES Intercalibration is now completed. This open access issue containing 24 papers is available on the following web site: http://www.aslo.org/lomethods/si/intercal2012.html.

Finally, a special issue dedicated to the results of the GEOTRACES Data-Model Synergy Workshop (14-17 November 2011, Barcelona) has been submitted to the journal *Progress in Oceanography*.

GEOTRACES science highlights

Below is a selection of recent GEOTRACES science discoveries:

Slow-spreading ridges could be major oceanic iron contributor

A large dissolved iron- and manganese-rich plume has been detected by Saito and co-authors over the slow-spreading southern Mid-Atlantic Ridge. This discovery calls into question the assumption that deep-sea hydrothermal vents along slow-spreading ridges were negligible contributors to the oceanic iron inventory. This result urges reassessment and a likely increase of the contribution of hydrothermal vents to the supply of iron.

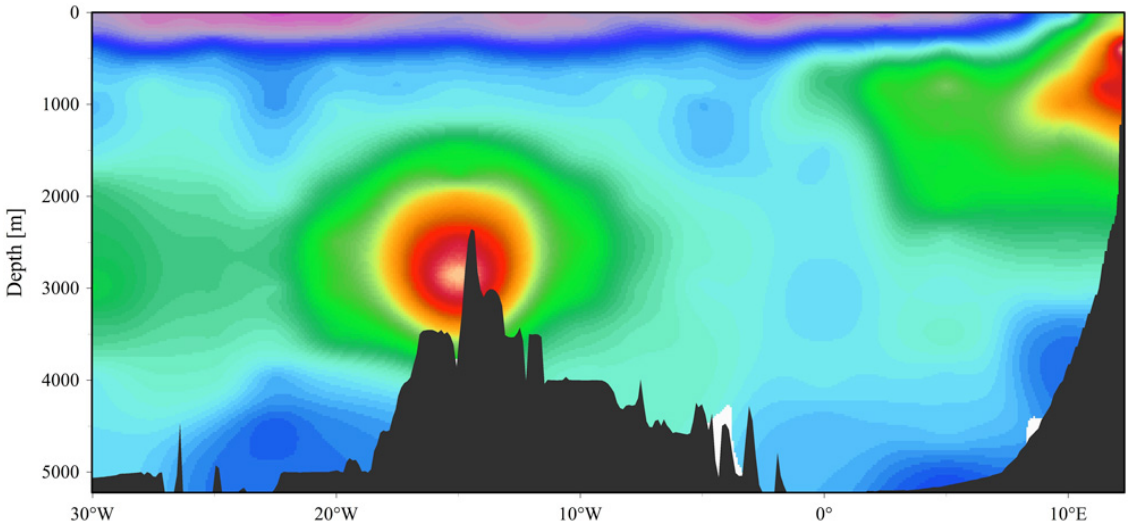

Figure 5. *A zonal section of dissolved iron in the South Atlantic. The higher iron concentrations (in warm colours red, orange) reveal a large plume at ~2,900 m depth and 2 km in height.*

Reference:

Saito, Mak A., Abigail E. Noble, Alessandro Tagliabue, Tyler J. Goepfert, Carl H. Lamborg, William J. Jenkins (2013) Slow-spreading submarine ridges in the South Atlantic as a significant oceanic iron source *Nature Geoscience* 6 (9), 775-770 DOI: 10.1038/ngeo1893

Latest discoveries in zinc concentrations and isotopes in the ocean (4 papers)

Zinc (Zn) is an essential micronutrient for phytoplankton and plays a key role in the productivity of the oceans. Despite the importance of this element, the processes which govern its cycling in the ocean are poorly understood. Thanks to GEOTRACES, an unprecedentedly large volume of data has been reported, revealing fascinating results (4 papers):

Copper and zinc oceanic mass balance revisited

Little and co-workers (2014; see references below) propose an update of the oceanic copper (Cu) and zinc (Zn) mass balance, with the original approach that takes into account the hitherto ignored constraint of their isotopes. They establish an up-to-date inventory of the input fluxes of these tracers with their isotopic signatures, discuss the internal processes that might fractionate both tracers and evaluate one major sedimentary sink: sediments deposited beneath an oxic water column. Although the Cu oceanic mass balance appears to be roughly in balance, the Zn one is far from being constrained... isotopes reveal that either an "isotopically light sink" or "isotopically heavy source" is missing.

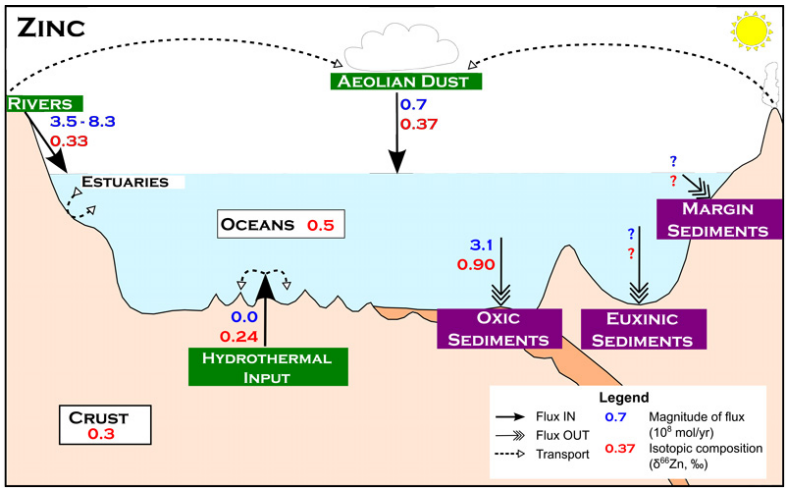

Figure 6. *This figure illustrates the global ocean isotopic mass balance of Zn.*

Sinking organic matter: a major driver of the oceanic zinc cycle?

A new study by John and Conway (2014), presenting the first high-resolution coupled profiles of both dissolved Zn and cadmium (Cd) concentration and isotope ratios from the GEOTRACES North Atlantic (GA03) section, suggests that scavenging of isotopically heavy Zn onto organic matter plays an important role in the surface marine cycling of Zn, and may be important for understanding why Zn, like silicon (Si), has a deeper regeneration in the oceans than nitrogen (N), phosphorus (P) and Cd. The new GEOTRACES data is supported by modelling and culture experiments, which show that whilst Cd and major nutrients are quickly released as phytoplankton degrade, a significant portion of the Zn is instead scavenged back onto organic matter.

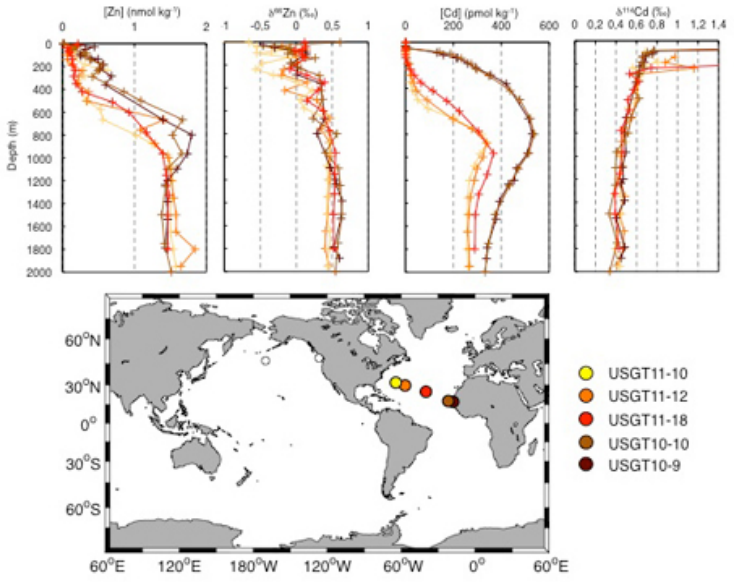

Figure 7. *Zn and Cd concentration and stable isotope profiles along the North Atlantic GA03 section.*

First full depth profiles of zinc isotopes in the ocean, thanks to IPY/GEOTRACES cruise (GIPY5)

Three major and original features are deduced from the first three full-depth profiles of zinc measured by Zhao and co-workers (2014) in the Southern Ocean:

- below 1000 m, the comparison of the results with North Atlantic and Pacific data reveals that the oceanic zinc (Zn) isotopic composition appears to be homogeneous ($\delta^{66}Zn = +0.53 \pm 0.14$ per mil (2SE = 0.03, n = 21)).
- oceanic Zn isotopic composition is more variable in the upper 1000 m ($\delta^{66}Zn$ values are more variable); these new Zn isotope data are consistent with a scenario whereby Zn removal from the surface ocean occurs via two processes: a dominant one that does not involve an isotopic fractionation (incorporation of Zn into organic matter associated with only diatom frustules, a type of phytoplankton) and a lesser one that preferentially removes the light isotope (metabolic uptake into the cells of all phytoplankton).
- a mass balance calculation is proposed to explain the homogeneous Zn isotopic composition of the deep ocean. The $\delta^{66}Zn$ value is slightly heavier than all the possible external sources (~+0.35 per mil). Thus, an isotopically light sink is required but not identified yet. The author's working hypothesis is that the burial of isotopically light Zn in cellular organic matter could represent the light sink from the oceanic dissolved pool.

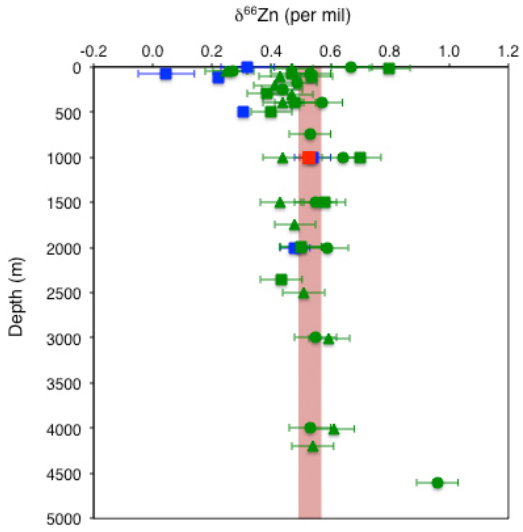

Figure 8. *Zinc (Zn) isotopic data for IPY GEOTRACES samples from the Southern Ocean (green), plotted with data from the same laboratory for the GEOTRACES BATS intercalibration site in the Atlantic (blue, Boyle et al., 2012) and for the SAFe sample at 1000m in the Pacific (red). There is variability in Zn isotopes at depths shallower than about 500m, and a sample from the sediment-water interface in one depth profile at 67°S is anomalous, but in between all seawater samples yet published have a mean δ^{66}Zn of 0.53 per mil, with a spread of only 0.06 per mil (± 2 standard errors of the mean).*

What does the largest data set of zinc concentration ever reported tell us?

Wyatt and colleagues (2014) measured Zn distribution at high resolution (556 discrete samples) between Cape Town and Montevideo in the South Atlantic Ocean (40°S) on board the UK GEOTRACES GA10 cruise.

The reported surface Zn concentrations are among the lowest reported for the world's oceans (0.015 – 0.39 nM). An intriguing result was the fact that Zn concentrations were very low down to depths of 500 m, which was similar to that of silicate (Si) concentrations. Using the strong relationship between Zn and Si, the authors present a new tracer Zn* (Zn* = Zn - 0.065 x Si + 0.209), which illustrates that Zn is removed from surface waters in the Southern Ocean and remineralised deeper in the water column. This results in very low Zn concentrations in Sub-Antarctic-Mode Water (SAMW), which is the main pathway for supplying nitrate and phosphate to the thermocline waters of the South and North Atlantic. These low Zn concentrations in SAMW may result in growth-limiting Zn concentrations in the surface waters of both the South and North Atlantic sub-tropical gyres.

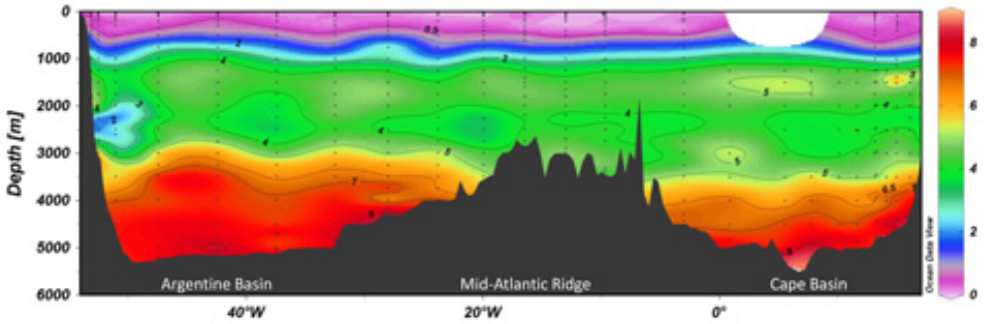

Figure 9. *Concentrations of Zn along GA10 section (~40°S). Warm colours indicate high concentrations.*

References:

Boyle, E. A., John, S., Abouchami, W., Adkins, J. F., Echegoyen-Sanz, Y., Ellwood, M., Flegal, A. R., Fornace, K., Gallon, C., Galer, S. (2012). GEOTRACES IC1 (BATS) contamination-prone trace element isotopes Cd, Fe, Pb, Zn, Cu, and Mo intercalibration. Limnology and Oceanography: Methods, 10, 653–665. doi: 10.4319/lom.2012.10.653

John, S. G., & Conway, T. M. (2014). A role for scavenging in the marine biogeochemical cycling of zinc and zinc isotopes. Earth and Planetary Science Letters, 394, 159–167. doi:10.1016/j.epsl.2014.02.053.

Little, S. H., Vance, D., Walker-Brown, C., & Landing, W. M. (2014). The oceanic mass balance of copper and zinc isotopes, investigated by analysis of their inputs, and outputs to ferromanganese oxide sediments. Geochimica et Cosmochimica Acta, 125, 673–693. doi:10.1016/j.gca.2013.07.046

Wyatt, N. J., Milne, A., Woodward, E. M. S., Rees, A. P., Browning, T. J., Bouman, H. A., Worsfold, P. J., Lohan, M. C. (2014). Biogeochemical cycling of dissolved zinc along the GEOTRACES South Atlantic transect GA10 at 40°S. Global Biogeochemical Cycles, 28(1), 44–56. doi:10.1002/2013GB004637.

Zhao, Y., Vance, D., Abouchami, W., & de Baar, H. J. W. (2014). Biogeochemical cycling of zinc and its isotopes in the Southern Ocean. Geochimica et Cosmochimica Acta, 125, 653–672. doi:10.1016/j.gca.2013.07.045.

Determining simultaneously iron, zinc and cadmium isotopes in small volumes of seawater is possible now!

The first simultaneous method for the determination of these three isotope systems in seawater has been published. This method is designed for use on only a single litre of seawater, representing a 1–20 fold reduction in sample size and a 4–130 decrease in blank compared to previously reported methods. The procedure yields data with high precision for all three elements, allowing estimation of natural variability in the oceans, which spans 1–3‰ for all three isotope systems. Simultaneous extraction and purification of three metals makes this method ideal for high-resolution, large-scale endeavours such as the GEOTRACES program.

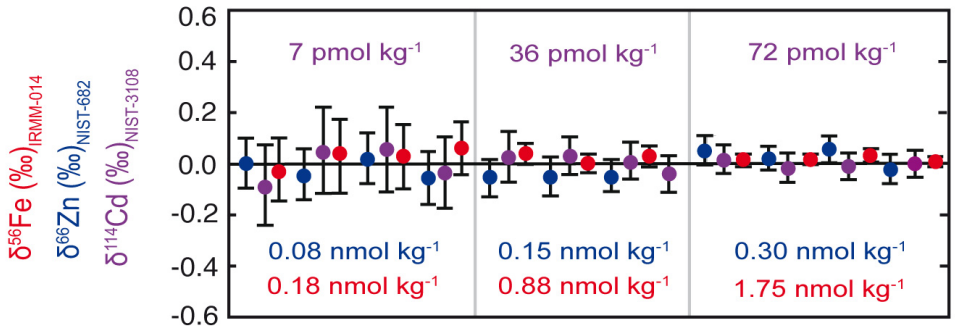

Figure 10. *'Metal-free' seawater doped with varying concentrations of 'zero' isotope standards, processed through the simultaneous method, and then analysed by double spike MC-ICPMS for Fe, Zn and Cd isotope ratios. All values were determined within 2 sigma error (error bars shown) of zero.*

Reference:

Tim M. Conway, Angela D. Rosenberg, Jess F. Adkins, Seth G. John (2013), A new method for precise determination of iron, zinc and cadmium stable isotope ratios in seawater by double-spike mass spectrometry, *Analytica Chemica Acta*, Volume 793, Pages 44-52, DOI: 10.1016/j.aca.2013.07.025.

New data on oceanic rare earth elements concentrations and neodymium isotopic compositions (3 papers)

Early 2014 was favourable to the publication of new data of rare earth elements (REE) concentrations and neodymium (Nd) isotopic compositions in extreme areas of the ocean: the southern Atlantic Ocean, the northeast corner of the Pacific Ocean and the remote South Pacific Ocean. Three different groups (Garcia-Solsona et al.; Haley et al.; Molina-Kescher et al.; see references below) published in *Geochimica Cosmochimica Acta* on REE distributions.

These three works confirm the conservative behaviour of Nd isotopic composition far from main biogeochemical disturbances, such as lithogenic inputs or significant biological activity. But more importantly, they reveal features in the behaviours of the REE that might need to be considered more closely. These features rely on particle/dissolved exchanges that are not understood yet, but they also yield unexpected decoupling along the REE array.

In January 2014 (Vol. 125), Garcia-Solsona and co-workers (Toulouse, France) described the distribution of dissolved and particulate REE and seawater Nd isotopic composition in samples from the IPY/GEOTRACES Bonus Good Hope (BGH) cruise between South Africa and the Southern Ocean (57°S). This work

- demonstrates the role of the South African submarine margins as sources of neodymium; shows that at open-ocean stations, dissolved and particulate REEs have acquired a marine signature (particles present negative cerium anomalies) as a result of dissolved/particulate exchange likely driven by the biological activity;
- reports positive Lanthanum (La) anomalies, observed in both particulate and dissolved phases, that could be linked to the oceanic barium cycle and the partial dissolution of barite crystals;
- finds that Nd isotopic composition behaves conservatively in the Antarctic Circumpolar Current (ACC), supporting the use of εNd as a water mass mixing tracer in BGH deep waters.

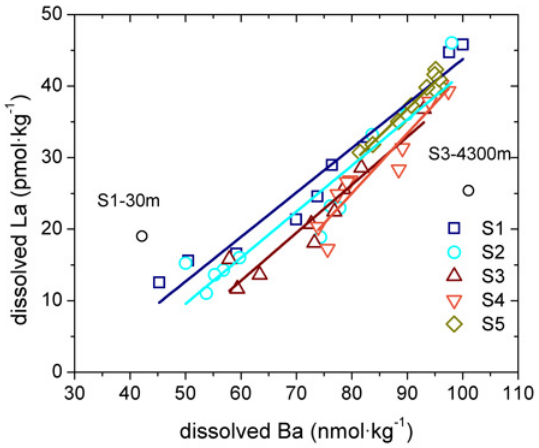

Figure 12. *This figure shows linear correlations between dissolved La and Ba concentrations.*

Two weeks later (Vol 126) Haley and co-workers (Corvallis, USA) presented the first combined distributions of dissolved REEs and Nd isotopes in the Gulf of Alaska. They reveal for the first time that:

- εNd signatures allow tracing eddies that carry shelf waters to open gyre regions;
- two pools of REEs could be distinguished in this productive area using a statistical approach: one pool complexed to carbonate ion and largely behaving "quasi-conservatively", the second pool "bioreactive" and complexed by organic molecules as siderophores and only significant in the near surface ocean;
- the conservative fraction of the REE and its Nd isotopic composition is consistent with the hypothesis that a pool of seawater older than 1000 years is maintained in this far northeast Pacific Ocean, as already indicated by ^{14}C ages.

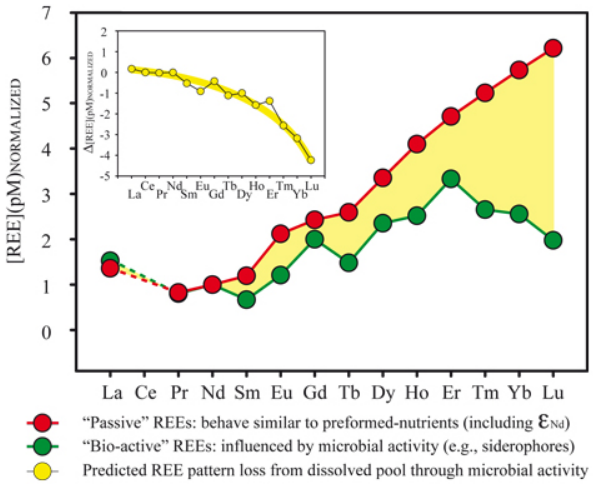

Figure 13. *REE patterns.*

In early February 2014 (vol 127), Molina-Kescher and co-workers (Kiel, Germany) proposed the first detailed analysis of dissolved Nd isotopes and REEs in intermediate and deep waters along a zonal transect between South America and New Zealand (~40°S). These authors:

- confirm the reliability of εNd as water mass tracer in this area;
- propose the tagging of South Pacific water masses never done before. Among others, they identify the influence of residual North Atlantic Deep Water (NADW) in the westernmost South Pacific, characterised by the most negative εNd;
- demonstrate that biogeochemical cycling and scavenging processes in the Eastern Equatorial Pacific and release of LREEs from the sediment in the southeast Pacific Ocean influence the distribution of the dissolved REE concentrations.

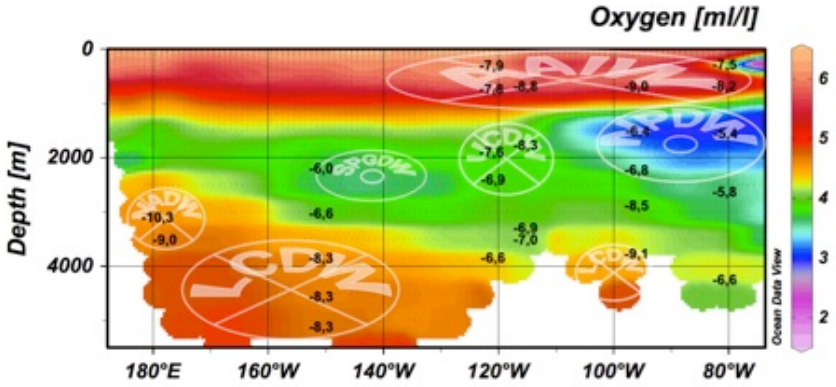

Figure 14. *Zonal cross section along the South Pacific at ~40°S showing oxygen concentrations (ml/l), represented by the colour gradient, and measured εNd signatures (black values) at their corresponding depths. The flow direction of the water masses are also shown by transparent circles, where crosses represent the sense of movement into the picture and centred dots represent movement out of the picture. Water mass abbreviations: LCDW (Lower Circumpolar Deep Water), NADW (North Atlantic Deep Water), AAIW (Antarctic Intermediate Water), SPGDW (South Pacific Gyre derived Deep Water) and NPDW (North Pacific Deep Water). Oxygen concentrations are from the database of the World Ocean Atlas 09.*

References:

Garcia-Solsona, E., Jeandel, C., Labatut, M., Lacan, F., Vance, D., Chavagnac, V., & Pradoux, C. (2014). Rare earth elements and Nd isotopes tracing water mass mixing and particle-seawater interactions in the SE Atlantic. *Geochimica et Cosmochimica Acta*, 125, 351–372. doi:10.1016/j.gca.2013.10.009.

Haley, B. A., Frank, M., Hathorne, E., & Pisias, N. (2014). Biogeochemical implications from dissolved rare earth element and Nd isotope distributions in the Gulf of Alaska. *Geochimica et Cosmochimica Acta*, 126, 455–474. doi:10.1016/j.gca.2013.11.012.

Molina-Kescher, M., Frank, M., & Hathorne, E. (2014). South Pacific dissolved Nd isotope compositions and rare earth element distributions: Water mass mixing versus biogeochemical cycling. *Geochimica et Cosmochimica Acta*, 127, 171–189. doi:10.1016/j.gca.2013.11.038.

New revelations on boundary scavenging in the North Pacific

Thorium (Th) and protactinium (Pa) are very efficient tracers of particle dynamics in the ocean. More particularly, their relative distributions inform on the intensity of "scavenging", in other words, the processes that remove dissolved elements from seawater by their precipitation or adsorption on particles. Thanks to 12 new profiles in the North Pacific, Hayes and co-authors observe a much larger relative difference in scavenging intensity between the Subtropical gyre and Subarctic Pacific gyre than within each of these regions. This effect is greater for Pa than for Th, likely reflecting the fact that biogenic silica, a phase produced by diatoms which has a strong affinity for Pa, is much more prevalent in the North. While highlighting the role of biogeography, the study also finds that in the deep ocean, manganese oxides, an inorganic phase, may play an additional role in Pa scavenging.

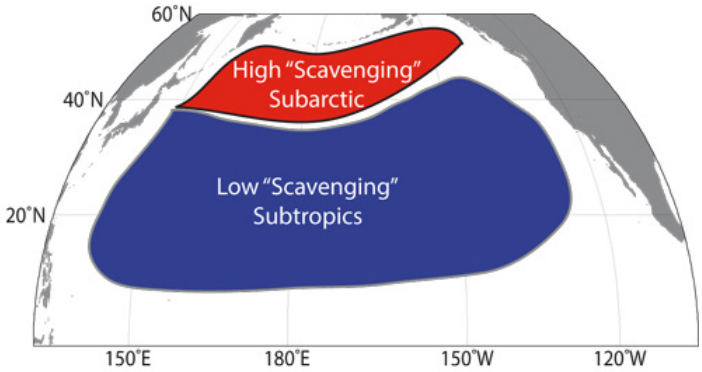

Figure 11. *Simplified figure showing scavenging intensity in the Pacific Ocean.*

Reference:

Hayes, C. T., Anderson, R. F., Jaccard, S. L., François, R., Fleisher, M. Q., Soon, M., & Gersonde, R. (2013). A new perspective on boundary scavenging in the North Pacific Ocean. *Earth and Planetary Science Letters*, 369-370, 86–97. doi: 10.1016/j.epsl.2013.03.008.

3. Activities

3.1 GEOTRACES intercalibration activities

During the 2012-2013 period, three major S&I Committee meetings occurred in order to review data that would eventually be incorporated into the 2014 Intermediate Data Product. Almost all of these data were from the GEOTRACES Crossover Stations where two section cruises occupied the same station during their transects. The S&I Committee members who reviewed these data were: Gregory Cutter (Chair; Old Dominion University, USA), Per Andersson (Swedish Natural History Museum), Louis Codispoti (University of Maryland, USA), Peter Croot (National University of Ireland, Galway), Roger Francois (University of British Columbia, Canada), Maeve Lohan (University of Plymouth, UK), Hajime Obata (University of Tokyo, Japan), and Michiel van der Loeff (Alfred Wegner Institute, Germany).

The first meeting to review TEI data was hosted by Maeve Lohan at the University of Plymouth in March 2012. Data and metadata from 6 Crossover Stations in the Atlantic Ocean were examined, totalling approximately 3600 pieces of data reviewed and discussed during the 3-day meeting. Although little radionuclide or particulate results were available for this review, we learned a lot about how to conduct the reviews for the 2013 meetings when more data would be available. One of the major problems we encountered was that most of these data had not been submitted to the GEOTRACES International Data Assembly Centre, so we had to reach out to investigators to collect them. Moreover, metadata were either missing or poorly presented, making the Committee's tasks much more difficult. These and other lessons learned were then applied to the 2013 meetings and in particular, there was a December 2012 deadline to submit data to GDAC for review by the S&I Committee and eventual incorporation into the IDP.

The second data review meeting occurred in May 2013 at the Swedish Museum of Natural History in Stockholm and was hosted by Per Andersson. All the data and metadata were compiled at GDAC, making the process of evaluations much easier. Our major effort was examining the Atlantic Crossover Stations and we completed all of these for which sufficient TEI results were available. All data

originators were sent our evaluations (meets individual TEI criteria; doesn't meet criteria, but with more information may be acceptable; doesn't meet criteria for multiple reasons and likely cannot be accepted), and they were asked to submit their revised data and metadata, and explanations for any discrepancies, by the end of August 2013 for our second meeting in September 2013. The reviewed data represented the bulk of hydrographic and TEI results that would be placed in the 2014 IDP, so this meeting represented a major step towards compiling the first 4 years of GEOTRACES field data.

The third S&I Committee meeting during the 2012-2013 period was held in conjunction with the Data Management Committee just prior to the International SSC Meeting in Bremerhaven, Germany at the Alfred Wegner Institute. The S&I Committee reviewed revised data that were based on recommendations from the May meeting, and additionally examined data from the Japanese Indian Ocean cruise (GI04) for which there was no crossover station. In the case of GI04, the cruise followed Intercalibration protocols by taking replicates samples and distributing them to various labs for TEI determinations. This was the first time the Committee had examined such data. Results indicated that the procedure worked very well. We also reviewed some of the Crossover Station data from 2009 IPY cruises that had not been previously examined. The Committee then met jointly with the DMC to recommend which data sets should be placed in the 2014 IDP.

After the last 2013 meeting, two members of the S&I Committee, Lou Codispoti and Roger Francois, completed their terms on the Committee and stepped down. The SSC Chairs sent them thank you letters for their years of service to GEOTRACES. Two new members were appointed: Karen Casciotti from Stanford University, USA, and Tina van der Flierdt, UK. Both of these scientists had served as Elemental Coordinators during the first intercalibration phase of GEOTRACES and are therefore ideal as the newest members of the Committee. In this respect, another intercalibration milestone during 2012 was the final publication/completion of the special volume of Limnology and Oceanography: Methods on Intercalibration in Chemical Oceanography in which much of the GEOTRACES intercalibration results from the 2008 and 2009 cruises are presented: http://www.aslo.org/lomethods/si/intercal2012.html. Finally, the Committee completed revisions of individual sections of the GEOTRACES Sampling Protocols by the end of 2013 for general editing, collating, and placement on the web site in 2014.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanography Data Centre (BODC), Liverpool, UK. GDAC is responsible for all GEOTRACES data activities from start to finish, including interacting with the Principal Investigators (PI) and national data centres, maintaining the data website, updating GEOTRACES maps and BODC's address book, liaising with the GEOTRACES data management committee and standards and intercalibration committee. GDAC will eventually become the central point for all GEOTRACES data; the office is staffed by a single person: Edward Mawji.

This year, GDAC would like to highlight the following tasks:

GEOTRACES Intermediate Data Project

In 2014, GEOTRACES released an intermediate data product (IDP) at the Ocean Sciences Meeting in Honolulu, Hawaii, USA. All of GDAC's efforts in 2013/2014 have focused on preparing the IDP2014.

The IDP was divided into two parts: tier 1 data and tier 2 data. Tier one data has been assessed by the Standards and Intercalibration committee (S&I) and has been deemed to meet the high data quality of GEOTRACES. Tier two data has not been intercalibrated/quality controlled by the S&I Committee. To help the S&I Committee carry out this role, GDAC spent considerable effort compiling data from crossover stations and supplying the supporting metadata. This process was very successful, although valuable lessons were learned that will be used when preparing the next IDP. In the future, improved communication between GDAC and the S&I Committee will be sought. The time frame allowed for the S&I Committee to quality control (QC) data was unrealistic; this unfortunately altered all other deadlines. For example, the final submission of QC data to GDAC was changed to 17 December 2013 leaving GDAC with a near impossible task of preparing data for the IDP2014 release in February.

GDAC's main role in preparing for the IDP2014 was to quality control metadata and load intercalibrated data from the IPY and GEOTRACES section cruises into BODC's database. Detailed data and metadata checks were carried out and XML method and quality control documents were created.

Working with the IPO

A good working mechanism has been established between GDAC and Elena Masferrer Dodas at the IPO. Information is freely exchanged between the two sites. The IPO has helped GDAC keep up to date with new developments and upcoming cruises. This year, the IPO has been hugely important in helping GDAC prepare the GEOTRACES IDP2014 and was fundamental in distributing tier 1 and tier 2 documents, keeping track of scientists' replies in regards to having their data included in the IDP2014.

Data overview

The data management of the project is now a huge undertaking, with 50 cruises associated with GEOTRACES and 1,014 data sets identified in BODCs database (expected to rise once missing metadata forms are submitted). More than 200 scientists have taken part in GEOTRACES cruises, with 14 different nations having run a major GEOTRACES/IPY section cruise or process study.

2013/2014 has been a successful period; considerable progress has been made collecting data, especially from the IPY cruises and section cruises included in the IDP2014. A massive effort was made over the last 12 months by the GEOTRACES research community to submit data to national data centres and GDAC. U.S. (with BCO-DMO) and Dutch scientists have really led the way and deserve a special mention.

Summary of GEOTRACES cruises
- 12 IPY cruises
- 5 compliant cruise
- 13 process studies
- 20 GEOTRACES cruises -14 sections

Six section cruises have taken place in the last 20 months; collecting data from these cruises and older section cruises will be the GDAC priority over the coming year.

In summary, GDAC policies are proving effective with clear results; PIs are following guidelines and metadata are being submitted in a timely manner.

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 web site and Facebook page; 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.

This has been a special year for the GEOTRACES programme and thus, the IPO, due to the release of the IDP2014. The IPO has been highly involved in the preparation of the IDP2014 and therefore, we would like to highlight the main tasks of the IPO in relation to the IDP:

- Assisting GDAC in keeping track of scientists' replies in regards to having their data included in the IDP2014.
- Building the IDP2014 publications on-line database and maintaining it up-to-date.
- Organising the GEOTRACES Intermediate Data Product Town Hall at Ocean Science Meeting 2014 (24 February 2014, Hawaii, USA).
- Coordination of the preparation of the eGEOTRACES thumb drives.
- Preparing materials for the release of the IDP2014 including:
    - 2 special issues of the GEOTRACES eNewsletter
    - 1 banner showing main relevant findings of the programme
    - 1 new brochure describing the IDP2014
    - Preparation of press releases about the IDP2014
- Communicating the release of the IDP2014 broadly. Special attention was given to identify and communicate it to main stakeholders in each national country, as well as other scientific communities that could be interested in the product.
- Assisting in the coordination of the SCOR Booth at Ocean Science and staffing it.
- Assisting in the organisation of the GEOTRACES Intermediate Data Product Town Hall that will be held at Goldschmidt 2014 (June 10, 2014, Sacramento, USA).

The number of GEOTRACES publications including scientific results is increasing progressively. The IPO is doing an important job of tracking GEOTRACES publication and preparing science highlights of main relevant findings. Since June 2013, 240 new peer-reviewed papers have been added in the database, which represents more than a doubling the total number of publications included (currently it contains 450 publications in total) since the last annual report to SCOR.

With 7 issues published, the bimonthly eGEOTRACES eNewsletter it is now well consolidated. The eNewsletter is very well received by the GEOTRACES community and the IPO is receiving very positive feedback about it.

3.4 Special sessions at international conferences featuring GEOTRACES findings

The major event this year has been the release of the GEOTRACES Intermediate Data Product at the Ocean Science Meeting 2014 (February 25, Honolulu, Hawaii, USA). The town hall session was very successful, with more than 350 participants and a special ovation from the public when the first eGEOTRACES 3D scene was displayed.

A second town hall session to introduce the Intermediate Data Product 2014 will be held at Goldschmidt 2014 (June 10, Sacramento, California, USA).

In addition, several special sessions with relevance to GEOTRACES were featured or planned in major international conferences including:

2013 Gordon Research Conference on Chemical Oceanography: Theme - Chemical Geography of the Sea, 4-9 August 2013, University of New England Biddeford, ME, United States.
For more information: http://www.grc.org/programs.aspx?year=2013&program=chemocean

*Overview of the US GEOTRACES North Atlantic Section
Discussion Leader: Robert Anderson (Columbia University)

*Results from US GEOTRACES North Atlantic Section
Discussion Leader: Laurie Juranek (Oregon State University)

*Benthic and nearshore processes
Discussion Leader: Lelia Hawkins (Harvey Mudd College)

Goldschmidt 2013, 25-30 August 2013, Florence, Italy.
For more information: http://goldschmidt.info/2013/index

*17d Isotopic and elemental tracers of marine biogeochemistry and circulation
Convenors: Seth John, Julie Granger, Katharine Pahnke and Gregory F. de Souza

*17g Metal-biota interactions in seawater
Convenors: Jay Cullen, Maeve Lohan and Martha Gledhill

*17b. Constraining rates of ocean processes
Convenors: Laura Robinson and Matt Charette

11th International Conference on Paleoceanography, 1-6 September 2013, Sitges, Spain.
For more information: http://www.icp2013.cat

*Invited plenary "Perspectives Lecture" publicising the forthcoming Intermediate Data Product: "New insights into geochemical proxies from GEOTRACES" by Bob Anderson.

Ocean Science Meeting 2014, 23-28 February 2014, Honolulu, HI, United States.
For more information: http://www.sgmeet.com/osm2014/default.asp

*018 - Advancing the frontiers of the Si cycle in terrestrial, coastal, and open ocean ecosystems
Organisers: Paul Treguer, European Institute for Marine Studies; Joanna Carey, U.S. Environmental Protection Agency; Mark Brzezinski, Marine Science Institute, University of California; Christina De La Rocha, European Institute for Marine Studies; Robinson Fulweiler, Boston University; Manuel Maldonado, Centro de Estudios Avanzados de Blanes.

*037 - Dynamics of Coupled Processes in the Ocean: A tribute to the career of Dr. James Murray
Organisers: Laurie Balistrieri, USGS/UW Oceanography; Kathryn Kuivila, USGS; Hans Jannasch, MBARI

*080 - Biogeochemistry of Trace Elements and their Isotopes
Organisers: Rob Middag, University of Otago; Alessandro Tagliabue, University of Liverpool; Peter Sedwick, Old Dominion University; Claudine Stirling, University of Otago; Andrew Bowie, University of Tasmania; Jingfeng Wu, University of Miami.

*092 - From VERTEX to GEOTRACES: honoring Ken Bruland's contributions to marine biogeochemical cycles
Organisers: Gregory Cutter, Old Dominion University; Ana Aguilar-Islas, University of Alaska; Kristen Buck, Bermuda Institute of Ocean Sciences; William Landing, Florida State University; Maeve Lohan, Plymouth University.

*114 - Application of natural and anthropogenic radionuclides to the study of ocean processes
Organisers: Matt Charette, WHOI; Marcus Christl, ETH Zurich; Nuria Casacuberta, ETH Zurich; Ken Buesseler, WHOI.

*116 - Advances in approaches to assess metal-binding organic ligands and perspectives on the impacts of ligands on metal-biota interactions in the oceans
Organisers: Maeve Lohan, University of Plymouth; Kristen Buck, Bermuda Institute of Ocean Sciences; Sylvia Sander, University of Otago.

*146 - Marine micronutrient trace element cycling in oxygen minimum zones
Organisers: David Janssen, University of Victoria; Maija Heller, University of Southern California; Christina Schallenberg, University of Victoria.

*060 - Submarine Groundwater Discharge - from Ridge to Reef: Groundwater Evolution, Climate, Land-Use, Coastal Hydrology and Marine Biogeochemical Impacts
Organisers: Steven Colbert, University of Hawaii Hilo; Henrieta Dulaiova, University of Hawaii; Craig R. Glenn, University of Hawaii; Jason Adolf, University of Hawaii

Forthcoming:

International Conference on Atmospheric Dust, 1-6 June 2014, Castellaneta Marina, Italy.
For further information: http://www.dust2014.org

*Dust in the Sea -- Impact on Biogeochemistry and Climate
Organisers: Christel S. Hassler, Université de Genève and Véronique Schoemann, Université Libre de Bruxelles.

Goldschmidt 2014, 8-13 June 2014, Sacramento, California, United States.
For further information: http://goldschmidt.info/2014/index

*17e: Trace Elements, Microbes, and Biogeochemical Cycles in the Ocean Environment
Co-convenors: Kathy Barbeau, Maite Maldonado, Benjamin Twining

*16g: Sources, sinks and stores: integrating isotope and geochemical proxies for past and present surface processes, from elementary reactions to global change
Co-convenors: Tim Conway, Penelope Lancaster, Damien Lemarchand

3.5 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. These opportunities are vital to the development of technical expertise in sampling and sample handling for contamination-prone elements aboard "dirty" ships.

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. A complementary goal is to establish a program whereby scientists who have accrued experience in operating these systems can share that knowledge with scientists from nations that either are in the process of acquiring clean sampling systems.

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 General Oceanics 1018 intelligent rosette system	12 x 10-L Teflon-lined Niskin-1010X	6000 m; 6 mm Dynex rope
Australia	2nd system (in progress)	Polyurethane powder-coated aluminium Seabird rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	12 x 10-L Teflon-lined OTE external-spring Niskin-style bottles	6000 m 24mm Dyneema rope
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	2300 m; conducting Vectran soon to be upgraded with 5000 m conducting Vectran 06/2013
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 aluminium with titanium pressure housings and fittings	24 X 12-L Niskin-X	8000 m; conducting Kevlar
Italy	Complete	Go-Flo bottles on Kevlar line	5 x 20-L Go-Flos	Kevlar
Japan	Complete	Powder coated aluminium	12-L Niskin-X	10000 m; titanium armored 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	5-L Teflon-lined Niskin-X	4000 m; 8 mm Kevlar line
South Africa	Complete	Powder coated aluminium, titanium housing/fittings	24 X 12-liter GO-Flo	6500 m; Kevlar cable
UK	In testing phase	Titanium frame, Ti pressure housings	24 10-L OTE	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. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	2000 m 0.5-inch Kevlar wire
USA – Polar Programs	Complete	Powder coated aluminium with titanium pressure housings and fittings	12 X12-L Niskin-X	3000 m; conducting Kevlar

4. GEOTRACES budget

GEOTRACES receives income from several nations. In the 2013-2014 period, income has been received from Dutch, French, German, Japanese, U.K., and U.S. sources. This multinational funding has been important for GEOTRACES. From the United States, the National Science Foundation is the major contributor to the work of GEOTRACES and in the reporting period, one grant ended and another one started. The current grant expires on 31 August 2015. The balance shown at the end of 2014 will be used for the first 8 months of 2015 until a new grant should start.

	2013	2014
Income		
Carried over from 2009 NSF Grant		
GDAC	$34,251	
IPO	$41,850	
SSC and Other Activities	$56,638	
Carried over from 2012 NSF Grant		
GDAC	$33,333	$276,775
IPO	$13,333	$97,859
SSC and Other Activities	$14,167	$116,488
NSF Funding for GEOTRACES-current year		
GDAC	$100,000	
IPO	$40,000	
SSC and Other Activities	$49,333	
UK funds for DMO	$42,533	
Japanese funding for IPO	$5,000	
Dutch funding for IPO	$13,450	
GEOMAR funding for IPO	$13,450	$13,450
AWI funding for IPO	$13,450	$13,450
French funding for IPO	$23,643	$23,643
Totals		
GDAC	$210,117	$276,775
IPO	$164,176	$148,401
SSC and Other Activities	$120,138	$116,488
Total Income	$494,432	$541,664
Expenses		
GDAC	$127,429	$129,897
IPO	$94,423	$96,873
SSC and Associated Meetings	$58,532	$50,970
Separate S&I Committee Meetings	$16,285	$15,000
Model-Data Synthesis meetings		
Particles Workshop	$10,126	
Intermediate Data Product		$5,459
Atlantic Synthesis Meeting		$20,000
Total Expenses	$306,795	$318,200
Balance	$187,637	$223,465

5. Plans for coming year

Field programme

Main cruises in the forthcoming year will happen in the Pacific and, specially, in the Arctic implementing the international GEOTRACES research Arctic programme defined during the GEOTRACES Arctic Workshop held in Vancouver, Canada, on 2-4 May 2012 (http://www.geotraces.org/images/stories/documents/workshops/Artic/2012_Arctic_Workshop_Canada/Arctic_report_June12.pdf).

Intermediate Data Product

While working to further develop the GEOTRACES Intermediate Data Product for a new release in 2016, a review of the process of building the IDP2014 will be done in the coming months. The main objective of this review is to prepare a document about the *lessons learned* in the process of producing the IDP2014 so that the next intermediate data product can benefit from them. The principal persons involved in the creation of the product include the S&I Committee, Ed Mawji (GEOTRACES Data Manager) and Reiner Schlitzer (GEOTRACES SSC co-chair). In addition, feedback received by IDP2014 users, through the form available on the site when downloading the product, will also be examined and included in the report.

Workshops

Atlantic Synthesis Workshop

GEOTRACES plans to organise an Atlantic Synthesis Workshop in order to synthesise Atlantic Ocean sections across the range of trace elements and isotopes. The aim of this workshop will be to make a comprehensive examination of Atlantic data (being the core data included in the IDP2014 but other data might be also included) and interpret results from the entire basin perspective. The workshop will include, as well, some thematic focused sessions (e.g. processes such as hydrothermal plumes, boundary exchange, etc).

Indian Ocean Planning Workshop

At the same time, GEOTRACES is planning to hold an Indian Ocean planning workshop to review the GEOTRACES action plan for this Ocean, considering other international initiatives in this area such as the International Indian Ocean Expedition Initiative (IIOE-2).

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