

Annual Report on GEOTRACES Activities in the U.S. (2013-2014)

Principal activities of the U.S. GEOTRACES program include:

1. Submitting manuscripts from a North Atlantic zonal section (GA03),
2. Completion of a Pacific section between Peru and Tahiti (GP16), and
3. Submission of proposals for work in the Arctic Ocean

Activities

North Atlantic: U.S. GEOTRACES investigators remain active in the synthesis and interpretation of results from section GA03 in the North Atlantic. Twenty-three manuscripts were submitted for a special issue of Deep-Sea Research Part-II featuring results from GA03. Bill Jenkins, Ed Boyle, Greg Cutter, Rana Fine and Bob Anderson serve as guest editors. Most of the manuscripts are currently under revision following review. A few have already been recommended for publication. It is anticipated that the review and revision process will be completed over the next few months.

A substantial amount of work remains to complete the interpretation and publication of results from GA03, especially for the more labor-intensive and time-consuming measurements. U.S. GEOTRACES will decide at a meeting of its SSC (23-24 June 2014) whether to pursue a second DSR-II volume or to allow investigators to publish in a journal of their choice.

Eastern Tropical Pacific: The second major section carried out by U.S. GEOTRACES, in the eastern tropical Pacific roughly between Peru and Tahiti (GP16, see figure below), was completed in October - December 2013. Chief scientists were James Moffett (University of Southern California) and Christopher German (Woods Hole Oceanographic Institution).

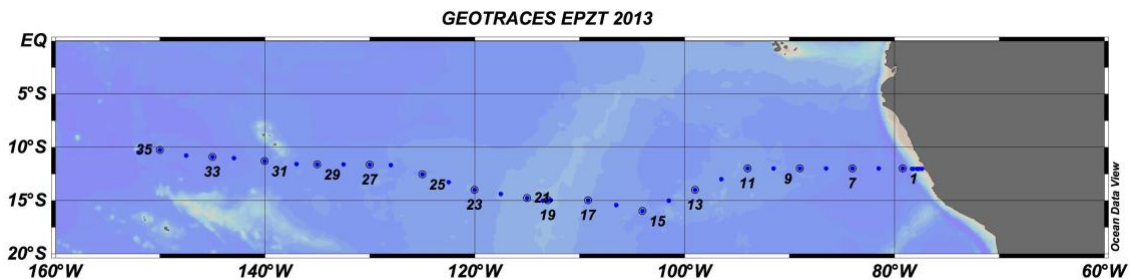


Figure 1. Locations of stations occupied on cruise TGT303 of the *Thomas G Thompson* in support of the US GEOTRACES completion of section GP16.

Cruise objectives included a comprehensive study of the biogeochemical cycle of trace elements and isotopes within: 1) the highly productive Peru upwelling system, 2) the intense oxygen minimum zone off Peru, and 3) the hydrothermal plume that extends eastward from the East Pacific Rise for up to 3000 km. Preliminary shipboard results from the cruise are presented in the figure below. These results, and other shipboard data, were presented at the Ocean Sciences Meeting (Honolulu, Hawaii, February 2014).

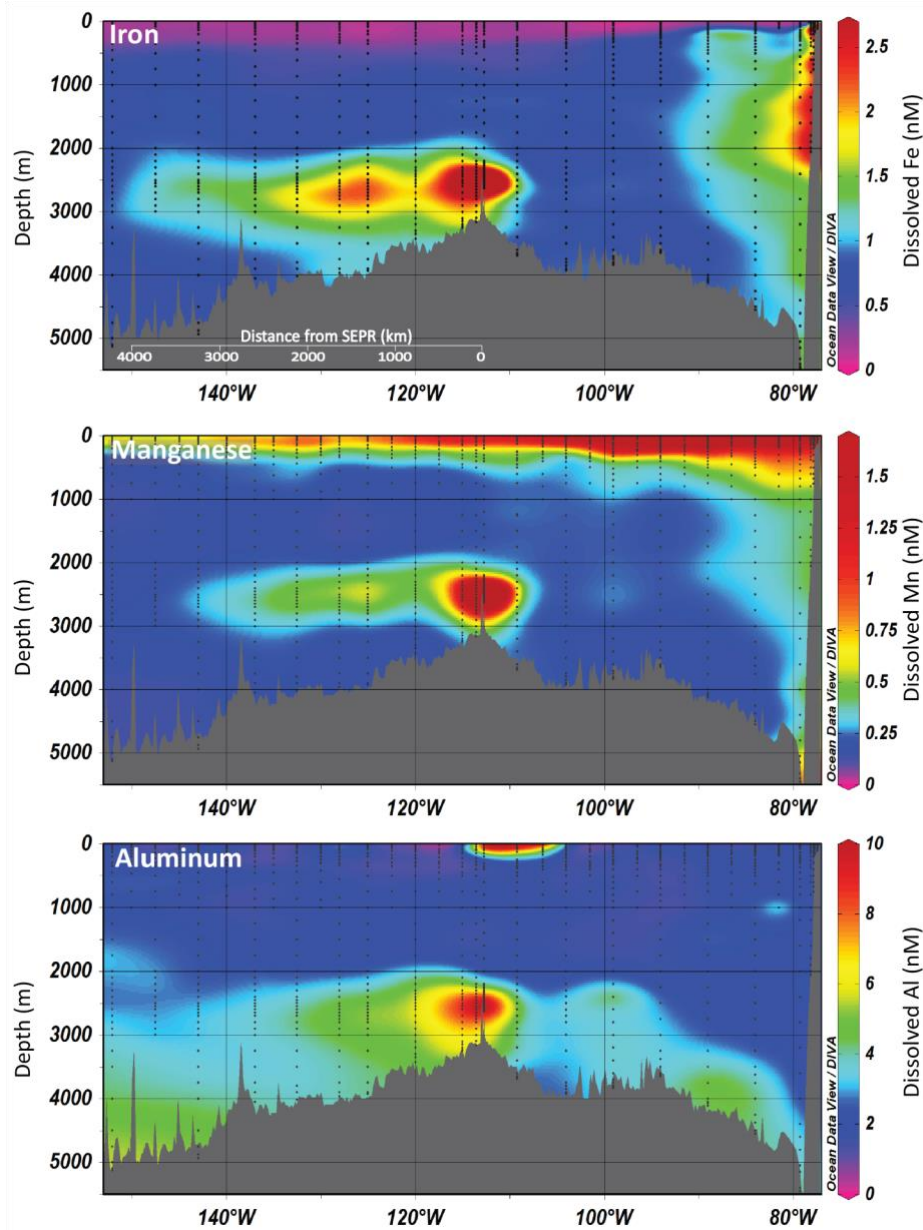


Figure 2. Shipboard data for dissolved Fe, Mn and Al collected along section (GP16) illustrate the chemical imprint of the hydrothermal plume extending more than 3000 km (see scale) to the west of the East Pacific Rise. Additional noteworthy features include surface enrichment of Mn, enrichment of Fe and Mn near the eastern boundary, potentially related to redox cycling, and an apparent benthic source of Al. Figure credit: Joe Resing (University of Washington) and Pete Sedwick (Old Dominion University).

Selected Research Highlights

Atlantic and Global: A method for distinguishing between pollution and natural mercury in the ocean has recently been published (Lamborg et al., Nature, in press, see publications below), which relies heavily on GEOTRACES data and sampling strategy. That study found that about 300 megamoles (1500 metric tons) of pollution mercury currently resides in the ocean, a number

which has never been measured before but is in agreement with some models. The data suggest that ocean waters shallower than 1000 m have more than doubled in their mercury concentration since pre-anthropogenic conditions.

Pacific

1. See results for Fe, Mn and Al above.
2. Measured distributions of ^7Be along GP16 have been modeled to constrain upwelling rates and vertical diffusion in the upper thermocline. (PI, David Kadko).
3. Over 900 samples of suspended particulate material were collected along GP16, accompanied by over 300 samples of co-occurring plankton cells that can be examined for trace metal contents across TEI gradients. (PIs Ben Twining and Rob Sherrell).
4. Complementary to results for dissolved Fe, Mn and Al, shown above, particulate ($>0.45\ \mu\text{m}$) Fe and Mn derived from the southern East Pacific Rise (EPR) hydrothermal system are advected west at least 3300km from the ridge crest as a distinct concentration maximum centered on $\sim 2500\text{m}$ depth. This is evidence of the largest hydrothermal particulate plume ever observed in the ocean. Additionally, a strong nepheloid layer is evident as a $>5\text{fold}$ increases in particulate metals from 4000m to near the bottom (5000m) in these central South Pacific waters (PIs Jessica Fitzsimmons and Rob Sherrell).

Planning for an Arctic Expedition

U.S. GEOTRACES submitted a proposal to the U.S. National Science Foundation in October 2012 requesting funding for management and logistics support of an Arctic cruise in 2015, contributing to the international GEOTRACES initiative. That proposal was declined. The management team (David Kadko, Bill Landing, Greg Cutter) submitted a revised proposal to NSF on 15 August 2013. That proposal was recommended for funding, although an award (grant) has not yet been made.

Individual investigators submitted proposals to the U.S. NSF on 15 February 2014 requesting support for their Arctic research. Evaluation of those proposals will be completed by the end of May. It is hoped that funding decisions will be released shortly thereafter.

In anticipation that the expedition will be funded, cruise leaders for the Arctic expedition (Dave Kadko and Greg Cutter) met in March 2014 (Seattle Washington, USA) with the captain and operators of the U.S. Coast Guard Cutter Healy, the ship that will be used in the Arctic if the expedition is funded. The meeting resolved logistics issues concerning GEOTRACES operations aboard the ship, specifically addressing procedures for operating within ice-covered waters.

New Funding

As noted above, the Arctic management proposal (providing the ship and logistic support) was recommended for funding, although an award (grant) has not yet been made.

Presentation of results

A large number of presentations based on results from the North Atlantic cruise as well as a few presentations based on preliminary results from the Pacific cruise were made at the Ocean

Sciences Meeting (Honolulu Hawaii, February 2014). Additional presentations are planned for the Goldschmidt Conference (Sacramento California, June 2014).

U.S. GEOTRACES Meetings

No meetings were held during the past year. However, the US GEOTRACES SSC is scheduled to meet at the US NSF on 23 and 24 June 2014.

Publications (GEOTRACES, GEOTRACES Compliant and GEOTRACES-related)

- Conway, T.M., Rosenberg, A.D., Adkins, J.F. and John, S.G., 2013. A new method for precise determination of iron, zinc and cadmium stable isotope ratios in seawater by double-spike mass spectrometry. *Analytica Chimica Acta*, 793: 44-52.
- Cutter, G.A., 2013. Intercalibration in chemical oceanography-Getting the right number. *Limnology and Oceanography-Methods*, 11: 418-424.
- Du, J.Z., Moore, W.S., Hsh, H.F., Wang, G.Z., Scholten, J., Henderson, P., Men, W., Rengarajan, R., Sha, Z.J. and Jiao, J.J., 2013. Inter-comparison of radium analysis in coastal sea water of the Asian region. *Marine Chemistry*, 156: 138-145.
- Fitzsimmons, J.N. and Boyle, E.A., 2014. Assessment and comparison of Anopore and cross flow filtration methods for the determination of dissolved iron size fractionation into soluble and colloidal phases in seawater. *Limnology and Oceanography: Methods*, 12: 244-261.
- Hayes, C.T., Anderson, R.F., Fleisher, M.Q., Serno, S., Winckler, G. and Gersonde, R., 2013a. Quantifying lithogenic inputs to the North Pacific Ocean using the long-lived thorium isotopes. *Earth and Planetary Science Letters*, 383: 16-25.
- Hayes, C.T., Anderson, R.F., Jaccard, S.L., Francois, R., Fleisher, M.Q., Soon, M. and Gersonde, R., 2013b. A new perspective on boundary scavenging in the North Pacific Ocean. *Earth and Planetary Science Letters*, 369: 86-97.
- Homoky, W.B., John, S.G., Conway, T.M. and Mills, R.A., 2013. Distinct iron isotopic signatures and supply from marine sediment dissolution. *Nature Communications*, r: DOI: 10.1038/ncomms3143.
- Hong, G.H., Baskaran, M., Church, T.M. and Conte, M., 2013. Scavenging, cycling and removal fluxes of ²¹⁰Po and ²¹⁰Pb at the Bermuda time-series study site. *Deep Sea Research Part II: Topical Studies in Oceanography*, 93: 108-118.
- Janssen, D.J., Conway, T.M., John, S.G., Christian, J.R., Kramer, D.I., Pedersen, T.F. and Cullen, J.T., 2014. Undocumented water column sink for cadmium in open ocean oxygen deficient zones. *Proceedings of the National Academy of Sciences*, 111(19): 6888-6893.
- John, S.G. and Conway, T.M., 2014. A role for scavenging in the marine biogeochemical cycling of zinc and zinc isotopes. *Earth and Planetary Science Letters*, 394(0): 159-167.
- Lagerström, M.E., Field, M.P., Séguret, M., Fischer, L., Hann, S. and Sherrell, R.M., 2013. Automated on-line flow-injection ICP-MS determination of trace metals (Mn, Fe, Co, Ni, Cu and Zn) in open ocean seawater: Application to the GEOTRACES program. *Marine Chemistry*, 155: 71-80.
- Lamborg, C.H., Hammerschmidt, C.R., Bowman, K.L., Swarr, G.J., Munson, K.M., Ohnemus, D.C., Lam, P.J., Heimbürger, L.-E., Rijkenberg, M.J.A. and Saito, M.A., in press. A global ocean anthropogenic mercury inventory based on water column measurements. *Nature*.
- Lee, H.M., Hong, G.H., Baskaran, M., Kim, S.H., Kim, Y.I. and Cho, K.C., 2014. Evaluation of plating conditions on the recovery of ²¹⁰Po onto the Ag planchet. *Applied Radiation and Isotopes*, 90: 170-176.

- Peucker-Ehrenbrink, B., Sharma, M. and Reisberg, L., 2013. Meeting Report: Recommendations for Analysis of Dissolved Osmium in Seawater. EOS, Transactions of the American Geophysical Union, 94: 12 February 2013.
- Zurbrick, C.M., Gallon, C. and Flegal, A.R., 2013. A new method for stable lead isotope extraction from seawater. *Analytica Chimica Acta*, 800: 29-35.

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