

Internal Cycling of Trace Elements

A GEOTRACES/OCB Collaborative Workshop

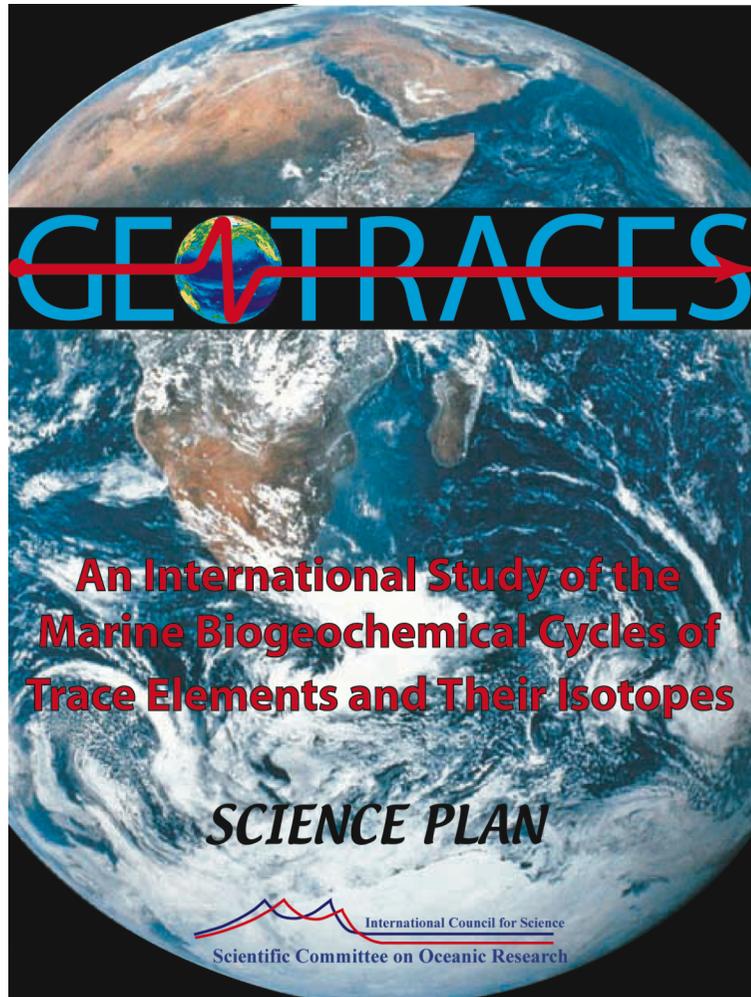
Bob Anderson - US GEOTRACES Project Office
Lamont-Doherty Earth Observatory

2015 OCB Summer Workshop
20-23 July 2015



<http://www.geotraces.org/>

GEOTRACES Mission



“To identify processes and quantify fluxes that control the distributions of **key trace elements and isotopes** (TEIs) in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions”

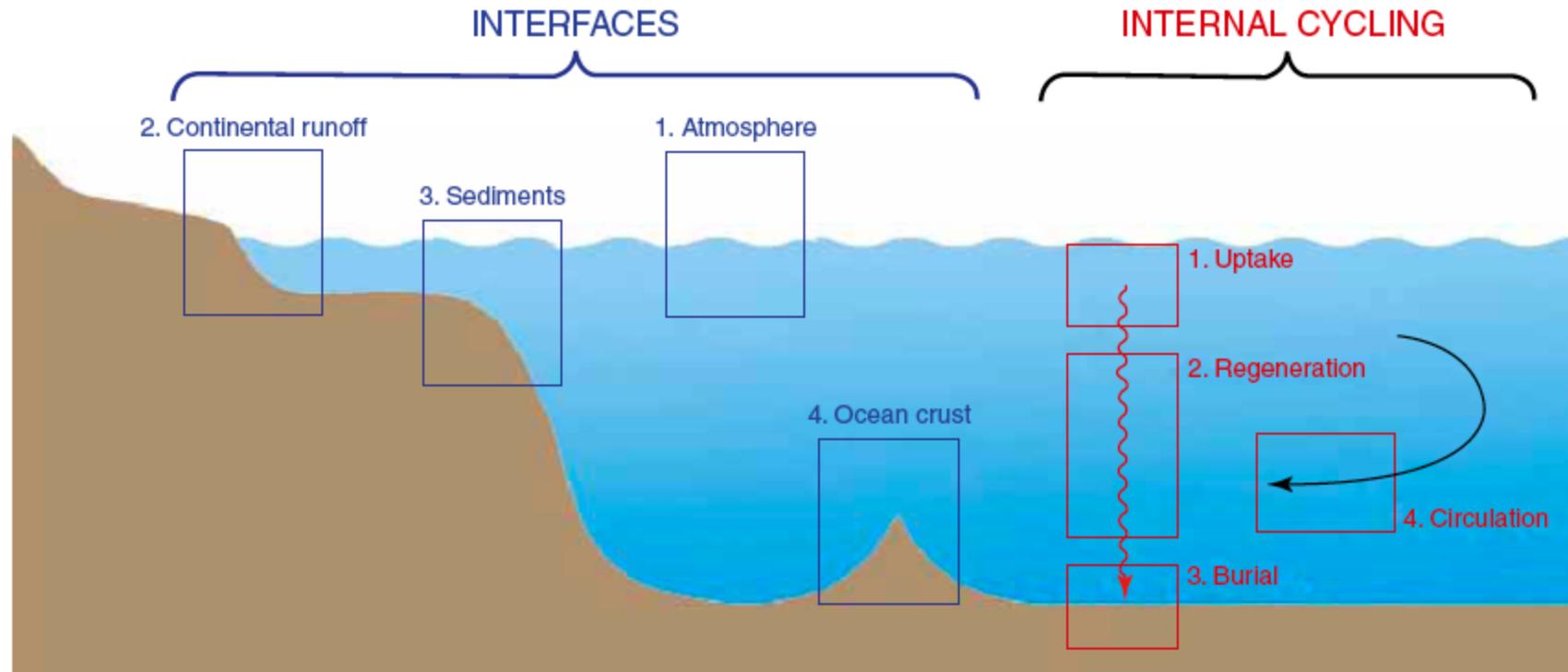


What are “key” elements?

They include:

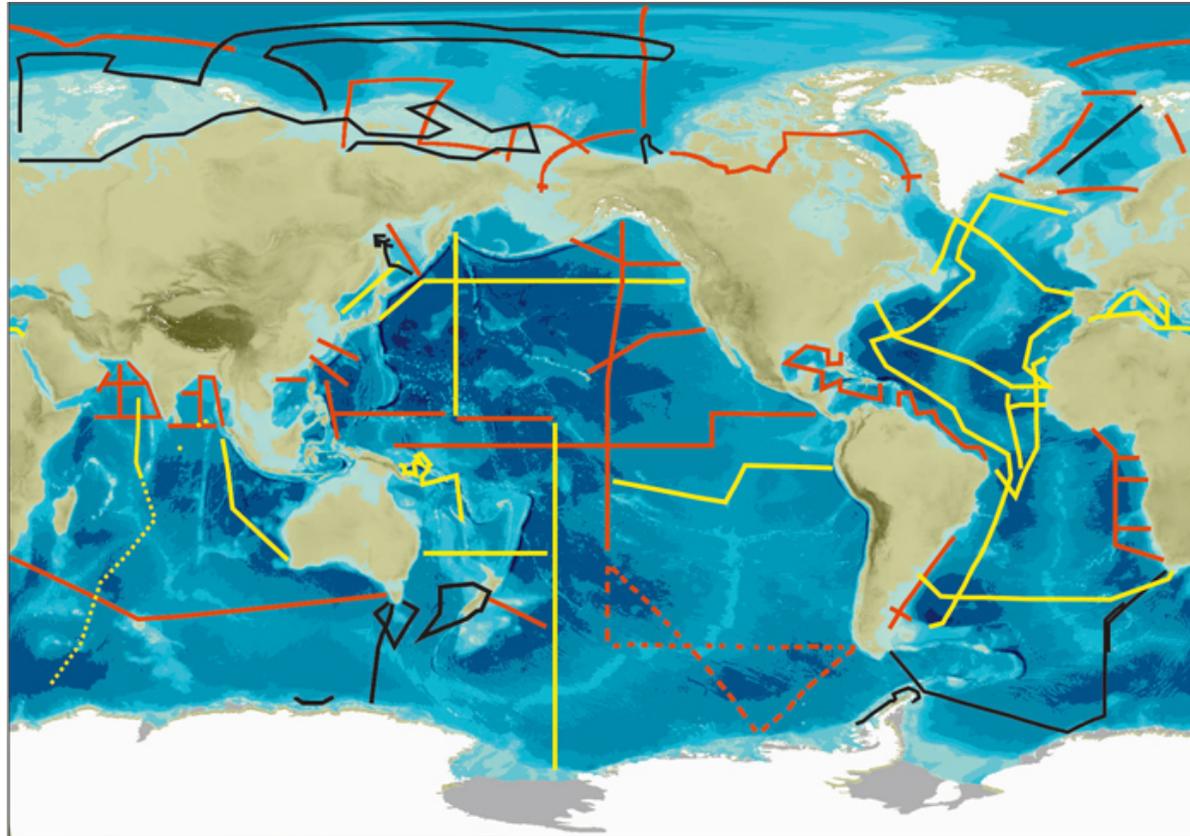
- Those acting as micronutrients to control ocean productivity and ecosystems
(e.g. Fe, Zn, Cd, Cu, Ni, Co, Mn)
- Those tracing modern processes in the ocean
(e.g. Al, Rare Earth Elements, Ra and Th isotopes, ^3He , ^{15}N)
- Contaminants in the present and future ocean
(e.g. Pb, Hg)
- Chemical species used as proxies to reconstruct ocean conditions in the past
(e.g. ^{231}Pa , ^{230}Th , Cd, ^{15}N , ^{30}Si , Ba)

Specific goals to define marine biogeochemical cycles of TEIs



- 1) Supply and removal of TEIs at ocean interfaces,
- 2) Internal cycling within the ocean

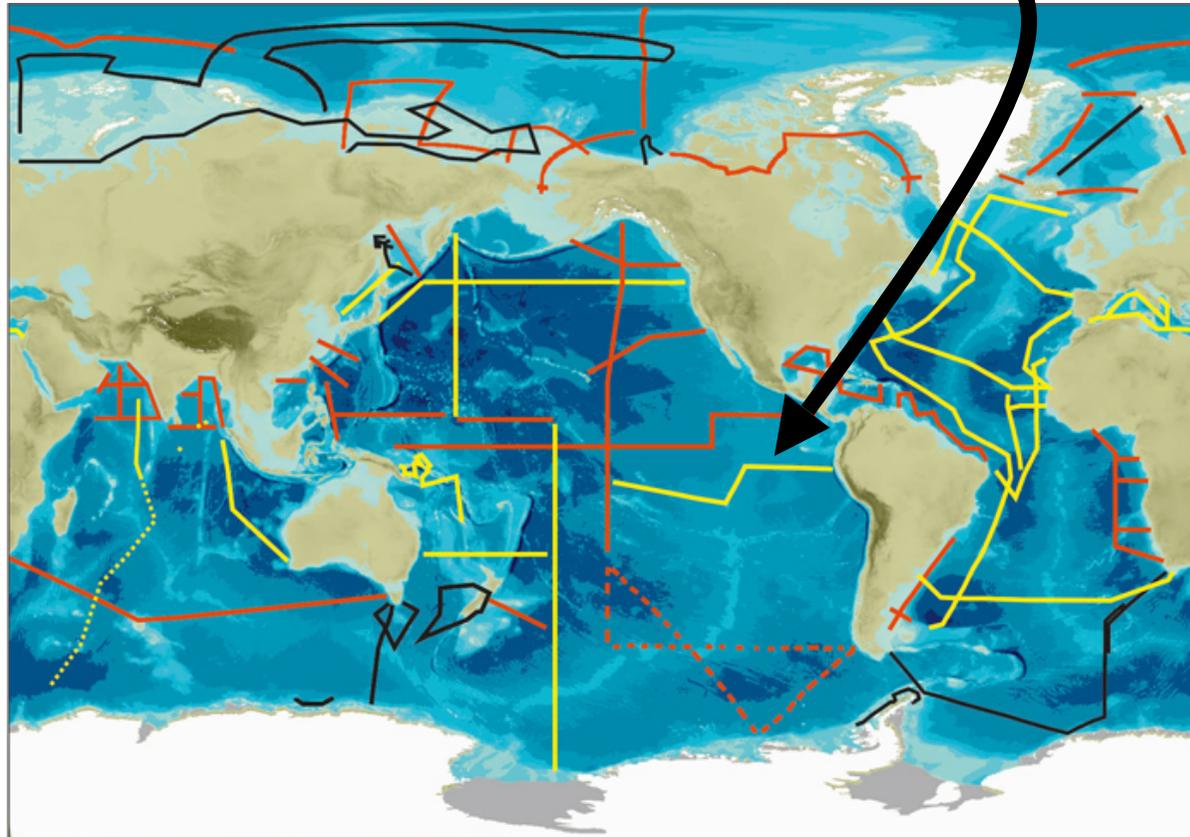
Progress toward global coverage



Summary of GEOTRACES cruises by 15 contributing national GEOTRACES programmes

- IPY cruises
- Completed sections (yellow)
- Desired future sections (red)

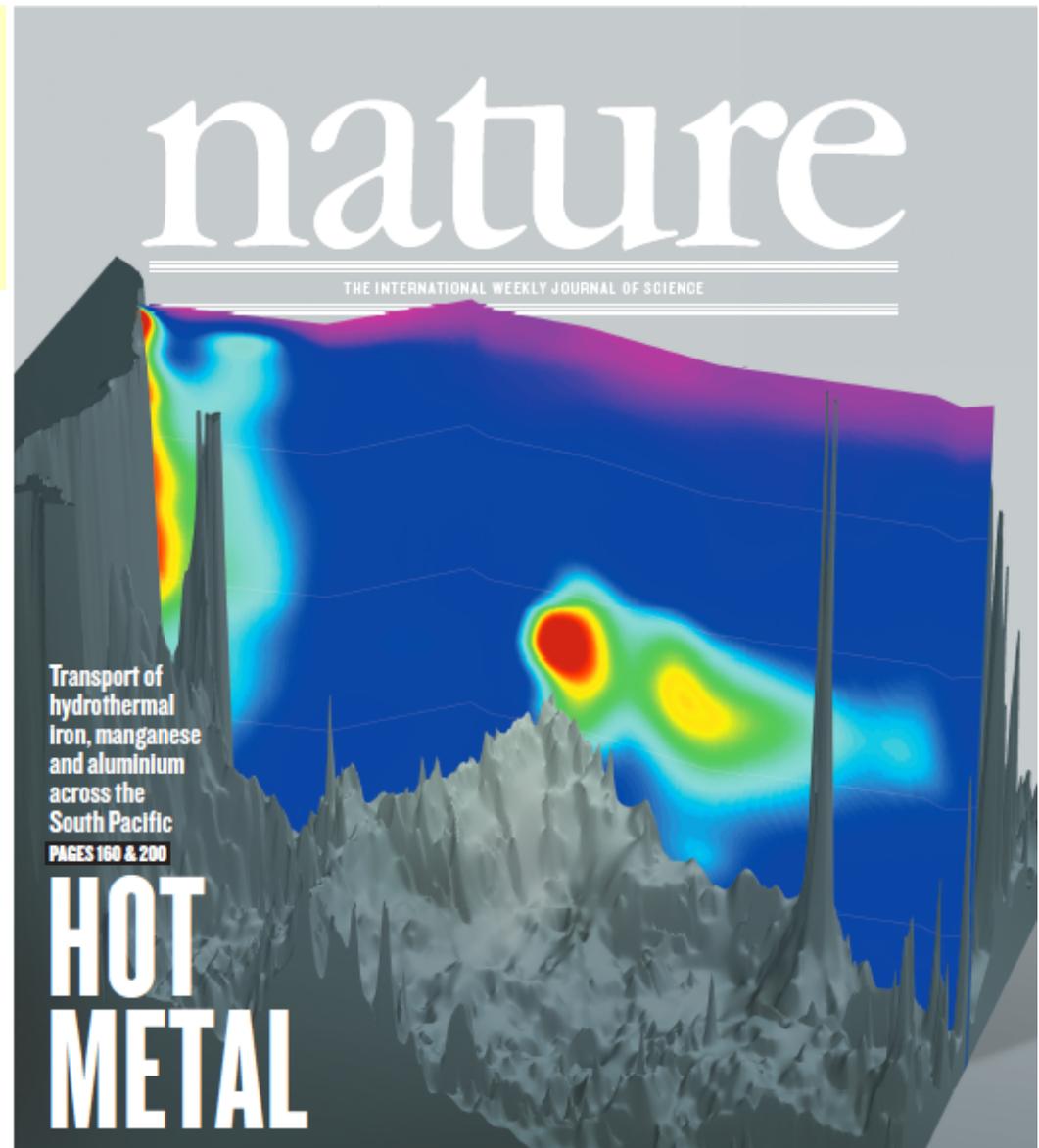
GP16 sampled by US GEOTRACES in 2013



GP16 “Visibility”

Paper by Joe Resing et al.

Cover Graphics by
Reiner Schlitzer



PUBLIC HEALTH
ENDGAME FOR HIV
We have the tools to quash the epidemic
PAGE 140

HUMAN GENOMICS
REACH FOR THE CLOUD
Embrace a data commons to speed processing
PAGE 149

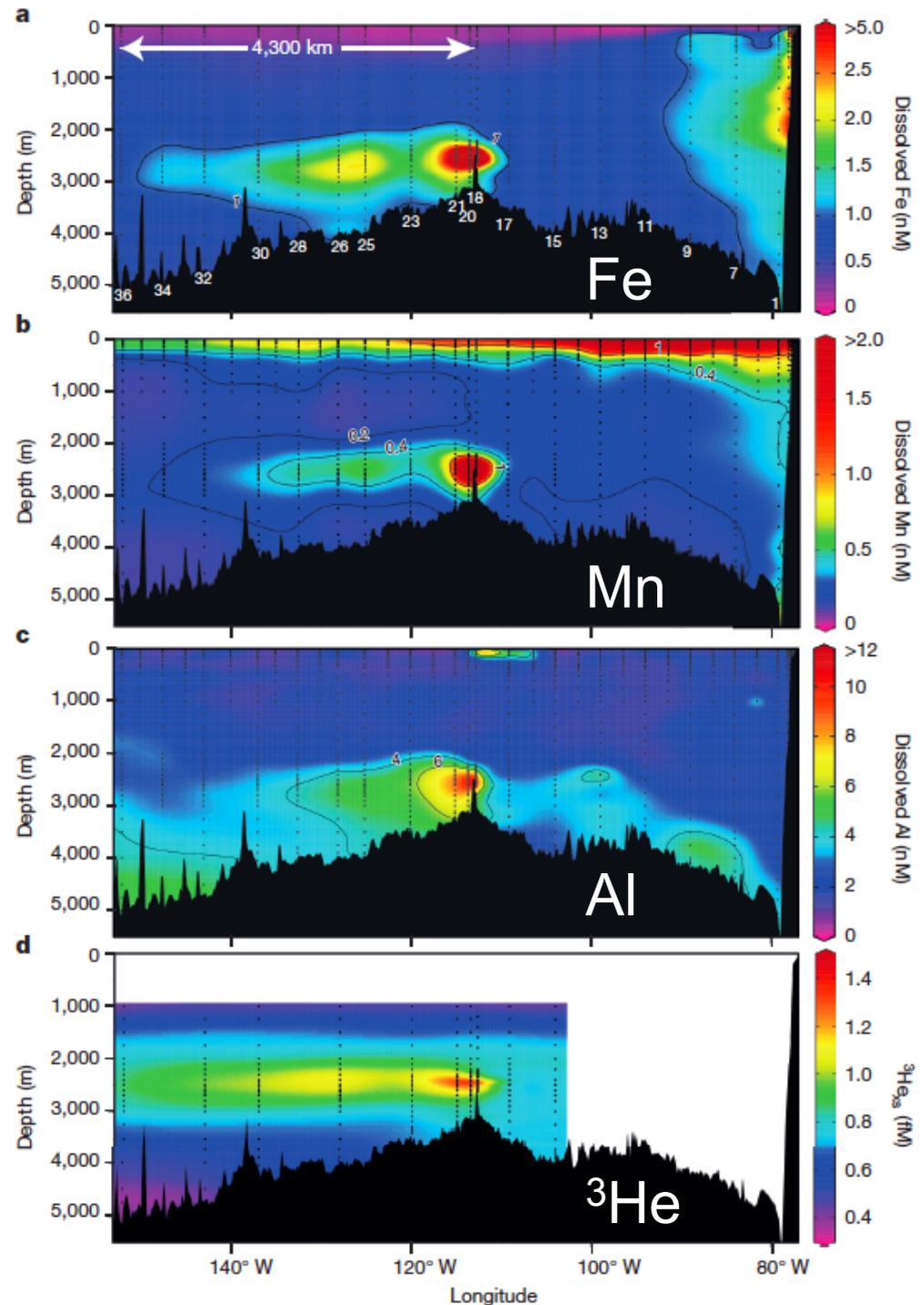
COSMOLOGY
CATCH A FORMING STAR
How feedback slowed star formation in early Universe
PAGE 189

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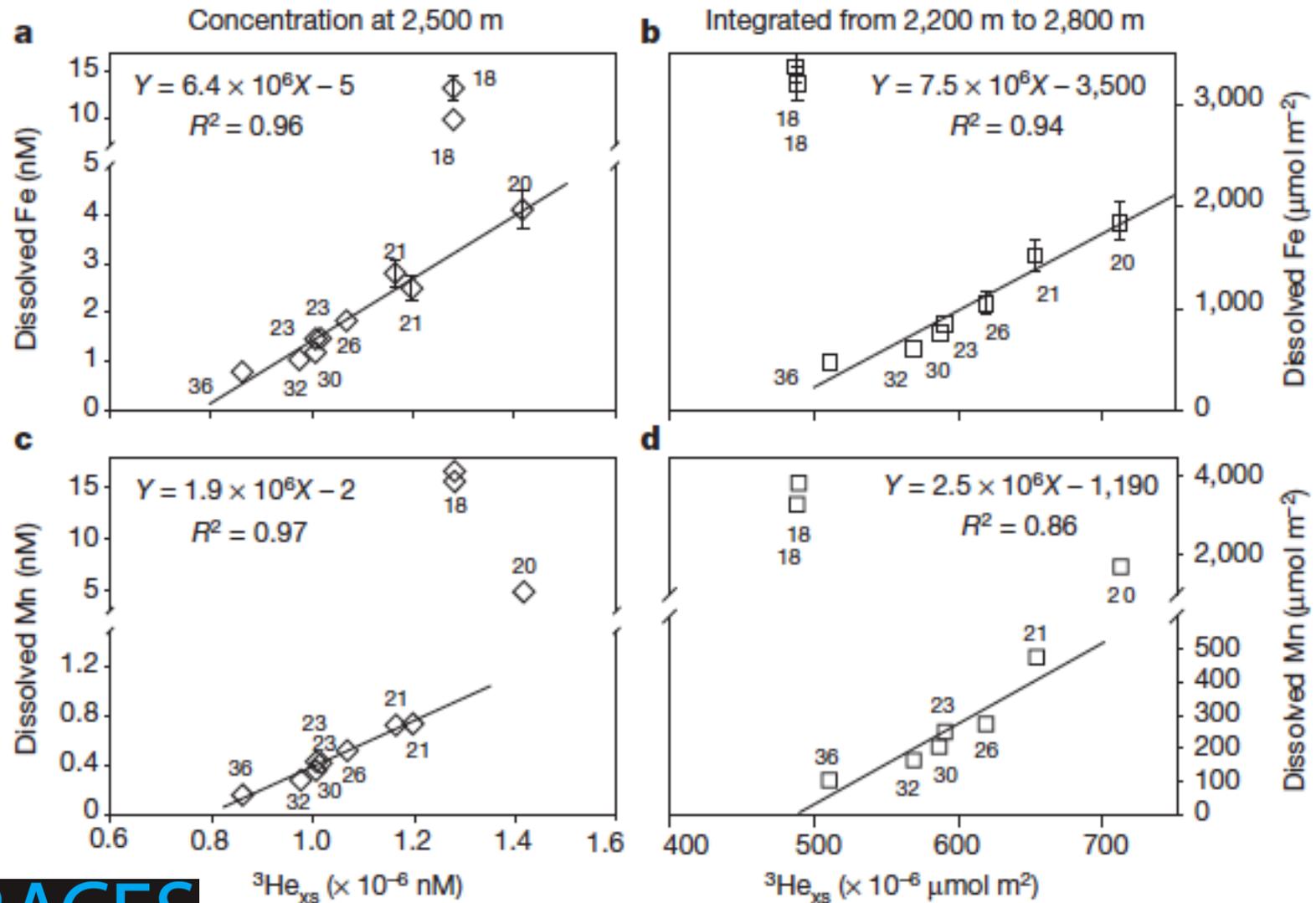


GP16 - EPR Hydrothermal plume: 4000 km

Resing, J. A., Sedwick, P. N., German, C. R., Jenkins, W. J., Moffett, J. W., Sohst, B. M. and Tagliabue, A. Basin-scale transport of hydrothermal dissolved metals across the South Pacific Ocean. **Nature**, 523 (2015) 200-203.

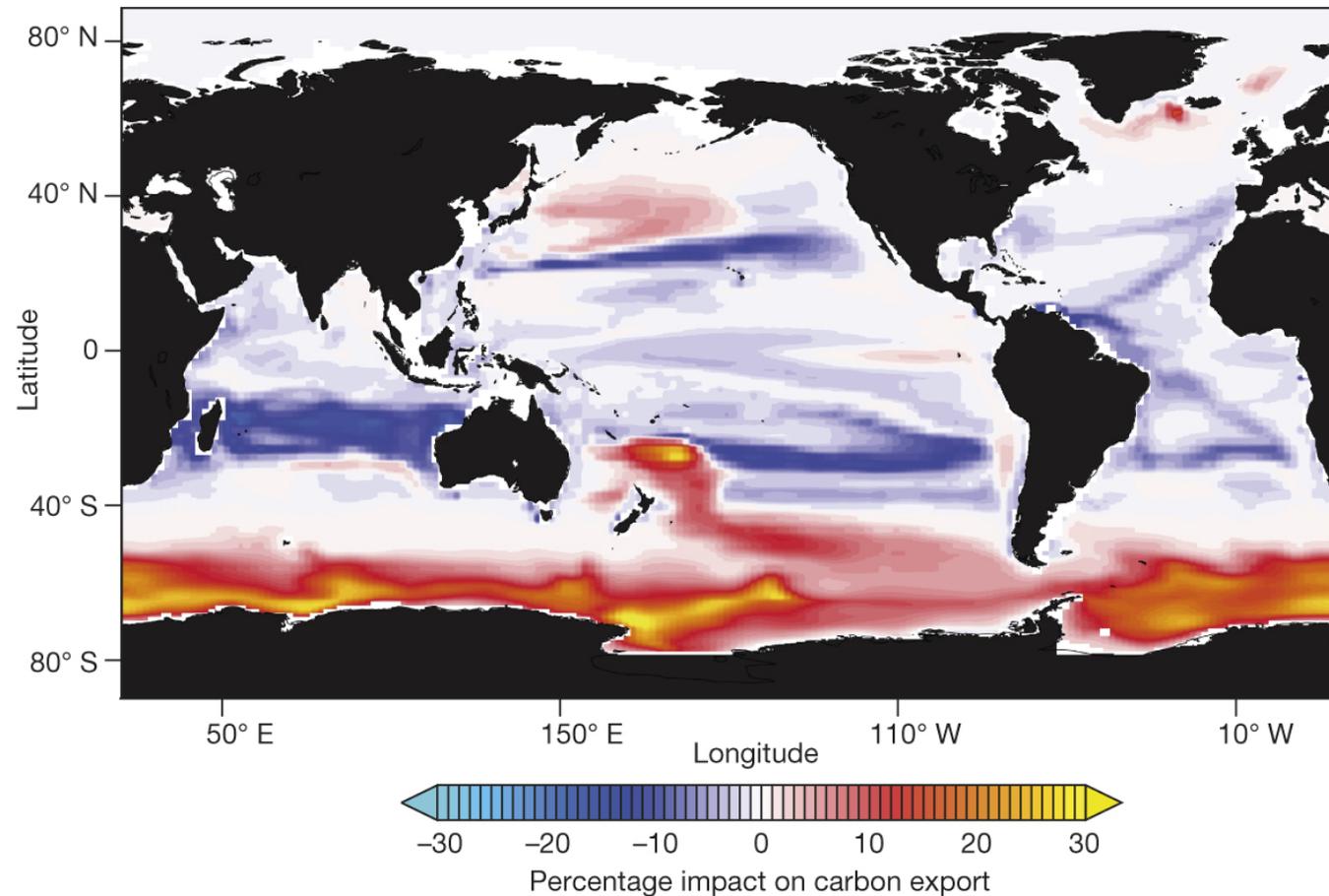


GP16 - EPR Hydrothermal plume: Dissolved Fe and Mn surprisingly conservative

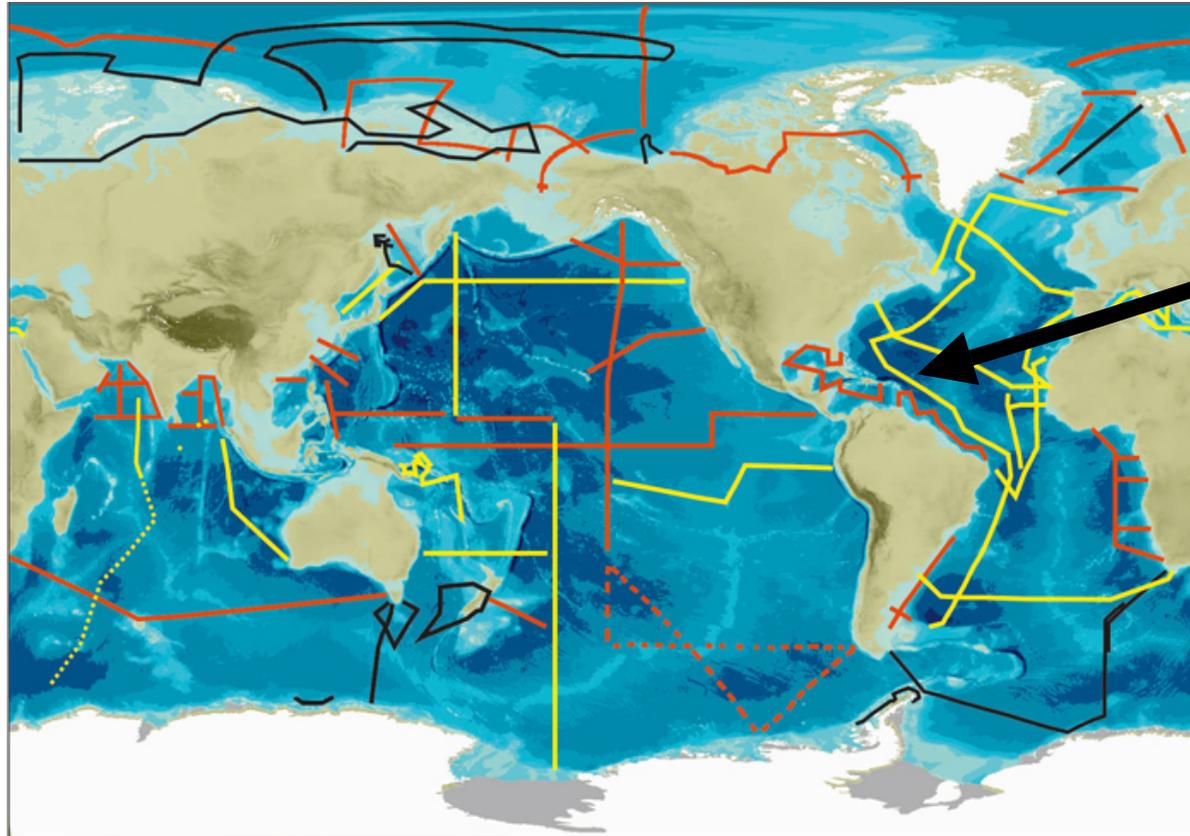


Model percentage annual carbon export attributable to hydrothermal Fe

Resing, J. A.,
Sedwick, P. N.,
German, C. R.,
Jenkins, W. J.,
Moffett, J. W., Sohst,
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Nature, 523 (2015)
200-203.



Unprecedented sections provide opportunities for synthesis and modeling



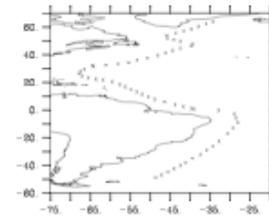
Line GA02 follows GEOSecs Western Atlantic section
Sampling on GA02 led by the Netherlands

12-model Intercomparison: Nitrate on GA02

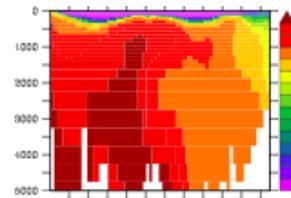
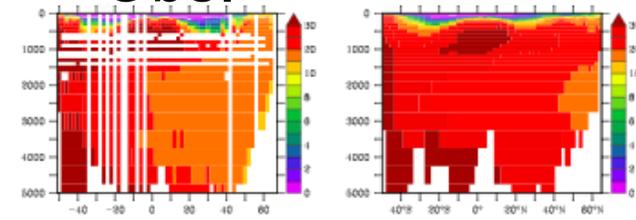
Models are reasonably consistent in simulating nitrate distributions along a meridional section down the western Atlantic.

Nitrate distribution is influenced strongly by ocean circulation.

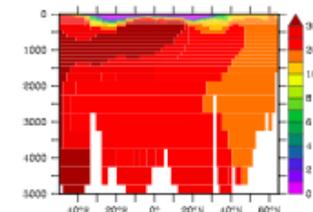
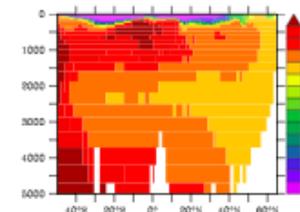
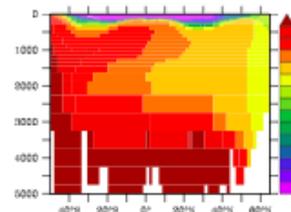
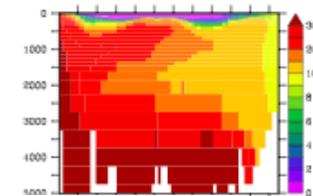
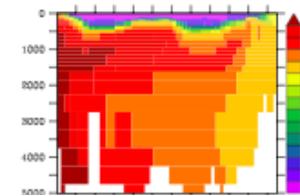
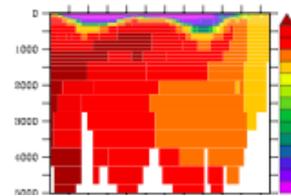
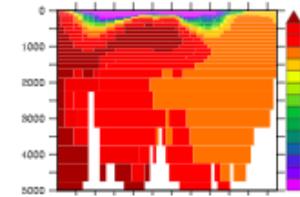
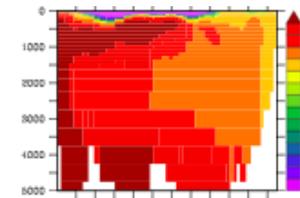
GA-02, Cruise



Obs.



S N

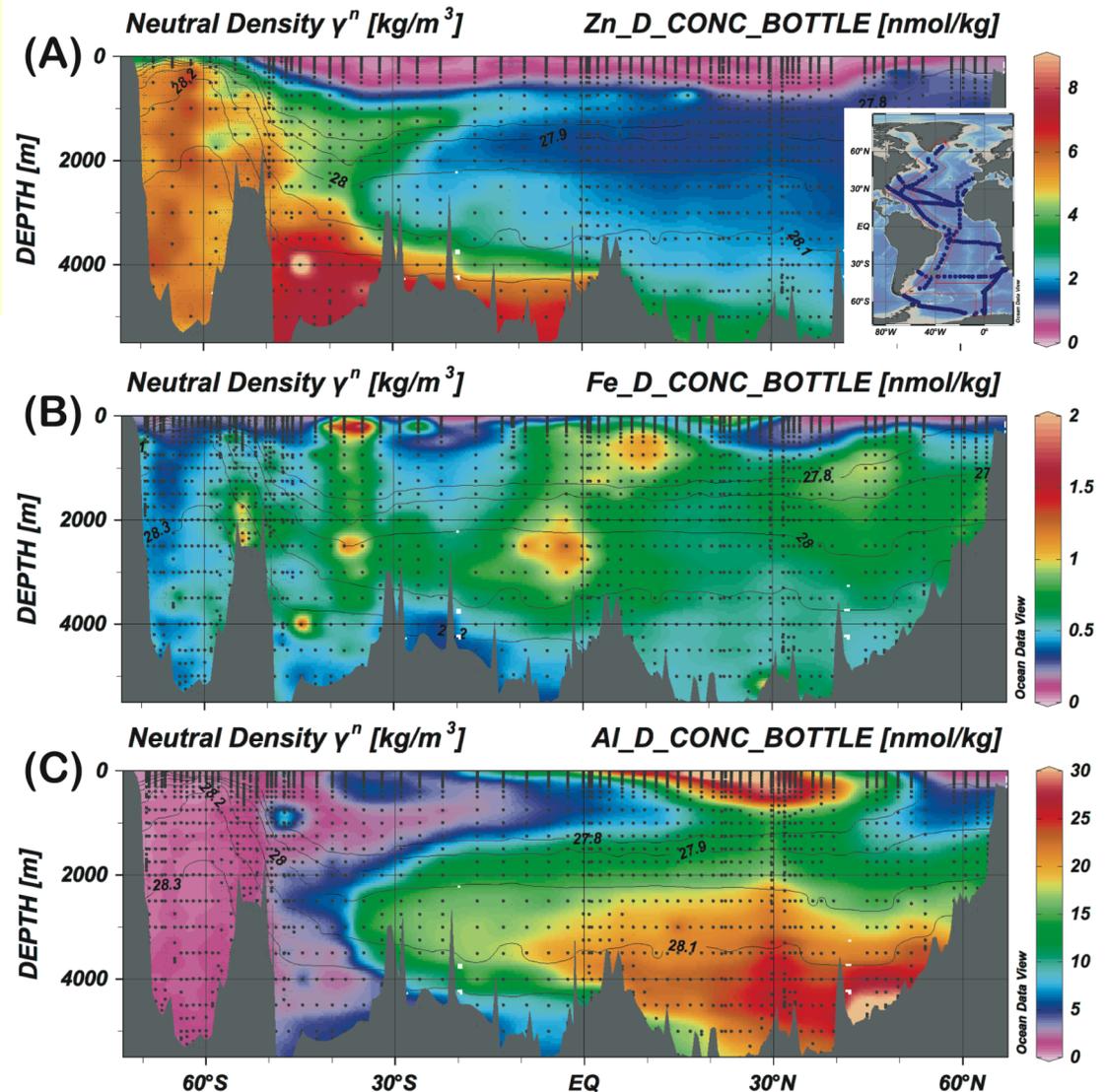


Trace elements on GA02

Distribution of Zn is similar to that of macronutrients.

Residence time of Fe is so low that its distribution is nearly unaffected by circulation.

Al is nearly the inverse of a macronutrient.



Sections are plotted using the ODV version of GEOTRACES
IDP2014 <<http://www.bodc.ac.uk/geotraces/data/idp2014/>>.

Data courtesy of P. Laan, M. Rijkenberg, H. de Baar, R. Middag, K.
Bruland, M. Klunder and P. Croot.

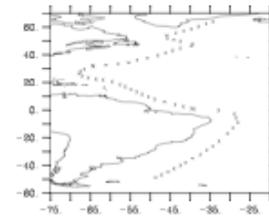
How do the models do with iron?

12-model Intercomparison: Iron

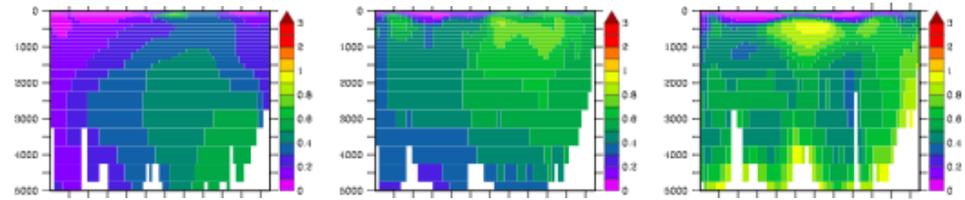
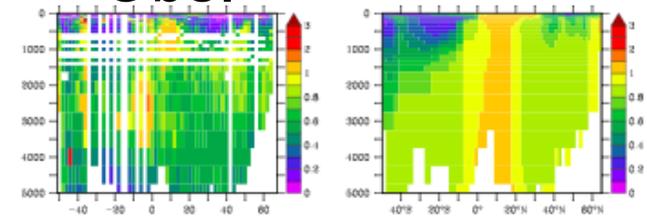
Models fail to reproduce measured Fe distribution.

Models are tuned to global average Fe concentration, but uncertainties in supply, removal and internal cycling are so large that no model reproduces the measured distribution very well.

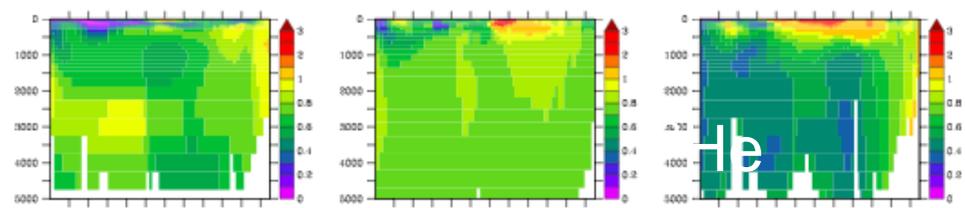
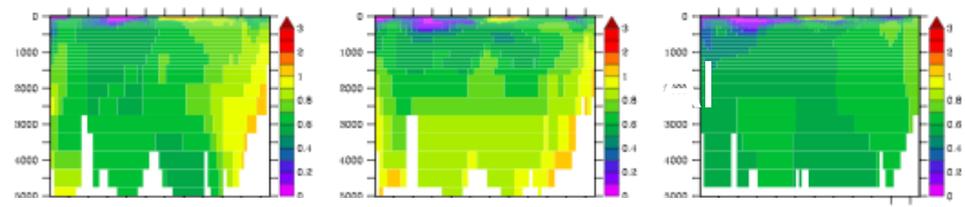
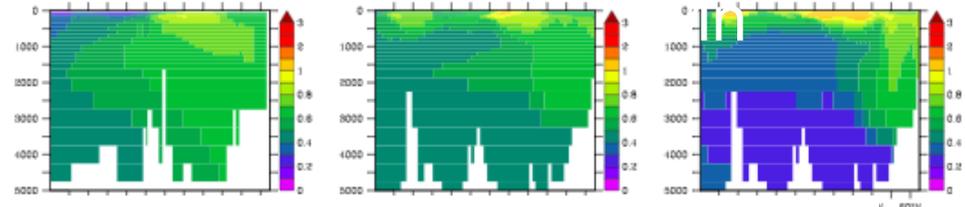
GA-02, Cruise



Obs.



S N



Ocean iron models need improvement

Fe fluxes and ocean residence times vary over 2 orders of magnitude in ocean models.

Keith Moore's presentation on Monday.

Results of Iron Model Intercomparison Project
Coordinated by Alessandro Tagliabue
University of Liverpool

Lessons:

We are still in the “discovery” phase with respect to marine biogeochemical cycles of iron...

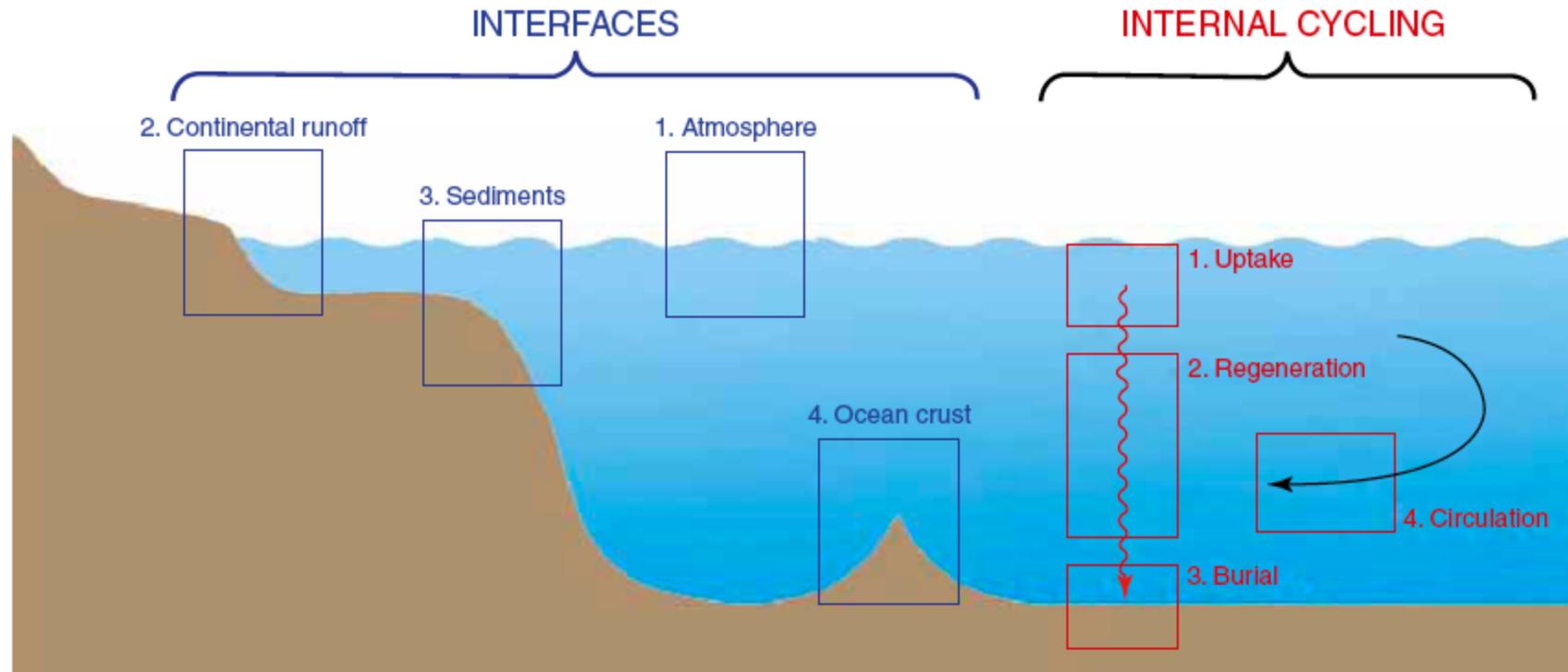
...and of other micronutrients.

Synthesis of GEOTRACES data will provide a more accurate knowledge of supply, removal and internal cycling of micronutrients...

...and of other trace elements.



Three-pronged synthesis of GEOTRACES results



- 1) Supply and removal of TEIs at ocean interfaces,
- 2) Internal cycling within the ocean
- 3) Paleo Proxies (not discussed here)

Benefits

A more accurate and quantitative knowledge of trace element cycles will benefit planning for emerging marine research programs:

EXPORTS

North Atlantic - Arctic initiative

SOCCOM

ICESOCC

others



Synthesis of supply and removal launch with Royal Society meeting 7-10 Dec 2015

The screenshot shows a web browser window with the URL <https://royalsociety.org/events/2015/12/ocean-chemistry/>. The page features the Royal Society logo at the top. Below the logo is a navigation menu with 'Events' selected. The main content area displays the event title 'Biological and climatic impacts of ocean trace element chemistry' and the dates '9:00 am on Monday 07 December 2015 – 5:00 pm on Tuesday 08 December 2015' at 'The Royal Society, London'. A 'Register now' button is visible. The event description states it is a scientific discussion meeting organized by Professor Gideon Henderson FRS, Professor Ed Boyle, Professor Maeve Lohan, Dr Micha Rijkenberg, and Dr Géraldine Sarthou. The 'Event details' section explains that trace metals are critical for life and are toxic pollutants, and that the meeting will discuss recent advances in oceanic cycling of trace elements. On the right side, there are two promotional cards: 'Open House Weekend' (Building open to public 19-20 Sep) and 'Volcanoes and us' (Stephen Sparks and Jim Al-Khalili 28 Sep). Below these is a 'Share this page' section with social media icons and an 'Events email newsletter' sign-up form with a 'Sign up' button.



Synthesis of internal cycling in partnership with OCB

Partnership reflects:

- Shared interest in micronutrient biogeochemistry
- Shared interest in supporting emerging programs
- Involvement of a broader segment of the ocean research community; e.g., biologists and physicists

Workshop goals:

Foundation for a long-range effort:

- Identify principal unknowns
- Define strategies to address unknowns using existing data
- Develop new initiatives to address unknowns that cannot be resolved with existing data.

Internal cycling:

- Transport by advection and mixing
- Redox processes
- Physical form and chemical speciation
- Biological uptake, transformation, regeneration
- Sorption and desorption
- Particle aggregation, disaggregation, settling
- Others to be defined.

Internal cycling workshop logistics:

- Funded jointly by OCB and US GEOTRACES
- Accommodates a substantial number of non-US participants
- Target dates in early summer 2016
- Venue to be determined
- Forming planning group now
- * Soliciting comments and recommendations here.

