Comparative behavior & distribution of iron in the Western Indian Ocean and Eastern Tropical South Pacific: A GEOTRACES Synthesis

James W. Moffett
University of Southern California

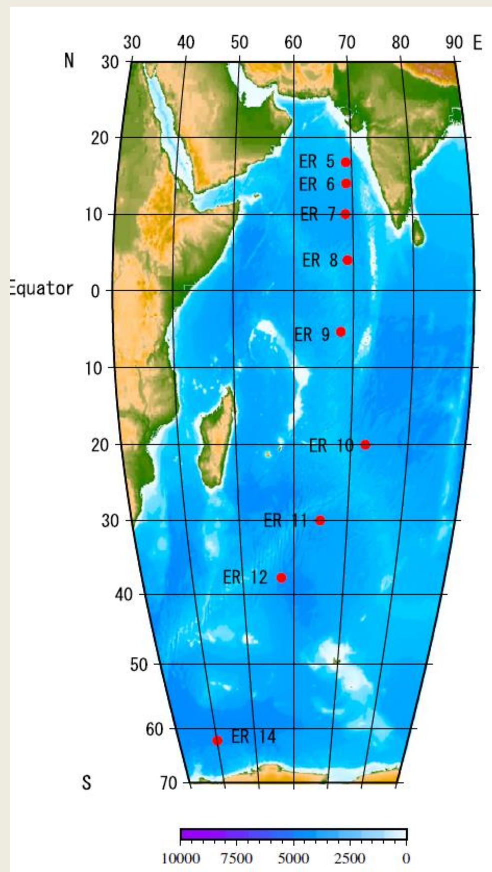
HIGHLIGHTS

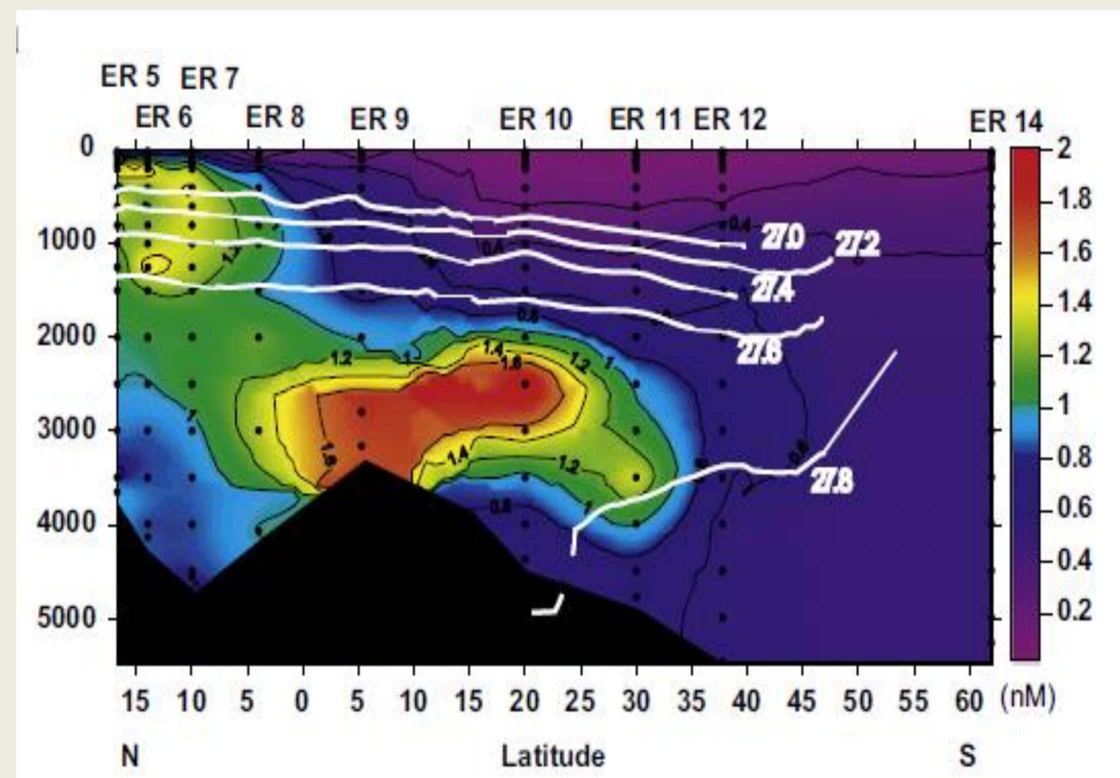
Results of GEOTRACES highlight the Importance of the Arabian Sea OMZ and Hydrothermal inputs of iron into the basin
There is an intriguing similarity with the Eastern Tropical South Pacific GEOTRACES Section, suggesting common processes
Modelling by Tim De Vries and Al Tagliabue enables and assessment of hydrothermal sources of iron to the Southern Ocean from the IO
It is unclear how the deep iron plumes underlying the OMZ within each basin arise.

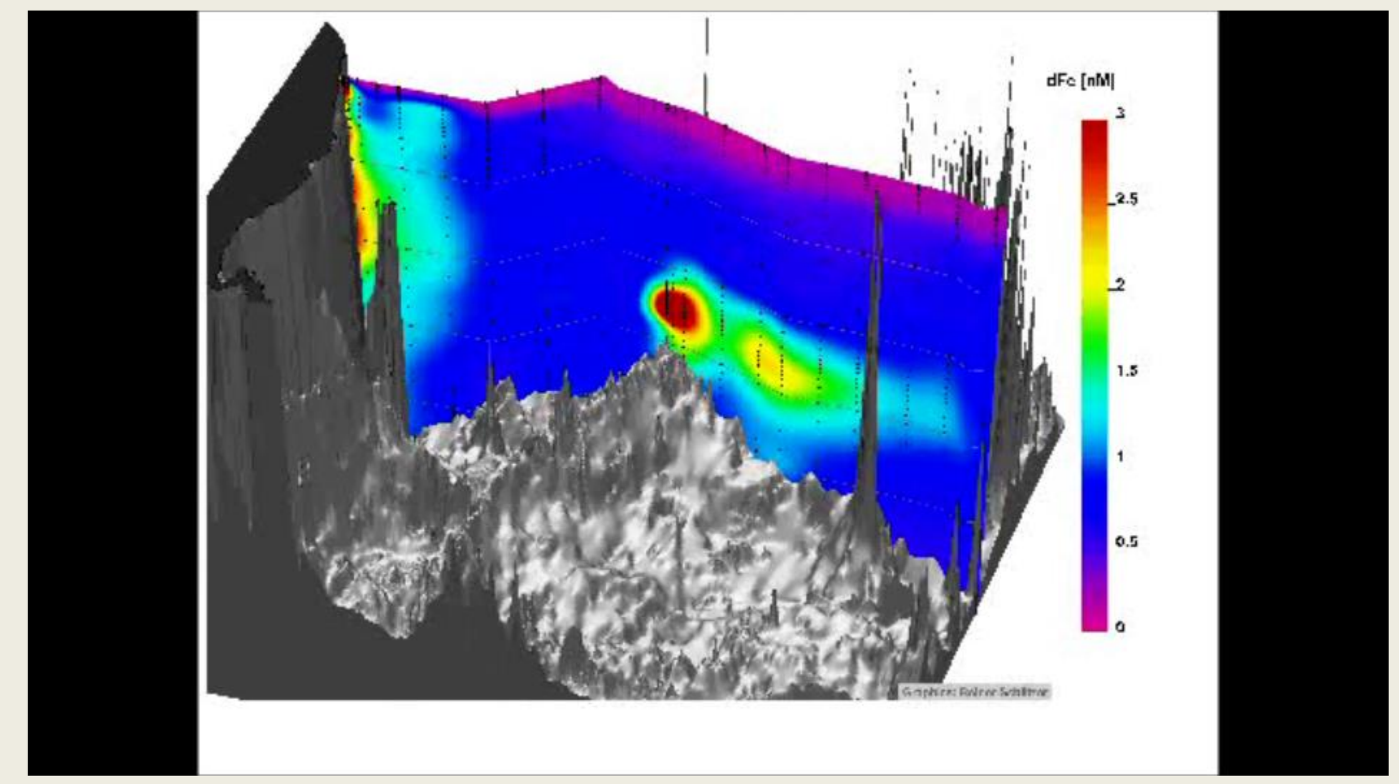
Can you see any similarities?

Japanese GEOTRACES Meridional Section, December 2009

- This was the first basin scale, surface to seafloor section carried out in the Indian Ocean to measure trace metals. It was part of the International GEOTRACES program.
- The northernmost 4 stations were within the Arabian Sea and had high nitrite and low O_2. Station 9 was centered over the Rodriguez Triple Junction, a source of hydrothermal Fe to the region.

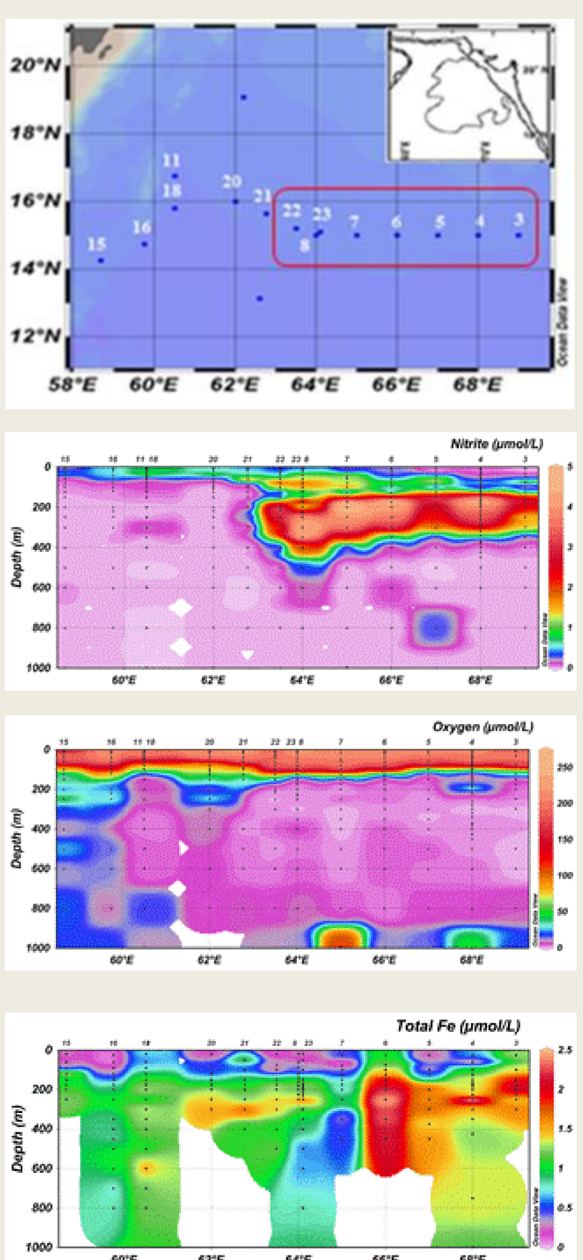






Left: Nishioka et al. (2013) (DOI:10.1016/j.epsl.2012.11.040) determined dissolved iron on the cruise and observed very high levels within the OMZ. They also observed a much deeper plume underlying the OMZ at a depth of 2000m and extending further to the south. This plume merges with a large hydrothermal plume arising from the Rodriguez Triple Junction region. *Right:* Dissolved iron from the US GEOTRACES Section from Peru to 140 W (Line GP16). Note the similarities: High Fe in the OMZ; a massive plume *below* the OMZ extending further offshore; a large hydrothermal plume (in this instance completely separated from the margin-derived feature). From Resing et al., 2015. doi: 10.1038/nature14577.

High iron within the Arabian Sea OMZ



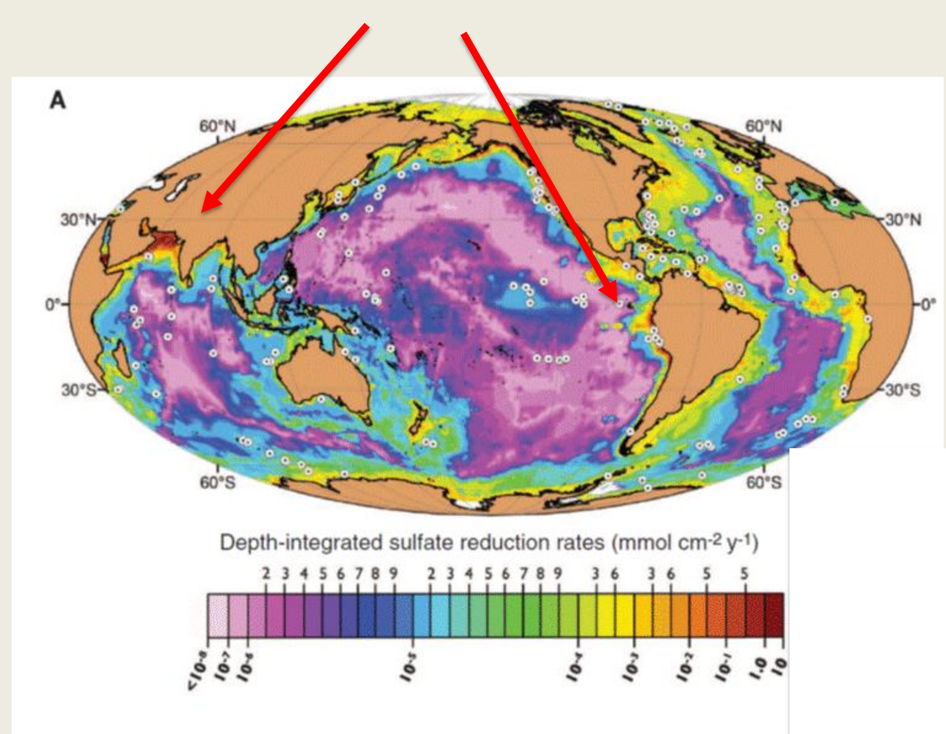
NIO Zonal Section, September 2007

- This transect was carried out during the SW Monsoon.
- The westernmost 8 stations were within the ODZ and had high nitrite, high iron and low O_2. Further west, the water column was more ventilated and oxygenated with low iron and low nitrite.

Moffett et al., 2015. DOI: 10.1002/lno.10132

How do deep iron plumes arise under OMZs?

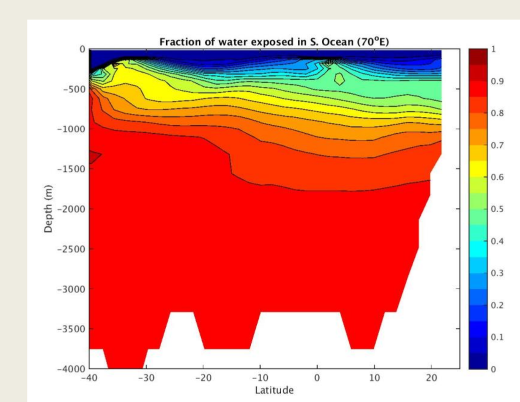
We assume that iron is turned over rapidly within OMZs – even though concentrations are high. In deeper waters, dissolved Fe persists, but where does it come from? One possible source is the strong reducing slope sediments in the Arabian Sea basin and Peru margin

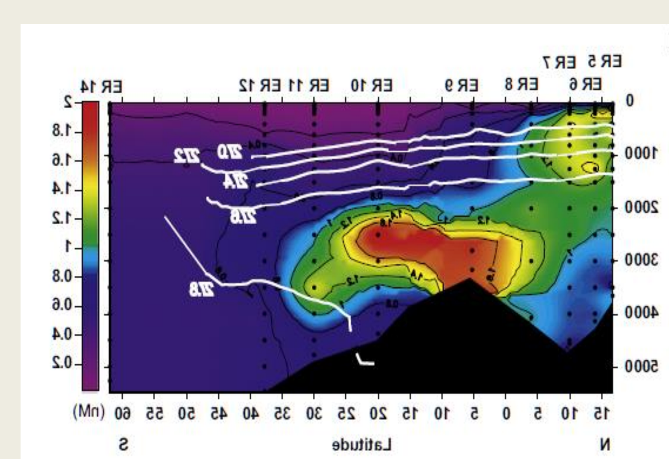


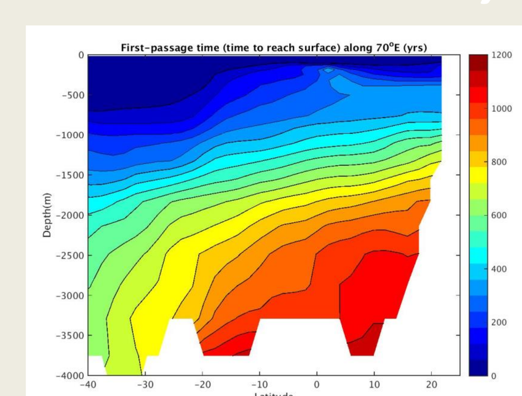
Model estimates of benthic sulfate reduction rates developed by Bowles et al., Science 2014 doi: 10.1126/science.1249213

Model Simulations to assess the importance of deep iron in the Indian Ocean to the Southern Ocean

This inverse model simulation by Tim De Vries (right) provides insight into the transport and timescales of deep water transport to the Southern Ocean. One conclusion is that iron in the OMZ plume may be a more important source than the hydrothermal plume because it reaches the Southern Ocean more quickly.





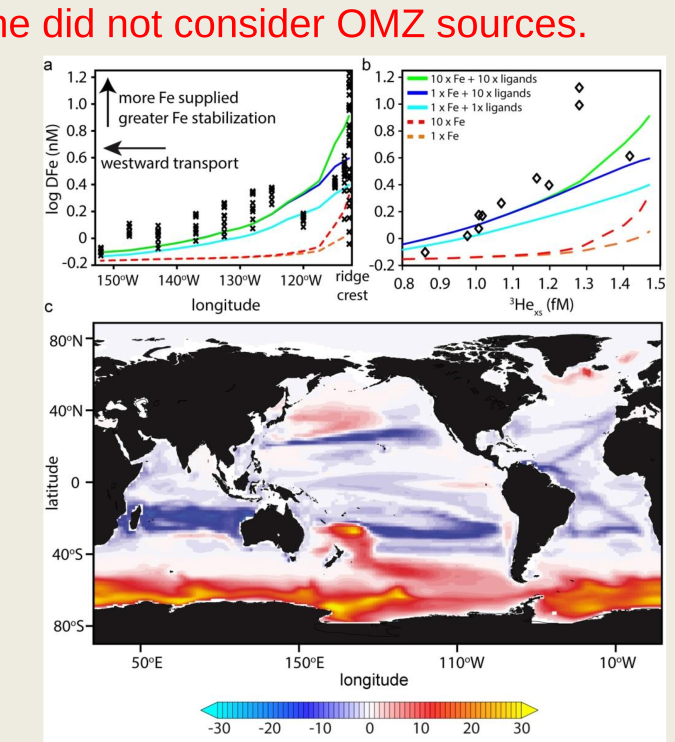


Transport and impact of hydrothermal DFe

Alessandro Tagliabue, using NEMO-PISCES model with "dynamic ligands" to stabilize iron in the water column, assessed the importance of hydrothermal sources globally, including the IO.

Modeled impact of hydrothermal iron flux on Southern Ocean NCP is large: ~20-30% greater export south of APF versus case without hydrothermal Fe

But, he did not consider OMZ sources.



CONCLUSIONS

Iron in the western Indian Ocean is influenced by hydrothermal processes, transformations within the Arabian Sea OMZ and advection from highly reducing margin sediments. Similarities with the eastern Tropical South Pacific provide insight into processes that may be common to both basins
The deep iron plumes underlying the OMZs in each basin are important but surprising, since they are in a more oxidizing part of the water column where iron residence time might be expected to be shorter. This implies that iron cycling (and scavenging) may be quite active within the OMZ.

Acknowledgements: Moffett's research in the Arabian Sea was funded by the Chemical Oceanography Program of the National Science Foundation, the University of Southern California and by the National Institute of Oceanography, Goa India. Thanks to the Captains and crew of research vessels *Knorr, Revelle* and *Thompson*.