NOAA PMEL EARTH-OCEAN INTERACTIONS PROGRAM

Impact of the solid Earth on ocean trace element biogeochemical cycles

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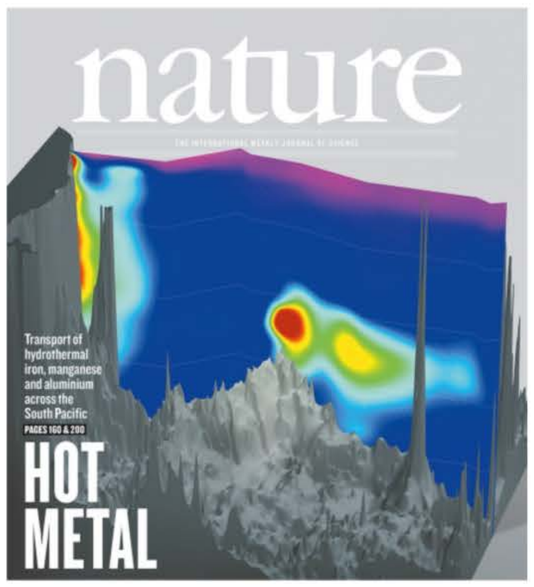
Hydrothermal trace metal fluxes: Sources, transport, and impact on global productivity



Resing et al., 2015. *Nature,* 523, 200-203.

Mapping hydrothermal trace metal inputs

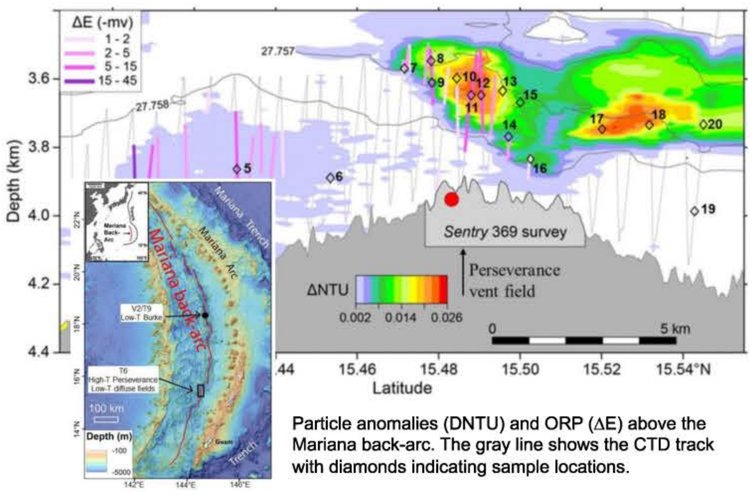
Observations across the southern East Pacific Rise documented long-range transport of hydrothermal Fe for the first time.

This work confirmed that previous paradigms substantially underestimated the far-field influence of hydrothermal Fe emissions, with inputs to the ocean interior at fourfold higher than previous estimates.

Understanding the stabilization and transport mechanisms for trace metals from hydrothermal sources

Some hydrothermal Fe is precipitated near vents, but a substantial portion remains in the water column.

Understanding the organic ligand complexation and nanoparticle formation that facilitate Fe dispersal are necessary to model the mechanisms by which vents influence global Fe distributions, carbon export, and marine ecosystems.

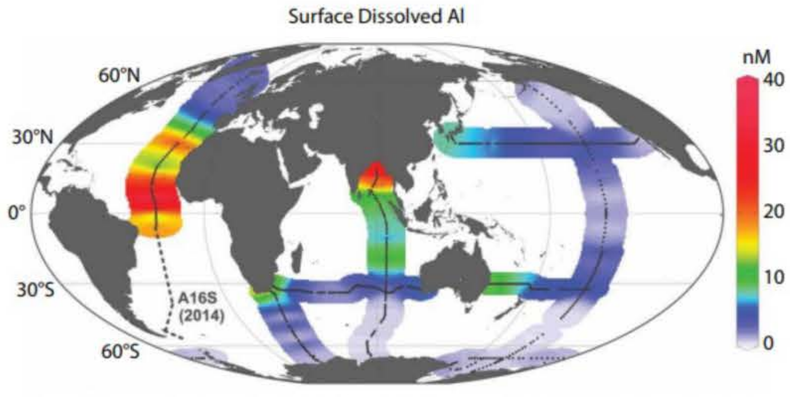


Particle anomalies (DNTU) and ORP (ΔE) above the Mariana back-arc. The gray line shows the CTD track with diamonds indicating sample locations.

Wang et al., 2021. *Geochim. Cosmochim. Acta,* 292, 24-36.

Biogeochemical cycling of Fe: Controls on Southern Ocean carbon uptake

In HNLC waters of the Southern Ocean, macronutrients are abundant but inadequate supply of iron limits biological productivity and ocean uptake of CO_2



Grand et al., 2014. *Oceanography,* 27, 62–65.

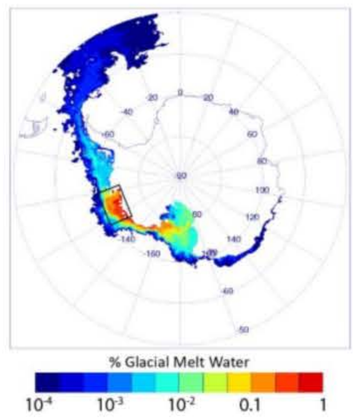
A decade of collaboration with US CLIVAR-CO_2 Repeat Program mapped various ocean tracers that allowed us to investigate controls on global Fe distributions.

Dissolved aluminum, a tracer for dust-derived Fe to the ocean, highlights low supply to Southern Ocean waters.

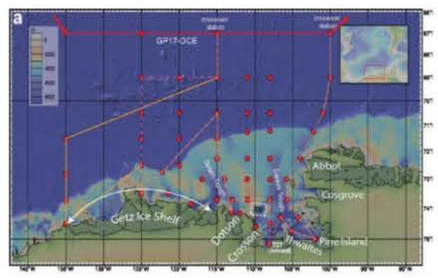
Understanding the Southern Ocean Fe cycle in a changing climate

Recent work on US GEOTRACES cruise GP17-ANT (2023-2024) investigates Fe supply from the Antarctic continental margin in the context of warming Antarctic waters and increased ice melt.

It is critical to understand Fe supply and regulation of the ocean-atmosphere balance of CO_2 under changing environmental conditions.

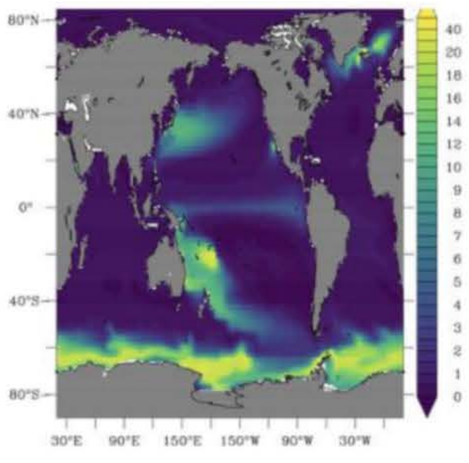


Modelled transport of glacial melt from the Amundsen Sea, a supply of Fe and other trace elements to the Southern Ocean

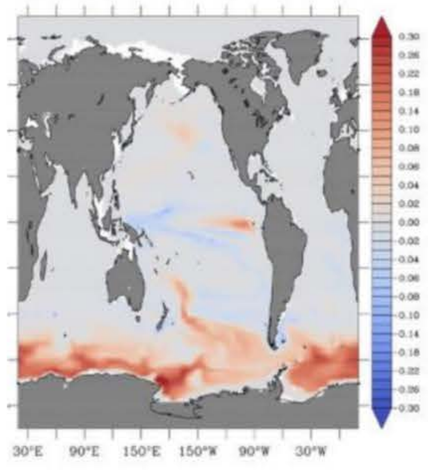


Sampling along recently completed GP17- ANT cruise showing the location of major ice shelves in the region whose melt rates have accelerated in recent decades.

Modelling the global impact of hydrothermal Fe on the biological pump



Modelled impact of hydrothermal vents on Fe in the upper ocean (μmol m^{-2})



Modelled impact of hydrothermal Fe on the biological carbon pump (mol C m^{-2} yr^{-1})

Tagliabue et al., 2022. *Front. Mar. Sci.*.

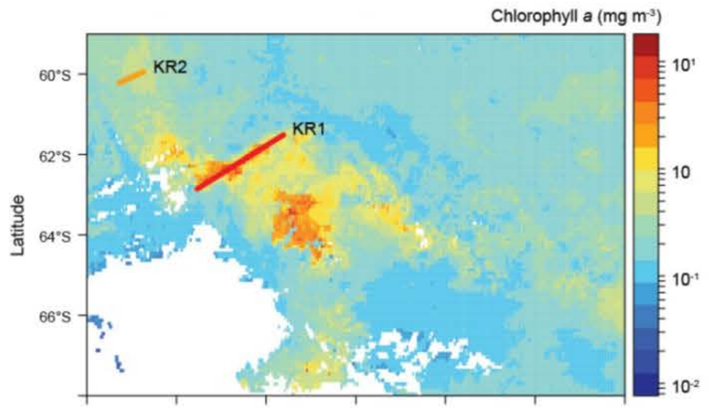
Our observations of Fe and ^3He are used in recent modelling work with collaborators revealing the important role of hydrothermal Fe in driving carbon export in the Southern Ocean.

Large-scale Southern Ocean blooms stimulated by hydrothermal Fe: Informing mCDR

Upcoming work (2024-2025) will investigate a massive phytoplankton bloom re-occurring along the Australian-Antarctic Ridge (AAR).

Study sites such as this one have been identified as useful natural analogs for assessing marine carbon dioxide removal (mCDR) strategies.

Understanding the dynamics of this large-scale, reoccurring perturbation to primary productivity stimulated by natural Fe sources will inform the design of proposed Ocean Iron Fertilization (OIF) programs.



Surface chlorophyll showing annual phytoplankton bloom with location of active vent fields KR1 and KR2 along the AAR.

Selected references

Tagliabue, A., A.R. Bowie, T. M. Holmes, P. Latour, P. C. van der Merwe, M. East, K. Wuttig, **J.A. Resing**, (2022) Constraining the contribution of hydrothermal iron to Southern Ocean export production using deep ocean iron observations. Frontiers in Marine Science, DOI=10.3389/fmars.2022.754517

Wang, H., **Resing, J.A.**, Yan, Q., **Buck, N.J.**, **Michael, S.M.,** Zhou, H., Liu, M., **Walker, S.L.**, Yang, Q., Ji, F. (2021) The characteristics of Fe speciation and Fe-binding ligands in the Mariana back-arc hydrothermal plumes, Geochimcica Cosmochimica Acta 292, 24-36..

Grand, M.M., A. Laes-Huon, S. Fietz, **J.A. Resing**, H. Obata, G. Luther, E. Achterberg, M. Maldonado, R. Middag (2019). Developing Autonomous Observing Systems for Micronutrient Trace Metals, Frontiers in Marine Science, 6, 35.

Tagliabue, A. and **J.A. Resing** (2016). Impact of hydrothermalism on the ocean iron cycle. Philosophical Transactions of the Royal Society A, 20150291.

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

Barrett, P.M., **J.A. Resing**, **N.J. Buck**, W.M. Landing, P.L. Morton, and R.U. Shelley (2015). Changes in the distribution of Al and particulate Fe along A16N in the eastern North Atlantic Ocean between 2003 and 2013: Implications for changes in aerosol dust deposition. Mar. Chem., 177, 57–68.

Resing, J.A., and **P.M. Barrett** (2014). Fingerprinting the sources of iron to the oceans. Nature, 511, 164–165.

Grand, M.M., C.S. Buck, W.M. Landing, C.I. Measures, M. Hatta, W.T. Hiscock, M. Brown, J.A. Resing (2014). Quantifying the impact of atmospheric deposition on the biogeochemistry of Fe and Al in the upper ocean: A decade of collaboration with the US CLIVAR-CO2 Repeat Hydrography Program. Oceanography 27, 62-65.