

## ANNUAL REPORT ON GEOTRACES ACTIVITIES IN SOUTH AFRICA

April 1st, 2019 to March 31st, 2020

### New GEOTRACES or GEOTRACES relevant scientific results

- Cloete et al. (2019): First measurements of labile dissolved copper (LdCu) and dissolved zinc (dZn) and nickel (dNi) in the Atlantic sector of the Southern Ocean in winter were compared with summer data at reoccupied stations in order to better understand the winter reset state and supply of these trace metals to support productivity. In summer, vertical profiles of zinc behaved similarly to silicate (Si). Copper profiles also resembled Si. First summer nickel data reported from this transect displayed comparatively higher surface concentrations increasing more rapidly to local intermediate depth maximums, similar to phosphate (PO<sub>4</sub>).

Trace metal seasonality was most apparent in the mixed layer where the average of winter concentrations within the mixed layer exceeded summer values by approximately 0.2 nmol kg<sup>-1</sup> for LdCu, 1.2 nmol kg<sup>-1</sup> for dZn and 0.3 nmol kg<sup>-1</sup> for dNi owing to low utilization under unfavourable growth conditions for phytoplankton.

Zinc ( $R^2 > 0.75$ ) and copper ( $R^2 > 0.73$ ) were strongly correlated with Si throughout the study implicating diatoms as strong controllers of their biogeochemical cycling. Nickel was more strongly correlated with PO<sub>4</sub> in the upper water column ( $R^2 > 0.75$ ), as compared to the whole water column ( $R^2 > 0.52$ ), while in the deep ocean nickel appears to correlate with Si although more deep ocean data is needed to confirm this.

Trace metal to major nutrient ratios were higher in winter suggesting reduced micronutrient requirement relative to macronutrients under stressed but low productivity conditions.

- Cloete et al. (prep. for submission): Winter measurements of dissolved cadmium (dCd) and particulate cadmium (pCd) were presented for the first time in the Indian Sector of the Southern Ocean (GEOTRACES section G1pr07) in order to investigate the biogeochemical cycling of the trace metal micronutrient during the winter reset period. Biological uptake of

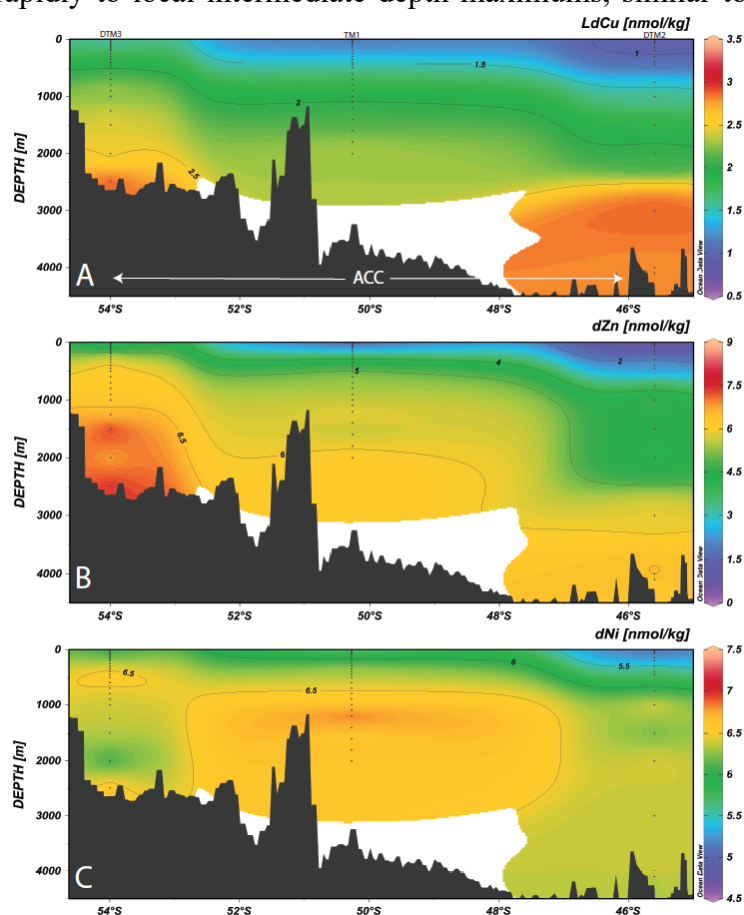


Figure 1. Winter distributions of a) dissolved labile copper (LdCu), b) dissolved zinc (dZn) and c) dissolved nickel (dNi). Figures generated in Ocean Data View (ODV). From Cloete et al., 2019 (<https://doi.org/10.1016/j.chemgeo.2018.10.023>)

dCd by phytoplankton in the surface ocean, and the resulting production of pCd, was assessed primarily through comparisons with dissolved phosphate ( $\text{PO}_4$ ) and particulate phosphorous (P). Although winter production was lower than that of typical spring/summer months, our results showed that biological uptake remains an important driver of cadmium cycling during winter, a season typically considered biologically dormant. While dCd and  $\text{PO}_4$  as well as pCd and P were well correlated throughout the transect, spot ratios of dCd: $\text{PO}_4$  (Figure 1a) and pCd:P (Figure 1b)

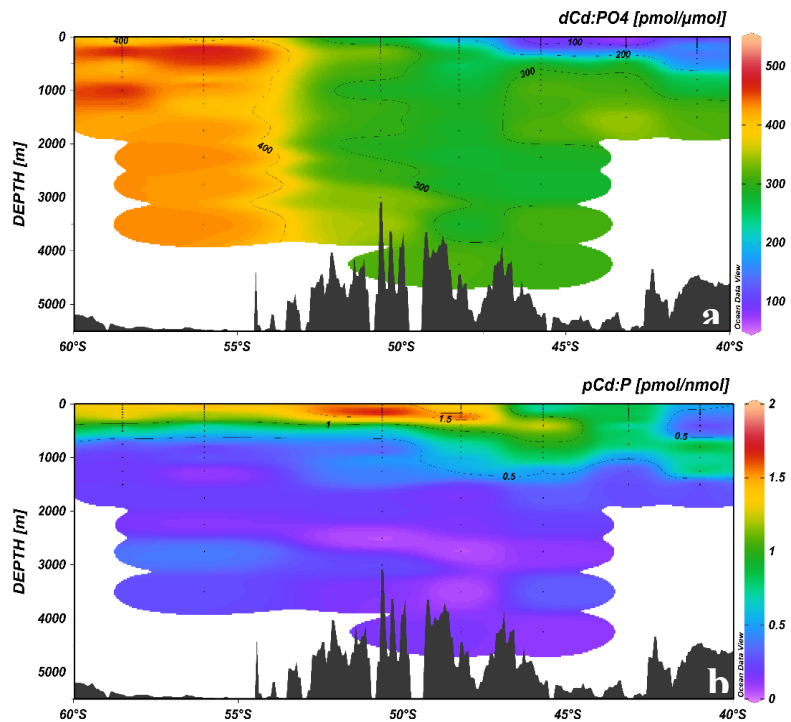


Figure 2. Spot ratios of (a) dCd: $\text{PO}_4$  and (b) pCd:P (Cloete et al., in prep.)

revealed distinct spatial features reflecting changes in local phytoplankton community assemblages and respective uptake strategies. Below the surface layer, simple water mass mixing between intermediate, deep and bottom waters suffices to explain dCd distributions.

- Mtshali et al. (2019): Four occupations in the Atlantic sector of the Southern Ocean (Southern Ocean Seasonal Cycle experiment III cruise: SOSCEX III cruises in winter (July – August 2015 and summer December 2015 to February 2016) examine the seasonal dynamics of dissolved iron (DFe) in the upper water column. DFe inventories from euphotic and aphotic depth horizons decreased progressively from July to February, while dissolved inorganic nitrogen (DIN) decreased from July to January with no significant change between January and February.

Results suggest that between July and January, DFe loss from both euphotic and aphotic reservoir was predominantly in support of phytoplankton growth (supported by iron to carbon uptake ratio of  $16 \pm 3 \mu\text{mol mol}^{-1}$ ) highlighting the important role of vertical nutrient supply. During January to February, excess loss of DFe relative to DIN (iron to carbon uptake ratio of  $44 \pm 8 \mu\text{mol mol}^{-1}$  and aphotic DFe loss rate of  $0.34 \pm 0.06 \mu\text{mol m}^{-2} \text{d}^{-1}$ ) suggests that scavenging is the dominant removal mechanism of DFe from the aphotic, while continued production is likely supported by recycled nutrients.

- Viljoen et al. 2019: Changes in the phytoplankton community related to macronutrient and bioactive trace metal distribution were assessed in surface waters of the Atlantic sector of

the Southern Ocean, between Cape Town and Antarctica along GEOTRACES GIPY\_05 in summer 2014–2015.

Several general community structure features were reaffirmed, such as the restriction of cyanobacteria to the northern Subtropical Zone, while haptophytes, such as *Phaeocystis*, along with diatoms, dominate the community north of the Polar Front, and diatoms dominate south of the Polar Front. These community structure changes were often linked with macro- and micro-nutrient composition changes. However, these links were not consistent along the entire transect, i.e., no individual nutrient, such as silica or iron, was linked to community composition changes across all water masses.

Each station showed a rather unique combination of nutrient and community compositions. Our findings also indicated impacts on the phytoplankton community through trace metal distributions that could be related to a deep mixing event at 54°S and to ice melt at 65°S and 68°S.

The study highlights the importance of considering a suite of trace metals when assessing controls of phytoplankton variability in the open ocean and emphasizes the need for higher resolution trace metal sampling and multi-element incubation studies to further study the complex relationships between phytoplankton and nutrients.

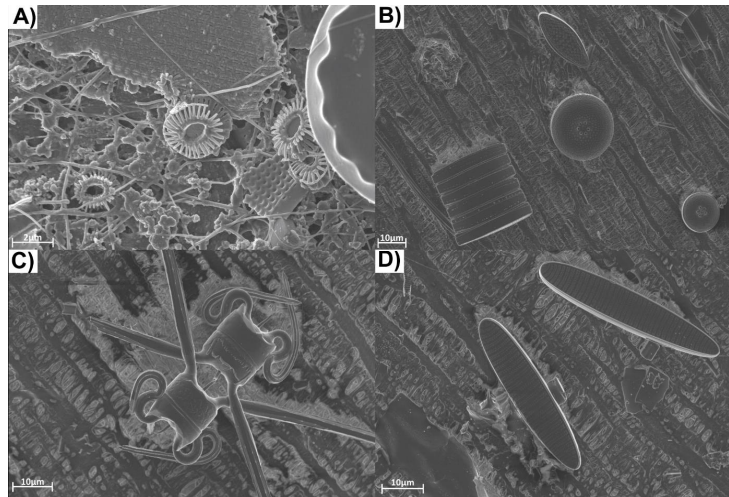


Figure 3. SEM images of dominant diatom species at station 56°S and A) *Cocolith platelets* B) *Fragiliaropsis kerguelensis* both chain-forming and solitary cells (*Fragiliaropsis* spp.), *Thalassiosira* spp. C) *Chaetoceros* spp. D) *Fragiliaria* spp. From Viljoen et al., 2019 (doi: 10.3389/fmars.2019.00295; Supplementary Material)

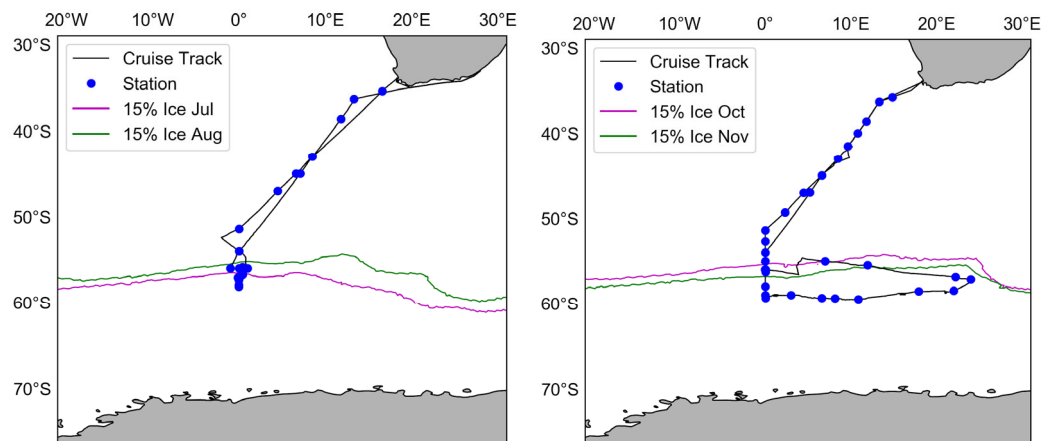
### ***GEOTRACES relevant cruises***

- SCALE Winter Cruise: 18th July 2019 - 12th August 2019
- SCALE Spring Cruise: 12th October 2019 - 20th November 2019

### **Chief Scientists**

Winter Cruise Chief Scientist, co-Chief Sc.: A/Prof Marcello Vichi, Dr Sandy Thomalla

Spring Cruise Chief Scientist, co-Chief Sc.: Dr Thomas Ryan-Keogh, A/Prof Marcello Vichi



### ***New projects and/or funding***

- Mackey B, Roychoudhury AN, Vichi M, Findlay, K (2019 – 2022) Humpback whales in changing climate, Donor funding AUD 4,019,503

### ***Ongoing projects and/or funding***

- Fietz S (2018-2020) South African National Antarctic Programme (SNA170506229934) Shifts in phytoplankton and microbial community composition and functional diversity related to trace metal cycling; R914,000
- Fietz S, Lloyd J (2018-2020) South African bilateral programme, SA-Iran (IRSA170718254901) Carbonic anhydrases from marine microbes and phytoplankton for enzymatic remediation of cadmium-contaminated water resources; R242,950
- Fietz S, Lloyd J, Makhalanyane T (2018-2020) South African bilateral programme, SA-Mexico (MESA170607237905) Exploiting microbes for remediation of pollution in oceans; R2,284,200
- Mtshali (2019 – 2020) SA/France PROTEA travelling funds between SA TracEx/CSIR Laboratory and France (LEMAR, UBO): R150, 000 per year
- Roychoudhury AN (2017-2019) Nanoparticles at Air-Sea interface. NRF Competitive Rated Researcher Grant, R1,550,000
- Roychoudhury AN (2017-2019) TraceEx: Establishment of Center of excellence in Trace and experimental Biogeochemistry, Donor funding, R 17 Million
- Roychoudhury AN (2018-2020) Distribution and Speciation of Bioactive Trace Elements in Southern Ocean, NRF SANAP, R1,820,000
- Ryan-Keogh T, Mtshali T (2018-2020) Seasonal evolution of biogeochemical Fe cycle in the Southern Ocean. NRF SANAP

***Outreach activities conducted (please list any outreach/educational material available that could be shared through the GEOTRACES web site)***

- Stellenbosch TracEx Team blogs:  
<https://southernoceanfe.wordpress.com/>  
<https://tracexsite.wordpress.com/>
- Stellenbosch TracEx Team's facebook page:  
<https://www.facebook.com/Environmental-Geochemistry-at-Stellenbosch-University-135430226505633/>
- And twitter account: <https://twitter.com/TracexS>
- Classroom activities with SA primary (120 pupils) and high school (20 pupils) learners on “Climate Change”, “Antarctic Research” and “Science going Places”
- SCALE cruise 2019 website:  
[scale.org.za](http://scale.org.za)



***New GEOTRACES or GEOTRACES-relevant publications (published or in press)***

*Main publications by SA researchers:*

- Cloete R, Loock JC, Mtshali TN, Fietz S, Roychoudhury AN\* (2019) Winter and summer distributions of Copper, Zinc and Nickel along the International GEOTRACES section GIPY05: Insights into deep winter mixing. *Chemical Geology* 511, 342-357. <https://doi.org/10.1016/j.chemgeo.2018.10.023>
- Gregor L\*, Ryan-Keogh TR, Nicholson S-A, Du Plessis MD, Giddy I, Swart S. GliderTools: A Python toolbox for processing underwater glider data (2019). *Front. Mar. Sci.* doi: 10.3389/fmars.2019.00738.
- Menzel Barraqueta J-L\* et al. (2019) Atmospheric aerosol deposition fluxes over the Atlantic Ocean: A GEOTRACES case study. *Biogeosciences*, 16, 1525–1542, <https://doi.org/10.5194/bg-16-1525-2019>
- Mtshali TN\*, van Horsten NR, Thomalla SJ, Ryan-Keogh TJ, Nicholson SA, Roychoudhury AN, Bucciarelli E, Sarthou G, Tagliabue A, Monteiro PMS (2019). Seasonal depletion of the dissolved iron reservoir in the sub-Antarctic zone of the Southern Ocean, *GRL* 46, 4386-4395, DOI: 10.1029/2018GL081355
- Smart SM\*, Fawcett SE, Ren H, Schiebel R, Tompkins EM, Martínez-García A, Stirnimann L, Roychoudhury A, Haug GH., Sigman DM (2020) The nitrogen isotopic composition of tissue and shell-bound organic matter of planktic foraminifera in Southern Ocean surface waters. *Geochemistry, Geophysics*, 21, doi: 10.1029/2019GC008440
- Viljoen J, Weir I, Fietz S\*, Cloete R, Loock J, Philibert R, Roychoudhury AN (2019). Links between phytoplankton community composition and trace metal distribution in the surface waters of the Atlantic Southern Ocean. *Frontiers in Marine Science*, 6, 295, <https://doi.org/10.3389/fmars.2019.00295>

*Co-authored by SA researchers:*

- Fripiat et al., incl. Fawcett SE (2019) The isotope effect of nitrate assimilation in the Antarctic Zone: Improved estimates and paleoceanographic implications. *Geochimica et Cosmochimica Acta* 247: 261-279. <https://doi.org/10.1016/j.gca.2018.12.003>
- Gourain et al., incl. Menzel Barraqueta J-L (2019) Inputs and processes affecting the distribution of particulate iron in the North Atlantic along the GEOVIDE (GEOTRACES GA01) section. *Biogeosciences*, 16, 1563-1582.
- Grand et al., incl. Fietz S (2019) Developing autonomous observing systems for micronutrient trace metals. *Frontiers in Marine Science* 6:35, <https://doi.org/10.3389/fmars.2019.00035>
- Louropoulou et al., incl. Menzel Barraqueta J-L (2019) Regulation of the phytoplankton heme B iron pool during the North Atlantic spring bloom. *Frontiers in Microbiology*, 10, 1566.
- Rapp et al., incl. Menzel Barraqueta J-L (2019) Controls on redox-sensitive trace metals in the Mauritanian oxygen minimum zone. *Biogeosciences*, 16, 4157-4182
- Tonnard et al., incl. Menzel Barraqueta J-L (2020) Dissolved iron in the North Atlantic Ocean and Labrador Sea along the GEOVIDE section (GEOTRACES section GA01). *Biogeosciences*, 17, 917-943

***Completed GEOTRACES PhD or Master theses***

- Smart, Sandi M. (2020-04), PhD. Modern-ocean ground-truthing of planktic foraminifer nitrogen isotopes : a proxy for surface ocean nutrient conditions. ([link: https://scholar.sun.ac.za/handle/10019.1/107746](https://scholar.sun.ac.za/handle/10019.1/107746))

***GEOTRACES presentations in international conferences***

- Cloete R, Loock J, Fietz S & Roychoudhury A (2019) First Cadmium and Zinc Measurements from the Indian Sector of the Southern Ocean. *Goldschmidt Abstracts*, 2019 635, <https://goldschmidt.info/2019/abstracts/abstractView?id=2019003193>
- Fietz S. & TracEx Team & partners. Phytoplankton community responses to iron and light in summer and wintertime Southern Ocean. Southern Ocean Biogeochemistry workshop, Hobart, Tasmania, Australia, 09/2019
- Fietz S. Proxies for the past. GEOTRACES Summer School, Cadiz, Spain, 09/2019.
- Kanguenzi K, Fietz S, Eckardt F & Von Holdt J (2019) Comparing Natural and Anthropogenic Dust Emitted in Southern Africa as Potential Sources of Nutrients to Open Oceans. *Goldschmidt Abstracts*, 2019 1604, <https://goldschmidt.info/2019/abstracts/abstractView?id=2019001564>
- Samanta S & Roychoudhury AN (2019) Synthesis of Dissolved Pb and Pb Isotope Data of Global Ocean: Sources, Cycling, and Mixing. *Goldschmidt Abstracts*, 2019 <https://goldschmidtabstracts.info/2019/2942.pdf>
- van Horsten N, Bucciarelli E, Planquette H, González-Santana D, Mtshali T, Roychoudhury A & Sarthou G (2019) Early Winter Dissolved Fe Distributions in the Southern Indian Ocean (GEOTRACES GIPr07 Cruise). *Goldschmidt Abstracts*, 2019 <https://goldschmidtabstracts.info/2019/3475.pdf>

***Submitted by Susanne Fietz (sfietz@sun.ac.za)***