Annual report on GEOTRACES activities in South Africa

May 1st, 2017 to March 30th, 2018

New scientific results

In 2017, we focused on trace metal distribution and associated community structures in summer and winter along the Good Hope Line (Atlantic) and along the WOCE I06 transect (Indian Ocean):

- PhD student Jean Loock investigated the change in Cd and Mn depth distribution along the Good Hope Line in austral summer and winter 2015 (Loock et al., submitted). Hydrothermal activity was indicated at 54 °S that will be further investigated in future. These trace metals were also measured along the I06 transect in winter 2017 (Figure 19; unpublished).

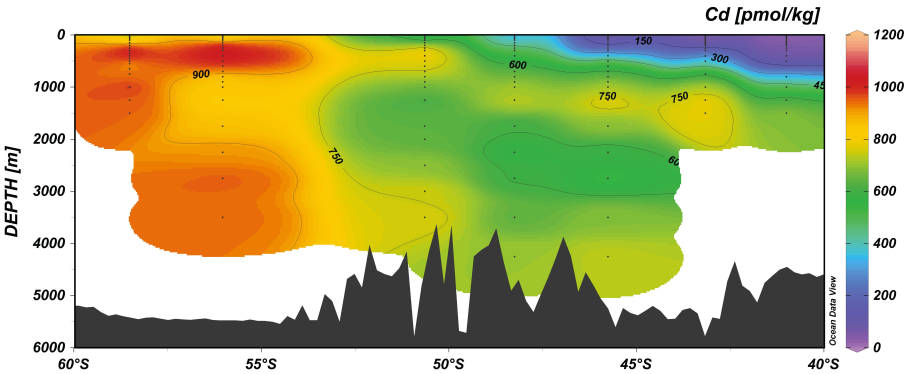

Figure 19*. Distribution of dissolved cadmium along the I06 transect (Indian Ocean) in austral winter (July 2017)*

- PhD student Ryan Cloete measured dissolved Cu, Zn and Ni along the same transects. He noticed strong seasonality in the Cu and Zn concentrations in the mixed layer, with average winter concentrations exceeding summer values by 0.2 nM for Cu and 0.9 nM for Zn (Cloete et al., submitted). These trace metals were also measured along the I06 transect in winter 2017 (Figure 20; unpublished).

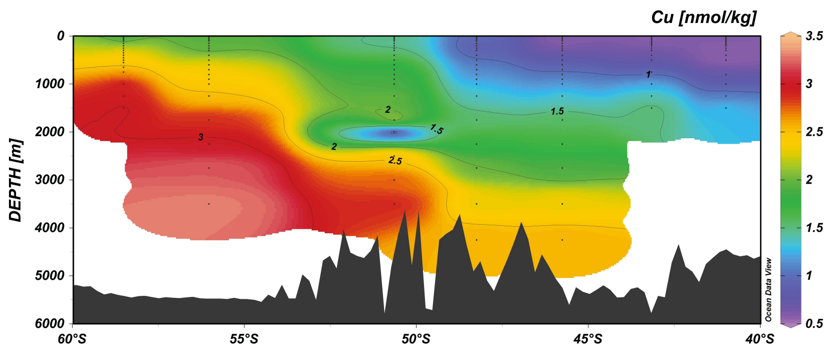

Figure 20. *Distribution of dissolved copper along the I06 transect (Indian Ocean) in austral winter (July 2017)*

- MSc students Ian Weir and Johan Viljoen looked at changes in the community structure (Figure 3; unpublished) with changes in macronutrients and bioactive trace metals in the surface ocean along the Good Hope Line (Atlantic sector of the Southern Ocean). Statistical analyses indicated that 65% of the variability in the community structure along the Good Hope Line could be explained by only three factors. Three factors (not necessarily the same) also explained 98% of the variability in the trace metal distribution. Interestingly, out of all bioactive trace metals, the variability of iron (along the surface transect) was the least related to total chl-a and phytoplankton community structure. MSc student J. Viljoen furthermore examined the change in phytoplankton community structure upon iron and light addition in on-board bottle incubations in the Atlantic sector of the Southern Ocean (Good Hope Line). Two experiments were conducted one at 46 °S and one at 65 °S. The community at 46 °S was more diverse than the community at 65 °S. However, at 46 °S, major shifts in the community composition occurred under higher light, rather than after iron addition. At 65 °S, in contrast, a shift occurred upon iron addition, independent of the light level, i.e. even under low light conditions (Viljoen et al., submitted).

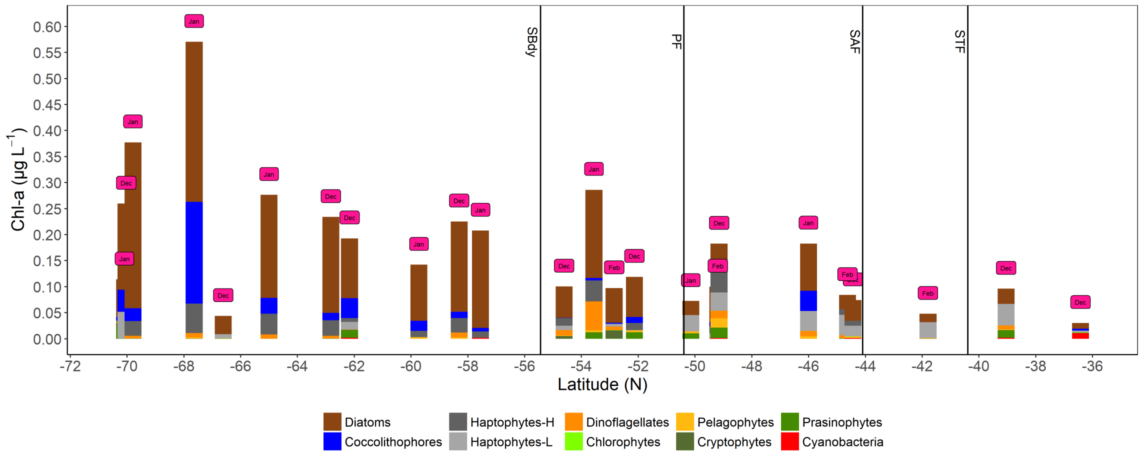

Figure 21. *Phytoplankton community structure in surface waters along the Good Hope Line (Atlantic Southern Ocean) in summer 2015.*

Cruises

Winter Cruise 2017 along the WOCE I06 transect (Indian Ocean) GEOTRACES related activities: The first key objective was to determine the trace metal (Fe, Cu, Zn, Mn, Ni, Cd, Co and Pb) and Rare Earth Element (lanthanide series, La through Lu) concentrations. The teams collected various samples to assess the partitioning of these elements between the total, dissolved, particulate and soluble fractions as well as to assess what influence the ligands have on these interactions. Physical (salinity and temperature) and biological (macronutrients, phytoplankton & bacterial abundance and composition) data were collected to further constrain the biogeochemical cycling of these elements. Other key objectives consisted in quantifying the inputs of hydrothermally derived trace elements (specifically Fe, Cu, Zn and REE's) into the deep waters of the Southern Ocean. Samples were also taken for determination of stable isotopes of Cu, Zn, Fe and Si. This should allow to better constrain what are the controlling factors on metal speciation once ejected into the ocean and how does this affect bioavailability. We also deployed our two McLane pumps successfully during this cruise and we attempted to collect dust samples. The latter was hindered by extreme tail winds throughout most of the winter cruise.

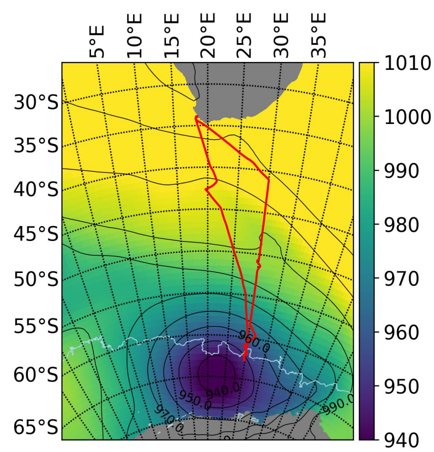

Figure 22. *Cruise track of the Winter 2017 expedition (red line) overlain to the 04/07/2017 mean sea level pressure from ERA-Interim reanalyses (shading and contours) and 15% sea ice concentration from AMSR2 (light blue line). From Vichi et al. (2017; Cruise Report)*

New projects and/or funding

- Roychoudhury AN (2018-2020) Distribution and Speciation of Bioactive Trace Elements in Southern Ocean, NRF SANAP, R 1,820,000
- Roychoudhury AN (2017-2019) TraceEx: Establishment of Center of excellence in Trace and experimental Biogeochemistry, Donor funding, R 17 Million
- Roychoudhury AN (2017-2019) Nanoparticles at Air-Sea interface. NRF Competitive Rated Researcher Grant, R 1,550,000
- 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
- Ryan-Keogh T, Mtshali T (2018-2020) Seasonal evolution of biogeochemical Fe cycle in the Southern Ocean. NRF SANAP

Outreach activities

- Team blog: https://southernoceanfe.wordpress.com/
- Team's facebook page: https://www.facebook.com/Environmental-Geochemistry-at-Stellenbosch-University-135430226505633/

New publications (published or in press)

- Ryan-Keogh TJ, Thomalla SJ, Mtshali TN, Little H (2017) Modelled estimates of spatial variability of iron stress in the Atlantic sector of the Southern Ocean, Biogeosciences, 14: 3883-3897, doi: 10.5194/bg-14-3883-2017.
- Das SK, Routh J, Roychoudhury AN, Veldhuis MJW, Ismail HE. (2017) Connecting pigment composition and dissolved trace elements to phytoplankton population in the southern Benguela Upwelling zone (St. Helena Bay). J Marine Systems 176, 13-23
- Von der Heyden BP, Roychoudhury AN, Tyliszczak T, Myneni SCB (2017) Investigating nanoscale mineral compositions: Iron L3-edge spectroscopic evaluation of iron oxide and oxy-hydroxide coordination. American Mineralogist 102, 674-685.

PhD & MSc theses

- KI Kangueehi, Trace metal concentrations and dissolution characteristics of dust emitted from known sources in southern Africa (MSc thesis, Dec 2017)

Presentations in international conferences

- S.M. Smart, S.E. Fawcett, H. Ren, R. Schiebel, M.A. Weigand, A.N. Roychoudhury, G.H. Haug, D.M. Sigman. Ground-truthing the Foraminifera-bound Nitrogen isotope paleo-proxy in the modern Southern Ocean, Ocean Science Meeting, Portland, USA, February 2018.
- Roychoudhury An, R. Cloete, J. Loock, T.Mtshali, S. Fietz. Bioactive trace elements (Cu, Zn, Cd and Co) in the Southern Ocean. Goldschmidt, Paris, August 2017
- Kangueehi K, S. Fietz, A. N. Roychoudhury, F. D. Eckardt, J. Von Holdt. Dust transport pathways and bioavailability of dust emissions from southern Africa. Goldschmidt, Paris, August 2017

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