GEOTRACES SCIENTIFIC STEERING COMMITTEE ANNUAL REPORT TO SCOR 2023/2024

July 2024

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN AUSTRALIA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

- Yaojia Sun (ANU) has submitted a manuscript for publication detailing strontium cycling in the Southern Ocean. Specifically, she has used dissolved strontium concentrations from the Southern Ocean water samples and strontium export fluxes from sediment traps to assess particulate organic carbon export associated with Acantharia. She found that there is a coincidence in the strontium export flux with the second peak of POC export implying a potential association of Acantharia biomass with summertime productivity. The results suggest that Acantharia can contribute up to 7% of the POC export flux. Samples for this study came from two Geotraces voyages in 2018 and 2020.
- Yaojia Sun (ANU) has submitted a second manuscript for publication detailing calcium concentration changes from subantarctic and polar waters. While previous studies have noted discrepancies between the relative changes in total alkalinity and calcium concentrations, she found a strong correlation between nutrient-corrected total alkalinity and calcium concentrations in the Southern Ocean, suggesting they are controlled by calcium carbonate production and dissolution. Samples for this study came from SOLACE Geotraces voyage in 2020

GEOTRACES or GEOTRACES relevant cruises

- MISO Jan-Mar 2024 (GS05). Samples collected:
 - TM rosette: trace metals; Cu isotopes; Cd, Fe, Zn isotopes; Pb isotopes; U isotopes; Cu ligands; Fe ligands; Siderophores; Ca and Mg; Total Hg
 - o CTD rosette: N isotopes; REE; Radiogenic isotopes [Th, Nd]
 - In situ pumps: particulate trace metals; labile particle trace metals; trace metal isotopes; radiogenic isotopes; Fe mineralogy; CHN
 - o Rainwater sampler: trace metals; soluble ions
 - Aerosol sampling manifold: trace metals; soluble ions.

New projects and/or funding

• First science voyage on the *RVS Nuyina* planned for late Feb to early April 2025 to the Denman Glacier, East Antarctica supported by the Australian Centre for Excellence in Antarctic Science. The voyage is largely focused on continental shelf oceanography, with some limited B in BGC due to the late timing. ANU and UTas teams are preparing for 25 trace metal rosette, 6 insitu pump deployments and some sediment kasten coring and multicoring.

Other GEOTRACES activities

- Data submitted to the IDP2025:
 - Dissolved ²³⁰Th and ²³²Th isotopes southern SR3 transect, collected during IN2018_V01 voyage in 2018
 - Dissolved trace metal concentrations and isotope values for iron and zinc from the SOLACE voyage in 2020
 - Dissolved strontium concentrations for the SOLACE voyage and the SR3 voyage in 2018

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

- Weis, J. *et al.* One-third of Southern Ocean productivity is supported by dust deposition. *Nature* 629, 603–608 (2024).
- Latour, P. *et al.* Characterization of a Southern Ocean deep chlorophyll maximum: Response of phytoplankton to light, iron, and manganese enrichment. *Limnology and Oceanography Letters* 9 (2), 145-154 (2024)
- Trail, CD. *et al.* Mechanistic constraints on the drivers of Southern Ocean meridional iron distributions between Tasmania and Antarctica. Global Biogeochemical Cycles 38 (3), e2023GB007856 (2024)
- Aflenzer H. *et al.* Effect of dissolved iron (II) and temperature on growth of the Southern Ocean phytoplankton species Fragilariopsis cylindrus and Phaeocystis antarctica. Polar Biology 46 (11), 1163-1173 (2023)

GEOTRACES presentations in international conferences

• Microbial Competition for Iron Determines its Availability to the Ferrous Wheel, R Strzepek, P Latour, MJ Ellwood, PW Boyd, 2024 Ocean Sciences Meeting

Submitted by Taryn Noble (<u>Taryn.Noble@utas.edu.au</u>).

ANNUAL REPORT ON GEOTRACES ACTIVITIES ARGENTINA

May 1st, 2023 to April 30th, 2024

GEOTRACES workshops and meetings

WORKSHOP: Iron supply in the Patagonian shelf-break front: Malvinas Current and the interaction with slope sediments and submarine canyons.

Dates: January 16-18, 2024

City: Buenos Aires, Argentina

Venue: Centro de Investigaciones del Mar y de la Atmósfera (CIMA) & Instituto Franco-Argentino del Estudio del Clima y sus Impactos (IFAECI) & Departamento de Ciencias de la Atmósfera y los Océanos (DCAO), at the Facultad de Ciencias Exactas y Naturales (FCEN) - Universidad de Buenos Aires (UBA).

Chairs: Federico Ibarbalz (CIMA-IFAECI) & Valeria Guinder (IADO-UNS-CONICET) Website: <u>https://workshop2024.github.io/web/</u>

Motivations

- The Patagonian Shelf-Break Front (PSBF) in the SW South Atlantic Ocean is a permanent thermohaline front with very high biological activity along 100s-1000s km. Intense phytoplankton blooms during spring and summer support large biodiversity and fisheries. Understanding the underlying physical and chemical processes that sustain this productivity and the associated carbon fluxes may allow delineating/predicting its trajectories and feedbacks in response to the ongoing climate change.
- Primary productivity requires not only C, N and P but also trace elements or 'micronutrients' such as iron, copper or manganese as fundamental components of enzymes or electron transporters. As this, their concentration and bioavailability regulate the phytoplankton yield and the ecosystem productivity.
- A biogeochemical hypothesis formulates that the high biological productivity and diversity of the PSBF beyond the initial spring bloom may be related to the supply of micronutrients (in particular, iron) into the shelf through intrusions of the Malvinas Current and its interaction with slope sediments and submarine canyons.
- Currently there are no trace element measurements in waters of the Argentine Patagonian shelf and adjacent westerly edge currents of the SW South Atlantic. One exception is found near Malvinas Islands (see Bowie et al., 2002) and then there is the western end of the <u>GA10 GEOTRACES section</u> (this has not been exploited; requires further examination to assess relevance for the more southern Patagonian shelf). Moreover, from the beginning, the international GEOTRACES programme has prioritised a micronutrient section along the Patagonian shelf (denoted <u>GA09</u>) due to the potential importance of micronutrients in this region.
- The sophisticated set of geochemical techniques for in-situ sampling and lab determination of trace elements is currently not available in Argentina. Therefore, a

careful planification and probably a joint international effort will be required. This would allow the obtention of reliable standardized data of its bio-available forms.

• The visit of Dr. Prof. Alessandro Tagliabue, expert in the global ocean iron cycle and ocean biogeochemical models (incoming co-chair of the Scientific Steering Committee of <u>GEOTRACES</u>), largely motivates the three-day workshop. His expertise fueled scientific discussion with Argentinean and international partners interested in the creation of a network to study the input, cycling and availability of iron, as well as other biogeochemical processes in the Patagonian shelf-break front and adjacent oceanic waters.

Objectives of the Workshop

- Discussing the science and most important gaps around our understanding of the biogeochemistry regulating the phytoplankton in the PSBF to then define specific scientific questions
- Presenting the state of the art regarding the key processes shaping the external input and internal cycling of iron in the region
- Evaluating the incorporation of the standard protocols of Fe measurements according to GEOTRACES
- Identifying future collaborations and funding sources
- Planning joint future research cruises
- Drafting a scientific project for a future proposal with the newly developed <u>BioGeoSCAPES</u> perspective (GEOTRACES + microbiomes)

List of in person participants

- 1. Alessandro Tagliabue. University of Liverpool, UK.
- 2. Federico Ibarbalz. CIMA-IFAECI, CONICET, UBA. Buenos Aires, Argentina.
- 3. Valeria Guinder. IADO, CONICET, UNS. Bahía Blanca, Argentina.
- 4. Pedro Flombaum. CIMA-IFAECI, CONICET, UBA. Argentina.
- 5. Martin Saraceno. CIMA-IFAECI, CONICET, UBA. Buenos Aires, Argentina.
- 6. Nicolas Cosentino. CIMA-IFAECI, CONICET, UBA. Buenos Aires, Argentina.
- 7. Flavio E. Paparazzo. CESIMAR, CONICET, Puerto Madryn. Argentina.
- 8. Silvia Romero. SHN, UBA, Buenos Aires, Argentina.
- 9. Ronald Buss de Souza. Earth System Numerical Modeling Division, INPE, Brazil.
- 10. Lucía Carolina Kahl. SHN, Buenos Aires, Argentina.
- 11. Graziella Bozzano. SHN, CONICET, Buenos Aires, Argentina.
- 12. Fernando Becker. SHN, Buenos Aires, Argentina.
- 13. Paola Dávila. SHN, Buenos Aires, Argentina.
- 14. Celeste Antieco. SHN, Buenos Aires, Argentina.
- 15. Milagro Urricariet. SHN, Buenos Aires, Argentina.
- 16. Ornella Silvestri. SHN, Buenos Aires, Argentina.
- 17. Axel Toledo. SHN, Buenos Aires, Argentina.
- 18. Melina Martínez, CIMA-IFAECI, CONICET, UBA. Buenos Aires, Argentina.
- 19. Carola Ferronato. IADO, UNS, Bahía Blanca, Argentina.

- 20. Juan Muglia. CESIMAR, CONICET. Puerto Madryn, Argentina.
- 21. Juan José Pierella Karlusich. Harvard University, USA.
- 22. Mónica Wallner. Universidad Federal de Río Grande, Brazil.
- 23. Juan Cruz Carbajal. CADIC, CONICET. Ushuaia, Argentina.

List of virtual participants

- 1. Helene Planquette. LEMAR, Brest, France
- 2. Martha Gledhill. GEOMAR, Kiel, Germany
- 3. Sebastián Giacomino. CESIMAR, CONICET, Puerto Madryn. Argentina.
- 4. Melisa Fernández Severini. IADO, UNS, Bahía Blanca, Argentina.
- 5. Santiago Gasso. NASA, USA
- 6. Daniela del Valle. INIDEP, Mar del Plata, Argentina.
- 7. Georgina Cepeda. INIDEP, Mar del Plata, Argentina.
- 8. Carla Berghoff. INIDEP, Mar del Plata, Argentina.
- 9. Ricardo Silva. INIDEP, Mar del Plata, Argentina.
- 10. María Inés Torres. INIDEP, Mar del Plata, Argentina.

As a result of the workshop, the following initiatives have been generated:

The long-term scientific objective that emerged from the workshop is to investigate the inventories and cycling of marine trace metals and their impact on primary production in the Patagonian shelf (Southwestern Atlantic).

With this objective, the following actions have been carried out to date:

- February-Currently. 2024 Virtual meetings. F. Ibarbalz organized a series of follow-up virtual meetings during 2024 to discuss trace metal studies and plan for future grant and shiptime applications. M. Gledhill, M. Saraceno, F. Paparazzo, N. Cosentino and L. Ruiz Etcheverry took part, as well as H. Planquette.
- Apr. 2024 Falkor (too) SOI submission. F. Ibarbalz, M. Saraceno, L. Ruiz Etcheverry and P. Flombaum presented in 2024 (in collaboration with researchers from the SHN and from marine stations in Argentina) a cruise proposal to the Schmidt Ocean Institute and its RV Falkor (too) for 2025. Objective: study the interaction between submarine canyons, ocean currents and plankton dynamics at two sites in the Patagonian shelf. If selected, the cruise could provide key information about the presence and extension of canyons relevant for trace metal fluxes between shelf and deep sea.
- A current proposal for the DAAD CONICET program is particularly aimed at funding face-to-face meetings to plan, train and learn to work together effectively.

Participant's contributions:

Principal investigators / project coordinators: Federico Ibarbalz and Martha Gledhill

Trace elements / isotopes in the ocean: Eric Achterberg, Martha Gledhill

Aerosols (sources, composition, deposition events, impact): Nicolas Cosentino, Flavio E. Paparazzo, Eric Achterberg Physical oceanography: Laura Ruiz Etcheverry, Martin Saraceno Plankton nutrient limitation, omics and ecology: Federico Ibarbalz, Pedro Flombaum, Tom Browning

Other related activities

- During 2023, a series of trace metal measurements were carried out in the Argentine Sea. Paparazzo and Fernandez-Severini conducted a study on the interconnection between land and sea, within the framework of the Pampa Azul initiative. The results of that study are in press in the journal "Science of the Total Environment."
- The CCT-CENPAT (Technological Scientific Center in which Dr. Paparazzo's institution is part), recently acquired an isotope ratio mass spectrometer (IRMS), Thermo Scientific Delta Q. Although it is not yet available for analysis, this will happen soon.

Submited by Flavio Emiliano Paparazzo (paparazzo@cenpat-conicet.gob.ar).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CANADA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

- Erin Bertrand's group found that hydroxycobalamin is the dominant form of cobalamin (vitamin B12- a cobalt-containing micronutrient) and thus that many of the dissolved marine cobalamin measurements in the literature appear to be chemically inconsistent with this finding. This reconciles some longstanding confusion in the literature and highlights the need for interconnecting trace element analytical methodologies with the developing field of marine metabolite quantification. See Bannon et al 2024 Limnology ad Oceanography Letters.
- Erin Bertrand's group continues collaboration with Rob Middag's group at NIOZ to use proteomic methodologies to examine particulate metal use in iron-limited regions of the North Atlantic and Southern Ocean, suggesting that iron limitation profoundly shapes Mn use in diatoms.

GEOTRACES or GEOTRACES relevant cruises

- Jean-Eric Tremblay (ULaval) and Jay Cullen (UVic) conducted trace element and isotope sampling in the Canadian Arctic as part of the ArcticNet supported NTRAIN program (<u>https://arcticnet.ulaval.ca/project/nutrient-fluxes-and-living-marine-resources-in-the-inuit-nunangat/</u>) in the eastern, central and western Arctic Ocean in summer 2023.
- Jay Cullen (UVic), Maite Maldonado (UBC), Andrew Ross (DFO) Samples for trace elements and copper ligand measurement were collected using GEOTRACES protocols during Line P cruises in 2021 and 2022 as part of the Line P Iron Program, a GEOTRACES Process Study (GPpr07). Samples for Fukushima derived radionuclides were collected in collaboration with John N. Smith (DFO).

New projects and/or funding

- Summer and Fall 2024 <u>REFUGE-Arctic</u> and <u>Transforming Climate Action</u> research programs aboard CCGS Amundsen will explore trace element cycling in the Inuit Nunangat Ocean. Contacts: Mathieu Ardyna, Jean-Eric Tremblay, Jay Cullen, Erin Bertrand
 - REFUGE-ARCTIC is a large international consortium of researchers studying lead by France and including collaborations with the USA, Denmark and Canada that will study how changing sea ice and the hydrological cycle in the Arctic will affect physical, chemical and biological fields (https://refuge-arctic.ulaval.ca/team.html). First field work planned for summer and fall 2024

 The Transforming Climate Action Canada First Research Excellence (TCA-CFREF) program will examine the roles of metals in carbon cycling in the North Atlantic and Arctic Gateway as part of its efforts to reduce uncertainty in the North Atlantic and Arctic Gateway carbon sink from 2024-2029. Contacts: Jean-Éric Tremblay, Erin Bertrand

Other GEOTRACES activities

 All 2012-2020 Line P data and intercalibration reports, for oxygen, nutrients and metadata (on behalf of Andrew Ross- Fisheries and Oceans Canada), as well as trace metals (on behalf of Jay Cullen and Robyn Taves, University of Victoria) was submitted by Racquelle Mangahas and Maite Maldonado, University of British Columbia

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

- Ardyna, M. et al (in review) The vital significance of the Arctic's Last Ice Area in a warming world. Nature Geoscience.
- Bannon, C., Mudge, E., Bertrand, E.M. (2024) Shedding light on cobalamin photodegradation in the ocean. Limnology ad Oceanography Letters. 9,2. https://doi.org/10.1002/lol2.10371
- Colombo, M., LaRoche, J., Desai, D., Li, J., & Maldonado, M. T. (2023). Control of particulate manganese (Mn) cycling in halocline Arctic Ocean waters by putative Mn-oxidizing bacterial dynamics. Limnology and Oceanography, 68(9), 2070-2087. <u>https://doi.org/10.1002/lno.12407</u>
- Meyer, A.C.S, J.T. Cullen, D.S. Grundle. (2023). Nitrous oxide distributions in the Oxygenated water column of the Sargasso Sea. Atmosphere-Ocean. 61(3), 173-185 <u>https://doi.org/10.1080/07055900.2022.2153325</u>
- Rogalla, B., Allen, S. E., Colombo, M., Myers, P. G., & Orians, K. J. (2023). Continental and glacial runoff fingerprints in the Canadian Arctic Archipelago, the Inuit Nunangat Ocean. Journal of Geophysical Research: Biogeosciences, 128, e2022JG007072.https://doi.org/10.1029/2022JG007072
- Brent M Robicheau, Jennifer Tolman, Sonja Rose, Dhwani Desai, Julie LaRoche, Marine nitrogen-fixers in the Canadian Arctic Gateway are dominated by biogeographically distinct noncyanobacterial communities, FEMS Microbiology Ecology, Volume 99, Issue 12, December 2023, fiad122, <u>https://doi.org/10.1093/femsec/fiad122</u>
- S. A. Rose, B. M. Robicheau, J. Tolman, D. Fonseca-Batista, E. Rowland, D. Desai, J. M. Ratten, E. J. H. Kantor, A. M. Comeau, M. I. G. Langille, J. Jerlström-Hultqvist, E. Devred, G. Sarthou, E. M. Bertrand, J. LaRoche. Nitrogen-fixation in the widely distributed novel marine γ-proteobacterial diazotroph Candidatus Thalassolituus haligoni. Science Advances (in press, 2024)

 Saito, M. A., Alexander, H., Benway, H. M., Boyd, P. W., Gledhill, M., Kujawinski, E. B., Levine, N. M., Maheigan, M., Marchetti, A., Obernosterer, I., Santoro, A. E., Shi, D., Suzuki, K., Tagliabue, A., Twining, B. S., & Maldonado, M. T. (2024). The Dawn of the BioGeoSCAPES Program: OCEAN METABOLISM AND NUTRIENT CYCLES ON A CHANGING PLANET. Oceanography, 37(2), 162–166. <u>https://www.jstor.org/stable/27309831</u>

Completed GEOTRACES PhD or Master theses

• Zee, M. (2024) A Chemical Characterization of the Endeavour Neutrally Buoyant Plume, Juan de Fuca Ridge. University of Victoria

GEOTRACES presentations in international conferences

- 2024 Bannon, C, Mudge, E, Bertrand E. Cobalamin cycling in the Northwest Atlantic Ocean Sciences Meeting 2024, Feb. 18-23, New Orleans LA, USA.
- 2024 Onak, C., **A.C.S. Meyer, H. Hunt, R.C. Hamme, J.T. Cullen and T. Conway. Iron Isotope Fractionation Associated with Spatial and Temporal Changes in Redox Conditions - A Time Series Analysis of Saanich Inlet, Ocean Sciences Meeting 2024, Feb. 18-23, New Orleans LA, USA.
- 2023 Cullen, J.T. Monitoring contamination from the Fukushima-Daiichi nuclear power plant in the subarctic northeast Pacific using a community science approach. Gordon Research Conference: Chemical Oceanography, July 16-23, Manchester NH, USA.
- 2023 Zee, M. and J.T. Cullen. Characterizing the trace element chemistry of the Endeavour Ridge neutrally buoyant hydrothermal plume. Chapman Conference on Hydrothermal Circulation and Seawater Chemistry, May 15-19, Argos Cyprus.
- 2023 Cullen, J.T. and **T. Anderlini. Variability in the Distributions of Dissolved Trace Metals in Surface Waters of Baffin Bay. Canadian Chemistry Conference and Exhibition 2023, June 4-8, Vancouver BC, Canada.
- 2023 Anderlini, T. and J.T. Cullen. The British Columbian Shelf as a Source of Trace Metals to the Subarctic Northeast Pacific Ocean. Canadian Chemistry Conference and Exhibition 2023, June 4-8, Vancouver BC, Canada.
- 2023 Zee, M. and J.T. Cullen. Characterizing the trace element chemistry of the Endeavour Ridge neutrally buoyant hydrothermal plume. Canadian Chemistry Conference and Exhibition 2023, June 4-8, Vancouver BC, Canada.

GEOTRACES relevant infrastructure

With funding from NSERC and in collaboration and with funding from Amundsen Science new trace element sampling infrastructure was installed on the CCGS Amundsen, a science capable icebreaker tasked with Arctic research. A 12 x 10L trace element rosette equipped with trace element clean OTE sampling bottles, a SBE CTD, oxygen sensor, altimeter and transmissometer will be deployed with a winch (2500 m synthetic sea cable) through the ship's moon pool. A trace element clean sampling laboratory was constructed in the moon pool. This infrastructure is now available to Amundsen users.

Submitted by Erin Bertrand (<u>erin.bertrand@dal.ca</u>).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CHINA-BEIJING

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

• ⁹⁰Sr in coastal oceans

The behavior and source of ⁹⁰Sr in the coastal ocean remain uncertain. Here, we investigated the distributions of ⁹⁰Sr in coastal fresh groundwater, river water, pore water, and seawater in three bays along the southeastern coast of China between 2019 and 2021 and evaluated the potential of submarine groundwater discharge (SGD) as a source of coastal ⁹⁰Sr. The ⁹⁰Sr activity in coastal fresh groundwater was higher than that in river water and seawater, while the ⁹⁰Sr activity in pore water was comparable to that in adjacent seawater. In addition, nonconservative mixing behavior of ⁹⁰Sr along the salinity gradient between river water and seawater was observed. These observations indicated that fresh SGD may serve as an additional source of ⁹⁰Sr in coastal seawater. Combining our groundwater ⁹⁰Sr data with the reported fresh SGD flux data, the estimated fresh SGD-derived ⁹⁰Sr in the coastal ocean. This subterranean pathway for transport of ⁹⁰Sr to the coastal ocean should be considered in the monitoring and risk assessment of coastal areas, especially those near nuclear facilities.



Figure CH-1. Comparison of the estimated fresh SGD-derived ⁹⁰Sr fluxes to the river inputs of dissolved ⁹⁰Sr (RID), river particulate desorption (RIPD), and atmospheric deposition (ATM) in XSB, DSB, and QZB.

• New insights on Fe, Ni, Cu and Zn behaviours in the Pearl River Estuary

The concentration data showed that Fe, Ni and Zn experienced removal, but Cu remained conservative along the salinity gradients. The metal isotopes reveal more complex estuarine processes, like the two-stage process which involved particle adsorption and colloidal flocculation at low salinities, followed by conservation at high salinities, as well as the three-endmember mixing process which is dominated by

riverine, oceanic endmembers and external sources. Specifically, capturing δ^{56} Fe fully proves challenging, yet it appears strongly influenced by inputs of benthic Fe within the PRE, characterized by dFe > 13 nmol kg⁻¹ and δ^{56} Fe < -0.80‰. δ^{60} Ni and δ^{66} Zn can be described by either two-stage or there-endmember mixing processes. The description of δ^{65} Cu is best achieved by a three-endmember mixing process, with the external source having dCu > 20 nmol kg⁻¹ and δ^{65} Cu < +1.3‰, indicative of processes like organic matter remineralization or discharge from wastewater treatment plant. This study highlights the need for more extensive and detailed studies on estuarine settings to elucidate their potentially crucial role in global dTMs budgets.

Table CH-1. The concentrations of dFe, dNi, dCu and dZn, and their isotopic compositions of δ^{56} Fe, δ^{60} Ni, δ^{65} Cu and δ^{66} Zn (values ±2 SD) along a salinity gradient in the Pearl River Estuary. We assume the long-term 2SD reproducibility of the secondary standards to represent uncertainty on each analysis, unless the internal precision is larger, in which case the latter is used.

Statio	nLongitude	Latitude	Salinity	dFe	dNi	dCu	dZn	δ ⁵⁶ Fe	δ ⁶⁰ Ni	δ ⁶⁵ Cu	δ ⁶⁶ Zn
	° E	٥N		nmol kg ⁻¹	nmol kg [_]	1 nmol kg ⁻	⁻¹ nmol kg ⁻¹	1 ‰	‰	‰	‰
1	113.5160	23.0500	0.13	44.07	67.63	22.38	24.92	$+0.04 \pm 0.10$	+0.92 ± 0.08	+2.50 ± 0.07	$+0.63 \pm 0.10$
2	113.5676	22.9159	0.16	63.47	76.94	26.67	20.28	$+0.08 \pm 0.16$	$+1.25 \pm 0.08$	-	$+0.52 \pm 0.11$
3	113.6865	22.6731	3.19	12.92	31.99	21.58	15.99	- 0.76 ± 0.09	+1.25 ± 0.08	+2.27 ± 0.07	$+0.69 \pm 0.06$
4	113.7411	22.5130	6.95	6.98	21.25	16.02	8.44	-0.18 ± 0.09	+1.15 ± 0.08	+1.77 ± 0.07	$+0.64 \pm 0.06$
5	113.7615	22.4114	7.85	6.68	28.14	17.61	10.17	-0.06 ± 0.08	$+1.09 \pm 0.08$	+1.63 ± 0.07	$+0.67 \pm 0.06$
6	113.8283	22.2078	13.03	2.71	31.63	16.56	9.79	-0.45 ± 0.06	+1.13 ± 0.08	+1.60 ± 0.07	$+0.76 \pm 0.07$
7	113.8379	22.1787	22.03	2.54	38.59	13.19	6.78	-0.24 ± 0.07	+1.13 ± 0.08	+1.44 ± 0.07	$+0.92 \pm 0.07$
8	113.8542	22.1346	24.24	1.95	20.94	11.94	3.65	$+0.69 \pm 0.09$	+1.12 ± 0.08	+1.25 ± 0.07	$+0.66 \pm 0.10$
9	113.8736	21.9807	28.19	0.48	13.11	8.26	0.87	$+0.04 \pm 0.10$	$+1.07 \pm 0.08$	+1.24 ± 0.07	+0.36 ± 0.31
10	113.8385	21.7213	32.95	1.37	4.09	3.61	0.69	+0.04 ± 0.19	$+0.94 \pm 0.08$	+0.82 ± 0.07	$+0.25 \pm 0.30$
11	114.1640	21.4562	33.78	0.62	2.59	1.15	0.23	+0.49 ± 0.13	+1.38 ± 0.08	+0.69 ± 0.07	- 0.05 ± 0.29
12	114.2785	21.1695	33.71	0.36	2.47	1.21	0.47	- 0.31 ± 0.12	+1.33 ± 0.08	-	- 0.17 ± 0.35
13	114.3970	20.8376	33.69	0.79	2.60	1.06	0.07	- 0.56 ± 0.20	+1.63 ± 0.08	+0.68 ± 0.07	-
14	114.4809	20.6295	33.81	0.13	2.39	1.08	0.24	+0.05 ± 0.25	+1.63 ± 0.08	+0.60 ± 0.07	-0.14 ± 0.44

- data not available due to measurement failure.

• Methylmercury cycling in the Bohai Sea and Yellow Sea: reasons for the low system efficiency of methylmercury production

Coastal seas contribute the majority of human methylmercury (MeHg) exposure via marine fisheries. The terrestrial area surrounding the Bohai Sea and Yellow Sea (BS and YS) is one of the mercury (Hg) emission "hot spots" in the world, resulting in high concentrations of Hg in BS and YS seawater in comparison to other marine systems. However, comparable or even lower Hg levels were detected in seafood from the BS and YS than other coastal regions around the word, suggesting a low system bioaccumulation of Hg. Reasoning a low system efficiency of MeHg production

(represented by MeHg/THg (total Hg) in seawater) may be present in these two systems, seven cruises were conducted in the BS and YS to test this hypothesis. MeHa/THa ratios in BS and YS seawater were found to be lower than that in most coastal systems, indicating that the system efficiency of MeHg production is relatively lower in the BS and YS. The low system efficiency of MeHg production reduces the risk of Hg in the BS and YS with high Hg discharge intensity. By measuring in situ production and degradation of MeHg using double stable isotope addition method, and MeHg discharge flux from various sources and its exchange at various interfaces, the budgets of MeHg in the BS and YS were estimated. The results indicate that in situ methylation and demethylation are the major source and sink of MeHg in the BS and YS. By comparing the potential controlling processes and environmental parameters for MeHq/THq in the BS and YS with the other coastal seas, estuaries and bays, lower transport efficiency of inorganic Hg from water column to the sediment, slower methylation of Hg, and rapid demethylation of MeHg were identified to be major reasons for the low system efficiency of MeHg production in the BS and YS. This study highlights the necessity of monitoring the system efficiency of MeHg production, associated processes, and controlling parameters to evaluate the efficiency of reducing Hg emissions in China as well as the other countries.



Figure CH-2. Comparisons of relevant parameters reflecting Hg methylation/demethylation potentials and transport efficiency of THg and MeHg among the BS, YS, and other coastal seas, bays, and estuaries. (A), transports of THg from seawater to sediment and MeHg from sediment to seawater; (B), methylation and demethylation of Hg in sediment; (C), biotic methylation/demethylation and photic demethylation of Hg in seawater. Systematic search was conducted in Web of Science using the keywords: (A), mercury, Hg, total mercury, total Hg, THg, methylmercury, methyl mercury, methyl Hg, or MeHg (Data of THg and MeHg in water and sediment of coastal seas, bays, and estuaries were subsequently utilized for doing the comparison); (B) and (C), mercury, Hg, methylmercury, methyl mercury, or MeHg and methylation, demethylation, production, or degradation (Data of Hg methylation and demethylation in water and sediment of coastal seas, bays, and estuaries were subsequently utilized for doing the comparison).

• MOTES: A new facility designed for trace element sampling in seawater

We present the modular trace element sampling facility that we have developed (MOTES). Vertical profiles of lead and iron, two trace metals particularly prone to contamination, are also shown to attest the reliability of MOTES.

The advantages of MOTES are that the improved Niskin-X sampling bottles could remain closed on the deck and open underneath the sea surface, and there is no need to remove and assemble the samplers during the whole process of sampling and filtration. Above the titanium CTD frame the Niskin-X bottles installed on, there is only a plastic-coated coaxial communication cable (12000 m) to minimize disturbance to the water column and potential contamination in the up-cast lift. There are three modular components in the facility, the winch system, the clean room and the L frame. The stainless-steel winch system and the clean room dedicated to sampling, and sample transfer and filtration are both installed in the standard-sized clean container which are very convenient to move. The hub part of winch system which contact with cable is cladded by nylon to avoid potential contaminations. The L frame system is installed in the 10 ft standard-sized container base. Last but not least, the three modular components can be detached for land transportation and reassembled on the deck of research vessels for sea-going cruises. Note also that the design concept can be adapted for other types of applications in a sea-going voyage, such as ships/cargo vessels and observational platforms, which require clean working conditions and must be self-sustaining in remote areas/situations.



Figure CH-3. Configuration of MOTES facility on deck for a sea-going cruise, which includes a plastic-coated coaxial cable and stainless-steel winch (right), clean room (left), and L frame with CTD and Niskin-X bottles (front). Winch and clean rooms are installed in standard-size container with clean air supply for road transportation and adaptation to different research vessels. For the purpose of illustration here, the side wall of container is "cut" so that the reader could see the set-up of winch and rosette Niskin-X inside.

GEOTRACES or GEOTRACES relevant cruises

• 2023 Northwest Pacific Ocean Multidisciplinary Cruise, water samples were collected to analyze monomethylmercury and dimethylmercury during this cruise.

New projects and/or funding

- Research on the Mechanisms of Light Regulation on Iron Uptake in Marine Diatoms, General Program of National Natural Science Foundation of China, No. 42376158, 2024-2027, leading PI: Liangliang Kong
- Science Fund Program for Excellent Young Scholars of Shandong Province (Overseas), 2024HWYQ-039, 2024-2026, leading PI: Liangliang Kong
- Taishan Scholar Young Expert Program, 2024-2026, leading PI: Liangliang Kong
- Mercury species distribution and in situ formation mechanisms of methylmercury in the Northwestern Pacific Ocean impacted by intensive human activities, National Natural Science Foundation of China, 42373076, 2024-2027, leading PI: Yanbin Li

GEOTRACES workshops and meetings organized

• We organize the Training and exchange Seminar on techniques for monitoring radioactivity in the Marine environment during April 9 and 10 in Shanghai.

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

- Peng, T., Yu, X., Liu, J., Zhu, Z., & Du, J. (2023). Capturing the influence of submarine groundwater discharge on nutrient speciation dynamics within an estuarine aquaculture ecosystem. Environmental Pollution, 336, 122467.
- Zhang, F., Wang, J., Huang, D., Zhong, Q., Yu, T., & Du, J. (2023). Fresh groundwater discharge as a major source of ⁹⁰Sr into the coastal ocean. Environmental Science & Technology, 57(32), 12033-12041.
- Yu, X., Liu, J., Chen, X., Yu, H., & Du, J. (2024). Fresh and saline groundwater nutrient inputs and their impacts on the nutrient budgets in a human-effected bay. Marine Pollution Bulletin, 199, 116026.
- Ruan, Y., Zhang, R., Yang, S. C., Jiang, Z., Chen, S., Conway, T. M., ... & John, S. G. (2024). Iron, Nickel, Copper, Zinc, and their stable isotopes along a salinity gradient in the Pearl River Estuary, southeastern China. Chemical Geology, 645, 121893.
- Cao, A., Liu, Q., Zhang, J., Shiller, A.M., Cai, Y., Zhang, R., Gilbert, M., Guo, X., and Liu, Z (2024), Dissolved rare earth elements in the North Pacific Subtropical Gyre: Lithogenic sources and water mass mixing control. Geochimica et Cosmochimica Acta, 372, 42-61.

- Cao, S., Liang, S., & Li, Y. (2023). Adsorption and environmental behavior of mercury on suspended particulate matter from the Yellow River and Xiaoqing River estuaries. Science of The Total Environment, 893, 164860.
- Zhou, Z., Tang, Z., Wang, H., Liu, K., Wang, Y., Xiao, X., ... & Li, Y. (2024). Spatial and temporal variations in the pollution status and sources of mercury in the Jiaozhou bay. Environmental Pollution, 123554.
- Chen, L., Cheng, G., Zhou, Z., Liang, Y., Ci, Z., Yin, Y., ... & Li, Y. (2024). Methylmercury cycling in the Bohai Sea and Yellow Sea: Reasons for the low system efficiency of methylmercury production. Water Research, 258, 121792.
- Li, D., Han, X., & Li, Y. (2024). Mechanism of methylmercury photodegradation in the yellow sea and East China Sea: Dominant pathways, and role of sunlight spectrum and dissolved organic matter. Water Research, 251, 121112.
- Zhang, J., Ni, Z. T., Ren, J. L., Yu, F., Diao, X. Y., Wang, Y., Zhang, S. J., Su, H., Cong, S. L., Lu, Z. J., Jiang, S., Ou, J., Chen, Y., Wang, Q., Zhang, Z. B., Ai, J. T., Wang, C. B., & Tao, Z. D. (2024). Modular ocean trace elements sampling for the international GEOTRACES studies Evidence from analysis of dissolved Fe and Pb. Progress in Oceanography, 221, 103212.

Completed GEOTRACES PhD or Master theses

- Yaqing Ruan. The transport of trace metal Iron and Copper to the ocean through estuaries—using the Changjiang Estuary and Pearl River Estuary as examples. Master thesis. Shanghai Jiao Tong University, 2023.
- Cao AX. Sources, processes affecting the distribution, and application of rare earth elements in the Northwest Pacific. PhD thesis. Ocean University of China, 2023.
- Guan WK. Spatiotemporal distribution, sources and deposition fluxes of trace elements in aerosols from the Northwestern Pacific. PhD thesis. Ocean University of China, 2023.
- Sijing Cao. Effects of suspended particulate matter in estuaries on the transport and transformation of mercury. PhD thesis. Ocean University of China, 2023.

GEOTRACES presentations in international conferences

 Liangliang Kong. Invited Speaker for International Webinar Series for Young Scholars: "Cutting-edge Research on Marine Science and Engineering", April 30, 2024, Hong Kong.

Submitted by Dalin Shi (<u>dshi@xmu.edu.cn</u>

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CHINA-TAIPEI

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

- Aerosol dissolvable metals, which influence marine phytoplankton growth and global elemental cycling, are challenging to measure in oceanic deposition due to complex pre- and post-deposition processes. Hsieh et al. (2023) collected lithogenic dust from Chinese deserts and aerosols from the East China Sea, analyzing their dissolvable metals using three leaching protocols (ultrapure water, buffer, and Berger leaches). They found that the solubilities of anthropogenic elements were extremely high, while those of lithogenic elements (Ti, Al, Fe) increased with particle size across all leaching methods. Without size-specific data on mass and solubility, deposition fluxes of lithogenic elements could be significantly overestimated. Notably, solubilities of desert dust in large aerosols were substantially enhanced, with Fe solubility increasing up to 68, 6, and 3 times for ultrapure water, buffer, and Berger treatments, respectively. These enhancements vary by region, suggesting regional specificity in the impact of transport processes. The study argues that buffer and Berger leaches provide more realistic solubility estimates for oceanic aerosols than ultrapure water. Conducting similar field studies in other regions is essential to refine global models of dissolvable aerosol metal fluxes in the ocean.
- Aerosol soluble metals, vital for marine phytoplankton growth and material cycling, dissolve in seawater through complex processes, notably interacting with organic ligands. Wu et al. (2023) have explored the dissolution kinetics of trace metals from fine and coarse aerosols over 30 days, with or without the organic ligand desferrioxamine B (DFB). Fine aerosols leached most metals quickly within an hour, while coarse aerosols with DFB saw a significant increase in Fe solubility from 0.1 to 10% and doubled solubility for other metals. Without DFB, soluble metals were still gradually released, except for Fe and Pb. Strong correlations between dissolved metals and silicate concentrations indicated that aluminosilicate-associated metals accounted for a significant portion of dissolved metals after 30 days. The findings emphasize the role of time-dependent interactions and organic ligands in seawater in determining the availability of dissolved metals to marine phytoplankton.
- The wind-driven meridional overturning circulation between tropical and subtropical oceans regulates decadal-scale temperature fluctuations in the Pacific and globally. An acceleration in this circulation reduces global surface temperatures by storing more heat in the ocean. The low-latitude western boundary current is crucial for this circulation, but long-term transport data is scarce. Chen et al. (2023) have reconstructed a 94-year ¹⁵N/¹⁴N ratio record from Porites spp. corals in the Solomon Sea, which reveals that this ratio declined as global temperatures rose, suggesting the South Pacific western boundary current has strengthened over the past century.

This record also indicates strong decadal variability linked to the Pacific Decadal Oscillation.

GEOTRACES or GEOTRACES relevant cruises

- NORI cruise (NOR1-T030) in the Taiwan Strait, December 2023 (3 days) Testing the new trace metal clean sampling system.
- NORI cruise (NOR1-068) in the North of South China Sea, the Luzon Strait, and the Western Philippian Sea, March 2023 (15 days).

New projects and/or funding

- Yu-Te Alan Hsieh, NSTC grant: Constraining the sources and sinks of barium isotopes in the ocean: implications for tracing the marine barium and carbon cycles, NSTC-113-2611-M-002-001. (2024-2025)
- Wen-Hsuan Liao, NSTC grant: Using laboratory experiment and field observation to study the important and underestimated sedimentary trace metal inputs to the ocean, NSTC-112-2611-M-006-006; NSTC-113-2611-M-006-001 (2023-2025)

GEOTRACES workshops and meetings organized

- Yu-Te Alan Hsieh, Taiwan trace metal clean sampling workshop, Institute of Oceanography, National Taiwan University; invited speaker: Greg Cutter (Old Dominion University, USA), December 2023.
- Tung-Yuan Ho, Haojia Abby Ren and Yu-Te Alan Hsieh, Taiwan GEOTRACES and BioGeoSCAPES session in 2024 Taiwan Ocean Science Conference, April 2024.

Other GEOTRACES activities

A new GEOTRACES trace metal clean sampling system was completed in December 2023. The system features a class ISO-6 clean room container, an ultra-clean CTD winch designed by Kley France, an 8000 m Vectran conducting cable, and a Sea-Bird GEOTRACES frame equipped with 911 plus CTD, titanium-housed sensors, and 24 x 12-L OTE external-spring Niskin-style bottles. A 3-day test cruise on the R/V New Ocean Researcher 1 was conducted in the Taiwan Strait with marine scientists from Taiwan. Greg Cutter (Old Dominion University, USA) joined the cruise and provided advice on testing the system. This new system ensures trace metal clean sampling for ocean research in the marginal seas around Taiwan and the Pacific Ocean.

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

- Chen, W.-H., Ren, H., Chiang, J.C.H., Wang, Y.-L., Cai-Li, R.-Y., Chen, Y.-C., Shen, C.-C., Taylor, F.W., DeCarlo, T.M., Wu, C.-R., Mii, H.-S., Wang, X.T. (2023) Increased tropical South Pacific western boundary current transport over the past century. Nature Geoscience, 16, 590-596.
- Deng, L., Cheung, S., Xu, Z., Liu, K., Liu, H. (2023) Microzooplankton grazing exerts a strong top-down control on unicellular cyanobacterial diazotrophs. Journal of Geophysical Research: Biogeosciences, 128(12), e2023JG007824.
- Ekka, S.V., Y.-H. Liang, K.-F. Huang and D.-C. Lee (2023) Molybdenum isotopic fingerprints in Taiwan rivers: Natural versus anthropogenic sources, WATER, 15 (10) DOI:10.3390/w15101873.
- Hsieh, C.-C., C.-F. You, and T.-Y. Ho (2023) The solubility and deposition flux of East Asian aerosol metals in the East China Sea: The effects of aeolian transport processes. Marine Chemistry doi: 10.1016/j.marchem.2022.104268.
- Liang, Y.-T., P.-C. Wu, S. Ekka, K.-F. Huang and D.-C. Lee (2024) Iron and Molybdenum isotope application for tracing industrial contamination in a highly polluted river, WATER, 16 (2):199, DOI:10.3390/w16020199.
- Liao, W.-H., Planquette, H., Moriceau, B., Lambert, C., de Gesincourt, F.D., Laurenceau-Cornec, E., Sarthou, G., Gorgues, T. (2023) The effect of temperature on the release of silicon, iron and manganese into seawater from resuspended sediment particles. Geochemica et Cosmochimica Acta, 351, 1-13.
- Liu, Y.-W., Lin, K., Morgan, K., Wang X. (2024) Ocean acidification in the tropical Indian Ocean over the past 37 years: Insights from ¹¹B and B/Ca records in a Maldives coral. Chemical Geology, 662. 122243.
- Wu, H.-Y., C.-C. Hsieh, and T.-Y. Ho (2023) Trace metal dissolution kinetics of East Asian size-fractionated aerosols in seawater: The effect of a model siderophore. Marine Chemistry doi: 10.1016/j.marchem.2023.104277.
- You, C.-F., Liao, W.-L., Huang, K.-F., Chung, C.-H., Liu, Z. (2024) Sediment source variation using REEs, Sr, and Nd isotopic compositions: a case study in MD05-2901, northwestern South China Sea. Frontiers in Marine Science, 10, 1292802.

Completed GEOTRACES PhD or Master theses

- Chih-Chiang Hsieh, Ph.D. thesis (July 2023), The Contribution of East Asian Aerosol Metals in the Ocean: Sources, Transformation Processes and Deposition Fluxes. National Taiwan University, URI: <u>https://tdr.lib.ntu.edu.tw/jspui/handle/123456789/88431</u>
- H.-Y. Chen, Master thesis (2023) Coral records of ocean acidification and marine lead pollution in the northern South China Sea. National Taiwan University, URI: <u>http://tdr.lib.ntu.edu.tw/jspui/handle/123456789/88209</u>

GEOTRACES presentations in international conferences

- Hsieh, Y.-T., Chiu, J.-T., Huang, K.-F., Wu, P.-C., Chen, S.-T., Constraining riverine barium isotopes to the ocean: insights from river and seawater mixing experiments. Ocean Sciences Meeting 2024. New Orleans, USA. February 2024.
- Hsieh, Y.-T., Paver, R., Tanzil, J.T.I., Bridgestock, L., Lee, J.N., Henderson, G.M., Barium isotopes in Singapore seawater and shallow-water corals. 5th Asia-Pacific Coral Reef Symposium. Singapore, June 2023.

Submitted by Yu-Te Alan Hsieh (alanhsieh@ntu.edu.tw)

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CROATIA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

The Croatian GEOTRACES activities were related to:

- interaction of trace metals with marine microplastics
- study of interactions between surface water chemistry, phytoplankton, atmospheric chemistry, and climate;
- application of improved electrochemical methods (in combination with ICPMS) for determination of number of trace metals, their speciation, fractionation and interaction with organic matter and sulphur species in natural waters, including monitoring of the coastal and open waters of the Adriatic Sea;
- mercury speciation and determination by CV-AAS in natural waters, including monitoring of the coastal and open waters of the Adriatic Sea;
- study of geochemistry of redox proxies and redox transformations in seawater under a range of critical environmental conditions (Cu, V, Re, Mo and U);
- study of geochemistry of technology critical elements (Li, Nb, Sc, Ga, Y, La, Sb, Ge, Te and W) in marine sediments;
- geochemical research and biological response in different environmental systems (coastal and open sea, marine lakes, anchialine caves, submarine groundwater discharge);
- development of new methods for ex- and in-situ determination of natural and anthropogenic radionuclides (focus is on ^{86/87}Sr, ^{89,90}Sr and ²¹⁰Pb);
- measurements of activity concentration of ⁷Be and ²¹⁰Pb in atmospheric precipitation (rain, aerosols - PM2.5) in order to monitor dynamics of particle transport, metrological information, origin of air mass transfer and seasonal variation of aerosol deposition;
- development of electroanalytical method for determination and characterization of polysulfides in anoxic seawater conditions;
- characterization of atmospheric precipitation (rain, aerosols PM2.5) regarding presence of major cations and anions, organic matter, sulphur species and trace metals;
- work on advanced technologies for water quality control/monitoring and prediction purposes.

New projects and/or funding

Current projects supported by the Croatian Ministry of Science, Education and Sport and Croatian Science Foundation (CSF):

- 2020-2024, CSF project: Marine (micro)plastic litter and pollutant metals interaction: a possible pathway from marine environment to human (METALPATH) (PI Vlado Cuculić)
- 2020-2024, CSF and Swiss National Science Foundation: Understanding copper speciation and redox transformations in seawater (PI: E. Bura-Nakić)
- 2018-2023, CSF: Biochemical REsponses of oligotrophic Adriatic surface ecosystems to atmospheric Deposition Inputs (BiREADI) (PI. Sanja Frka)

Other projects:

- 2020-2023; HAMAG-BICRO: "Application of artificial intelligence in advanced predictive technologies for online water quality control". (PI. D. Omanović)
- 2020-2023; INTERREG CRO-ITA: InnovaMare "Model of innovation ecosystem in the field of underwater robotics and sensors for control and monitoring purposes with a mission focused on the sustainability of the Adriatic Sea". (PI. M. Mlakar)
- 2020-2023; INTERREG CRO-ITA: Hadriaticum Data Hub Data management, protocols harmonization, preparations of guidelines: cross-border tools for maritime spatial planning decision-makers (HATCH). (PI. M. Krželj)
- 2021–2023; Cogito Hubert Curien project: Photochemistry of marine phytoplankton surfactant films at the air-water interface: impact to atmospheric particle formation (PI. Sanja Frka; co-lead C. George)
- 2024–2025; project funded by IRB: KP2-Establishment of a new facility to study photoinduced changes in the physico-chemical properties of atmospheric aerosols (PI. Sanja Frka)

GEOTRACES workshops and meetings organized

- International scientific symposium: XVI International Estuarine Biogeochemistry Symposium (IEBS 2023), 23-26 May 2023, Šibenik
- International scientific symposium: Interdisciplinary Approach to the Scientific Research of the Adriatic Sea (InspireAdriatic 2023); 11-12 September 2023, Ruđer Bošković Institute, Zagreb
- Advanced school on aqua ions and hydrolysis-related equilibria, COST Action CA18202 - NECTAR (Network for Equilibria and Chemical Thermodynamics Advanced Research); 29 September 2023, Ruder Bošković Institute, Zagreb

Other GEOTRACES activities

- I. Ciglenečki (Ruđer Bošković Institute, Zagreb) is a member EMB working group on Ocean Oxygen.
- D. Omanović (Ruđer Bošković Institute, Zagreb) is a member of the GESAMP working group 45 Climate Change and Greenhouse Gas Related Impacts on Contaminants in the Ocean.
- Members of the European Marine Board (EMB): Institute of Oceanography and Fisheries, Split (Melita Peharda Uljevic and Daria Ezgeta-Balić) and Ruđer Bošković Institute, Zagreb (Martin Andreas Pfannkuchen (vice-Chair) and Ivica Vilibić).

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

- Strmečki, S., Dešpoja, I., Penezić, A., Milinković, A., Alempijević, S. B., Kiss, G., ... Frka, S. (2024). How do certain atmospheric aerosols affect Cu-binding organic ligands in the oligotrophic coastal sea surface microlayer?. *Environmental Science: Processes & Impacts*, *26*(1), 119-135. Doi: 10.1039/D3EM00415E
- Grozdanić, O., Cindrić, A. M., Finderle, I., Omanović, D. (2024). Examining the Impact of Long-Term Industrialization on the Trace Metal Contaminants Distribution in Seawater of the Pula Bay, Croatia. *Journal of Marine Science and Engineering*, 12(3), 440. Doi: 10.3390/jmse12030440
- Cukrov, N., Cukrov, N., Omanović, D. (2024). Early Diagenetic Processes in the Sediments of the Krka River Estuary. *Journal of marine science and engineering*, 12(3), 466. Doi: 10.3390/jmse12030466
- Cukrov, N., Cindrić, A. M., Omanović, D., Cukrov, N. (2024). Spatial Distribution, Ecological Risk Assessment, and Source Identification of Metals in Sediments of the Krka River Estuary (Croatia). *Sustainability*, *16*(5), 1800. Doi: 10.3390/su16051800
- Vidović, K., Hočevar, S., Grgić, I., Metarapi, D., Dominović, I., Mifka, B., ... Ciglenečki,
 I. (2024). Do Bromine and Surface-Active Substances Influence the Coastal
 Atmospheric Particle Growth?. *Heliyon*. Doi: 10.1016/j.heliyon.2024.e31632
- Supić, N., Budiša, A., Ciglenečki, I., Čanković, M., Dautović, J., Djakovac, T., ... Vilibić, I. (2024). Are winter conditions impacting annual organic production in the northern Adriatic? Verifications and future projections. Progress in Oceanography, 224, 103247. Doi: 10.1016/j.pocean.2024.103247
- Mateša, S., Marguš, M., Šegota, S., Ciglenečki, I. (2024). Characterization of polysulfides (Sx2–) in seawater euxinic conditions by electroanalytical methods. *Marine Chemistry*, 104398. Doi: 10.1016/j.marchem.2024.104398
- Simonović, N., Marguš, M., Paliaga, P., Budiša, A., Ciglenečki, I. (2024). Changes in organic carbon properties during intense plankton blooms and macroaggregate formation in the coastal Adriatic Sea, Croatia (case studies in 2020-2022). *Mediterranean Marine Science*, *25*(1), 160-178. Doi: 10.12681/mms.35082

- Simonović, N., Dominović, I., Marguš, M., Matek, A., Ljubešić, Z., Ciglenečki, I. (2023). Dynamics of organic matter in the changing environment of a stratified marine lake over two decades. *Science of the total environment*, 865, 161076. Doi: 10.1016/j.scitotenv.2022.161076
- Marguš, M., Ahel, M., Čanković, M., Ljubešić, Z., Terzić, S., Kobasić, V. H., Ciglenečki, I. (2023). Phytoplankton pigment dynamics in marine lake fluctuating between stratified and holomictic euxinic conditions. *Marine pollution bulletin*, 191, 114931. Doi: 10.1016/j.marpolbul.2023.114931
- Mifka, B., Telišman Prtenjak, M., Kavre Piltaver, I., Mekterović, D., Kuzmić, J., Marciuš, M., Ciglenečki, I. (2023). Intense desert dust event in the northern Adriatic (March 2020); insights from the numerical model application and chemical characterization results. Earth and space science, 10(7), e2023EA002879. Doi: 10.1029/2023EA002879
- Debi, M., Wang, J., Bi, Q., Xu, R., Aftabuddin, S., Cukrov, N., Du, J. (2023). Atmospheric depositional fluxes of 210Pb in bulk precipitation at the Adriatic coast, Croatia. *Marine pollution bulletin*, *194*, 115353. Doi: 10.1016/j.marpolbul.2023.115353
- Mikelić, I. L., Oreščanin, V., Cukrov, N., Tomašić, N., Rubčić, M., & Barišić, D. (2023). Relationships between radionuclides, metals, and sediment properties in sediment of a bay exposed to anthropogenic pressure and mixed sediment sources (Kaštela Bay, Adriatic Sea, Croatia). *Marine pollution bulletin*, 197, 115731. Doi: 10.1016/j.marpolbul.2023.115731
- Ciglenečki, I., Orlović-Leko, P., Vidović, K., Simonović, N., Marguš, M., Dautović, J., ... & Galić, I. (2023). The possibilities of voltammetry in the study reactivity of dissolved organic carbon (DOC) in natural waters. *Journal of Solid State Electrochemistry*, 27(7), 1781-1793. Doi: 10.1007/s10008-023-05423-y
- Kapetanović, D., Smrzlić, I. V., Kazazić, S., Omanović, D., Cukrov, N., Cindrić, A. M., ... Marijić, V. F. (2023). A preliminary study of the cultivable microbiota on the plastic litter collected by commercial fishing trawlers in the south-eastern Adriatic Sea, with emphasis on Vibrio isolates and their antibiotic resistance. *Marine pollution bulletin*, 187, 114592. Doi: 10.1016/j.marpolbul.2023.114592
- Matek, A., Mucko, M., Casotti, R., Trano, A. C., Achterberg, E. P., Mihanović, H., ... Ljubešić, Z. (2023). Phytoplankton Diversity and Co-Dependency in a Stratified Oligotrophic Ecosystem in the South Adriatic Sea. *Water*, *15*(12), 2299. Doi: 10.3390/w15122299
- Tomaš, A. V., Šantić, D., Šolić, M., Skejić, S., Milinković, A., Kušan, A. C., ...Frka, S. (2023). How do open coastal fire episodes' impact sea surface microlayer neuston communities? *Science of the total environment*, 861, 160593. Doi: 10.1016/j.scitotenv.2022.160593
- Vrana, I., Gašparović, B., Geček, S., Godrijan, J., Novak, T., Kazazić, S. P., ...Pfannkuchen, D. M. (2023). Successful acclimation of marine diatoms Chaetoceros

curvisetus/pseudocurvisetus to climate change. *Limnology and oceanography*, 68, S158-S173. Doi: 10.1002/lno.12293

- Gašparović, B., Vrana, I., Frka, S., Marić Pfannkuchen, D., Vlašiček, I., Djakovac, T., ...Godrijan, J. (2023). Paradox of relatively more phospholipids in phytoplankton in phosphorus limited sea. Limnology and oceanography, 68(12), 2800-2813. Doi: 10.1002/lno.12464
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- Knežević, L., & Bura-Nakić, E. (2023). Investigation of thiol compounds (L-cysteine, thioacetic acid and ethanethiol) with V (V) and V (IV) using combined spectroscopy and chromatography. *Journal of inorganic biochemistry*, 242, 112158. Doi: 10.1016/j.jinorgbio.2023.112158

Completed GEOTRACES PhD or Master theses

- Doctoral Thesis: Andrea Milinković, Biological and chemical responses of sea surface layer to atmospheric deposition, Univ. of Zagreb, 2023
- Doctoral Thesis: Niki Simonović, Dynamics and properties of organic matter in the changing environment of a marine Rogoznica Lake, Univ. of Zagreb, June 2023

GEOTRACES presentations in international conferences

- Dora Crmarić, Elvira Bura-Nakić: Copper redox speciation in the Krka River estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario, Cobelo-García, Antonio, Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 35
- Marcinek Saša, Cindrić Ana Marija, Omanović Dario: Trace elements and dissolved organic matter in estuarine surface microlayer - Case study in the Krka River estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 34

- Lucija Knežević, Nuša Cukrov, Elvira Bura-Nakić: Vanadium redox speciation in the extractable fraction of surface sediment in Krka River estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 28
- Igor Živković, Lucija Knežević, Polona Klemenčič, Leja Rovan, Marta Jagodic Hudobivnik, Elvira Bura-Nakić: Contrasting behavior of mercury in marine sediments from two marine lakes // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 45
- Hollister Adrienne, Marcinek Saša, Omanović Dario, Schulte Mai-Brit, Koschinsky Andrea: Elbe, Weser and Ems rivers as sources of platinum to the southern North Sea // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario; Cobelo-García, Antonio; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 41-42
- Ana Rapljenović, Željko Kwokal, Marko Viskić, Vlado Cuculić: Plastic debris as a medium for trace metal adsorption in the estuarine environment // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 16
- Nuša Cukrov, Abel Barré, Elisa Catao, Remi Chemin, Damien Sous, Jean-Francois Briand, Veronique Lenoble: Impact of biofilm on the microplastics settling velocities // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 14
- Jadranka Pelikan, Dijana Pavičić-Hamer, Marin Glad, Kristina Pikelj, Bojan Hamer: Assessment of marine sediments quality of Rovinj coastal area and Lim bay estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 23-24
- 35th Topical Meeting of the International Society of Electrochemistry, Gold Coast, Australia, May 2023: Electrochemical analysis of Co(II) complex with L-glutathione under seawater conditions; Bačinić A., Mlakar M.
- Saša Marcinek, Ana Marija Cindrić and Dario Omanović: Does seasonal differences in organic matter influence copper bioavailability in Krka River estuary? // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 28
- Andrea Milinković, Abra Penezić, Ana Cvitešić Kušan, Valentina Gluščić, Silva Žužul, Sanda Skejić, Danijela Šantić, Ranka Godec, Gordana Pehnec, Dario Omanović, Sanja Frka: Variabilities of biochemical properties of the sea surface microlayer: Insights to

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- Nuša Cukrov, Lucijan Ljubičić, Vlado Cuculić, Anamarija Frankić and Neven Cukrov: Microplastic in the Adriatic Sea, urban vs remote areas // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea -InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 30-31
- Marija Parać, Nuša Cukrov, Neven Cukrov: Conducted research about microplastics analysis in Krka River estuary and its further prospects // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea -InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 31-32
- Ivica Vilibić: What we know after centurial thermohaline observations in the Adriatic Sea? // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 22
- Iva Tojčić, Clea Denamiel, Petra Pranić, Ivica Vilibić: Kilometer-scale coupled atmosphere-ocean climate modelling in the Adriatic region // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 23
- Neven Cukrov, Marija Parać, Nuša Cukrov, Željko Kwokal, Sandi Orlić, Dario Omanović, Branko Jalžić: Anchialine caves around Krka River estuary // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 25
- Vedran Damjanović, Valentina Gašo, Stijepo Grljević, Marko Kapelj, Iva Kostanjšek, Viktorija Milec, Marko Pervan, Anamarija Tremljan, Antonio Brcković, Tomislav Fiket: Ocean bottom seismometers – a new way of researching the seabed in Croatia // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 27
- Frka Milosavljević, Sanja; Penezić, Abra; Wang, Xinke; Perrier, Sebastian; George, Christian I Photochemistry of marine organics at the air-water interface as a source of volatile organic compounds influencing new particle formation // abstracts of keynote invited lectures and contributed papers. Beograd, Srbija: Vinča Institute of Nuclear Sciences, Serbia; Environment and Climate Research Institute NILU, Norway, 2023
- Milinković, Andrea; Penezić, Abra; Gluščić, Valentina; Žužul, Silva; Godec, Ranka;
 Pehnec, Gordana; Frka Milosavljević, Sanja | Atmospheric deposition of nitrogen and

phosphorus to the Central Adriatic area and biogeochemical implications // International conference and 13th Croatian scientific and professional meeting "Air Protection 2023": Book of Abstracts. Zagreb: Hrvatsko udruženje za zaštitu zraka (HUZZ), 2023.

 Žužul, Silva; Gluščić, Valentina; Bešlić, Ivan; Milinković, Andrea; Penezić, Abra; Frka, Sanja I The impact of anthropogenic and natural sources on particle-bound metals at the middle Adriatic // 28HSKIKI : 28th Croatian Meeting of Chemists and Chemical Engineers and 6th Symposium Vladimir Prelog : Book of Abstracts / Rogošić, Marko (ur.). Zagreb: Hrvatsko društvo kemijskih inženjera i tehnologa (HDKI), 2023.

Submitted by Saša Marcinek (smarcin@irb.hr).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN FRANCE

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

Mercury fluxes from hydrothermal venting at mid-ocean ridges constrained by measurements.

Torres-Rodriguez, N., Yuan, J., Petersen, S., Dufour, A., González-Santana, D., Chavagnac, V., ... & Heimbürger-Boavida, L. E. (2024). Nature Geoscience, 17(1), 51-57.

Torres-Rodriguez et al. (2024) investigate the contribution of hydrothermal vents at midocean ridges to the global mercury cycle. The study utilizes in situ measurements of mercury concentrations in vent fluids and solid-phase sulfides from various mid-ocean ridge locations. The authors quantify the mercury fluxes by combining these concentration measurements with estimates of hydrothermal fluid flow rates.

Key findings highlight that mercury emissions from hydrothermal vents are significant and comparable to those from volcanic eruptions, thus representing an important source of mercury to the ocean. The study reveals that hydrothermal vents release mercury both as dissolved species and particulate-bound forms. It also emphasizes the variability in mercury fluxes between different ridge segments, driven by variations in geological and hydrothermal activity.



Figure FR-1. This work underscores the necessity of considering hydrothermal vents in global mercury budgets and highlights the potential impact of mid-ocean ridge venting on marine mercury levels. The findings advocate for further investigation into the biogeochemical cycling of mercury in the ocean, particularly in areas influenced by hydrothermal activity, to better understand its implications for marine ecosystems and global mercury distribution.

Fig. 4 Is chematic model of Hg inputs at TAG. Seawater percolates the oceanic crust and is heated up reaching its maximum temperature close to the magna source. The vent fluid end member ascends through the hydrothermal vent

Significant impact of hydrothermalism on the biogeochemical signature of sinking and sedimented particles in the Lau Basin.

Tilliette, C., Gazeau, F., Chavagnac, V., Leblond, N., Montanes, M., Leblanc, K., ... & Guieu, C. (2023). Journal of Geophysical Research: Oceans, 128(12), e2023JC019828.

A new paper was published in JGR following the TONGA cruise (GEOTRACES GPpr14, nov-dec 2019 https://doi.org/10.17600/18000884). The aim was to better understand how hydrothermal activity influences the Western Tropical South Pacific Ocean (WTSP) both in terms of hydrothermally-derived trace metal concentrations and their influence on biological activity, and how volcanic activity impacts the footprint of metal particles. Ultimately, this study established whether hydrothermal sources have a significant influence on the biogeochemical signature of particles in the Lau Basin at large spatial (up to 200 km from the arc, over the entire water column) and temporal (from seasonal to centennial scales in seafloor sediments) scales. We analysed the composition (lithogenic, organic matter, CaCO3 and opal) of the sinking material collected with sediment traps at 200 and 1000 m (over few days with drifting traps during the cruise and over one-year at a fixed mooring) along with the composition of the seafloor sediments. A series of geochemical tracers including metals and LSi, allowed to distinguish the hydrothermal vs volcanic origin of the particles. Results indicate that a myriad of shallow and deep hydrothermal sources, located along the Tonga Arc, fertilize the entire Lau Basin with numerous elements, including Fe, triggering significant POC production during the austral summer period. These hydrothermal sources, along with submarine volcanism, have a significant impact on the biogeochemistry of the Lau Basin, at very large spatial (from the Tonga Arc to the Lau Ridge) and temporal (from seasonal to centennial time scales in seafloor sediments) scales.





New projects and/or funding

- JRP CNRS Africa, Seasonality of iron and manganese in the Southern Ocean (SIMSON): 300 keuros, PI H Planquette
- IsBlue PRECISE, developing new standards for intercalibration of Si and Ge isotopes, PI J. Sutton

GEOTRACES workshops and meetings organized

• 2nd SWINGS postcruise meeting in Auxerre, Flateurville, 22-25 May, 2023, Flateurville, Auxerre, France)

The 35 attendees shared their results, data and first publications. Plenary sessions and small group discussions allowed deepening the discussions on the description of the water masses and the OMPA simulation, the TEI transport, remineralization processes and the island mass effects (Marion and Crozet Islands only). Small consortia have been set up to develop new publications that will come out this year.

A small group presented the SWINGS cruise scientific objectives in a high-school. The SWINGS consortium is also thinking of a big exhibition, merging art and science, in 2025 (Year of the Ocean).



Outreach activities conducted

- Hélène Planquette : Climatoscopie Des ports aux pôles, les océans en danger
 ? Océanopolis, Brest (22/11/2023)
- Catherine Jeandel: Training of public servants Formation des Fonctionnaires aux enjeux du Climat, de la Biodiversité et des Ressources (13/12/2023)
- Nolwenn Lemaitre: Presentation of the Marie Skłodowska-Curie Actions at the Observatory Midi-Pyrénées (11/01/2024)
- Marion Lagarde: Présentation du métier d'océanographe, (Ecole Matisse, 29/01/2024, St Sulpice sur Tarn, France

- Pieter van Beek: Missions océanographiques dans l'Océan Austral (Ecole Régionale de la 2ème chance, Toulouse, le 02/02/2024)
- Catherine Jeandel Environnement et activité économique, un conflit permanent?
- Autour de l'océan, focus Méditerranée et Océan Austral. Conférence invitée à l'IAE de Lyon (06/03/2024)
- Catherine Jeandel : L'océan et l'Humanité, missions australes. Intervention dans le cadre 1) des Etoiles Brillent pour Tous (MA de Seysses, 21/03/2024)
- Catherine Jeandel: Training of public servants Formation des Fonctionnaires aux enjeux du Climat, de la Biodiversité et des Ressources (24/04/2024)
- Catherine Jeandel « L'océan, enjeux et grand programmes internationaux » Intervention devant les représentants de l'OCDE, invitation MESRI (23/04/2024)

Other GEOTRACES activities

- Nolwenn Lemaitre, Emilie Le Roy, Hélène Planquette: Participation in the International BioGeoSCAPES Science Planning Meeting (6-9 November 2023, in Woods Hole, USA)
- Catherine Jeandel, as Senior Scientist of the IPO, led her to participate to miscellaneous meetings.

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

- Cabrol, L., Capo, E., Van Vliet, D. M., von Meijenfeldt, F. B., Bertilsson, S., Villanueva, L., ... & Heimburger Boavida, L. E. (2023). Redox gradient shapes the abundance and diversity of mercury-methylating microorganisms along the water column of the Black Sea. Msystems, 8(4), e00537-23.
- Bonnet, S., Guieu, C., Taillandier, V., Boulart, C., Bouruet-Aubertot, P., Gazeau, F., ... & Tilliette, C. (2023). Natural iron fertilization by shallow hydrothermal sources fuels diazotroph blooms in the ocean. Science, 380(6647), 812-817.
- Grenier, M., Van Beek, P., Lerner, P., Sanial, V., Souhaut, M., Lagarde, M., ... & Reyss, J. L. (2023). New insights on the 7Be cycle in the ocean. Deep Sea Research Part I: Oceanographic Research Papers, 194, 103967.
- Le Roy, E., Van Beek, P., Lacan, F., Souhaut, M., Sanial, V., Charette, M. A., ... & Deng, F. (2023). The distribution of 227Ac along the GA01 section in the North Atlantic. Marine Chemistry, 248, 104207.
- Hamilton, D.S., Baker, A.R., Iwamoto, Y., Santiago Gassó, Bergas-Masso, E., Deutch, E., Dinasquet, J., Kondo, J., Llort, J., Myriokefalitakis, S., Perron, M.G., Wegmann, A., Yoon, J.-E. (2023). An aerosol odyssey: Navigating nutrient flux changes to marine ecosystems. *Elementa: Science of the Anthropocene*; 11 (1): 00037. doi: https://doi.org/10.1525/elementa.2023.00037

- Liao, W. H., Planquette, H., Moriceau, B., Lambert, C., de Gesincourt, F. D., Laurenceau-Cornec, E., ... & Gorgues, T. (2023). The effect of temperature on the release of silicon, iron and manganese into seawater from resuspended sediment particles. Geochimica et Cosmochimica Acta, 351, 1-13.
- Arnone, V., Santana-Casiano, J. M., González-Dávila, M., Planquette, H., Sarthou, G., Gerringa, L. J., & Gonzalez, A. G. (2023). Natural copper-binding ligands in the Arctic Ocean. The influence of the Transpolar Drift (GEOTRACES GN04). Frontiers in Marine Science, 10, 1306278.
- Shelley, R., M. M. G. Perron, D. S. Hamilton, and A. Ito (2024), The open ocean, aerosols, and every other breath you take, *Eos*, *105*, https://doi.org/10.1029/2024EO240091.
- Perron, M. M., Fietz, S., Hamilton, D. S., Ito, A., Shelley, R. U., & Tang, M. (2024). Preface to the inter-journal special issue "RUSTED: Reducing Uncertainty in Soluble aerosol Trace Element Deposition". Atmospheric Measurement Techniques, 17(1), 165-166.
- Tilliette, C., Gazeau, F., Portlock, G., Benavides, M., Bonnet, S., Guigue, C., ... & Guieu, C. (2023). Influence of shallow hydrothermal fluid release on the functioning of phytoplankton communities. Frontiers in Marine Science, 10, 1082077.
- Dulaquais, G., Fourrier, P., Guieu, C., Mahieu, L., Riso, R., Salaun, P., ... & Whitby, H. (2023). The role of humic-type ligands in the bioavailability and stabilization of dissolved iron in the Western Tropical South Pacific Ocean. Frontiers in Marine Science, 10, 1219594.
- Mériguet, Z., Vilain, M., Baudena, A., Tilliette, C., Habasque, J., Lebourges-Dhaussy, A., Bhairy, N., Guieu C., Bonnet S. & Lombard, F. (2023). Plankton community structure in response to hydrothermal iron inputs along the Tonga-Kermadec arc. Frontiers in Marine Science, 10, 1232923.
- Tilliette, C., Gazeau, F., Chavagnac, V., Leblond, N., Montanes, M., Leblanc, K., ... & Guieu, C. (2023). Significant impact of hydrothermalism on the biogeochemical signature of sinking and sedimented particles in the Lau Basin. Journal of Geophysical Research: Oceans, 128(12), e2023JC019828.
- Zhang, X., Lemaitre, N., Rickli, J. D., Suhrhoff, T. J., Shelley, R., Benhra, A., ... & Vance, D. (2024). Tracing anthropogenic aerosol trace metal sources in the North Atlantic Ocean using Pb, Zn and Ni isotopes. Marine Chemistry, 258, 104347
- Torres-Rodriguez, N., Yuan, J., Petersen, S., Dufour, A., González-Santana, D., Chavagnac, V., ... & Heimbürger-Boavida, L. E. (2024). Mercury fluxes from hydrothermal venting at mid-ocean ridges constrained by measurements. Nature Geoscience, 17(1), 51-57.
- Léon, M., van Beek, P., Sanial, V., Souhaut, M., Henderson, P., & Charette, M. A. (2024). Comparison of methods to determine extraction efficiencies of Ra isotopes and 227Ac from large volume seawater samples. Marine Chemistry, 258, 104328.

- Léon, M., van Beek, P., Sanial, V., Baudet, C., Charette, M. A., Souhaut, M., ... & Planquette, H. (2024). Investigation of hydrothermal activity in the South West Indian ridge region using Ra isotopes and 227Ac as tracers. Progress in Oceanography, 221, 103191.
- Aguilar-Islas, A., Planquette, H., Lohan, M. C., Geibert, W., & Cutter, G. (2024). INTERCALIBRATION. Oceanography, 37(2), 21-24
- Mahieu, L., Whitby, H., Dulaquais, G., Tilliette, C., Guigue, C., Tedetti, M., ... Bonnet S., Guieu C. & Salaün, P. (2024). Iron-binding by dissolved organic matter in the Western Tropical South Pacific Ocean (GEOTRACES TONGA cruise GPpr14). Frontiers in Marine Science, 11, 1304118.

Please indicate if there is any forthcoming or planned GEOTRACES special issue publication

- As discussed in Auxerre, we are planning to propose a special issue for Progress in Oceanography on the topic of the GEOTRACES GS02 section: South West Indian Geotraces Section (SWINGS). The chief editor answered positively to our request and we are currently setting it up.
- Research Topic "Hydrothermal and submarine volcanic activity: Impacts on ocean chemistry and plankton dynamics" still open in Frontiers in Marine Science & Frontiers in Microbiology. https://www.frontiersin.org/researchtopics/49099/hydrothermal-and-submarine-volcanic-activity-impacts-on-oceanchemistry-and-plankton-dynamics/articles

Completed GEOTRACES PhD or Master theses

PhD theses

- **Corentin Baudet** : « Cycles BlOgéochimiques des METaux traces dans le secteur indien de l'océan austral", thèse SWINGS, December 2023, LEMAR (H. Planquette/G. Sarthou/E. Bucciarelli)
- Morgane Léon, 2023. Etude des isotopes du radium et de l'actinium-227 le long de la section SWINGS dans l'océan Austral. Université Paul Sabatier Toulouse III.
- Chloé Tilliette, Influence of iron and other trace elements from shallow hydrothermal sources on marine biogeochemistry in the Southwest Pacific Ocean, Sorbonne Université, 2023, 383 pp. (in French)

<u>Master</u>

• Antoine Ringard : « Saisonnalité du fer et manganèse particulaires dans l'océan Austral », M2 2023, LEMAR (H. Planquette/E. Bucciarelli)
GEOTRACES presentations in international conferences

Goldschmidt 2023, 9-15 July 2023, Lyon, France

- Kazuyo Tachikawa, François Beny, Marine, Cornuault, Abel Guihou, Pierre Deschamps, Hartmut Schulz, Francisco J. Sierro, Marie Boyé. The modern Mediterranean Sea neodymium isotopic budget: insight from core-top sediments and box model calculations. (talk)
- Ringard, A., Planquette, H., Bucciarelli, E., Cloete, E., Roychoudhury, A.N., 2023. Spatial and temporal variability of particulate iron and manganese in the Atlantic sector of the Southern Ocean: spring vs winter. (poster)
- Léon, M., van Beek, P., Sanial, V., Baudet, C., Charette, M.A., Souhaut, M., Vivier, F., Kestenare, E., Jeandel, C., Planquette H. Investigation of hydrothermal activity in the South West Indian Ridge region using Ra isotopes and 227Ac as tracers. (talk)
- N. Lemaitre, E. Faure, M. Ellwood, C. Hassler, L. Maignien, D. Vance. Nickel cycling in the ocean: insights from isotopes and metagenomics. (talk)
- Jeandel, C., Belhadj, M., Lagarde, M., Baudet, C. and Planquette, H. REE distributions in the Southern Indian Ocean with a focus on land-ocean inputs SWINGS GEOTRACES cruise) (poster)
- Lagarde, M., Pham, V.Q., Lemaitre, N., Belhadj Senini, M. and Jeandel, C.: Rare Earth element partition coefficients in the subpolar North Atlantic (GEOVIDE cruise) (talk)
- Pham, V., Lagarde, M., Belhadj Senini, M., Ouillon, S., Jeandel, C.: Anthropogenic dissolved samarium and gadolinium in the Van Uc River. Environmental issue in the estuary, impact on the Gulf of Tonkin. (poster)
- Le Roy E., Jacquet S., Baudet C., Dufour A., Cardinal D., González-Santana D., Liao W-H, Hamelin B., Vorrath M-E, Piejus M., Jeandel C. & Planquette H. Barium Excess as Remineralization Proxy in the Southern Ocean – Indian Sector (SWINGS-Gs02) https://doi.org/10.7185/gold2023.17436 (talk)

BioGeoScapes Science Planning Meeting, Woods Hole (USA), 2023.

• Lemaitre, N., Faure, E., Ellwood, M., Hassler, C., Maignien, L., Vance, D. Biological processes drive Ni distributions in the Southern Ocean. (Poster)

EGU Vienna, 2024

 Heimbürger-Boavida, L.-E., Torres-Rodriguez, N., Yuan, J., Petersen, S., Dufour, A., Gonzalez-Santana, D., Chavagnac, V., Planquette, H., Horvat, M., Amouroux, D., Cathalot, C., Pelleter, E., Sun, R., Sonke, K., Luther, G. Mercury fluxes from hydrothermal venting at mid-ocean ridges constrained by measurements.

Submitted by Hélène Planquette (<u>helene.planquette@univ-brest.fr</u>).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN GERMANY

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

- https://www.geotraces.org/overlooked-riverine-contributions-of-dissolvedneodymium-and-hafnium-to-the-amazon-estuary-and-oceans/
- https://www.geotraces.org/decoupling-of-barium-and-silicon-transport/

GEOTRACES or GEOTRACES relevant cruises

- GP11 section cruise 'Cycling of trace elements and their isotopes in the Equatorial Pacific Ocean and consequences for ocean productivity'on FS Sonne (SO298) in the Equatorial Pacific Ocean (Guayaquil_Ecuador – Townsville_Australia) has been sailed in the period April 14 – June 2 2023 PIs Achterberg, Frank, Koschinsky, and important involvement by Scholten, Walter Geibert, S Galer, W Abouchami.
- EMS FORE cruise on Meteor (M187) 'Impact of climate on ecosystem functioning and carbon export in Eastern Mediterranean' sailed from Limassol (Cyprus) to Catania (Italy) between January 3 and February 6 2024. PIs Tom Browning, Eric Achterberg, Zvi Steiner.

New projects and/or funding

- INSPIRES-PhD studentship Alexandra Bettinelli (Trimborn/Geibert, AWI) for PS144: Impact of Ice Drift on Nutrient and Trace-Metal Distribution, Ocean Productivity, and Carbon Export
- Research cruise M206 (RV Meteor) as a follow-up study of cruise M147 (GApr11) for studying trace metal and DOM input from the Amazon estuary into the Atlantic funded and scheduled for Dec. 2024; will be applied for as a GEOTRACES process study again.

Outreach activities conducted

- 22.03.2024 Web release: Annette-Barthelt-Preis würdigt herausragende Abschlussarbeiten, https://idw-online.de/de/news830805.
- 28.09.2023 Web release: 'How trace elements affect marine CO₂ sinks', https://www.awi.de/ueber-uns/service/presse/presse-detailansicht/wie-spurenelemente -die-co2-speicherung-im-ozean-veraendern.html.
- 06.06.2023 Web release: https://www.simona.de/en/company/news/detail/ ?tx_news_pi1%5Bnews%5D=534&cHash=28ce6f380118ea9bad7153d4b7db4651

- Educational videos from GEOTRACES Summer School in Bremerhaven 2022 on video platforms:
 - 1. ICP-MS and ICP-OES for analysing marine samples 1/3
 - 2. Calibrating and validating analyses of marine samples 2/3
 - 3. Trace metal clean preparation of marine samples 3/3

Other GEOTRACES activities

• Preparation and release of IDP2021v2 (R. Schlitzer, July 2023)

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

- Arnone, V., Santana-Casiano, J. M., González-Dávila, M., Sarthou, G., Krisch, S., Lodeiro, P., Achterberg, E. P. and González, A. G. 2024. Distribution of copperbinding ligands in Fram Strait and influences from the Greenland Shelf (GEOTRACES GN05). Open Access Science of the Total Environment, 909. DOI 10.1016/j.scitotenv.2023.168162.
- Balaguer, J., Koch, F., Flintrop, C., Völkner, C., Iversen, M., Trimborn, S. 2023 Iron and manganese availability drive primary production and carbon export in the Weddell Sea. Current Biology, doi:10.2139/ssrn.4342993.
- Balaguer, J., Thoms, S., Trimborn, S. 2023 The physiological response of an Antarctic key phytoplankton species to low iron and manganese concentrations. Limnol Oceanogr 68:2153-2166, doi:10.1002/lno.12412.
- Böckmann, S., Trimborn, S., Schubert, H., Koch, F. 2024 Grazing by nano- and microzooplankton on heterotrophic picoplankton dominates the biological carbon cycling around the Western Antarctic Peninsula. Polar Biology 47:279-294, doi:10.1007/s00300-024-03231-2.
- Browning, T. J., Al-Hashem, A. A., Achterberg, E. P., Carvalho, P. C., Catry, P., Matthiopoulos, J., Miller, J. A. O. and Wakefield, E. D. 2023. The role of seabird guano in maintaining North Atlantic summertime productivity. Science of The Total Environment, 897. Art.Nr. 165309. DOI 10.1016/j.scitotenv.2023.165309.
- Browning, T. J., Saito, M. A., Garaba, S. P., Wang, X., Achterberg, E. P., Moore, C. M., Engel, A., Mcllvin, M. R., Moran, D., Voss, D., Zielinski, O. and Tagliabue, A. 2023. Persistent equatorial Pacific iron limitation under ENSO forcing. Open Access Nature . DOI 10.1038/s41586-023-06439-0.
- Camoying, M., Koch, F., Stimpfle, J., Hassler, C., Trimborn, S Distinct responses of diatom- and flagellate-dominated Antarctic phytoplankton communities to altered iron and light supply. In revision for Front Mar Sci on 30.5.24, minor

- Camoying, M., Trimborn, S. 2023 Physiological response of an Antarctic cryptophyte to increasing temperature, CO2 and irradiance. Limnol Oceanogr 68:1880-1894, doi:10.1002/lno.12392.
- Chen, X. G., Milne, A., Klar, J. K., Gledhill, M., Lohan, M. C., Hsieh, Y. T., Henderson, G. M., Woodward, E. M. S. and Achterberg, E. P. 2024. Controls on distributions of aluminium, manganese and cobalt in the South Atlantic Ocean along GEOTRACES transect GA10. Open Access Geochimica et Cosmochimica Acta, 373. pp. 177-196. DOI 10.1016/j.gca.2024.03.019.
- Chen, X. G., Gledhill, M., Lohan, M. C., Milne, A. and Achterberg, E. P. 2024. Surface ocean biogeochemistry and deep ocean circulation control relationships between nutrient-type trace metals (Cd, Ni, Cu, and Zn) and nutrients in the South Atlantic Ocean near the subtropical front. Open Access Geochimica et Cosmochimica Acta, 370. pp. 144-160. DOI 10.1016/j.gca.2024.01.001.
- Chen, X. G., Rusiecka, D., Gledhill, M., Milne, A., Annett, A. L., Birchill, A. J., Lohan, M. C., Ussher, S., Woodward, E. M. S. and Achterberg, E. P. 2023. Ocean circulation and biological processes drive seasonal variations of dissolved Al, Cd, Ni, Cu, and Zn on the Northeast Atlantic continental margin. Marine Chemistry. Art.Nr. 104246. DOI 10.1016/j.marchem.2023.104246.
- Chen, X. G., Rusiecka, D., Gledhill, M., Milne, A., Annett, A. L., Beck, A. J., Birchill, A. J., Lohan, M. C., Ussher, S. and Achterberg, E. P. 2023. Physical and biogeochemical controls on seasonal iron, manganese, and cobalt distributions in Northeast Atlantic shelf seas. Geochimica et Cosmochimica Acta, 348. pp. 278-295. DOI 10.1016/j.gca.2023.03.023.
- Conway, T.M., R. Middag, and R. Schlitzer. 2024. GEOTRACES: Ironing out the details of the oceanic iron sources? Oceanography 37(2):35–45, <u>https://doi.org/10.5670/oceanog.2024.416</u>.
- Fourquez, M., Cabanes, D., Janssen, D., Conway, T., Jaccard, S., Sieber, M., Ellwood, M., Trimborn, S., Hassler, C. 2023 Chasing iron bioavailability in the Southern Ocean: Insights from Phaeocystis antarctica and iron speciation. Science Advances 9(26), eadf9696, doi: 10.1126/sciadv.adf9696.
- Gosnell, K. J., Heimbürger-Boavida, L. E., Beck, A. J., Ukotije-Ikwut, P. R. and Achterberg, E. P. 2023. World war munitions as a source of mercury in the southwest Baltic Sea. Chemosphere, 345. Art.Nr. 140522. DOI 10.1016/j.chemosphere.2023.140522.
- Gu, Y., James Hopwood, M., Gledhill, M., Rapp, I., Wuttig, K. and Achterberg, E. 2024. Spatial and temporal variations in the micronutrient Fe across the Peruvian shelf from 1984-2017. Progress in Oceanography, 221. Art.Nr. 103208. DOI 10.1016/j.pocean.2024.103208.
- Krause, J., Carroll, D., Höfer, J., Donaire, J., Achterberg, E. P., Alarcón, E., Liu, T., Meire, L., Zhu, K. and Hopwood, M. J. 2024. The macronutrient and micronutrient (iron and manganese) signature of icebergs. DOI 10.5194/egusphere-2023-2991.

- Krause, J., Zhu, X., Höfer, J., Achterberg, E. P., Engel, A., Meire, L., Stuart-Lee, A. E. and Hopwood, M. J. 2023. Glacier-Derived Particles as a Regional Control on Marine Dissolved Pb Concentrations. Journal of Geophysical Research: Biogeosciences, 128 (10). Art.Nr. e2023JG007514. DOI 10.1029/2023JG007514.
- Kurahashi, E., Poehle, S. and Koschinsky, A., 2024. Determination of vanadium redox species V (IV) and V (V) in seawater using chelating resin and inductively coupled plasma mass spectrometry. Deep Sea Research Part I: Oceanographic Research Papers, p.104261. https://doi.org/10.1016/j.dsr.2024.104261
- Liu, T., Hopwood, M. J., Krisch, S., Vieira, L. H. and Achterberg, E. P. 2023. Trace metal fluxes of Cd, Cu, Pb and Zn from the Congo River into the South Atlantic Ocean are supplemented by atmospheric inputs. Open Access Geophysical Research Letters, 50 (24). e2023GL107150. DOI 10.1029/2023GL107150.
- Massmann, G., Abarike, G., Amoako, K., Auer, F., Badewien, T.H., Berkenbrink, C., Böttcher, M.E., Brick, S., Cordova, I.V.M., Cueto, J., Dittmar, T., Engelen, B., Freund, H., Greskowiak, J., Günther, T., Herbst, G., Holtappels, M., Marchant, H.K., Meyer, R., Müller-Petke, M., Niggemann, J., Pahnke, K., Pommerin, D., Post, V., Reckhardt, A., Roberts, M., Schwalfenberg, K., Seibert, S.L., Siebert, C., Skibbe, N., Waska, H., Winter, C., Zielinski, O. (2023). The DynaDeep observatory – a unique approach to study high-energy subterranean estuaries. Frontiers in Marine Science 10. doi:10.3389/fmars.2023.1189281.
- Paul, S. A. L., Schmidt, K., Achterberg, E. P. and Koschinsky, A. 2024. The importance of the soluble and colloidal pools for trace metal cycling in deep-sea pore waters. Open Access Frontiers in Marine Science, 11. Art.Nr. 1339772. DOI 10.3389/fmars.2024.1339772.
- Pedre, I., Fröhberg, N., Waska, H., Koschinsky, A., Pahnke, K. (2024). Simple and affordable colorimetric sensing strips for quantitative determination of total manganese in porewater samples. Limnology and Oceanography: Methods. doi:https://doi.org/10.1002/lom3.10615.
- Schlitzer, R., and S. Mieruch-Schnülle. 2024. The GEOTRACES intermediate data products: Rich resources for research, education, and outreach. Oceanography 37(2):25–33, https://doi.org/10.5670/oceanog.2024.402.
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- Steiner, Z., Antler, G., Berelson, W. M., Crockford, P. W., Dunlea, A. G., Hou, Y., Adkins, J. F., Turchyn, A. V. and Achterberg, E. P. 2023. Trace Element Geochemistry in North Pacific Red Clay Sediment Porewaters and Implications for Water-Column Studies. Open Access Global Biogeochemical Cycles, 37 (11). e2023GB007844. DOI 10.1029/2023GB007844.
- Ukotije-Ikwut, P. R., Steiner, Z., Gledhill, M., Müller, M., Oakes, J. M., Sukri, R. S., Jiang, S. and Achterberg, E. P. 2023. The distribution and behaviour of Fe, Al, Si, Mn, Cu and Ni in ombrotrophic tropical peat draining blackwater estuaries on Borneo

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- Waltemathe, H., Struve, T., Rehbein, M., Pahnke, K. (accepted). Influence of water mass mixing and hydrothermal processes on the distribution of dissolved Nd isotopes and concentrations in the South Pacific. Earth and Planetary Science Letters.
- Xu, A., Hathorne, E., Laukert G. and Frank, M. (2023): Overlooked riverine contributions of dissolved neodymium and hafnium to the Amazon estuary and oceans.- Nature Communications 14, 4156, https://doi.org/10.1038/s41467-023-39922-3.
- Zhang, Z., Yu, Y., Hathorne, E.C., Vieira, L.H., Grasse, P., Siebert, C., Rahlf, P. and Frank, M. (2023): Decoupling of barium and silicon at the Congo River-dominated Southeast Atlantic margin: Insights from combined barium and silicon isotopes.-Global Biogeochemical Cycles 37, e2022GB007610, https://doi.org/10.1029/2022GB007610.
- Zhang, Z., Zhou, L., Chen, X. G., Achterberg, E. P., Yu, Y., Hathorne, E., Steiner, Z., Siebert, C. and Frank, M. 2024. Introduction of isotopically light barium from the Rainbow hydrothermal system into the deep Atlantic Ocean. Open Access Earth and Planetary Science Letters, 625. Art.Nr. 118476. DOI 10.1016/j.epsl.2023.118476.
- Zhou, L., Liu, F., Achterberg, E. P., Engel, A., Campbell, P. G. C., Fortin, C., Huang, L. and Tan, Y. 2024. Promoting effects of aluminum addition on chlorophyll biosynthesis and growth of two cultured iron-limited marine diatoms. Open Access Limnology and Oceanography. DOI 10.1002/Ino.12558.
- Zhu, K., Achterberg, E. P., Bates, N. R., Gerringa, L. J. A., Middag, R., Hopwood, M. J. and Gledhill, M. 2023. Influence of changes in pH and temperature on the distribution of apparent iron solubility in the oceans. Open Access Global Biogeochemical Cycles, 37 (5). e2022GB007617. DOI 10.1029/2022GB007617.

Completed GEOTRACES PhD or Master theses

- Al-Hashem, A. (2023) The Biogeochemical Cycling of Particulate Trace Metals off the Southwest African and Peruvian Shelves. (PhD/ Doctoral thesis), Christian-Albrechts-Universität zu Kiel, Kiel, Germany.
- Liu, T. (2023) Trace Metal Biogeochemical Cycling and Fluxes in the eastern South Atlantic. (PhD/ Doctoral thesis), Christian-Albrechts-Universität zu Kiel, Kiel, Germany, IX, 175 pp
- Antao Xu (PhD thesis): Neodymium and Hafnium Isotope and Rare Earth Element Geochemical Cycling and Fluxes from the Amazon to the tropical western Atlantic, defended in Feb. 2024

GEOTRACES presentations in international conferences

- Balaguer, J., Koch, F., Trimborn, S. 2024 The combined effect of light, iron and manganese availability on Southern Ocean phytoplankton growth and productivity. Ocean Science Meeting, 17-23 February New Orleans, USA.
- Fourquez, M., Cabanes, D., Janssen, D., Conway, T., Cabanes, D., Ellwood, M., Sieber, M., Trimborn, S., Hassler, C. 2023. Extreme variability of iron bioavailability in the Southern Ocean. Goldschmidt Conference, 9-14 July, Lyon, France.
- Liu, T., Hopwood, M. J., Krisch, S., Vieira, L. H. and Achterberg, E. P. 2023. Trace metal fluxes from the Congo River into the South Atlantic Ocean are supplemented by atmospheric inputs from gas flaring. [Talk] In: Goldschmidt Conference 2023, 9.- 14.07.2023, Lyon, France
- Pedre, I., Fröhberg, N., Waska, H., Koschinsky, A., Pahnke, K. (2023). Simple and portable devices for measuring manganese in pore- and coastal water samples, Goldschmidt Conference, Lyon, France. doi:10.7185/gold2023.17048.
- Stimpfle, J., Koch, F., Ebner, B., Zitoun, R., Henkel, S., Trimborn, S. 2024 Quantifying the bioavailability of nearshore iron sources from South Georgia to natural phytoplankton communities. Ocean Science Meeting, 17-23 February New Orleans, USA.
- Vieira, L. H., Steiner, Z., Scholten, J., Beck, A. J. and Achterberg, E. P. (2023) Is the Rainbow ultramafic hydrothermal system a poor source of radium isotopes to the Atlantic Ocean? Open Access [Poster] In: Goldschmidt Conference 2023. , 9.-14.07.2023, Lyon, France .
- Zander, M., Struve, T., Lamy, F., Pahnke, K. (2024). Influence of water mass mixing and non-conservative modifications on dissolved neodymium isotopes in the eastern Tasman Sea. Ocean Sciences Meeting, New Orleans, USA.
- Poster: Ebner, B., Henkel, S., Köster, M., Trimborn, S., Koch, F., Stimpfle, J., Staubwasser, M., Laufer-Meiser, K., Kattein, L., Geibert, W., Müller, D., Kasten, S. 2023. Iron transport and reaction pathways traced by sedimentary stable iron isotopes from South Georgia into the adjacent Southern Ocean. Ocean Science Meeting, 17-23 February New Orleans, USA.

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN INDIA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

• Understanding the source of mineral dust in the Indian Ocean

Aeolian transportation of mineral dust is an important contributor of trace elements and nutrients to the ocean surface. Further, the Aeolian supply of mineral dust also influences the biogeochemical cycling of C and N. The effect of Aeolian mineral dust supply on the ocean biogeochemistry and nutrient and trace element cycling can be better understood through studies focussed on latitudinal variability of dust provenances and fluxes.

Working with these primary objectives, radiogenic Sr (⁸⁷Sr/⁸⁶Sr) and Nd (_{Nd}(0)) isotopic compositions of silicate fraction of mineral aerosols collected over the Indian Ocean (both pelagic northern and southern Indian Ocean regions) were studied. The samples were collected during GEOTRACES-India research expeditions (GI-01: March-April 2014 and GI-02: April-May 2014). The Sr and Nd isotopic compositions of the collected aerosol samples show the significant spatial distribution in different parts of the region: (i) the Bay of Bengal, (ii) the Arabian Sea, (iii) the equatorial Indian Ocean, and (iv) the



southern sector of Indian Ocean.

Figure IN-1: Spatial distributions of (a) 87 Sr/ 86 Sr and (b) ${}_{Nd}$ (0) in the silicate fraction of dust samples collected over the Indian Ocean (GI01 and GI02 cruises).

Major findings of this work are:

(i) Based on the Sr and Nd isotopic composition of the dust collected over the Bay of Bengal, the source region was identified to be from the Thar Desert.

(ii) The dust falling over the Arabian Sea shows a very limited spread both in 87 Sr/ 86 Sr and ${}_{Nd}(0)$, varying from 0.71520 to 0.71642 and -10.9 to -10.1, respectively. The isotopic data in conjunction with the air mass back trajectories, indicates dust supply from the Arabian Peninsula.

(iii) For the Equatorial Indian Ocean, it was established that the region receives dust flux primarily from three different sources: The Thar Desert, sand dunes in northern Australia, and the Indonesian Archipelago.

(iv) The southern sector of the Indian Ocean region receives dust from three major source regions: Antarctica, western Australia, and South Africa/South America.

These results have great implications for understanding the pathway of dust deposition over the Indian Ocean region and modeling the dust transport and dispersal in the region.

• Biogeochemical cycling of dissolved Nickel in the Indian Ocean

The dissolved Nickel concentration (dNi) in the samples collected from the GEOTRACES-India research expedition GI09 was measured. The samples were collected across the latitudinal gradient in the Indian Ocean from 17 stations Overall, the dissolved Ni concentration in these waters varies from 2.0 to 9.7 nM. In the surface and sub-surface layers (< 100 m), the dissolved Ni abundance varies from 2 to 4 nM. The dissolved Ni concentration in the intermediate waters (100 - 1000 m) was measured to be ~ 2 to 8 nM. In the deeper layers of the Indian Ocean waters (1000 – 6000 m), the dissolved Ni concentrations vary from ~6 to 11 nM. Overall, the dissolved Ni concentrations in the northern Indian Ocean are relatively higher (reaching ~10 nM) than in the equatorial and southern Indian Ocean. The relatively higher dNi in the northern Indian Ocean is possibly due to higher particulate remineralization in the relatively oxygen deficient waters of the northern Indian Ocean. Further, the amount of Ni released from the remineralization of the sinking particulate matter (Nixs) was estimated using an inverse modeling approach. Based on the inverse model, excess Ni (Nixs) in the water column of the Indian Ocean was estimated to range from 0.2 to 4.2 nM. The Nixs represent the part of Ni sourced from the remineralization of the sinking particles within the water column, unsupported by the water mass circulation.

GEOTRACES or GEOTRACES relevant cruises

• There was no new sample collection done throughout the last year. However, various water and sediment/particulate samples are being analyzed currently for their trace element and isotopic composition and other key parameters.

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

- Singh N. D., Singh S.K., Malla N., and Chinni V., Biogeochemical cycling of dissolved manganese in the Arabian Sea, Geochimica et Cosmochimica Acta 343 (2023) 396– 415.
- Rahaman W., Singh S.K., Behaviour of barium in the tropical estuaries: Implications to its marine budgets and paleo-oceanographic applications, Marine Chemistry 254 (2023) 104278.
- Bikkina S., Shukla A., Singh S.K., Karri D., Singh N.D., Sahoo B., Link of the short-term temporal trends of Sr and Nd isotopic composition of aeolian dust over the Arabian Sea with the source emissions, Science of the Total Environment 892 (2023) 164680.
- A Shukla, SK Singh, DP Singh, A Sharma, AP Dimri, Strong climate control on the millennial-scale dust variability and sediment provenances in the Equatorial Indian Ocean inferred from Sr-Nd isotopes, Paleoceanography and Paleoclimatology 39 (3), e2023PA004808
- D Karri, S Bikkina, SK Singh, Tracing the provenance of mineral dust over the northern and southern Indian Oceans during the GEOTRACES-India (GI-01, GI-02) expeditions, Geochimica et Cosmochimica Acta 366, 141-153

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN IRELAND

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

Wilson et al. (2024). Global subterranean estuaries modify groundwater nutrient loading to the ocean



• (a) Global map of meta-dataset site locations (n = 216), including local-scale groundwater sample size (count) indicated by point size and lithology indicated by shape. Histograms of log-transformed groundwater (all samples) nutrient concentrations (μ M) including (b) DIN (n = 5660), (c) DON (n = 1890), and (d) DIP (n = 4569). Scatter plots of groundwater (e) DIN, (f) DON, and (g) DIP concentrations

(µM) vs. groundwater sample salinity (note the different Y-axes). Interactive sample map available at: <u>https://marineresearch.shinyapps.io/Gobal_STE_Nutrients/</u>.

The main nutrient sources to the ocean include atmospheric deposition, rivers, and groundwater. Of these sources, groundwater-borne nutrients transported to the ocean via submarine groundwater discharge have remained the most uncertain at the global scale. We quantified global nutrient loading via groundwater by compiling the largest meta-dataset of coastal groundwater nutrient concentrations available. Dissolved organic nitrogen was identified as a key component of the groundwater nutrient pool and salinity and land cover were important drivers of nutrient concentrations. We provide evidence that nutrients behave non-conservatively in subterranean estuaries resulting in increases in groundwater inorganic nitrogen and phosphorus but decreases in organic nitrogen. Lastly, estimates of groundwater nutrient to findings indicate that submarine groundwater discharge is an important source of nitrogen and phosphorus to the ocean as rivers and nitrogen fixation. Our findings indicate that submarine groundwater discharge is an important source of nitrogen and phosphorus to the ocean that should be accounted for in nutrient budgets.

GEOTRACES or GEOTRACES relevant cruises

 iCRAG (Irish Centre for Research in Applied Geoscience) researchers participated in an international research expedition CE23011 SiTrAc (Signal Tracking to unveil Arctic Climate variability to the Arctic) onboard the Celtic Explorer. Chief Scientist, Dr Audrey Morley (iCRAG@UG), this was a follow up expedition to the 2020 expedition CIAAN (Constraining the Impact of Arctic Amplification in the Nordic Sea: A biogeochemical approach).

New projects and/or funding

 There were no new projects or funding initiated during the reporting period. A preproposal had been submitted (Dec 2023) to SFI for a new SFI centre focused on the Marine Environment (FORCE – Future Ocean Research CEntre), in June 2024, SFI announced that they were delaying making a decision on this until later in 2024.Currently iCRAG is funded until the end of 2026.

GEOTRACES workshops and meetings organized

 There were no GEOTRACES specific workshops run in Ireland during the reporting period. On January 19, 2024, an IMBER workshop, as part of an EPA/Marine Institute funded project 'NUTS & BOLTS' was held at the University of Galway on the topic of 'The sustainability of Irish marine transitional zones' This workshop which included a presentation on new trace metal data from Irish estuaries and coastal waters which were collected and analyzed following the GEOTRACES cookbook.

Other GEOTRACES activities

- Prof. Croot is a member of the Chemical Speciation Group Joint Committee on the Properties of Seawater (2023-present).
- Prof. Croot is an associate member of SCOR Working Group 167 Reducing Uncertainty in Soluble aerosol Trace Element Deposition (RUSTED) (2022 present).
- Prof. Croot attended the annual SCOR meeting, held in Guayaquil, Ecuador in October 2023, in his role as Secretary of the SCOR Executive Committee.

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

- Daly, E., Nolan, G., Berry, A., Büscher, J.V., Cave, R.R., Caesar, L., Cronin, M., Fennell, S., Lyons, K., McAleer, A., McCarthy, G.D., McGovern, E., McGovern, J.V., McGrath, T., O'Donnell, G., Pereiro, D., Thomas, R., Vaughan, L., White, M., Cusack, C. Diurnal to interannual variability in the Northeast Atlantic from hydrographic transects and fixed time-series across the Rockall Trough. Deep Sea Research Part I: Oceanographic Research Papers 204, 104233, doi:https://doi.org/10.1016/j.dsr.2024.104233 (2024).
- Grégoire, M., Oschlies, A., Canfield, D., Castro, C., Ciglenečki, I., Croot, P., Salin, K., Schneider, B., Serret, P., Slomp, C.P., Tesi, T., Yücel, M., 2023. Ocean Oxygen: the role of the Ocean in the oxygen we breathe and the threat of deoxygenation., in: Rodriguez Perez, A., Kellett, P., Alexander, B., Muñiz Piniella, Á., Van Elslander, J., Heymans, J.J. (Eds.), Future Science Brief No. 10 of the European Marine Board. European Marine Board, Ostend, Belgium. https://www.marineboard.eu/sites/marineboard.eu/files/public/EMB_FSB10_Ocean_oxyge n_Web-150DPI_V7.pdf
- Gregory, C., Cave, R.R., Raine, R., McDermott, G. Phytoplankton abundance and biodiversity in adjacent estuaries: the importance of submarine groundwater discharge. Hydrobiologia, doi:10.1007/s10750-024-05497-3 (2024).
- Jiang, S., Jin, J., Wei, Y., Wu, Y., Zhang, Y., Rocha, C., Ibánhez, J.S.P., Zhang, G., Zhang, J., 2023. Sandy seepage faces as bioactive nitrate reactors: Biogeochemistry, microbial ecology and metagenomics. Geoscience Frontiers 14, 101529, doi:https://doi.org/10.1016/j.gsf.2022.101529 (2023).
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• Xu, H., Wang, H., Singh, B.P., Croot, P., Zhang, C., 2023. Identification of possible sources for potentially toxic elements and polycyclic aromatic hydrocarbons and their spatially varying relationships in urban soils of Dublin, Ireland. Environmental Pollution 333, 122034, doi:https://doi.org/10.1016/j.envpol.2023.122034 (2023).

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN ISRAEL

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

Response of Dissolved Trace Metals to Dust Storms, Sediment Resuspension, and Flash Floods in Oligotrophic Oceans (Benaltabet et al., 2023): Trace metals (TM) delivered by atmospheric dust play a key role in oceanic biogeochemical cycles. However, the impact of short-term environmental perturbations such as dust storms and sediment resuspension events on the oceanic water column is poorly constrained due to the low temporal sampling resolution and episodic nature of these events. Benaltabet et al. (2023) present a 2-year time series of dissolved manganese, cobalt, nickel, copper, zinc, cadmium, and phosphate concentration profiles sampled in the Gulf of Agaba (GoA), Red Sea. The GOA is a highly accessible deep oligotrophic water body featuring exceptionally high atmospheric deposition fluxes that provide the main source of TMs to its surface waters. The study focuses on daily time scale dust storms and episodes of sediment resuspension to quantify the immediate impact of these events on dissolved TM cycling. Counter-intuitively, upper mixed layer TM inventories decrease with increasing aerosol loads, with the effects of aerosol-induced TM scavenging and dissolution peaking 5-6 days after aerosol deposition. Dust storms promote intense TM scavenging, with TM inventories decreasing by up to 44%, but seldom lead to TM enrichment. Similarly, sediment resuspension and flash flood events triggered significant TM scavenging. These findings highlight the potential dual role of atmospheric deposition in the oceans as a long-term source of dissolved TMs and a short-term sink. These in situ observations may be used to understand and quantify the global impact of abrupt environmental events on oceanic chemical compositions.



Figure IS-1. Seawater density, oxygen, PO4 and dissolved trace metals concentrations at station A, Gulf of Aqaba during 2017-2018. Black dots denote the timing and depth of sampling.



Figure IS-2. Correlation values (R2) between dissolved trace metal mixed layer concentrations (TMML) and integrated dust (TSaP) loads at varying time intervals prior to seawater sampling. Background profiles (full symbols) display higher correlations to TSaP relative to the entire set of profiles (empty symbols). The highest corelations for CoML, NiML, CuML, CdML and AIML were achieved for TSaP integration periods of 120-144hours, whereas MnML and PO4ML R2 values remained poor.

<u>Reference:</u> Benaltabet, T., Lapid, G. and Torfstein, A., 2023. Response of dissolved trace metals to dust storms, sediment resuspension, and flash floods in oligotrophic oceans. Global Biogeochemical Cycles, 37(10), p.e 2023GB007858.

Accumulation of total mercury in deep-sea sediments and biota across a bathymetric gradient in the Southeastern Mediterranean Sea (Sisma-Ventura et al., 2024): This study explores the accumulation of total mercury (THg) in deep-sea sediments and demersal megafauna of the ultra-oligotrophic Southeastern Mediterranean Sea (SEMS) across bathymetric gradients in the range 35–1900 m, sampled in seven cruises during 2013, 2017–2021, and 2023. Measurements of THg were conducted in surficial (0.0–0.5 cm) and subsurface (9.0–10 cm) sediments, demersal sharks, demersal teleost fish, and benthic crustaceans. Sedimentary organic carbon and biota δ^{13} C and δ^{15} N values were determined to explore possible foraging habitats and dietary sources of THg. The results exhibit an increasing trend of THg in surficial sediments with increasing bottom depth, while in the subsurface, pre-industrial sediments, THg remains lower, slightly increasing with depth. Having no major terrestrial point sources in this area, this increasing trend of THg in surficial sediments across bathymetric gradients is controlled by atmospheric mercury deposition, scavenged by the biological pump, and by lateral transport of particulate Hg in winnowed fine particles from the shelf. Similarly, the THg in benthic crustaceans and demersal fish ranged between 0.02 and 2.71 μ g g⁻¹ wet weight (0.06 and 10.8 μ g g⁻¹ dry weight) and increased with muscle δ^{13} C as a function of distance offshore, while presenting a low THg- δ^{15} N bio-magnification power. Our results suggest that foraging habitats, longevity, and species-specific depth distribution control their muscle THg bioaccumulation. Despite this complexity, the pooling of THg in megafauna into specific deep zones reflected the trend of increasing anthropogenic THg across bathymetric gradients. Furthermore, many of the biota measurements exceeded safe consumption thresholds for Hg and therefore, should be considered carefully in the development and regulation of deep-sea trawling in this region.



<u>Reference:</u> Sisma-Ventura, G., Silverman, J., Guy-Haim, T., Stern, N., Shachnai, A., Mori, M.M., Khadra, M.A., Jacobson, Y., Segal, Y., Katz, T. and Herut, B., 2024. Accumulation of total mercury in deep-sea sediments and biota across a bathymetric gradient in the Southeastern Mediterranean Sea. *Chemosphere*, *351*, p.141201.

• Costs of dust collection by Trichodesmium: effect on buoyancy and toxic metal release (Wang et al., 2024): The marine cyanobacterium Trichodesmium has the remarkable ability to interact with and utilize air-borne dust as a nutrient source. However, dust may adversely affect Trichodesmium through buoyancy loss and exposure to toxic metals. This study explored the effect of desert dust on buoyancy and mortality of natural Red Sea puff-shaped Trichodesmium thiebautii. Sinking velocities and ability of individual colonies to stay afloat with increasing dust loads were studied in sedimentation chambers. Low dust loads of up to ~400 ng per colony did not impact initial sinking velocity and colonies remained afloat in the chamber. Above this threshold, sinking velocity increased linearly with the colony dust load at a slope matching prediction based on Stoke's law. The potential toxicity of dust was assessed with regards to metal dissolution kinetics, differentiating between rapidly released metals, which may impact surface blooms, and gradually released metals that may impact dust-centering colonies. Incubations with increasing dust concentrations revealed colony death, but the observed lethal dose far exceeded dust concentrations measured in coastal and open ocean systems. Removal of toxic particles as a mechanism to reduce toxicity was explored using SEM-EDX imaging of colonies incubated with Cu-minerals, yet observations did not support this pathway. Combining our current and former experiments, we suggest that in natural settings the nutritional benefits gained by Trichodesmium via dust collection outweigh the risks of buoyancy loss and toxicity. Our data and concepts feed into the growing recognition of the significance of dust for Trichodesmium's ecology and subsequently to ocean productivity.



Figure IS-3: Compilation of dust dissolution experiments conducted in seawater using different dust samples and concentrations. The data set combines new measurements (circles) and published data from Mackey et al. (2015) and includes seven dust samples plotted as different symbols. Metal

release kinetics is presented by two categories - rapidly released metals (black, up to 6 hr) and gradually released metals (red, up to 7 days). Regression slopes linking dust and dissolved metal concentrations are plotted and summarized in the table next to the graph.

<u>Reference:</u> Wang, S., Zhang, F., Koedooder, C., Qafoku, O., Basu, S., Krisch, S., Visser, A.N., Eichner, M., Kessler, N., Boiteau, R.M. and Gledhill, M., 2024. Costs of dust collection by Trichodesmium: effect on buoyancy and toxic metal release. *Journal of Geophysical Research: Biogeosciences*, *129*(4), p.e2023JG007954

GEOTRACES or GEOTRACES relevant cruises

- The National Monitoring Program (NMP) for the Gulf of Eilat/Aqaba operates out of the IUI (http://www.iui-eilat.ac.il/Research/NMPAbout.aspx). Activities include monthly cruises across the north Gulf of Eilat/Aqaba, during which physical, chemical and biological measurements are performed in depth profiles (at a water depth of 700 meters) together with spatial-surface coverage. The main-relevant parameters monitored are: Temperature, salinity, dissolved oxygen, pH, alkalinity, POC, NO₂, NO₃, Si(OH)₄, PO₄, Chl-a. The samples are collected with the IUI Research Vessel, which has a powder coated aluminium Rosette (SeaBird) with 12 niskin bottles (12 liters each), and a CTD (SeaBird electronics). These measurements have been performed continuously since the year 2000.
- The National Monitoring Program of Israel's Mediterranean waters –Hydrographic and sedimentological cruises on board R.V. Bat Galim along E-W transects across the Israeli Mediterranean EEZ (Water – bi-annual (nutrients, alkalinity, pH, DO, Chl-a, pico-phytoplancton, PP, BP); Sediments – annual).
- Marine particulate fluxes, dust and dissolved seawater compositions are studied in the oligotrophic Gulf of Aqaba (GOA), northern Red Sea as part of the *Red Sea Dust*, *Marine Particulates and Seawater Time Series* (*REDMAST*, *GIpr09*). This includes a continuously deployed bottom tethered mooring mounted with sediment traps (e.g., Torfstein et al., 2020).
- Focused field campaigns:
 - Research cruise M197 (RV METEOR) sailed during January-February 2024 from Cyprus to Italy, with the aim of investigating the seawater and sediment biogeochemistry in the eastern Mediterranean Sea. The two specific foci of the research cruise were to (i) investigate the physical, chemical and biological factors regulating the productivity and sinking carbon flux in this region, and (ii) investigate natural and human induced changes in the region over the last few thousands of years. This cruise was led by GEMOAR scientists, with the University of Haifa and Israel Oceanography and Limnology Research institute as participating institutions.
 - Eastern Mediterranean Sea transect. Quantification of dissolved and particulate fluxes (²³⁴Th, POC, DNA, trace metal concentrations of particulate matter).
 January 2024, Yishai Weinstein (BIU) in collaboration with Adi Torfstein (HUJI).
 - Daily timescale variability in particulate trace element concentrations in the Gulf

of Aqaba, 2023, Aden Clarfield (MSc student, advised by Adi Torfstein; HUJI). See figure below:

Figure IS-4: Particulate trace element concentrations in the Gulf of Aqaba, northern Red Sea, 2023 Clarfield & Torfstein, unpublished). The left panel displays the particulate Co and Cd concentrations, where each color represents a different profile and corresponds to the transmissometer attenuation data in the right panel. Note the clear differences between shallow and deep waters, and the compositional range between upper crust and typical



local seawater compositions. This project is in progress.

New projects and/or funding

- Eyal Rahav and Barak Herut (IOLR), Assessing the survival and diversity of airborne bacteria in response to different anthropogenic and natural aerosols upon interaction with seawater, Israel Science Foundation (2022-2026)
- Yeala Shaked and Dani Mandler (HUJI), Iron Oxide Nanoparticles Detection and Effect on Microorganisms, Hebrew University Center for Sustainability (2023-2024)

GEOTRACES workshops and meetings organized

• The Israel Association of Aquatic Sciences (IAAS) annual meeting (2023) included GEOTRACES relevant talks on trace metal concentrations, fluxes and availability in open ocean and coastal environments. The IAAS president is Yeala Shaked.

Other GEOTRACES activities

- Yeala Shaked served as an active associate member of the SCOR working group: PRIMO - Physiology and Rates of Microbial Oceanography. This working group involves Geotraces (and biogeotraces) people and is part of the new program Biogeoscapes.
- Yeala Shaked served as an active associate member of the SCOR working group: RUSTED – Reducing Uncertainty in Soluble aerosol Trace Element Deposition. Joined meetings and special session in ASLO 2023 and online meetings

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

- Alkalay, R., Weinstein, Y., Herut, B., Ozer, T., Zlatkin, O., Bar, T., Berman-Frank, I. and Katz, T., 2024. Temporal pattern and profile of a coastal-deep sea conveyor at a marginal deep oligotrophic sea. Journal of Geophysical Research: Oceans, 129(6), p.e2023JC020441.
- Benaltabet, T., Lapid, G. and Torfstein, A., 2023. Response of dissolved trace metals to dust storms, sediment resuspension, and flash floods in oligotrophic oceans. Global Biogeochemical Cycles, 37(10), p.e2023GB007858.
- Eichner, M., Inomura, K., Karlusich, J.J.P. and Shaked, Y., 2023. Better together? Lessons on sociality from Trichodesmium. Trends in Microbiology, 31(10), pp.1072-1084.
- Sisma-Ventura, G., Silverman, J., Segal, Y., Hauzer, H., Khadra, M.A., Stern, N., Guy-Haim, T. and Herut, B., 2024. Exceptionally high levels of total mercury in deep-sea sharks of the Southeastern Mediterranean sea over the last~ 40 years. Environment International, 187, p.108661.
- Haim, N., Grigorieva, V., Soffer, R., Mayzel, B., Katz, T., Alkalay, R., Biton, E., Lazar, A., Gildor, H., Berman-Frank, I. and Weinstein, Y., 2024. Multiyear surface wave dataset from the subsurface "DeepLev" eastern Levantine moored station. Earth System Science Data, 16(6), pp.2659-2668.
- Herut, B., Goldman, R., Ozer, T., Lazar, A., Biton, E., Gertman, I., Silverman, J., Segal, Y., Sisma-Ventura, G., Gertner, Y. and Rubin-Blum, M., 2024. Tar pollution event (2021) at the Southeastern Levantine oligotrophic basin, short-term impacts and operational oceanography perspectives. Marine Pollution Bulletin, 198, p.115892.
- Herut, B., Guy-Haim, T., Almogi-Labin, A., Fischer, H.W., Ransby, D., Sandler, A., Katz, T. and Avnaim-Katav, S., 2023. Marine oligotrophication due to fine sediments and nutrient starvation caused by anthropogenic sediment and water retention in large rivers: the Nile damming case. Frontiers in Marine Science, 10, p.1226379.
- Katz, T., Bookman, R., Herut, B., Goodman-Tchernov, B. and Sisma-Ventura, G., 2024. Far-field effects of the Nile damming on the silica cycle in the Southeastern Mediterranean Sea. Science of The Total Environment, 921, p.171274.
- Levy, N., Torfstein, A., Schiebel, R., Chernihovsky, N., Jochum, K.P., Weis, U., Stoll, B. and Haug, G.H., 2023. Temperature calibration of elevated Mg/Ca in planktic Foraminifera shells from the hypersaline Gulf of Aqaba. Geochemistry, Geophysics, Geosystems, 24(7), p.e2022GC010742.
- Rahav, E., Herut, B. and Paytan, A., Blowing in the wind: The hitchhiker guide to microbial transport in the atmosphere. Frontiers for Young Minds. 11, p. 1172757.
- Rubin-Blum, M., Makovsky, Y., Rahav, E., Belkin, N., Antler, G., Sisma-Ventura, G. and Herut, B., 2024. Active microbial communities facilitate carbon turnover in brine pools found in the deep Southeastern Mediterranean Sea. Marine Environmental Research, 198, p.106497.

- Shaked, Y., de Beer, D., Wang, S., Zhang, F., Visser, A.N., Eichner, M. and Basu, S., 2023. Co-acquisition of mineral-bound iron and phosphorus by natural Trichodesmium colonies. Limnology and Oceanography, 68(5), pp.1064-1077.
- Sisma-Ventura, G., Silverman, J., Guy-Haim, T., Stern, N., Shachnai, A., Mori, M.M., Khadra, M.A., Jacobson, Y., Segal, Y., Katz, T. and Herut, B., 2024. Accumulation of total mercury in deep-sea sediments and biota across a bathymetric gradient in the Southeastern Mediterranean Sea. Chemosphere, 351, p.141201.
- Velasquez, X., Morov, A.R., Astrahan, P., Tchernov, D., Meron, D., Almeda, R., Rubin-Blum, M., Rahav, E. and Guy-Haim, T., 2024. Bioconcentration and lethal effects of gas-condensate and crude oil on nearshore copepod assemblages. Marine Pollution Bulletin, 203, p.116402.
- Wang, S., Zhang, F., Koedooder, C., Qafoku, O., Basu, S., Krisch, S., Visser, A.N., Eichner, M., Kessler, N., Boiteau, R.M. and Gledhill, M., 2024. Costs of dust collection by Trichodesmium: effect on buoyancy and toxic metal release. Journal of Geophysical Research: Biogeosciences, 129(4), p.e2023JG007954.
- Whitby, H., Park, J., Shaked, Y., Boiteau, R.M., Buck, K.N. and Bundy, R.M., 2024. New insights into the organic complexation of bioactive trace metals in the global ocean from the GEOTRACES era. Oceanography, 37(2), pp.142-155.

Completed GEOTRACES PhD or Master theses

- Tal Benaltabet, PhD, 2016 2023, "Dissovled trace metal and Pb isotope dynamics in response to dust storms in the Gulf of Aqaba, northern Red Sea", advisor: Adi Torfstein (HUJI)
- Siyuan Wang, PhD, 2023, "Iron and Phosphorus-utilization from Dust by Natural Trichodesmium Colonies in the Gulf of Aqaba", advisor: Yeala Shaked (HUJI)

GEOTRACES presentations in international conferences

- Benaltabet T., Lapid G., Alkalay R., Weinstein Y., Steffens T., Achterberg E.P. and Torfstein A. (2023) Dissolved trace metals, rare earth elements and Pb isotopes in the eastern Mediterranean Sea. Goldschmidt meeting, Lyon, France
- Edvardson G., Torfstein A., Subhas A., Wang A., Titmuss F.D., Morkeski K. and Wurgaft E. (2023) Heterogeneous reactions and their effect on dissolved inorganic carbon and total alkalinity. Gordon Research Conference on Chemical Oceanography, USA
- Edvardson G., Torfstein A., Wang A., Titmuss F.D., Lazar B., Churchill J., Morkeski K. and Wurgaft E. (2023) Heterogeneous reactions and their effect on dissolved inorganic carbon and total alkalinity. Israel Geological Society Annual Meeting
- Levy N., Torfstein A., Schiebel R., Chernihovsky N., Jochum K.P., Weis U., Stoll B., and Haug G.H. (2024) Inter-chamber elemental ratio variability in two planktic

Foraminifera species from the Gulf of Eilat: Globigerinoides ruber albus and Turborotalita clarkei. Israel Geological Society Annual Meeting.

- Shaked Y., Koedooder C., Zhang F., Wang S., Glendhill M., Eichner M., de Beer D., Boiteau R., Visser A.N., Kessler N. and Basu S. (2023) Reclaiming the "Bio" Term for Aerosol Iron Bioavailability. ASLO meeting, Palma de Mallorca, Spain
- Shaked Y., Jacobson Y., de Beer D., Wang S., Zhang F., Visser A.N., Eichner M., Morag N., Angert A. and Basu S. (2023) Acquisition of Fe and P from Natural and Anthropogenic Aerosols by Marine Phytoplankton. Goldschmidt meeting, Lyon, France
- Torfstein A., Benaltabet T. and Lapid G. (2023) Long- and short- term interplay between dissolved and particulate trace elements: insights from the Red Sea dust, marine particles and seawater timeseries (REDMAST). Goldschmidt meeting, Lyon, France (Invited talk)

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN JAPAN

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

Ueki et al. (2024) reported the distributions of zirconium (Zr), hafnium (Hf), and niobium (Nb) in the Indian Ocean (Japanese GEOTRACES cruise by R/V *Hakuho-maru*, GI04). They discussed the results considering the distributions of silicon (Si), aluminum (Al) and neodymium isotope composition. The concentrations of dZr and dHf in the deep waters of the Indian Ocean were higher than those in the North Pacific Ocean, which is different from nutrients like Si. The surface dZr and dHf distributions were strongly affected by lithogenic inputs. This feature is similar to that of dAl, a good tracer for lithogenic supplies. In deeper layer (<1400 m), the dZr/dHf ratio increased northward, which suggests the preferential removal of dHf over dZr along the water mass age together with the strong lithogenic supply in the Indian Ocean. The authors proposed that dissolved Zr/Hf molar ratio is promising as a tracer for global ocean circulation in the Indian and Pacific Oceans.

<u>Reference:</u> Ueki, R., L. Zheng, S. Takano, and Y. Sohrin, 2024. Distributions of zirconium, hafnium, and niobium in the Indian Ocean: Influence of lithogenic sources on incompatible elements. Marine Chemistry, 260, 104365. doi: <u>https://doi.org/10.1016/j.marchem.2024.104365</u>

GEOTRACES workshops and meetings organized

- The domestic session entitled "Marine Geochemistry" related to GEOTRACES studies was held during the annual meeting of Geochemical Society of Japan 2023 (September 21 – 23, in person at Tokyo University of Marine Science and Technology). We had 14 oral and 11 poster presentations.
- The domestic session entitled "Biogeochemical cycles of trace elements, isotopes, and radionuclides" related to GEOTRACES studies was held during the fall meeting of The Oceanographic Society of Japan (September 25 – 27, 2023, in person at Kyoto University). We had 10 oral and 4 poster presentations.

Outreach activities conducted

- A special issue was published in the Japanese journal "Chikyukagaku" by the Geochemical Society of Japan (Editorial committee: Hajime Obata, Yoshiko Kondo, Keiji Horikawa, Shotaro Takano, Kazuya Tanaka). 13 review articles (Main text was written in Japanese, Free access) were published.
 - Obata, H. et al. "Findings on marine geochemistry of trace elements and their isotopes: recent achievements by GEOTRACES project"
 - Nishioka, J. et al. "Building a GEOTRACES global dataset of trace elements and isotopes in the ocean"
 - Kumamoto, Y. "Radiocarbon as a tracer for ocean circulation"

- Horikawa, K. "Studies of past ocean circulation based on neodymium isotope analysis"
- Takano, S. "Isotopic distributions of iron, nickel, copper, zinc, and cadmium in the ocean and their analytical methods"
- Sakata, K. et al. "Relationships of emission sources and atmospheric processes of aerosol Fe with its solubility"
- Kanna, N. "Dynamics of trace metals in the Antarctic ice sheet, glaciers and sea ice"
- Mashio, A. S. et al. "Present status and next issues of platinum group elements studies in seawater"
- Marumoto, K. et al. "Distribution and fate of mercury in the ocean"
- Tada, Y. "Microorganisms involved in the mercury transformations in the ocean"
- Kondo, Y. "Dynamics of vitamin B12 and its importance in the ecosystem in the ocean"
- Misumi, K. et al. "Modelling of marine iron cycle"
- Kobayashi, H. "Modelling the ocean carbon cycle during glacial periods"

Cruise

 Two GEOTRACES section cruises (GP22), KH-22-7 (30 June - 1 September 2022) and KH-23-2 cruise (1 - 25 June 2023), were conducted by using R/V Hakuho-Maru (PI: Hajime Obata). During these cruises, we collected clean seawater samples for trace element analyses in the western Pacific.

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

During the past year, Japan GEOTRACES investigators published a total of 20 peerreviewed journal articles.

- Alam, M., T. Muguli, G. P. Gurumurthy, M. Arif, Y. Sohrin, A. D. Singh, T. Radhakrishna, D. K. Pandey, and K. Verma, 2023. Hydroclimatic conditions and sediment provenance in the northeastern Arabian Sea since the late Miocene: insights from geochemical and environmental magnetic records at IODP Site U1457 of the Laxmi Basin. Geological Magazine 2023, 160 (4), 813-829. doi: 10.1017/S0016756822001273 From Cambridge University Press Cambridge Core.
- Chan, C.-Y., L. Zheng, and Y. Sohrin, 2024. The behavior of aluminium, manganese, iron, cobalt, and lead in the subarctic Pacific Ocean: boundary scavenging and temporal changes. Journal of Oceanography, 80 (2), 99-115. doi: 10.1007/s10872-023-00710-8.
- Fukazawa, T., H. Obata, S. Matsuoka, S. Usui and K. Norisuye, 2024. Determination
 of ultra-trace Te species in open ocean waters based on Mg(OH)2 coprecipitation,
 anion exchange resin column separation and inductively coupled plasma sector-field
 mass spectrometry using a 125Te-enriched isotope spike. Analytica Chimica Acta,
 1300, 342430: doi.org/10.1016/j.aca.2024.342430.

- Hamilton, D. S., A. R. Baker, Y. Iwamoto, S. Gassó, E. Bergas-Masso, S. Deutch, J. Dinasquet, Y. Kondo, J. Llort, S. Myriokefalitakis, M. M. G. Perron, A. Wegmann, J.-E. Yoon, 2023. An aerosol odyssey: Navigating nutrient flux changes to marine ecosystems. Elem Sci Anth 11(1), 00037. https://doi.org/10.1525/elementa.2023.00037
- Ikhsani, I. Y., K. H. Wong, T. J. Kim, A. Mashio and H. Obata, 2024. Biogeochemistry of dissolved trace metals in the Bay of Bengal. Marine Chemistry, 260, 104394. doi.org/10.1016/j.marchem.2024.104394.
- Kong X., J. Zhang, Y. Li, S. Otsuka, Q. Liu, and Q. He, 2023. Selenium in the liver facilitates the biodilution of mercury in the muscle of Planiliza haematocheilus in the Jiaozhou Bay, China. Ecotoxicology and Environmental Safety. doi: 10.1016/j.ecoenv.2023.114981.
- Kondo, Y., N. Takahashi, T. Takatani, T. Suzuki, M. Wada, S. Takeda, and S. A. Sañudo- Wilhelmy, 2024. Temporal variation in vitamin B12 concentration and their impact on phytoplankton composition of surface waters of a coastal ocean off Japan (Ariake Sea). Journal of Oceanography, 80, 117-128. https://doi.org/10.1007/s10872-023-00711-7.
- Matsuoka, K., T. Tatsuyama, S. Takano, and Y. Sohrin, 2023. Distribution of stable isotopes of Mo and W from a river to the ocean: signatures of anthropogenic pollution. Frontiers in Marine Science, 10, Original Research. doi: 10.3389/fmars.2023.1182668.
- Obata, H., A. Mase, N. Kanna, S. Takeda, J. Nishioka and K. Kuma, 2024. Dissolved Fe(II) and its oxidation rates in Kuroshio area, subarctic Pacific and Bering Sea. Geochemical Journal, 58, 71–79. doi.org/10.2343/geochemj.GJ24006.
- Sieber, M., N. T. Lanning, X. Bian, S. C. Yang, S. Takano, Y. Sohrin, T. S. Weber, J. N. Fitzsimmons, S. G. John, and T. M. Conway, 2023. The Importance of Reversible Scavenging for the Marine Zn Cycle Evidenced by the Distribution of Zinc and Its Isotopes in the Pacific Ocean. Journal of Geophysical Research: Oceans, 128 (4), e2022JC019419. https://doi.org/10.1029/2022JC019419. doi: 10.1029/2022JC019419.
- Takano, S., H. Kanamura, and Y. Sohrin, 2024. Multielemental isotopic analysis for trace metals in geochemical samples, part 1: dissolved iron, nickel, copper, zinc, cadmium, and lead in seawater. ACS Earth and Space Chemistry, 8 (4), 702-711. doi: 10.1021/acsearthspacechem.3c00305.
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- Teresa Nakajima, M., N. Takahata, H. Obata, T. Kagoshima, and Y. Sano, 2024. An easier approach for helium isotope flux estimation in a submerged caldera. Geochemical Journal, 58, 2, 46-50.

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- Yamada, M., A. Suzuki, and N. Iwasaki, 2023. Growth rate estimation by 210Pb chronology in precious corals collected off the southern coast of Japan. Frontiers in Marine Science, 10, 1091594. doi:10.3389/fmars.2023.1091594.
- Zhu, S. J., J. Zhang, T. Matsuno, E. Tsutsumi, S. Kambayashi, K. Horikawa, K. Takayama, M. Inoue, and S. Nagao, 2023. Quantifying the water contribution of subtropical mode water and related isopycnal/diapycnal water mixing in the western Pacific boundary current area using radiocesium: A significant nutrient contribution from subtropical Pacific gyre to the marginal region. Journal of Geophysical Research: Oceans, 128, 4, doi: 10.1029/2022JC018975.

Completed GEOTRACES PhD or Master theses

- Ryuta Ueki (2024), Marine geochemistry of zirconium, niobium, hafnium, and tantalum in the subarctic North Pacific and Indian Oceans. PhD (Sci), Kyoto University
- Zhu Siteng (2024), Quantifying ocean mixing in the North Pacific and adjacent marginal seas using multiple chemical tracers. PhD (Sci), University of Toyama
- C. Rojubally (2024), Sectional distribution and source contribution of lead (Pb) isotopes in the eastern Indian Ocean. M.S. (Sci), Niigata University
- Kodai Shimizu (2024), Sectional distributions of suspended particulate trace elements in the western North Pacific in relation to sea region characteristics. M. S. (Sci), Niigata University

- Koki Marui (2024), The distributions and behavior of platinum in the aquatic environment. M. S. (Engineering), Kanazawa University
- Tetsuhiro Ueno (2024), Establishment of an analytical method for precious metals in hydrothermal fluid using dithiocarbamate-modified cellulose resin. M. S. (Engineering), Kanazawa University
- Yuki Sakashita (2024), Establishment of analytical method of palladium in marine sediments using isotope dilution-inductively coupled plasma mass spectrometry. M. S. (Engineering), Kanazawa University

GEOTRACES presentations in international conferences

- Chan, C.-Y., L. Zheng, and Y. Sohrin, 2023. Factors affecting the supply and scavenging of trace metals in the subarctic North Pacific Ocean. In Goldschmidt2023, Lyon, France, July, 2023.
- Deng, H., K. Suzuki, I. Yasuda, H. Ogawa, and J. Nishioka, 2024. Phytoplankton responses to iron and macronutrient fluxes from subsurface waters in the western North Pacific. Ocean Sciences Meeting, New Orleans, USA, February 2024.
- Fukazawa, T., H. Obata, and K. Norisuye, 2023. Distribution of Te species in the eastern Indian Ocean. Goldschmidt Conference, Lyon, France, July 2023.
- Fukazawa, T., H. Obata, and K. Norisuye, 2024. Distributions of dissolved Te(IV) and Te(VI) in the eastern Indian Ocean. Ocean Sciences Meeting, New Orleans, USA, February 2024.
- Norisuye, K., Y. Hayashi, H. Obata, T. Gamo, H. Minami, and Y. Nakaguchi, 2023. The sectional distributions of several particulate trace elements in the western South Pacific. Goldschmidt Conference, Lyon, France, July 2023.
- Norisuye, K., H. Kuriyama, S. Kakuta, and H. Obata, 2024. Distributions of dissolved bismuth and lead isotope ratios in the East China Sea and adjacent waters. Ocean Sciences Meeting, New Orleans, USA, February 2024.
- Obata, H. Wiwit, K. H. Wong, C.-J. Lu, H. Fukuda, H. Ogawa, K. Takahashi, A. S. Mashio, and S. Takeda, 2024. Effect of copper-binding organic ligands on phytoplankton growth in Japanese coastal waters, Ocean Sciences Meeting, New Orleans, USA, February 2024.
- Rojubally. C., J. A. Sheba, T. Fukazawa, H. Obata, K. Okamura, K. Nagaishi, T. Ishikawa, and K. Norisuye, 2023. The distribution and origins of Pb isotopes in the Northeast Indian Ocean. Goldschmidt Conference, Lyon, France, July 2023.
- Shimizu, K., T. Fukazawa, H. Obata, J. Nishioka, H. Minami, Y. Nakaguchi, and K. Norisuye, 2024. North-south longitudinal distributions of suspended particulate trace elements in the western North Pacific. Ocean Sciences Meeting, New Orleans, USA, February 2024.

- Toyoshima, E., H. Obata, N. Kanna, and H. Ogawa, 2023. Distributions and biogeochemical cycles of dissolved Mn, Fe, Cu, Zn and Pb in the eastern South Pacific, 17th International Symposium on Water-Rock Interaction and the 14th International Symposium on Applied Isotope Geochemistry, Sendai, Japan, August 2023.
- Ueki, R., L. Zheng, S. Takano, and Y. Sohrin, 2023. Distribution of zirconium, niobium, hafnium, and tantalum in the subarctic North Pacific Ocean and the Indian Ocean. In Goldschmidt2023, Lyon, France, July 2023.
- Zheng, L., T. Minami, C.-Y. Chan, S. Takano, and Y. Sohrin, 2023. Basin-scale distributions of 9 trace metals (Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb) in the entire Pacific Ocean. In Goldschmidt 2023, Lyon, France, July 2023.

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN MEXICO

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES-relevant publications

- Avendaño, K.A., Ponce-Jahen, S.J., Valenzuela, E.I., Pajares, S., Samperio-Ramos, G., Camacho-Ibar, V.F., Cervantes, F.J. 2024. Nitrogen loss in coastal sediments driven by anaerobic ammonium oxidation coupled to microbial reduction of Mn(IV)-oxide. Science of the Total Environment, 923. https://doi.org/10.1016/j.scitotenv.2024.171368.
- Contreras-Pacheco, Y.V., Herzka, S.Z., Vallejo-Espinosa G., Herguera J.C. 2023. Particulate organic carbon in the deep-water region of the Gulf of Mexico. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1095212.
- Díaz-Asencio, M., Herguera, J.C., García Romero, F., Rafter, P., 2023. Sediment accumulation rates and carbonate fluxes of deep-sea sediments in the southern Gulf of Mexico. Marine Geology, 464. https://doi.org/10.1016/j.margeo.2023.107131.
- Frías-Espericueta, M.G., Sánchez-Betancourt, A., Ruelas-Inzunza, J. Escobar-Sánchez, O., Osuna-Martínez, C.C., Aguilar-Juárez, M.A., Soto-Jiménez, M.F., Valenzuela-Quiñonez, F.V., Nieves-Soto, M., Bojórquez-Sánchez, Delgado-Alvarez, C.G. 2023. Total Mercury and Selenium in wild Shrimp from Coastal Lagoons of Northwest Mexico: Human Health risk Assessment. Bulletin of Environmental Contamination and Toxicology 110, 42. https://doi.org/10.1007/s00128-022-03683-4.
- Garcia-Orozco, J., Huerta-Diaz, M.A., Otero, X.L., Mejia-Piña, K.G., Valdivieso-Ojeda, J.A., Gregory, D.D., Díaz-de-Alba, M., Arenas-Islas, D., Cervantes-Flores, R. 2023. Reactive vanadium and iron fluxes in different modern sedimentary environments. Geochimica et Cosmochimica Acta, 356. https://doi.org/10.1016/j.gca.2023.07.006.
- Hernández-Sánchez, O.G., Camacho-Ibar, V.F., Barbero L., Herguera J.C., Herzka S.Z. 2023. A gulf-wide synoptic isoscape of zooplankton isotope ratios reveals the importance of nitrogen fixation in supporting secondary production in the central Gulf of Mexico. Frontiers in Marine Science, 9. https://doi.org/10.3389/fmars.2022.1025387.
- Mejia-Piña, K.G., Valdivieso-Ojeda, J.A., Huerta-Diaz, M.A., Chavez-Jimenez, M., Otero, X.L., Fernández-Díaz, V.Z., Arreguín-Rodríguez, G.J., 2023. Geochemical footprint of dredged material discharges and sediment health status in Todos Santos Bay, Mexico. Regional Studies in Marine Science, 62. https://doi.org/10.1016/j.rsma.2023.102962.
- Millán-Núñez, E., Delgadillo-Hinojosa, F., Hakspiel-Segura, C., Torres-Delgado, E.V., Félix-Bermúdez, A., Segovia-Zavala, J.A., Camacho-Ibar, V.F., Muñoz-Barbosa, A. 2023. Phytoplankton composition and biomass under oligotrophic conditions in the Guaymas Basin (Gulf of California) Composición y biomasa fitoplanctónica bajo condiciones oligotróficas en la cuenca de Guaymas (Golfo de California). Ciencias Marinas, 49, e3302. https://doi.org/10.7773/cm.y2023.3302.

- Ontiveros-Cuadras, J.F., Ruiz-Fernández, A.C., Cardoso-Mohedano, J.G., Pérez-Bernal, L.H., Santiago-Pérez, S., Velázquez-Reyes, D.A., Cisneros-Ramos, Z.J., Crisanto-Ruiz, A.S., Gómez-Ponce, M.A., Flores-Trujillo, J.G., Sanchez-Cabeza, J.-A., 2024. Potentially toxic elements fluxes in 210Pb-dated sediment cores from a large coastal lagoon (southern Gulf of Mexico) under environmental stress. Marine Pollution Bulletin, 201. https://doi.org/10.1016/j.marpolbul.2024.116226.
- Rechimont, M.E., Ruelas-Inzunza, J., Amezcua, F., Páez-Osuna, F., Castillo-Géniz, J.L. 2024. Hg and Se in muscle and liver of blue shark (Prionace glauca) from the entrance of the Gulf of California: An insight to the potential risk to human health. Archives of Environmental Contamination and Toxicology, 86, 165-177. https://doi.org/10.1007/s00244-024-01054-0.
- Rodríguez-Pérez, M.Y., Sánchez-Velasco, L., Ruvalcaba-Aroche, E.D., Beier, E., Tenorio-Fernandez, L. 2024. δ13C and δ15N zooplankton isoscapes as trace of water masses and mesoscale activity in the Pacific Tropical-Subtropical Convergence off Mexico during June 2010. Science of The Total Environment, 909. https://doi.org/10.1016/j.scitotenv.2023.168497.
- Samperio-Ramos, G., Hernández-Sánchez, O., Camacho-Ibar, V.F., Pajares, S., Gutiérrez, A., Sandoval-Gil, J.M., Reyes, M., De Gyves, S., Balint, S., Oczkowski, A., Ponce-Jahen, S.J., Cervantes, F.J. 2024. Ammonium loss microbiologically mediated by Fe(III) and Mn(IV) reduction along a coastal lagoon system. Chemosphere, 349. https://doi.org/10.1016/j.chemosphere.2023.140933.
- Uc-Peraza, G.R., Gutiérrez-Galindo, E.A., Delgado-Blas, V.H. et al. 2024. Trace metals in the mussel Mytilus californianus from the West Coast of Baja California, Mexico. Bulletin of Environmental and Contamination Toxicology, 112, 38. https://doi.org/10.1007/s00128-024-03862-5.
- Whitehead, D.A., Gayford, J.H., Pancaldi, F., Gobbato, J., Boldrin, G., Tringali, M., Ketchum, J.T., Galvan Magaña, F., Seveso, D., Montano, S. 2024. Heavy metal and trace element concentrations in the blood of scalloped hammerhead sharks (Sphyrna lewini) from La Paz Bay, México. Marine Pollution Bulletin, 201. https://doi.org/10.1016/j.marpolbul.2024.116155.

New GEOTRACES or GEOTRACES-relevant Books

 Olascoaga, M.J., Herzka, S.Z., Aguirre-Macedo, M.L., Delgadillo-Hinojosa, F., Eds. (2023). Novel insights into the circulation, biogeochemistry, and ecosystem function of the Gulf of Mexico: A perspective from Mexican waters in support of oil spill preparedness. Lausanne: Frontiers Media SA. https://doi.org/10.3389/978-2-8325-4028-2

Submitted by Maria Lucila Lares (<u>llares@cicese.mx</u>).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN THE NETHERLANDS

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

- Submitted to GEOTRACES portal: total dissolvable Fe and Mn and dissolved Fe and Mn data from cruises PE401 (Black Sea) and PE411 (Baltic See) with associated intercalibration report. The data and calibration report are currently undergoing internal checking within the GEOTRACES DOOR portal. Associated publications:
 - Lenstra et al. 2019. The shelf-to-basin iron shuttle in the Black Sea revisited. Chemical Geology, 511, 314–341. doi: 10.1016/j.chemgeo.2018.10.024
 - Lenstra et al. 2020 Controls on the shuttling of manganese over the northwestern Black Sea shelf and its fate in the euxinic deep basin. Geochimica et Cosmochimica Acta, 273, 177–204. doi: <u>https://doi.org/10.1016/j.gca.2020.01.031</u>
 - Lenstra et al. 2020 Coastal hypoxia and eutrophication as key controls on benthic release and water column dynamics of iron and manganese. Limnology and Oceanography, 66, 807–826. <u>doi: 10.1002/lno.11644</u>,

GEOTRACES or GEOTRACES relevant cruises

- EASI-2 (PS140), GIpr12. GEOTRACES process aboard RV Polarstern expedition to the Southern Ocean from Cape Town (South Africa), 28/11/2023, Hobart (Australia), 31/01/2024. Completed.
- CDeepSea Cruise Leg 2 (ship: G.O. Sars (University of Bergen); Longyearbyen Longyearbyen; 8-7-2024 - 12-7-2024) – Scheduled.

New projects and/or funding

• NWO Veni project (280.000 euro) titled: Continental margin sediments as a source of bio-essential iron and manganese to high-latitude waters

Outreach activities conducted

• Presentation about upcoming GEOTRACES fieldwork campaigns at the Radboud University: Dynamics of iron and manganese in polar regions (11-3-2024)

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

• Middag, R., Zitoun, R. and Conway, T.M., 2023. Trace Metals. In: J. Blasco and A. Tovar-Sanchez (Editors), Marine Analytical Chemistry. Springer, Cham, Switzerland. https://doi.org/10.1007/978-3-031-14486-8_3

- Tian, H.-A., van Manen, M., Bunnell, Z.B., Jung, J., Lee, S.H., Kim, T.-W., Reichart, G.-J., Conway, T.M. and Middag, R., 2023. Biogeochemistry of iron in coastal Antarctica: isotopic insights for external sources and biological uptake in the Amundsen Sea polynyas. Geochimica et Cosmochimica Acta, 363: 51-67, https://doi.org/10.1016/j.gca.2023.10.029
- Conway, T., Fitzsimmons, J., Middag, R., Noble, T. and Planquette, H., 2024a. Introduction to the special issue on twenty years of GEOTRACES: An international study of the marine biogeochemical cycles of trace elements and isotopes. Oceanography, 37(2): 6-7.
- Conway, T., Middag, R. and Schlitzer, R., 2024b. GEOTRACES: Ironing out the details of the oceanic iron sources. Oceanography, 37(2).

Completed GEOTRACES PhD or Master theses

• Tian, H.-A., 2024. Sources and biogeochemistry of bio-active trace metals in the Southern Ocean and coastal Antarctica; perspectives from their isotopes. PhD completed 15 March 2024.

GEOTRACES presentations in international conferences

- Middag, R., Tian, H.-A., 2024. Trace metals in the Southen Ocean. Invited keynote oral presentation at the NL polar day, 23 April, 2024, The Hague, Netherlands.
- Conway, T.M., Hunt, H.R., Sieber, M., Tian, H.-a., Summers, B.A., Lanning, N.T., Steffen, J.M., Homoky, W.B., Fitzsimmons, J.N. and Middag, R., 2024. The Fe isotope case for sediments as an important marine Fe source, 2024 Goldschmidt Conference. GOLDSCHMIDT.
- Eich, C., van Manen, M., McCain, J.S.P., Jabre, L.J., van de Poll, W.H., Jung, J., Pont, S.B., Tian, H.-A., Ardiningsih, I. and Reichart, G.-J., 2024. Temperature-enhanced effects of iron on Southern Ocean phytoplankton. EGUsphere, 2024: 1-45.
- Humphreys, M.P., Ádler, M.A., Temmerman, D., Middag, R. and Mienis, F., 2024. Carbon and nutrient exchange between the North Sea and Atlantic Ocean: the NoSE project, 2024 Ocean Sciences Meeting. AGU.
- Jabre, L., van Manen, M., Eich, C.U., van de Poll, W., Rowland, E., Brussaard, C.P., Middag, R. and Bertrand, E.M., 2024. Metaproteomic insights into elemental stoichiometry in a changing Southern Ocean, 2024 Ocean Sciences Meeting. AGU
- Tian, H.-A., van Manen, M., Bunnell, Z., Reichart, G.-J. Conway, T.M., and Middag, R., 2024. Isotopic Composition of Dissolved Fe in the Weddell Sea: Fate of Sedimentary Fe and Evidence for its Transport. Oral presentation at the Ocean Science Meeting 2024, New Orleans, USA, 18-23 February
- Olivelli, A., Paul, M., Xu, H., Rijkenberg, M.J.A., Middag, R., Henderson, G., Weiss, D.J., van de Flierdt, T. and Rehkämper, M. Lead isotopes as tracers of anthropogenic

pollution and oceanographic processes in the South Atlantic Ocean. Oral presentation at the Ocean Science Meeting 2024, New Orleans, USA, 18-23 February

- B. Rabe, M. Janout, Lars-Eric Heimbürger, Rob Middag, Ellen Damm, Sinhue Torres Valde, Kirstin Schulz. Does turbulence matter to vertical mass fluxes in the central Arctic Ocean? A case example from 2015. Poster presentation at the Ocean Science Meeting 2024, New Orleans, USA, 18-23 February.
- Middag, R., Liao, W.-H., Zitoun, R. and Laan, P., 2023. Distribution of dissolved Fe and Mn in the Atlantic-Arctic transition zone. Oral presentation at the Goldschmidt 2023 Conference, Lyon, France, 9-14 July.
- Tian, H.-A., van Manen, M., Bunnell, Z., Jung, J.Y., Kim, T.-W., Conway, T.M., Reichart, G.-J. and Middag, R., 2023. Isotopic insights for external iron sources and biogeochemical cycling in the Amundsen Sea Polynyas. Oral presentation at the Goldschmidt 2023 Conference, Lyon, France, 9-14 July.
- Xu, H., van de Flierdt, T., Rehkämper, M., Weiss, D., Moore, R.E. and Middag, R., 2023. Seawater Pb concentrations and isotope compositions in the western tropical North Atlantic (GEOTRACES cruise GA02,). poster presentation at the Goldschmidt 2023 Conference, Lyon, France, 9-14 July.
- Tissot, F.L., Kipp, M.A., Li, H., Ellwood, M.J., John, S.G., Middag, R. and Adkins, J.F., 2023. Reappraising the U isotope composition of seawater and deep-sea corals: Implications for paleo-environmental reconstructions. Oral presentation at the Goldschmidt 2023 Conference, Lyon, France, 9-14 July.
- Olivelli, A., Murphy, K., Bridgestock, L., Wilson, D.J., Rijkenberg, M., Middag, R., Weiss, D.J., van de Flierdt, T. and Rehkämper, M. Decline of anthropogenic lead in South Atlantic Ocean surface waters from 1990 to 2011: New constraints from concentration and isotope data. Oral presentation at the Goldschmidt 2023 Conference, Lyon, France, 9-14 July.

Submitted by Caroline Slomp (caroline.slomp@ru.nl).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN RUSSIA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

- Berezhnaya and Dubinin from Shirshov Institute of Oceanology, Russian Academy of Sciences (SIO RAS, Moscow, Russia) prepared the overview of the current state of Platinum Group Elements (PGEs) geochemistry in the ocean. The behavior of PGEs in the aquatic environment is determined by their oxidation state, the ability to change it, and complexation. The difference in chemical properties leads to PGEs fractionation in the ocean. This is their characteristic feature, along with their ultralow contents. The paper describes the sources of PGEs supply to the ocean, PGEs behavior in the river–sea mixing zone, and their distribution in seawater. The processes of PGE accumulation in sediments, seafloor sulfides, and ferromanganese deposits of the ocean are reviewed in the paper. Possible mechanisms of PGE accumulation on ferromanganese oxyhydroxides are discussed in [Berezhnaya, Dubinin, 2024].
- Migdisova and co-authors (SIO RAS) have published the first results of microprobe analyses of settling particles in the sediment system of the Lofoten Basin (Norwegian Sea). The settling material was collected using sediment traps deployed during a year. Trace element analyses showed that there is a significant barium enrichment of particles during the winter months. Scanning electron microscopy and microprobe elemental analysis of particles revealed several morphological types of authigenic barite [Migdisova et al., 2023]. Rectangular particles are closest to the crystalline form, while grains of more rounded shape show signs of dissolution primarily of the ribs and tops of crystals (Fig. RU-1). As the size of barite grains is less than 5 µm, their deposition at the bottom is only possible as part of aggregates and faecal pellets, which is not so common in winter time. At the same time, the maximum barium flux was recorded in summer during the period of intensive phytoplankton



blooming, which coincides with the maximum fluxes of organic and carbonate carbon. Thus, under wintertime conditions of low productivity and low particle flux, a substantial fraction of sediment is authigenic barite, which by all indications which apparently dissolves in water column before reaching seafloor.

Figure RU-1. Authigenic barite grains: group 1 - ellipsoid barite; group 2 - crystalline barite; group 3 - ellipsoid barite with signs of dissolution; group 4 - barite of rectangular shape "with whiskers".

 Demina and co-authors (2024) (SIO RAS) examined the distribution of TEs and organic carbon in the benthic mass taxa of cold methane seeps in the Laptev Sea and outside of them in the background area. The authors of the cited article focused on the bioaccumulation potential (BP), which was evaluated by taking into account in addition to the concentration of elements in organisms, their biomass. On the methane seeps, the ophiuroid population accumulates each element per square meter of seafloor up to 40 times greater than at the background station. Ophiuroids and bivalves exhibited elevated BP for Ni, As, Ba, Cu, Ti, V, Mn, and Zn compared to other elements (Fig. RU-2). At the same time, the BP of ophiuroids is significantly higher than that of bivalves. It is suggested that the increased bioaccumulation of some TEs is related to greater bioavailability of organic matter in the bottom sediments of methane seeps.



Figure RU-2. Comparison of the average concentrations of trace elements in whole bodies of detritus feeder Opriuroidea Ophiocten sericeum inhabited methane seep -15 (st. 5625 at the shelf) and referent areas (st. 5636 in the Vilkitsky strait and st. 5624 at the shelf).

Semkin and co-authors (2023) from Il'ichev Pacific Oceanological Institute (Vladivistok, Russia), investigated interaction of surface water and groundwater that is of great importance for the environment of coastal basins and affects hydrological conditions, oxygen regime, carbon and nutrient exchange. This study demonstrates a dynamic connection between the salt-wedge region and its underlying aquifer in the eutrophic estuary (Fig. RU-3). In winter, this estuary is covered with ice and the river flow is at its lowest; that is why specific response to groundwater discharge is best marked in this season. Groundwater admixture was detected in the salt-wedge region by highly active radium isotopes: 223Ra — 4.80 ± 0.42 dpm 100L-1, 224Ra admixture is accompanied by a lower level of oxygen concentration. In waters with a high activity of radium isotopes, there was a maximum partial pressure of CO2 and also observed extremum of NH4+, NO2-, and dissolved phosphorus. The surface water-groundwater interaction through anoxic sediment can form localized anaerobic areas despite the general oxygen-supersaturation of eutrophic estuary waters and also cause local recycling of nutrients from bottom sediments [Semkin et al., 2023].


Figure RU-3. Map of study area: (a) Sea of Japan, (b) The Peter the Great Bay, and (c) position of monitoring stations at Razdolnaya R. estuary.

The distributions (Fig. RU-4) of 228Ra and 226Ra concentrations and the values of their ratio for the upper mixed layer of the Black Sea waters were investigated [Kozlovskaia et al., 2023]. It has been found that these distributions were not homogeneous: the concentrations of 228Ra and 226Ra varied in a range from 17.2 to 172.2 dmp/m3 and from 38.0 to 270.1 dmp/m3, respectively, while their activity ratio ranged from 0.13 to 4.03. The spatial variability of 228Ra concentration showed a tendency to decrease from the deep-sea to the shelf, while 226Ra concentration field was more complex: relatively increased and decreased values were observed both in the coastal and deep-sea parts. It has been shown that the influence of submarine sources in the region under study was local and manifested by increasing the concentrations of these radionuclides by 1.5–2.3 times. The mesoscale eddies observed in the region of the Southern Coast of Crimea Peninsula influenced the spatial variability of the radium isotope concentration fields, resulting in local decrease or increase of their concentrations by 2.3–2.8 times. The propagation of the Sea of Azov waters in the Black Sea was traced by the 228Ra and 226Ra concentration fields from the Kerch Strait to the Gulf of Feodosia: the increased by 2.3-2.6 times values of the contents of both isotopes were observed. The concentration of both radium isotopes first increased and then decreased with distance from the coast in areas affected by river runoff.



Figure RU-4.

Concentrations of ²²⁸Ra (a) and ²²⁶Ra (b) and their ratio (c) in the Black Sea surface layer (dots show the sampling station locations, their color corresponds to the cruise number of the R/V Professor Vodyanitsky)

- The trace metal speciation in sediments from meromictic lakes with different stage of isolation from the White Sea have been studied by Budko and co-authors from Shirshov Institute of Oceanology RAS [Budko et al., 2023]. Despite the anoxic conditions in the sediments (Eh < 0 mV), the form of sulfides was not the predominant form for any of the metals, with an average of approximately a quarter of the total content for V, Cr, Fe, Mn, Co, Ni, Cu, and Zn. The distribution of Cu, Mo, and U in the sediments of the studied lakes is primarily influenced by organic matter. The significant proportion of forms associated with OM was identified for Cu (up to 76.5% of total content), which makes this metal a more reliable tracer of biogenic processes in the sediment of meromictic lakes than other metal. The progress of isolation water bodies from the sea results in the development of auxinic conditions, which in turn lead to a notable increase in the organic carbon, sulfur as well as Cu, Mo, Cd, and U contents in sediments.
- Dubinin and co-authors reported on the distribution of elemental sulfur and polysulfides in the upper part of the Black Sea anoxic water column on the continental shelf off the coast of the Caucasus and Crimea. Sulfur served as a proxy of reductive processes. Sulfur was sampled, filtered, and determined under strictly anoxic conditions in an argon atmosphere. The concentration of zero-valent sulfur (ZVS elemental sulfur together with polysulfides) increases with depth and along with sulfide concentration from 0.01 µmol/kg S at the redox interface to 0.67 µmol/kg at a depth of 600 m (Fig. RU-5). The elemental sulfur fraction in the composition of ZVS is 23 ± 5%. Based on thermodynamic data, calculation of the

polysulfides concentration in equilibrium with suspended sulfur shows that deeper than 20–25 m of the upper boundary of the anoxic zone, their concentration was higher than measured ZVS and at a depth of 600 m they differed about threefold (fig.2). The predominance of elemental sulfur over sulfide sulfur in the polysulfide molecules in the anoxic water at depths of 450 and 600 m may be the reason for its isotopic fractionation by 2.2‰ with respect to sulfur of dissolved sulfide (–41.0‰ VCDT) [Dubinin et al., 2024].



Figure RU-5. Distribution of ZVS concentrations with increasing hydrogen sulfide up to depth of 600 m in Black Sea anoxic water. Black line shows empirical dependence [H2S] = $1490.18[ZVS]^{2.75}$, $R^2 = 0.894$. Dotted line is calculated polysulfides.

- Gordeev et al. (2023) presented results for a broad set of trace elements in the largest rivers of the Russian Arctic (Ob, Yenisey, Lena, and Kolyma). For context, we also present results for major elements that are more routinely measured in these rivers. Water samples for this study were collected during an international campaign called PARTNERS from 2004 through 2006. A comparison of element concentrations obtained for Arctic rivers in this study with average concentrations in the world's rivers shows that most elements in the Arctic rivers are similar to or significantly lower than the world average. Fluxes of all major and trace elements were calculated using average concentrations and average water discharge for the 2004–2006. Based on these flux estimates, specific export (i.e., t/km2/y) for most of the elements was greatest for the Lena, followed by the Yenisey, Ob, and Kolyma in decreasing order.
- Gippius and co-authors (2023) from Kovalevsky Institute of Biology of the Southern Seas investigated the structure and dynamics of different water masses in the Tropical Atlantic is investigated using the results of instrumental measurements. The main attention is focused on the Vema fracture zone and the northern part of the WOCE A15 section. Despite the advances in the development of numerical models and reanalyses, instrumental observations remain a source of valuable data on the structure and dynamics of oceanic waters. Using such data, we revealed some features of deep-water circulation and long-term variability in the Tropical Atlantic.

Thus, in the Vema FZ was described a quasi-diurnal variability in the location of isotherms as well as in current direction and velocities. The boundary between the lower NADW and AABW can experience a vertical displacement of about 100–150 m within a day. We also described evidences of long-term variability along the WOCE A15 section during the last 28 years. Almost all layers corresponding to NADW and AABW experience an increase in both potential temperature and salinity. A decrease of potential temperature was observed in the layer corresponding to lower NADW.

GEOTRACES or GEOTRACES relevant cruises

 Multidisciplinary studies of the system "bottom sediments-water columnatmospheric layer near the surface" were conducted in the Barents Sea, Pechora Sea and South Kara Sea (Baidaratskaya Bay) during the 93rd cruise of the RV Akademik Mstislav Keldysh from November 8 to December 7, 2023. The expedition "European Arctic-2023: Geological Record of Environmental and Climate Change" was carried out within the framework of the regular program of the Shirshov Institute of Oceanology, Russian Academy of Sciences (SIO RAS) to study sedimentation, climatic variability and regional features of methane emission. Principal researchers of the cruise are Dr. Marina Kravchishina (Past SSC member), Dr. Alexey Klyuvitkin, and Dr. Alexander Novigatsky (SIO RAS). The research was carried out in the season



of polar night and active development of autumn-winter convection. During the expedition, fundamentally new data were obtained in various filds of oceanography.

Figure RU-6. Map of the expedition route and oceanographic stations in the Russian part of the western Eurasian Arctic shelf, November–December, 2023. 1 – comprehensive stations; 2 – comprehensive stations with sediment core sampling using a large-diameter geological corer; 3 – vectors of currents; 4 – vessel route; 5 – ice cover; 6 – boundaries of the economic zones of the RF and Norway, and Svalbard fishery protection zone.

Current vectors are constructed from reanalysis data (<u>http://bulletin.mercator-ocean.fr/en/PSY4#3/75.50/-51.33</u>) and are given in accordance with (Ivanov, Tuzov, 2021). The ice edge position is shown for the date of work in this part of the sea

according to data of the Norwegian Meteorological Institute, <u>https://cryo.met.no</u>. Based on GEBCO bathymetry, <u>https://www.gebco.net</u>.

In the Baidaratskaya Bay, methane emission due to molecular diffusion was registered with an intensity of several hundreds µgCH₄·m⁻²·h⁻¹, reaching locally units of mgCH₄·m⁻²·h⁻¹ due to gas *bubbles* transport *methane* from the seafloor on the Priyamal shelf. The highest methane concentrations in the water column and bottom sediments were determined in the Baidaratskaya Bay and Pechora Sea. Background methane concentration exceeded 2018 ppb in the *atmospheric layer near* the sea *surface* based on continuous minute measurements by two *Picarro gas* concentration *analysers* simultaneously [Kravchishina et al., in press]. The study of methane discharge areas was supported by Russian Science Foundation, grant No. 20-17-00157-P, https://rscf.ru/project/20-17-00157/.

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

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Completed GEOTRACES PhD or Master theses

• Elizaveta Makarova MSc thesis (June 2023). Application of multi-element analysis in the study of pore water of the Barents Sea (Moscow Paedagogical State University (Institute of Biology and Chemistry)

GEOTRACES presentations in international conferences

 Berezhnaya E.D., Dubinin A.V. The specific features of the cycle of platinum group elements in the ocean. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia

- Budko D.F., Demina L.L., Krasnova E.D., Starodymova D.P. Heavy metals in sediments of subarctic meromictic lakes of the White Sea as possible tracers of environmental changes. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
- Budko D.F., Demina L.L., Krasnova E.D., Starodymova D.P. Heavy metals in sediments of meromictic lakes of the White Sea coast as possible tracers of environmental changes. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
- Demina L.L., Galkin S.V., Solomatina A.S., The Bioaccumulation potential of the benthic organisms on methane seepage fields in the Laptev Sea. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
- Demina L.L., Solomatina A.S., Starodymova D.P., Lukyanova O.N. Element accumulation in different size fractions of the Copepoda zooplankton in the eastern Kara Sea in autumn 2022. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
- Dubinin A.V., Dubinina E.O. Evolution of the Black sea anoxia according to sulfur isotopic data of sulfate and sulfide. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
- Gordeev V.V., Pokrovsky O.S., Filippov A.S., Zhulidov A.V., Gurtovaya T.Yu., Kosmenko L.S. Concentrations and fluxes of dissolved major and trace elements in waters of the largest rivers of the Russian Arctic: Ob', Yenisey, Lena and Kolyma. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
- Klyuvitkin A.A., Kravchishina M.D., Novigatsky A.N., Politova N.V., Dara O.M., Bulokhov A.V. Vertical particle fluxes in the Barents sea in August, 2021. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
- Kochenkova A.I., Starodymova D.P., Gordeev V.V. Forms of occuring of metals in the suspended sedimentary matter of the Northern Dvina estuarine zone during 2016.
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- Kravchishina M.D., Prokofiev V.Yu., Klyuvitkin A.A., Dara O.M., Yakimova K.S., Kalgin V.Yu., Baranov B.V., Lein A.Yu. Barite research in hydrothermal sediments of the Mohns Ridge
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- Novigatsky A.N., Klyuvitkin A.A., Kravchishina M.D., Bulokhov A.V., Politova N.V., Filippov A.S., Shevchenko V.P. Average annual flux of organic carbon to the bottom in the Arctic seas of Russia: a comparison of estimated primary production data and research instrument data from sediment traps. 25th International Scientific Conference-School on Marine Geology, 13–17 November 2023, Shirshov Institute of Oceanology RAS, Moscow, Russia
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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN SLOVENIA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

The results of four relevant topics can be considered:

- Recent studies on mercury contamination reveal significant findings across various environments. In the Isonzo River plain (NE Italy), Hg0 fluxes from soil surfaces were assessed, showing higher emissions in summer due to increased UV radiation and temperature, with vegetation reducing these fluxes. In the northern Adriatic Sea, despite higher DGM production in heavily contaminated areas, Hg0 fluxes were comparable across sites, influenced by water turbulence and stagnation. A coordinated assessment of metallic contaminants in seafood highlighted reliable methods for measuring arsenic, cadmium, mercury, and lead, ensuring food safety. Finally, research on hydrothermal venting quantified natural mercury release, emphasizing the predominance of anthropogenic mercury in oceans and the potential impact of emission reduction policies. These studies underscore the need for ongoing monitoring and regulatory efforts to address mercury pollution.
- Further, the studies also addressed metrological issues related to the measurement and analysis of mercury contamination. For instance, the assessment of metallic contaminants in seafood, coordinated by the Government Laboratory in Hong Kong, highlighted the use of advanced techniques like microwave-assisted acid digestion and inductively coupled plasma mass spectrometry (ICP-MS) to ensure accurate measurements. The results were evaluated against supplementary comparison reference values (SCRVs) to ensure consistency and reliability across different laboratories. This approach confirms the measurement capabilities of participating institutes in determining inorganic elements in high-organic-content matrices like seafood, which is crucial for maintaining public health standards. These efforts underscore the importance of metrological accuracy and consistency in environmental monitoring and food safety assessments.
- The levels of metal(loid)s at the beginning of the coastal pelagic food web, providing an insight into accumulation in the suspended particulate matter (SPM) and sizefractionated plankton, were studied in the shallow coastal marine environment of the Gulf of Trieste (northern Adriatic Sea) affected by the metal polluted Isonzo/Soča River as a result of historical Hg, and Pb and Zn mining activities in the hinterland. The study suggests that the Redfield stoichiometric concept is unreliable for coastal marine plankton regarding metal(loid)s. Bioconcentration factors can help establish metal(loid) levels at the base of the food web, providing crucial information for marine organisms consumed by humans.
- Additionally, the study on mucilage events in the Adriatic Sea highlighted the impact of plankton exometabolites and allochthonous material on the formation of macroaggregates, affecting tourism, fisheries, and the coastal economy.

Phytoplankton colloidal organic matter was predominantly composed of polysaccharides, contributing mainly to the marine colloidal organic matter pool.

• The study investigates how river inputs affect the carbonate system in the northern Adriatic Sea (NAd), focusing on total alkalinity (AT) and dissolved inorganic carbon (DIC) in seawater. The region receives substantial freshwater input, impacting the carbonate equilibrium and biological processes. The DIC flux is influenced by mineral weathering and biological activity in river basins, though these processes can be altered by anthropogenic activities. The study highlights the importance of quantifying these disturbances to better understand their impact on the carbonate system and acidification in coastal regions.

New projects and/or funding

 IAEA TC Project INT7022: Strengthening Ocean Health for Sustainable Development: A Global Approach using Isotopic and Nuclear Techniques started in 2024. The project aims to improve the health of the oceans and achieving the United Nations Sustainable Development Goals (SDGs) SDGs 13, 14, and 17, which relate to the insufficient integrated scientific research at the global level on marine pollution, climate change, ocean acidification, and the carbon cycle.

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

- BENEDIK, Ljudmila, ROVAN, Leja, FALNOGA, Ingrid, JERAN, Zvonka, LIPEJ, Lovrenc, PROSEN, Helena, FAGANELI, Jadran. Po-210 in plankton and fish from coastal waters (gulf of Trieste, northern Adriatic Sea). Marine Chemistry 2024, 265-266, art. 104425, 8 str. ISSN 0304-4203. DOI: 10.1016/j.marchem.2024.104425.
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- GIANI, Michele, OGRINC, Nives, TAMŠE, Samo, COZZI, Stefano. Elevated river inputs of the total alkalinity and dissolved inorganic carbon in the Northern Adriatic Sea. Water. 2023, vol. 15, no 5, str. 894-1-894-22. DOI: 10.3390/w15050894.

Special issue publication

- OGRINC, Nives, GIANI, Michele, FAGANELI, Jadran. Editorial: the changing carbonate systems in coastal, estuarine, shelf areas and marginal seas. Frontiers in marine science. 2023, vol. 10, [art. no.] 1325363, 1 https://www.frontiersin.org/articles/10.3389/fmars.2023.1325363/full, DOI: 10.3389/fmars.2023.1325363.
- OGRINC, Nives, FAGANELI, Jadran. Preface to the special issue of the 15th International Symposium on the Interactions Between Sediments and Water. Journal of soils and sediments 2023, vol. 23, iss. 12, [article no.] 1325363, str. 4081-408. https://link.springer.com/article/10.1007/s11368-023-03681-x, DOI: 10.1007/s11368-023-03681-x.

GEOTRACES presentations in international conferences

- FAGANELI, Jadran, KOGOVŠEK, Tjaša, MAZEJ, Darja, MALEJ, Alenka, FALNOGA, Ingrid. Mercury in the coastal pelagic food web: phytoplankton, zooplankton and jellyfish. V: EGU General Assembly 2024: Vienna, Austria & online, 14-19 April 2024. Göttingen: EGU - European Geosciences Union. 2024, 1 spletni vir. https://meetingorganizer.copernicus.org/EGU24/EGU24-15021.html, DOI: 10.5194/egusphere-egu24-22463.
- RELITTI, Federica, OGRINC, Nives, ESPOSITO, Veronica, GAMBI, Maria Cristina, POTOČNIK, Doris, GIANI, Michele, DE VITTOR, Cinzia. Stable isotope values of the seagrass Posidonia oceanica in Panarea hydrothermal vents = Isotopi stabili della fanerogama marina Posidonia oceanica nei sistemi idrotermali di Panarea. Biologia marina mediterranea, 52° Congresso della Società Italiana di Biologia Marina, 12-15 Giugno 2023, Messina. 2024, vol. 28, no. 1, str. 5-8, ilustr. ISSN 1123-4245.

Submitted by Prof. Dr. Nives Ogrinc (nives.ogrinc@ijs.si).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN SOUTH AFRICA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

• Flynn et al. 2024 <u>https://www.science.org/doi/10.1126/sciadv.adi3059</u>: Size fractionated uptake rates of carbon, nitrogen and iron in the Atlantic sector of the Southern Ocean. This unique dataset from spring 2019 as part of the SCALE program provide the opportunity to determine the iron requirements of different phytoplankton, including which groups preferentially take up inorganic vs organically bound iron. The low iron requirements of the diatom Chaetoceros sp. allowed it to dominate biomass, primary production and nitrate uptake across this basin, where it was estimated to account for 25% of the annual export production.



Figure SA-1: Scatter plots of (A) total iron uptake versus NPP, (B) the iron-to-carbon (Fe:C) uptake ratio versus the f ratio, and (C) the Fe:C uptake ratio versus the iron-to-nitrogen (Fe:N) uptake ratio determined for each experimental depth. The symbol shapes in all panels indicate the size classes (circle, picoplankton; square, nanoplankton; diamond, microplankton). The colors in (A) and (C) denote the stations (MIZ, purple; OAZ, pink; PFZ, orange; SAZ, yellow), and those in (B) denote the Fe:N uptake ratios. The black dashed lines in (A) show literature-based average Fe:C uptake ratios (cyanobacteria, 250:1; dinoflagellates, 60:1; haptophytes, 20:1; diatoms, 7:1), and the gray dashed lines show the literature-based minimum Fe:C uptake ratios (cyanobacteria, 200:1; dinoflagellates, 15:1; haptophytes, 6:1; diatoms, 2:1) for the main phytoplankton groups identified in this study (<u>30</u>). The black dashed line in (C) shows the Redfield C:N ratio (6.63:1), and the blue shaded area indicates the data points associated with coincident luxury iron and NO₃⁻ uptake.

GEOTRACES or GEOTRACES relevant cruises

 Oceanographic cruise to Gough Island, 14/09/2023 – 17/10/2023, on board the RV SA Agulhas II. South African team members on board: Dr Thato Mtshali (DFFE), Dr Ole Valk (Stellenbosch University), PhD candidate Thapelo Ramalepe (Stellenbosch University) and MSc candidate Miranda Sitofile (Stellenbosch University). The team sampled 10 stations around the island for samples, including dissolved, particulate, ligands and DOM.



New projects and/or funding

- Dr T. Ryan-Keogh, CSIR, National Research Foundation of South Africa (NRF; 2024-2027): "ECOSOPHY: Emergent constraints on Southern Ocean Phytoplankton physiology"
- Prof. S Fietz, Stellenbosch University, National Research Foundation of South Africa (NRF; 2024-2027): "Micronutrient and pollutant trace elements at the air-sea interface of the Southern Ocean"
- Prof. S. Fietz, Stellenbosch University, CPRR of South Africa (2023-2026): "Metals in southern African aerosols and their potentially toxic impact on marine phytoplankton"
- A. Prof. S Fawcett, University of Cape Town, ERC Synergy Grant (2024-2030): "WHIRLS: The impact of ocean fine-scale whirls on climate and ecosystems"
- A. Prof. S. Fawcett, University of Cape Town, Schmidt Sciences Ocean Biogeochemistry Virtual Institute Grant (2024-2029): "Oxygen and biogeochemical dynamics along the west African margin: Processes and consequences"

Outreach activities conducted

- Newspaper interview: <u>Climatologists outline their agenda for Africa in</u> <u>2023.</u> University World News, Africa edition, Jan 2023
- Radio interview: Radio 786, "Pollution and oxygen levels in our oceans", November 2023
- School engagement: The Antarctic Year, at Ukhanyo Primary, Cape Town, June 2024

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

South African led publications:

- Demasy C., Singh A., Samanta S., Ryan-Keogh T.J., Roychoudhury A.N (2024 Submitted) Toxic impact of aluminium on the natural phytoplankton community during spring in the Southern Ocean. Science of The Total Environment
- Ramalepe, T., Samanta, S., Cloete, R., Ryan-Keogh, T.J., Roychoudhury, A.N. (2024 In revision) Winter physical supply of dissolved manganese for springtime biological consumption in the Southern Atlantic Ocean. Limnology and Oceanography

- Flynn, E.F., Haraguchi, L., McQuaid, J., Burger, J.M., Lunga, P.M., Stirnimann, L., Samanta, S., Roychoudhury, A.N., and Fawcett, S.E. (2023) Nanoplankton: the dominant vector for carbon export across the springtime Southern Ocean. Science Advances, V9(48), 1-17, doi: 10.1126/sciadv.adi3059
- Singh, A., Fietz, S., Thomalla, S.J., Sanchez, N., Ardelan, M.V., Moreau, S., Kauko, H.M., Fransson, A., Chierici, M., Samanta, S., Mtshali, T.N., Roychoudhury, A.N. and Ryan-Keogh, T.J. (2023) Absence of photophysiological response to iron addition in autumn phytoplankton in the Antarctic sea-ice zone. Biogeosciences, V20, 3073– 3091, doi: 10.5194/bg-20-3073-2023
- Stirnimann, L., Bornman, T.G., Forrer, H.J., Mirkin, J., Flynn, R.F., Ryan-Keogh, T.J., Dorrington, R.A., Verheye, H.M., Fawcett, S.E. A circum-Antarctic plankton isoscape: Carbon export potential across the summertime Southern Ocean. Global Biogeochemical Cycles 38, 10.1029/2023GB007808 (2024).
- Marshall, T.A., Beal, L.M., Sigman, D.M., Fawcett, S.E. Instabilities across the Agulhas Current enhance upward nitrate supply in the southwest subtropical Indian Ocean. AGU Advances 4, 10.1029/2023AV000973 (2023).
- Editors' highlight in Eos (https://eos.org/editor-highlights/how-nutrients-get-back-up-to-the-surface-ocean)

Publications with South African contribution:

- Deteix, V., Cotard, E., Caquineau, S., Landing, W.M., Planchon., F., Ryan-Keogh, T.J., Cardinal, D., (2024), Biogenic and lithogenic silicon along the GEOTRACES South West Indian Ocean section (SWINGS-GS02) and the islands mass effect on regional Si biogeochemical cycle, Marine Chemistry, doi: 10.1016/j.marchem.2024.104412
- J. Duan, R. Cloete, J. C. Loock, A. Lanzirotti, M. Newville, A. Martinez-Garcia, D. M. Sigman, P. J. Lam, A. N. Roychoudhury, S. C.B. Myneni (2024) Biogenic-to-Lithogenic Handoff of Particulate Zinc Controls the Zn-Cycle in the Southern Ocean. Science V384, 1235-1240, doi: 10.1126/science.adh8199
- Buck, C.S., S. Fietz, D.S. Hamilton, T.-Y. Ho, M.M.G. Perron, and R.U. Shelley. 2024. GEOTRACES: Fifteen years of progress in marine aerosol research. Oceanography 37(2):116–119, https://doi.org/10.5670/oceanog.2024.409.
- Perron, M. M. G., Fietz, S., Hamilton, D. S., Ito, A., Shelley, R. U., & Tang, M. (2024). Preface to the inter-journal special issue "RUSTED: Reducing Uncertainty in Soluble aerosol Trace Element Deposition", Atmospheric Measurement Techniques 17, 165– 166, https://doi.org/10.5194/amt-17-165-2024.
- Shalileh, F, Gheibzadeh, MS, Lloyd, JR, Fietz, S, Shahbani Zahiri, H, Zolfaghari Emameh, R. Evolutionary analysis and quality assessment of ζ-carbonic anhydrase sequences from environmental microbiome. J Basic Microbiol. 2023; 1– 14. https://doi.org/10.1002/jobm.202300323

- Vos, H.C., Kangueehi, K.I., ... Fietz S. Spatial variability of dust concentration and deposition around an industrial port in South Africa emphasises the complexity of sources and transport. Air Qual Atmos Health (2024). https://doi.org/10.1007/s11869-024-01581-8
- Casciotti, K.L., Marshall, T.A., Fawcett, S.E., Knapp, A.N. Advances in understanding the marine nitrogen cycle in the GEOTRACES era. Oceanography 10.5670/oceanog.2024.406 (2024).
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Completed GEOTRACES PhD or Master theses

- Lide Jansen van Vuuren, MSc, "Dynamics of dissolved iron in the marginal ice zone in the South Atlantic and Southern Ocean", Stellenbosch University
- Liam Quinlan, MSc, "Characterising Southern Ocean Phytoplankton Community Variability and Environmental Coupling: Zonal, Sectoral, and Seasonal Perspectives", Stellenbosch University, https://scholar.sun.ac.za/items/90c0592b-f381-4f03-ad88-3ae7a774ec27
- Tanya Marshall, PhD, "Nitrogen cycling in the South Atlantic and South Indian Oceans investigated using nitrate isotopes: implications for nutrient supply, ocean fertility, carbon export and climate", University of Cape Town, https://open.uct.ac.za/items/505ed141-c1c8-4f27-94f2-81f18091704d
- Luca Stirnimann, PhD, "Plankton dynamics of the open Southern Ocean and surrounding the (Sub)Antarctic islands", University of Cape Town, https://open.uct.ac.za/items/8eaeb7e2-a92e-4415-84e2-07b2c5d55e50
- Joshua Mirkin, MSc, "Nitrogen cycle-based estimates of carbon export potential in the waters adjacent to Larsen C Ice Shelf in the western Weddell Sea, Antarctica", University of Cape Town, https://open.uct.ac.za/items/2fc6d193-c750-48ac-8eb7-8f474674a5d2
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GEOTRACES presentations in international conferences

- Saumik Samanta and Alakendra Roychoudhury (2024) Don't save the whales, so says the iron biogeochemistry. Goldschmidt Conference, Chicago, USA, 18 23 August.
- Alakendra Roychoudhury, Kayla Buchanan, Saumik Samanta (2024) Marginal sea-ice is not a major source of iron to support spring blooms in the South Atlantic. EGU general assembly, Vienna, Austria, 14 – 19 April.

- Saumik Samanta, Kayla Buchanan, Alakendra N Roychoudhury (2023) Is marginal sea ice a source of Fe and impacts productivity in South Atlantic? SOOS Symposium, Hobart, Australia, 14 – 18 August.
- Saumik Samanta, Ryan Cloete, Lide Jansen van Vuuren, Alakendra N Roychoudhury (2023) Seasonal cycling of Fe in the marginal ice zone of Southern Ocean around zero meridian: linkage to phytoplankton bloom. SOOS Symposium, Hobart, Australia, 14 – 18 August.
- R. Cloete, S. Samanta, Nadine Ellis, Lide Jansen van Vuuren, Corentin Baudet, Pierrick Penven, Steven Herbette, Alakendra Roychoudhury, Eva Bucciarelli and Helene Planquette (2023) Iron and mesoscale eddy dynamics in the South West Indian Ocean. Goldschmidt Conference, Lyon, France, 9 – 14 July.
- Satish Myneni, Jianshu Duan, Ryan Cloete, Daniel M. Sigman, Phoebe J. Lam, Antonio Lanzirotti, Matthew Newville, Alfredo Martinez-Garcia and Alakendra Roychoudhury (2023) Speciation of Particulate Zn in the Southern Ocean: Implications for Zn-cycling. Goldschmidt Conference, Lyon, France, 9 – 14 July.
- A. Ringard, H. Planquette, Eva Bucciareli, R. Cloete, A.N. Roychoudhury (2023) Spatial and temporal variability of particulate iron and manganese in the Atlantic sector of the Southern Ocean: spring vs winter. Goldschmidt Conference, Lyon, France, 9 – 14 July.
- Lide Jansen van Vuuren, Saumik Samanta, Ryan Cloete, Alakendra N Roychoudhury (2023) Seasonal cycling of dissolved Fe in the South Atlantic marginal ice zone of the Southern Ocean. Goldschmidt Conference, Lyon, France, 9 – 14 July.
- Saumik Samanta, Lide Jansen van Vuuren, Ryan Cloete, Alakendra N Roychoudhury (2023) Dissolved iron dynamics in the marginal ice zone and spring blooms. ASLO Aquatic Sciences Meeting, Palma De Mallorca, Spain, 4 – 9 June.
- S Fietz, K Kangueehi, S Samanta, AN Roychoudhury, F Eckardt (2023) Trace metal concentrations and solubility in aerosols over the oceans south of South Africa. ASLO Aquatic Sciences Meeting, Palma De Mallorca, Spain, 4 – 9 June.
- Marshall, T.A., Sigman, D.M., Beal, L.M., Granger, R., Foreman, A., Martínez-García, A., Auderset, A., Blain, S., Campbell, E.C., Fripiat, F., Harris, E., Haugh, G., Marconi, D., Oleynik. S., Rafter, P.A., Roman, R., Sinyanya, K.Y., Smart, S.M., Fawcett, S.E. "Nitrogen cycling in the Agulhas Current I: Local and remote signals of Indian Ocean processes," Ocean Sciences Meeting, 2024.
- Ryu, Y., Marconi, D., Luu, V.H., Smart, S.M., Fawcett, S.E., Run, Z., Johnson, R.J., Knapp, A.N., Ward, B.B., Sigman, D.M. "Isotopic evidence for two sources of dissolved organic nitrogen in the deep ocean," Ocean Sciences Meeting, 2024.
- Flynn, R.F., Bornman, T.G., Mirkin, J., Smith, S., Altieri, K., Granger, J., Fawcett, S.E. "Phytoplankton group-specific contributions to new production in the summertime Weddell Sea," Ocean Sciences Meeting, 2024.

- Fawcett, S.E., Marshall, T.A., Sinyanya, K.Y., Flynn, R.F., Forrer, H.J., Ryu, Y., Walker, D.R., Sigman, D.M., Beal, L.M. "Nitrogen cycling in the Agulhas Current II: Agulhas Current dynamics drive (sub)mesoscale nitrate fluxes that fuel new production," Ocean Sciences Meeting, 2024.
- Wallschuss, S., Bourbonnais, A., Granger, J., Flynn, R.F., Burger, J., Pillay, K., Fawcett, S.E. "Mechanisms of nitrous oxide (N2O) production in the southern Benguela upwelling system: insights from isotopic tracers," Ocean Sciences Meeting, 2024.
- Stirnimann, L., Bornman, T.G., Verheye, H.M., Michel, L.N., Puccinelli, E., Forrer, H.J., Mirkin, J., Ryan-Keogh, T.J., Flynn, R.F., Dorrington, R., Suaria, G., Fawcett, S.E. "Using a circum-Antarctic plankton isoscape to assess carbon export potential and plankton trophic structure across the Southern Ocean," Ocean Sciences Meeting, 2024.
- Thomas, R.K., Fawcett, S.E., Kranz, S.A., Chappell, P.D., Einarsson, S., Forrer, H.J., Graves, E., Haraguchi, L., Robinson, C.M., Roychoudhury, A.N., Ryan-Keogh, T., Knapp, A.N. "Evaluating the role of light and iron on nitrate assimilation isotope effect estimates in the Southern Ocean," Aquatic Sciences Meeting 2023.
- Marshall, T.A., Sigman, D.M., Beal, L.M., Foreman, A., Martínez-García, A., Blain, S., Campbell, E., Fripiat, F., Granger, R., Harris, E., Haug, G.H., Marconi, D.M., Oleynik, S., Rafter, P.A., Roman, R., Sinyanya, K., Smart, S.M., Fawcett, S.E. "Nutrient fluxes in the greater Agulhas Current region: signals of local and remote Indian Ocean nitrogen cycling," EGU General Assembly, 2023.

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN SOUTH KOREA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

• Lee H.S et al (2024) reported the atmospheric deposition flux of ²¹⁰Pb in the equatorial western Indian Ocean, In addition, they calculated the atmosphere-derived dissolvable Pb in seawater using the budget of ²¹⁰Pb. Based on the mass balance of the total ²¹⁰Pb budget in the water column, they estimated the atmospheric deposition flux of 210Pb and the residence time of Pb for the first time in this region. The atmospheric deposition flux of ²¹⁰Pb was estimated to be 0.1–0.5 dpm cm⁻² yr⁻¹, and these values agreed with the general global estimations for the major oceans (0.1–0.7 dpm cm⁻² yr⁻¹). Considering the residence time of 210Pb (29–41 years) in the water column (estimated from the ²¹⁰Pb inventory and ²³⁴Th-based Pb scavenging rate), the atmospheric input of seawater-dissolvable Pb was quantified to be 0.08–0.1 nmol cm⁻² yr⁻¹, which is about eight times higher than the estimated input in the early 1990s in the region. Therefore, these results imply that radioactive ²¹⁰Pb could be a useful tracer for quantifying Pb flux in seawater.



Figure SK-1. Vertical profiles of (a) dissolved ²¹⁰Pb and (b) total ²¹⁰Pb in the Indian Ocean. The GEOSECS data from the 1970s obtained from nearby stations in our study area are shown for comparison (Left figure) and A schematic box model accounting for residence time of dissolved Pb, Pb inventory, and atmospheric flux of seawater-dissolved Pb (nmol cm⁻² yr⁻¹) in the equatorial western Indian Ocean.

• Actinium-227 (227 Ac) has been used as a powerful tracer of diapycnal mixing in the ocean, assuming that it is conservative and originates mainly from deep-sea sediments. However, here Dr. Seo H.J. et al. show an unexpectedly large source (continental margin) and sink (scavenging) of 227 Ac in the ocean, based on high-resolution 227 Ac distributions obtained for the first time by mooring Mn-fibers in the East Sea (Japan Sea). Although we expected a decrease in radium-228 (228 Ra) to 227 Ac ratios with depth owing to their different half-lives, the ratios increased with depth in the upper layer, indicating efficient removal of 227 Ac by particle scavenging. In addition, unusually high 227 Ac activities (~15 dpm m –3) were observed in the surface layer, likely due to the

horizontal transport of ²²⁷Ac-enriched shelf water. Thus, our results suggest refining our understanding of the geochemical cycle and application of ²²⁷Ac in the ocean.



Figure SK-2. Vertical profiles of (a) ²²⁸Ra (dpm m⁻³), (b) ²²⁷Ac (dpm m⁻³), and (c) the activity ratios of ²²⁸Ra to ²²⁷Ac in the upper layer of the East Sea by fitting to different ratios of particulate to dissolved ²²⁷Ac (K) using a reversible scavenging model.



Iron (Fe) is an essential micronutrient for phytoplankton growth, and its availability limits primary production in half of the global ocean. Traditionally, atmospheric input of natural mineral dust has been considered as a main source of Fe in the surface ocean. However, here Dr. Seo H.J. et al. show that about 45% of the water-soluble Fe in aerosols collected over the East Sea (Japan Sea) is anthropogenic, which originates mainly from heavy fuel oil combustion, based on the analyses of various chemical tracers (Al, K, V, Ni, Pb, and ²¹⁰Pb). It is striking that a tiny quantity of oil, less than 1% of the aerosols in mass, can constitute the majority of water-soluble Fe in aerosols due to its high Fe solubility. Furthermore, they show that a quarter of dissolved Fe in the East Sea

is anthropogenic using a ²¹⁰Pb-based scavenging model. Since this sea is almost fully enclosed (200–3,000 m) and located at the forefront of the Asian human footprint, these results provide an insight that the marine Fe cycle may be already perturbed by human activities.



Figure SK-3. Relationship between Fe and other elements. (a) Water-soluble Fe (sFe) versus water-soluble AI (sAI). The dashed line represents the Fe-to-AI ratio from soils of the Asian continent. (b) Excess sFe versus water-soluble vanadium (sV). (c) Excess sFe versus water-soluble nickel (sNi). (d) Excess sFe versus water-soluble lead (sPb). The color gradient indicates Fe solubility. Sources of anthropogenic Fe and its relationship with ²¹⁰Pb in aerosols. (a) Plot between non-sea-salt potassium-to-aluminum ratios (nss-K/AI) and non-sea-salt vanadium-to-aluminum ratios (nss-V/AI). The error bars for each end-member represent a 1-standard deviation from average values. The color gradient indicates Fe solubility. (b) Anthropogenic Fe in water-soluble fraction versus excess ²¹⁰Pb. The dashed line represents the slope and intercept of a linear regression of data (r = 0.66 and p < 0.001). The error bars for excess ²¹⁰Pb are based on 1-standard deviation counting statistics.

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

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- Seo, H., Lee, H., & Kim, G. (2024). New insight into the source and sink of 227Ac in the ocean. Geophysical Research Letters, 51(2), e2023GL105853.
- Seo, J., Kim, G., Seo, H., Na, T., Noh, S., & Hwang, J. (2023). Sources and behaviors of particulate organic carbon, iron, and manganese in the bottom nepheloid layer of the southwestern East Sea (Japan Sea). Marine Chemistry, 257, 104323.
- Seo, J., Kim, I., Kang, D. J., Lee, H., Choi, J. Y., Ra, K., ... & Kim, S. H. (2024). Particulate organic carbon export fluxes across the Seychelles-Chagos thermocline

ridge in the western Indian Ocean using 234Th as a tracer. Frontiers in Marine Science, 10, 1288422.

• Lee, H., Lee, J., Lee, H., & Kim, I. (2023). The Atmospheric Input of Dissolvable Pb Based on the Radioactive 210Pb Budget in the Equatorial Western Indian Ocean. Journal of Marine Science and Engineering, 11(6), 1120.

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ANNUAL REPORT ON GEOTRACES ACTIVITIES IN SPAIN

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

- Cu transport and complexation by the marine diatom *Phaeodactylum tricornutum*. The combination of adsorption and complexation experiments to understand the Implications for trace metal complexation kinetics in the surface ocean.
- Fe(II) kinetics in the deep Atlantic waters, to increase our knowledge about the Fe(II) level in the ocean and the Fe pool in the ocean.
- Ocean alkalinity enhancement (OAE) implications in the Fe chemistry during mesocosms experiments.

GEOTRACES or GEOTRACES relevant cruises

 DICHOSO project: Contribution of Water Masses of Deception Island to biogeochemical inventories of the Southern Ocean: current budgets and future trends. IP: Antonio Tovar-Sánchez, Isabel Emma Huertas Cabilla. First Campaing: February 22 - March 20, 2024. Deception Island, Antarctic



 FAR-DWO-DS1 Cruise 19/07/2023 Reykjavik (Iceland) - 12/08/2023 Reykjavik (Iceland) at the Denmark Strait aboard RV Sarmiento de Gamboa. The Denmark Strait (DS), situated between Iceland and Greenland, serves as a compelling study area for researchers in various fields of oceanography. This strait acts as a critical gateway, connecting the Arctic and Atlantic Oceans. Its unique geographic location and complex oceanographic dynamics make it an ideal location for investigating a wide range of phenomena related to ocean circulation and climate patterns. In DS the dense water being formed at the Nordic Seas, consisting of the Norwegian, Greenland, and Iceland Seas, overflows the strait's central sill and the East Greenland Shelf (EGS), eventually reaching the Irminger Basin in the North Atlantic Ocean. The Denmark Strait Overflow (DSO) is the main focus of the FAR-DWO DS1 cruise onboard RV Sarmiento de Gamboa.

Linked to GEOTRACES, more than 200 seawater samples were collected for Nd isotopes (\mathcal{E}_{Nd}) and rare earth element (REE) analysis. The goal is to obtain an unprecedented detailed geochemical characterization of the DSO waters to improve our understanding of the mixing processes of this water mass as a precursor of present day North Atlantic Deep Water (NADW). The analysis of these samples is currently 50% complete as a part of a PhD (Sara Espinosa, University of Barcelona) under the supervision of Leopoldo D. Pena (University of Barcelona). The preliminary results will be presented at the ISMS in Valencia in July 2024.



 CONSTRAINING DENMARK STRAIT OVERFLOW WATER EXPORT USING ND ISOTOPES, Espinosa-Paz, S., Regada, I., Campderrós, S., Garcia-Solsona, E., Paredes-Paredes, E., Arjona-Camas, M., Frigola, J., Cerdà-Domènech, M., Lastras, G.,Sanchez-Vidal, A., Amblàs, D., Pena, L.D. Seminario Ibérico de Química Marina (SIQUIMAR) Valencia (Spain), 10-12th July 2024

New projects and/or funding

- COMETA, Organic matter as a driver of bioavailability and behaviour of trace metals (Fe, Co, Cu, Pb) in coastal areas under a global change scenario. (PID2022-139975OB-I00). IP: Juan Santos-Echeandía, Paula Sánchez-Marín
- FeRIA, Fe Response In an Acidified ocean. (PID2021-123997NB-100). IP: J. Magdalena Santana-Casiano, Aridane G. González
- Multi-CO2ast, Multidisciplinary Analysis of Blue Carbon Sinks in Coastal Waters (TED2021-130892B-100). IP: Aridane G. González, J. Magdalena Santana-Casiano.

 MORIA - Mediterranean Outflow Reach and Impact into the north Atlantic: present and past variability using neodymium isotopes. MINECO Generación del Conocimiento. IP: L.D. Pena & I. Cacho. Ref: PID2022-138010OB-I00 (2023-2027). Funding: 378.750€ (25 days of vessel + PhD student).

This project will request official GEOTRACES endorsement as a **Process Study** for the Summer 2025 cruise (see Figure).



New GEOTRACES or GEOTRACES-relevant publications

- Santos-Echeandía, J., Bernárdez, P., Sánchez-Marín, P. (2023). Trace metal level variation under strong wind conditions and sediment resuspension in the waters of a coastal lagoon highly impacted by mining activities. Science of the Total Environment, 905, 167806.
- Amaral, V., Santos-Echeandía, J., Ortega, T., Álvarez-Salgado, X.A., Forja, J. (2023). Dissolved organic matter distribution in the water column and sediment pore water in a highly anthropized coastal lagoon (Mar Menor, Spain): Characteristics, sources, and benthic fluxes. Science of the Total Environment, 896, 165264.
- Barber-Lluch, E., Nieto-Cid, M., Santos-Echeandía, J., Sánchez-Marín, P. (2023). Effect of dissolved organic matter on copper bioavailability to a coastal dinoflagellate at environmentally relevant concentrations. Science of the Total Environment, 901, 165989.
- González-Santana, D., Segovia, M., González-Dávila, M., Ramírez, L., González, A. G., Pozzo, L. J., Arnone, V., Vázquez, V., Riebesell, U., and Santana-Casiano, J. M. (2023). Ocean alkalinity enhancement using sodium carbonate salts does not impact Fe dynamics in a mesocosm experiment, EGUsphere https://doi.org/10.5194/egusphere-2023-2868
- González-Dávila, M., Maldonado, M. T., González, A. G., Guo, J., González-Santana, D., Martel, A., and Santana-Casiano, J. M. (2024). Cu transport and complexation by the marine diatom Phaeodactylum tricornutum: Implications for trace metal complexation kinetics in the surface ocean. Science of The Total Environment, 170752.
- Bonnet, S., Guieu, C., Taillandier, V., Boulart, C., Bouruet-Aubertot, P., Gazeau, F., ... González-Santana, D., ... & Tilliette, C. (2023). Natural iron fertilization by shallow hydrothermal sources fuels diazotroph blooms in the ocean. Science, 380(6647), 812-817.
- Wang, W., Lough, A. J., Goring-Harford, H., Flanagan, O., González-Santana, D., Resing, J., ... & James, R. H. (2023). Fractionation of iron and chromium isotopes in

hydrothermal plumes from the northern Mid-Atlantic Ridge. Earth and Planetary Science Letters, 624, 118468, https://doi.org/10.1016/j.epsl.2023.118468.

- Torres-Rodriguez, N., Yuan, J., Petersen, S., Dufour, A., González-Santana, D., Chavagnac, V., ... & Heimbürger-Boavida, L. E. (2024). Mercury fluxes from hydrothermal venting at mid-ocean ridges constrained by measurements. Nature Geoscience, 17(1), 51-57, https://doi.org/10.1038/s41561-023-01341-w.
- María Andrea Orihuela-García, Marina Bolado-Penagos, Iria Sala, Antonio Tovar-Sánchez, Carlos M. García, Miguel Bruno, Fidel Echevarría, Irene Laiz. Trace metals distribution between the surface waters of the Gulf of Cadiz and the Alboran Sea. Science of the Total Environment, Volume 858, Part 2, 1 February 2023, 159662 https://doi.org/10.1016/j.scitotenv.2022.159662
- Gema Ruiz Gutiérrez, Erica Sparaventi, Berta Galan Corta, Antonio Tovar-Sánchez, Javier R. Viguri Fuente. Penguin guano trace metals release to Antarctic waters: A kinetic modelling. Science of the Total Environment, 02 (2023) 166448. https://doi.org/10.1016/j.scitotenv.2023.166448
- Daniel García-Veira; Camila Sukekava; Erica Sparaventi; Gabriel Navarro; I. Emma Huertas; Antonio Tovar-Sánchez; Luis M. Laglera. A first estimation of the role of penguin guano on copper cycling and organic speciation in coastal Antarctic waters. Science of the Total Environment, Volume 912, 169266, 2024 https://doi.org/10.1016/j.scitotenv.2023.169266
- Antonio Cobelo-García, Patricia Bernárdez, Clara Mendoza-Segura, Enrique González-Ortegón, David Sánchez-Quiles, Ricardo F. Sánchez-Leal and Antonio Tovar-Sánchez. Rare Earth Elements Distribution in the Gulf of Cádiz (SW Spain): Geogenic vs. Anthropogenic Influence. Frontiers in Marine Science. Volume 11 – 2024 https://doi.org/10.3389/fmars.2024.1304362
- Álvarez-Vázquez, M.A., Farinango, G., Prego, R., 2023. Uranium as reference element to estimate the background of "Anthropocene" sensitive trace elements in sediments of the land-ocean continuum (Ulla-Arousa, NW Iberian Atlantic Margin). Continental Shelf Research, 261: 105021. DOI: 10.1016/j.csr.2023.105021
- Farinango, G., Álvarez-Vázquez, M.A., Prego, R., 2023. Trace Element Patterns in Heterogeneous Land-Sea Sediments: A Comprehensive Study of the Ulla-Arousa System (SW Europe). Geosciences, 13: 292. DOI: 10.3390/geosciences13100292
- Basak, Chandranath, Yingzhe Wu, Brian A. Haley, Jesse Muratli, Leopoldo D. Pena, Louise Bolge, Jessica N. Fitzsimmons, Robert M. Sherrell, and Steven L. Goldstein. "Suspended Particulate Matter Influence on Dissolved Nd Concentration and Isotopic Composition along GEOTRACES Section GP16." Earth and Planetary Science Letters 635 (June 2024): 118692. https://doi.org/10.1016/j.epsl.2024.118692.
- Villa-Alfageme, M., Briggs, N., Ceballos-Romero, E., de Soto, F.C., Manno, C., Giering, S.L.C., 2024. Seasonal variations of sinking velocities in Austral diatom

blooms: Lessons learned from COMICS. Deep Sea Res. Part II Top. Stud. Oceanogr. 213, 105353. https://doi.org/10.1016/j.dsr2.2023.105353

 Periáñez, R., Abascal-Ruíz, U., López-Gutiérrez, J.M., Villa-Alfageme, M., 2023. Sediments as sinks and sources of marine radionuclides: Implications for their use as ocean tracers. Mar. Pollut. Bull. 194, 115316. https://doi.org/10.1016/j.marpolbul.2023.115316

Completed GEOTRACES PhD or Master theses

• María Sol Hernández Conesa (Master Theses) supervised by Juan Santos Echeandía and Paula Sánchez Marín. Copper complexation capacity and its relation with dissolved organic mater in the Mar Menor lagoon (SE Spain). July 2023.

GEOTRACES presentations in international conferences

- Santos-Echeandía, J., González, A.G., Sarthou, G., Sánchez-Marín, P. (2023, 2023, June). The potential importance of bioavailable iron regarding eutrophication events in coastal lagoons. In ASLO Aquatic Sciences Meeting 2023.
- Santos-Echeandía, J., Bernárdez, P., Sánchez-Marín, P. (2023, October). The utility of passive samplers to monitor changes in trace metal levels in a coastal lagoon under different singular environmental events. In DGT Conference 2023.
- Green Ruiz, C., Rodellas, V., Rodríguez Puig, J., Santos Echeandía, J., Feliu, M.D., Alorda Montiel, I., Bravo, A.G., Bernárdez Rodriguez, P. (2023, May). Potentially toxic element input into Mar Menor coastal lagoon (Spain) through submarine groundwater discharge. In EGU 2023 conference.
- Santana-Casiano, J. M., Gonzalez, A., González-Santana, D., & González-Dávila, M. (2024, February). Fe (II) biogeochemistry in a changing ocean. In 2024 Ocean Sciences Meeting. AGU.
- González-Santana, D., González, A. G., González-Dávila, M., Arnone, V., & Santana-Casiano, J. M. (2023, July). Can subaerial lava form iron rich buoyant plumes in the ocean?. In Goldschmidt 2023 Conference. GOLDSCHMIDT.
- Arnone, V., Santana-Casiano, J. M., González-Dávila, M., Sarthou, G., Krisch, S., Lodeiro, P., ... & González, A. G. (2023, July). Copper-binding ligands in Fram Strait and the Greenland shelf (GEOTRACES cruise GN05). In Goldschmidt 2023 Conference. GOLDSCHMIDT.
- Pena, L.D., Campderrós, S., García-Solsona, E., Paredes-Paredes, E., Frigola, J., Rodríguez-Díaz, C. N., Lucas, A., Calvo, E., Pelejero, C., and Cacho, I.: Geochemical characterization of Mediterranean Outflow Waters in the modern ocean: Nd isotopes, carbon cycle and new export constraints, EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-16921, https://doi.org/10.5194/egusphere-egu24-16921, 2024.

- Wu, Y., Basak, C., Muratli, J.M., Pena, L.D., Bolge, L., Haley, B.A., Goldstein, S.L.: Neodymium isotopes along the GEOTRACES GP16 Eastern Pacific Zonal Transect. Goldschmidt 2023 Conference (Poster).
- https://conf.goldschmidt.info/goldschmidt/2023/meetingapp.cgi/Paper/17196
- Campderrós, S., Pena, L.D., Cacho, I., García-Solsona, E., Paredes, E. : Present and past variability of the Mediterranean Outflow Water using Nd isotopes. Poster a: XXII INQUA Congress 2023, Roma. http://hdl.handle.net/2445/202069
- González-González, B., Hurtado-Bermúdez, S., Villa-Alfageme, M., 2024. Developing machine learning algorithms to quantify carbon export fluxes in the ocean, in: EGU General Asembly 2024. Vienna.
- Abascal-Ruíz, U., López-gutiérrez, J.M., Wen, Y., Villa-Alfageme, M., 2023. Presence of Fukushima derived radionuclides in the Arctic Ocean, in: ENVIRA. pp. 17-22 September.
- González-González, B., Ceballos-Romero, E., Hurtado-Bermúdez, S., Abascal, U., Villa-Alfageme, M., 2023. Building a database from radioisotopes measurements: the case of 234 Th in seawater, in: ENVIRA. pp. 17-22 September.
- Abascal-Ruiz, U., Lérida-Toro, V., López-Gutiérrez, J.M., Periañez, R., Hicks, N., Klar, J., Abril, J.M., Villa- Alfageme, M., 2023. Transport and accumulation of artificial radionuclides in a marine core from the Celtic Sea, in: ENVIRA. pp. 17-22 September.
- López-Rodríguez, Á., Mas, J.L., Giering, S.L.C., García-Prieto, C., Mantero, J., Villa-Alfageme, M., 2023. Improving the measurement of 210Po in seawater, in: ENVIRA. pp. 17-22 September.

Submitted by Juan Santos Echeandía (juan.santos@ieo.csic.es).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN SWITZERLAND

May 1st, 2023 to April 30th, 2024

GEOTRACES or GEOTRACES-relevant cruises

- Mingzhao Sun (ETH Zurich) participated in cruise EMB 324 of R/V Elisabeth Mann Borgese (Leibniz Institute of Baltic Sea Research Warnemünde) in the Baltic Sea in summer 2023, collecting seawater, porewater and sediment samples for analysis of transition metal concentrations and isotopes.
- Dr. Isabelle Baconnais (University of Lausanne) collected a set of seawater and particulate samples along Line P (NE Pacific) in September 2023 (SCrIPT Project).
- Prof. Samuel Jaccard (University of Lausanne) and Dr. Christel Hassler (EPFL) collected an array of seawater samples along southwestern Greenland in August–September 2023 (GreenFjord project).

New projects and/or funding

• Dr. D. J. Janssen (EAWAG) received funding from the Swiss National Science Foundation to investigate the biogeochemical cycling of Mn, Fe and paleoredox proxies in a redox-stratified Swiss lake, 2024–2028.

New GEOTRACES or GEOTRACES-relevant publications

- Ai, X. E., L. M. Thöle, A. Auderset, M. Schmitt, S. Moretti, A. S. Studer, E. Michel, M. Wegmann, A. Mazaud, P. K. Bijl, D. M. Sigman, A. Martínez-García, and S. L. Jaccard. 2024. The southward migration of the Antarctic Circumpolar Current enhanced oceanic degassing of carbon dioxide during the last two deglaciations. Communications Earth & Environment 5, 10.1038/s43247-024-01216-x.
- Casacuberta, N. and J. N. Smith. 2023. Nuclear reprocessing tracers illuminate flow features and connectivity between the Arctic and Subpolar North Atlantic Oceans. Annual Review of Marine Science 15:203-221, doi: 10.1146/annurev-marine-032122-112413.
- Du, J. 2023. SedTrace 1.0: a Julia-based framework for generating and running reactive-transport models of marine sediment diagenesis specializing in trace elements and isotopes. Geosci. Model Dev. 16:5865-5894, 10.5194/gmd-16-5865-2023.
- Fleischmann, S., J. Du, A. Chatterjee, J. McManus, S.D. Iyer, A. Amonkar, and D. Vance. 2023. The nickel output to abyssal pelagic manganese oxides: A balanced elemental and isotope budget for the oceans. Earth and Planetary Science Letters 619:118301, 10.1016/j.epsl.2023.118301.

- Fourquez, M., D. J. Janssen, T. M. Conway, D. Cabanes, M. J. Ellwood, M. Sieber, S. Trimborn, and Christel Hassler. 2023. Chasing iron bioavailability in the Southern Ocean: Insights from Phaeocystis antarctica and iron speciation. Science Advances 9, 10.1126/sciadv.adf9696.
- He, Z., C. Archer, S. Yang, and D. Vance. 2023. Sedimentary cycling of zinc and nickel and their isotopes on an upwelling margin: Implications for oceanic budgets and paleoenvironment proxies. Geochimica et Cosmochimica Acta 343:84-97, doi: 10.1016/j.gca.2022.12.026.
- Little, S. H., G. F. de Souza, and R. C. Xie. 2024. Metal stable isotopes in the marine realm. Treatise on Geochemistry, Vol. 3e, 10.1016/B978-0-323-99762-1.00019-X.
- Raimondi, L., A.-M. Wefing, and N. Casacuberta. 2024. Anthropogenic carbon in the Arctic Ocean: perspectives from different transient tracers. Journal of Geophysical Research: Oceans 129, doi: 10.1029/2023JC019999.
- Zhang, X., N. Lemaitre, J.D. Rickli, T.J. Suhrhoff, R. Shelley, A. Benhra, S. Faye, M.A. Jeyid, and D. Vance. 2024. Tracing anthropogenic aerosol trace metal sources in the North Atlantic Ocean using Pb, Zn and Ni isotopes. Marine Chemistry 258:104347, https://doi.org/10.1016/j.marchem.2023.104347.

Forthcoming or planned GEOTRACES special issue publications

• de Souza, G. F. and A. K. Morrison. 2024. The Southern Ocean hub for nutrients, micronutrients, and their isotopes in the global ocean. Oceanography 37:46-59, Special Issue on Twenty Years of GEOTRACES, 10.5670/oceanog.2024.414.

Completed GEOTRACES PhD or Master theses

- Chen, Manyu. 2023. Insights of silicon benthic flux by studying silicon stable isotope in porewater from the abyssal sediments in the equatorial Pacific Ocean. M.Sc. thesis.
- Eisenring, Claudia. 2023. A data-constrained view of the marine biogeochemical cycle of zinc and its isotopes: advances in data-driven modelling. Ph.D. thesis, ETH Zurich. https://www.research-collection.ethz.ch/handle/20.500.11850/673686.
- Müsing, Kim. 2023. The record of oceanic zinc and nickel isotopes in marine sediment archives. Ph.D. thesis, ETH Zurich. https://www.research-collection.ethz.ch/handle/20.500.11850/603222.
- Schmitter, Janine. 2024. Testing the fidelity of diatom silicon stable isotope composition as a tracer of past changes in the marine silicon cycle. M.Sc. thesis, ETH.
- Sun, Mingzhao. 2023. Records of transition metal abundances and isotope compositions in the ancient ocean. Ph.D. thesis, ETH Zurich. https://www.research-collection.ethz.ch/handle/20.500.11850/635795.

Submitted by Gregory de Souza (gregory.desouza@eaps.ethz.ch).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN TURKEY

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

From May 2023 to May 2024, two comprehensive basin-wide cruises were conducted in the Sea of Marmara and the Black Sea during the May-June period. These expeditions were funded by both national sources (TÜBİTAK, strategic infrastructure funds) and the European Union's Horizon Program. Over 100 stations were investigated in both areas, with CTD casts and bottle sampling reaching depths of 1800 meters.



Figure TU-1. Stations of EU H2020 BRIDGE Black Sea Project 2023 June Cruise with R/V Bilim-2.

In the Black Sea, biogeochemical parameters were measured, including on-board measurements of redox species such as hydrogen sulfide, oxygen, and manganese. Sediment samples were collected in selected stations using a multi-corer on the Black Sea shelf for detailed biogeochemical analysis of porewater and solid sediment.

The European Research Council (ERC) Consolidator Grants program has funded the ERC DeepTrace project, which has recently completed the establishment of a new facility for metal inorganic nanoparticle analysis. This facility is one of the very few in the world, and the first of its kind in Turkey. It offers researchers cutting-edge capabilities for nanoparticle characterization using Field Flow Fractionation (FFF) and Dynamic Light Scattering (DLS).

Time-of-flight ICP-MS (icpTOF, Tofwerk), specifically designed for multi-elemental characterization of single nanoparticles. Notably, this TOF-ICP-MS is also equipped with an online microdroplet system (Quantistar, Tofwerk), enabling direct analysis with seawater matrices. Method development for a holistic methodology will begin soon. The TOF-ICP-MS with microdroplet calibration will work synergistically with the existing Nexlon 350X ICP-MS and its ESI SC4 DX SeaFast system for method comparison.



FigureTU-2. TOF-ICP-MS (icpTOF) with online microdroplet system (Quantistar).



Figure TU-3. FFF and DLS instruments on the left.

Additionally, on the metal-sulfur nanoparticles aspect, an acid-volatile sulfur speciation system has been established, and new results are expected to be obtained shortly. A deep-sea voltammetric system has acquired for deep sea dives, the system rates for 4000m depths.

GEOTRACES or GEOTRACES relevant cruises

• R/V Bilim, May-June 2023, Sea of Marmara and the Black Sea

New projects and/or funding

- Prof. Dr. Mustafa Yücel selected to become an associate member of the Turkish Academy of Science
- MARMOD-Phase 3: New Phase of the Sea of Marmara Integrated Modelling System Project: Prof. Dr. Mustafa Yücel, METU IMS, as Pl.

Other GEOTRACES activities

- Prof. Dr. Mustafa Yücel become the Turkey's ambassador for the BioGeoSCAPES community and attended the general assembly meeting in Woods Hole Oceanographic Institute.
- PhD student Nimet Alimli applied for the fellowship program of the BioGeoSCAPES.

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

- Correggia M, Di Iorio L, Bastianoni AB et al. Standard Operating Procedure for the analysis of trace elements in hydrothermal fluids by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) [version 1; peer review: 3 approved with reservations]. Open Res Europe 2023, 3:90 (https://doi.org/10.12688/openreseurope.15699.1)
- Correggia M, Di Iorio L, Bastianoni AB et al. Standard operating procedure for the analysis of major ions in hydrothermal fluids by ion chromatography [version 2; peer review: 2 approved with reservations]. Open Res Europe 2024, 3:94 (https://doi.org/10.12688/openreseurope.15605.2)

GEOTRACES presentations in international conferences

- Yücel, M., Alımlı, N., Gülmez, Z. A., Cura, H., & Demir, N. Y. (2023 0). Organic carbon distributions and carbon burial in a modern Proterozoic ocean analogue: the Sea of Marmara. Goldschmidt 2023 Conference, Lyon, Fransa. https://conf.goldschmidt.info/goldschmidt/2023/meetingapp.cgi/Paper/16176
- Yücel, M., Örek, H., Alımlı, N., Mantıkçı, M., Özhan, K., Fach Salihoğlu, B. A., Tezcan, D., Örek, Y., Kalkan, E., Arkın, Ş. S., & Salihoğlu, B. (2023 0). Phosphorus build-up, nitrogen loss and sulfide accumulation in response to recent deep-water deoxygenation in the Sea of Marmara. Goldschmidt 2023 Conference, Lyon, Fransa. https://conf.goldschmidt.info/goldschmidt/2023/meetingapp.cgi/Paper/15805
- Yücel, M., Alımlı, N., Cura, H., Demir, N. Y., Myroshnychenko, V., Fach Salihoğlu, B. A., Arkın, Ş. S., Tuğrul, S., & Salihoğlu, B. (2023 0). Western Black Sea suboxic layer biogeochemical structure during the December 2022 R/V Bilim Expedition.

Goldschmidt 2023 Conference, Lyon, Fransa. https://conf.goldschmidt.info/goldschmidt/2023/meetingapp.cgi/Paper/16120

- Alımlı, N., & Yücel, M. (2023 0). Benthic Iron Redox Mobilization Via Iron Reductive Respiration in Low Oxygen Seas: The Case of The Sea of Marmara. Goldschmidt 2023 Conference, Lyon, Fransa. https://conf.goldschmidt.info/goldschmidt/2023/meetingapp.cgi/Paper/16601
- Yücel, M., Alımlı, N., Borovinskaya, O., Demir, N. Y., Cura, H., Tanner, M., & Djurdjevic, S. (2023 0). Towards multi-element characterization of marine metal nanoparticles: First results from the suboxic zone of the Black Sea. Goldschmidt 2023 Conference, Lyon, Fransa.

https://conf.goldschmidt.info/goldschmidt/2023/meetingapp.cgi/Paper/15070

Submitted by Nimet Alimli (nimet@ims.metu.edu.tr).
ANNUAL REPORT ON GEOTRACES ACTIVITIES IN UNITED KINGDOM

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

MAHIEU, L., OMANOVIC, D., WHITBY, H., BUCK, K. N., CAPRARA, S. & SALAUEN, P. 2024. Recommendations for best practice for iron speciation by competitive ligand exchange adsorptive cathodic stripping voltammetry with salicylaldoxime. Marine Chemistry, 259.

 In this paper, the authors provide a set of best practices for the determination of the dissolved Fe organic speciation using the electroanalytical CLE-AdCSV titration method with the added ligand salicylaldoxime (SA). Detailed conditioning procedures are given to ensure a stable signal as well as a set of step-by-step guidelines to simplify and automate the often subjective CLE-AdCSV data treatment. The reproducibility of the method and the effect of varying equilibration procedures are assessed and discussed. This is important because it serves to resolve a range of issues hampering intercalibration of metal binding ligand methods and approaches.



Figure UK-1. Titration of the test seawater used for voltammetric cell and tubes conditioning with 25 μ M SA and buffered at pH 8.18 with 10 mM of borate. Duplicates voltammograms were recorded with 60s deposition time at +0.05 V. The green circles represent the data selected to determine LFe and log Kcond Fe'L. Grey circles represent the discarded data, corresponding to carry-over Fe in the cell from previous analysis at the start of the titration, and saturation of the working electrode with the last aliquot.

GEOTRACES or GEOTRACES relevant cruises

- GEOTRACES process study, GApr19 'N-ARC' completed in the Arctic Ocean (PI: Claire Mahaffey, GEOTRACES PI: Maeve Lohan)
- 17/1/24 9/3/24: The GEOTRACES approved process study cruise for Processes Influencing Carbon Cycling: Observations of the Lower limb of the Antarctic Overturning (PICCOLO) GApr20 was completed. The main objective of the cruise was to investigate and quantify the main processes that determine carbon cycling in the lower limb of the Southern Ocean overturning circulation, as such, the cruise was focussed around the Weddell Sea. Some analysis was conducted on board, but the main bulk of samples retuned to the UK last week (and are still making their way 'home').

New projects and/or funding

 New £4M NERC Large Grant on iron and manganese cycling in the Southern Ocean awared to Alessandro Tagliabue (PI, University of Liverpool), with several UK GEOTRACES co-investigators: Maeve Lohan (University of Southampton), Angela Milne and Simon Ussher (University of Plymouth) and Alex Baker (University of East Anglia)

Outreach activities conducted

- Arianna Olivelli translated to Italian all seven GEOTRACES Education videos available on YouTube and made subtitles available with the support of the GEOTRACES IPO office.
- Contribution to new Treatise chapter:
 - Little S.H., de Souza, G.F., Xie R. (2024) Metal Stable Isotopes in the Marine Realm. Treatise in Geochemistry 3rd Ed. [doi.org/10.1016/B978-0-323-99762-1.00019-X]

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

- Mahieu, L., Whitby, H., Dulaquais, G., Tilliette, C., Guigue, C., Tedetti, M., Lefevre, D., Fourrier, P., Bressac, M., Sarthou, G., Bonnet, S., Guieu, C., Salaün, P., 2024. Ironbinding by dissolved organic matter in the Western Tropical South Pacific Ocean (GEOTRACES TONGA cruise GPpr14). Frontiers in Marine Science 11. https://doi.org/10.3389/fmars.2024.1304118
- Little S.H., de Souza, G.F., Xie R. (2024) Metal Stable Isotopes in the Marine Realm. Treatise in Geochemistry 3rd Ed. [doi.org/10.1016/B978-0-323-99762-1.00019-X]
- Tagliabue, Alessandro and Thomas Weber, Novel insights into trace metal cycling from biogeochemical models, Oceanography, in press. 2024.

- Anugerahanti, P., and Alessandro Tagliabue, Response of Southern Ocean Resource Stress in a Changing Climate, Geophysical Research Letters, 51(10), doi:10.1029/2023gl107870. 2024
- Wang, W., A. J. M. Lough, H. Goring-Harford, O. Flanagan, D. González-Santana, J. Resing, D. Connelly, M. C. Lohan, Alessandro Tagliabue, and R. H. James, Fractionation of iron and chromium isotopes in hydrothermal plumes from the northern Mid-Atlantic Ridge, Earth and Planetary Science Letters, 624, doi:10.1016/j.epsl.2023.118468. 2023.
- MAHIEU, L., OMANOVIC, D., WHITBY, H., BUCK, K. N., CAPRARA, S. & SALAUEN, P. 2024a. Recommendations for best practice for iron speciation by competitive ligand exchange adsorptive cathodic stripping voltammetry with salicylaldoxime. Marine Chemistry, 259.
- König, D. and Alessandro Tagliabue, The fingerprint of climate variability on the surface ocean cycling of iron and its isotopes, Biogeosciences, 20, 4197–4212, https://doi.org/10.5194/bg-20-4197-2023, 2023.
- Xue-Gang Chen, Angela Milne, Jessica K. Klar, Martha Gledhill, Maeve C. Lohan, Yu-Te Hsieh, Gideon M. Henderson, E. Malcolm S. Woodward, Eric P. Achterberg, (2024). Controls on distributions of aluminium, manganese, and cobalt in the South Atlantic Ocean along GEOTRACES transect GA10. Geochemica et Cosmochimica Acta, Volume 373, 15th May 2024, Pages 177-196, https://doi.org/10.1016/j.gca.2024.03.019

Please indicate if there is any forthcoming or planned GEOTRACES special issue publication

 Portlock. G, Whitby. H, Salaün. P., 2024. Distribution and behaviour of reduced sulfur substances in the oligotrophic and hydrothermal waters of the Western Tropical South Pacific. Frontiers (in review) – Special issue (Hydrothermal and submarine volcanic activity: Impacts on ocean chemistry and plankton dynamics)

Completed GEOTRACES PhD or Master theses

- Yee-Lap Leung, Imperial College London, submitted a PhD thesis associated with the GEOTRACES GA13 (FRidge) and GS01 transects, entitled "Lead Isotope Tracing of Terrigenous, Hydrothermal and Anthropogenic Lead Sources in the Ocean". Completed August 2023.
- PORTLOCK, G. 2023. The sources and sinks of thiols, reduced sulphur substances, and humic-like substances in hydrothermal waters. PhD Thesis, University of Liverpool.
- MAHIEU, L. 2023. Analytical challenges, development and application of CLE-ACSV for the determination of the organic speciation of iron in marine waters. PhD Thesis, University of Liverpool.

GEOTRACES presentations in international conferences

- Olivelli, A., Paul, M., Xu, H., Rijkenberg, M., Middag, R., Henderson, G., Weiss, D.J., van de Flierdt, T. and Rehkämper, M. Lead isotopes as tracers of anthropogenic pollution and oceanographic processes in the South Atlantic Ocean. Ocean Sciences Meeting 2024.
- Olivelli, A., Murphy, K., Bridgestock, L., Wilson, D.J., Rijkenberg, M., Middag, R., Weiss, D.J., van de Flierdt, T. and Rehkämper, M. Decline of anthropogenic lead in South Atlantic Ocean surface waters from 1990 to 2011: New constraints from concentration and isotope data. Goldschmidt 2023.
- Millie Goddard-Dwyer. Biogeochemical Cycling of Iron Binding Humic Ligands in the South-West Indian Sector of the Southern Ocean. Oral Presentation. Challenger Society for Marine Science 150 Conference September 2022
- Millie Goddard-Dwyer. The Role of Humic Substances in Fe Cycling in the South-West Indian Sector of the Southern Ocean. Oral Presentation. Ocean Sciences Conference February 2024
- Alessandro Tagliabue. Mineral iron cycling. Oral Presentation. Ocean Sciences Conference February 2024

Submitted by Alessandro Tagliabue (a.tagliabue@liverpool.ac.uk).

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN UNITED STATES

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

With 32 peer-reviewed publications in the past year (see attached list) there are too many results to describe them all. Therefore, the approach here is to begin by listing the projects involving US GEOTRACES investigators that were featured as GEOTRACES science highlights during the reporting period. See: < https://www.geotraces.org/category/science/newsflash/>. Following that we will report briefly on the status of GEOTRACES section GP17-ANT, completed in January 2024, and then on US GEOTRACES process studies.

<u>Science highlights</u>, in reverse chronological order, with the name of the lead investigator, included:

Highlight Date	Lead P.I.	Synopsis
March 20, 2024	W.S. Moore	<i>Moore and colleagues</i> establish radium-228 (²²⁸ Ra, half-life of 5.7 years) distributions along the GP15 meridional transect from Alaska to Tahiti. Because ²²⁸ Ra is sourced from sediments, regions of enhanced activity represent water that has recently interacted with sediments on the continental margin or seabed. The ²²⁸ Ra data allow the authors to trace surface and subsurface ocean current patterns in the Pacific and to compare with earlier measurements of ²²⁸ Ra to reveal the origins of the enriched regions. An enriched region at the Alaska margin was source locally. A large shallow region between 47° and 32°N. was sourced from the west by the North Pacific Current; another shallow enriched region between 11° and 5°N was also sourced from the west by the North Equatorial Countercurrent. Subsurface enrichments (100–400 m) between 18 and 47°N were associated with Central Mode Water and North Pacific Intermediate Water. Near the seabed they discovered a region of enhanced ²²⁸ Ra activity indicating intense sediment-water interactions. For example, between 27 and 47°N near-bottom inventories average four times greater than the other stations on GP15, likely resulting from a sluggish circulation in this region, leading to long water residence times and ²²⁸ Ra

		build-up. Such regions may control the release of trace elements and isotopes (TEIs) from the seabed to the water column. On global scales, the study compares ²²⁸ Ra distributions integrated in the near-surface in the Pacific, Indian and Atlantic oceans. The different ²²⁸ Ra distributions emphasize how ocean circulation features are reflected in the ²²⁸ Ra abundances. <i>doi:</i> <u>10.1029/2023JC020564</u>
February 21, 2024	Y. Gu	<i>Gu and co-authors</i> investigate the interannual variability in dFe concentrations and their response to El Niño–Southern Oscillation (ENSO) events from multiple cruise campaigns during the period 1984-2017, including GEOTRACES GP16 section among those. Oxygen minimum zones are well recognized as hotspots of redox sensitive trace metal cycling, often featuring especially high concentrations of the micronutrient iron (Fe). The Peruvian shelf, particularly between 9° S and 17°S where the shelf is broad, is extremely productive and known to feature benthic dFe effluxes which are amongst the highest measured globally. The authors find that, in a narrow coastal band Fe correlates to the ENSO index with lower Fe concentrations during El Niño events and higher, more variable, concentrations during cold ENSO phases. Both surface and subsurface layers dFe concentrations tend to be lower as wind speed increases. In contrast, upwelling intensity has a limited impact on dFe concentrations, and no significant correlation was found for the southern Peru coastal region. <i>doi:</i> 10.1016/i.pocean.2024.103208
January 31, 2024	CY. Chang	<i>Chang and co-authors</i> report the distribution of the dissolved and labile particulate aluminum (Al), manganese (Mn), iron (Fe), cobalt (Co), and lead (Pb) in the subarctic Pacific Ocean during the GEOTRACES Japan KH-17-3 cruise and along the 47° N zonal transect (GEOTRACES GP02). In addition, vertical distributions of dCo were compared at crossover stations (GP15). The study provides a comprehensive view of dissolved and particulate trace metal distribution in the

		subarctic Pacific Ocean. An intensive boundary scavenging occurs off the coast of Alaska covering ca. 250 km width, limiting the impact of the continental sources (fluvial and sediment inputs) in this area. At the easternmost station, the effect of the hydrothermal activity of the Juan de Fuca Ridge influences the distribution of deep-water trace metals. The authors also analyze the full-depth transport of dMn and lpMn along isopycnal surfaces along the GP02 section. In addition, the temporal study of Pb distributions confirms that declining of anthropogenic emissions of Pb resulted in a decadal change in dPb in the center of the subarctic gyre. <i>doi:</i> 10.1007/s10872-023-00710-8
November 21, 2023	M. Fourquez	Fourquez and co-authors conducted dissolved iron (dFe) uptake experiments with Phaeocystis antarctica, in order to establish processes controlling the dFe bioavailability in natural samples of the Southern Ocean. They show that the degree of bioavailability varied regardless of in situ dFe concentration and depth. This first result challenges the consensus that sole dFe concentrations can be used to predict Fe uptake in modeling studies. In addition, the range of this degree of bioavailability is wider than previously thought (<1 to ~200% compared to free inorganic Fe') with higher bioavailability found near glacial sources. The study's coupled dataset of Fe-binding ligands, dFe bioavailability, and δ^{56} Fe offers a chance to tease apart these processes further. Contrasting again with previous assumptions, they observe a negative correlation between dissolved δ^{56} Fe and total ligand concentrations, which might suggest against a role for complexation in driving dissolved δ^{56} Fe toward higher values. <i>doi:</i> <u>10.1126/sciadv.adf9696</u>
October 17, 2023	Ö. Z. Mete	Mete and colleagues used Machine Learning (ML) to predict the global distribution of oceanic barium (Ba). Models were first trained to predict [Ba] from standard oceanographic observations using GEOTRACES data from the Arctic (GIPY11, GN01), Atlantic (GA03, GA10, GA02), Pacific (GP15, GP16), and Southern oceans (GIPY04, GIPY05). Model predictions of [Ba] were then

		compared with actual [Ba] data from the Indian
		Ocean (GEOSECS, INDIGO 1-3, SR3, SS259) with
		the best models achieving a mean absolute
		percentage error of just 6.0 %. This successful
		comparison allowed the authors to calculate the
		global distribution of [Ba], Ba*, and marine barite
		saturation using data from the World Ocean Atlas
		2018. This approach revealed four significant
		findings: 1) the ocean contains 122±7 Tmol of
		dissolved Ba; 2) the variability in the barium–
		silicon relationship is consistent with the
		biogeochemical characteristics of both elements;
		3) marine barite saturation exhibits systematic
		spatial and vertical variations; 4) taken as a whole,
		the ocean below 1000 m is at equilibrium with
		respect to barite. These results have broad
		implications, both for the modern ocean and for
		interpreting paleo-records of barite, with minor
		adjustments, their approach could be employed
		to make predictions for other dissolved tracers in
		the sea. The model, the data used in training and
		validation, and global outputs are available in
		Horner and Mete (2023,
		https://doi.org/10.26008/1912/bco-
		dmo.885506.2). <i>doi</i> : <u>10.5194/essd-15-4023-2023</u>
October 16, 2023	N. Kemnitz	Kemnitz and co-authors examine Actinium-227
		(²²⁷ Ac), radium-226 (²²⁶ Ra) and radium-228 (²²⁸ Ra)
		profiles in sediments that were measured and
		modeled at 5 stations in the Northeast Pacific
		Basin with the objective of characterizing their
		behavior and fluxes into the overlying water
		column. Data allowed the distribution coefficient
		(Kd) between the solid and liquid phases for Ac
		and Ra. A strong positive correlation is observed
		between Ra and ²²⁷ Ac Kd values, with ²²⁷ Ac being
		almost 6.6 times higher than Ra Kd values, and
		both co-varying with the MnO2 in solid phases.
		The source function of ²²⁷ Ac in the Northeast
		Pacific was determined by two independent
		methods: core incubation and reaction transport
		models. The authors also established the Ra
		fluxes. The largest ²²⁷ Ac and Ra isotope fluxes are
		near the center of the Northeast Pacific (~37°N).
		Smaller ²²⁷ Ac, ²²⁸ Ra and ²²⁶ Ra fluxes occur north of
		40°N, primarily due to dilution of their
		protactinium and thorium ancestors by higher

		sediment accumulation rates. doi:		
		j.marchem.2022.104180		
July 3, 2023	N. Lanning	The ratios of stable dissolved Pb (dPb) isotopes		
-		(²⁰⁶ Pb/ ²⁰⁷ Pb & ²⁰⁸ Pb/ ²⁰⁶ Pb) have been used to trace		
		the origin of oceanic dPb capable of		
		distinguishing anthropogenic versus natural		
		sources. In the modern North Pacific,		
		anthropogenic dPb input from Asia is the		
		dominant Pb source to the upper ocean,		
		exhibiting a characteristic isotope signature. dPb		
		concentrations deep in the North Pacific water		
		column have also been progressively increasing.		
		This is hypothesized to result from intense		
		scavenging of anthropogenic dPb isotopes to		
		sinking particles in the upper ocean with		
		subsequent 'reversible-scavenging' desorbing Pb		
		back into the dissolved phase of the deep ocean		
		as the particles sink. Lanning and co-authors have		
		observed how changes in scavenging intensity		
		and particle loading influence this isotope		
		exchange on a basin-scale. The authors assessed		
		the role of particle-rich 'veils' in the vertical		
		transport of anthropogenic dPb isotopes using		
		the GEOTRACES GP15 section. Only within the		
		particle veils do anthropogenic dPb isotope ratios		
		extend from the upper ocean to the seafloor.		
		overprinting the background pre-industrial water		
		column isotope signatures. These isotope effects		
		coincide with elevated particulate inorganic		
		carbon (PIC) and suspended particulate matter		
		emphasizing the importance of high particle-		
		loading to facilitate sufficient isotope exchange		
		A 1-D box model was implemented to quantify		
		how only within high-flux yeils is reversible dPb		
		isotope exchange between the particulate and		
		dissolved phases fast enough to supply		
		anthropogenic dPb from the upper ocean to		
		depth. The work further contains the role that		
		reversible scavenging may play in the cycling of		
		Ph in the ocean, an ever-evolving global		
		experiment where Pb contamination can be		
		tracked in real-time doi:		
		10 1073/ppas 2219688120		
May 17 2023	M Sieber	Sieber and co-authors explain some of the		
11109 17,2020		mechanisms that control the behavior of 7n in the		
		Pacific Ocean, and more globally, from		

		measurements of dissolved Zn concentration and
		isotopic compositions ($m{\delta}^{ m \scriptscriptstyle 66}$ Zn) along the
		GEOTRACES GP15 section (from Alaska to Tahiti
		along 152°W). Their data reveal a relationship
		between Zn and Si in the north Pacific,
		contrasting with a linear relationship in the
		Southern part of the section (equatorial and
		tropical parts). The main findings of this study are:
		1) reversible scavenging is required as an
		additional process transferring Zn from surface to
		depth, explaining a deep Zn concentration
		maximum below the PO4 maximum that is not
		specifically linked to Si and 2) reversible
		scavenging together with fractionation during
		ligand assimilation provides an explanation for
		the observed isotope distribution, leaving
		subsurface upper ocean waters imprinted by
		lower δ^{66} 7n. Deeper, release of heavy 7n then
		coincides with the PO ₄ maximum during particle
		remineralization causing a subtle mid-depth
		δ^{66} 7n maximum. Moreover, making use of δ^{66} 7n
		data from a crossover station between US
		GEOTRACES GP15 and Japanese GP02 the
		authors were able to show that this mechanism of
		scavenging of isotopically heavy zinc is linked to
		seasonal physical stratification and is an important
		process influencing surface and subsurface δ^{66} 7n
		signals in the North Pacific Ocean. Globally, it
		also provides an evolution for isotopically light
		also provides an explanation for isotopically light
		Zi at shallow depths and corresponding elevated \mathbf{S}_{0}^{607} as a single score dominantly in
		mid-depth o 2h signals, seen dominantly in
		ocean regions away from strong Southern Ocean
M 1/ 2022		control. dol: <u>10.1029/2022jc019419</u>
May 16, 2023	M. Sieber	Sieber and colleagues established the
		distribution of dissolved cadmium (Cd)
		concentrations and isotopes at 23 stations
		(represented as o ¹¹ Cd) along the meridional
		GEOTRACES GP15 section from Alaska to Tahiti
		along 152°W. The data reveal northern Cd-rich
		high-nutrient low-chlorophyll waters and Cd-
		depleted waters in the subtropical and equatorial
		Pacific. In the open ocean, a biogeochemical
		model simulates the data in Cd-depleted surface
		waters, with the lowest Cd concentrations
		influenced by atmospheric inputs of isotopically
		light Cd. Below the surface (and surprisingly even

		in the North Pacific Ocean), Cd parameter distributions are essentially controlled by Southern Ocean processes, water mass mixing and regeneration. Cd-depleted Antarctic Intermediate Water has a far-reaching effect on North Pacific intermediate waters as far as 47°N, contrasting with northern-sourced Cd signatures in North Pacific Intermediate Water. The study also reveals that a correlation between the North Pacific phosphate maximum and a negative Cd* signal at depth in the North Pacific Ocean reflects a regeneration signal of Cd and PO ₄ at a slightly lower Cd:P ratio than the deep ocean ratio (0.35 mmol mol–1), contradicting the hypothesis that a negative Cd* signal is due to in situ removal processes in low-oxygen waters. <i>doi: 10.1029/2022gb007441</i>
May 12, 2023	M. Grenier	<i>Grenier and co-authors</i> measured the ⁷ Be activity in suspended particles collected in and below the mixed layer in oceanic regions of the Mediterranean Sea, the Southern Ocean and the subpolar Atlantic (section GEOVIDE/GEOTRACES GA01). While the ⁷ Be _p activity generally monotonically decreases with depth below the mixed layer, they reveal that, at least in some oceanic regions, the removal of ⁷ Be by marine particles may be significant. The ⁷ Be _p fraction ranges from 2% to 32% of the total ⁷ Be activity along the GEOVIDE section in the North Atlantic. In the Labrador Sea, the comparison of the ⁷ Be _p inventories with the dry ⁷ Be deposition fluxes estimated from aerosol samples collected during GEOVIDE suggest that a significant portion of ⁷ Be _p may be removed by sinking particles. The authors propose that future research should focus on quantifying the downward export of ⁷ Be _p to deep waters, and on assessing its temporal and spatial variability and recommend that future sampling programs should aim to collect seawater and particulate samples at the same locations, depths and time. <i>doi:</i> <u>10.1016/j.dsr.2023.103967</u>

GEOTRACES or GEOTRACES relevant cruises

Section Cruises

During the reported period, GEOTRACES Section GP17 was completed. GP17 was planned as a two-leg expedition, with its first leg (GP17-OCE) as a southward extension of the 2018 GP15 Alaska-Tahiti expedition and the second leg (GP17-ANT) sailing into coastal and shelf waters of Antarctica's Amundsen Sea.

The U.S. GEOTRACES GP17-ANT expedition departed Punta Arenas, Chile on November 29th, 2023 and arrived in Lyttelton, New Zealand on January 29th, 2024. The cruise took place in the Amundsen Sea aboard the R/V Nathaniel B. Palmer with a team of 35 scientists led by Peter Sedwick (Old Dominion University), Phoebe Lam (University of California, Santa Cruz) and Robert Sherrell (Rutgers University).

A primary objective of this cruise was to determine the sources of trace element nutrients that support the intense phytoplankton blooms that are often observed in coastal regions around Antarctica. Essential micronutrients include iron, zinc, manganese, copper, nickel and cobalt. Other trace elements and isotopes (TEIs; e.g., aluminum, manganese, and isotopes of nitrogen, thorium and neodymium) are intended to help constrain the source(es) of micronutrients. In the Southern Ocean, the Antarctic continental margins are important as sources of micronutrient trace elements such as iron, which fuels biological production and carbon export over the Antarctic shelf and in offshore waters of the Antarctic Circumpolar Current. Moreover, these regions are experiencing rapid environmental changes that are expected to impact oceanic circulation and biogeochemical cycles, for which TEIs provide crucial tracers and provide data needed to test and refine numerical models of the Earth system. The Amundsen Sea sector holds particular interest because of the pronounced, decadal-scale increases in the basal melt rates of glacial ice shelves that border the region, driven by intrusions of warm Circumpolar Deep Water (CDW) onto the continental shelf. This melting has potentially major impacts on global sea level, on the formation of Antarctic Bottom Water in the Ross Sea, and on primary production via mobilization of benthic and glacial iron and other TEIs mediated by these processes. This cruise was designed to address a wide range of topics such as the sources, fate and impacts of bioactive trace elements; the distribution and transport of glacial melt; the compositional evolution of CDW as it upwells and circulates on the shelf; the rates and elemental stoichiometry of biological and biogeochemical processes; and the veracity of paleoenvironmental proxies and numerical model simulations.

The almost two-month cruise was largely successful in achieving its science goals, with 21 stations over the Amundsen Sea continental shelf, 3 stations over the continental slope and 3 off-shelf stations, including one deep-ocean station as a crossover with the preceding GP17-OCE cruise. All stations included collections of samples with a near-surface towfish, a conventional CTD-rosette, a trace-metal clean CTD-rosette, and McLane in-situ pumps. Additional sampling activities included the collection of aerosols, precipitation, sea ice and snow as well as sediment cores for pore-fluid extraction and high-volume pumped seawater samples for radium isotopes and beryllium-7. The heavy sea ice cover prevented access to a number of planned stations including the Thwaites Ice Shelf, Pine Island Bay and the eastern portion of the outer Amundsen Sea shelf.

Nonetheless, samples were collected from stations adjacent to the Dotson and Getz Ice Shelves, as well as on- and off-shelf stations impacted by melting sea ice, polynya stations where phytoplankton biomass was extraordinarily high (up to 30 μ g chl/liter), and a station adjacent to fast ice with near-zero chlorophyll fluorescence. With support from the U.S. National Science Foundation samples were collected for 23 separate science projects, which together encompass measurements of nearly all of the GEOTRACES key trace elements and isotopes.



Figure US-1. Track and station locations for GEOTRACES Section GP17-ANT.

Samples that were collected on GP17-ANT for distribution to investigators in the US are summarized in the following tables.

Table US-1: GP17-ANT Sampling Stations

Here, approximate station coordinates and bottom depths are presented to the nearest 0.1' or 10 m, respectively.

Station	Latitude (S)	Longitude (W)	Туре	Dates	Depth (m)
1	61°36.6'	62°46.2'	soak	2 December 2023	3450
1.5	65°25.8'	72°55.2'	towfish test	4 December 2023	ND
2	65°13.8'	78°51.6'	test	5 December 2023	4040
3	67°00.0'	100°00.0'	full	7-10 December 2023	4700
4	71°00.0'	113°00.0'	full	12-14 December 2023	2740
5	71°31.5'	116°21.2'	shelf	14-15 December 2023	1020
6	72°20.0'	116°00.0'	shelf	16 December 2023	530
7	72°57.9'	115°45.1'	super	17 December 2023	680

8	73°20.0'	116°00.0'	shelf	18 December 2023	500
9	74°04.0'	116°00.0'	shelf 19 December 2023		1070
10	73°38.5'	115°58.8'	shelf	20 December 2023	730
11	73°44.0'	114°00.0'	shelf	21 December 2023	530
12	74°05.4'	110°16.4'	shelf	22 December 2023	460
13	74°14.7'	112°20.1'	shelf	23-24 December 2023	1070
14	74°11.0'	113°22.0'	super	24-25 December 2023	550
15	73°20.0'	115°00.0'	shelf	25-26 December 2023	890
16	73°00.1'	113°46.7'	shelf	26-27 December 2023	470
17	73°00.4'	112°11.7'	super 27-28 December 2023		420
18	73°02.8'	111°11.7'	shelf 28 December 2023		320
19	73°00.0'	118°00.0'	shelf	29-30 December 2023	410
20	73°50.9'	118°20.5'	shelf	30-31 December 2023	1240
				31 December 2023-	580
21	73°29.3'	118°22.1'	shelf	1 January 2024	
22	72°59.0'	118°49.9'	shelf 1-2 January 2024		400
23	72°33.5'	118°56.3'	shelf 2 January 2024		470
24	71°58.3'	119°08.1'	super 3 & 6 January 2024		1410
25	71°30.9'	119°00.5'	full	4-5 January 2024	2060
26	74°22.2'	130°56.2'	shelf	9-10 January 2024	470
27	74°21.1'	128°33.5'	shelf	10-11 January 2024	820
28	73°54.5'	127°22.7'	shelf	11 January 2024	780
29	73°27.7'	132°54.0'	semi-super	12-13 January 2024	1590

 $\label{eq:table_transform} \textbf{Table US-2}. \ \textbf{PI}, \ \textbf{parameters}, \ \textbf{and} \ \textbf{samplers} \ \textbf{of ODF} \ \textbf{(standard)} \ \textbf{rosette system}.$

Role/PI(s)	Parameter	Sampler
SIO-ODF team	dissolved oxygen	Barna/Chung
SIO-ODF team	salinity, nutrients	Matthias/Mau
Loose, Seltzer	noble gases, noble gas isotopes	Passacantando
Woosley	DIC, pH, alkalinity	Woosley
Wang	${f \delta}^{{\scriptscriptstyle 15}}$ N in nitrate, TDN, ammonium	ODF Supertechs
Wagner, Loose	δ ¹⁸ O and δ ² H in H ₂ O	ODF Supertechs
Loose	3Н	Passacantando
Saito	vitamin B-12	ODF Supertechs
Resing	DMn	ODF Supertechs
Cutter	DOS	ODF Supertechs
Hayes	Th isotopes and ²³¹ Pa	ODF Supertechs
Zheng	REEs	ODF Supertechs
Management team	pigments	ODF Super techs
Sherrell	F _v /F _m	Passacantando
Buesseler	²³⁴ Th	Bam

Charette	Ra isotopes	ODF Supertechs/Debyser
Debyser	δ ³² Si	ODF Supertechs/Debyser

 Table US-3. PI, parameters, and samplers of GTC (trace metal clean) rosette system.

<u>Membrane side</u>			<u>Acropak side</u>		
<u>PI</u>	Sample type		<u>PI</u>	<u>Sample type</u>	
Becker	Oxygen*		Becker	Salinity*	
Moffett	Fe(II), I**		Becker	Nutrients*	
Becker	Salinity*		Whitmore	V, Ga, Ba	
Loose	¹⁸ O of seawater*		Hawco	Zn ligands	
Twining	Cell quotas SXRF*		Resing	Archive ICP-MS, FIA	
Morton	Diatom frustule Zn*		Resing	Shipboard DAI, DMn, DFe	
Mason	Hg speciation**		Fitzsimmons	Dissolved TMs	
John	Cu/Ni isotopes**		Fitzsimmons	Colloidal TMs	
Mix Go-Elos	Attach 25 mm		Conway	Fe/Zn/Cd isotopes	
WIX 00-1103	Swinnex filter holder				
Boiteau	SPE ligands***		K. Buck/Bundy	Ligands (CSV)	
Complete particle	2 h or filter clogs***				
filtration –	(Acropak used to		K Buck/Bundy	Ligands (CSV)	
Sherrell/Morton	finish SPE ligand		R. Buck/Bundy	Liganus (CSV)	
	sample as necessary)				
*unfiltered sample			Saito	DCo	
**Acropak filtered			Saito	Labile Co	
			Boyle	Pb isotopes	

 Table US-4.
 PI and parameters from the Niskin-X sampler deployed on the multicorer.

<u>PI</u>	Subsample type	<u>PI</u>	Subsample type
1. Becker	Salinity (unfilt.)	Acropak-filtered	(continued)
2. Becker	Nutrients (unfilt.)	12. Saito	DCo
3. Loose	¹⁸ O of seawater (unfilt.)	13, Saito	Labile Co
Attach Acropak		14 Basak	DEE
filter			
4. Moffett	Fe(II), I	15. K. Buck/Bundy	Ligands (CSV) -1
5. Whitmore	V, Ga, Ba	16. K. Buck/Bundy	Ligands (CSV) -2
6. Hawco	Zn ligands	17. Mason	Hg speciation, Acropak
7. Resing	Archive ICP-MS, FIA	18. John	Cu/Ni isotopes
8 Posing	Shipboard DAl, DMn,	Mix Niskin-X	Attach 0.45 µm Supor membrane
o. Resing	DFe	sampler	filter
9. Fitzsimmons	Dissolved TMs	19. Mason	Нд
10. Fitzsimmons	Colloidal TMs	20. Boiteau	SPE ligands
11. Conway	Fe/Zn/Cd isotopes	21. Sherrell/Morton	Particles on 0.45 µm Supor

		membrane

PI	parameter	Sample fraction and processing notes	container	representative at sea
Hayes/Anderso n/ Edwards	²³⁰ Th/ ²³¹ Pa	¼ Qp, 5/16 Supor: laminar dry	cleanroom bags	Marty Fleisher
Zheng	Nd, REE	3/16 Qp: laminar dry; Supor: share w/ Th/Pa	cleanroom bag	Marty Fleisher
Buesseler (CafeTh)	²³⁴ Th	¼-7/8 Sp: CafeTh rinse onto Ag then oven dry; 25 mm QMA: oven dry	150mm petri (from CafeTh)	Wokil Bam, Steve Pike
Wang/ Sigman	δ ¹⁵ N	32 mm QMA, 1/8 Sp: laminar dry	cleanroom bag	Kameko Landry
Charette	²²⁶ Ra	"rest of QMA": oven dry	Ziploc bag	Margot Debyser
C. Buck/Marsay	⁷ Be	"rest of QMA": oven dry	Ziploc bag	Chris Marsay
John	TM isotopes	Supor: laminar dry	cleanroom bag	none
Ohnemus	pTM total	1/16-1/8 Qp: rinse onto 0.8 µm Supor then laminar dry; 3/16 Supor: laminar flow dry	Qp: leached petrislide; Supor: cleanroom bag	Phoebe Lam, Allison Laubach
Lam	pTM leach	1/16 Qp, 1/16 Supor: laminar dry	cleanroom bag	Phoebe Lam, Allison Laubach
	XRF	1/16 Supor: laminar dry	cleanroom bag	Phoebe Lam, Allison Laubach
	bSi	1/16 Qp, 1/16 Supor: laminar dry	cleanroom bag	Phoebe Lam, Allison Laubach
	PIC	1/16 Qp: laminar dry; 25 mm QMA: oven dry	cleanroom bag	Phoebe Lam, Allison Laubach
	C/N+ isotopes	Sp, QMA: post ²³⁴ Th	see ²³⁴ Th	Phoebe Lam, Allison Laubach
	archive	0-1/16 Qp, 0-3/4 Sp, 4*1/16 Supor: laminar dry; 32 mm QMA: oven dry	cleanroom bag	Phoebe Lam, Allison Laubach
Mason/Lambor g	рНд	2*1/16 Qp, 2*25 mm QMA: laminar dry	Qp: cleanroom bags; QMA: petrislides	Carl Lamborg, Marissa Despins
Moffett	I	25 mm QMA: oven dry	60 mm petri dish	Alexis Floback
Boiteau/Repeta	ligands	32 mm QMA: -80°C	teflon-lined Ziplocs	Nicole Coffey
Saito	proteins	1/8 Qp, 47 mm QMA: -80°C	Qp, QMA: 5 mL cryovials; QMA	Annie Stefanides

Table US-5. McLane pump particle subsamples.

leftovers: Ziploc	
bags	

Notes: All "oven dry" QMA samples were dried on reused 150 mm polystyrene petri dishes in the Cafe-Th oven set at 55°C. All "laminar dry" samples were dried on leached eggcrate grids on eggcrate shelves in a Mystair laminar flow bench inside the bubble. The "rest of QMA" samples were the leftovers after punching out all subsamples. These were oven dried for ²²⁶Ra (Charette) at 11 stations (Stations 3-10; 24, 25, 29); at the remaining 16 stations (Stations 11-23, 26-28), the "rest of QMA" samples were folded and placed fresh into Ziplocs into the fridge, then subsequently into - 80°C for proteins (Saito). At Stations 3, 4, 24, 25, 29, the upper 200 m samples will be first counted for ⁷Be (Buck/Marsay) by Mark Stephens before sending to Charette for ²²⁶Ra.

Station	Cores collected	Pore water	Pore water	Sectioned	Cores used
	(of possible 12)	intervals	intervals	solid-phase	for radium
		sampled	sampled for REE	samples	incubation
5	12/12	12	10	15 intervals	3 cores
7	11/12	13	10	15 intervals	1 core
10	11/12	12	12	15 intervals	1 core
14	8/12	11	12	15 intervals	-
15	12/12	12	12	15 intervals	1 core
17	11/12	11	12	15 intervals	1 core
21	12/12	12	12	15 intervals	1 core
25	10/12	11	9	13 intervals	-
27	12/12	12	10	15 intervals	-

Table US-6. Summary of cores collected during the cruise and core subsampling details.

Table US-6 (continued). Summary Core subsampling details

Station	Intervals	Intervals	Intervals	Intervals	Intervals	Intervals
	sampled for	sampled for				
	acidified	Hg in pore	Fe(II) in	ligands* in	N isotopes in	nutrients in
	pore waters	waters	pore waters	pore waters	pore waters	pore waters
5	12	12	11	11	12	12
7	13	11 + bulk	10	11	12	12
10	12	11	10	9	11	11
14	11	11	11	10	11	11
15	12	12	10	9	11	12
17	11	10 + bulk	10	11	11	10
21	12	11 + bulk	11	11	11	11
25	11	10 + bulk	11	11	10	11
27	12	11 + bulk	10	11	12	11

*this is the maximum number intervals sampled for the two groups measuring ligands

Table US-7. Summary of sea-ice stations and associated sampling.

Stn 4	Start	2023-12-16 04:08	-71.5345 N, -116.7368 E	
		UTC		Community, TM Sectioned,
Stn 4	End	2023-12-16 07:22	-71.5478 N, -116.7495 E	Seawater, Brine, DNA, Snow
		UTC		
Stn 12	Start	2023-12-23 06:09	-74.0674 N, -109.954 E	Community, Fe-differential Melt,
		UTC		Overflow, Snow (TM, Beryllium,
Stn 12	End	2023-12-23 13:28	-74.0674 N, -109.9539 E	Tritium), Tritium, Radium,
		UTC		Temperature
Stn 20	Start	2023-12-31 17:09	-73.6737 N, -118.4846 E	
		UTC		Snow, TM Sectioned, Brine,
Stn 20	End	2023-12-31 20:33	-73.6507 N, -118.5042 E	Temperature
		UTC		
Stn 24	Start	2024-01-07 03:06	-71.9362 N, -119.4478 E	Community, TM Sectioned,
		UTC		Temperature/DNA, Tritium,
Stn 24	End	2024-01-07 06:26	-71.939 N, -119.4411 E	Radium, Snow (TM, Beryllium,
		UTC		Tritium)
Stn 28	Start	2024-01-12 10:16	-73.9111 N, -128.0697 E	
		UTC		Snow (TM, Beryllium), Seawater,
Stn 28	End	2024-01-12 12:15	-73.9111 N, -128.0424 E	Slush
		UTC		

Process Study Cruises

A seven-PI GEOTRACES process study on the West Florida Shelf (WFS), "STING" (Submarine Groundwater discharge, Trichodesmium, Iron, and Nitrogen in the Gulf of Mexico) has completed two cross-shelf cruises in Feb/Mar and July 2023, as well as quarterly sampling of submarine groundwater wells, rivers, and estuaries. The team presented preliminary results at the Ocean Sciences Meeting in February 2024, including evidence for geochemically distinct margin sources entering the WFS from the north vs. south of Tampa Bay, as well as distinct organic matter composition and dynamics associated with Trichodesmium spp. and with a bloom of the harmful algae *Karenia brevis* encountered on the Feb/Mar cruise. Next, the team will determine cross-shelf elemental fluxes from distinct margin sources using radium isotopes mass balances. They will also evaluate whether submarine groundwater discharge is the dominant source of bioavailable organic nutrients and iron on the WFS, and whether submarine groundwater discharge-derived trace metals influence the distribution and rates of nitrogen fixation by Trichodesmium spp. on the WFS.

New projects and/or funding

• There is no new funding for US GEOTRACES during the current reporting period, but proposals for two process studies are under preparation, and we anticipate that proposals for these process studies will be submitted in the next year. A proposal for work in the Gulf of Mexico is to be submitted in August 2024, and we anticipate that a proposal to work off the west coast of the US will be submitted to the US NSF in February, 2025. Additional information about these process studies is provided in the next section of this report.

GEOTRACES workshops and meetings organized

- The US GEOTRACES SSC met in person in Alexandria Virginia on 20 and 21 June 2023. At its previous meeting, with approval from the US NSF (which funds US GEOTRACES), the SSC decided that US GEOTRACES would undertake no more section cruises. The SSC reached this policy decision by concluding that the GEOTRACES global survey is nearly complete, and that it is time to transition into studies that are focused on specific processes that supply, cycle or remove TEIs in the ocean. US GEOTRACES also plans to pursue synthesis of GEOTRACES findings.
- US GEOTRACES is planning two process studies, one focusing on freshwater supply (rivers and submarine groundwater discharge) in the Gulf of Mexico and one that partners with physical oceanographers to work off the west coast of the US and test a hypothesis about the process(es) that mobilize Fe from continental margin sediments to create the large plumes of dissolved Fe emanating from continental margins that are observed in many GEOTRACES sections. Although neither process study has held in-person meetings, the investigators involved in the Gulf of Mexico study have held planning meetings via Zoom at approximately monthly intervals, while the west coast process study planning group has held Zoom meetings less frequently.
- Process studies in the Gulf of Mexico and off the west coast of the US were inspired by GEOTRACES sections GA05 and GP05, respectively, and are intended to replace these sections in the GEOTRACES global survey.

Outreach activities conducted

- For the first time, US GEOTRACES attempted to create a virtual reality experience during GP17-OCE. Production of this virtual reality outreach product was under the direction of Christina Wiederwohl, at Texas A&M University, who presented a first look at the production during the 2023 Goldschmidt meeting in a presentation entitled "Reimagining oceanographic biogeochemistry: bringing the ocean to the community through virtual reality". The project is not yet completed, but a progress report was presented by Jessica Fitzsimmons to the US GEOTRACES SSC on June 21, 2024.
- A journalist, Sophia Moutinho, sailing aboard GP17-ANT, followed multiple pathways to publicize GEOTRACES research objectives. Although both of the following occurred after 30 April 2024, they are reported here to accompany the write-up about GP17-ANT. First, Sophia Moutinho published in AGU's EOS science news magazine about her experience on board the US GEOTRACES cruise in the Southern Ocean (EOS, Volume 105, No 6, June 2024). This article is described on the GEOTRACES web site at https://www.geotraces.org/us-geotraces-cruise-in-the-southern-ocean-makes-the-cover-of-eos-science-news-magazine/.
- More recently, a series of podcasts about GP17-ANT was prepared by Sophia Moutinho and produced by Rachel Feltman at Scientific American as a part of their

"Science Quickly" standard podcast channel. It is a four-episode series under their special "Fascination." The first three episodes can be found at:

- <u>https://www.scientificamerican.com/podcast/episode/could-iron-from-melting-glaciers-affect-global-climate/</u>
- <u>https://www.scientificamerican.com/podcast/episode/researchers-sample-antarctic-sea-ice-amid-rapid-melting/</u>
- <u>https://www.scientificamerican.com/podcast/episode/how-researchers-live-and-work-onboard-an-icebreaker-in-a-west-antarctic-sea/</u>

The US GEOTRACES website hosts an updated publication database, information about completed and future cruises, submitted GEOTRACES Annual reports to SCOR, and information related to the annual SSC meetings. The web site <<u>https://usgeotraces.ldeo.columbia.edu</u>> also has pages to accommodate educational and outreach materials that can be used by the US GEOTRACES Community.

During the reporting period, US GEOTRACES published two issues of the seasonal US GEOTRACES Newsletter covering project updates, events, science highlights, featured publications, funding opportunities. The issues are distributed via the US GEOTRACES mailing list and is also available at the website

(https://usgeotraces.ldeo.columbia.edu/content/newsletters).

Other GEOTRACES activities

• The US GEOTRACES project office continues to offer small amounts of funding (<\$5k) to support travel and/or publication costs related to synthesis papers. During the reporting year the project office provided travel support for a synthesis group working on trace elements in the halocline of the Arctic Ocean (July, 2023). A manuscript from this group was submitted to a journal in August 2023. As of May 2024 the manuscript still had not been sent out for review, nor had the lead authors received a response to any of their three inquiries about the status of the manuscript. The lead authors are currently looking into alternative journals for publication.

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

- A list of publications is appended at the end of this report
- In addition, although the final publication dates will be in the 2024-2025 reporting period, most of the work for two special publications was done during the 2023-2024 reporting period, so they will be mentioned briefly here and reported on in greater detail next year.
 - A special issue of Oceanography Magazine, celebrating 20 years of GEOTRACES, (<u>https://doi.org/10.5670/oceanog.2024.415</u>

;<u>https://usgeotraces.ldeo.columbia.edu/news/twenty-years-geotraces</u>) has been compiled by guest editors Tim M. Conway, Jessica N. Fitzsimmons, Rob Middag , Taryn L. Noble and Hélène Planquette. Conway and Fitzsimmons are members of the US GEOTRACES community, and the cost of the special issue was covered by the US NSF through the grant under which the US GEOTRACES project office operates.

 Articles are still being published as part of the Special (virtual) Issue of the U.S. GEOTRACES Pacific Meridional Transect (GEOTRACES Section GP15) (https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1944-9224.GP15).

Completed GEOTRACES PhD or Master theses

• A list of dissertations is included in the list of publications appended at the end of this report.

GEOTRACES presentations in international conferences

• The number of US GEOTRACES presentations at international meetings and conferences is too large to track. However, we do note four special sessions at the recent Ocean Sciences Meeting (February, 2024, New Orleans, Louisiana USA) that were organized by US GEOTRACES investigators:

1) Geochemical tracers of ocean processes Lauren Kipp, Christopher Hayes, Erin Black, and Thomas S Weber.

2) Biogeochemical Cycling in the Caribbean Sea, the Gulf of Mexico and Beyond Tim Conway, Angela Knapp, Juan Carlos Herguera, and Jessica Fitzsimmons.

3) Speciation and Bioavailability of Trace Metals in the Marine Environment Kristen Buck, Ana Aguilar-Islas, Randelle Bundy, Maeve Lohan, and Machakalai Rajesh Kumar.

4) Heading South: Contrasting Biogeochemical Cycling of Trace Elements and Isotopes from Tropical to Southern Ocean Waters Gregory Cutter, Jessica Fitzsimmons, Benjamin Twining and Isuri Kapuge.

Submitted 6 July 2024 by:

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2023-2024 US GEOTRACES and GEOTRACES-related Publications

References 1 May 2023 – 30 April 2024 plus papers missed in previous reports

32 Publications, 6 PhD Dissertations, 5 Masters theses

Related Publications include:

- 1) US GEOTRACES PIs publishing results that support the GEOTRACES mission but the results are not from GEOTRACES cruises,
- 2) Papers that use data from US GEOTRACES cruises but do not include US GEOTRACES PIs as co-authors, and
- 3) Papers describing international collaboration on which US GEOTRACES PIs appear as co-authors.

Peer-reviewed Journal Publications

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Dissertations, including those not listed in previous years

PhD

- Amaral, V. J. (2023), Cycling and export of particulate organic carbon in the ocean, PhD thesis, University of California Santa Cruz
- Buckley, N. R. (2024), Hydrogen Sulfide as a Strong Ligand Affecting Trace Metal Cycling in the Pacific and Southern Oceans, PhD thesis, Old Dominion University.
- Lanning, N. T. (2023), The Biogeochemical Cycling of Dissolved Iron, Manganese, and Lead in the Equatorial & North Pacific Oceans, PhD thesis, Texas A&M University.

- Liang, H. (2023), Investigating the global ocean biogeochemical cycling of alkalinity, barium, and copper using data-constrained inverse models, PhD thesis, University of Southern California.
- Moore, L. E. (2023), The Impact of Organic Ligand Complexation on the Stabilization and Transport of Dissolved Iron, PhD thesis, University of Washington.
- Starr, L. (2022), Hg and Hg methylation along the freshwater to marine continuum, PhD thesis, Wright State University.

Masters

- Crawford, C. M. (2023), Labile Dissolved Nickel Concentrations in the North Pacific, MS thesis, University of South Florida, Tampa, Florida USA.
- Li, Y. (2024), Comparison of in-situ and Remotely Sensed Biological Carbon Pump Proxies along the GEOTRACES GP17-OCE transect, MA thesis, University of California, Berkeley.
- Parente, C. (2024), Dissolved nickel speciation at the Bermuda Atlantic Time-series Study (BATS) site, MS thesis, University of South Florida, Tampa, Florida USA.
- Wei, Z. (2021), 210Pb and 7Be as Coupled Flux and Source Tracers for Aerosols in the Pacific Ocean, MS thesis, , Stony Brook University.