Welcome !

This summer school is held in Brest, France, between the 20th and 26th August 2017. It brings together over 60 students and 20 world-leading international scientists, and is supported by the LabexMER, the Scientific Committee on Oceanic Research (SCOR) and the Institut de Recherche et Développement (IRD).

This summer school aims at teaching the skills and knowledge necessary for a good understanding of the biogeochemical cycles of trace metals. It will allow PhD students and early career researchers to see how their work fits within the international community of GEOTRACES.

General lectures will be given by international experts in the field of the GEOTRACES program and practical workshops in the laboratory will be ran throughout the week.

We wish you a very nice week.

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The Organisation of the 2017 GEOTRACES Summer School is a collaborative work and is being overseen by highly dedicated people. They will also be the people able to answer your questions about your Summer School journey.

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Hélène

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SCHEDULE

SUNDAY 20th AUGUST

13h45-14h30	Welcome coffee
14h30-15h00	Introduction
15h00-16h00	Introduction to GEOTRACES : motivation & design of the program By B. Anderson
16h00-16h30	Coffee/Tea break
16h30-17h30	Sampling and sample handling proocols By G. Cutter
17h30-18h30	Exploring GEOTRACES data with Ocean Data View By R. Schlitzer
18h30-22h	Diner at IUEM

MONDAY 21st AUGUST

09h00-10h30	Dissolved trace elements in the ocean : a review By M. Lohan
10h30-11h00	Coffee/Tea break
11h00-12h30	Particulate trace elements and particle dynamics By P. Lam
12h30-13h45	Lunch break
13h45-16h45	Practical sessions
17h00-18h00	2 Sampling and sample handling protocols 1 3 4 5 6 Free time
18h00-19h30	5 6 Poster session
From 19h30	Free evening

TUESDAY 22nd AUGUST

09h00-10h00	Trace metals in the oxygen minimum zones by E. Achterberg
10h00-10h30	Coffee/Tea break
10h30-12h30	Organic speciation By K. Buck The organic speciation of trace elements in sea water By P. Croot
12h30-13h45	Lunch break
13h45-16h45	Practical sessions
17h00-18h00	3 Sampling and sample handling protocols 1 2 4 5 6 Free time
20h00-22h00	Diner at «La Base» (185 Quai Eric Tabarly, Brest)

WEDNESDAY 23rd AUGUST

09h00-10h00	Three basic steps to generating high quality trace metal data using ICP-MS By P. Field
10h00-10h30	Coffee/Tea break
10h30-12h30	The modern oceanic cycles of Zn & Ni and their isotopes By D. Vance Iron isotopes in the ocean By F. Lacan
12h30-13h45	Lunch break
13h45-16h45	Practical sessions
17h00-18h00	4 Sampling and sample handling protocols 1 2 3 5 6 Free time
18h00-19h30	1 2 Poster session
From 19h30	Free evening

SCHEDULE

THURSDAY 24th AUGUST

09:00-12:00	Practical Workshops
12h30-13h45	Lunch break
13h45-16h45	Practical sessions
17h00-18h00	6 Sampling and sample handling protocols 1 2 3 4 5 Free time
18h00-19h30	1 Sampling and sample handling protocols 2 3 4 5 6 Free time
20h00-22h00	Diner at «Océanopolis» (Port de Plaisance du Moulin Blanc, Brest)

FRIDAY 25th AUGUST

09:00-10:30	Radium isotopes By W. Geibert
10:30-11:00	Coffee/Tea break
11:00-12:30	^{234}Th as a tracer of upper ocean particle dynamics By F. Planchon
12h30-13h45	Lunch break
13h45-16h45	Practical sessions / Recreational activities
17h00-18h00	5 Sampling and sample handling protocols 1 2 3 4 6 Free time
18h30-19h30	3 4 Poster session
From 20h00	Free evening

SATURDAY 26th AUGUST

09:00-10:30	Rare Earth Elements (REE) and Nd isotopes in the ocean: a review By C. Jeandel
10:30-11:00	Coffee/Tea break
11:00-12:30	Marine biogeochemical modeling By L. Bopp
12h30-14h00	Lunch break
14:00-15:30	Atmospheric inputs of trace elements and their isotopes to the ocean By A. Baker
15:30-16:00	Coffee/Tea break
16:00-19:00	Oral presentations and final debriefing
20h00-23h00	Diner at the «Monument Café» (50 Rue des Mouettes, Brest)

SUNDAY 27th AUGUST

Departure

RECREATIONAL ACTIVITIES

Take away lunches will be provided and a bus will leave from IUEM one hour before the activities begin. More details will be provided.

1. Monday 21st August, 14h00-17h00: Kayak
2. Tuesday 22nd August, 14h00-17h00: Kayak
3. Wednesday 23rd August, 14h00-17h00: Kayak
4. Thursday 24th August, 9h00-12h00: Kayak
5. Thursday 24th August, 14h00-17h00: Zodiac tour
6. Friday 25th August, 14h00-17h00: Zodiac tour

LECTURES

Introduction to GEOTRACES: Motivation and design of the program

ANDERSON Bob

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Marine geochemistry experienced a revolution in the 1970's and 1980's when the development of new sampling and analytical techniques permitted the reliable determination of the concentrations of trace elements and isotopes in seawater at extremely low concentrations. Previous efforts to study trace elements and their isotopes had been limited by sample contamination or by requirements for sample volumes so large that high-resolution sampling was not practical. With this revolution came the prospect of defining the marine biogeochemical cycles of a number of trace elements and isotopes, including those used as tracers of ocean circulation, those that serve as essential micronutrients, those exploited in paleoceanography, and those that occur largely as anthropogenic contaminants.

However, two decades after this revolution it was clear that work was proceeding so slowly that this goal would never be achieved. First-order questions about the basic distribution of trace elements remained unresolved. Clearly, a new business model was required to address these global issues, one that involved the development and application of new technologies in a globally coherent and coordinated fashion. This need, recognized by a large segment of the marine geochemistry community, led to the formation of the GEOTRACES program.

Building an international effort to study processes on a global scale faces a number of challenges. Weaving together a global program consisting of diverse national contributions, each with its unique priorities, requires frequent communication and a high level of coordination. Technically challenging measurements made in labs worldwide must be internally consistent to allow interpretation of a global database, thus necessitating a vigilant and persistent effort at standardization and intercalibration. An efficient open-access data management system is required to facilitate the merging of diverse data sets to identify the environmental factors that regulate the distributions of trace elements in the ocean. Synthesis initiatives lead to an advanced understanding of the processes that regulate trace element biogeochemistry that would be unachievable by individual studies of a single element or by studies confined to limited geographic regions. Meanwhile, ongoing training of young investigators now prepares the foundation for future interdisciplinary research programs that will build on GEOTRACES findings.

Sampling and Sample Handling Protocols

CUTTER Greg

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Acquiring any water column sample in GEOTRACES, dissolved or particulate, requires that they are representative of the conditions at the station – hydrographically consistent - and free of contamination or handling artifacts. This means that they must be hydrographically and analytically accurate, which is closely coupled with intercalibration, the topic of another lecture. Of course there are many steps in assuring that good samples are taken and in this respect we will discuss:

- water budgets;
- station sampling sequence;
- sampling systems;
- intercalibration requirements;
- maintenance of sampling systems (focus on GO FLO-type samplers);
- actual deployment and recovery of samplers;
- sample filtration methods;
- sample processing and storage;
- methods to evaluate quality of samples via hydrography, nutrients, and shipboard trace metal analyses;
- data/sample logging.

The format of this lecture will be one half classroom and one half demonstration and hands-on applications.

Exploring GEOTRACES data with Ocean Data View

SCHLITZER Reiner

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This hands-on workshop will teach standard and advanced ODV methods for the exploration and scientific analysis of environmental data. The GEOTRACES Intermediate Data Product 2017 (IDP2017) will be used as example dataset. Participants will learn how to create publication-ready maps, property-property plots and sections and how to apply simple or advanced station and sample filters. In addition, an overview over the wide range of derived variables available in ODV will be given and a number of variables often needed in geochemical research will be described and applied. The workshop starts with presentations of general software concepts and capabilities, followed by hands-on-sessions for the creation of specific plot types and scientific discussion rounds explaining the findings.

Dissolved trace elements in the ocean: a review

LOHAN Maeve

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Over the past ten years the GEOTRACES programme has coordinated the efforts of marine geochemists worldwide to identify processes and quantify fluxes that control the distributions of trace elements in the ocean. Despite the analytical challenges of collecting trace metal clean samples and analysing these very low concentrations, many more laboratories throughout the world are now determining accurate trace metal data. This has led to an unprecedented amount of dissolved trace metal data spanning all Ocean Basins leading to intriguing results. GEOTRACES data has revealed that hydrothermal activity is an important component of the ocean iron cycle and plays an important role in shaping the distributions and magnitude of ocean productivity in the Southern Ocean. Bioactive trace metals such as iron, copper, zinc, cadmium and cobalt have important controls on marine productivity and plankton can also influence the oceanic trace metal cycling. Phytoplankton can concentrate bioactive trace metals intracellulary by more than a million fold relative to dissolved concentrations in seawater and influence the redox speciation of trace metals. GEOTRACES data has revealed that the Southern Ocean plays an important role in shaping the distributions of bioactive trace metals such as zinc and cadmium. This course will introduce trace element biogeochemistry and review recent developments in this rapidly expanding field and highlight emerging questions.

Particulate trace elements and particle dynamics

LAM Phoebe

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Following the lecture on dissolved trace metals, I will start by comparing the dissolved and particulate profiles for several categories of trace elements. Some particulate profiles will appear as mirror images of their dissolved counterparts, some will have a similar shape, and others will be wholly different. We will discuss the major aspects of the origins and fate of particles in the ocean, and of particle cycling and dynamics, to start to understand how to interpret particulate trace element profiles.

Trace metals in the Oxygen Minimum Zones

ACHTERBERG Eric

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Oxygen minimum zones (OMZs) are present in the eastern tropical oceans between 100 and 700 m depth. These zones are caused by a combination of weak ventilation responsible for the shadow zones of the ventilated thermocline, and elevated oxygen consumption due to remineralization of sinking particles associated with high primary production in surface waters near coastal upwelling regions. The recently reported expansion of OMZs in the World Ocean has major implications for biogeochemical cycles, particularly those of carbon, nitrogen and potentially iron (Fe), and might also have adverse effects on ecosystem function and services.

In OMZs, the pelagic fluxes of Fe, other redox sensitive elements, and phosphorus from the bottom boundary layer to surface waters and off shore are enhanced, whilst N fluxes are reduced due to anammox and denitrification. This has significance consequences for the overall supply of these important nutrients to the areas of the ocean that support primary productivity and diazotrophy. This presentation will discuss sedimentary elemental fluxes to the bottom boundary layer, in addition to diapycnal and isopycnal transport. The processes affecting Fe behaviour in OMZs will be discussed, with an emphasis on the effects of spatial and temporal variations in redox conditions in the water column. We will also cover Fe cycling during sporadic hydrogen sulfide releases from anoxic sediments. In addition, the talk will discuss the impacts of Fe, Co N, P supplies on ocean productivity in OMZ regions and further off shore.

Organic Speciation

BUCK Kristen

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Organic complexation plays a fundamental role in the marine biogeochemical cycling of iron and copper. Competitive ligand exchange-adsorptive cathodic stripping voltammetry (CLE-AdCSV) methods in particular have been widely used to characterize metal-binding organic ligands in seawater. As part of the GEOTRACES program, this method has been applied to ocean section transects to determine the basin-scale distributions of iron- and copper-binding organic ligands. This lecture will review the CLE-AdCSV approaches employed in the GEOTRACES program, including the outcomes of intercalibration activities for these methods, and will highlight results from the basin scale studies.

The organic speciation of trace elements in seawater

CROOT Peter

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Understanding the controls on the chemical speciation of trace elements in seawater is critically important for deciphering their reactivity, cycling and ultimate distribution within the ocean. The strong physical and inorganic chemistry backgrounds of the first Marine Chemists established very early on good models for the inorganic speciation of trace elements in seawater based on acid-base chemistry, however for many elements the first measurements indicated the overall importance of organic complexes to the biogeochemical cycling of elements such as iron and cobalt. The determination of organic species, of unknown composition, however is not a trivial exercise and over the last 50 years numerous methods have helped advance this field; chiefly through a combination of applying new techniques in analytical chemistry (e.g. acid-base titration, polarography/voltammetry, LC-MS, proteomics, metabolomics etc.) along with refining models of the chemical speciation (i.e. thermodynamic equilibrium or kinetic control). In this presentation, I will provide a brief overview of the history of the analytical and theoretical approaches applied to measuring the organic speciation of trace elements in seawater, illustrated with examples from GEOSECS up to the present-day studies of GEOTRACES.

Three Basic Steps to Generating High Quality Trace Metal Data using ICP-MS

FIELD Paul

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Producing high quality data is important in all areas of research and paramount to the success of large programs, such as GEOTRACES. Although ideas may change, high quality data will stand the test of time. Historically, a paucity in oceanographic trace metal data was due to the difficulty in collecting and measuring metals at low levels. This lecture will focus on the determination of trace metals in oceanographic samples by Inductively Coupled Plasma Mass Spectrometry (ICPMS).

The lecture will be broken down into three core components:

- Sample preparation and introduction; how to get your sample into the plasma.
- ICPMS; understanding the basics from ionization and interference removal to ion detection.
- Calibration and data reduction; internal standards, external calibration, method of standard additions and isotope dilution.

The modern oceanic cycles of Zn and Ni and their isotopes

VANCE Derek

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Many transition metals are important players in ocean biogeochemistry. Oceanic phytoplankton are responsible for about half the photosynthetic carbon fixation on Earth, and the biochemical mechanisms they use to fix this carbon require essential trace metal micronutrients (Fe, Zn, Cd, Ni, among others) in addition to the major nutrients (C, P, N, Si). As a result, these trace metal micronutrients display "nutrient-like" depth profiles in the modern ocean: their dissolved concentrations are small, sometimes vanishingly small, in the sunlit upper ocean where phytoplankton uptake depletes them. In the deep ocean, where respiration regenerates them into the dissolved phase, their concentrations are often 2-3 orders of magnitude higher. Thus, when the stable isotope systems of these systems were first developed, and given that cellular uptake often induces substantial isotope fractionations, there was significant hope that they could be used as tracers of these processes on the recent Earth. Moreover, different groups of microbial organisms have different requirements for different metals. Thus, there also seemed to be potential for tracking the evolution of the biosphere as a whole, particularly in the approximately 4 Gyr of Earth history before multi-cellularity and macroscopic fossils appeared.

This lecture will focus on two exemplar metals, nickel (Ni) and zinc (Zn). A building database, largely derived from GEOTRACES samples, shows that the oceanic dissolved pool of both elements is isotopically heavier than the known inputs, implying an output with light isotope compositions. The modern oceanic cycle of both these elements is dominated by biological uptake into photosynthesised organic matter and output to sediment. It is increasingly clear, however, that such uptake is associated with only very minor isotope fractionation. The isotopic balance instead appears to be closed by the sequestration of light isotopes to sulphide in anoxic and organic-rich sediments. So it is ocean chemistry that controls these isotope systems, suggesting a different but equally interesting array of questions in Earth history that can be addressed with these systems.

Iron isotopes in the ocean

LACAN François

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Iron isotopes have been measured in open ocean waters for a decade, thanks to the advent of Multi-Collection Inductively Coupled Plasma Mass Spectrometry (MC-ICPMS). Such measurements remain difficult, especially at the low iron concentrations found in surface waters of High Nutrient Low Chlorophyll areas. Our vision of the oceanic iron isotope cycle remains therefore partial. Nonetheless, this isotopic system, studied both at the ocean boundaries and within the water column, allowed significant improvement in our understanding of the iron cycle (and other elemental cycles), giving insight of, both, its external sources (as well as removal processes) and its internal cycling.

This lecture will present:

- a brief description of the oceanic iron cycle,
- general and theoretical aspects of iron isotopes,
- methodological aspects of the iron isotope measurements in seawater,
- the iron isotopic signatures of various external iron sources to the ocean (dusts, rivers and their particulate loads, hydrothermal vents…),
- the preservation of isotopic signatures within water masses, and
- the effects of internal processes, such as primary production and dissolved/particle interactions, on the iron isotopic compositions in the water column.

Radium isotopes

GEIBERT Walter

Alfred Wegener Institute
Bremerhaven, Germany
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Radium and other soluble radiotracers are powerful tools to study the release and fate of dissolved contents of sea water. Due to the various half-lives of different radium isotopes, they allow the investigation of sources of solutes and their transport at ocean boundaries on different spatial and temporal scales. Applications of radium isotopes therefore range from small-scale coastal features like pore-water release or submarine groundwater discharge (SGD) to shelf-ocean exchange or deep upwelling and large-scale circulation. This course will give an overview of applications of radium isotopes using some in-depth examples from the existing literature. It will also present analytical techniques for the analysis of radium and related radiotracers, and it will give an outlook on possible combinations of radium with trace element studies. Beyond radium, the course will also address the soluble radiotracers ^{222}Rn, ^{227}Ac, and ^{234}U, which share some relevant similarities with radium.

^{234}Th as a tracer of upper ocean particle dynamics

PLANCHON Frédéric

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The learning goals of this lecture are to understand how the radionuclide pair ^{238}U-^{234}Th can be used to study some of the processes affecting marine particles in the water column. After a brief introduction on the fundamental concept of secular equilibrium and disequilibrium along a decay series, we will review how the ^{234}Th distribution offers a means to quantify the sinking flux of particles and their chemical constituents from the upper ocean. We will present the methodological aspects behind this application including sampling at sea, analytical determination and scavenging models currently in use. Based on different case studies, we will discuss the strengths and weaknesses of this approach and how over the past decades it has become a recognized and an increasingly used proxy of the biological carbon pump.

Rare Earth Elements (REE) and Nd isotopes in the ocean: a review

JEANDEL Catherine

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Rare Earth Elements are probably one of the most challenging frontiers for marine geochemistry these years. Since the pioneer works of our eminent colleagues as H. Elderfield (GB), E. Sholkovitz (USA) or Y. Nozaki (J), the development of the GEOTRACES international program improved the number of seawater REE and Nd isotope data, be it in the framework of process studies or along oceanographic sections. Many recent publications suggest that sediments deposited along ocean margins are capable of releasing a fraction of their constituting elements to seawater. This hypothesis was raised by the oceanic distribution of neodymium (Nd) isotopes and concentrations, which suggest that 1 to 3% of continental sediments deposited along ocean margins are involved in this releasing process, behaviour consistent with observations made in estuaries and suggesting a sediment and/or suspended material source for REE to the ocean and within the ocean itself. Although the release of Nd and other REE could also result from the dissolution of particle coatings, the oceanic budget of Nd isotopes constraints the involvement of a detrital lithogenic end member in the release process. Quantifying such mechanism is a major challenge, because it likely affects other chemical element oceanic budgets and cycles (e.g nutrients as Si or Fe).

The course will introduce the Rare Earth Elements and Nd isotope marine geochemistry. It will make the link between the first hypotheses on the oceanic REE behaviours, our present understanding of their cycle and some tracks for future research on this fascinating family of oceanic tracers.

Marine Biogeochemical Modeling

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AUMONT Olivier

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In this lecture, we will review the basic principles that underlie the modeling of biogeochemical cycles in the ocean. Starting with the ocean carbon cycle, we will describe the strategies that have been used to represent complex processes in such models. We will discuss the evolution of these models over the last decades (see Figure), from very simplified models to more complex models as used now in the latest generation of Earth System Models. We will provide examples of applications ranging from estimating the ocean carbon sink to projecting the response of marine ecosystems to climate change. We will finish with examples of GEOTRACES-focused modelling studies and show how these models may also be used to simulate the cycles of trace metals and isotopes in the ocean.

Atmospheric Inputs of Trace Elements and their Isotopes to the Ocean

BAKER Alex

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Aerosols are an important source of trace metals and isotopes to the ocean. This session will provide an introduction to some fundamentals of aerosol science (aerosol particle sizes, composition, mixing states, transport pathways and removal from the atmosphere). Sampling techniques will be discussed, as these play a significant part in determining what we understand about aerosol behaviour and interactions with the oceans. Aerosol chemical composition, and its relationship to natural and anthropogenic particle sources and reactions with gas-phase species, will be examined.

The impacts of atmospheric deposition on marine biogeochemical cycles are often dependent on the fraction of aerosol components that are soluble (or bioavailable) in seawater. The solubility of many aerosol components (including iron) appears to increase during transport through the atmosphere. The processes potentially responsible for this change in solubility will be discussed.

The presentation will also illustrate recent developments in isotopic analysis of aerosols and how these enhance our understanding of aerosol sources and transport, and the impacts of aerosol deposition on the ocean.

Atmospheric chemical transport models are an essential tool to evaluate atmospheric inputs to the ocean (and their impacts) on large spatial scales and over time. Assessment of the performance of these models in quantifying atmospheric inputs to the open ocean is extremely difficult. Methods by which models can be evaluated over the open ocean will be discussed.

PRACTICAL SESSIONS

Practical Session Lecturers

BUCCIARELLI
Eva

GERMAIN
Yoan

GONZALEZ
Aridane

GUÉGUEN
Bleuen

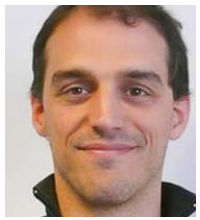
MÉMERY
Laurent

NONNOTTE
Philippe

SUTTON
Jill

WHITBY
Hannah

AUMONT
Olivier



BOPP
Laurent

LACAN
François

PONZEVERA
Emmanuel

JEANDEL
Catherine

FIELD
Paul

LAM
Phoebe

PLANQUETTE
Hélène

BUCK
Kristen

CROOT
Peter

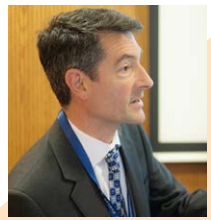
LOHAN
Maeve

SARTHOU
Géraldine

CUTTER
Greg

SCHLITZER
Reiner

GORGUÈS
Thomas



BAKER
Alex

MODELING

Training by: **AUMONT Olivier, BOPP Laurent, MÉMERY Laurent**

This modeling practical teaches the main principles behind the modeling of biogeochemical tracers. In our course, we will focus on the Thorium isotopes and most specifically on ^{230}Th and ^{234}Th. Using a commonly used spreadsheet software, participants will first apply basic modeling principles to reproduce the vertical distribution of dissolved and particulate ^{230}Th. In the second part of the practicals, a more complex case will be explored using fortran to model the time-evolution of ^{234}Th. Implications concerning realistic 3D models will be discussed.

MULTI-COLLECTION INDUCTIVELY COUPLED PLASMA MASS SPECTROMETERS

Training by: **LACAN François, PONZEVERA Emmanuel**

Multi-Collection Inductively Coupled Plasma Mass Spectrometers (MC-ICPMS) allow the measurements of isotopic ratios, with a high precision (thanks to the simultaneous detection of the different isotopes) and a high ionisation efficiency (thanks to the plasma source). It is suited to many isotopic systems, such as Fe, Cd, Zn, Ni, Ca, Si, Cu, Nd, Sr and many others. This short practical training (with a Thermo Neptune MC-ICPMS), will very briefly present:

- the hardware and the introduction system,
- tuning the instrument for a particular isotopic system,
- setting the acquisition parameters,
- setting the automatic data correction equations,
- setting and running a measurement sequence,
- and finally evaluating the results.

THERMAL IONIZATION MASS SPECTROMETRY

Training by: **NONNOTTE Philippe, JEANDEL Catherine.**

This hand-on pratical will introduce the principles and different steps to measure isotope compositions of natural marine samples by MC TI-MS (Multicollector Thermal Ionization Mass Spectrometry):

- Instrument operation
- Sample preparation: making filaments, sample loading and sample wheel
- preparation
- Running data acquisition: filament heating, finding the signal,
- tuning, positionning the detectors
- Running isotope ratio measurements and discussing the collected datas
- (calculation, corrections, standards)
- This pratical will be based on the MC TI-MS Triton of the PSO - IUEM.

HIGH RESOLUTION INDUCTIVELY COUPLED PLASMA MASS SPECTROMETERS

Training by: **FIELD Paul, GERMAIN Yoan, GUÉGUEN Bleuen, LAM Phoebe, PLANQUETTE Hélène.**

This hands-on practical will introduce the steps one needs to run samples on a HR-ICP-MS. The practical includes: description of the sample introduction system parts, description of the instrument tuning before measurement, ways to monitor drift of the instrument during acquisition, assessing matrix effects (using an internal standard and running two dilutions, for example), design of the calibration standards series for calculating concentrations in the samples, typical sequence of analyses (calibration standards, blanks, samples, certified reference materials, etc), and data reduction. The practical will take place on a Element 2 and Element XR (ThermoFischer).

VOLTAMMETRY

Training by: **BUCK Kristen, CROOT Peter, GONZALEZ Aridane, WHITBY Hannah.**

Voltammetry is the measurement of the current as a function of applied potential, across a conductive analyte such as seawater, used in trace metal analysis and speciation. Voltammetry can be adapted for a variety of experimental procedures depending on the electrode and conditions, but in marine chemistry it is most commonly used to measure very low (pico and nanomolar) concentrations of various metals and organic compounds, reaction kinetics and the ligand concentration (L) and binding strength (log K'ML) of a metal-ligand complex, using competitive ligand exchange/adsorptive cathodic stripping voltammetry (CLE/AdCSV).
This short practical training session, on a µAutolab III potentiostat with a hanging mercury drop electrode (HMDE), will briefly present :

- the hardware,
- either the NOVA or GPES software,
- electrode maintenance and repair,
- setting up and running a measurement and finally
- peak measurement and data interpretation

FLOW INJECTION ANALYSIS - CHEMILUMINESCENCE DETECTION

Training by: **BUCCIARELLI Eva, LOHAN Maeve, SARTHOU Géraldine.**

Flow Injection coupled to chemiluminescence (FIA-CL) allow the measurements of sub-nanomolar concentrations of dissolved iron (dFe). This short practical training will be carried out in class 10000 clean rooms and will briefly present the constrains of the work in clean conditions, as well as the principle of the FIA-CL analysis. Standard addition calibrations using a low-Fe seawater sample and measurements of a series of replicates to assess the reproducibility of the method will be performed.

SAMPLING & SAMPLE HANDLING

Training by: CUTTER Greg, PLANQUETTE Hélène.

This practical will be divided in two parts: the first part will teach how to disassemble/reassemble a GO-Flo bottle and mount GO-Flos on carousel, while the second part will take place inside a clean container. **There, the instructors will provide guidance on how to sample cleanly for dissolved and particulate TEIs, sample preservation and data logging.**

OCEAN DATA VIEW

Training by: **SCHLITZER Reiner, GORGUES Thomas.**

This hands-on workshop will teach standard and advanced ODV methods for the exploration and scientific analysis of environmental data. The GEOTRACES Intermediate Data Product 2017 (IDP2017) will be used as example dataset. Participants will learn how to create publication-ready maps, property-property plots and sections and how to apply simple or advanced station and sample filters. In addition, an overview over the wide range of derived variables available in ODV will be given and a number of variables often needed in geochemical research will be described and applied. The workshop starts with presentations of general software concepts and capabilities, followed by hands-on-sessions for the creation of specific plot types and scientific discussion rounds explaining the findings.

SCIENTIFIC COMMUNICATION

Training by: BAKER Alex, SUTTON Jill.

Scientific communication, both written and oral, is essential to succeed in scientific research. This practical will permit participants to improve their scientific communication skills by learning how to effectively present and critically evaluate the results of scientific research. Each participant is required to present the results of their current research, in poster form, which will be evaluated by their peers. The instructors will provide guidance on how to improve written and oral presentation skills.

STUDENTS & POSTERS

MONDAY SESSIONS 5 6

ANAND Subha

^{234}Th based carbon export flux along the Indian Ocean GEOTRACES GI01, GI02 and GI03 sections in the Indian Ocean.

Physical Research Laboratory
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ANDRADE Raiza

Chronology of Anthropogenic impacts in Todos os Santos Bay.

Universidade Federal da Bahia Ondina
Salvador, Brazil
raizalbandrade@gmail.com

CHATERJEE Aditi

The output of transition metals from the oceans to reducing sediments.

ETH Zurich
Zurich, Switzerland
aditi.chatterjee@erdw.ethz.ch

CHINNI Venkatesh

Distributions of dissolved Zinc along the GEOTRACES GI-10 transect.

Physical Research Laboratory
Ahmedabad, India
venkateshchinni19@gmail.com

CINDRIĆ Ana-Marija

The distribution and speciation of selected trace metals were studied in the water column of the highly stratified estuary.

Ruđer Bošković Institute
Zagreb, Croatia
ana-marija.cindric@irb.hr

COLOMBO Manuel

Trace metal distribution in remote rivers in the Canadian Arctic Archipelago: Geochemical characterization of a pristine environment.

University of British Columbia,
Vancouver, Canada
mcolombo@eoas.ubc.ca

GRIFFITHS Alexander

Neodymium isotopic composition of East Antarctic continental shelf and deep water.

Imperial College London
London, UK
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HE Zhiwei

An experimental study of reductive cleaning procedures for investigating metal isotopes in ancient carbonate.

ETH Zurich
Zurich, Switzerland
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MONDAY SESSIONS 5 6

HUNNESTAD Annie Vera

Uptake of Fe^{2+} and Fe^{3+} in the marine cyanobacterium Synechococcus sp. PCC7002

Norwegian University of Science and Technology,
Trondheim, Norway
annie.v.hunnestad@ntnu.no

KARRI Damodararao

Dissolved Nd isotopes in the Arabian Sea, implications to the water masses and sources of Nd in the Arabia.

Physical Research Laboratory
Ahmedabad, India
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LIGUORI Bianca

Silicon Cycling and Terrestrial Input in the Central Arctic Ocean along the German GEOTRACES cruise PS9.

University of Oldenburg,
Oldenburg, Germany
bianca.liguori@uni-oldenburg.de

MAAROUF Rabea

The nexus between the availability of micronutrients (Fe and Zn), macronutrients and phytoplankton biomass in the sea water interfaces and boundary layers.

Alexandria University,
Alexandria, Egypt
rabea_ali2001@yahoo.com

PAFFRATH Ronja

Dissolved rare earth element concentrations from the Barents Sea to the central Arctic.

University of Oldenburg,
Oldenburg, Germany
rpaffrat@mpi-bremen.de

PEDREIRA Rodrigo

Anthropogenic impacts on the distributions of Rare Earth Elements in coastal waters.

Universidade Federal da Bahia Ondina
Salvador, Brazil
rodrigomaguiarp@gmail.com

SIEBER Matthias

The role of Southern Ocean processes in controlling the distribution of Cd isotopes at lower latitudes in the South West Pacific.

ETH Zurich
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matthias.sieber@erdw.ethz.ch

VALK Ole

^{231}Pa and ^{230}Th in the Arctic Ocean: Changes between 1991 and 2016.

Alfred Wegener Institute
Bremerhaven, Germany
ole.valk@awi.de

Monday sessions 5 6

VAN HORSTEN Natasha

Seasonal characterization of Fe-binding ligands and physical speciation of Fe in the Southern Ocean (Atlantic).

The Council for Scientific and Industrial Research
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nvhorsten1805@gmail.com

WANG Wenhao

Behaviour of iron isotopes in hydrothermal systems: Beebe and Von Damm vent fields on the Mid-Cayman ultraslow-spreading ridge.

National Oceanography Centre, University of Southampton
Southampton, UK
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YAO Wanxuan

A sensitivity study of the scavenging intensity and the microbial loop recycling in the 40S Atlantic Section.

GEOMAR Helmholtz Institute for Ocean Sciences
Kiel, Germany
bencat.xuan@gmail.com

YONG Jaw-Chuen

Sources and composition of water-soluble trace elements in aerosols over the South Atlantic Ocean and the Arctic.

GEOMAR Helmholtz Institute for Ocean Sciences
Kiel, Germany
jyong@geomar.de

Wednesday sessions 1 2

AL-ASHEM Ali

Exploration of Safer Digest Methods for Analysis of Marine Particles from Angola Basin, Arctic Ocean and Eastern Tropical South Pacific Ocean.

GEOMAR Helmholtz Institute for Ocean Sciences
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aalhashem@geomar.de

ARTIGUE Lise

Biological iron isotopic fractionation in the Southern Ocean.

Université Paul Sabatier, LEGOS
Toulouse, France
lise.artigue@legos.obs-mip.fr

BRUGGMANN Sylvie

Chromium isotopes cycling across the Peruvian oxygen minimum zone.

University of Copenhagen
Copenhagen, Denmark
sybr@ign.ku.dk

CLOETE Ryan

The biogeochemical cycling of bio-active trace metals (Cu & Zn) in the Southern Ocean, Atlantic Sector.

Stellenbosch University
Stellenbosch, South Africa
15994619@sun.ac.za

Wednesday sessions 1 2

DUGGAN Brian

Biogeochemical cycling of neodymium along the Bering/ Chukchi Shelf into the Canadian Basin.

University of South Carolina
Columbia, USA
bduggan@geol.sc.edu

HARA Takuya

Distribution of Nd isotopic composition and REE concentrations in surface seawater in the North Pacific Ocean.

TUniversity of Tokyo
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HOLMES Thomas

Iron speciation in proximity to an active volcanic hotspot, Kerguelen Plateau, Southern Ocean.

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KIM Intae

The distribution of glacial meltwater in the Amundsen Sea, Antarctica, revealed by dissolved helium and neon.

Korea Institute of Ocean Science and Technology
Ansan, Korea
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KUNDE Korinna

Iron bioavailability and co-limitation in the sub-tropical North Atlantic.

National Oceanography Centre, University of Southampton
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K.Kunde@soton.ac.uk

LE ROY Émilie

Radium-226 and barium as tracers of water masses in the North Atlantic (GA01-GEOTRACES).

Université Paul Sabatier, LEGOS
Toulouse, France
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MICHAEL Susanna

Using Aluminum and Manganese to Constrain the Contribution of the Solomon Sea to the Equatorial Undercurrent Trace Metal Pool.

University of Washington
Seattle, USA
smicha@uw.edu

PACKMAN Hollie

Zinc and Cadmium: geochemically alike but divergent in the ocean.

University College London
London, UK
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Wednesday sessions 1 2

PAĐAN Jasmin

Determination of chromium in oxic/anoxic marine environment.

University of Zagreb
Zagreb, Croatia
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PETROVA Mariia

Determination of mercury species in the Arctic Ocean.

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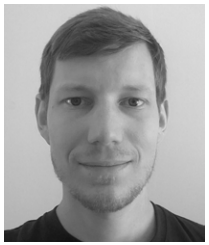

RAHLF Peer

Tracing water mass circulation in the Angola Basin with neodymium isotopes.

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RIGBY Shaun

Nutrient Deficiency, Limitation and Driving Mechanisms Vary Throughout the Atlantic Ocean.

University of Liverpool,
Liverpool, UK
S.J.Rigby@liverpool.ac.uk

RUFAS Anna

Towards a mechanistic understanding of the ocean biological carbon pump.

University of Oxford
Oxford, UK
anna.rufasblanco@earth.ox.ac.uk

THOBY Marie

An expanded molybdenum isotope dataset for Precambrian stromatolitic carbonates.

Université de Bretagne Occientale, LGO
Brest, France
marie.thoby@univ-brest.fr

TONNARD Manon

Iron-binding dissolved and soluble organic ligands near the Kerguelen Archipelago (B-transect) and around.

LEMAR, Brest, France/ IMAS, Hobart, Australie
manon.tonnard@utas.edu.au

XIANG Yang

Lateral input of particulate Mn and Fe from the shelves to Arctic basins.

University of California
Santa Cruz
yaxiang@ucsc.edu

Friday sessions 3 4

AFLENZER Hélène

Light, carbon dioxide and temperature effects on iron availability of coastal water of the Southern Ocean.

Institute for Marine and Antarctic Studies
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BEGHOURA Houda

Sedimentary particulate iron: the missing micronutrients?

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BENALTABET Tal

Trace metal cycling and Pb isotopic composition of seawater in the Gulf of Aqaba, Red Sea.

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Interuniversity Institute for Marine Sciences
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BOLT Channing

Role of Arctic Sea Ice on Particulate Bioactive Trace Metal Cycling.

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BROWNING Gabriel

The Direct Detection of Humic-Type Iron-Binding Ligands in Samples from GEOTRACES Cruise GP16 in the Tropical East Pacific

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GOURAIN Arthur

Organic complexation of copper along the GEOTRACES GA01 section.

University of Liverpool,
Liverpool, UK
arthur.gourain@liverpool.ac.uk

HOFFMAN Colleen

Near-field iron and carbon chemistry of non-buoyant hydrothermal plume particles, Southern East Pacific Rise 15˚S.

University of Minnesota-Twin Cities,
Minneapolis, USA
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JENSEN Laramie

The speciation of trace metals Fe, Cu, Zn, Ni, Mn, Co and Cd into the soluble and colloidal phase along the US Arctic GEOTRACES section GN01.

Texas A&M University
College station, USA
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Friday sessions 3 4

KRISCH Stephan

GRIFF: Greenland Ice Sheet <=> Shelf Interactions and Fram Strait Iron Fluxes.

GEOMAR Helmholtz Centre for Ocean research
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LERNER Paul

On the effect of particle composition on thorium scavenging in the North Atlantic.

Woods Hole Oceanographic Institution
Woods Hole, USA
plerner@whoi.edu

LOOCK Jean Christian

The biogeochemistry of trace elements cadmium and cobalt in the Southern Ocean, Atlantic sector.

Stellenbosch University
Stellenbosch, South Africa
16041399@sun.ac.za

MACOVEI Vlad

Temporal variability in the biogeochemistry of the surface North Atlantic – more than a decade of Ship of Opportunity data.

National Oceanography Centre, University of Southampton
Southampton, UK
vlad.Macovei@noc.soton.ac.uk

MENZEL BARRAQUETTA Jan Lukas

Aerosol deposition estimates in the Atlantic Ocean: A GEOTRACES case study.

GEOMAR Helmholtz Centre for Ocean research
Kiel, Germany
jmenzel@geomar.de

NASEMANN Philipp

Multiple controls regulate the isotopic composition of dissolved iron exported from sulphide-rich hydrothermal.

Jacobs University Bremen
Bremen, Germany
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PERRON Morgane

Aerosol Iron and other Trace Elements Solubility along the East Australian Coast.

Institute for Marine and Antarctic Studies
Hobart, Australia
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PLAß Anna

Benthic cycling of trace metals under low oxygen conditions.

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Friday sessions 3 4

POEHLE Sandra

Trace metal-clean seawater samples have been collected during GEOTRACES research cruise M81/1 alon.

Jacobs University Bremen
Bremen, Germany
s.poehle@jacobs-university.de

RAPP Insa

Iron biogeochemistry in the Peruvian oxygen minimum zone during the 2015/16 El Niño.

GEOMAR Helmholtz Centre for Ocean Research
Kiel, Germany
irapp@geomar.de

ROWLAND George

Tracing terrestrial inputs to the tropical North Atlantic over the last glacial cycle.

University of Bristol
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gr1850@bristol.ac.uk

ZHANG Zhouling

Spatial distribution of the dissolved silica in the Baltic Sea and its controlling processes inferred by stable silicia.

Lund University
Lund, Sweden
zhouling.zhang@geol.lu.se

USEFUL INFORMATIONS

HOTEL

Students are hosted at: « **Le Vauban** » hotel (17 Avenue Georges Clemenceau, 29200 Brest).
Lecturers are hosted nearby, at: **L'Océania** » hotel (82 Rue de Siam, 29200 Brest).

GETTING THERE

Everyday, a private shuttle service will take you from your hotel to IUEM and back in the evening.

LECTURES - PRACTICALS

All lectures and most practical sessions will be given at Institut Universitaire Européen de la Mer (Technopôle Brest Iroise, 29280 Plouzané) and are mandatory. Out of the six practical sessions, three (MC-ICP-MS, SF-ICP-MS and sampling at sea) will be given on the Ifremer site, therefore you will have to carry with you a valid proof of ID all the time.

MEALS

Lunches are provided on the IUEM site.

WIFI

You will have to access to « congres » wireless network.
Password is: sensatett!2016.

SOCIAL EVENTS

Four social evenings are proposed. See the general schedule for specific locations, time and transportation.

RECREATIONAL ACTIVITIES

Kayak sessions will take place in Plougonvelin, at the « Centre Nautique en Pays d'Iroise ».
Zodiac tours will depart from Le Conquet.
Concerning all recreational activities, a private bus is booked.

USEFUL NUMBERS

Emergency: 15
On site:

- Nadine Reniers: 02 98 49 88 20
- Aurélie Pinna: 02 98 49 86 29