**FINAL REPORT PROGRAM LEFE**

**Two pages to be written in English**

| **Program LEFE/ CYBER** | **Project Title**<br>**Contribution of iron isotopes to the study of dissolved-particle interactions in the ocean. INTERFERIC.** | **Years 2019 – 2021** |
|---|---|---|

| | |
|---|---|
| PI : François LACAN, LEGOS,<br>https://www.legos.omp.eu/author/francois-lacan/<br>Participating Laboratories : LEGOS. Collaborations with LEMAR and LOPS in the context of the GEOVIDE cruise. With GET-OMP for MC-ICPMS analyses. | Contribution to<br>*GEOTRACES*<br>Other funding sources : ANR, OSU OMP, LEGOS |

*Context*

The oceanic iron cycle is an essential component of the oceanic and planetary system. Iron is an essential micronutrient for phytoplankton growth. Iron oxide particles play a major role in the cycles of other micronutrients (Cu, Cd, Co, Ni, Zn), tracers (rare earths, Th, Pa Ra) and contaminants (e.g. Pb).

*Objectives / scientific questions*

This project aims at exploiting the combined studies of dissolved and particulate iron phases on the one hand, and of iron concentrations and isotopic compositions on the other hand, with a double objective, 1) to progress in our understanding of biogeochemical cycles in the North Atlantic, GEOVIDE cruise, and 2) to progress in our understanding of the tracer that constitutes the iron isotopic composition.

*Main results*

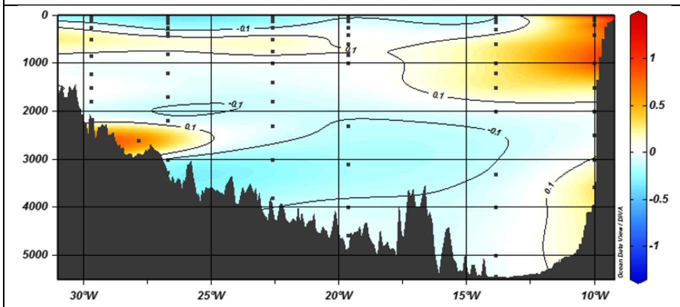


Figure 1: 'Biogeochemical' component of the dissolved iron content (concentrations, in nmol/kg) along the western part of the GEOVIDE section (Mid Atlantic ridge on the left (~30°W), Portugal on the right).

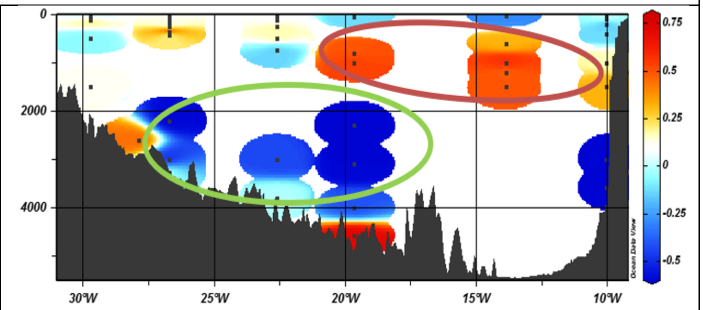


Figure 2 : Same as figure 1 but for the dissolved iron isotopic composition, expressed as $\delta^{56/54}Fe_{IRMM\text{-}014}$

Iron concentrations and isotopic compositions in dissolved and particulate phases have been produced on 6 full depth profiles over the main part of the GEOVIDE section, from Portugal to the Rekjanes ridge. As originally planned in the project, the results have been combined with an optimum multiparameter mixing analysis to estimate the part of the signal contributed by the water masses. This allows to deduce (by difference) the part of the signals, not originating from the transport by water masses, and thus resulting from biogeochemical processes at the basin scale. For example, external inputs (atmospheric deposition, sedimentary sources), subtractions (e.g., scavenging) and all types of dissolved/particulate exchanges (e.g., remineralization of organic matter).

Figure 1 illustrates these results with respect to dissolved iron concentration. It shows iron inputs, probably of sedimentary origin at the Portuguese margin, including at the bottom at about 4000 m depth, a punctual input on the flank of the mid-oceanic ridge, and a subtraction between 2000 and 4000m in the center of the basin.

Figure 2 illustrates these results for the isotopic composition of dissolved iron. The results coincide spatially in part with the concentration results, but also show contrasts with the latter illustrating the additional dimension brought by the isotopes (e.g., a strong signal appears around 1000 m at 20°W in isotope while nothing is visible there in concentration). This figure shows a heavy isotope enrichment of the dissolved phase between Portugal and 20°W at about 1000 m depth (red ellipse), which corresponds fairly well to the enrichment shown by the concentrations at the Portugal margin, but seems to extend further offshore. This isotopic signature could provide information on the nature of the iron input process (sedimentary or possibly atmospheric). In particular, it suggests the absence of involvement of iron reduction processes. Conversely, the iron subtraction zone (green ellipse) discussed above appears to be associated with a light isotopic signature of iron remaining in the water column. This suggests that isotopically heavy iron would have been preferentially subtracted. These observations similarly imply constraints on the subtraction processes, which are still under investigation.

Results of this type, combining concentration/isotopy/optimum multiparameter mixing analysis, have also been obtained for iron in suspended particles. Finally, the differences of iron isotopic compositions in the biogeochemical component of these two phases, dissolved and particulate (after correction of the part contributed by the water masses) have also been studied.

As these measurements are particularly challenging, analytical developments are always carried out in parallel. Work on the quality/validity of iron isotope and concentration measurements by ICPMS has been published (Lacan et al. 2021; Yeghicheyan et al. 2019). A review work on iron isotopy has been published (Horner et al. 2021). Work has been done combining an optimum multiparameter mixing analysis and an aluminum section in the North Atlantic as well, south of GEOVIDE (20°N). This work is not directly related to this iron/GEOVIDE project, but it has contributed to it through the study of water masses and their trace element contents (including iron, Artigue et al. 2020, 2021).

*Future of the project :*

Measurements are underway to complete the GEOVIDE section in the Irminger and Labrador Seas. We will have to conduct the interpretative work and publish the whole.

**Number of publications, communications and theses**

**Peer review publications**

Lacan F., Artigue L., Klar J.K., Pradoux C., Chmeleff J., Freydier R. 2021. Interferences and matrix effects on iron isotopic composition measurements by 57Fe-58Fe double-spike multi-collector inductively coupled plasma mass spectrometry (MC-ICPMS); the importance of calcium and aluminium interferences. Frontiers in Environmental Chemistry. doi:10.3389/fenvc.2021.692025 , Open Science Repository: https://hal.archives-ouvertes.fr/hal-03358745

Horner T.J., Little S.H., Conway T.M., Farmer J.R., Hertzberg J.E., Lough A.J.M., McKay J., Tessin A., Galer S.J.G., Jaccard S.L., Lacan F., Paytan A., Wuttig K., and GEOTRACES–PAGES Biological Productivity Working Group Members. 2021. Bioactive trace metals and their isotopes as paleoproductivity proxies: An assessment using GEOTRACES-era data. Global Biogeochemical Cycles. doi.org/10.1029/2020GB006814 , Open Science Repository: https://hal.archives-ouvertes.fr/hal-03003951

Artigue L., Wyatt N.J., Lacan F., Mahaffey C., Lohan M.C. 2021. The importance of water mass transport and dissolved-particle interactions on the dissolved aluminum cycle in the subtropical North Atlantic. Global Biogeochemical Cycles. doi.org/10.1029/2020GB006569 , Open Science Repository: https://hal.archives-ouvertes.fr/hal-03358768

Artigue L., Lacan F., van Gennip S., Lohan M.C., Wyatt N.J., Woodward M.S., Mahaffey C., Hopkins J., Drillet Y. 2020. Water mass analysis along 22°N in the subtropical North Atlantic for the JC150 cruise (GEOTRACES, GApr08). Deep Sea Research I. doi.org/10.1016/j.dsr.2020.103230 , Open Science Repository: https://hal.archives-ouvertes.fr/hal-03101871

Yeghicheyan D., Aubert D., Bouhnik-Le-Coz M., Chmeleff J., Delpoux S., Djouraev I., Granier G., Lacan F., Piro J.-L., Rousseau T., Cloquet C., Lanazanova A., Menniti C., Pradoux C., Freydier R., Silva Filho Vieira Da Silva-Filho E., Suchorski, K. 2019. A New Interlaboratory Characterisation of Silicon, Rare Earth Elements and Twenty-Two Other Trace Element Concentrations in the Natural River Water Certified Reference Material SLRS-6 (NRC-CNRC). Geostandards and Geoanalytical Research doi.org/10.1111/ggr.12268 , Open Science Repository: https://hal.archives-ouvertes.fr/insu-02123880

**Master thesis**

Nadal J. 2022. PROJET GEOVIDE. Trace element and isotopes in the North Atlantic Ocean. 26p.

**Oral communications (talks) in international conferences**

Klar J., Fabre S., Lacan F., Jeandel C., Estrade N., Yefsah H., Artigue L. Experimental study investigating the abiotic dissolution kinetics of iron during lithogenic particle-water interactions in high-energy regions. Ocean Sciences Meeting, February 2020, San Diego (USA).

*Data availablility*

*The GEOVIDE cruise data are not published yet. So not yet publicly available.*