

FINAL REPORT PROGRAM LEFE

<p style="text-align: center;">Program LEFE/ action(s)</p> <p>AO INSU 2019 Section « Océan-Atmosphère » » Dossier scientifique LEFE (Action 1 : IMAGO et Action 2 : CYBER)</p>	<p style="text-align: center;">Project Title</p> <p style="text-align: center;">STING: Temporal and spatial reconstruction of intermediate water masses in the Bay of Biscay during the last climate cycle</p>	<p style="text-align: center;">Years 2019 – 2021</p>
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Context

The upper branch of the AMOC (>1500 m) plays a key role in millennial climate variability (Illustration 1). Yet, few data tracing its dynamics are present in the eastern part of the North Atlantic. Based on two sediment cores and a laboratory experiment, STING provides new constraints on the dynamics of intermediate waters (~1000 m depth) and their evolution from the end of the last glacial period until today in the Bay of Biscay (BoB).

Objectives / scientific questions

The main scientific questions addressed are: i) How did the benthic environments of the intermediate depths along the BoB margin record the climatic variations of the last 36,000 years? ii) How has the European slope current evolved during this period? And what was its role in these oscillations? iii) How can we improve the use of benthic foraminifera as proxy carriers?

Main results

- The evolution of benthic foraminiferal assemblages indicates significant changes on the seafloor (hydrodynamics, oxygenation) independently highlighted by sedimentary and geochemical proxies.
- A decrease in the abundance of high energy indicator species suggests a systematic slowing of the European slope current, and by extension of the AMOC, during each Heinrich stadial (HS).
- The strength of the slope current (Illustration 1) decreases significantly during the Holocene and could result from the decrease in insolation and the intensity of the subpolar gyre.
- Paleo-reconstitutions based on foraminifera can be influenced by the size fraction considered. We proposed a standardized protocol for paleo-environmental studies with a separate analysis of the size fractions.
- Our culture laboratory experiment (decoupled carbonate chemistry) (Illustration 2) proved that incorporation of Sr in deep-sea foraminifera is mainly controlled by DIC and/or [HCO₃].

Illustration 1

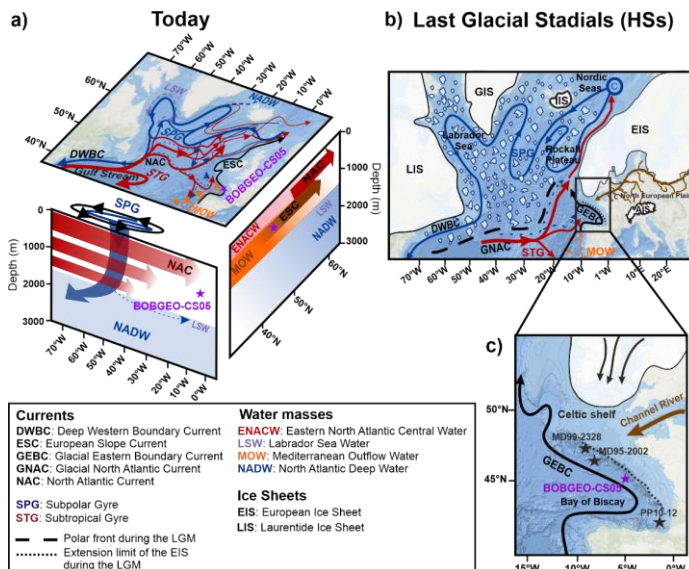
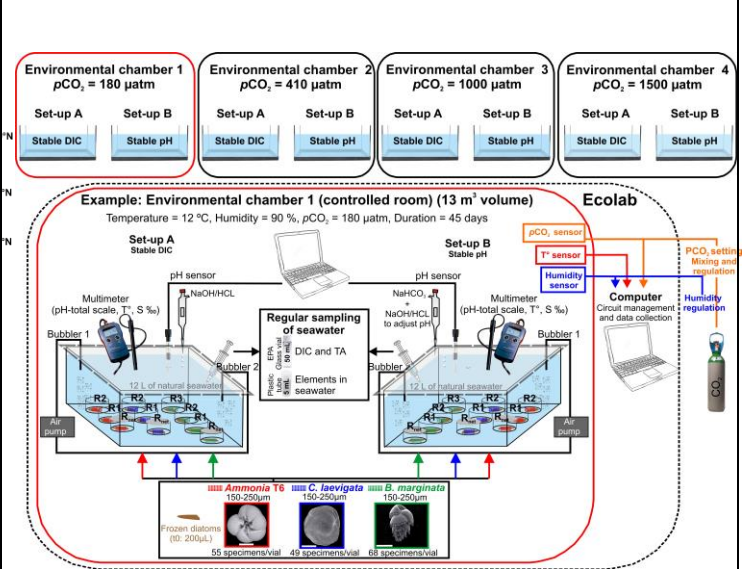


Illustration 2



The slope paleocurrent data, derived from sedimentological and benthic foraminiferal data (GEB, Illustration 1), covary over time between the northern and southern BoB. As this current represents the upper branch of the most eastern AMOC of the North Atlantic basin, we extended our understanding to the fluctuations of the AMOC, the millennial climatic variations, and the dynamics of the European Ice Sheet. To trace the sources of the water masses transported by this slope current, we performed controlled growth laboratory experiments (Illustration 2). We explored the use of Sr/Ca of benthic foraminifera as a potential seawater C-system proxy with two deep-sea species (*B. marginata* and *C. laevigata*) and one intertidal species (*Ammonia* T6). We decoupled carbonate chemistry, i.e., changing pH at constant dissolved inorganic carbon (DIC) and changing DIC at constant pH.

Future of the project: STING opened the way to several questions that need to be addressed in future projects: i) Extend the N-S transect to trace the dynamics of intermediate environments along the European margin; ii) Better document Heinrich stadials older than HS3; iii) Explore the vertical fluctuation of intermediate water masses over time; iv) Better document the Holocene variability and the arrival of the Mediterranean waters to the Bay of Biscay; v) Better understand biomineralization processes of foraminifera since the calcification of deep-sea species showed a very high sensitivity (dissolution) to low DICs. Some of these questions are explored already in current projects (e.g., CultForam2 for (v)). An ERC project focussing on the Holocene part (EXOTIC) will be resubmitted next year.

Number of publications, communications, and theses

Publications issues de STING:

1. Depuydt, P., **Mojtahid, M.**, Fossile, E., Toucanne, S., Barras, C., Accepted after moderate revisions. Implication of size fraction on paleostudies using benthic foraminifera: a case study from the Bay of Biscay. *Marine Micropaleontology*.
2. **M. Mojtahid**, P. Depuydt, A. Mouret, S. Le Houedec, S. Fiorini, S. Chollet, F. Massol, F. Dohou, H.L. Filipsson, W. Boer, G.-J. Reichart, C. 2023. Barras Assessing the impact of different carbonate system parameters on benthic foraminifera from controlled growth experiments. *Chemical Geology*, 121396. <https://doi.org/10.1016/j.chemgeo.2023.121396>.
3. Depuydt, P., **Mojtahid, M.**, Barras, C., Bouhdayad, F.Z., Toucanne, S., 2022. Intermediate ocean circulation and cryosphere dynamics in the northeast Atlantic during Heinrich Stadials: benthic foraminiferal assemblage response. *J. Quat. Sci.* 1–15. <https://doi.org/10.1002/jqs.3444>.
4. **Mojtahid, M.**, Schweizer, M., Douarin, M., Gabriel, J., Colin, C., Tisnérat-Laborde, N., Elliot, M., 2021. From glacial times to late Holocene: Benthic foraminiferal assemblages from cold water coral habitats off northwest Scotland. *Marine Geology* 440, 106581. <https://doi.org/10.1016/j.margeo.2021.106581>.
5. P. Depuydt, S. Toucanne, C. Barras, E. Michel, S. Le Houedec, **M. Mojtahid**. **To be submitted soon**. New insights on the glacial-interglacial dynamics of the European Slope Current based on a 36,000-year sediment record from the southern Bay of Biscay

Communications

1. Depuydt, P., **Mojtahid, M.**, Barras, C., Bouhdayad, F., and Toucanne, S.: Links between intermediate ocean circulation and cryosphere dynamics during Heinrich Stadials in the NE Atlantic: a foraminiferal perspective, EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-1792, <https://doi.org/10.5194/egusphere-egu22-1792>, 2022, Talk.
2. **M. Mojtahid**, P. Depuydt, A. Mouret, F. Rihani, S. Le Houedec, S. Fiorini, S. Chollet, F. Massol, F. Dohou, H. L. Filipsson, W. Boer, G.-J. Reichart, S. Quinchar, C. La, C. Barras. Decoupling the impact of different carbonate system parameters from controlled growth experiments with deep-sea benthic foraminifera. EGU, April 2022, Vienna (Austria), Talk.
3. **M. Mojtahid**, P. Depuydt, A. Mouret, F. Rihani, S. Le Houedec, S. Fiorini, S. Chollet, F. Massol, F. Dohou, H. Filipsson, W. Boer, C. Barras. Decoupled carbonate chemistry experimental work involving deep-sea benthic foraminifera and new generation environmental simulators. Global Ocean Acidification Observing Network, Webinar, Nov 2021.
4. Depuydt, P., **Mojtahid, M.**, Barras, C., Bouhdayad, F., and Toucanne, S.: A new 35 kyr-high resolution record from the Bay of Biscay (NE Atlantic): new insights on hydrological and environmental changes and their potential impact on intermediate water masses revealed by benthic foraminifera, Journées “Climat et Impacts”, Paris Saclay, Nov 2020, Poster.
5. **Mojtahid M.**, Schweizer M., Douarin M., Gabriel J., Colin C., Tisnérat-laborde N., Pons-branchu E., Elliot M. From glacial times to late Holocene: benthic foraminiferal communities from cold water coral reefs off northwest Scotland. Talk, Journées “Climat et Impacts”, Nov 2020, Paris Orsay.

Theses

Pauline Depuydt (2019-2023): Sedimentary and biotic evolution of the upper-slope environments of the Bay of Biscay and implications for ocean-cryosphere dynamics: window on the last 36,000 years. **Defended 15th of February 2023.**

Data availability: Data is available on Open Access Data Repositories: <https://doi.org/10.17882/89623>; <https://doi.org/10.17882/91758>; <https://doi.org/10.17882/88029>; <https://doi.pangaea.de/10.1594/PANGAEA.932647>

