Titel: Marine bio-indicators for freeze-thaw cycles of Arctic sea ice; chronicle of recent changes

Keywords: Climate change in polar region; Sea ice dynamics in Arctic fjords; Historical variability of ice formation/melting; Brine intensity; Sediment discharge from coastal glaciers; Benthic Foraminifera

Duration: 36 months, full time, start in September 2018
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Doctoral School: *Sciences de la Mer et du Littoral*; **ED SML n°598**; https://ed-sml.u-bretagneloire.fr/

Application: in the "**Make Our Planet Great Again**" initiative, candidate must not be French citizen
From April 5 to 20 at http://Doctorat.campusfrance.org

Abstract: Climate change challenges the Arctic region. Due to decreasing sea ice/snow cover observed in the last decades, the reduction of albedo is accelerating the warming effects in the area. Continental glaciers and sea ice production/melting cycles are the major controls of marine ecology in the Arctic. They influence the annual cycles of primary production and the salinity of seawater, through the release of nutrients and fresh water, during melting, and the production of brines during sea ice formation. The observed deregulation of these production/melting-ice cycles would have huge effects, at regional and global scale, that are now difficult to predict, due to scarce knowledge of the involved processes.

The scientific priority is to understand the **effects of sea ice cycles on benthic communities** living in two contrasting Svalbard fjords that are affected, either by strong brine cascading (salty and low-pH waters) during sea ice production phases, or by massive releases of sediments and nutrients from the coastal glaciers and high primary production during melting phases.

The research strategy is to follow the coastal ice dynamics by studying the response of the bioindicators “benthic foraminifera”. This phylum consists of unicellular eukaryotes, with a quick turnover and a shell that fossilizes. Foraminiferal ecological responses to ice cycles will allow identifying assemblages-based bioindicators respectively for ice production and melting phases. Consequently, the fossilizing potential of their shells will allow to reconstruct production/melting ice cycles in the recent past (hundreds of years), also before the industrial revolution. This approach will allow having a precise knowledge of the periodicity of the ice cycles in the recent past and evaluating if the present-day accelerated decline of Arctic ice cover, suggested on the base of short-term (decades) satellite observations, is significant on a longer time scale, and at what extent it is going on.

Our project aims firstly to extend our knowledge on the short and long-term response of benthic foraminifera to seasonal stress in high latitudes, and their resilience capacity after perturbations due to production and melting cycles of Arctic sea ice, and secondly to **chronicle recent changes in benthic environments** related to sea ice dynamics.

Methodology and planning

Phase 1: calibration (15 months). The 1st scientific objective is to calibrate foraminiferal ecological responses to freeze-thaw cycles, thanks to the study of living faunas in relation to bottom seawater and sediment characteristics. Living assemblages of benthic foraminifera inhabiting the first 5 cm of sediment will be analysed in short interface cores, in relation to bottom water mass parameters (i.e., organic matter availability, pH, O_2, salinity), and sedimentology (grain-size, water content). The aim is to identify the assemblages characteristic of particular settings (e.g., trapped brines, summer algal blooms, high sediment discharge..). A comparison between living and recently dead faunas (from layers corresponding to the last 5-10 years) will allow estimating the taphonomic loss due to early diagenesis, in order to adjust the bio-indicator indices calibrated on living faunas to fossil assemblage interpretation. Thanks to the possibility for foraminifer to calcify their shells in equilibrium with the

ambient water, geochemical shell composition will also be investigated (e.g., Li/Ca, B/Ca, Ba/Ca, Sr/Ca) in order to obtain complementary proxies to be associated to foraminiferal assemblages (multi-proxy approach), as a guarantee to obtain robust results. The analyses will be performed using LA-ICP-MS, on singular specimens and separately for each species, to avoid bias due to species-specific effects, ontogenetic and microhabitat issues.

Phase 2: application on historical records (12 months). The 2nd objective is, through the study of fossilized faunas at high time resolution, to reconstruct historical data on ice production in terms of intensity and frequency in the recent past, which is impossible to achieve by direct measurements. The fossil content of two long cores (200-500 years of sediment record) sampled close to the Storfjorden mouth and in the central Kongsfjorden, will be analysed. The foraminiferal assemblages will be identified with a resolution of 1 cm which, associated to the very high sedimentation rates of the study areas (0.2 to 2 mm/year), would allow obtaining an historical reconstruction of past ice dynamics with an incredibly high temporal resolution (few years per layer). The environmental changes reconstructed on the basis of the assemblages will be further verified and deepened through the geochemistry variability of calcareous shells, which would more precisely reveal the nature of the change(s) (e.g., pH, and/or nutrients, and/or salinity..).

Phase 3 (9 months). Thesis manuscript and scientific papers writing (Proxy development, chronicle ...)

Candidate desired profile

1. Intellectual curiosity
2. Master degree with strong score (e.g., top 10 percent)
3. Need a solid grounding in marine sciences (oceanography, ecology, sedimentology…)
4. Experience in micropaleontological tools and observation at binocular microscope are welcomed
5. Research experience (either arising from a thesis at the Undergraduate or Master's degree programme) will be a strong plus.
6. Proficiency in spoken and written English
7. Strong recommendation letters
8. Availability for short stays abroad

Evaluation of the motivation letter written by the applicant will form an important part of the admission process. A candidate's proficiency and depth of understanding of her or his research statement (Statement of Research Interests) will be tested during a phone interview (for shortlisted candidates).

Partnership

This project will be conducted in close collaboration with the **Norwegian Polar Institute** (Tromsø) that offers us access to sampling devices and ship-time. The CAGE institute (**Center for Arctic Ga Hydrate, Environment and Climate**) is also a privileged partner with which mobility of researchers is financially supported by Angers University.