SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Analytical, Environmental and Geo- Chemistry

has the honour to invite you to the public defence of the Joint PhD of

Nolwenn LEMAÎTRE

to obtain the degree of Doctor of Sciences (VUB) and

Doctor in Marine Sciences (UBO-IUEM)

Title of the PhD thesis:

Multi-proxy approach (^{234}Th, Ba_{xs}) of export and remineralisation fluxes of carbon and biogenic elements associated ith the oceanic biological pump.

Promotors:
Prof. Dr. Frank Dehairs (VUB)
Dr. Geraldine Sarthou (IUEM)

The defense will take place on

Friday January 20th 2017 at the Université de Bretagne Occidentale, Brest, Institut Universitaire Européen de la Mer

Members of the jury:

Prof. Stéphane Blain (chairman, Paris VI, Banyuls)
Dr. Lionel Guidi (secretary, Paris VI, Villefranche/Mer)
Prof. Filip Meysman (VUB, AMGC)
Dr. Hélène Planquette (IUEM-LEMAR, UBO)
Dr. Frédéric Planchon (IUEM-LEMAR, UBO)
Dr. Frédéric Lemoigne (Geomar, Kiel, Germany)
Dr. Ian Salters (AWI, Bremerhaven, Germany)

Curriculum vitae

2013-Jan 2017: **PhD student**, Joint supervision between the Université de Bretagne Occidentale (UBO, IUEM, France) and Vrije Universiteit Brussel (VUB, Belgium); **Research project**: '*Multi-proxy approach (^{234}Th, Ba_{xs}) of export and remineralization fluxes of carbon and biogenic elements associated with the oceanic biological pump*'

2012-13: **University Degree "Passerelles"**, UBO, Brest, France; **Research project**: '*Tracing the circulation: development and analysis of marine isotope tracers (Rare earth elements and Nd)*'

2010-12: **MSc** Marine Chemistry, IUEM, Brest, France; **Research project (2012)**: '*Behavior of Rare Earth Elements and other trace elements in cold seeps: Example of the pockmark Regab*'; **Research project (2011):** '*Biogeochemical investigation of the cold seep tubeworm Southwardae (Siboglinidae): method development*'

2007-2010. **BSc** Chemistry, UBO, Brest, France

Abstract of the PhD research

The aim of this thesis is to improve our understanding of the different controls that affect the biological pump in the North Atlantic and around the Kerguelen Island in the Southern Ocean.

The GEOTRACES GA01 cruise (GEOVIDE, May-June 2014, transect from Portugal to Newfoundland) provided an ideal framework to investigate export fluxes of particulate organic carbon (POC), particulate nitrogen, biogenic silica and particulate trace elements, as well as deep ocean remineralization fluxes, using two biogeochemical proxies: thorium-234 (^{234}Th) and biogenic barium (Ba_{xs}).

The North Atlantic Ocean is characterized by a strong spring bloom generating a pulse of sinking particles. This process impacts the export of photosynthetically produced organic carbon from surface to deep ocean. POC export fluxes were highest in the western European basin and the Labrador Sea. We observed the higher export fluxes to be associated with the presence of biogenic (biogenic silica or calcium carbonate) and lithogenic particles, known to have a ballasting effect on particle settling. As the ballasting effect of biogenic silica is the smallest, the composition of the phytoplankton and the sinking particles will impact export efficiency to the deep ocean. Export efficiency was generally low (< 10% of primary production) and appeared inversely related to primary production, highlighting that a phase lag exists between production and export, but also probably that the North Atlantic biopump is not as efficient as previously thought. The highest transfer efficiencies, i.e. the fraction of POC that reached 400 m depth, appeared to be driven by sinking particles ballasted by calcite or lithogenic minerals.

The important regional variation of mesopelagic remineralization could be attributed to bloom intensity, phytoplankton cell size and community structure as well as physical forcing, including downwelling. Surprisingly, carbon remineralization balanced, or even exceeded, POC export. Excess remineralization, relative to export can be explained by the fact that measurements of primary production, export and remineralization integrate different timescales. Overall our results highlight the important impact of mesopelagic remineralization on the biological carbon pump with a near-zero, deep carbon sequestration efficiency for spring 2014.

As observed for POC, export of trace metals (Fe, Zn, Mn) appeared strongly influenced by lithogenic material advected from the margins. However, at open ocean stations not influenced by lithogenic matter, trace metal export rather depended on phytoplankton activity and biomass.

A last part of this work focused on export of particulate nitrogen, biogenic silica and iron in the Southern Ocean Kerguelen Island area. This area is characterized by a natural iron-fertilization of a recurrent large phytoplankton bloom extending up to 1000 km downstream of the Island (KEOPS2 cruise, austral spring 2011). Our findings indicate that Fe-fertilization increases N, biogenic Si, Fe and POC export fluxes and also that flux variability inside the fertilized area is related to phytoplankton community composition.

This thesis represents one of the first attempts to characterize export and remineralization fluxes in the North Atlantic and represents a reference point for subsequent studies of the biological carbon pump that will be conducted in this area. A further strongpoint of the work resides in the comparison of the biopump functioning between the Southern Ocean and the Sub-Arctic Ocean.