FINAL REPORT PROGRAM LEFE

Program LEFE/ IMAGO	Project Title Reconstruction of deep-water Circulation and Hydrological cycle across the Mid Pleistocene Transition and Mid Brunhes Event (RICH)	Years 2016-2018

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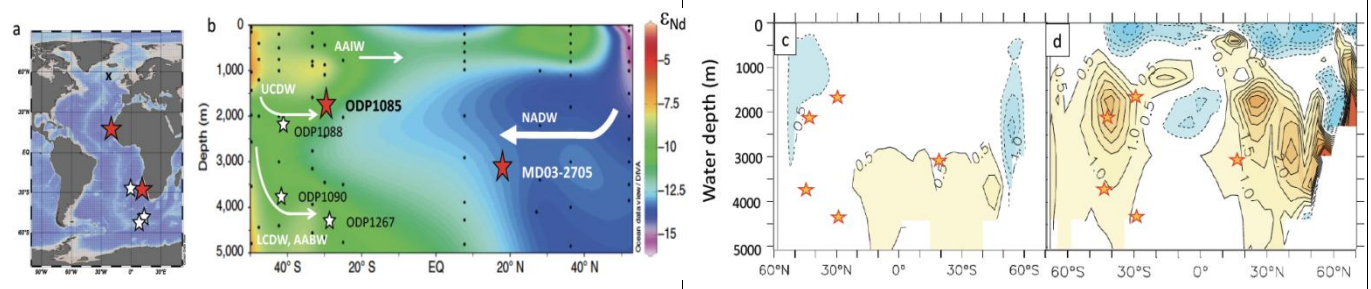
Contribution to
IMAGES, ODP
Other funding sources: CEREGE own founds (M2 internship)

Context: The role of deep-water circulation during the past major climate events is of great interest because oceanic circulation affects heat transport and carbon cycle on global scale, contributing to feedback processes. RICH project treated the variability in Atlantic Meridional Overturning Circulation (AMOC) over the past 1100 kyr.

Objectives: For the past 1500 kyr, glacial/interglacial cycle has intensified and climate cycle has shifted from 41 kyr to 100 kyr world without corresponding solar insolation changes (Mid-Pleistocene Transition, MPT, 1250 to 700 kyr). We aim at clarifying the role of AMOC to the MPT by reconstructing deep-water circulation.

Main results: It was known that a major perturbation of ocean carbon chemistry occurred on global scale during the Mid-Pleistocene, and the most marked change is called the "900-ka event". Carbon isotopic composition recorded in benthic foraminifera indicates either reduction of AMOC or active deep-water formation in the Southern Ocean during the 900-ka event. We reconstructed bottom water Nd isotopic composition ($^{143}Nd/^{144}Nd$ or ε_{Nd}) of two cores (MD03-2705 and ODP1085; red stars in figures a and b) and compared with already available records in the South-eastern Atlantic (white stars in figures a and b). All results indicate an increase in ε_{Nd} at the 900-ka event relative to the present value in the eastern Atlantic Ocean. Comparison of reconstructed and simulated seawater ε_{Nd} distribution (figures c and d) suggest that the shift cannot be explained solely by more active formation of southern-sourced water that has a higher ε_{Nd} value than the northern-sourced water. We suggest that the reduction in the AMOC and/or changes in Nd sources to the North Atlantic were the main cause(s) of the observed ε_{Nd} change in relation to the evolution of the Northern hemisphere cryosphere.



(a) Core location map in the Atlantic Ocean: the two red stars indicate MD03-2705 (18°N, 21°W, 3085m water depth) and ODP1085 (29°S, 14°E, 1725m) studied in this work, the three white stars indicate the sites of previous studies: ODP1088 (41°S, 13°E, 2082 m) and 1090 (43°S, 9°E', 3702 m) (Pena and Goldstein, 2014) and ODP1267 (28°S, 2°E, 4360 m) (Farmer et al., 2019). (b) Latitudinal transect of present-day seawater ε_{Nd} values in the Atlantic Ocean (Howe et al., 2016) with the main water masses: NADW=North Atlantic Deep Water; UCDW and LCDW=Upper and Lower Circumpolar Deep Water, AABW=Antarctic Bottom Water, AAIW=Antarctic Intermediate Water. (c) Comparison between the reconstructed and zonally averaged simulated seawater ε_{Nd} anomalies in the case of enhanced southern-sourced water formation. The orange stars present the sites of reconstructed seawater ε_{Nd} with positive anomalies at the 900-ka event whereas the orange and blue areas correspond to oceanic zones characterized by positive and negative simulated ε_{Nd} anomalies. (d) the same as (c) in the case of reduced northern-sourced water formation. The simulation results from Friedrich et al. (2014). All the figures are from Tachikawa et al. (submitted).

*<u>Future of the project</u>: RICH project focused on deep water circulation in the Atlantic Ocean. In order to better understand the mechanism of AMOC variability, José N. Pérez-Asensio has joined us in the framework of **Marie H2020 Curie Individual Fellowship** INDEXCLIMA project (Indian-Atlantic interocean exchange as modulator of global climate) in 2019-2021 (supervisor K. Tachikawa).*

Publications and communications (2 publications, 3 communications, 3 internship reports)

Tachikawa, K., Rapuc, W., Dubois-Dauphin, Q., Guihou, A., Skonieczny, C., submitted. Reconstruction of ocean circulation based on neodymium isotopic composition: potential limitations and application to the Mid-Pleistocene transition. Oceanography. Volume special, **invited contribution**.

Tachikawa, K., Rapuc, W., Vidal, L., Dubois-Dauphin, Q., Guihou, A., Westerhold, T., Bickert, T., Pérez-Asensio, J.N., Skonieczny, C., to be submitted to Quaternary Science Review in 2020. Eastern Atlantic deep-water circulation inferred from neodymium and carbon isotopic compositions over the past 1100 thousand years.

Tachikawa, K., Rapuc, W., Vidal, L., Dubois-Dauphin, Q., Guihou, A., Westerhold, T., Bickert, T., Skonieczny, C. 2018. Eastern Atlantic deep-water circulation inferred from neodymium and carbon isotopic compositions over the past 1200 thousand years. EGU General Assembly EGU2018-8683, Vienna, Austria, 8-13 April 2018.

Tachikawa, K. 2019. Neodymium isotopic composition as a proxy of water mass provenance in the Atlantic Ocean: the modern ocean and the past 1200 kyr. The 13th International Conference on Paleoceanography in Sydney, Australia, 2 – 6 September 2019. **Invited**.

Rapuc, W., Tachikawa, K., and Guihou, A., 2017. Application of Neodymium isotopic ratio to reconstruct North-eastern Atlantic deepwater mass sources over the last 1Myr. Colloque "Observing and understanding the Atlantic Meridional Overturning Circulation (AMOC)": Journées LEFE-IMAGO Plouzané, 3-5 Mai 2017.

Rapuc, W., 2017. Reconstruction de la circulation océanique en utilisant les isotopes du néodyme pendant le dernier million d'années. Master SET. Aix-Marseille University.

Gerbaud, O., 2016. Caractérisation géochimique des sédiments marins dans le Pacifique Ouest équatorial : stratigraphie et fractions détritiques. Licence SVT Mer option Physique et Biogéochimique. Aix-Marseille University.

Chmielewska, M., 2018. Application de la géochimie de tests de foraminifères à la reconstitution de la circulation océanique dans l'Atlantique sud durant le dernier million d'années. Licence SVT Océanographie biologique. Aix-Marseille University.