

FINAL REPORT PROGRAM LEFE

Program LEFE/ IMAGO	Project Title	Years 2017 – 2019
	SEASALT : conStraining future Evolution of Asian monsoon precipitation by quantifying paSt seA surface saLiniTy changes.	
PI name, email and lab: CALEY Thibaut, thibaut.caley@u-bordeaux.fr , EPOC Participating Laboratories: LSCE, Ifremer, NIOZ		Contribution to Other funding sources :
<p><i>Context (2-3 lignes)</i> The hydrological cycle plays an important role in the Earth's climate. Changes in seawater salinity reflect mainly the combination of evaporation and precipitation and thereby the intensity of the hydrological cycle. There are some qualitative proxies for sea surface salinity, but quantitative reconstructions with reasonable uncertainties remain a challenge in paleoceanography.</p> <p><i>Objectives / scientific questions (2-3 lignes)</i> In this project we proposed to develop and apply a multiproxy approach to quantify past sea surface salinity and improve our understanding of the past hydrological cycle around the Indian Ocean.</p> <p><i>Main results</i></p> <p><u>1) Development of new methods to quantify past sea surface salinity</u> Within the Seasalt project, we have initiated a new approach to quantify past sea surface salinity (SSS). The $\delta^{18}\text{O}$ of the calcite of planktonic foraminifera has a strong relationship with the two variables determining the density of seawater, temperature and salinity. Within the project we demonstrated the applicability of the $\delta^{18}\text{O}$ calcite of foraminifera to the past quantification of surface ocean density (Caley et al., <i>in prep</i> ; Figure 1). By reconstructing density and temperature (Mg/Ca or clumped isotopes) of seawater it is then possible to reconstruct past SSS quantitatively. This new approach will be developed in the future ANR JCJC Hydrate (see part Future of the project). Within the Seasalt project we also developed an organic geochemistry laboratory at EPOC to realize lipids extraction and purification. This is a first fundamental step towards measurements of the hydrogen isotopic composition of lipids produced by marine organisms (δD analyses on alkenones), another innovative approach to constrain past SSS changes.</p> <p><u>2) Past hydrological cycle dynamic around the Indian Ocean</u> Within the Seasalt project, we reconstructed the dynamic of the past hydrological cycle in two major locations around the Indian Ocean (southeastern Africa and the Bay of Bengal). - Among the works realized in southeastern Africa we applied a multiproxy approach on a marine sediment core off the Limpopo river (Figure 2). We demonstrated that major changes in the hydrological cycle have taken place over the last two million years, which may have influenced human evolution and in particular could have played a role in the extinction of the robust australopith <i>Paranthropus robustus</i> (Caley et al., 2018 ; Figure 2). - For the Bay of Bengal, we conducted a multiproxy approach ($\delta^{18}\text{O}$ of planktonic foraminifera, multiple trace elements analyses on planktonic foraminifera, foraminifera assemblages, Dinoflagellate analyses, XRF) on marine sediment core MD12-3411CQ (age constrained by C14 dates, tephra layer and benthic foraminifera $\delta^{18}\text{O}$) to precisely reconstruct past asian monsoonal changes through river discharges, creating reference points and test cases for climate models. We are currently finalizing the last analyses and a draft article is in preparation (Caley et al., <i>in prep</i>).</p>		

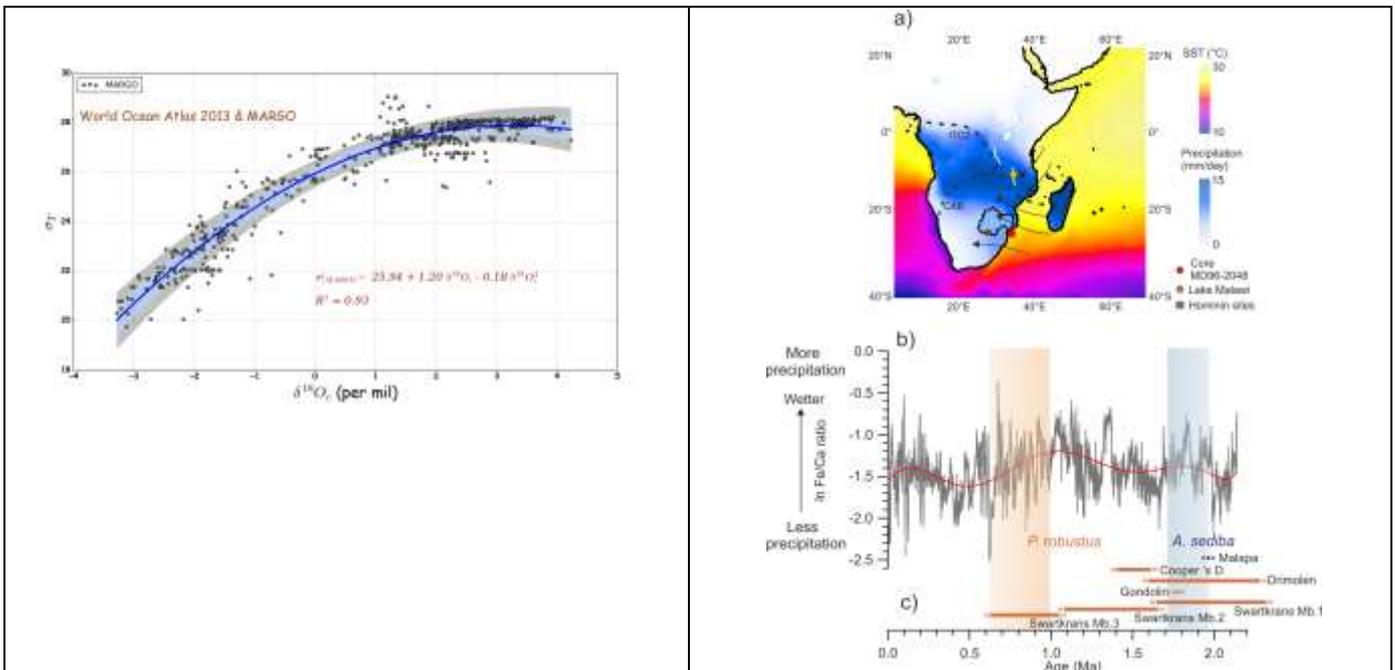


Figure 1 : Relationship between the $\delta^{18}O$ signal measured on planktonic foraminifera (sedimentary core tops, MARGO project) and surface water density (Caley et al., in preparation).

Figure 2 : a) Modern climatology in southern Africa, location of the sediment core used (MD96-2048) and that of Lake Malawi, and main hominid sites for *Paranthropus robustus* and *Australopithecus sediba*.

b) Temporal evolution of the $\ln Fe / Ca$ ratio (indicator of hydrological changes) for the MD96-2048 record of the Limpopo river basin and c) estimated age for the main sites containing remains of *Paranthropus robustus* and *Australopithecus sediba*. Gray / red boxes indicate respectively wetter / drier periods. (Figure modified from Caley et al. 2018 Nature).

Future of the project : The LEFE IMAGO seasalt project has allow to initiate new approaches to quantify past sea surface salinity. This work will be extended in the ANR JCJC HYDRATE (evaluate the low latitude HYDrological cycle in numeRiCal climate models by consTraining past ocean salinity changEs) submitted to the AAPG 2021 in which Thibaut CALEY is the PI.

Nombre de publications, de communications et de thèses
(citer au maximum 5 publications en lien direct avec le projet)

Articles (revue internationale, Rang A)

- 1) **Caley, T.**, Extier, T., Collins, J. A., Schefuß, E., Dupont, L., Malaizé, B., ... & Giraudeau, J. (2018). A two-million-year-long hydroclimatic context for hominin evolution in southeastern Africa. *Nature*, 560(7716), 76-79.
- 2) Fauquembergue, K., Fournier, L., Zaragosi, S., Bassinot, F., Kissel, C., Malaize, B., **Caley, T.**, Moreno, E., Bachèlery, P. (2019). Factors controlling frequency of turbidites in the Bengal fan during the last 248 kyr cal BP: Clues from a presently inactive channel. *Marine Geology*, 415, 105965.
- 3) Zhao, X., Koutsodendris, A., **Caley, T.**, & Dupont, L. (2020). Hydroclimate change in subtropical South Africa during the mid-Piacenzian Warm Period. *Quaternary Science Reviews*, 249, 106643.

In preparation

- 4) **Caley, T.**, Roche, D., Happé, T., Waelbroeck, C., Surface ocean density and salinity from planktonic foraminifera calcite $\delta^{18}O$. In preparation.
- 5) **Caley, T.**, et al., Hydroclimate changes in the Asian monsoon region over the last 150 kyr. In preparation.

Communications (colloques internationaux et nationaux).

- EGU 2019 : Didier Roche, **Thibaut Caley**, and Claire Waelbroeck. On upper ocean density reconstructions using planktic foraminiferal calcite $\delta^{18}O$.
- Q12 2020 : Antoine Souron et **Thibaut Caley**. On the paleoecology of *Paranthropus robustus* (Mammalia, Hominidae) from South Africa and the potential impact of climatic changes on its extinction.