## The MASCOT project

In recent years, unprecedented marine-related extremes have underscored the planet approaching to an irreversible climate crisis. Understanding these changes in the context of past variations is essential to forecasting future trends and their impacts. This is the core motivation of the MASCOT project, which takes a paleoceanographic approach to examine past oceans to understand their future. Focusing on the Mediterranean Sea, where anthropogenic changes are accelerating faster than in the global oceans, the project investigates the carbonate chemistry underpinning these transformations. Anthropogenic CO2 uptake has triggered a sharp decline in Mediterranean pH, as evident from instrumental records and our own recent paleoreconstructions, with profound consequences for marine calcifiers.

The MASCOT project aims to reconstruct key aspects of the Mediterranean and global ocean's carbonate chemistry over past climate cycles. Using sediment cores strategically located in regions of high sedimentation, it will compare changes in the chemistry of Atlantic water entering the Mediterranean at the surface through the Strait of Gibraltar with that of the Mediterranean Outflow Water (MOW) exiting this Strait at depth. Marine sediment cores from the Gulf of Cadiz and the Strait of Sicily will provide insights into the surface and deep-water chemistry evolution and the differences between the Western and Eastern Mediterranean basins. A central innovation lies in applying boron isotopes in planktonic and benthic foraminifera to reconstruct surface and deep-water paleo-pH, alongside B/Ca ratios in benthic foraminifera for carbonate ion concentrations. These geochemical proxies, combined with molecular biomarkers, will enable reconstructions of millennial-to-centennial scale abrupt changes.

To bridge the gap between past and present conditions, modern instrumental seawater data from time-series in the Catalan coast will be compared with sediment core records recently sampled nearby. Additionally, experimental cultures of benthic foraminifera will refine calibrations for boron isotopes and B/Ca ratios, building on innovative aquaria techniques developed in prior work. This research will explore the roles of MOW and Levantine Intermediate Water (LIW) in modulating seawater chemistry, supporting cold-water coral development, regulating the carbon cycle, and influencing atmospheric $CO_2$ levels over glacial/interglacial timescales. By integrating cutting-edge techniques such as LA-MC-ICPMS and a newly available MC-ICPMS in Barcelona, the project provides an ideal training framework for a PhD student in global change, paleoceanography, geochemistry and advanced isotope ratio analyses.

Ultimately, the MASCOT project seeks to open a window into the past, offering critical insights into ocean-climate interactions and feedbacks that improve projections of future climate and ocean changes. These findings will contribute to addressing global challenges like ocean acidification, environmental sustainability, and climate resilience, while fostering awareness of the intricate connections between the ocean and the climate system. By advancing the understanding of the oceans role in regulating climate over geological timescales, the project reinforces the vital importance of protecting marine ecosystems in the face of escalating environmental pressures.

The MASCOT project builds on the expertise of E. Calvo and C. Pelejero in developing and applying organic and inorganic geochemical techniques to reconstruct past ocean and climate conditions. Below a selection of some relevant articles:

- Rodríguez-Díaz, C.N., Paredes, E., Pena, L.D., Cacho, I., **Pelejero, C.** and **Calvo, E.** (2024). Nanogram-scale boron isotope analysis through micro-distillation and Nu Plasma 3 MC-ICP-MS. *Talanta*, 269, 125473. https://doi.org/10.1016/j.talanta.2023.125473.

- García-Ibáñez, M.I., Guallart, E.F., Lucas, A., Pascual, J., Gasol, J.M., Marrasé, C., **Calvo, E.** and **Pelejero, C.** (2024). Two new coastal time-series of seawater carbonate system variables in the NW Mediterranean Sea: rates and mechanisms controlling pH changes. *Frontiers in Marine Science*, 11:1348133, https://doi.org/10.3389/fmars.2024.1348133.

- Martínez-Dios, A., **Pelejero, C.**, Cobacho, S., Movilla, J., Dinarès-Turell, J. and **Calvo, E**. (2021). A 1-million-year record of environmental change in the Central Mediterranean Sea from organic molecular proxies. *Paleoceanography and Paleoclimatology*. 36, e2021PA004289. https://doi.org/10.1029/2021PA004289.

- Moy, A.D., Palmer, M.R., Howard, W.R., Bijma, J., Cooper, M.J., **Calvo, E., Pelejero, C.**, Gagan, M.K. and Chalk, T.B. (2019). Varied contribution of the Southern Ocean to deglacial atmospheric $CO_2$ rise. *Nature Geoscience*, 12, 1006-1011, https://doi.org/10.1038/s41561-019-0473-9

- de la Fuente, M., Skinner, L., **Calvo, E., Pelejero, C.** and Cacho, I. (2015). Increased reservoir ages and poorly ventilated deep waters inferred in the glacial Eastern Equatorial Pacific. *Nature Communications* https://doi.org/10.1038/ncomms8420

**- Pelejero, C., Calvo, E.** McCulloch, M.T., Marshall, J.F., Gagan, M.K., Lough J.M. and Opdyke, B.N. (2005) Preindustrial to modern interdecadal variability in coral reef pH. *Science*, 309, 2204-2207