# Lessons from the Past: Using micropaleontology & geochemistry to understand past & future climate changes

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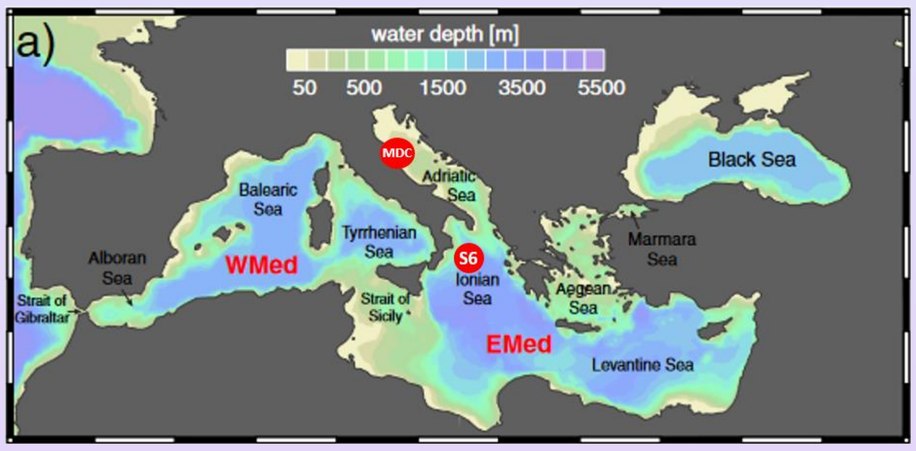
## Introduction

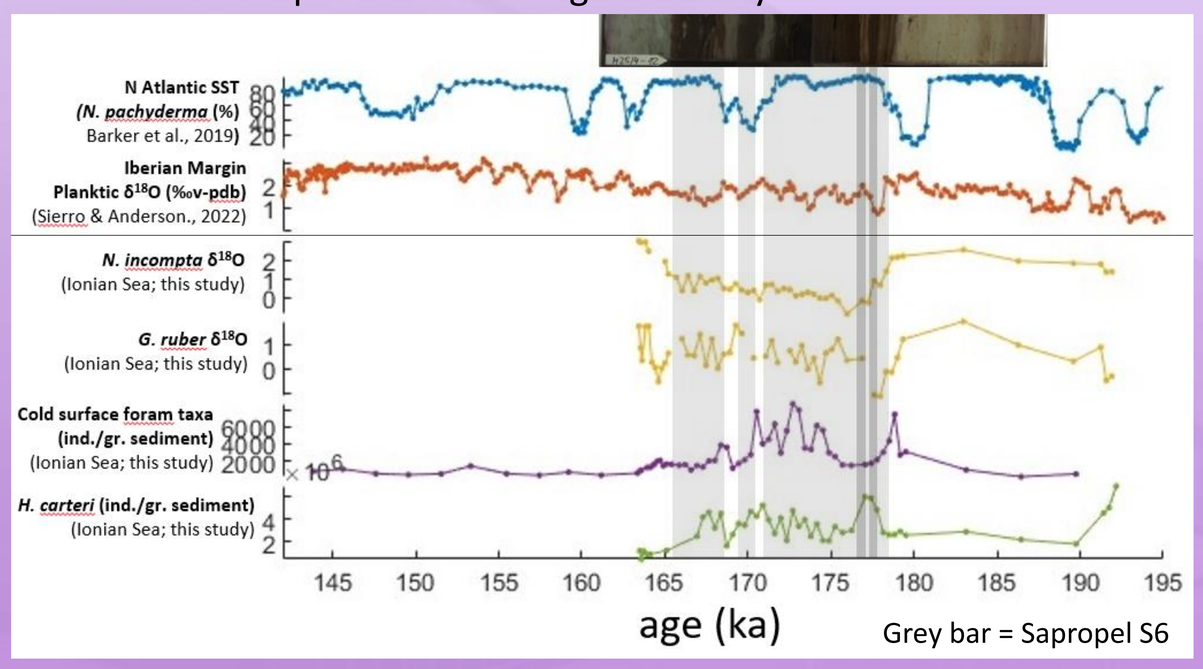



F1: Map of Mediterranean Sea basins and sample locations

Sequences of dark colored, organic-rich sediment layers, called sapropels have been observed throughout the geological archive of the Mediterranean Sea, but the mechanisms behind their cyclical deposition are not yet fully understood (Rohling et al., 2015). They are representative of large-scale bottom water deoxygenation and are attributed to combinations of surface-water freshening, reduced deep-water ventilation, and increased export production (Rossignol-Strick et al., 1982). As oxygen minimum zones expand around the world due to consequences of human-induced global warming sapropels are of increasing importance, as they are natural testbeds for deep sea redox and carbon burial processes (Grant et al., 2022). My research applies micropaleontology, paleoecology, and geochemistry to better constrain the complex network of mechanisms behind them.

## Sapropel S6: A Mediterranean "cold case"

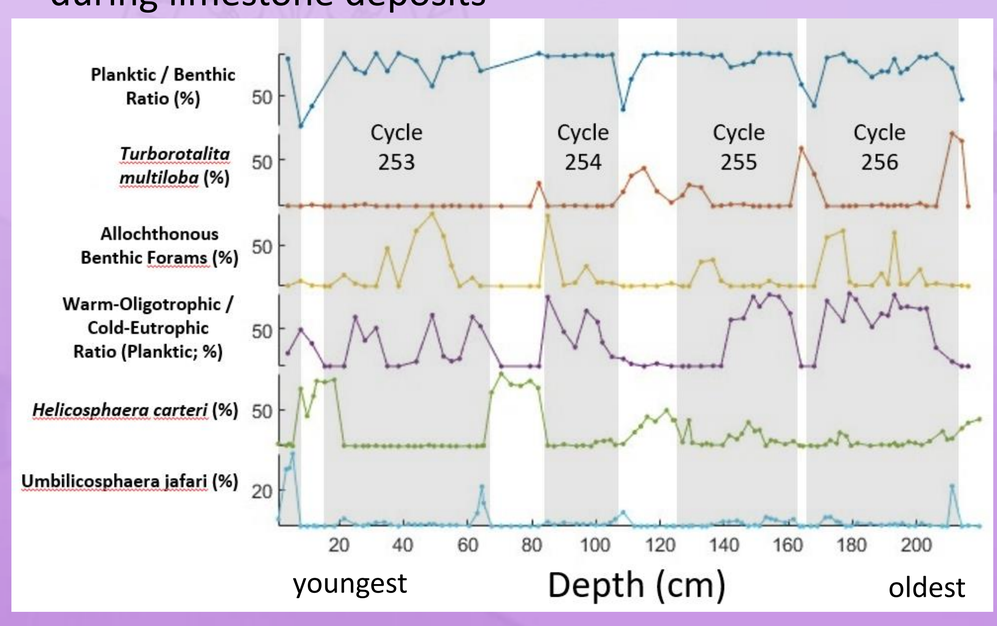
- S6 was deposited between **178.5 – 165.5 ka** during the Penultimate glacial cycle of Marine Isotopic Stage (MIS) 6.
- Millennial-scale **climate variability** (warm-cold climate cycles) is in effect due to interactions b/w ocean-atmosphere-ice sheets.
- Proxies used from Ionian Sea piston core:
  - Fossil forams, coccoliths, pollen, dinocysts, foraminiferal $\delta^{18}O$
- **Results:** Dual-mechanism initiated S6 deposition; Freshwater influx identified (cold foram peaks + $\delta^{18}O$ depletions); Mild glacial climate – "warm" temperatures and high humidity




F2: Multiproxy data collected from core M25/4-12 compared with previous studies.

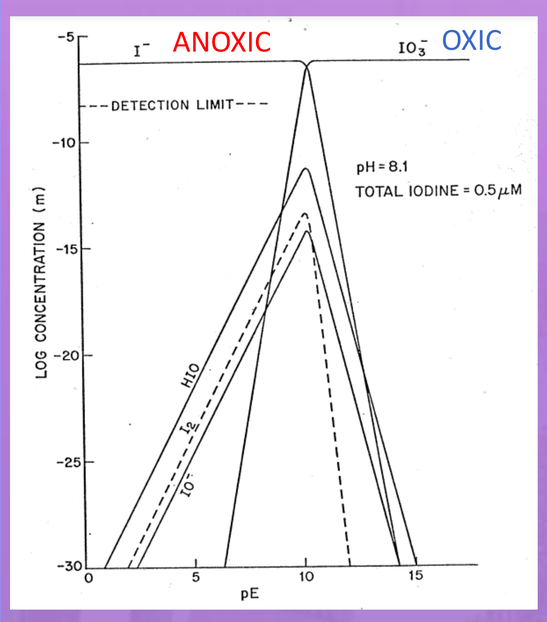
## Monte dei Corvi (MDC): Paleoecological Analysis

- One of the most complete **Miocene outcrop** sections of the Med Sea
  - **Rhythmic** deposition of sapropels intercalated with limestone/marl astronomically-tuned and dated to immediately before the **Messinian Salinity Crisis** (MSC, 5.97 – 5.33 Ma)
  - Constriction of the Med-Atlantic connection promoted weak THC causing periodic deterioration of bottom water ventilation in the studied interval leading up to the MSC
- Proxies used from MDC outcrop: Fossil forams and coccoliths
- Preliminary **Results:** Refined biostratigraphy; Highly stratified water column during sapropel deposition; Recovery of mixing processes during limestone deposits




F3: Multiproxy data collected from Euxinic Shale section of MDC. Grey bar represents a sapropel. White represents limestone.

## Deoxygenation Proxy: I/Ca



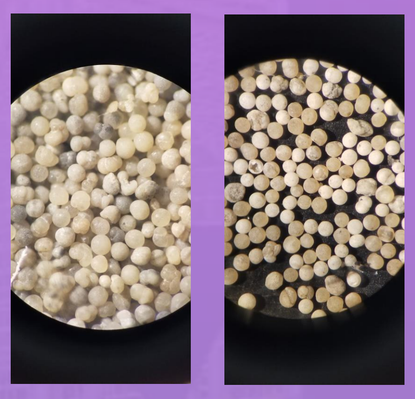

F4: Iodine system in an aqueous solution (Wong, 1977)

Constraining the **evolution of bottom water deoxygenation** throughout sapropel deposition is essential for potentially applying these sediment layers as **analogues for future** deoxygenation.

- **Iodine** is one of the first elements responding to ocean deoxygenation
- $IO_3$ is the sole species **incorporated into calcite** (Lu et al., 2010)
- To this end, I will **test** this fairly new proxy on the highly studied **sapropel S5** under the guidance of Prof. Yair Rosenthal at Rutgers Uni.

## Monte dei Corvi: Geochemical Analysis

F5: MDC study interval (Conero Riviera).



F6-F7: Samples of *O. universa* from MDC.

The isotopic composition of **boron** ($\delta^{11}B$) in the calcareous tests of foraminifera is pH-dependent. The tight coupling of pH and $CO_2$ in the ocean carbonate system allow $\delta^{11}B$ to be a powerful **proxy for past atmospheric $CO_2$** (Foster & Rae, 2016).

- **Objective:** Assess the **suitability** of the of the microfossils at MDC
- **Results:** Elemental and isotopic measurements tests of the planktic species, ***Orbulina universa***, did not fall within the expected range suggesting meteoric **digenesis alterations.**

**References**

**Barker**, S., Knorr, G., Conn, S., Lordsmith, S., Newman, D., & Thornalley, D. (2019). Early Interglacial Legacy of Deglacial Climate Instability. Paleoceanography and Paleoclimatology, 34(8), 1455–1475.

**Foster,** G. L., & Rae, J. W. B. (2016). Reconstructing Ocean pH with Boron Isotopes in Foraminifera. Annual Review of Earth and Planetary Sciences, 44(1), 207–237.

**Grant**, K. M., Amarathunga, U., Amies, J. D., Hu, P., Qian, Y., Penny, T., Rodriguez-Sanz, L., Zhao, X., Heslop, D., Liebrand, D., Hennekam, R., Westerhold, T., Gilmore, S., Lourens, L. J., Roberts, A. P., & Rohling, E. J. (2022). Organic carbon burial in Mediterranean sapropels intensified during Green Sahara Periods since 3.2 Myr ago. Communications Earth & Environment, 3(1), Article 1.

**Rohling**, E. J., Marino, G., & Grant, K. M. (2015). Mediterranean climate and oceanography, and the periodic development of anoxic events (sapropels). Earth-Science Reviews, 143, 62–97.

**Rossignol-Strick**, M., Nesteroff, W., Olive, P., Vergnaud-Grazzini, C., 1982. After the deluge, Mediterranean stagnation formation. Nature 295, 105-110 .

**Sierro**, F. J., & Andersen, N. (2022). An exceptional record of millennial-scale climate variability in the southern Iberian Margin during MIS 6: Impact on the formation of sapropel S6. Quaternary Science Reviews, 286, 107527. https://doi.org/10.1016/j.quascirev.2022.107527

**Lu**, Z., Jenkyns, H. C., & Rickaby, R. E. (2010). Iodine to calcium ratios in marine carbonate as a paleo-redox proxy during oceanic anoxic events. Geology, 38(12), 1107-1110.

**Wong**, G. T., & Brewer, P. G. (1977). The marine chemistry of iodine in anoxic basins. Geochimica et Cosmochimica Acta, 41(1), 151-159.

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