Deglacial sapropel formation in the Mediterranean Sea

Marine sediment archives of the Mediterranean Sea show remarkable variations in organic matter deposition over the last deglaciation cycle. Organic rich layers, classified as sapropel layers, appear within organic matter poor sediment records being typically for the present-day eastern Mediterranean Sea (EMed). Moreover, the sapropel formation occurred under anoxic conditions, a stark contrast to the well-ventilated present-day EMed. The most prominent hypothesis on sapropel formation is related to the change in the African monsoon during the early Holocene, the so-called African Humid Period (AHP). During the AHP, an enhanced river discharge could have suppressed deep water formation, increased stagnation of the water column and, thus, reduced the ventilation of the deep ocean. Furthermore, an increased nutrient supply during the AHP could have fuelled biological production and led to enhanced organic matter flux towards the sea floor. Consequently, the demand of oxygen from remineralisation would increase, which when combined with reduced ventilation, could have resulted in anoxic conditions. However, proof of this concept is still missing, and earlier studies tend to question the AHP as the sole driver of sapropel formation.

Within the project **CLICCS (bm1173): A4, African Asian Monsoon Margins (mh1212)**, we developed a model framework for the Mediterranean Sea to address the question of the drivers of sapropel formation. The regional ocean general circulation model comprises physical and biogeochemical processes in the water column and the sediment, an adaption of the land-sea-mask and the bathymetry to account for the sea level rise of about 80-100 m from the Last Glacial Maximum to today and changes in the river mouth location due to variable river routing during the deglacial. We use a downscaled consistent forcing over the entire deglaciation from transient simulations with an atmosphere–ocean–vegetation–icesheet– solid-earth model (MPI-ESM/mPISM/VILMA) (Mikolajewicz etal. 2025). The conditions at the Last Glacial Maximum were archived by a 1000-year spinup run (Six et al. 2024). Two main deglacial simulations under different forcing conditions and a set of sensitivity studies were performed to disentangle the drivers of sapropel formation.

We show that a millennium-scale stagnation of the Mediterranean Sea prior to the AHP is necessary to archive deep anoxic conditions under a realistic enhanced nutrient supply. In addition, the global warming signal during the deglaciation only reaches the deeper layers with a time delay of several thousand years. As cold temperatures lead to low remineralisation rates and consequently facilitate a substantial transfer of organic matter to greater depth, we find large settling fluxes of organic matter towards the sea floor two millennia after the onset of the AHP. These fluxes are intensified as soon as low oxygen conditions appear in the water column and eventually form sapropel layers. All results are presented in a manuscript “The nature of sapropel formation derived from transient deglacial simulations” by Katharina D. Six, Uwe Mikolajewicz, and Gerhard Schmiedl which will be submitted soon. The application for a new DKRZ project is necessary due the fact that none of the group members is involved in the new CLICCS II project, the successor of CLICCS. We plan to finalise the current paper and extend the analysis to cover new aspects of these unique simulations.

Mikolajewicz et al. https:// doi:10.5194/cp-21-719-2025 (2025)

Six, K. D. et al. https://doi.org/10.5194/cp-20-1785-2024 (2024)