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Quaternary Marine Ecosystem Response to Fertilisation (MERF): Enhanced productivity under anoxic conditions during sapropel events in the eastern Mediterranean Sea

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Sediment cores from the eastern basins of the eastern Mediterranean Sea contain series of sapropel layers (cm to m thick) that are rich in organic carbon and were deposited during periods when the deep waters were anoxic. Deep-water anoxia in the Eastern Mediterranean Sea is unambiguously linked to climate, as evidenced by the close correlation of sapropel intervals with maxima of insolation on the Northern Hemisphere and periods of decreasing ice volume.

In the framework of EUROCORES-EUROCLIMATE, Project MERF (**Ma**rine **E**nvironmental **R**esponse to **F**ertilisation) investigates the biogeochemical processes that caused the rise in marine productivity, which must have been a response to natural fertilization of the Mediterranean Sea during sapropel events. Our specific project aims to quantify the relationship between present-day nutrient and productivity regimes of the Mediterranean Sea with geochemical (organic carbon and phosphorus accumulation rates, composition of amino acids) and isotopic (15N/14N of sedimentary nitrogen) proxies in surface sediments. We then proceed to investigate gradients in productivity and in nutrient regime during isochronous time periods of enhanced productivity in the past.

Gradients of productivity in the modern sea surface are reflected in eastward decreasing 15N/14N ratios (5 to 2.5 permil); this has been interpreted as a reflection of phosphate limitation of today's production. In short cores, the 15N/14N ratio increases from values of 2.5 permil to $>$5 permil a few cm below the sediment-water interface.

This is accompanied by a shift in the patterns of amino acids suggesting downcore degradation, which may limit the use of 15N/14N as a proxy for nutrient utilization and nitrogen sources (marine nitrate versus nitrogen fixation). Alternatively, the modern pattern may reflect an eastward increasing relative proportion of reactive N deposition from the atmosphere, which was less important before industrialisation.

We postulate that increased accumulation of organic matter during sapropel events was a consequence both of higher productivity and enhanced preservation of organic matter. Both were caused by anoxic conditions at the sea floor. Very low (-1 to 1 permil) δ15N ratios in sapropels require a very light source of nutrient-N assimilated at a minimum of ten times the modern export flux. Our preliminary data on isochronous sapropels are consistent with phosphorus release from sediments and denitrification at a relatively shallow redox boundary which both resulted in an imbalanced supply of N:P ($<$16:1) to the photic zone. The result was extensive dinitrogen-fixation providing additional reactive N that fuelled greatly increased productivity and organic carbon export flux from a N-limited system.