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Changing paleoceanographic and paleoclimatic parameters during sapropel formation in the Aegean Sea

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A high-resolution record of paleoenvironmental changes during the last 80,000 years, monitored using a mean temporal sampling interval of ~900 years, has been determined for two 8-meter long piston cores collected from North Skiros and North Ikaria basins in the northern Aegean Sea. Paleoceanographic and paleoclimatic trends are revealed by geochemical, stable-isotope and trace-element analyses and by micropaleontological studies. Trace-element concentrations were obtained from the carbonate tests of the planktonic foraminifer Globigerinoides ruber using laser-ablation ICP-MS. The data are intended to evaluate the role of two theoretical factors, organic-matter preservation and biological productivity, in the formation of sapropels.
On the basis of total organic carbon (TOC) content, visual examination and color, four distinct sapropel units (S1, S2, S3, and S4) were identified throughout the cores. The chronostratigraphy of the cored successions is based on the ages of identified tephra layers and correlation of oxygen-isotope curves for the benthic foraminifer Uvigerina mediterranea with the global oxygen-isotope curve.
Mg incorporation into foraminiferal calcite is predominantly regulated by temperature. Mg/Ca ratios are used to calculate sea surface temperature (SST) and sea surface salinity (SSS) variations. The latter variable is obtained from the oxygen-isotopic composition of sea water (δ^{18}Ow):salinity relationship where δ^{18}Ow can be extracted from the paleotemperature equation based on the independent calculation of temperature. SST, SSS and δ^{18}Ow plots show that the surface waters were predominantly cool and less saline prior to the onset of sapropel deposition, but became progressively warmer and more saline during and after sapropel deposition. The observed fluctuations in salinity (and possibly temperature) demonstrate that there was an increased influx of fresh and/or brackish waters to the Aegean Sea, probably originating from the Black Sea, supplemented by local influx from nearby rivers. Before the initiation of sapropel deposition, low-density surface waters must have acted as a cap, causing stratification within the water column. Accordingly, bottom-water ventilation was diminished. Respiration then resulted in a progressive decline in the dissolved oxygen levels, creating favorable conditions for organic carbon preservation on the seafloor. During times of sapropel formation, δ^{34}S and C/S profiles display excursions toward lower values signifying that bottom waters were dysoxic but never anoxic. This interpretation is further supported by the sustained presence of benthic foraminifera in the cored succession.
Cd/Ca and inorganic δ^{13}C (primary productivity indicators) increased during times of sapropel formation in the N. Skiros Basin – highest values occurred during accumulation of sapropels S3 and S4. In contrast, primary productivity in the N. Ikaria Basin was low except during accumulation of sapropel S3. This interpretation suggests that primary productivity fluctuated both temporally and spatially and played a comparatively more important role in the N. Skiros Basin, particularly for the two lower sapropels. Both water-column stratification and primary productivity contributed to sapropel formation in the Aegean Sea, to varying degrees. Thus, these two hypothesis may not be mutually exclusive.