Geophysical Research Abstracts
Vol. 15, EGU2013-2595-3, 2013
EGU General Assembly 2013

Simulating the early Holocene eastern Mediterranean sapropel formation using an ocean biogeochemical model

Rosina Grimm (1), Ernst Maier-Reimer (1), Uwe Mikolajewicz (1), Gerhard Schmiedl (2), Fanny Adloff (3), and Kay Emeis (2)

(1) Max-Planck Institute for Meteorology, Hamburg, Germany (rosina.grimm@zmaw.de), (2) University of Hamburg, Hamburg, Germany, (3) CNRM-GAME, Météo-France, Toulouse, France

The early Holocene sapropel S1 is an organic-rich sediment layer deposited under oxygen depleted conditions below 1800 m between 10 to 6.5 kyr BP in the eastern Mediterranean Sea. Whereas this silled ocean basin is well-ventilated and has a low biological productivity today, the S1 formation indicates drastic changes in the deep water circulation and/or productivity. Commonly, both of these processes are attributed to an enhanced humidity over the broader Mediterranean area. In particular, an increase in the strength of the African monsoon during the African humid period (AHP) is thought to have provided enhanced Nile runoff and nutrient load. However, the exact mechanisms leading to S1 formation are still being debated.

Here we apply a regional ocean general circulation model coupled to a marine biogeochemical model covering the entire Mediterranean Sea to explore some of the many published hypotheses on sapropel formation. With a set of simulations we show that S1 formation cannot be explained by either enhanced biological productivity fueled by increased riverine nutrient input, or by an AHP climatic induced stagnating deep water circulation combined with enhanced biological productivity. The main reasons are: (i) Enhanced biological productivity cannot overcome the effect of a continuous deep ventilation, so that a stagnating deep water circulation is a prerequisite for S1 formation. (ii) The pre-sapropel period is characterized by low particulate organic carbon (POC) sediment burial fluxes, implying that river induced eutrophication is not a viable scenario. (iii) The time span required for complete oxygen depletion within the stagnating deep water circulation exceeds the time span between the beginning of the AHP and the onset of the S1 oxygen deficiency, so that the enhanced Nile runoff fueled by the AHP climate is an unlikely trigger for deep water isolation that caused S1 formation.

Available data suggest substantial freshening and warming of the Mediterranean upper ocean during the last glacial-interglacial transition that stabilized stratification and prevented deep water ventilation. Imposing the climatic signals of the last glacial-interglacial transition triggers a persistent (> 4 kyr) deep water stagnation in this simulation. The productivity regime in this simulation was assumed similar to the present-day oligotrophic regime, and the simulated POC burial fluxes agree with observed pre-sapropel burial fluxes in sediments. No deep water anoxia evolves in the short time frame of this simulation (4 kyr) relative to the temporal extent of the deglaciation period, which started at ∼17.5 kyr BP. The trend of the modeled oxygen consumption suggests that it takes at least 6.5 kyr until deep water anoxia is established. The simulation also suggests that addition of freshwater is required to maintain the stratification in order to meet the reconstructed spatial extent and duration of the S1 deposition. An examination of records of epibenthic deep-sea foraminifera δ18O supports our findings, and indicates that the stagnation of the deep circulation started ∼6 kyr before the onset of the S1 deposition.