Interplanetary dust particles in the Mediterranean: using helium isotopes to constrain sediment fluxes during sapropel events

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Can helium isotopes be used as a flux proxy in marginal marine environments? To answer this question, we studied sapropel layers in the Eastern Mediterranean (core RC9-174). Sapropels are dark layers rich with organic material deposited in the Mediterranean during massive freshwater flooding events, associated with the strengthening of monsoonal activity in the sub-Sahara tropics. Helium isotopes (^{3}He and ^{4}He) in sedimentary environments reflect mixing between high-^{3}He interplanetary dust particles (IDPs) that accrete to Earth at a constant rate and can thus be used as proxies of sediment fluxes, and a low-^{3}He terrigenous component. In the case of sapropel events, an abrupt increase in the flux of terrigenous material provides us with the opportunity to study the patterns of helium isotope distribution before, during, and after these perturbations, which have a well-constrained chronology and thus a known sedimentation rate. We focused on two events, S1 and S4, dated 8 and 105 kyr, respectively. Samples were leached using acetic acid and the fractions of insoluble residue and carbonate were calculated. Helium isotope measurements were performed on the insoluble residue fraction. The results were compared to a quantitative calculation modeling several scenarios, and we further investigated the possible effects of diagenetic processes such as anoxia.

The total range the insoluble residue weight fraction in the samples is between 37.35% and 81.10%, with sapropel samples containing on average 14% more insoluble residue compared to the rest of the samples. Typical measurements of the carbonate content in sapropels, however, show an average difference of 30-40% between sapropels and non-sapropels. We also observed a range of ^{3}He/^{4}He ratios between $7.408 * 10^{-8}$ and $2.001 * 10^{-6}$ (duplicates reproduce themselves within 20% on average), with ^{3}He and ^{4}He concentrations in the range of $2.059 * 10^{-13}$ to $4.014 * 10^{-12}$ cc/g and $1.569 * 10^{-6}$ to $5.440 * 10^{-6}$ cc/g, respectively. The extraterrestrial ^{3}He fraction in the samples ranges between 86.5% and 99.5%, as derived from a mixing scheme between the terrigenous and extraterrestrial end members. The ^{3}He/^{4}He ratios and ^{3}He and ^{4}He concentrations show relatively constant values before, during, and after each of the sapropel events. However, a surprisingly high content of ^{3}He is observed above S1, at approximately 5 kyr of age. The lack of a shift in ^{3}He/^{4}He during S1 and S4 compared to the under and over lying sediments, despite the strong mixing with a “new” terrigenous component can be explained in several ways. Relatively small differences in the insoluble residue content beneath, within and above the sapropels might limit the possibility to observe trends in ^{3}He/^{4}He ratios. The onset of anoxic conditions associated with the sapropels might have caused mineral recrystallization and thus loss of helium.

The use of helium isotopes for the reconstruction of sediment fluxes in marginal marine and continental environments is limited by the strong mixing with terrigenous material. A

major unknown is the mechanism of transportation of IDPs from the land to the sea and whether this process delivers material with relatively high or low IDP content. The results from this research will improve the understanding of the use of helium as a constant flux proxy and will contribute to other efforts attempting to constrain the global distribution patterns of the IDPs on Earth.