Geophysical Research Abstracts
Vol. 12, EGU2010-8621-1, 2010
EGU General Assembly 2010

Evaluating terrestrial input into the upper Cretaceous western tropical Atlantic by biomarker and compound specific isotope analyses

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The mid Cretaceous represents one of the most prominent episodes of greenhouse climate with high atmospheric CO_2 levels, much higher global temperatures and lower latitudinal gradients than today. Massive and widespread deposition of organic carbon in black shales occurred during several Oceanic Anoxic Events (OAEs) which led to a significant reduction in pCO$_2$. Thus, OAEs are associated with prominent shifts in carbon isotopes, representing major disturbances of the ocean system and the global carbon cycle. In the past, research on the dynamics of the mid Cretaceous greenhouse world was almost exclusively based on marine proxy data, while up to now, only few information is available on the terrestrial response to mid-Cretaceous climatic and carbon-cycle perturbations.

We investigate organic-rich black shales from a stratigraphic splice covering the Cenomanian/Turonian boundary event (CTBE) at ODP Site 1258, drilled approx. 350km off Suriname at Demerara Rise, in a proximal position relative to the tropical South American mainland. By application of a combined petrographic and biomarker approach we have the unique opportunity to link terrestrial environmental information with a wide range of marine paleoclimatic and paleoceanographic proxy data, thus allowing a direct land/sea correlation. Our current focus is on the stable carbon isotope composition of selected biomarkers that can generally provide important information on parent organisms, carbon source, and environmental conditions.

Petrographic observations reveal a dominating amount of amorphous organic matter (AOM) of probable marine origin; particulate organic matter is dominated by fragments of marine organisms with variable amounts of terrestrially derived material. This is further corroborated by biomarker investigations, indicating a dominantly marine origin of the organic matter with algae, cyanobacteria and archaea among biological precursors. Terrigenous organic matter is present at variable levels throughout the investigated interval as evident from the occurrence of long-chain n-alkanes with an odd-over-even carbon number predominance and long-chain saturated n-fatty acids with an even-over-odd predominance, derived from epicuticular waxes of higher plants. However, other biomarkers typical for terrestrial contribution (e.g. oleanane) are missing.

Bulk $\delta^{13}C_{org}$ values evidence a positive shift of approximately 6‰ across the CTBE, in the same order of magnitude as reported from other Atlantic sites. Carbon isotope values of compounds associated with algae, cyanobacteria, and archaea show a positive excursion in the order of 5 ‰ 6 ‰ and 8 ‰ respectively, as could be expected in dominantly marine sediments. Interestingly, the $\delta^{13}C_{org}$ signal of plant wax n-alkanes and saturated n-fatty acids exhibit a considerable positive shift of up to 14 ‰ overall coinciding with the positive excursion observed in the bulk $\delta^{13}C_{org}$ signal. Generally, the carbon isotopic fractionation associated with photosynthetic fixation of CO_2 is significantly correlated with the concentration of dissolved CO_2 in the environment. Most terrestrial plants however, do not show pronounced isotopic fractionation values on pCO$_2$, meaning that only small isotopic variability can be expected. Whether the large isotopic shift in leaf wax material can be attributed to changes from C_3 to C_4 type plants, related to the extensive burial of organic matter and resulting drop in pCO$_2$, or is associated with variations in humidity is uncertain at this point and needs further investigation.