First high-resolution δ^{13}C-records of the Early Aptian OAE 1a within the mid-latitudes of NW-Europe (Germany, Lower Saxony Basin)

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Two mid-Cretaceous sediment cores (Hoheneggelsen 9 and Ahlum 1 cores) from the area south of Brunswick, North Germany, were investigated in detail on the base of biostratigraphy, δ^{13}C-stratigraphy and geochemistry. Results suggest a latest Barremian to early Late Aptian age for the deposits. In both cores, three lithological units are recognized: a lower claystone unit including finely laminated black shale horizons (“Blättertone”), an overlying prominent black shale horizon (“Fischschiefer”) and an upper marly section (*Hedbergella* marls). Isotope stratigraphy allows to subdivide the deposits into segments (C1-C7), which are used for high-resolution stratigraphy globally. These segments also allow to identify the Late Early Aptian Oceanic Anoxic Event 1a (OAE 1a). The present study represents the first high-resolution $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ records across this event within the mid-latitudes of NW-Europe. Our results confirm that the regional sedimentary expression of the OAE 1a is the above-mentioned “Fischschiefer” horizon, a 2-3 m-thick laminated black shale layer known from NW Germany and the southern North Sea.

The main trends of the δ^{13}C isotope curves of both cores can be correlated with global curves. However, several bulk carbonate samples of the Early Aptian, including those of the OAE 1a, are considerably depleted in δ^{13}C. This might be explained by authigenic carbonate formation, induced by microbial sulphate reduction and –in cases of extreme ^{12}C enrichment- also by microbial methane generation and oxidation processes. Such processes are confined to anoxic enironments. Consequently, strong ^{12}C enrichement mainly correlates with the black shales, including the “Fischschiefer” horizon (OAE 1a), which are associated with anoxic bottom water conditions. The overlying marls (*Hedbergella* marl unit), deposited under oxic seafloor conditions, show values closer to normal marine levels. The early diagenetic processes of the carbonates discussed above did not affect the $\delta^{13}C_{org}$ ratios of both cores to greater extent. These are close to normal marine levels and show variations in the range of a few permil only. Our study shows, that $\delta^{13}C_{org}$ data is better suited for stratigraphy in mid-Cretaceous anoxic sediments of the Lower Saxony Basin.

Causes and consequences of outer core compositional stratification

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We report on a detailed investigation of the structure of the topmost outer core using seismic waves travelling across it at depths between 60-700 km. The observations are regional array recordings of between 120-200 seismograms from the same earthquake using stations in Europe and Japan. The use of arrays allows high-precision measurements of differential SmKS travel times and slownesses for multiple (m) values up to 5. The study [1] yields a well constrained velocity structure for the topmost 500 km of the outer core. The uppermost 300 km is gradationally slower than the PREM model by up to 0.3%. Applying Birch's homogeneity test to the velocity profile shows that it differs at more than the 95% confidence level from compression of a simple liquid of fixed composition. Thus the outer core is stratified in its composition.

The thickness of the layer requires the layer’s bulk to be derived from the core rather than from the core-mantle boundary given known diffusivity of core liquids. Consequently, the gradient must arise from light element addition within the core, probably from the growth of the inner core. A rough material balance may be made between the density jump at the inner core boundary and the thickness of the layer. Using a core liquid velocity model in the Fe-O-S system, the velocity change requires a 3-5 wt% light element concentration increase in the topmost core. Maintaining a 300 km thick layer against convective mixing in the outer core suggests that the shallowest core is stagnant. One way to suppress convection there is by making the outermost core isothermal, suggesting that there is not a significant thermal boundary layer at the base of the mantle.

[1] Helffrich & Kaneshima (2010) *Nature* **468**, 807-810.