COMPOSITION AND ORIGIN OF APTIAN AND ALBIAN BLACK SHALE IN THE EVOLVING SOUTH ATLANTIC AND SOUTHERN OCEAN

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Young oceanic basins have been identified as globally important carbon sinks, due to restricted basin geometry and high shelf-to-open ocean ratio. The opening of the South Atlantic and Southern Ocean are accompanied by the basin-wide occurrence of Early Cretaceous (i.e., Aptian to Albian) black shale deposits as well as the formation of prolific hydrocarbon reservoirs on both conjugate continental margins. Modelling results suggest that carbon burial in the South Atlantic and Southern Ocean during the Early Cretaceous (representing 5% of the Cretaceous global ocean by area) accounted for 35% of the atmospheric carbon sequestered by the world's ocean (McAnena et al., 2013).

We hypothesize that the young South Atlantic and Southern Ocean were sites propitious to drawdown, biotransformation and burial of atmospheric carbon and that widespread carbon sequestration in these regions at least partly caused global scale carbon cycle perturbations (cooling events). We further propose that the spatial and temporal extent of black shale deposition in these critical regions were controlled by the configuration and opening of multiple tectonic gateways, regulating water mass exchange between the basins, and that short-term variations in organic carbon burial were linked to climatic-driven fluctuations in supply of continent-derived nutrients.

We present Aptian to Albian biomarker records from DSDP Sites 361 (Cape Basin), 511 (Falkland Plateau) and ODP Site 693 (Weddell Sea), in conjunction with elemental data. Our data reveal changes in organic matter source (i.e., terrigenous vs. marine) and water column properties (i.e., redox state and stratification).

The concurrent deposition of organic rich shales in the South Atlantic and Southern Ocean was controlled by multiple gateway openings. In the Early Aptian the Falkland Plateau acted as bathymetric barrier limiting the water mass exchange between the Southern Ocean and South Atlantic. Restricted circulation in and between both basins led to conditions favouring enhanced carbon burial throughout the Early Aptian in both the Southern Ocean and the South Atlantic. The widening of the South Atlantic eventually opened a deep water passage offshore southern Africa in the Late Aptian. Strong bottom water ventilation linked to the opening of the Georgia Basin Gateway caused a distinct change in sedimentation, with grey shale and red beds and very low organic carbon content.

Results from DSDP Site 361 in the South Atlantic Cape Basin show short-term variation in total organic carbon (TOC) contents between 4% and 24% throughout the Early Aptian. Intervals of high TOC content are accompanied by strongly reducing conditions, consistent with high sulphur content of up to 10% and enrichment of redox-sensitive trace metals. The distribution of 28,30-bisnorhopane closely follows the redox trend. We presume that anomalously high abundance of 28,30-bisnorhopane indicates high abundance of chemoautotrophic bacteria thriving under anoxic conditions. Furthermore, the distribution of short-chain *n*-alkanes and 24-*n*-propylcholestane suggests that enhanced TOC accumulation coincided with intensified surface water productivity. Along with that changes in water column stratification occurred, evidenced by fluctuating abundance of gammacerane, enhancing carbon burial during periods of stronger water column stratification (except for the duration of OAE 1a). Combining all this evidence we conclude that short-term variability of carbon burial in the South Atlantic was likely driven by river run-off from the proximal African continent. Humid conditions over the African continent would have led to increased river run-off delivering fresh water and nutrients to the Cape Basin. The resultant intensification of stratification and primary production promoted oxygen deficiency in the bottom water, ultimately leading to enhanced carbon burial. Although the periodicity of the alternations remains to be identified (mostly due to poor core recovery) we speculate that humidity changes were linked to shifts of the atmospheric frontal system, which in turn are likely to be controlled by orbital forcing.

References

McAnena, A., Flögel, S., Hofmann, P., Herrle, J.O., Griesand, A., Pross, J., Talbot, H.M., Rethemeyer, J., Wallmann, K., Wagner, T., 2013. Atlantic cooling associated with a marine biotic crisis during the mid-Cretaceous period. Nature Geoscience 6, 558-561.