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Implications of gateway opening for carbon burial in the young South Atlantic: New constrains from Nd-Isotopes and general circulation modelling

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Young ocean basins emerging during the break-up of supercontinents provide favorable conditions for draw down and burial of atmospheric carbon. Extensive black shale deposition, the formation of petroliferous sedimentary basins along continental margins, and carbon cycle modelling suggest that the young South Atlantic (south of the Rio Grande Rise/Walvis Ridge) and the Southern Ocean acted as important carbon sinks during the Early Cretaceous break-up of Gondwana.

In this study, we reconstruct the Aptian and Albian history of the South Atlantic and Southern Oceans in order to determine if carbon burial in these ocean basins had a direct impact on the global carbon cycle perturbations known as “Oceanic Anoxic Events 1a and 1b” and the “Late Aptian Cold Snap”. We provide an improved and revised stratigraphic framework for several South Atlantic and Southern Ocean deep sea drill sites using carbon isotope stratigraphy to reconstruct the influence of multiple gateway openings controlling deep water circulation (Georgia Basin/ Falkland Gateway and Walvis Ridge Gateway) and carbon burial dynamics in the South Atlantic. Carbon burial, redox and deep-water circulation histories are evaluated using bulk geochemical parameters and sea water-derived neodymium (Nd) isotope signatures combined with a novel general circulation model (KCM).

Our results show that during the lowermost Aptian, prior to $\sim$124 Ma, the paleobathymetric position of the Falkland Plateau hindered deep and intermediate water mass mixing between the South Atlantic and Southern Ocean as indicated by divergent Nd-isotope signatures. Restricted overturning circulation in the South Atlantic favored reducing conditions and enhanced organic carbon burial as indicated by high sulfur content and redox-sensitive trace metal enrichment in deep-sea sediments. A first shift in water mass characteristics occurred at $\sim$124 Ma, marked by the onset of intermediate water mass exchange between the South Atlantic and Southern Ocean via the Falkland Plateau. At that time, a trace metal-enriched and radiogenic intermediate water mass reached the Falkland Plateau. This water masses most likely originated on the shallow shelves of the subtropical northern part of the South Atlantic as predicted by the KCM model. Nd isotopic gradients between the deep-water mass of the South Atlantic and the shallower water mass at the Falkland Plateau persistently indicate a stratified South Atlantic that continued to function as a carbon sink. After $\sim$116 Ma, Nd-isotope signatures of the deep South Atlantic, Southern Ocean and Falkland Plateau converged, indicating the opening of a deep water gateway via the Georgia Basin and free water mass exchange between all sub-basins. Consequently black shale deposition ceased in the South Atlantic and Southern Ocean.

Our results provide a revised and improved framework for an ongoing modelling study that attempts to quantify the contribution of carbon burial in the South Atlantic to the global carbon budget during the Aptian-Albian global carbon cycle perturbations (i.e. “Oceanic Anoxic Event 1a and b” and “Late Aptian Cold Snap”).