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Mid-Cretaceous High-Resolution Age Modeling using Cyclostratigraphy

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Introduction

The Aptian–Albian interval of the mid-Cretaceous, coinciding with the initial opening of the South Atlantic Ocean, was characterized by frequent short-lived perturbations in the global carbon cycle, including a series of Oceanic Anoxic Events (OAEs) such as the 113/Jacob, Kilian, Paquier/Urbino, and Leenhardt events. These events had significant impacts on marine ecosystems and the ocean-climate system and are recognized globally, although their precise chronology remains debated. Importantly, these OAEs created widespread anoxic conditions that favored the exceptional preservation of organic matter, playing a fundamental role in the formation of petroleum source rocks in Brazilian sedimentary basins. Their geochemical and stratigraphic signatures not only mark global environmental crises but also represent key intervals of hydrocarbon potential, especially along the Brazilian equatorial margin**.** The southern South Atlantic, particularly Deep Sea Drilling Project (DSDP) Site 511 drilled on the Falkland Plateau, provides a rare, nearly continuous stratigraphic record from southern high latitudes, making it a key area for studying mid-Cretaceous paleoceanography and paleoclimate. This study aims to refine the chronostratigraphy of the Aptian–Albian periods through high-resolution cyclostratigraphic analysis, improving our understanding of the timing and mechanisms underlying these global disturbances. Furthermore, the results may contribute to establishing global stratigraphic correlations and support the standardization of stratigraphic nomenclature in Brazilian sedimentary basins, which currently lack direct ties to the global time scale.

Method and/or Theory

Multiproxy datasets—including carbonate carbon ($\delta^{13}C$), oxygen ($\delta^{18}O$) isotopes, and gamma-ray (GR) measurements—were utilized to identify Milankovitch-band cyclicities. Time-series analysis revealed prominent ~405 kyr long-eccentricity cycles within $\delta^{13}C$, $\delta^{18}O$, and GR profiles. Astronomical tuning, employing low-pass filtering of eccentricity cycles and alignment with the La2004 g_2–g_5 target curve, facilitated the construction of a floating Astronomical Time Scale (ATS) for the Aptian–Albian interval. For estimating the optimal sedimentary accumulation rates (SARs), as well as to verify the best fit of in-depth and astronomical time records, we carried out time-scale optimization (TimeOpt) analysis (Meyers, 2015). This approach enabled refined age estimates for the onset and duration of the observed oceanic perturbations and proposed a cyclostratigraphic framework for the Aptian–Albian boundary.

Results and Conclusions

Our findings enhance the chronostratigraphic resolution of mid-Cretaceous oceanic events in the South Atlantic realm and underscore the role of astronomical forcing in modulating paleoceanographic and climatic conditions. This study contributes to a more precise understanding of the pacing and global synchroneity of Cretaceous climate perturbations.