

Assessing Milankovitch Forcing in the Middle Eocene Carbonates, Saudi Arabia: Insights to Carbonate Parasequences Development and Reservoir Predictions

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Abstract

The Eocene period was a time of great climatic significance owing to its records of Paleocene-Eocene Thermal Maximum, Early Eocene Climate Optimum and Middle Eocene Climate Optimum events. Events were marked by elevated sea-surface temperature and relative sea-level rise which aided the deposition of vast amounts of carbonate sediments globally, including across the Arabian plate. The Middle Eocene successions in Saudi Arabia are characterized by intensely bioturbated, cyclic shallow water carbonates with meter-scale parasequences. However, the controlling process behind the development of carbonate parasequences remains enigmatic, particularly on the relative dominance between random and quasi-periodic Milankovitch forcing. In this study, for the first time, we coupled continuous records of Spectral Gamma Ray (SGR) and Magnetic Susceptibility (MS) data measured from a shallow subsurface core of the Middle Eocene Damman formation to assess the influence of astronomical forcing on this formation and determine its sedimentation rate and stratigraphic completeness, using Acycle software. Results from correlation coefficient (COCO) and evolutive COCO analyses showed that the optimal sedimentation rate of the formation is 1.5cm/kyr (with the null hypothesis of <1%) and evolved through time with a peak of 2.3cm/kyr and a trough of 0.8cm/kyr. Significant peaks at ~1.2Myr (long-term obliquity modulation; ~18.2m), ~405kyr (long eccentricity; ~6m), and ~100kyr (short eccentricity; 1.5m) are apparent in both the tuned SGR and MS power spectra, but higher frequency cycles of 40kyr (obliquity; 0.6m), and 20kyr (precession; 0.3m) are only apparent in the tuned MS spectra. Although obliquity and precession are apparent in MS spectra, its evolutive spectra indicated that they are present only at the topmost tiny portion of the series.

Minimal tuning of the two data series yielded a duration of 5.85Myr instead of the published 8.2Myr, and a stratigraphic completeness of 71% for the formation. We thus attributed the non-completeness to the absence of two members (Saila? And Alat) in the locality of this study. The overall low and nearly stable sedimentation rate recorded in Damman formation is compatible with the low accommodation space, in the carbonate ramp platform, during the Eocene period of the Arabian plate. The deposition of units of this formation was interpreted to be astronomically influenced based on the null hypothesis, and the strong match between the stratigraphic spectra and the target spectra of La2004 solution. The dominance of the eccentricity cycle over obliquity and precession cycles could be attributed to the intense bioturbation especially in the lower section of the formation, amplified by the SGR low resolution. This work provides cyclostratigraphic information which could be used not only in regional correlation but also in reservoir prediction of the Middle Eocene succession in the Gulf.