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Rhythmic bedding in prodeltaic deposits of the ancient Colorado River: Exploring genetic processes

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Prodeltaic deposits represent a valuable archive for the characterization of deltaic depositional systems, offering a distal, minimally reworked record of dominant processes active at the fluvial-marine interface. The Fish Creek Basin (CA, US) preserves a $\sim$ 3-km thick, lower Pliocene, progradational deltaic succession formed when the ancestral Colorado River infiltrated a marine rift basin (the early Gulf of California). The unit in this succession interpreted as prodeltaic, corresponding to the upper Mud Hills Member of the Deguynos Formation, consists of $\sim$ 300 m of muddy siltstones. A striking attribute of parts of this unit is the presence of rhythmic bedding, with consistently alternating silt- to fine sand-dominated and clay-dominated beds forming couplets with an average thickness of 12 cm. By performing a detailed sedimentological analysis of the rhythmites and investigating periodicities in bed thickness, our study aimed at reconstructing the mode of deposition of this enigmatic prodeltaic succession.

We measured at high stratigraphic resolution 265 consecutive couplets, for a total thickness of 33 m. Individual beds have good lateral persistence of at least tens of meters and gradational to sharp, flat contacts. Observed sedimentary structures are concentrated on the coarser portion of the couplets and mostly consist of parallel and wavy lamination, with subordinate ripple cross-lamination and localized internal scours. Bioturbation appears low in intensity or absent. Most notably, grain size analysis performed with laser diffraction techniques on several couplets shows a consistent pattern of inverse grading transitioning to normal grading. The cumulative evidence of these sedimentological features indicates that deposition of the rhythmites was accomplished via hyperpycnal flows, each couplet most likely representing an individual event in a setting characterized by high overall depositional rates.

We performed time series analysis on bed thickness of the 265 measured couplets, obtaining a prominent spectral peak above the 99% confidence level (generated with a Monte Carlo red noise simulation) corresponding to a periodicity of about 18 couplets. We also performed time series analysis on image brightness values of a composite photographic log converted to grayscale, covering a subset of 159 consecutive couplets (22 m) and obtaining a spectral peak that could be roughly equivalent to the periodicity indicated by the bed thickness series. Our results appear to offer a source-to-sink example of the effect of modulations in intensity of aperiodic or quasi-periodic hyperpycnal flows in the sedimentary record of prodeltaic successions.