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Contrasting modulation of early Mesozoic sedimentary environments in open (Colorado Plateau) vs closed (Eastern North American Rifts) drainage basins by Earth System response to orbital pacing revealed by XRF chemistry

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Early Mesozoic continental sequences on the Colorado Plateau consist largely of thick fluvial and floodplain deposits with chaotically interbedded sandstones and mudstones, interspersed with less common, well-ordered, cyclical, tabular-bedded loessic, pedogenic, and lacustrine to paralic successions. Deposited on a vast tropical to subtropical alluvial plain draining westward to the sea, these sequences display markedly different sedimentary architectures across millions of years and geographically distinct regions.

First-order comparison with contemporaneous pCO_2 proxy records suggests that chaotic fluvial deposits correspond to intervals of high pCO_2, whereas well-ordered, cyclical sequences coincide with low pCO_2. In contrast, Triassic–Early Jurassic lacustrine sequences in the closed drainage rift basins of eastern North America show the opposite pattern: the most strongly cyclical successions occur during high pCO_2.

We propose that background climate states governed by radiative balance modulated continental sedimentary systems in distinct, predictable ways depending on basin drainage. In open systems, extreme climate variability under high pCO_2 produced alternating wet fluvial and arid pedogenic episodes, yielding chaotic architectures. Low pCO_2 led to more stable hydrology and muted variability, allowing orbital cyclicity to be preserved in loessic, shallow lacustrine, and pedogenic settings. In closed basins, however, high pCO_2 amplified lake-level fluctuations between perennial lakes and dry playa or loessic plains, producing strong cyclicity; low pCO_2 yielded more subdued lake-level changes but still tracked orbital forcing.

Continuous XRF geochemical data from magnetostratigraphically correlated and U–Pb dated cores of the Chinle Formation (Colorado Plateau) and the Lockatong and lower Passaic Formations (Newark Basin) spanning ~10 Myr support this pattern. Although the Chinle record is chaotic overall, the highest orbital fidelity occurs during low pCO_2, while the Newark record exhibits its strongest orbital pacing during high pCO_2.

Because the studied Chinle interval represents only ~20% of the Triassic–Early Jurassic record, full testing of this hypothesis requires continuous core coverage of the complete 70 Myr sequence with high-resolution geochemical and geochronologic control, as envisioned in the MESAS (née CPCP-2) project.