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Condensation for concentration: relationships between sedimentation rate and phosphogenesis in reworked sediments of the Monterey Formation of central California

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Strata of the Miocene Monterey Formation have been the subject of geological inquiry for nearly a century, and serve as the primary source and reservoir rock for the majority of California's hydrocarbon resources. Phosphorites of the Monterey Formation, which are found throughout central California, have been associated with periods of intensified upwelling and productivity in the Miocene Californian borderlands. Here, we contextualize the organic carbon- and phosphate-rich strata of the Monterey formation within a new chronostratigraphic framework. New high-resolution age models, constrained by U-Pb ages on zircon derived from volcanic ashes intercalated within Monterey Fm strata, reveal significant variability in modeled sedimentation rates at multiple localities in the Santa Barbara and Santa Maria basins. These age models demonstrate that concentrated phosphogenesis occurred diachronously across the Californian borderlands, and that both total organic carbon and authigenic phosphate (calcium fluorapatite) concentrations in Monterey Formation strata are inversely correlated with sedimentation rate. The most concentrated phosphorite horizons in the Monterey Formation are associated with local nadirs in sedimentation rate, and are the product of localized winnowing and reworking of previously-deposited sediments. Laterally discontinuous phosphorite horizons incorporate authigenic phosphate clasts derived from underlying and adjacent shale horizons, with winnowed accumulations of these clasts serving as the host substrate for subsequent precipitation of additional calcium fluorapatite. Instead of productivity and upwelling, we propose a model in which both phosphogenesis and total organic carbon contents in the Monterey Formation are primarily modulated by sedimentation rate, which was in turn controlled by a combination of local tectonics and eustasy.