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**$CO_2$-decline and the origin and abundance of Devonian-Mississippian carbonate mud mounds.**

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Carbonate mud mounds were unusually large and abundant ~350 Ma ago, during the Late Devonian-Early Mississippian (LDEM). An origin by sediment baffling was suggested, but a suitable source of off-mound carbonate mud has been difficult to identify. Late Devonian atmospheric $pCO_2$ reduction and $pO_2$ increase were sufficiently large to induce $CO_2$ concentrating mechanisms (CCM) in cyanobacterial phytoplankton. CCM act to maintain photosynthesis, and include bicarbonate transport into cells. This promotes extracellular pH rise that can cause water column precipitation of fine-grained carbonate ('whitings') if aquatic carbonate saturation state is elevated. It is proposed that imported off-mound whiting mud substantially augmented and may have exceeded LDEM on-mound carbonate production.

Typical features of LDEM mud mounds that are consistent with current-driven accumulation of fine-grained carbonate include their (i) layered structure; (ii) geometries such as orientation, asymmetry, progradation and amalgamation, (iii) grainstone haloes; (iv) presence of current-reliant filter feeding organisms (bryozoans, crinoids, sponges); (v) formation over a wide depth range; and (vi) internal collapse structures (stromatactis and slumps). Carbonate mud derived from phytoplanktic whitings can be rich in organic matter which could have promoted microbial lithification (e.g., by bacterial sulfate reduction, BSR) that produced widespread development of clotted-peloidal microfabric. Off-mound carbonate mud production mediated by cyanobacterial oxygenic photosynthesis could therefore have been augmented by on-mound syndepositional lithification mediated by BSR mineralization of whiting organic matter.

In addition to increase in carbonate mud mounds, $CO_2$-induced changes in phytoplankton during the LDEM can potentially be linked to diverse and broadly coeval events in the marine realm whose relationships were hitherto unsuspected. These include black shale deposition, crinoid diversification, and acritarch and reef extinction. It is proposed that the proximal stimulus for these changes was $CO_2$-decline that induced $CO_2$-concentrating mechanisms in cyanobacteria, promoting their productivity by allowing them to overcome carbon-limitation. Increase in cyanobacterial sheath-calcification (and in whiting mud) is consistent with CCM induction. Proliferation of planktic cyanobacteria during this interval is suggested by increases in cyanobacterial biomarkers, positive $\delta^{13}C$ PDB excursions, and organic-rich black shale accumulation. Cyanobacterial picoplankton could have contributed to the diversification of camerate and advanced cladid echinoderms by increasing the abundance of fine food particles. Phytoplankton community restructuring is also implied by

marked decline in diversity of acritarchs, which may have been ill-equipped to respond to reduced $CO_2$ availability. Changes in phytoplankton food supply (and in toxic bloom formation) could also have contributed to extinction of reef-building sponges and corals. Whether or not Late Devonian reef demise was linked to changes in phytoplankton, it would have left surplus $CaCO_3$ in solution in seawater, favoring whiting precipitation.

This reasoning, based on LDEM conditions, should not be applied to carbonate mud mounds in general or even to all LDEM mounds. Furthermore, an off-mound mud source in biogenic whitings does not exclude additional on-mound processes of carbonate production. Nonetheless, an external mud source appears consistent with many features of LDEM mounds, and assists development of an integrated explanation linking otherwise apparently unrelated contemporaneous global changes. It may also be applicable to episodes of increased carbonate mud and silt abundance at other times in the geological record. Not least, support for an off-mound mud source at a time when mounds were exceptionally abundant calls for reappraisal of concepts of on-mound origin that have dominated interpretation of carbonate mud mounds for decades.