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Stable strontium isotope constraints on the rise of the skeletal carbonate factory

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The formation of carbonate in the oceans—the marine carbonate factory—plays a central role in regulating the cycling of carbon between the oceans, atmosphere, and Earth's interior. However, the processes that produce carbonate sediments and their sinks have changed over geologic time. Today, marine carbonate factories primarily reflect the abundance, distribution, and preservation of the remains of calcifying organisms. But biological carbonate production has existed for only a small portion of Earth's history. Debate surrounds whether the rise of biomineralization during the latest Precambrian and early Paleozoic caused significant changes in seawater carbonate chemistry, and whether the principal loci of carbonate sediment accumulation changed as a result. Stable strontium isotopes ($\delta^{88/86}$Sr)—an emerging geochemical proxy—provide a potential window into the evolution of the marine carbonate factory and seawater carbonate saturation state. The $\delta^{88/86}$Sr system is characterized by a pronounced kinetic isotope effect such that carbonates that precipitate rapidly (under higher carbonate saturation states) are characterized by more negative $\delta^{88/86}$Sr values (relative to the precipitating fluid). In contrast, carbonates precipitated more sluggishly (under lower saturation states) are characterized by less negative $\delta^{88/86}$Sr values. $\delta^{88/86}$Sr records suggest that seawater carbonate saturation state may have been higher during the Precambrian than the Phanerozoic, which is consistent with sedimentological evidence for widespread Precambrian abiotic, microbial, and early authigenic carbonate precipitation. Recent work has also suggested that the formation of authigenic carbonate in siliciclastic seafloor settings may have been a more substantial carbonate sink during the Precambrian than during the Phanerozoic. The radiation of calcifying organisms in shallow marine settings has been proposed to have drawn down seawater carbonate saturation states and shifted the dominant locus of carbonate accumulation toward shallow marine environments. However, high-resolution stable strontium isotope data from lower Paleozoic successions are scarce. To test the hypothesis that the ecological expansion and increase in the abundance of calcifying animals in the early Paleozoic—and particularly the Great Ordovician Biodiversification Event—drove changes in carbonate saturation state, we present stable strontium isotope data from the western USA spanning the upper Cambrian through the Middle Ordovician.