Of babies and bathwater - do carbonate sediments in the geologic record track the global carbon cycle?

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Carbonate sediments sequester the majority of the CO_2 emitted from Earth's interior and their chemical and isotopic composition has been widely used to reconstruct Earth's chemical, biological, and climatic history. However, carbonate sediments preserved in the geologic record constitute only a fraction of the initial carbonate sediments deposited - the majority is recycled at Earth's surface through uplift and weathering or in Earth's interior through metamorphism and subduction.

Calcium isotopes offer a unique opportunity to test the representativeness of carbonate sediments in the geologic record as the calcium isotopic composition of carbonate sediments is ultimately all derived from the chemical weathering of silicate rocks. As a result, the expectation is that the calcium isotopic composition of the average global carbonate sink should be indistinguishable from bulk silicate Earth (BSE). I show that this is the case for carbonate sediments going back to Archean with the notable exception of intervals associated with large and dramatic carbon isotope excursions (CIE's) in carbonate sediments. These intervals are often characterized by calcium isotopic values that depart significantly and systematically from the bulk silicate Earth value. Futhermore, these deviations cannot be explained by large perturbations to the global calcium cycle in seawater but rather appear to record variations in primary sediment mineralogy and the style of early marine diagenesis that are typical of many shallow water carbonate sediments today.

Importantly, because the carbonate sediments hosting many of these CIE's also host calcium isotope values that deviate signficantly from BSE they cannot be representative of the average global calcium sink in carbonate sediments at that time. I discuss the consequences of this hypothesis for the interpretation of CIE's in the geologic record and present an alternative view that frames the carbon isotope record largely in terms of the local geochemical evolution of shallow water carbonate-producing environments.