Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.33522

A deep dive into the planktic foraminiferal I/Ca in global core-tops

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The carbonate iodine-to-calcium (I/Ca) ratio is a widely used proxy for reconstructing upper-ocean oxygenation. However, its application has been limited by the lack of a quantitatively constrained threshold for low-oxygen conditions due to insufficient core-top data. In this study, we compile and statistically analyze an expanded dataset of published core-top planktic foraminiferal I/Ca (N=393 from 87 sites), integrated with benthic I/Ca and water column data. Using serial t-tests to identify minimum p-values, we define three critical I/Ca thresholds — 0.85, 2.3, and 5 μmol/mol—which correspond to minimum oxygen concentrations of approximately 50, 90, and 140 μmol/kg, respectively. The 2.3 μmol/mol threshold, which distinguishes between low and high regional oxygen states, aligns with previous empirical studies and theoretical calculations for seawater iodate reduction. This expanded global dataset validates the I/Ca proxy for ancient carbonates across most continental margin settings. Furthermore, we demonstrate that: (1) Linear regressions between I/Ca and modern seawater oxygen are unlikely to yield reliable paleo-estimates; (2) Seasonal oxygen fluctuations, advective flux (mixed-layer depth), and marine particle microenvironments can decouple I/Ca signals from mean water-column O_2; (3) I/Ca in both surface- and deep-dwelling species can effectively track deep oxyclines or the margins of oxygen-deficient zones; (4) Systematic differences between oxidative- and reductive-cleaning protocols necessitate a standardized analytical approach. These findings clarify the strengths and limitations of the I/Ca proxy, emphasizing that while it is a robust indicator of redox state, deep-time applications must still account for the complex mechanisms of iodate incorporation and long-term iodine budget constraints.