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Ocean Redox Influence on Sulfur-Iron Partitioning and Pyrite Framboid Formation in the Devonian Foreland Basin and Upper Cretaceous Carbonate Shelf of the Western Interior Seaway

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The study compares the occurrence and distribution of iron and sulfide in two distinct mudstone formations: the siliciclastic-dominated Marcellus Formation, deposited in a deep-water foreland basin during Middle Devonian, and the carbonate-rich Eagle Ford Group (EFG) mudstones deposited on the deep-water Comanche shelf during Upper Cretaceous. By analyzing iron partition in carbonate cements, the sizes and abundance of pyrite framboids, and the relative proportions of pyrite and marcasite, this study links mineralogical variations to ocean redox conditions.

Pyrite framboids serve as valuable indicators of past ocean conditions, particularly oxygen levels, as their size and abundance reflect the redox environment in which they formed. Their occurrence has fluctuated over geological time, with one of the notable peaks from the Middle Devonian to Early Carboniferous, a period of widespread, persistent anoxia and favorable iron-sulfide chemistry. In contrast, during the Cenomanian-Turonian, warmer, stratified oceans and fluctuating iron dynamics limited framboid abundance, even during the intense anoxic conditions of OAE2. When present in Cretaceous, framboids tend to be large, suggesting formation under constant reworking or dysoxic rather than fully euxinic conditions.

The Upper Cretaceous Western Interior Seaway was characterized by high temperatures, elevated CO2, and significant organic carbon burial conditions. However, the EFG records of the major OAE2 event shows episodes of reoxygenation, such as in the Benthic Zone, disrupting the persistent sulfidic conditions necessary for widespread framboid formation. Additionally, higher sulfate levels in the Cretaceous oceans**,** driven by increased volcanic activities (e.g., Large Igneous Provinces), did not necessarily result in more pyrite formation. Instead, much of the sulfur was incorporated into OM via sulfurization**,** reducing the pool available for pyrite precipitation. This is evidenced by the presence of Type IIS kerogen in the EFG. Iron availability may have been another limiting factor, further restricting pyrite framboid formation. Furthermore, marcasite, a radial fibrous iron sulfide occurs commonly in the EFG. Marcasite formation requires low pH and oxidizing condition, and its higher marcasite-to-pyrite ratio in the UEF compared to the LEF supports the interpretation that the UEF was deposited under relatively suboxic condition. Lastly, iron was partitioned in limestone cements during more oxygenated times.