Paleoceanography, sedimentology, and geochemistry of Middle Ordovician ironstone, Welsh Basin, United Kingdom

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Middle Ordovician phosphatic ironstone (ca. 467 Ma) of the Welsh Basin, United Kingdom, provides new information about the cycling of bioessential Fe and P in this ancient back-arc basin during the opening of the Rheic Ocean. Located on the northeastern margin of eastern Avalonia, this narrow fault-controlled basin received terrigenous clastic sediment from the emergent Irish Sea Horst Complex and the Midland Platform. Bimodal volcanism punctuated ironstone deposition along the northeastern margin of the basin.

Lithofacies stacking patterns indicate that deposition occurred in a distal to middle shelf environment, below fair-weather wave base. Ironstone occurs in a single aggradational parasequence composed of variably bioturbated, chamositic mudstone that is overlain by a packstone composed primarily of phosphatic intraclasts and coated chamosite grains. The top of the parasequence is a trough cross-stratified, coated grain grainstone capped by a submarine erosion surface interpreted as the regressive surface of marine erosion.

The Fe-silicate and phosphatic mineralogy of lithofacies suggests that ironstone accumulation was stimulated by upwelling of phosphate-rich ferruginous seawater on the distal shelf. Increased primary productivity in the surface ocean and degradation of this organic matter on the seafloor likely established an oxygen minimum zone allowing the establishment of a stable Fe-redox boundary just beneath the sediment-water interface. The mineralogy of cortical layers forming large, granule-size coated grains records vertical fluctuations of this boundary in the sediment. These changes in pore water Eh are interpreted to reflect variability in surface ocean productivity and the export of organic carbon to the seafloor.

Lithofacies associations support an emerging model of ironstone deposition where upwelling of anoxic ferruginous seawater drives Fe precipitation. An additional continental source of Fe is inferred from the major and trace element chemistry of associated Fe-rich mudstone and siltstone. Research results illuminate a possible connection between increased seafloor spreading and the development of ferruginous bottom waters as the Iapetus Ocean closed and the Rheic Ocean opened. Further evaluation of this relationship will help clarify longstanding questions regarding the oxygenation history of Ordovician seawater during the apex of the Great Ordovician Biodiversification Event.

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