Middle to Upper Ordovician ironstone of the Western Asturian-Leonese Zone, Spain: coastal upwelling, ocean anoxia, and Paleozoic biodiversity

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Middle to Upper Ordovician ironstone and associated sedimentary rocks of the Western Asturian-Leonese Zone (WALZ), Spain, provide new information regarding the paleoceanography of the Rheic Ocean and the Paleozoic Fe cycle. The Rheic Ocean formed when the peri-Gondwanan terrane Avalonia drifted northward from Gondwana during the Late Cambrian and Early Ordovician. Examination of drill cores and outcrops indicates the southeastern margin of this narrow seaway was a dynamic continental shelf where upwelling of ferruginous seawater and storm currents controlled lithofacies character.

Parasequence composition and stacking relationships suggests the accumulation of ironstone occurred between fairweather and storm wave base as accommodation increased from lowstand conditions. Proximal parasequences consist of interbedded hummocky cross-stratified sandstone and organic-rich siltstone that shallows upwards into swaley cross-stratified sandstone and granular hematitic ironstone. Distal parasequences are composed of variably bioturbated organic-rich siltstone with thin Fesilicate and phosphorite layers. These lithofacies associations support an emerging model for ironstone deposition that relies on coastal upwelling to deliver and stimulate the precipitation of Fe in shelf sediment.

This notion provides further evidence for the development of persistent anoxic water masses in an Ordovician ocean that was near the threshold of becoming fully ventilated. New data suggests that minor extinction events punctuating the Great Ordovician Biodiversification Event may be traced to these anoxic waters, which in addition to Fe were also enriched in biologically toxic trace elements. Precipitation of upwelling-related ironstone may have helped sequester these redox sensitive elements, providing a negative feedback response to aid post-extinction recovery.

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