# Evidence for euxenia in two late Devonian black shale basins

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Models for the black shale-hosted base metal deposits are typically linked to the eruption of metal-enriched fluids into a euxinic ocean water column, providing a simple mechanism for metal transport and precipitation. Such models implicitly assume that bottom waters are generally euxinic during the deposition of organic-rich black shales. However it is now recognized that rich accumulations of organic matter can form in the presence of low levels of oxygen.

We examine three types of evidence for euxinia in long cores from two Upper Devonian black shale sequences, the Woodford Shale in the Permian Basin, west Texas, USA, and the Horn River Shale, Horn River Basin, northeastern British Columbia, Canada: trace metal concentrations, pyrite framboid sizes, and in a low maturity Woodford core, the concentration of the biomarker isorenieratane, which records the presence of green-sulfur bacteria in the water column.

In the Woodford Shale, all parameters clearly record euxenic conditions in one relatively narrow interval: greatly elevated isorenieratane concentrations, which indicate the presence of sulfidic waters extending into the photic zone; small pyrite framboid sizes, which indicate precipitation of pyrite in the water column, and elevated Mo/Al ratios, consistent with euxenic conditions. But outside of this ~ 3 meter zone, evidence for strongly developed euxenia is generally lacking and is only supported by elevated Mo/Al ratios, despite the presence of strong enrichment in organic carbon. If euxenic bottom water developed, it was restricted to a thin layer at the base of the water column. In the Horn River Shale, Mo and Mo/Al ratios are lower by 4X relative to the Woodford, indicating even less development of euxenia. Thus evidence from these black shale sequences indicates that euxenia was an episodic and uncommon phenomenon. This in turn suggests that the stratigraphically restricted ore horizons may result not from short-lived incursions of metals into a basin but instead from short-lived euxenic events.