Redox gradients in the Early Mississippian Appalachian Basin: evidence from iron speciation and trace metal abundances

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Organic-rich black shales were deposited extensively in many North American intracratonic basins during the Middle Devonian to Early Mississippian periods. In the Appalachian Basin, these units comprise important petroleum source rocks and have been linked to the regional development of bottom-water anoxia, perhaps resulting from increased terrestrial weathering and nutrient loading associated with the rise of vascular land plants. Although the spatial extent and persistence of anoxia and/or euxinia in the Appalachian Basin remain the subject of debate, most previous paleo-redox studies have examined trace element proxies applied to individual study sections. Here, we focus on the Lower Mississippian (Tournaisian) Sunbury Shale and present a new geochemical dataset that spans five drillcores across a basinal transect from northeastern Ohio to southern Kentucky (USA). Iron speciation reveals a strong paleo-redox gradient that can be related to water depth and basin hydrography. In the northeasternmost core, oxic conditions are recorded, likely related to proximity to the Catskill deltaic wedge complex that fed freshwater into the basin. In these oxic facies, total organic carbon (TOC) and trace metal (Mo, V, U, Zn) abundances are low. In central and southern Ohio, iron speciation reveals the development of ferruginous conditions associated with the deep central axis of the Appalachian Basin. In these facies, both TOC and trace metal abundances rise to intermediate levels. Further to the south in Kentucky, two cores reveal dominantly euxinic conditions, which developed as environments shoaled towards the basin-bounding sill. These facies are characterized by strong but variable enrichments in TOC and trace metals. Comparison to trace metal data from the Upper Bakken Shale (Williston Basin) reveals that strongly euxinic conditions characterized some intracratonic basins of North America during the Early Mississippian Period—however, development of bottom-water euxinia was spatially heterogeneous and highly dependent on basin hydrography.