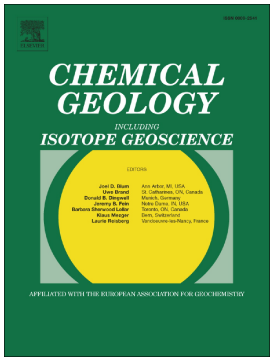

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Evidence for episodic oxygenation in a weakly redox-buffered deep mid-Proterozoic ocean

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ABSTRACT

Over the last two decades, popular opinion about prevailing conditions in the mid-Proterozoic deep ocean has evolved from fully oxygenated to globally euxinic (sulfidic) to a more heterogeneous, stratified water column with localized pockets of euxinia existing in predominantly iron-rich (ferruginous) deep waters. The Animikie Basin in the Lake Superior region has been essential in shaping our view of marine redox evolution over this time period. In this study, we present a multi-proxy paleoredox investigation of previously unanalyzed strata of the late Paleoproterozoic Animikie Basin using drill cores through the ~1.85 Ga Stambaugh Formation (Paint River Group) in the Iron River-Crystal Falls district of the Upper Peninsula of Michigan, USA. Based on previous tectonic reconstructions and analysis of sedimentary regimes, the Iron River-Crystal Falls section captures strata from among the deepest-water facies of the Animikie Basin. In contrast to previous work on sedimentary rocks in this basin, we find evidence from iron speciation, trace metal, and Mo isotope data for episodes of at least local deep-water oxygenation within a basin otherwise dominated by ferruginous and euxinic conditions. While trace-metal enrichments and iron speciation data suggest predominantly anoxic conditions, the occurrence of Mn-rich intervals (up to 12.3 wt % MnO) containing abundant Mn-Fe carbonate, and a wide range of Mo isotope data with extremely negative