

# **Geochemical evidence for variable redox structure in the Paleoproterozoic Animikie Basin, Lake Superior region**

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There has been extensive debate about Proterozoic marine redox evolution over the past two decades. The Animikie Basin in the Lake Superior region has played a central role in shaping in this conversation. To further develop our understanding of the Animike basin and of Proterozoic redox evolution, we carried out a multi-proxy geochemical and isotopic study of previously unanalyzed drill cores from the Stambaugh Formation in the Iron River-Crystal Falls district of Upper Michigan. Based on previous tectonic reconstructions and sedimentary models, this district contains the deepest water facies of the Animikie Basin. Within the Stambaugh, we have identified highly variable redox conditions—including ferruginous, euxinic, and at least short-lived suboxic and oxic marine conditions. Mineralogy and trace and major element evidence supports deposition under ferruginous conditions while coupled Mn enrichments and Mo isotope values provide evidence for suboxic to oxic conditions. We propose that this large redox variability is characteristic of the Proterozoic oceans broadly, and that these oceans lacked a strong redox buffer, in contrasts with very iron-rich Archean oceans and very oxygen-rich Phanerozoic oceans. The hallmark of Proterozoic oceans thus may not be a single redox structure, but instead short-term redox variability and the lack of a strong redox buffer.