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Comparative Rare Earth Element Systematics from Three Mesoarchean Carbonate Platforms

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Rare Earth Elements (REE) are powerful paleoenvironmental tracers that are generally well-preserved in carbonate rocks and provide important information on the composition of ancient seawater. Here we present and compare the REE systematics of three important Mesoarchean carbonate platforms preserved on the NW Superior Craton, Canada: the 2.93 Ga Red Lake platform, the 2.86 Ga Woman Lake platform, and the 2.80 Ga Steep Rock platform. All three sites show typical seawater signatures with elevated La/La*, Y/Ho, and Pr/Yb that reflect a variety of environments that were affected differently by particulate flocculation and other estuarine processes. They also show appreciable Eu anomalies indicative of hydrothermal input to contemporaneous seawater. The presence of negative Ce anomalies at all three sites provides strong evidence of redox conditions conducive to Ce oxidation. Bearing the smallest Ce anomalies, the largest Eu anomalies, and relatively high Fe but rather low Mn concentrations, Red Lake is interpreted as weakly oxidizing, with O_2 concentrations buffered by the abundance of Fe from nearby hydrothermal sources. Steep Rock, which shows intermediate Fe and Mn concentrations, seems to capture more oxidizing conditions than Red Lake, with oxidative loss of Fe and Mn occurring in conjunction with increasingly oxic local conditions, as tracked by the Ce anomaly. Woman Lake, richer in Mn and more depleted in Fe, appears to record the most oxidizing conditions, where Mn oxides were delivered directly to the sediment pile from a severely Ce-depleted water column. The REE systematics of these three platforms confirms their marine sedimentary origin and reveals that O_2-driven oxidative processes were operating at each of these sites via strong evidence for coupled redox cycling of Ce, Fe, and Mn.