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Elemental and carbonate isotope chemostratigraphy of the Mesoarchean carbonate platform at Red Lake (Canada)

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The Mesoarchean carbonate platform at Red Lake, Ontario, Canada, presents a unique opportunity to fill the knowledge gap on sedimentology and evolution of ocean chemistry for Earth's oldest known large occurrence of carbonate. The 490 m thick succession was deposited between 2940 ± 2 to 2925 ± 3 Ma ago in the Ball assemblage of Red Lake Greenstone Belt [1]. The carbonate portion of the platform is composed of mainly stromatolitic dolostone and a lesser occurrence of massive limestone. These overlie and contain successions of chert, oxide iron formation, black slate, sulfidic slate, siltstone, and sandstone. This study presents the first detailed chemostratigraphy of major, trace, and rare earth elements, and carbon and oxygen isotopes from five cored drill holes spanning shallow-to-deep water chemical and siliciclastic sedimentary rocks in this carbonate platform. Our data reveal multiple phases of carbonate deposition punctuated by sedimentation of siliciclastic and deeper water facies indicating marine transgression and regression events. The diverse lithofacies display PAAS-normalized features similar to both Archean and modern oceans. The occasional presence of oxygen is deduced from the Ce anomalies (both positive and negative) and associated Mn and Cr enrichments in some iron formation and limestone samples that suggest periodic oxygenation of the water column, at least locally. The carbon and oxygen isotopic composition of carbonates is likely mineralogically, and water depth controlled, and stromatolitic dolostone of shallow water origin shows meteoric water interaction during dolomitization while the deeper water limestone captured the open ocean DIC pool. Notably, the Red Lake carbonate platform provides context for and evidence of dynamic ocean chemistry, remarkable carbon and metal cycling, and the occasional presence of oxygen during an early phase of carbonate sedimentation on Earth.

[1] Corfu & Wallace (1986) Can. J. Earth Sci. 23, 27-42.