Late Mesoproterozoic Oceanic Oxygenation caused Widespread Sedimentary Manganogenesis

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The oxygenation of Earth's atmosphere and oceans across two major transitions in the Paleoproterozoic (~2.5-2.3 Gyr ago), and again in the Neoproterozoic (~0.8 Gyr ago), resulted in oxidation of marine manganese (Mn) and widespread deposition of marine sedimentary Mn oxides. The intervening period, the Mesoproterozoic (1.6-1.0 Gyr ago), conversely, is widely regarded as a time of redox evolutionary stasis with persistently low oxygen, which apparently caused a hiatus in sedimentary Mn deposition.

Marine Mn oxidation requires significant free dissolved oxygen (O_2) in the water column, and evidence for Mn oxide deposition in ancient sedimentary rocks has long been used as a proxy for atmospheric-ocean oxygenation, as has its absence been used as evidence for periods of anoxia or low-oxygen environments, including the Mesoproterozoic. A model of a more dynamic and heterogeneous redox structure in the Mesoproterozoic is emerging with suggestions there were at least localized or temporary oxidized environments. Critically, however, evidence for widespread Mn oxide deposition in the Mesoproterozoic, which would suggest a globally-significant ocean oxygenation event, is hitherto lacking.

Here we present mineralogical, geochemical and iron (Fe) speciation data from 1.1 Gyr old marine mudstones underlying a supergene Mn deposit from the Bangemall Supergroup in Western Australia. The analyses show intense Mn oxide deposition in the late Mesoproterozoic before diagenetic conversion to Mn carbonates, consistent with oxygenation of an otherwise anoxic water column. Furthermore, reappraisal of contemporaneous global Mn occurrences are also shown to be sedimentary in origin, which combined with our data, reflect a global period of sedimentary manganogenesis in the late Mesoproterozoic commensurate with the scale following the second major oxygenation transition from ~0.8 Gyr ago. Our findings suggest that spatially-widespread surface oxygenation occurred in the late Mesoproterozoic.