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The formation of marine red beds and iron cycling on the Mesoproterozoic North China Platform

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Abstract

Marine red beds (MRBs) are common in sedimentary records, but their genesis and environmental implications remain controversial. Genetic models proposed for MRBs variably invoke diagenetic or primary enrichments of iron, with vastly different implications for the redox state of the contemporaneous water column. The Xiamaling Formation (ca. 1.4 Ga) in the North China Platform hosts MRBs that offer insights into the iron cycling and redox conditions during the Mesoproterozoic Era. In the Xiamaling MRBs, well-preserved, nanometer-sized flaky hematite particles are randomly dispersed in the clay (illite) matrix, within the pressure shadow of rigid detrital grains. The presence of hematite flake aggregates with multiple face-to-edge ("cardhouse") contacts indicates that the hematite particles were deposited as loosely bound, primary iron oxyhydroxide flocs. No greenalite or other ferrous iron precursor minerals have been identified in the MRBs. Early diagenetic ankerite concretions hosted in the MRBs show non-zero I/(Ca+Mg) values and positive Ce anomalies (>1.3), suggesting active redox cycling of iodine and manganese and therefore the presence of molecular oxygen in the porewater and likely in the water column during their formation. These observations support the hypothesis that iron oxyhydroxide precipitation occurred in moderately oxygenated marine waters above storm wave base (likely <100 m). Continentally sourced iron reactivated through microbial dissimilatory iron reduction, and distal hydrothermal fluids may have supplied Fe(II) for the iron oxyhydroxide precipitation. The accumulation of the Xiamaling MRBs may imply a slight increase of seawater oxygenation and the existence of long-lasting adjacent ferruginous water mass.

Keywords: Marine red beds, hematite, ferruginous, dissimilatory iron reduction, Xiamaling Formation, oxygenation