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Understanding the origin of hematite in red beds occurring in Paleoproterozoic fluvial-alluvial rocks of northern Saskatchewan and Nunavut

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Background

The Earth has undergone fundamental changes in oxygenation throughout its history, with the first significant accumulation of atmospheric oxygen occurring in the Great Oxidation Event at ca. 2.4 Ga. One piece of evidence for the Great Oxidation Event is the appearance of red beds deposited in fluvial-alluvial terrestrial environments, which contain oxidized minerals such as hematite. One potentially overlooked aspect is whether the mineral constituents of red beds represent primary oxygenation from the atmosphere or inheritance from a source rock. To draw conclusions on the atmospheric state, hematite or its precursors must form during deposition or early diagenesis from the infiltration of oxidizing fluids that precipitate iron oxide minerals.

Methods

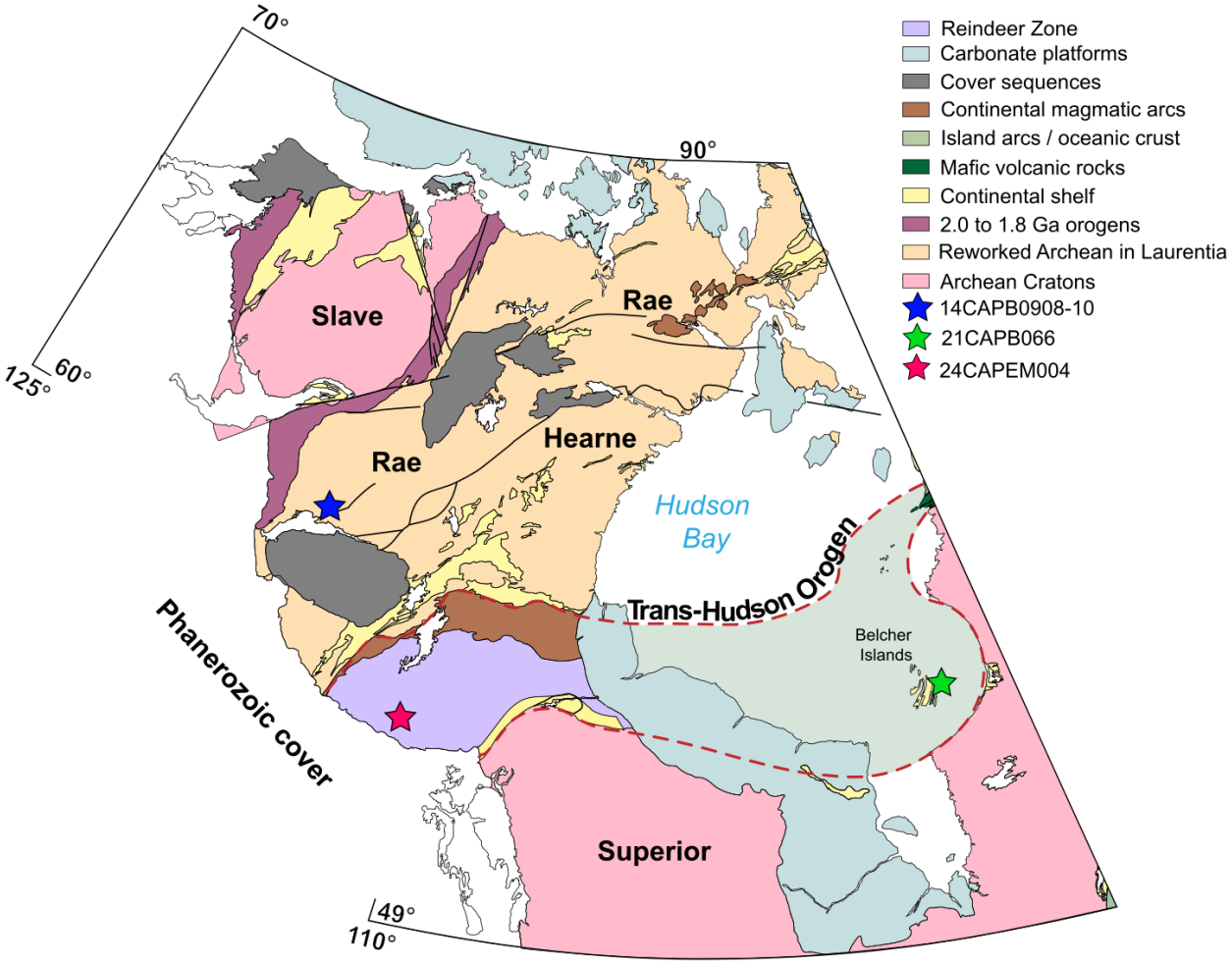


Figure 1. A map of the Archean cratons of Canada with sample locations marked as stars. Blue = Martin Group, red = Missi Group, green = Belcher Group. Modified from McDonald & Partin 2025 and Corrigan et al. 2021.

Three sample suites (Figure 1) were studied to test the main hypothesis that these rocks will show evidence of this oxidative weathering, but a competing alternative hypothesis is that these rocks will not contain evidence of oxidative weathering because of a Deoxidation Event that began around 2 billion years ago. The Belcher Group of Nunavut, Canada, was deposited ca 2.0 to 1.8 Ga and contains alluvial-fluvial red beds that have not been studied in detail. Red bed samples from the group are compared with those from the Missi Group and the Martin Group of similar ages to determine global redox conditions of the atmosphere-oceans at ca. 2.0 - 1.8 Ga. Samples were examined at the University of Saskatchewan using a Nikon D300 optical microscope under transmitted and reflected light. Identification of bulk iron oxide composition was

carried out using powder X-ray diffraction. Iron oxide phases were further distinguished using Raman microscopy. Backscattered electron imaging to document mineral textures for each sample and chemical analysis were carried out via electron microprobe analysis.

Results

Evidence of oxidizing conditions during the deposition and formation of the red beds of the ca. 1.85-1.83 Ga studied units of the Belcher, Missi, and Martin groups is present in the form of authigenic hematite as black rims on quartz, as alteration of phyllosilicate minerals such as biotite and muscovite, and as martitization of detrital magnetite grains. However, red beds provide only qualitative information on atmospheric oxygenation; more quantitative evidence is required to determine atmosphere O_2 dynamics during this time interval.

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