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Overwriting of sedimentary magnetism by bacterially mediated mineral alteration

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Marine and lacustrine sediments represent a primary source of global paleomagnetic data. Although it is usually assumed that detrital iron oxides record most of the magnetic signal in sediments, iron sulfides - which form during bacterial sulfate reduction - can also represent a significant source of sedimentary magnetism. Knowing how sulfate reduction impacts sedimentary magnetism is critical to the interpretation of paleomagnetic records. Here, we show that three distinct types of magnetic particles can be produced by bacterial sulfate reduction, each impacting the bulk sedimentary magnetism in a different way. We used a combination of magnetic force microscopy and electron probe micro-analysis to image magnetic extracts from Dead Sea sediments from a glacial and an interglacial period. In sediments from the dry interglacial period, during which bacterial sulfate reduction was suppressed, we found greigite framboids (Fe3S4) with strongly interacting magnetic domains. Contrastingly, in sediments from the wet glacial period, which experienced extensive sulfate reduction, pyrite (FeS2) is the dominant sulfide phase. High resolution magnetic imaging of the glacial pyrite framboids revealed that greigite is in fact present as single domain inclusions within pyrite, explaining how paramagnetic pyrite can retain a strongly magnetic signal. We also found that as titanomagnetite grains undergo bacterially-mediated alteration to pyrite, the original magnetic grain becomes divided into smaller regions, facilitating the acquisition of secondary magnetization by the reorganization of magnetic domains. This represents a previously unknown mechanism by which bacterially mediated alteration can overwrite primary detrital magnetic records.