Searching for magnetic needles in marine haystacks: Promise and Progress with *in situ* visualization of magnetofossils in marine sediment chips

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Magnetofossils are the fossil remains of iron-biomineralizing organisms. Conventional magnetofossils are ~50 nm-sized particles biomineralized by magnetotactic bacteria (MTB), whereas giant magnetofossils are ~1 μm-sized particles made by, as yet, unidentified organisms. The stable single-domain magnetic state of most magnetofossils makes them distinguishable by their distinct magnetic coercivity components. Some of the organisms responsible for these components flourish in specific environmental conditions and may be proxies for environmental change throughout the geologic record. One challenge to this proxy development is that micromagnetic simulations of magnetofossil organization mimicking collapsed magnetofossil chains and particle aggregates, predicted to form as the organisms are preserved in sediments (in contrast to *in vivo* arrangements), show that magnetofossil arrangement can influence the magnetic response and make these coercivity components indistinguishable from one another. These observations underscore the need for visual study of magnetofossils *in situ* within the sediment, as magnetofossils are typically imaged after they are removed from the sediments in which they are preserved. Here we image and reconstruct purported magnetofossils using focused ion beam scanning electron microscopy slice-and-view nano-tomography (FIB-SEM-SAV-nT). We show the first application of FIB-SEM-SAV-nT to image putative magnetofossils and, potentially, the first *in situ* images of conventional magnetofossils. Our results document how these particles are arranged within the sediment. We also demonstrate how surface meshes of these imaged particles are used to generate 3D volumetric meshes. With improved imaging resolution and meshing software, 3D volumetric meshes will be made of presumptive magnetofossils and be used to directly inform micromagnetic simulations.