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Unmixing Magnetic Hysteresis Loops

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Magnetic hysteresis loops provide important information in rock and environmental magnetic studies. Natural samples often contain an assemblage of magnetic particles composed of components with different origins. Each component potentially carries important environmental information. Hysteresis loops, however, provide information concerning the bulk magnetic assemblage, which makes it difficult to isolate the specific contributions from different sources. For complex mineral assemblages an unmixing strategy with which to separate hysteresis loops into their component parts is therefore essential.

Previous methods to unmix hysteresis data have aimed at separating individual loops into their constituent parts using libraries of type-curves thought to correspond to specific mineral types. We demonstrate an alternative approach, which rather than decomposing a single loop into monomineralic contributions, examines a collection of loops to determine their constituent source materials. These source materials may themselves be mineral mixtures, but they provide a genetically meaningful decomposition of a magnetic assemblage in terms of the processes that controlled its formation. We show how an empirically derived hysteresis mixing space can be created, without resorting to type-curves, based on the co-variation within a collection of measured loops. Physically realistic end-members, which respect the expected behaviour and symmetries of hysteresis loops, can then be extracted from the mixing space. These end-members allow the measured loops to be described as a combination of invariant parts that are assumed to represent the different sources in the mixing model. Particular attention is paid to model selection and estimating the complexity of the mixing model, specifically, how many end-members should be included.

We demonstrate application of this approach using lake sediments from Butte Valley, northern California. Our method successfully separates the hysteresis loops into sources with a variety of terrigenous and authigenic origins.