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Finite element micromagnetic modeling of thermally activated magnetization processes

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Thermally activated magnetization processes at different temperatures are the most important remanence acquisition mechanisms in rock magnetism. They are the central mechanisms for acquisition of thermoremanent, viscous, or chemical magnetization, they determine the quality of natural remanent magnetization, and they are closely related to many other remanence and magnetization parameters. A fundamental understanding of thermally activated magnetization processes thus lies at the heart of rock magnetism. We here develop a method to physically model such processes in a general way. The backbone of this method is a fast relaxation algorithm for finding optimal transition paths between local energy minima in a finite element three-dimensional micromagnetic model. It combines a nudged elastic band technique with action minimization. Initial magnetization paths are obtained by drag method using repetitive minimizations of modified energy functions. For octahedral pseudo-single domain magnetite particles, all different local energy minima are identified and all optimal energy barriers between them are numerically calculated for zero external field. These results also provide estimates for energy barriers in weak external fields, and thus permit to construct time dependent transition matrices which describe the continuous homogeneous Markov processes of isothermal acquisition and decay of viscous remanent magnetization.