Electron holography of oxy-exsolution microstructures in synthetic titanomagnetites

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Intergrowths of titanomagnetite and titanohematite or ulvospinel resulting from oxy-exsolution or spinodal decomposition are regularly observed in paleomagnetic specimens. This microstructure is thought to be responsible for anomalous paleointensity measurements of historic lavas and experiments have shown that bulk magnetic properties are dramatically affected by the creation of these structures. However, previous studies have not been able to rigorously measure the effects of the geometry and composition of the magnetic phases. Electron holography, a TEM technique that allows the quantitative measurement of the magnetic flux at a nanometer scale, provides an opportunity to investigate how these variables influence magnetostatic interactions and inform our interpretation of magnetic data from rock samples showing these textures. The samples used in this study are synthetic polycrystalline spinels with compositions spanning the magnetite-ulvospinel solid solution, which were re-sintered under oxidizing conditions to create oxy-exsolution structures of paramagnetic titanohematite lamellae separating blocks of ferrimagnetic titanomagnetite. The composition of the titanomagnetite is governed by the starting material and oxygen fugacity during the re- sintering process; using the appropriate conditions we were able to exsolve samples with compositions approaching pure magnetite, and the size of the ferrimagnetic particles are pseudo-single-domain to multidomain. Electron holography was carried out on thinned samples to measure the magnetic flux between these interacting particles. Measurements of these magnetostatic interactions will inform micromagnetic models of interacting pseudo-single-domain particles, and future work will allow us to more carefully control the width of the paramagnetic lamellae and hence inter-particle spacing to accurately interpret the effect of these microstructures on the properties of natural paleomagnetic samples.