Simulations of electron holographic observations of magnetic microstructure in exsolved titanomagnetites

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Titanomagnetite inclusions in slowly-cooled rocks can contain exsolution microstructures that consist of closely-spaced ferrimagnetic magnetite (Fe_3O_4) prisms separated by paramagnetic ulvöspinel (Fe_2TiO_4) lamellae. Off-axis electron holography has recently been used to image the magnetic remanent states of such inclusions, and to show that the prisms are mostly magnetostatically-interacting single domains. The overall magnetic microstructure is found to depend sensitively on the shapes, spacings and orientations of the prisms, as well as on the shape of the inclusion and on its magnetic history. In order to understand the observed magnetic microstructures, we have carried out analytical simulations of linear arrays of uniformly-magnetized magnetite prisms by making use of known expressions for demagnetization factors. By systematically varying the size and spacing of the magnetite prisms in the simulations, it is possible to chart the magnetic microstructures of such mineral assemblages in the form of a "magnetic microstructure phase diagram". Whereas shape anisotropy suggests that the long dimension of each prism should be its easy axis, if more than one element is considered then interactions change the energy balance of the combined magnetic state. We consider linear arrays of identical prisms that are magnetized either in antiparallel directions perpendicular to the line joining them or parallel to each other and to the line joining them. For two 100-nm-wide prisms that are separated by 10 nm in a specimen of thickness 20 nm, the simulations suggest that the transition between the two states occurs at a prism length of 122 nm. A more general treatment that includes the influence of magnetocrystalline anisotropy on the energy balance will be presented, and the simulations will be compared with experimental observations.