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Magnetic Domain Patterns in Natural Magnetite Grains seen by Magneto-optical Imaging

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1. Magneto-optical (MO) imaging was used to visualize magnetic field distribution on the surface of magnetite-bearing skarns thin sections (16x32x0.03 mm3). The images show individual magnetite grains (10-200 microns) separated by 0.5 micron wider grain boundaries. Intragrain spatial arrangement of magnetic domain can be viewed by simple image processing. On these images different structural heterogeneity (topological, chemical, strain) of the sample can be distinguished with the same evidence as using Bitter decoration, for example.

2. MO-imaging also gives unique possibility to study real-time visualization of magnetic domain dynamics and how magnetic domain pattern appears at any point on the hysteresis loop. By slowly varying the external magnetic fields within a full major loop excursion we found that the spatial distribution of the magnetic field changes in two different ways. Movies show irregular shaped 5-30 micron sized domain jumping near the penetration front of the global magnetic field sliding. The total number of jumps is near 300 for 200-micron sized magnetite grain.

3. By repeating the same experiment many times (one or more full excursion around the major loop) we found unexpected results. The sequence and spatial pattern of domain jumps and field slides is reproducible and within experimental error always lead to the same overall magnetic field distribution for any given external magnetic fields. However, local domain shapes and penetration front are surprisingly irreproducible up to 40 % of the areas of the individual domains. Thus on a small scale ($<$ 10 microns) the domain behavior responsible for magnetic domain patterns seems to be fully independent on the structural heterogeneity.

4. We discuss the following model which can explain the observed phenomena. The domains of the magnetite grain exhibits behavior intermediate between two end member cases: 1) during each experiment the domains follow the same deterministic way according the prediction of all current zero-temperature microscopic theories (see E.A. Jagla, PRE 046240), 2) domains evolve in different ways and it is important to take thermal disorder into account.