Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 423 (C-112), 2018, pp. 65-66
DOI: 10.25171/InstGeoph_PAS_Publs-2018-034
16th Castle Meeting New Trends on Paleo, Rock and Environmental Magnetism, Chęciny, Poland, 2018

Magnetic Sub-fabrics in Rocks: Measuring Techniques and Geological Interpretation

František HROUDA[1,2,✉]

[1]AGICO Ltd., Brno, Czech Republic

[2]Charles University, Faculty of Sciences, Prague, Czech Republic

✉ hrouda@agico.cz

Abstract

The Anisotropy of Magnetic Susceptibility (AMS) is in general controlled by all minerals present in a rock. However, the individual magnetic minerals or their groups may behave in different ways in various geological situations and it is therefore desirable to resolve the rock AMS fabric into components corresponding to individual magnetic mineral sub-fabrics. The resolution is based on specific behaviour of suscep-tibility of individual minerals in variable magnetic fields or at variable temperatures.

Variation of susceptibility of paramagnetic minerals with temperature is represented by hyperbola, while in ferromagnetic minerals it is a complex curve characterized by acute susceptibility decrease at the Curie temperature and at the Verwey or Morin transition. In strong magnetic fields of the order of tesla, the difference between principal susceptibilities is proportional to squared field in paramagnetic minerals, to field in ferrimagnetic/antiferromagnetic minerals of pyrrhotite/hematite type and field independent in ferrimagnetic minerals of magnetite type. In weak magnetic fields, some minerals, such as titanomagnetite, pyrrhotite, hematite for instance, show low-field variation of susceptibility, while the susceptibility of paramagnetic minerals and pure magnetite is field independent. At variable operating frequencies, the low-field susceptibility is frequency-dependent in ultrafine (in the order of tens of nm) magnetically viscous grains of magnetite or maghemite, while in larger grains it is frequency-independent. The out-of-phase component of susceptibility is non-zero in titanomagnetite, pyrrhotite, hematite and in ultrafine magnetite, and effectively zero in multidomain magnetite and paramagnetic minerals. In addition, the anisotropy of magnetic remanence (AMR), which is solely controlled by the ferromagnetic minerals, can also be used to determine the preferred orientation of these minerals uninfluenced by paramagnetic minerals.

Unfortunately, there is no universal method for determining the magnetic fabric of individual minerals or mineral groups. Nevertheless, the above specific behaviours offer us at least partial solutions. Techniques were developed for separating the magnetic sub-fabrics of magnetite and paramagnetic minerals as well as those for separating the magnetic sub-fabric of the minerals of pyrrhotite/hematite type from paramagnetic mineral sub-fabric. Besides, techniques were developed for direct determination of the magnetic sub-fabrics of the minerals that exhibit low-field variation of susceptibility such as titanomagnetite, pyrrhotite, hematite and those showing frequency-dependent susceptibility such as magnetically viscous grains of magnetite or maghemite. The direct determination of the magnetic sub-fabrics of the same minerals can also be made through the anisotropy of out-of-phase component of susceptibility. The last anisotropy can be used in the determination of magnetic sub-fabric of weakly magnetic, but strongly conductive minerals like graphite. Through suitable selection of magnetizing fields in the AMR, one may investigate sub-fabrics within ferromagnetic minerals differing in magnetic viscosity.

As known since the first half of the 20th century, the sub-fabrics of individual rock-forming minerals can possess more or less identical symmetries or differ in symmetry considerably. The former fabrics, called homotactic by Sander, are indicative of very similar configurations of the stress fields controlling the formations of individual sub-fabrics, while the latter fabrics, called heterotactic, indicate changing configurations of the stress fields that control formation of the individual sub-fabrics probably originating in different stages of rock fabric formation. Similar situation exists in magnetic anisotropy components. The present paper shows some applications of the above resolution techniques to solving various geological problems.

Keywords: magnetic sub-fabric, low-field anisotropy, high-field anisotropy, remanence anisotropy.