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Anisotropy of out-of-phase magnetic susceptibility of rocks as a tool for direct determination of magnetic sub-fabrics of some minerals

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The magnetic susceptibility measured in alternating field can in general be resolved into a component that is in-phase with the applied field and a component that is out-of-phase. While in diamagnetic, paramagnetic and many ferromagnetic materials the phase is effectively zero, in some ferromagnetic minerals, such as pyrrhotite, hematite, titanomagnetite or ultra-fine magnetically viscous grains of magnetite, it is clearly non-zero. The anisotropy of out-of-phase susceptibility (opAMS) offers itself as a tool for the direct determination of the magnetic sub-fabrics of the minerals with non-zero phase.
The SAFYR program, originally destined for computing the in-phase AMS (ipAMS) measured with the MFK1-FA Kappabridge, was modified in such a way that it calculates also the opAMS using exactly the same calculus; the ipAMS and opAMS are determined in one measuring process. Five groups of specimens showing clearly non-zero phase were used to investigate the precisions in determining both the ipAMS and opAMS as well as the relationship between the ipAMS and opAMS. In the specimens investigated, the out-of-phase susceptibility is one to two orders of magnitude lower than the in-phase susceptibility. If the mean out-of-phase susceptibility is higher than 5 $\times$ 10-5 [SI], the accuracy in determination of the opAMS, expressed in terms of fitting error and confidence angles, is comparable to or only slightly worse than that of the ipAMS. In the specimens whose magnetism is dominantly carried by a mineral with non-zero phase, the ellipsoids of opAMS and ipAMS show similar shapes and orientations of respective principal directions. The degree of anisotropy, however, is significantly higher in opAMS than in ipAMS. The reasons for this phenomenon are not fully known, one of them can be masking effect of the minerals with zero-phase. In the specimens possessing non-coaxial magnetic sub-fabrics of the minerals with non-zero and zero-phase, not only the degrees of AMS, but also ellipsoid shapes and principal directions differ.