



Single-crystal magnetic anisotropies of rock-forming minerals

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Anisotropy of magnetic susceptibility (AMS) is often used as an indicator of mineral fabric in rocks. For a quantitative estimate of mineral fabric, it is necessary to know and understand the intrinsic magnetic anisotropy of each mineral in the rock. Susceptibility, and thus AMS, is a superposition of paramagnetic and ferromagnetic components. In general, the paramagnetic contribution can be related to silicates, whereas the ferromagnetic component arises from iron oxide inclusions. We determined single-crystal AMS in both low and high magnetic fields for a series of olivine, amphibole, clinopyroxene and orthopyroxene compositions. Analysis of high-field data allows for separation of ferromagnetic and paramagnetic contributions to the magnetic anisotropy. Acquisition of isothermal remanent magnetization (IRM) was measured in order to further characterize the ferromagnetic inclusions. Often, the iron oxides grow epitaxially on the silicate structure and have specific orientations with respect to the silicate. The ferromagnetic component of the AMS can provide information on the orientation or shape of the inclusions. The paramagnetic AMS in a single crystal is related to the distribution of cations with a strong magnetic moment, e.g. ferric and ferrous iron, in the lattice structure. Relationships between the anisotropy, e.g. the anisotropy degree (delta k) or principal susceptibility directions, and iron content were thus established for each mineral group. For example, the orientation of the intermediate and minimum susceptibility axes in olivine depends on the iron content – the minimum susceptibility is parallel to the crystallographic a-axis for 3-5 wt.% FeO and parallel to b for 7-9 wt.% FeO at room temperature; and for amphiboles, the degree of AMS increases linearly with increasing iron content. AMS in a rock depends on the single-crystal properties, which are influenced by lattice structure and composition, as well as the crystallographic preferred orientation of crystals. Information on single crystal AMS can thus be used to predict bulk AMS of ultrabasic rocks, when the orientation distribution function of the constituent minerals is known.