



Magnetic anisotropy in pyroxene single crystals

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Anisotropy of magnetic susceptibility (AMS) is often used as a proxy for the mineral fabric in a rock. This requires understanding the intrinsic magnetic anisotropy of the minerals that define the rock fabric. With their prismatic habit, pyroxenes describe the texture in mafic and ultramafic rocks. Magnetic anisotropy in pyroxene crystals often arises from both paramagnetic and ferromagnetic components that can be separated from high-field magnetic data. The paramagnetic component is related to the silicate lattice, whereas the ferromagnetic part arises from the magnetic properties of ferromagnetic inclusions that were further characterized by isothermal remanent magnetization measurements. These inclusions often have needle-like habit and are located on the well-defined cleavage planes within the pyroxenes. We characterize low-field and high-field AMS in pyroxene single crystals of diverse orthopyroxene and clinopyroxene minerals. In addition to the magnetic measurements, we analyzed their chemical composition and Fe²⁺/Fe³⁺ distribution. The anisotropy arising from inclusions in some augite crystals displays consistent principal susceptibility directions, whereas no preferred orientation is found in other crystals. The principal susceptibilities of the paramagnetic component can be related to the crystal lattice, with the intermediate susceptibility parallel to the b-axis, and minimum and maximum in the a-c-plane for diopside, augite and spodumene. The degree of anisotropy increases with iron concentration. Aegirine shows a different behavior; not only is its maximum susceptibility parallel to the c-axis, but the anisotropy degree is also lower in relation to its iron concentration. This possibly relates to a predominance of Fe³⁺ in aegirine, whereas Fe²⁺ is dominant in the other minerals. In orthopyroxene, the maximum susceptibility is parallel to the c-axis and the minimum is parallel to b. The degree of anisotropy increases linearly with iron concentration. The difference in principal directions between clino- and orthopyroxene reflects their different crystal structure; in clinopyroxene, iron mainly occupies M1 sites, whereas it prefers the distorted M2 sites in orthopyroxene. The difference in anisotropy degree between aegirine and the other clinopyroxenes suggests that Fe²⁺ causes a stronger anisotropy than Fe³⁺. Thus, the magnetic anisotropy in pyroxenes is mainly dominated by the concentration, oxidation state and site occupancy of iron. The results from this study are important when interpreting magnetic fabrics in ultramafic rocks that contain both olivine and pyroxenes.