American Mineralogist, Volume 108, pages 1642–1657, 2023

Oriented secondary magnetite micro-inclusions in plagioclase from oceanic gabbro

Ge Bian[1,*], Olga Ageeva[1,2,†], Vladimir Roddatis[3], Gerlinde Habler[1], Anja Schreiber[3], and Rainer Abart[1]

[1]University of Vienna, Department of Lithospheric Research, Josef-Holaubek-Platz 2, 1090 Vienna, Austria
[2]Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry (IGEM), Staromonetnyi 35, Moscow 119017, Russia
[3]Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Telegrafenberg, D-14473, Potsdam, Germany

Abstract

Plagioclase-hosted submicrometer to micrometer-sized oriented needle- and lath-shaped magnetite micro-inclusions with their elongation direction aligned parallel to the plagioclase [001] (PL[001]) direction were investigated using correlated optical, scanning electron, and scanning transmission electron microscopy. The PL[001] magnetite micro-inclusions formed from older generations of differently oriented magnetite micro-inclusions by recrystallization during hydrothermal alteration. Six orientation variants of PL[001] magnetite micro-inclusions occur, and they share the same shape orientation but differ in their crystallographic orientation relationships to the plagioclase host. The magnetite-plagioclase interfaces are facetted. High-resolution scanning transmission electron microscopy revealed that interface facets are aligned parallel to low-index lattice planes corresponding to oxygen layers of either magnetite or plagioclase. In addition, the linkage between prominent crystal structure elements of magnetite and plagioclase across the interfaces and accommodation mechanisms minimizing misfit between the two crystal structures were discerned. Combined evidence suggests that the shape and shape orientation, as well as the crystallographic orientation relationships between the magnetite micro-inclusions and the plagioclase host, are crystallographically controlled. The close crystal-structural link between magnetite precipitates and plagioclase host ensures a low-energy configuration driving recrystallization of older generations of differently orientated magnetite micro-inclusions into those that are aligned parallel to PL[001] and facilitates the underlying reaction kinetics. Due to their single to pseudo-single domain characteristics, the plagioclase-hosted magnetite micro-inclusions are particularly robust carriers of natural remanent magnetization. Recrystallization of differently oriented preexisting magnetite micro-inclusions into magnetite micro-inclusions with uniform shape orientation parallel to PL[001] has interesting consequences for the magnetic anisotropy of magnetite-bearing plagioclase grains.

Keywords: Plagioclase-hosted magnetite micro-inclusions, crystal and shape orientation relationships, interface facets, scanning transmission electron microscopy, crystallographic control