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Orientation relationships between magnetite micro-inclusions and plagioclase host

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Magnetite micro-inclusions in silicate minerals are important carriers of the remanent magnetization of rocks. Their shape orientation relationships (SOR) and crystallographic orientation relationships (COR) to the host crystal are of interest in the context of the bulk magnetic properties of the inclusion-host assemblage. We investigated the SOR and COR of magnetite (MT) micro-inclusions in plagioclase (PL) from oceanic gabbro using correlated optical microscopy, scanning electron microscopy, Electron backscatter diffraction analysis and Transmission electron microscopy.

In the mm-sized PL crystals of the investigated gabbros MT is present as equant, needle- and lath-shaped (sub)micrometer sized inclusions. More than 95% of the needle-shaped inclusions show SOR and specific COR to the plagioclase host. Most of the needles are elongated perpendicular to one of the MT{111} planes, which is aligned parallel to one of the (112), (1-12), (-312), (-3-12), (150), (1-50) or (100) planes of plagioclase. These inclusions are classified as “plane-normal type”. The needle elongation parallel to MT<111>, which is the easy direction of magnetization, ensures high magnetic susceptibility of these inclusions. The underlying formation mechanism is related to the parallel alignment of oxygen layers with similar lattice spacing across the MT-PL interfaces that are parallel to the elongation direction [1].

Apart from the SOR and the alignment of a MT{111} with one of the PL low index planes, the MT crystals rotate about the needle elongation direction. The rotation angles are statistically distributed with several maxima representing specific orientation relationships. In some cases one of the MT<001> axes is aligned with PL[14 10 7] or PL[-14 10 -7], which ensures that FeO_6 octahedra of MT well fit into channels // [001] of PL, which are formed by six membered rings of SiO_4 and AlO_4 tetrahedra [2]. This COR is referred to as the “nucleation orientation” of magnetite with respect to PL. There are several other possibilities to fit FeO_6 octahedra into the [001] channels of PL, but the alignment stated above allows for the additional parallel alignment of one of the MT{111} with one of the above mentioned low index lattice planes of PL. MT crystals with one of these nucleation orientations can undergo directional growth to develop laths and needles. MT crystals with other nucleation orientations that do not allow for the parallel alignment of MT{111} with the above mentioned PL lattice planes, do not significantly grow and form the equant inclusions.

For some needles one or more of the MT{011} planes that are parallel to the needle elongation direction, are aligned with low-index planes of plagioclase such as PL (112), PL(150), PL(1-50) etc., and form MT facets. This situation corresponds to achievement of the best possible match between the two crystal lattices. This can either be generated during primary growth or during re-equilibration of the micro-inclusions and the plagioclase host.

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Reference

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