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Fe-Ti-oxide textures and microstructures in shear zones from oceanic gabbros at Atlantis Bank, Southwest Indian Ridge

Jessica Till, Luiz F.G. Morales, and Erik Rybacki
Deutsches GeoForschungsZentrum (GFZ Potsdam), Section 3.2, Potsdam, Germany (till@gfz-potsdam.de)

Ocean drilling expeditions at several oceanic core complexes formed at slow- and ultra-slow-spreading ridges have recovered cores containing numerous zones of oxide-rich gabbros containing ilmenite and magnetite. In these cores, high modal concentrations of Fe-Ti-oxides are systematically associated with high-temperature plastic deformation features in silicates. We present observations of Fe-Ti-oxide mineral structures and textural characteristics from a series of oxide-rich shear zones from Atlantis Bank (ODP Site 735B) on the Southwest Indian Ridge aimed at determining how oxide mineral abundances relate to strain localization.

Fe-Ti-oxide minerals in undeformed oxide gabbros and in highly deformed samples from natural shear zones generally have morphologies characteristic of crystallized melt, including highly cuspate grains and low dihedral angles. Anisotropy of magnetic susceptibility in oxide-rich shear zones is very strong, with fabrics mainly characterized by strong magnetic foliations parallel to the macroscopic foliation. Crystallographic preferred orientations (CPO) in magnetite are generally weak, with occasionally well-defined textures. Ilmenite typically displays well-developed CPOs, however, the melt-like ilmenite grain shapes indicate that at least part of the crystallographic texture results from oriented ilmenite growth during post-deformation crystallization. The oxides are hypothesized to have initially been present as isolated pockets of trapped melt (intercumulus liquid) in a load-bearing silicate framework. Progressive plastic deformation of silicate phases at high-temperature mainly produced two features: (i) elongated melt pockets, which crystallized to form strings of opaque minerals and (ii), interconnected networks of melt regions. The latter lead to intense strain localization of the rock, which appears as oxide-rich mylonites in the samples. In some samples, abundant low-angle grain boundaries in both magnetite and ilmenite suggest that deformation may have continued after crystallization of the late melt, imposing a weak strain on the oxides.

Recent experimental deformation results indicate that magnetite and ilmenite should be weaker than most mafic silicates under anhydrous conditions. However, melt-like oxide morphologies observed in Atlantis Bank shear zones indicate that the redistribution of Fe-Ti-oxide melts may have more influence on the strength and strain localization behavior of oceanic gabbros than their solid-state rheology.