Microstructures of lower crust gabbros from the Oman Ophiolite: Analyses of the drilled cores of the Oman Drilling Project

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Oman Drilling Project in 2016 to 2017 recovered 400 m long cores of layered gabbros at Site GT1 in the Wadi Tayin Massif of the Oman Ophiolilte. The purpose of this research is to describe microstructures of the layered gabbro core samples and to discuss the conditions of magmatic and hypersolidus deformation that operated in the lower crust beneath the Oman paleoridge.

Core samples were cut into slabs parallel to foliation and slabs normal to foliation and parallel to lineation, which were made into thin sections for microscopic observations. Structural fabrics and the relationships between crystal shapes and alliginment were described to identify magmatic and hypersolidus deformation structures.

Cored samples are predominantly olivine gabbros consisting of anhedral olivine, anhedral to subhedral clinopyroxene and subhedral to euhedral plagioclase. Grain size ranges from 0.5 mm to a few millimeters irrespective of mineral species.

The structures shown by the gabbros are classified into three regimes by temperature or the amount of melt present: Regime I, magmatic conditions without or minimal plastic deformation; regime Ⅱ, plastic deformation assisted by interstitial melt (Dunn, 2000); regime Ⅲ, near solidus deformation. Regime Ⅱ is identified by ameboid grain boundaries with no intracrystalline deformation and equigranular textures, resulted from decreasing internal strain energy by at high temperatures. The presence of melt is evidenced by the clear euhedral plagioclase rims with resorbed turbid cores as discussed below.

Regime I. Magmatic structures are identified as modal layering due to changes in mineral mode, no preferred orientation or shape-preferred orientation of clinopyroxene and plagioclase, poikilitic texture of olivine enclosing plagioclase laths and ophitic texture of clinopyroxene including plagioclase laths.

Regime II. The hypersolidus deformation structures overprint igneous structures: ameboid olivine with or without strain in the crystal, elongated olivine, and lenticular aggregates of olivine grains with an asymmetric quarter structure. Single clinopyroxene crystals show an asymmetric quarter structure like olivine aggregates. Ophitic clinopyroxenes consist of subgrains with slightly different orientations <10°. Plagioclase shows deformation twin and undulose extinction. Equigranular fine-grained plagioclase with grain boundaries intersecting at 120° are common. Large plagioclases have a resorbed core with a wavy outline and are surrounded by euhedral rim.

Regime III. Subsolidus recrystallization includes buldging and grain boundary migration resulted in ameoboid grain boundaries of clinopyroxene. Undulose extinction and kinked twinning of plagioclase are observed.

It is well known that mid-ocean ridge basalt magma commonly crystallizes in the order of olivine, plagioclase and clinopyroxene, which is also true for the gabbros of the Oman Ophiolite (Adachi and Miyashita, 2003). Nevertheless, only plagioclase shows euhedral to subhedral shapes in the observed

layered gabbro core samples. Deformed olivine aggregates and clinopyroxene with quarter structures are embedded in plagioclase with equilibrium granoblastic textures and large euhedral plagioclases with resorbed turbid cores. Considering these textures combined with the mechanical strength of the three constituent minerals, these gabbros suffered deformation under the presence of melt, which assisted complete recovery of strain through recrystallization of fine-grained plagioclase and overgrowth of euhedral rims around magmatic plagioclase cores. Poikilitic olivine occurs through the hole, whereas ophitic Cpx occurs at 73 m and 220 m in depth. Most deformation structures of regime II are present irrespective to depth. The asymmetric structures of olivine and clinopyroxene were used to determine the relative sense of shear. Both dextral and sinistral sense of shear are observed within the same samples.

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