The magmatic conditions and hypersolidus deformation of lower crustal magma chamber below a fast-spreading ridge — Insight from the core analyses of the Oman ICDP drill holes GT1A & GT2A

Trinh Nguyen*, S. Umino, T. Fudai, Y. Kusano, O. Ishizuka, A. Tamura, and T. Morishita

The ICDP Oman Drilling Project drilled the lower crustal section of the Oman Ophiolite in Wadi Gideah, north of Ibra and recovered 400 m long cores each from Hole GT1A and GT2A. Microscope observations and La-ICP-MS analyses were conducted on the core samples to obtain microstructural data and trace element concentrations, which help to understand the magmatic conditions and hypersolidus deformation operated in the lower crustal magma chamber beneath the Oman paleoridge axis.

Progressive downhole variations in cumulate gabbro microstructures are observed throughout the hole GT2A to GT1A. Plagioclase changes from flat, platy crystals with high aspect ratios to short, stubby crystals with wavy outlines. The proportion of primary, cumulus plagioclase decreases from more than 70% to around 3% in GT2A, and from about 7% to less than 1% in GT1A, while that of broken plagioclase increases from approximately 25% to 95%, and from nearly 85% to 90% in GT2A and GT1A, respectively. The amount of recrystallized plagioclase crystals ranges from 0% to 5% in GT2A, smaller than that in GT1A ranging from 5% to 10%. Clinopyroxene is deformed to distorted rectangular shapes with a quarter structure, and then changes into crystals with sub-grains, which eventually forms neoblasts. Equilibrium texture shown by polygonal crystals that meet at a triple junction of obtuse angles around 120° appears in downhole. The percentages of primary clinopyroxene in GT2A drop from 100% to 80%, most of them are more than 90% while in GT1A, they fall from 90% to 60%. In contrast, secondary clinopyroxene crystals including subgrains, neoblasts, and recrystallized grains increase to 20% in GT2A, and vary between 10% and 40% in GT1A. Ophitic clinopyroxene is present throughout the drill holes, although gradually decrease in number downhole.

The progressive deformation and recrystallization of cumulus crystals shown above are associated with compaction of cumulus piles that led to entrapment of interstitial melts. Subsequent cooling of cumulus mushes caused in-situ fractionation of the trapped melts to form zoning in the rims. Most cumulus clinopyroxene shows normal zonings, while there are a few unzoned crystals in GT2A and in the lower GT1A. Trapped melt fractions were estimated by mass balance calculations on the basis of the modes of olivine, clinopyroxene and plagioclase, and the concentrations of La, Ce and Pr in clinopyroxene crystals.

Ophitic texture is present throughout the holes suggesting that all cumulus plagioclase and clinopyroxene crystallized under large degrees of supercooling, which is typically observed in the sheeted dikes and the roof zone upper gabbros. Furthermore, high trapped melt fraction and the common presence of zoned cumulus minerals suggest that both GT2A and GT1A drill holes penetrate the thick foliated gabbros in Wadi Gideah section, which crystallized on the axial melt lens floor and were transported downward in the lower crust.

Keywords: Oman ICDP, GT1A&GT2A, magma chamber, fast-spreading ridge, foliated gabbro

***Corresponding author:** ngtmtrinh@hcmus.edu.vn