Geophysical Research Abstracts
Vol. 21, EGU2019-5759, 2019
EGU General Assembly 2019

Olivine gabbros from IODP Hole U1473A (SWIR, 57°E): Record of reactive porous flow through ultraslow-spreading oceanic crust?

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The IODP Expedition 360 drilled Hole U1473A in the Oceanic Core Complex (OCC) Atlantis Bank, at the ultraslow-spreading Southwest Indian Ridge. Hole U1473A is composed of gabbros dominated by olivine gabbro (77.7%), gabbro (5.2%), gabbro with > 1% of oxides (17.1%), and minor diabase dikes and felsic veins. Olivine gabbro (i.e. olivine content 10-18%) display primary textures mostly subophitic and locally granular. Shipboard bulk-rock geochemistry of olivine gabbro suggest that they formed by fractional crystallization from a melt with relatively primitive composition. On the other hand, textural observations on board highlighted the occurrences of plagioclase chadacrysts having irregular shape and resorbed grain boundaries against the enclosing clinopyroxene oikocrysts, suggesting that melt-rock interactions may occurred. Olivine gabbros from Atlantis Bank display intense grain size variability throughout the Hole from fine- to coarse-grained. Contacts between domains of different grain sizes are common; they locally define an igneous layering, but are mainly irregular and sutured. Although those widespread features attest of a primary magmatic process, and likely document processes related to melt migration, their origin remains elusive. In this study, we investigate the origin of grain size variations in olivine gabbro from Hole U1473A, as evidence of melt migration and reactive porous flow through the ultraslow-spreading oceanic crust. We aim at understanding the primary magmatic processes that contribute to the formation of the lower oceanic crust (e.g., dissolution-precipitation, reactive porous flow, fractional crystallization). At contacts, the grain boundaries of coarser grained plagioclase and clinopyroxene are resorbed against the finer grained olivine gabbros, suggesting partial dissolution by a melt that crystallized the fine grained material. Relicts of partially dissolved coarse grained plagioclase and clinopyroxene are also embayed in fine grained domains. Overall, minerals chemical composition define a trend of fractional crystallization, and vary away from contacts between different grain sizes. Coarser grained minerals have more primitive composition (Mg#OLIVINE = 72-74 mol%; Mg#CLINOPYROXENE = 80-86 mol%) compared to the finer grained (Mg#OLIVINE = 71-72 mol%; Mg#CLINOPYROXENE = 78-80 mol%). Coarse grained clinopyroxenes have primitive cores and more evolved rims, which are in chemical equilibrium with fine grained clinopyroxene that show no core-to-rim variations. Preliminary geochemical data on clinopyroxenes display significant enrichments in the most incompatible elements (from Zr = 10 ppm and Ce/Y = 0.2 in coarse crystal core, to Zr = 100 ppm and Ce/Y = 0.5 in fine grained), associated to melt-rock reactions. Structural, microstructural and chemical constraints point to a multi-stage and multi-process origin of these grain size variations: (i) crystallization of primitive coarse grained olivine gabbro, (ii) reactive porous flow by a MORB-type migrating melt leading to partial assimilation of the pre-existing coarse grained matrix, and re-equilibration at coarse crystal rims, (iii) segregation of the reacted melt, which crystallizes the fine grained olivine gabbro and completely re-equilibrates the relicts of coarse grained olivine gabbro. The widespread occurrence of grain size variations in olivine gabbro from IODP Hole U1473A indicate that melt migration and melt-rock reactions are primary and fundamental processes in the formation of the ultraslow-spreading oceanic crust.