Geophysical Research Abstracts
Vol. 14, EGU2012-3228, 2012
EGU General Assembly 2012

Shape-preferred orientation (SPO) of oceanic gabbros at IODP Hole 1256D: Implications for magmatic processes

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Magmatic fabrics in oceanic gabbros close to the sheeted dike-gabbro transition at superfast spreading centers (>200 mm/y) remain poorly investigated. At ∼1407 mbsf at IODP Hole 1256D, Expedition 312 recovered non-azimuthally oriented core samples from two gabbro bodies of undetermined shapes: Gabbro 1; 52 m-thick and Gabbro 2; 24 m-thick.

Oceanic gabbros in the upper part of the plutonic complex are expected to be macroscopically isotropic, therefore investigating the existence and strength of a fabric requires a highly sensitive method. The Intercept method (Launeau and Robin, 1996), based on quantification of shape-preferred orientation (SPO) in 3-D, has a remarkably high sensitivity for shape anisotropy (0.3%). This method has been used on 33 oceanic gabbro samples from Hole 1256D as a function of depth for each mineral phase.

Image analysis using the Intercept method on gabbroic fabrics provides new constraints on crustal accretion mechanisms, the timing of deformation relative to crystallization, i.e. pre-full crystallization fabric vs crystal plastic strain fabric. Observed fabrics provide constrains to test the two-end member ocean accretion models: (A) the “Gabbro Glacier” model; (B) the “Sheeted Sills” model or a hybrid model between (A) and (B). The following lines of evidence are distinct and allow testing of the two models respectively:

Model A- The “Gabbro Glacier” model – Microstructures including fractured grains and mechanical twins in plagioclase grains should indicate increasing amounts of strain. SPO is expected to increase as a function of depth. A transitional zone from steeply foliated cumulate gabbros to horizontally layered gabbros is anticipated to occur below the sheeted dike complex.

Model B- The “Sheeted Sills” model - No specific correlation between SPO and depth is expected unless geochemical investigations indicate Gabbros 1 and 2 were convecting. Fine-grained margins are expected to occur along the tops and bottoms of the sills. Microstructures should be equilibrated with high angle grain boundaries and should lack syn-magmatic/high-temperature plastic deformation fabrics. If sills are convection-driven then the magmatic foliation may be oblique to compositional layering.

SPO image analysis has been performed for major primary silicate phases (plagioclase, orthopyroxene, clinopyroxene, and olivine) and oxides. The Intercept and Ellipsoid softwares have been used to calculate SPO tensors and errors. The results of this research will prove either the “Gabbro Glacier” model or the “Sheeted Sills” model and will provide new quantitative structural data on the mechanisms controlling magmatic accretion at the sheeted dike-plutonic transition zone.