MAGMA FLOW PATTERN IN DYKES OF THE AZORES REVEALED BY THE ANISOTROPY OF MAGNETIC SUSCEPTIBILITY

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Abstract: The localization of magma melting areas at the lithosphere bottom, in extensional volcanic domains is poorly understood. Presently two main models debate the localization of the magma sources and how it influence the emplacement geometry and magma flow sense of the dykes in the upper crust. One model involves mainly vertical magma flow, coming from elongated or elliptical reservoirs, roughly 10 to 20 km depth, which in a oceanic environment, is around the crust-mantle boundary. The shallow magma chambers that can exist beneath a volcano edifice are the result of magma trapping in high levels of the crust. In any case the deep source feed vertically, both the shallow magma chambers and the crustal planar intrusions and dyke swarms.

We favor another model (Geoffroy et al., 2007) proposing that in a extensional volcanic zone, dykes result mainly from the lateral magma flow from shallow (~ 2 to 4 km) magma chambers. These magma chambers are, in that way, essentially localized beneath central volcanoes implying that melting at depth may be focused at specific points within the mantle. The dyke swarms will be developed preferentially from the edges of magma chambers, injected orthogonal to the minimum stress $\sigma 3$ and along the horizontal maximum stress σ_H.

To corroborate the hypothesis that the magma feeding a mafic crust, incomes mainly from permanent localized shallow crustal reservoirs beneath central volcanoes, we developed a study focused on the determination of the orientation of the fossilized magma flow in dykes of a complex volcano-tectonic setting, the Azores Archipelago, a hot-spot related triple junction, between North American, Eurasia and African plates.

The magmatic flow fabric in a dyke is represented by the fabric of the early crystallized phenocrysts, usually with high aspect ratios, that act as rigid particles. The mechanism that favours the preferred orientation of phenocrysts in a conduit, assuming a Newtonian laminar flow, is due to the mechanical drag and force moment produced

close to the interface between the magma and the solid wall. Using the anisotropy of magnetic susceptibility (AMS) we obtain magmatic flow vectors from 34 alkaline basaltic dykes from the islands of São Jorge (linear volcanism), São Miguel and Santa Maria (central volcanoes) in the Azores Archipelago.

The sampling was carried out along the chilled margins of narrow dykes. Low and high field magnetic measurements, thermo-magnetic measurements and chemical analysis reveal that the magnetic phases of dykes contain titano-magnetite showing a wide spectrum of solid solution ranging from Ti-rich to Ti-poor compositions, with vestiges of maghemitization. Most of the sampled dykes exhibit a normal magnetic fabric and the shape of the ellipsoid is predominantly oblate. The foliation k1-k2 plane is sub-parallel or imbricated relative to the dyke plane. The orientation of the magnetic lineation axes k1 are more dispersed than that of the k3 axes, which are systematically well grouped. To assess the uncertainty concerning the interpretation of the magnetic lineation as the preferred orientation of the longer axis of opaque ferromagnetic grains and as a consequence, a proxy of the fossilized magmatic flow direction, we performed a petrofabric analysis in oriented thin sections. We use the “Intercept” method to obtain the statistical directional distribution of the opaque minerals (Fe and Ti oxydes) and phenocrysts (mainly plagioclase) and to understand the relationship with the principal axes of the magnetic susceptibility. The obtained result show that the calculation of the direction and sense of the magmatic flow vectors should be calculated from the analysis of the geometric relations of the imbrication of the magnetic foliations, relative to dike margins.

The dykes of Sao Jorge and Sao Miguel, show a predominance of lateral and sub-horizontal magmatic flows. However In Santa Maria the deduced flow pattern is less systematic changing from sub-horizontal in the southern part of the island to oblique in north. In any case we have not found evidences of vertical or sub-vertical magmatic flows. These results imply that the ascent of magma beneath the islands of Azores is predominantly over localized melting sources and then collected within shallow magma chambers. According to this concept, dykes in the upper levels of the crust in the Azores environment have been installed mainly by lateral and sub-horizontal propagation of magma, away from the magma chambers, and thus feeding the lava flows observed at the surface.

Keywords: AMS, Azores, dykes, magmatic flow, volcanism.

Geoffroy, L., C. Aubourg, J.-Paul Callot. (2007): Mechanisms of crustal growth in large igneous provinces : The north Atlantic province as a case stud. *Geological Society of America Special Papers*, *430*, 747-774.