European Mineralogical Conference
Vol. 1, EMC2012-318-1, 2012
European Mineralogical Conference 2012

Deformation fabrics in quartz and feldspar phenocrysts: indicators of rapid ascent and cooling of magma in an active shear zone

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Porphyritic dykes, formed in an active strike-slip shear zone, represent a laboratory of fabric development at high temperature, high cooling rates and variable strain and provide insight into processes during rapid magma ascent related to volcanism in a continent collision zone. 640 – 675 °C hot tonalitic magma injected the SE-margin of the Western Alps along the Insubric Line between Locarno in the NE and the Val d'Ossola in the SW at ∼ 10 km depth and rapidly cooled to the wall-rock temperature of ∼ 480 – 520 °C (Stäb and Kruhl, subm.). During injection of magma into fractures and ascent over probably several km the high amount of quartz and feldspar phenocrysts leads to rapid stress increase at punctual grain contacts and to (i) magmatic fractures in feldspars and (ii) mechanical nuclei in quartz. Based on high misorientation of neighbouring crystals and fast grain-boundary migration, finally the enlarged nuclei may fill the entire host grains. Such fabrics indicate interplay between high strain rates and annealing at high temperatures, i.e. strong strain-rate variations as probably typical situation in magma, feeding active volcanoes through narrow fissures. Local stress increase on the micro-scale, leading to small nuclei subsequently enlarged by grain-boundary migration, is also known from high-T shear zones with locally and temporally strongly increased strain rate (Kruhl et al., 2007) as well as from experimentally-generated shear zones (Vernooij et al., 2006).

The onset of cooling of the stuck magma is in the high-quartz field. Chessboard subgrain patterns in quartz are probably formed by stress transfer through the melt. Coarse grain-boundary suturing and quartz-c cross-girdles with opening angles of ∼ 70 °C indicate high-T deformation during and immediately after crystallization of the dykes. Locally, the quartz phenocrysts experience flattening of up to 80 % without recrystallization, as a result of high defect mobility at elevated temperatures. In general, the variation of cooling rate and strain in different dykes, together with well-known wall-rock conditions, such as temperature, pressure and regional kinematics and cooling, form the basis of far-reaching investigations of the interaction between rock and mineral fabrics and variable deformation rates and provide insight into conditions of strongly localized movements along convergent plate boundaries.

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