Microfabrics and deformation processes in magmatic veins of the Thuringian Forest, Germany *Poster*

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Introduction

The research area is located in the Ruhla-Brotterode crystalline complex in the western part of the Thuringian Forest (Germany), about 20 km south-southwest of Eisenach. The investigated outcrops occur at the eastern and western flanks of the valleys north of the villages Trusetal and Hohleborn. Deformed magmatic veins only occur in the Hohleborn area. Both areas have relative fresh outcropping rocks, due to the steep relief, former quarries and fresh road cuts. According to Obst & Katzung (2000) several periods with the formation of magmatic veins with different chemical composition occur in the Ruhla-Brotterode crystalline complex. Presumably older lamprophyric veins and younger doleritic, syenitporphyric and granitporphyric veins have been identified (Obst & Katzung 2000). Benek & Schust (1988) already pointed out that some of these magmatic veins have experienced ductile deformation. The subject of this work is the occurrence of deformed magmatic veins in the Hohleborn area. The contact to their host rocks, their petrography and their microfabrics have been investigated and related to deformation processes, which led to a better understanding of their deformation conditions within the late- to post-variscan development of the area.

Regional geological framework

The Ruhla-Brotterode crystalline complex is part of the Mid-German Crystalline High (Fig. 1). The Crystalline High is a 50–70 km broad zone striking NE–SW and forms the NW border of the Variscan Saxothuringian zone (Seidel 1995). During the main phase of the Variscan orogeny, in the lower to middle Carboniferous, the Mid German Crystalline High is considered to have been part of the active continental margin of the Saxothuringian (micro)continent (Seidel 1995), which overrode the more northwestern Rhenohercynian (micro)continent. This phase continued during upper Carboniferous time with the segmentation of the Variscan orogen through an E–W extensional stage within Central-Europe. The investigated area lies in the southeastern part of the Crystalline Complex. Its rocks mainly consist of paragneisses, which are intruded and bordered by numerous permocarboniferous granites and a diorite (Lützner et al., 1997). According to Zeh et al. (1996), the paragneisses are part of the Truse Formation and represent an accretionary wedge. The crystalline rocks are covered by Permotriassic sedimentary rocks and crosscut by numerous E-W- to SSE-NNW-trending, magmatic veins. These veins are of basaltic, andesitic and dacitic to rhyolithic nature (Obst & Katzung, 2000) and appear as simple veins, mixed or combined veins (Mädler & Voigt 1994). U-Pb zircon dating of the veins by Brätz (2000) shows ages between 285 ± 5 Ma and 264 ± 7 Ma for un-

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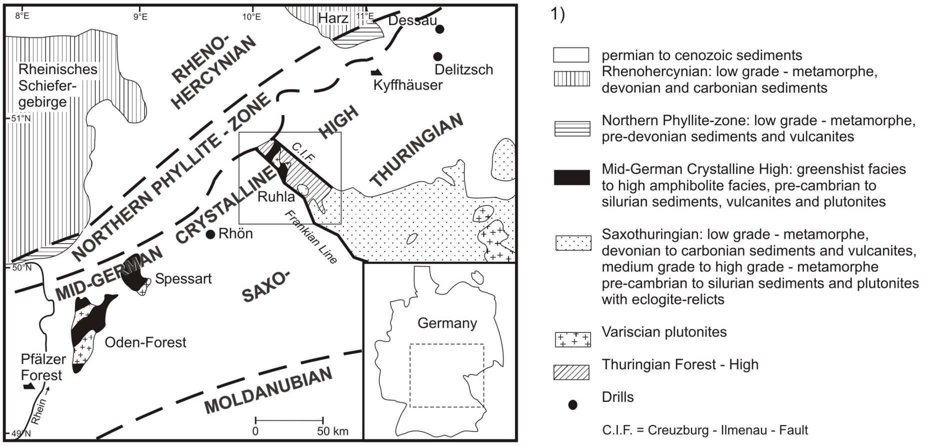

Figure 1: Position of the Mid-German Crystalline High within the variscan orogen (modified after Hansch & Zeh (1999)

deformed veins and ages between 305–320 Ma and 294±4 Ma for the deformed veins.

Methodology

From 10 oriented samples of deformed veins (2 sections per sample, perpendicular to the foliation) as well as for comparison purposes from 10 samples of macroscopically undeformed vein (1 section per sample) thin sections have been prepared for microscopic structural and petrographical analysis. The sections have been investigated for mineralogical composition, micro-fabrics, deformation structures and deformation intensity trough measurement of length-width-relation of quartz crystals (shape preferred orientation, SPO) and extension-relation of feldspars crystals as well as the crystallographic preferred orientation (LPO) of the quartz crystals with the universal stage. The structural data from veins and host rocks have been evaluated with the program 'Wintek' for integration of the deformed veins within the late to post-variscan context.

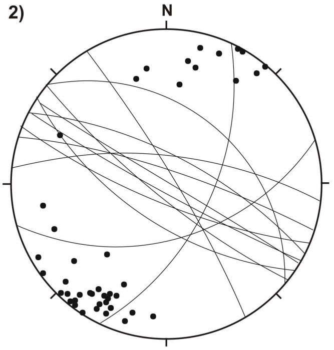

Figure 2: Stereographic projection (lower hemisphere) of vein-host rock contacts of undeformed, magmatic veins in the research area; n = 44.

Structural Analysis

Figure 2 shows the stereographic projection of the contacts of undeformed magmatic veins with their host rocks. Nearly all veins strike E–W to NW–SE

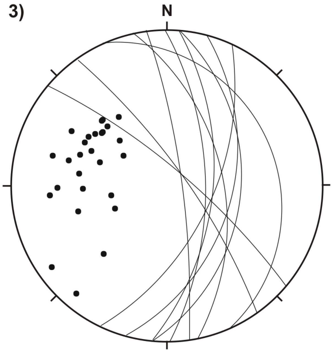

Figure 3: Stereographic projection (lower hemisphere) of vein-host rock contacts of deformed, magmatic veins in the research area; n = 28.

and dip steeply with 65–85° to N–NE respectively SSW–WSW. In contrast the deformed magmatic veins in Figure 3 strike mostly N–S to NE–SW and dip with 40–65°to ENE to SE. The structural inventory of the host rocks (Fig. 4a & 4b) shows a predominance of N–S to NE–SW striking and 30–75° dipping schistosity S_3 and NW–NNE striking 20–60° dipping S_2 which both seem to be partly refolded by B_4. This leads to the possible directions of 5–35°to ENE–E for B_3 respectively 35–60° to ESE–SSE for B_4 folding axes.

The main rock-forming minerals of the deformed veins own the following characteristics.

- Feldspars (potassic feldspar & plagioclase): microboudinage, sericitisation, fissures (often filled with antitaxial and syntaxial quartz- and feldspar-fibers), incipient fractures, growth rims of quartz parallel and perpendicular to schistosity and in strain shadows of crystals, undulatory extinction & microclinic & myrmekitic structures (pot. feldspar) or uniform extinction and mechanical twins (plagioclase).
- Quartz: occurs as porphyroclast, matrix-quartz or growth-rims. Porphyroclast have a strong elongation (extreme length-wide-relation, long axis parallel to schistosity), undulatory extinction, deformation ribbons, subgrain structures (size ca. 1 mm), recrystallised grains with highly irregular grain boundaries (size 10–15 µm); as coarse strain-shadow of crystals or vein filling; grain size spectrum: coarse / fine matrix = 15–50 µm / 10–15 µm, strain shadow = ca. 50 µm, growth rim = 100–300 µm.
- Biotite: structures indicating sliding of layer-packages parallel to cleavage or bending with undulatory extinction in extreme fracturing perpendicular to schistosity; single clasts as well as small orientated fragments (frequently marks the schistosity together with chlorite, hematite, sericite and opaque phases), partly strongly alterated.

The evaluation of the quartz-elongation and the stretched feldspars in the Flinn-Diagramm shows that the deformation regime is flattening and that the intensity of the quartz deformation (in all directions) is higher than that of the feldspars. The determination of recrystallized grain size of quartz and the calculation of differential stress after Blenkinsop (2000) and Twiss (1977) yielded relative high differential stresses in the range of 95–125 MPa for this flattening deformation stage. The deformation also resulted in the development of a lattice preferred orientation (LPO) of

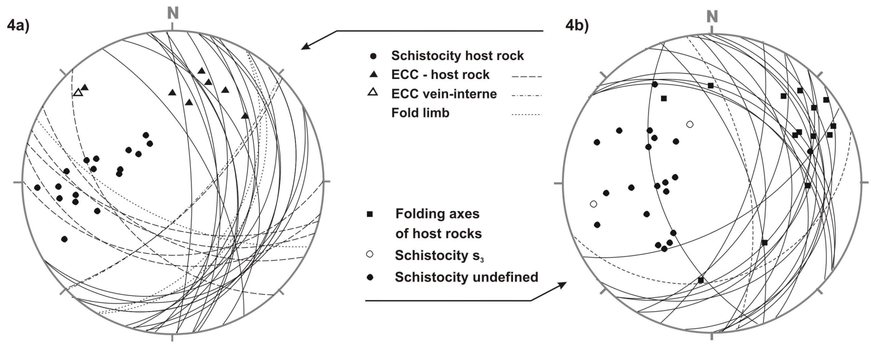

Figure 4: a) and b) Stereographic projection (lower hemisphere) of the host rock structural inventory in the research area; a) of outcrop A, n = 28; b) of outcrop B, n = 35.

the quartz in the deformed veins. The preferred orientation of the c-axis for isometric and elongate quartz grains is not well defined. Nevertheless the measured quartz c-axes suggest an uniform reorientation with increasing deformation intensity. The c-axis reorientation is to within the plane of the vein internal schistosity.

Conclusions

The investigation shows deformed andesitic and rhyolitic veins with quartz-growth rims mostly orientated parallel to the schistosity. This strongly suggests that a fluid was available during deformation of the veins. The comparison with the position of the main schistosity in the host rocks indicates that the deformed magmatic veins intruded before or during the last deformation phase of the host rocks (D_4). This inference is supported by the nearly parallel orientation of the veins with the shallower schistosity planes of the main schistosity (S_3), the formation of ecc-structures in the deformed veins as well as fabrics of similar deformation intensity within the younger quartz-veins in the host rocks. The different orientation of deformed and undeformed veins also argues for their formation during different time episodes with a changed orientation of σ_3. The sparse age determinations for the magmatic veins do not contradict this conclusion. The observed micro-fabrics limit the boundary conditions during the deformation to a regime with relative high differential stresses of 95–125 MPa and low temperatures. The microstructures and the LPO of quartz indicate that the vein-deformation took place between the deformation regimes of low temperature plasticity and dislocation creep of quartz.

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