Effect of crystallography and temperature on the development of quartz high-angle grain boundaries in metamorphic rocks *Poster*

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Grain boundary migration during dynamic recrystallization of quartz results in grain boundary suturing of various extent. The geometry of the sutured boundaries is affected not only by temperature, strain rate, finite strain and differential stress, but also by internal properties such as the defect distribution and crystallographic orientations. Consequently, the grain boundary geometry may provide information about these conditions and properties.

In continuation of a previous study (Kuntcheva et al.) the complete crystallographic orientation of quartz grain boundaries was measured, based on a combination of electron backscatter diffraction (EBSD) and universal-stage (U-stage) measurements. For this purpose a sample of granite from the northern Aar Massif (Central Alps, Switzerland) was taken, deformed at temperatures up to 300–350°C at the end of the Lepontine event of the Alpine Orogenesis. The former magmatic quartz partly recrystallized dynamically to grains of ca. 50–100 micrometer diameter, with weakly sutured grain boundaries showing no curved but always straight segments (Fig. 1) as typical for quartz grain boundaries in metamorphic rocks (Kruhl & Peternell, 2002). In addition, at grain boundary triple junctions the dihedral angles generally deviate from 120 degree. These observations indicate anisotropy of grain boundary energies.

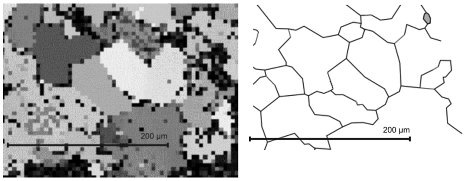

Figure 1: Thin-section outline (right) and orientation image map (OIM) (left) for part of the measured area, obtained as result of the combined beam/stage EBSD measurements; confidence index >0.2; step size 5 micrometer; boundary levels: 15°.

The measurement of the Aar Massif granite sample by combined EBSD/U-stage methods led to 3144 quartz grain boundary segments, the orientation of which was calculated with respect to both neighbouring grains so that a final data set of 6288 segment orientations was achieved. In accordance with Kuntcheva et al. the segments do not occupy preferred low-index or coincidence site lattice orientations with respect to both neighbouring grains, i.e., they do not represent special boundaries. They preferentially occupy rhombohedral, trapezohedral and bipyramidal positions, i.e. positions in a ca. 30–50 degree girdle to the c-axis, however, to a less extent than the quartz analyzed by Kuntcheva et al. The strongest maxima in the girdle are near the $(10\bar{1}2)$ plane of quartz, the other two near the $(10\bar{1}1)$ and the $(11\bar{2}3)$ planes. In general, however, positions near the basal and near the prism planes occur, too (Fig. 2, right).

With such a high number of measurements special grain boundary geome-

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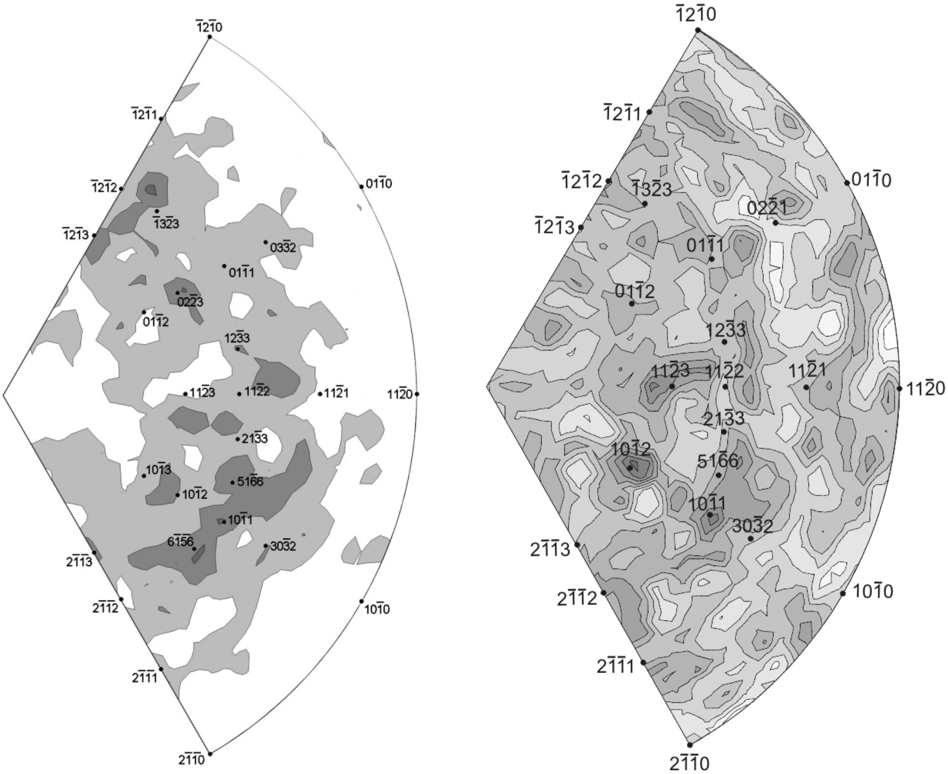

Figure 2: Frequency distribution of quartz grain boundaries (inverse pole figure, Schmid net, upper hemisphere). Each grain boundary is represented with respect to the crystallographic system of both neighbouring grains and, consequently, occurs in two different orientations. For comparison, low-index planes of quartz are indicated. Left: 3320 measurements from a quartzite from the Barrow metamorphic zones of the Scottish Highlands, deformed during increasing temperatures up to mid-amphibolite facies conditions. Contour intervals = 0.5× uniform distribution, starting at 1. Modified after Kuntcheva et al.. Right: 6288 measurements from a granite from the northern Aar Massif (Central Alps, Switzerland), deformed at temperatures up to 300–350°C. Contour intervals = 0.25× uniform distribution, starting at 1.

tries, like triple junctions or zigzag structures, or segment orientations with respect to both neighbouring quartz grains could be investigated on a sufficiently broad data basis. Specifically, the orientations of grain boundary segments at triple junctions show a distinct dependency on the size of the angles at the triple junctions. In general, segments with a preferred crystallographic orientation, with respect to one neighbouring quartz grain, often shows a preferred orientation with respect to the other neighbouring grain, too.

As shown by HRTEM studies on gold crystals, a partly ordered transition from one to the other crystal occurs across straight grain boundary segments

(Wolf & Merkle, 1992). Consequently, the atoms across such a boundary are bound in periodically repeated sections, whereas in other sections the crystal is strongly elastically distorted. We suggest that these results may also serve as an explanation for the present observations on quartz grain boundaries.

Together with the previous study by Kuntcheva et al. the present study confirms the preliminary results on the temperature-dependency of the crystallographic control of quartz grain boundaries, based exclusively on universal-stage measurements (Kruhl & Peternell 2002). At relatively low temperatures, i.e., just above the quartz recrystallization temperature of about 300°C, the grain boundary segments occupy a broad spectrum of crystallographic orientations with only a weak preference for rhombohedral and trapezohedral positions. However, at mid-amphibolite facies temperatures the segments concentrate in a ca. 30Ũ-50 degree girdle to the c-axis. Further investigations will show if this relationship holds to higher temperatures and represents a general reduction to rather few (meta)stable crystallographic grain boundary orientations with increasing temperatures, which may represent a potential geothermometer. Since the development of sutured grain boundaries is a geologically short process that takes place during and immediately after deformation, the studied quartz grain boundaries can be considered as stabilized post-tectonic textures, with more or less stable crystallographic orientations for the given geological conditions, mainly the temperature immediately after deformation.

Literatur

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