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Dauphiné twins or not, that's the question

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Dauphiné twinning in trigonal low-quartz is defined by a two-fold axis (180° rotation) about the crystallographic c-axis [0001]. Dauphiné twinning has thus no effect on the orientation of the crystallographic axes of quartz, but transposes the positive and negative rhombs. Therefore, Dauphiné twinning remain undetectable by standard optical microscopy. Dauphiné twins were first resolved in euhedral quartz crystals by natural or artificial etching. In texture analysis, the different orientation distribution of the positive and negative rhombs indicates that Dauphiné twinning has likely been active within many polycrystalline quartz aggregates. Since the introduction of EBSD-OIM (SEM) Dauphiné twin boundaries can effectively be mapped in polycrystalline quartz aggregates.

Dauphiné twins in quartz can be a primary microstructure, formed during crystal growth, or a secondary microstructure, resulting from transformational or mechanical twinning. Transformational Dauphiné twinning, occurring at the polymorphic transition of hexagonal high-quartz to trigonal low-quartz (573°C at atmospheric conditions), causes a variant selection through slight atomic displacements arising from internal thermal vibrations. Mechanical Dauphiné twinning in low-quartz, on the other hand, is stress-induced. It acts to align the direction of greatest elastic compliance, orthogonal to the positive rhombs, with the compressive principal stress direction.

Dauphiné twin boundaries separate the two variant domains within the quartz grain. The question, though, is which of the variant domains is the 'twin' and which is the 'host'. In previous work on mechanical Dauphiné twinning in naturally deformed quartz-bearing rocks, the distinction between 'host' and 'twin' has been made mostly arbitrarily, guided by an observations bias (e.g. smallest fraction in grain represents the 'twin') or an interpretational bias (e.g. twins develop at grain boundaries). However, with respect to grains that are (nearly) free of Dauphiné twin boundaries, it is impossible to unequivocally conclude whether the grain has been (nearly) completely twinned (and should be labeled 'twin') or has remained (nearly) completely untwinned (and should be labeled 'host'). Whether or not Dauphiné twinning initiated or went to completion, largely depends on the crystallographic orientation of the quartz grain with respect to the principal stresses that have triggered mechanical Dauphiné twinning in the polycrystalline quartz aggregate.

Only by means of a procedure, in which the orientation distribution of the rhombs in the individual variant domains of individual quartz grains is related to the compressive principal stresses, an attempt can be made to correctly label the different variant domains within an individual quartz grain as 'r-domains' or 'z-domains', rather than 'twin' and 'host' respectively (cf. 'r-twin' and 'z-twin' of Menegon et al., 2011). This procedure is based on the assumption that grains (nearly) free of Dauphiné twin boundaries are, on the one hand, favorably oriented with respect to the principal stresses so that twinning could easily go to completion, or, on the other hand, have a 'stable' crystallographic orientation with respect to the principal stresses, so that they remained untwinned. In both cases, these grains can be labeled as 'single r-domain grains'. We will illustrate this procedure for a sample taken from a massive quartz vein that precipitated and deformed in low-grade metamorphic conditions during the late stages of orogeny.

References

Menegon et al. 2011. Contribution to Mineralogy and Petrology 161, 635-652.