Syntectonic antitaxial fibrous vein growth: inferences from the microstructure of natural samples

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Introduction

Fibrous veins are used to deduce progressive deformation histories from rocks, based on the assumption that fibre grain boundaries follow the movement of the wall (Taber 1916, Grigor'ev 1965 p.200, Durney & Ramsay 1973). The technique is routinely applied, although the growth mechanism is still not clear and no experiments so far failed to reproduce fibrous growth under subsurface conditions (Spencer 1991, Bons & Jessell 1997). We present detailed studies of natural antitaxial fibrous veins from a range of different low grade areas. SEM- and CL-observations combined with U-stage measurements indicate, that the growth mechanism is complex, controlled by an interplay of crystal growth processes, kinematics and fluid distribution.

Observations

The samples are black shales which contain thin layers enriched in quartz and some calcite. Antitaxial fibrous calcite veins at high angle to bedding are concentrated in the shale layers. Some veins could be proved to be isolated in three dimensions.

Transmitted light and SEM

Optically undeformed calcite fibres are curved, can be traced from one wall to the other and connect marker layers on both sides of the wall. Bedding is curved around the vein (Fig. 1a). Inclusion bands in vein calcite are rare and do not crosscut fibre grain boundaries. Calcite is twinned in the central part of the vein only. U-stage data show no preferred orientation of calcite c-axes, measured along the vein-wall interface.

The vein-wall interface is a selvage zone of quartz and white mica. In contrast to the wall rock, opaque minerals are absent in both the selvage and in the white mica included in the vein calcite. Quartz grains show growth competition towards the vein centre (syntaxial) and have an elongate-blocky morphology with both straight and curved grain boundaries. Grain boundaries of the quartz selvage are normal to the wall of the slaty substrate and often abut about ninety degrees against the calcite-quartz interface. Both interfaces (selvage-wall and selvage-vein) cannot be matched with their counterpart on the other side of the vein. Calcite fibre grain boundaries are commonly located at antiformal peaks of the selvage wall.
Fig. 1. (a) Sketch of symmetric curvature of bedding around a fibrous vein (from sample NY-19A, scale bar of 2 mm length). (b) SEM image of the tip of a fibrous vein. Wall rock continues across the vein (width of picture 580μm).

CL and microprobe analysis

Most veins show a symmetric CL banding parallel to the median line, crosscutting single crystals (Fig. 2). A morphology of the zonation can be observed (Fig. 2b). The luminescence generally continues in the selvage, but is absent in the wall rock.

Mapping of elements such as Mg$^{2+}$, Mn$^{2+}$ and Fe$^{3+}$ with the microprobe clearly shows micas in the calcite vein and the quartz selvage. The zonation visible in CL corresponds to the one in microprobe.

Fig. 2. Fibrous calcite vein in slate shown with crossed nicols (a) and CL mode (b). A marked CL banding can be observed parallel to the wall (white line). None of the irregularities can be correlated with one another. Width of vein: 3 mm, sample NY-36 (locality as Urai et al. 1991).

Discussion

The absence of opaque minerals in the white mica and its occurrence within the vein suggest mica formation during calcite precipitation. Several quartz grains show face controlled growth towards the calcite (similar observations by Koehn, pers. com.), suggesting growth during or after calcite precipitation.

Deformation of the wall rock at the vein's tip is indicated by undulose extinction of micas. CL zonation is interpreted to show the wall morphology at earlier stages of vein growth, also suggesting a continuous change of the wall morphology.

The crystallographic orientation is random. This indicates random nucleation of calcite in the centre of the vein. The fibres' continuity across the vein points to the absence of growth competition. This in turn implies that during fibre growth the calcite was not growing into a free fluid for significant distances without some interaction with the wall.
References


