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Three sets of fine extinction bands in a tectonically deformed vein-quartz single crystal

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Intracrystalline fine extinction bands (FEBs) in quartz, are narrow (less than 5μm thick), planar microstructures with a misorientation up to 5° with respect to the host crystal, occurring in closely spaced sets (spacing of 4-5μm). FEBs have been commonly attributed to a large range of brittle and/or crystal-plastic mechanisms, revealing considerable disagreement on the responsible crystal-plastic slip systems and the ambient conditions. Another question that arises, is whether or not the FEBs rotate from a basal plane orientation to orientations ranging between the basal and prism planes. Usually only one set of FEBs occurs in a single crystal, though two sets are observed, in particular with increasing strain. Tentatively, a maximum of two sets of sub-basal FEBs has been postulated to develop in a single quartz crystal in a tectonic context.

However, we identified several crystals in naturally deformed vein-quartz containing three sets of FEBs. The vein-quartz has been deformed under sub-greenschist metamorphic conditions, during the late Palaeozoic Variscan orogeny, in the High-Ardenne slate belt (Belgium). The vein-quartz has been subjected to bulging dynamic recrystallisation and shows a high degree of undulatory extinction, abundant subgrains and wide extinction bands sub-parallel to the c-axis. We attempted to characterise these three sets of FEBs by means of light microscopy, EBSD-OIM and universal stage microscopy. In both cases studied the c-axis is inclined less than 8° with respect to the thin-section plane. The different sets of FEBs show a consistent orientation with respect to the c-axis. One set of FEBs deviates maximum 10° from the basal plane. The other two sets deviate between 15 and 35° from a basal plane orientation. Corresponding FEBs, at the same angle with respect to the c-axis, have similar morphologies. In relative EBSD orientation maps FEBs show a maximum misorientation of 3°, and have a lower pattern quality than the host crystal. The FEB boundaries often coincide with Dauphiné twin boundaries. The misorientation inside FEBs gradually increases and can be asymmetrically distributed across the FEBs. Plotting the FEB orientations in the New Stereographic Projection Template (used for identifying the crystallographic orientation of planar deformation features), the FEBs appear to deviate from any particular crystallographic orientation. No trigonal symmetry is detected in the FEB orientation distribution.

Firstly, the question arises whether the exceptional observation of three sets of FEBs is due to an observational bias caused by the particular orientation of the optical axis of the quartz crystals sub-parallel to the thin section plane, or whether the FEBs formed because of a specific crystallographic orientation with respect to the principal stresses during deformation. Secondly, we suggest that the development of FEBs is related to a range of possible slip systems, or to a combination of different slip systems. Dauphiné twinning seems to have taken place after FEB formation. Finally, we seriously question that FEBs could be formed solely by means of a single slip system, that FEBs rotate after their formation and that there could be a genetic relation between FEBs and primary growth banding.