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Is EBSD a more efficient tool than Universal stage to collect calcite twin data as used in calcite twin inversion for stress ?

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Inversion of calcite twin data is a powerful tool to reconstruct paleostresses in sedimentary basins. Twin data are commonly collected optically from three perpendicular thin sections using a U-stage. 30 grains are generally analysed in each section, and for each grain the orientations of the optical axis and of the three potential e-twin planes are measured and their twinned/untwinned status is defined. In addition to being long and tedious, optical data collection suffers from several issues that may impact the results of inversion: it is impossible to measure twin planes oblique at low angle to the thin section; it is difficult to measure grains without any or with a single twinned plane and to make sure that some potential twin planes are twinned or not.

EBSD(Electron Back-Scatter Diffraction) is commonly used to obtain quantitative information about microstructures and crystallographic orientations of minerals, even from very small grains, and can theoretically solve U-stage measurement issues. To date however, only few authors have reported the use of EBSD to collect calcite twin data and measurements were taken from a very limited number of grains.

Calcite grains in veins and sedimentary rocks may be large (100-500μm) and may contain very thin twins ($< 1\mu$m) for small twinning strain (<2-4%) and temperature <200°C. Twin data acquisition using EBSD therefore faces the problem of the number and spacing of spots against the low twin thickness and the number and large size of the grains to be measured. We investigated a new procedure to collect twin data, which is a compromise between improving the quality and reducing the time of measurements: twin data are collected along perpendicular lines in grains -which requires preliminary identification of the grain boundaries- with a 0.5μm step. The efficiency of this procedure was tested against U-stage measurements on the same grains. Putting both twin datasets in the same reference for comparison requires the knowledge of EBSD standard and of the orientation of the calcite crystal lattice with respect to this standard, which deserves caution since EBSD standard may vary depending on the manufacturer (OIM, AztecHKL). 3 cases were encountered: EBSD is (1) better, (2) equivalent or (3) worse than U-stage for the detection of twinned/untwinned planes for the same grains. This third case is related either to the too large EBSD measurement step that may lead to miss very thin twin lamellae, or to the strategy of data collection along lines that may miss heterogeneously distributed twins. Although this third case is likely to be rare, the impossibility to exactly determine how frequently it occurs casts some doubts on the reliability of this procedure.

EBSD therefore allows a more accurate twin data collection and determination of the twinned/untwinned status, but requires a much longer time than U-stage to collect thin twins from numerous and large calcite grains. If time acquisition is not an issue, the best procedure is to automatically investigate the whole surface of the grains with a 0.1μm measurement step.