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Comparing 3D vs 2D approach in vorticity estimates

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Kinematic analysis of flow is becoming a well-established methodology, increasingly applied for its capability to contribute to the solution of complex topics in structural geology and tectonics, such as shear zones deforming by general shear.

Vorticity evaluations based on stable porphyroclasts method have been used for many years to deduce large-scale tectonics of shear zones with different kinematics (Fossen & Cavalcante, 2017). However, limitations occur because a complex three dimensional problem, the motion of rigid clasts in a flowing matrix, is reduced to its two-dimensional analysis on the XZ plane of the finite strain ellipsoid (Iacopini et al., 2011; Mancktelow, 2013). Therefore vorticity estimates are limited by the extrapolation to three dimensions of two-dimensional data.

We propose a totally new 3D approach based on the use of X-ray micro-computed tomography (X-ray micro-CT) that reflects the real 3D geometry and orientation of the porphyroclasts population. X-ray micro-CT allows to face the loss of dimensionality information imaging the rock sample in three dimensions and produces stacks of 2D grey-scale value images, called “slices”, that combined in 3D allow observing the internal structure of the scanned sample.

We tested this approach chiefly on mylonitic orthogneiss from an intensively studied crustal scale shear zone: the Main Central Thrust zone (MCTz) of the Himalaya orogenic belt. Mylonites samples from other regional-scale shear zones in the Alps have been also used for comparison.

The first and foremost consideration is that the use of micro-CT certainly increases the number of investigated clasts because hand samples are scanned: all clasts are evaluated. Micro-CT minimizes the problems due to the isolation factor, as it becomes possible to only select the clasts that do not interact with each other. Moreover, observation in three dimensions allows a more realistic evaluation of the aspect ratios and radii of clasts, avoiding erroneous measurements that generate systematic errors in the vorticity evaluation.

We would like to stress that using the microCT we are able to evaluate all the clasts in the sample, avoiding those which do not meet the prerequisites of the method, otherwise not possible using classical 2D thin section based analysis.

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