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Constraints on three-dimensional vorticity analysis using the porphyroblast system: natural examples and theoretical discussion.

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The kinematic vorticity number Wk has its origin in fluid dynamics and records the amount of rotation relative to the amount of stretching at a point in space and for an instant in time. It has been introduced into geological literature because it represents a basic flow parameter able to describe flow kinematics e.g to distinguish between pure and simple shear within shear zones. For assumptions of steady state deformation, this application in geology has been facilitated by the use of Mohr circle for strain that permits efficient correlation of Wk to the velocity gradient tensor and the deformation matrix (Passchier, 1988). To estimate Wk, several methods (termed vorticity gauges), based on different microstructures have been proposed and are currently in various stages of development. The methods that we will re-analyse are those based on rotational behaviour of rigid object within non coaxial flow (Jeffery, 1922). To determine the amount of vorticity, these methods use the geometry, the aspect ratio(s) of mantled porphyroclasts (Passchier, 1987) and the inclusion trails geometry of porphyroblasts (Gosh, 1987; Holcombe & Little, 2001). The main limits of such methods have been partly investigated (Tikoff & Fossen, 1995;). We groups these limits into two types:

a) The errors associated with the large number of physical assumptions (e.g, steady state, homogeneous flow, no interference between clasts and perfect coupling with the matrix) that are rarely true for natural systems;

b) The errors derived by the fact that these vorticity techniques require measurement of

the geometry of porphyroclasts and porphyroblasts system by using outcrop surfaces or thin section that are inherently two dimensional.

Focusing on the second aspect, we show theoretically and by means of natural example, that in (1) recognition of the vorticity vectors orientation and (2) in measurement of the porphyroclast aspect ratio two main systematic errors has to be encountered especially where the strain intensity recorded by the deformed rocks is not high. We suggest that only non - invasive technique that can adequately describe structures in 3D (such as the X-Ray tomography, Ketcham, 2005) can significantly help to recognize if the investigated rocks match with the above physical assumptions and therefore help to satisfactorily minimize the systematic errors described.

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