Geophysical Research Abstracts, Vol. 8, 02321, 2006
SRef-ID: 1607-7962/gra/EGU06-A-02321

Kinematic modelling of non-isochoric distortion

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Kinematic models generally rely on the assumption of constant volume during progressive deformation. Accordingly, the geometry of structures can be described simply as a function of the imposed flow field and can therefore be expressed by the ratios of pure and simple shear, i.e. the kinematic vorticity number W_k. However, naturally deformed rocks often display features such as stylolites, pressure solution seams, crenulation cleavages or preferential dissolution around rigid clasts, which all account for volume change during deformation. The present study extends existing continuum mechanic models to a quantitative description of deformation with non-isochoric distortion. A new velocity gradient tensor and the corresponding Mohr Circle are introduced. The intent of this contribution is to illustrate the special characteristics of such flow types and to demonstrate their abundance in nature.

Our model is characterised by the boundary conditions: (1) Plane strain flow. (2) The shear zone retains a constant length during deformation. (3) Area loss normal to the shear zone boundary. Kinematic modelling with these boundary conditions reveals the existence of a non-rotating and non-stretching orientation parallel to the shear zone boundary (like in simple shear) for any vorticity number. The other distinctive feature in physical space is the continued existence of a second eigenvector, even under quasi simple shear conditions, which can only be achieved by non-isochoric distortion.

In Mohr space plotting stretching rate on the abscissa (ε) and rotation rate on the ordinate (ω) the special characteristics of the velocity gradient tensor can be shown by a Mohr Circle that touches the origin of the coordinate system. Due to a decrease in area during deformation the centre of the Mohr Circle is always to the left of the ordinate, which is a further characteristic of these flow types. The W_k and the kinematic dilatancy number A_k (Passchier, 1991) are not independent. This model has been quantitatively applied to various natural examples including greenschist facies

shear zones (Tauern Window, Austria) and deformed soft sediments (Hölzel et al., in press) demonstrating that these flow types are probably quite common in nature but often remain undiscovered.

Passchier, C. W. (1991). Journal of Structural Geology 13(1): 101-104.

Hölzel, M., Grasemann, B. and Wagreich, M. (in press) Intern. J. of Earth Sciences.