Estimating volume change in metamorphic rocks using deformed vein sets example of the Del Puerto canyon region, in the Franciscan belt, W USA

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Three independent components of finite rock deformation can be defined: strain, rotation and volume change. Studies in structural geology since the 1960s have helped develop many different methods for estimating finite strain. Since the 1990s new methods have been developed to estimate the rotational component of deformation. However, in most studies the third component of deformation is unknown or only poorly constrained. Developing methods to estimate volume change is needed to investigate the importance of mass transfer and fluid transport within the deeper, metamorphic domains of accretionary complexes. One of the few approaches used to estimate volume change in rocks is the Isocon method (Grant, 1986). The Isocon method is a chemical approach that uses the bulk rock composition to discuss changes in element concentrations of the rock. Knowledge of the original rock composition combined with assumptions about immobile elements can be used to estimate those elements that have been added or removed and hence the volume change. However, the need to know the original composition introduces major uncertainties and in the estimates. These uncertainties are compounded by possibility of major differences in the mobility of different elements in different chemical environments. Another method based on identifying microstructural domains of dissolution and reprecipitation have been proposed but their effectiveness has not been assessed (Ring & Brandon 1999).

The potential for deformed vein sets to be used to determine all three components of finite deformation was recognized in the 1990s (Passchier 1990, Wallis 1992) but has not been developed and applied to regional studies. This method is geometric and uses orientation and deformation style (shortened, extended or shortened and then extended) of deformed veins to define a Mohr diagram for finite deformation and hence derive the three deformation parameters. This method does not require information on the composition of the original rock. By combining the vein-set method with other deformation analyses such as strain analysis can help constrain the deformation parameters more accurately.

Deformation analysis of metagraywacke in the Del Puerto canyon in the Franciscan belt was performed using this method, and finite strain, vorticity and volume change were estimated. Pressure solution of quartz particles in the metagraywacke was observed, and deformed quartz veins were observed in outcrops in this study area. Finite strain was estimated from the shape of quartz particles by the Rf / Φ method, and deformed vein analysis was performed on quartz veins. The results of these analyses indicate volume change of the rock between 8 and 60 %. This contradicts previous estimates based on microstructural studies of about -30% (Ring and Brandon 1999).

References

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