Combined structural analysis and dating of authigenic/synkinematic illite: A step towards unravelling brittle faulting processes in time and space

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Faulting accommodates momentous deformation and its style reflects the complex interplay of often transient processes such as friction, fluid flow and rheological changes within generally dilatant systems. Brittle faults are thus unique archives of the stress state and the physical and chemical conditions at the time of both initial strain localisation and subsequent slip(s) during structural reactivation. Opening those archives, however, may be challenging due to the commonly convoluted (if not even chaotic) nature of brittle fault architectures and fault rocks. This is because, once formed, faults are extremely sensitive to variations in stress field and environmental conditions and are prone to readily slip in a variety of conditions, also in regions affected by only weak, far-field stresses. The detailed, multi-scalar structural analysis of faults and of fault rocks has to be the starting point for any study aiming at reconstructing the complex framework of brittle deformation. However, considering that present-day exposures of faults only represent the end result of the faults' often protracted and heterogeneous histories, the obtained structural and mechanical results have to be integrated over the life span of the studied fault system. Dating of synkinenatic illite/muscovite to constrain the time-integrated evolution of faults is therefore the natural addition to detailed structural studies. By means of selected studies it will be demonstrated how careful structural analysis integrated with illite characterization and K-Ar dating allows the high-resolution reconstruction of brittle deformation histories and, in turn, multiple constraints to be placed on strain localisation, deformation mechanisms, fluid flow and mineral authigenesis within actively deforming brittle fault rocks. Multi grain-size illite dating permits the investigation in time coordinates of the subtle details of initial localisation and subsequent reactivation(s). This innovative approach makes it possible to refine the understanding of fundamental geological processes such as seismogenesis and strain localisation/partitioning.