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Illite authigenesis during faulting and fluid flow - a microstructural study of fault rocks

Thomas Scheiber (1,2), Giulio Viola (3), Roelant van der Lelij (1), and Annina Margreth (1)

(1) NGU - Geological Survey of Norway, Trondheim, Norway, (2) Western Norway University of Applied Sciences, Sogndal, Norway, (3) Department of Biological, Geological and Environmental Sciences, University of Bologna, Italy

Authigenic illite can form synkinematically during slip events along brittle faults. In addition it can also crystallize as a result of fluid flow and associated mineral alteration processes in hydrothermal environments. K-Ar dating of illite-bearing fault rocks has recently become a common tool to constrain the timing of fault activity. However, to fully interpret the derived age spectra in terms of deformation ages, a careful investigation of the fault deformation history and architecture at the outcrop-scale, ideally followed by a detailed mineralogical analysis of the illite-forming processes at the micro-scale, are indispensable. Here we integrate this methodological approach by presenting microstructural observations from the host rock immediately adjacent to dated fault gouges from two sites located in the Rolvsnes granodiorite (Bømlo, western Norway). This granodiorite experienced multiple episodes of brittle faulting and fluid-induced alteration, starting in the Mid Ordovician (Scheiber et al., 2016). Fault gouges are predominantly associated with normal faults accommodating mainly E-W extension. K-Ar dating of illites separated from representative fault gouges constrains deformation and alteration due to fluid ingress from the Permian to the Cretaceous, with a cluster of ages for the finest (<0.1 μm) fraction in the early to middle Jurassic.
At site one, high-resolution thin section structural mapping reveals a complex deformation history characterized by several coexisting types of calcite veins and seven different generations of cataclasite, two of which contain a significant amount of authigenic and undoubtedly deformation-related illite. At site two, fluid ingress along and adjoining the fault core induced pervasive alteration of the host granodiorite. Quartz is crosscut by calcite veinlets whereas plagioclase, K-feldspar and biotite are almost completely replaced by the main alteration products kaolin, quartz and illite. Illite-bearing micro-domains were physically separated by means of microsawing and drilling devices. K-Ar and XRD data from these separates are compared with bulk K-Ar and XRD data from the adjacent fault gouges, which may help to further unravel complex histories archived in multiply activated brittle fault zones.

Scheiber, T., Viola, G., Wilkinson, C.M., Ganerød, M., Skår, Ø., and D. Gasser (2016): Direct 40Ar/39Ar dating of Late-Ordovician and Silurian brittle faulting in the southwestern Norwegian Caledonides. Terra Nova 28, 374–382.