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Direct dating of Mesoproterozoic brittle fault reactivation by K-Ar gouge ages

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Fault reactivation contributes significantly to the weakening of the crust. It is well acknowledged that fault zones may be reactivated during successive deformation episodes, because they represent distinct weaker inhomogeneities within the undeformed country rock. In the reactivated zones, superposition of multiple cataclasis events may generate complex fault products and detailed (micro)structural analysis is required to unravel their structural evolution.

We present new K-Ar ages from well developed clay fault gouges from Olkiluoto island, SW Finland, where the Finnish authorities are building a deep repository for the storage of high-grade nuclear waste. The bedrock of Olkiluoto consists of variably migmatitic high-grade metasupracrustal rocks deformed ductilely during the Paleoproterozoic Svecofennian orogeny c. 1.9-1.8 Ga ago. Detailed structural analysis of the brittle component is ongoing with the goal to develop a consistent model. Multiple reactivations of fracture and fault sets were caused by the many orogenic episodes that affected the region during 1.8 Ga of geological evolution in the brittle deformational realm. Aiming at a better understanding of this evolution we have investigated 5 fault gouge samples with a total of 29 grain-size fractions ranging from 0.1 to 2-6 micron, as well as several whole rock fault gouge splits. All dated sample fractions were characterized by XRD, SEM and TEM prior to conventional K-Ar age dating.

Preliminary results indicate brittle activity in the Mesoproterozoic and repeatedly in the Neoproterozoic and corroborate the structural analysis and paleo-stress tensor computations.

Two samples were taken from a single, c. 15 cm thick cataclastic to ultracataclastic/gougy brittle deformation zone core formed in a heterogeneous diatexitic gneiss. The fault core is characterized by two texturally distinct domains, a gray, coarse gouge fraction within a leucosomatic portion of the gneiss and a black, finer-grained and equigranular gouge. The latter shows minor intruding features in the former, suggesting a younger formation age, whereas it is separated from the undeformed host rock by a sharp, thin planar fracture. The K-Ar ages obtained from the $<2\mu$m fraction of authigenic illite separated from both fault products are 1240 ± 26 and 980 ± 20 Ma, respectively, thus confirming the textural observations. These two gouge samples are characterized by distinct illite clay morphologies, mainly illite flakes. The younger samples show fine grained illite fibres growing on larger illite particles. Further TEM work is currently in progress to investigate distinct clay morphology. Preliminary XRD results indicate a mixture of 2M and 1M illite and chlorite as the main clay mineral phases as well as K-feldspar traces. K-Feldspar content does not significantly influence the ages of the clay fractions indicating partial resetting during brittle deformation. Analysis of the 5 other grain size fractions for each sample confirms the different formation ages and points to a Sveconorwegian faulting history, wherein both the early shortening history and the late orogenic extensional events are documented.