Microstructural Analysis — A Key to the Successful Dating of Faults by K–Ar Illite Geochronology

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The high concentration and physical interconnectivity of fine-grained, mechanically weak minerals in brittle fault rocks accounts for the faults' intrinsic weaknesses in the crust. Therefore, faults rarely express only one single, discrete deformation episode, but are the cumulative result of several superimposed slip events. This protracted history complicates the interpretation of multi grain-size K–Ar illite ages from fault gouges and, if (micro)structural constraints are missing, may lead to incorrect conclusions as to the timing of fault initiation and possible reactivations. Here we present the results of an integrated structural, petrographical and K–Ar geochronological study of a multiply-reactivated, Palaeozoic brittle–ductile fault in northern Norway. Two samples from two structurally distinct sites give two significantly different age ranges (~800–530 Ma and ~440–120 Ma, respectively). Our study shows that the age ranges and the age difference between the two samples reflect the localized reactivation of only selected parts of the fault core during at least two geologically distinct and significant events. We demonstrate that the in-depth understanding of the mechanical and chemical processes that control fault architecture and fault rock composition is key to successfully date faults by K–Ar illite geochronology. This includes also the study of how temperature and deformation mechanisms may vary through time during faulting, and of the intensity of wall–rock disintegration by strain accommodation, fluid–rock interaction and associated mineral authigenesis.