K-Ar dating of Proterozoic fault reactivation at the Olkiluoto site of high-level nuclear waste repository, Finland

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In 2014 the Finnish government granted a construction license to the nuclear waste management company Posiva Oy to build an underground high-level nuclear waste repository at Olkiluoto Island, SW Finland. By 2023 the first nuclear waste canisters will be placed in the bedrock. The bedrock is formed by the crystalline basement of the Fennoscandian Shield and consists of Proterozoic amphibolite-facies gneissic metasedimentary rocks and felsic plutons, intersected by distinct sets of low-angle and subvertical faults. During the process of site investigations, illite-bearing fault gouges were collected from representative faults, characterised and dated by K-Ar to produce a time-constrained conceptual geometrical scheme for the development of brittle structures at the site and in the region and to to assess the timing of both fault nucleation and reactivation. Combined with detailed analysis of kinematic data from the faults, the K-Ar ages enable to constrain the paleostress history of the site from the Mesoproterozoic. K-Ar ages indicate a main faulting episode during the Mesoproterozoic, ca. 1.4-1.2 Ga ago and a significant episode of structural reactivation during the Neoproterozoic ca. 1.0-0.8 Ga ago. When coupled with detailed structural analysis, the K-Ar ages indicate that the Olkiluoto bedrock reached the state of structural maturity already during the Mesoproterozoic, i.e. a state where the crust is essentially saturated with brittle structures of different orientations. Due to this, after the Mesoproterozoic, reactivation of pre-existing brittle strctures became the main mode of deformation at the site and, as a consequence, the probability of formation of new large-scale structures in the future can be considered low.