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Deciphering the brittle evolution of SW Norway through a combined structural, mineralogical and geochronological approach

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SW Norway has experienced a complex brittle history after cessation of the Caledonian orogeny, and the recent discoveries of major hydrocarbon reserves in heavily fractured and weathered basement offshore SW Norway has triggered a renewed interest in understanding this complex tectonic evolution. In this contribution we present results from a multidisciplinary study combining lineament analysis, field work, paleo-stress inversion, mineralogical characterization and radiometric dating in the Bømlo area of SW Norway in order to develop a tectonic model for the brittle evolution of this important region.
The study area mainly consists of the Rolvsnes granodiorite (U-Pb zircon age of ca. 466 Ma), which is devoid of penetrative ductile deformation features. The first identified brittle faults are muscovite-bearing top-to-the-NNW thrusts and E-W striking dextral strike-slip faults decorated with stretched biotite. These are mechanically compatible and are assigned to the same NNW-SSE transpressional regime. Ar-Ar muscovite and biotite dates of ca. 450 Ma (Late Ordovician) indicate fault activity in the course of a Taconian-equivalent orogenic event. During the subsequent Silurian Laurentia-Baltica collision variably oriented, lower-grade chlorite and epidote-coated faults formed in response to a ENE-WSW compressional stress regime.
A large number of mainly N-S striking normal faults consist of variably thick fault gouge cores with illite, quartz, kaolinite, calcite and epidote mineralizations, accommodating mainly E-W extension. K-Ar dating of illites separated from representative fault gouges and zones of altered granodiorite constrain deformation ranging from the Permian to the Late Jurassic, indicating a long history of crustal extension where faults were repeatedly activated. In addition, a set of ca. SW-NE striking faults associated with alteration zones give Cretaceous dates, either representing a young phase of NW-SE extension or reactivation of previously formed faults.
By applying paleo-stress analysis on fault sets grouped according to characteristic mineralizations, orientations and kinematics, and obtained radiometric data, we are able to document a complex brittle evolution from the Mid Ordovician onwards. Brittle faults formed already during the Caledonian orogeny in compressional/transpressional stress fields. Some of these faults were later reactivated in subsequent extensional stress fields, and new faults formed over a protracted time period.