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The Lærdal-Gjende Fault (southwestern Norway): A new, high-resolution, combined structural-geochronological study

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The Lærdal-Gjende Fault is a major fault in southwestern Norway with a strike length of over 180 km. It is a multiply reactivated fault dipping gently to the NW and accommodating predominantly top-to-the-NW extensional brittle faulting. At the sampled site in Lærdal, the fault is made up of a several metre thick cohesive greenish cataclastic damage zone and a c. 1 m thick gouge core, developed at the expense of mylonitic orthogneiss. The brittle component is generally interpreted as the spatial, upward continuation of the Hardangerfjord Shear Zone, one of the large Devonian detachments that reactivated as an extensional fault at shallower structural levels accommodating major top-to-the-NW ductile shearing during the Caledonian orogenic collapse.

The Lærdal-Gjende faulting has been dated so far by paleomagnetic methods between the Permian and Early Cretaceous (Andersen et al., 1999). Fossen et al. (2016) have costrained further faulting at about 140 Ma by K-Ar illite analysis.

Our main aim is to present preliminary data on a work still in progress, dealing with a high-resolution reconstruction of the temporal evolution of this complex, long-lived fault zone, by means of a detailed structural analysis of the fault architecture coupled with K-Ar geochronology of synkinematic illite.

To better constrain the fault's evolution and to further refine the K-Ar dating methodology, we collected, characterised and dated five samples representing different structural domains. Detailed structural analysis allowed to sample a coarse, angular cataclasite (sample LG_GVI_4), an indurated red gouge (LG_GVI_6), a fine grained foliated greenish gouge (LG_GVI_5), a more plastic, clay rich gouge (LG_GVI_7) and, finally, a very continuous and only a few mm thick brown clay smear along the main slip surface (LG_GVI_8). Illite from all samples was separated into five different grain size fractions (10-6, 6-2, 2-0.4, 0.4-0.1, < 0.1 μm), each of which was also analysed by XRD and TEM.

Ages vary between 200 and 57 Ma with a strong correlation with grain size, whereby the coarser fractions yield the older ages and the finer the younger ones. The ages of the coarse grain size fractions are identical within the analytical error, c. 184 Ma, thus documenting a likely and significant faulting episode during the Jurassic rifting phase of the North Sea. The finest fractions, mostly barren of inherited protolithic K-bearing phases and enriched instead in authigenic synkinematic illite, constrain the maximum age of the latest recorded increment of faulting. Data permit to identify up to four different slip episodes at 120, 87, 78, 57 Ma, suggesting that the Lærdal-Gjende Fault accommodated the hyperextension of the Mid-Norwegian margin up to the Late Cretaceous and then reactivated during a Paleocene tectonic event whose meaning is not yet understood.

Our new data provide an extraordinary and unprecedented temporal resolution of the faulting history of this important structure, permitting to constrain extensional faulting onshore southwestern Norway all the way down to the Paleocene.