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Geometric back-analysis of ancient rockslides in Tafjord (Norway)

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In the past, numerous large rockslides occurred in the Norwegian fjords and that caused catastrophic tsunamis in the narrow fjords. 12 post-glacial rockslide deposits are found in the Tafjord fjord in Western Norway. Amongst them are the deposits of the 1934 Langhammaren rockslide, which created a tsunami wave with a run-up of up to 63 m and killed 40 people in nearby villages.

Since 2005 potential rock slope instabilities in the Tafjord area are investigated within the Åknes/Tafjord project. The scope of this study is the detection of past rockslides and to back-analyse these events using a high-resolution digital elevation model (HRDEM) derived from aerial laser scanning, orthophotos, and field mapping. Hillshade maps coupled with field data enabled the characterization of 17 past rockslide scars (including the 1934 event) that were mainly constituted of orthogneisses and augengneisses.

The spatial orientations of major discontinuity sets and the relevant rockslide structures, i.e. the basal sliding surface, the lateral auxiliary sliding surface, the lateral release surface(s), and the back-scar(s), were calculated using Coltop3D software and the HRDEM. This analysis showed the pre-dominant role of the main foliation that dips towards the South with a dip angle of 37° to 63°. The foliation generally formed the basal sliding surface, while the other discontinuity sets controlled the orientation of other main rockslide structures.

In order to compute the volume of ancient rockslides, the pre-rockslide topography was reconstructed by fitting planes on the surroundings of the scars using PolyWorks® software. The orientation of these planes was constrained by the orientation of major discontinuity sets. The rockslide volumes were computed by subtracting the present HRDEM from the pre-rockslide DEM. The volumes range from 29000 m^3 up to 63.5 million m^3 for Langhammaren area. The Langhammaren area led to several rockslides, including the 1934 event with a computed volume of 2.62 million m^3. The volumes of the past rockslides follow power-law distributions.

The failure mechanism of the past rockslide events was determined using the major rockslide structures and the pre-rockslide topography. In 16 out of all 17 rockslide scars, the sliding occurred as wedge failure formed by the intersection of the gneiss foliation and auxiliary sliding surfaces that are generally dipping steeply towards the NW (between W and N). The plunge angle of the wedge intersection lines varies between 25° and 59°. Shallow-plunging intersection lines (<35°) are related to low friction angle and low cohesion fault gouge or mica-rich layers along the basal sliding surface.

This study improves the understanding of the structures and mechanisms of ancient rockslides in the Tafjord area and provides essential data for the characterization of the potential slope instabilities found in the vicinity of past rockslides.