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Analysis and characterization of potential slope instabilities in Tafjord (Norway)

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Large slope instabilities are common in the Norwegian fjords and several historic events testify a high rockslide activity. For the 8 km long Tafjord (Western Norway) the annual probability for rockslides exceeding 1 million m^3 is >1/1000. In April 1934, a 2.6 million m^3 rockslide created a huge tsunami in the narrow Tafjord fjord that destroyed nearby villages and killed 40 people.

A deep-seated gravitational slope deformation (DSGSD) at Hegguraksla and related smaller instabilities are currently investigated and monitored within by Åknes/Tafjord project. This study focuses on the detection and characterization of potential slope instabilities on the north-western flank of Tafjord using a high-resolution digital elevation model (HRDEM) derived from aerial laser scanning, orthophotos, and detailed geomorphic, geological and structural field mapping. The study area is mainly constituted of Proterozoic orthogneisses with well developed foliation surfaces and augengneisses.

19 potential instabilities were mapped in the Tafjord area; 8 of them are located within three DSGSDs. The morphological and structural settings of these instabilities were assessed based on the HRDEM (shaded relief representation and Coltop3D representation) and field investigations, wherever access to the site was possible. This analysis showed great similarities to past rockslides, like the strong control of discontinuities on the major structures delimiting the rockslides. The main foliation dips 37° to 63° towards the South and generally forms the basal sliding surface or is part of a complex failure surface in the DSGSDs.

Based on these findings the basal failure surface of each rockfall was constructed in PolyWorks®. This enabled afterwards the computation of rockslide volumes and potential failure mechanisms. In 75% of all instabilities the failure mechanism is a wedge sliding formed by the intersection of the main foliation with an auxiliary sliding surface that is often steeply dipping with a dip direction varying from W to NW.

The volumes of the localized instabilities range from 11250 m^3 to 2.39 million m^3, while the DSGSD imply much more important rock masses (21.3 to 47.7 million m^3). The volume-frequency distribution, i.e. the frequency of rockslides exceeding a given volume, of these rockslides follows different power-law distributions for the medium-size instabilities (<750000 m^3), the large instabilities and the DSGSD.

Combined to historical data and the inventory of deposits in Tafjord, these power-law distributions provide a volume-based probability estimation for rockslides. The results of this study contribute to the hazard analysis of rock slope instabilities and related tsunamis in the Tafjord region.