



Hazard mapping of rockfalls and rock avalanches in Norway - how to prioritise areas?

Thierry Oppikofer (1), Luzia Fischer (1), Reginald L. Hermanns (1), Graziella Devoli (2), Halvor Bunkholt (1), Andrea Taurisano (2), and Olianne Eikenæs (2)

(1) Geological Survey of Norway, Trondheim, Norway (thierry.oppikofer@ngu.no, 004773921620), (2) Norwegian Water Resources and Energy Directorate, Oslo, Norway

As part of the plan for national landslide hazard mapping in Norway, this study focuses on needs and priorities for hazard mapping of rockfalls and rock avalanches. Although guidelines and methods for hazard mapping still need to be defined, our project aimed to prioritise areas that need detailed investigations and hazard mapping. Due to high differences in probability, but also in consequences, we separated the different types of landslides in rocks in two main groups: (i) rock avalanches involve large volumes (hundred thousands to millions of cubic meters), are characterized by an excessive run-out distance due to a flow-like behaviour of the avalanche and can create tsunamis in case they impact a water body; (ii) rockfalls have generally smaller volumes (few to hundred thousands of cubic meters) and generally come to rest at shorter run-out distances on the talus slope or at the foot of the slope.

The priority list for rock avalanches is based only on the inventory in the national landslide database (available on www.skrednett.no). Using the event description in the database in combination with an aerial photo analysis, rock avalanches were distinguished from large rockfalls and small rockfalls. A weighting was attributed to each event, taking into account the landslide type and the consequences (damages to forest, landscape and buildings, life loss, landslide dam, and tsunami). Only 17 historic events can be classified as rock avalanche. Due to this limited number, we included the historic large rockfalls (429 events, 134 events with casualties) in the priority list. This inclusion is also justified by the difficulty to differentiate unstable rock slopes leading to rock avalanches or large rockfalls before their collapse. Such uncertainties in the dataset also emphasize the need for a more detailed and systematic mapping of historic and pre-historic rock avalanches and large rockfalls at a national scale. However, the Møre og Romsdal and Sogn og Fjordane counties have the highest priority with several historic rock avalanches (9 and 5, respectively), which confirms previous priority lists established by NGU. Only 0 or 1 historic rock avalanche have occurred in the counties of Hordaland, Troms, Rogaland, and Nordland, but many catastrophic large rockfalls make these counties 2nd priority for detailed mapping of unstable rock slopes and rock avalanche deposits.

The priority list for rockfalls was produced in two steps using 1) a GIS analysis showing conflict zones between settlements and the potential run-out areas of the rockfall susceptibility map, and 2) an aerial photo analysis. For the GIS analysis the nationwide rockfall susceptibility map was combined with the population potentially exposed to rockfalls resulting in 1123 conflict zones. During the comprehensive aerial photo analysis of all conflict zones, signs of rockfall activity, such as visible cliffs, scree deposits and historic events were assessed. Further criteria taken into account are hazard-reducing factors, such as dense forest in the run-out area. In this way, each conflict zone gets a weighting for the rockfall activity. Combining this factor with the total population exposed in a given zone leads to a total priority score. 21 sites are classified as 1st priority and 94 sites have 2nd priority, affecting potentially more than 55000 people. Sites with 1st and 2nd priorities are located in the counties of Sogn og Fjordane (9 sites with 1st priority / 26 sites with 2nd priority), Møre og Romsdal (5/24), Hordaland (3/13), Telemark (2/1), Rogaland (1/7), Nordland (1/4), Oppland (0/5), Troms (0/5), Buskerud (0/3), Finnmark (0/3), Vest-Agder (0/2), Aust-Agder (0/1).

These priority lists for rockfalls and rock avalanches will guide the Norwegian authorities in the coming years in their effort to map, assess and mitigate the hazard caused by landslide in rock slopes.