Geophysical Research Abstracts
Vol. 12, EGU2010-13657, 2010
EGU General Assembly 2010

Towards a hazard classification system for large rock slope failures in Norway

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Systematic rock slope analyses carried out in Norway in three different provinces in the past years has revealed more than 200 rock slopes with significant postglacial deformation, which might present localities of large future rock slope failures. This large number makes a prioritization of follow up activities necessary which was based in the past on a qualitative hazard and risk assessment. However, to compare sites so that political and financial decisions can be taken it might be useful to develop both a quantitative hazard and risk classification based on formulas. This contribution focuses on the hazard classification only.
Historical experience and possible future rockslide scenarios in Norway indicate that hazard assessment of large rock slope failures is not only restricted to a magnitude, intensity and probability analyses of the rockslide event. The most critical part are the secondary effects resulting in generation of tsunamis or landslide damming of valleys with the potential of later outburst floods increasing significantly the size of the affected area. In addition, the probability analyses is not restricted to a frequency analyses as multiple rockslides have occurred within one century on a single slope while other slopes have frequencies below the recurrence of several thousand years or even higher than glacial cycles, however both frequency do not indicate necessarily which slope will fail next. Intensity estimation is in general the easiest estimate as complete destruction in the area of impact can be assessed for fast rockslides in general.
The hazard assessment leading towards a hazard classification will therefore include the assessment of a potential for displacement wave and/or landslide dam formation within the magnitude analyses. The most difficult task is the probability analyses and the best approach seems to be a likelihood assessment of the occurrence of a future event for a given time period. This includes the frequency analyses of similar events based on geological mapping combined with absolute or relative dating methods, and a frequency analysis of the slope section itself if possible. In addition, we also include different structural information such as the existence of single or multiple structures which may form a sliding plane and release surfaces. Those are evaluated to estimate if slope deformation has advanced so that sliding without further rock deformation is possible or not. Last we also include velocity measurements of the displacement of the deforming slope. This includes periodic displacement measurements (e.g. dGPS) and analysis of InSAR data. In some cases we also perform dating of sliding planes to understand the long term behavior of the slope, which helps to understand if actual movement compares to long term movements, is accelerating or decelerating. As different structural scenarios require different extent of deformation prior to failure which is related to different velocities we did not applied a formula to calculate the hazard, however the possibility of formulating such a formula will be discussed.