Passive seismic monitoring of a hazardous rock slope.

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A sudden failure of the instable rock slope at Aaknes, Norway has the potential to generate a local tsunami in the fjord system, which in turn endangers close by villages and ship traffic. The site has an estimated volume of 40-70 million cubic meters and a movement rate of 4 cm/year up to 15 cm/year. The site attracted a lot of attention after 2004 when more detailed geodetical and geophysical investigations revealed the extend and volume of the instability. Currently, several continuous monitoring systems are in operation at the site, one amongst them is a seismic system. The purpose of the seismic system is to monitor seismic events related to the mass movements and eventually provide input for an early warning system.

The seismic network, which was installed in October 2005, consists of 8 three-component geophones spread out over an area of about 250 x 150. The data are recorded with a central acquisition unit located in a concrete bunker and immediately forwarded over a radio link and an internet connection for further processing to NORSAR. Within the first year of monitoring (until August 2006) the system recorded continuously with a sampling rate of 8 msec resulting in a data volume of about 1 Gbyte/day. In that time period we observed various types of seismic events ranging from teleseismic and regional earthquakes to local microseismic events associated with small-scale slide, rock falls and, as we think, with the movement itself. After a maintenance visit in August 2006, we switched the acquisition system to an event-triggered monitoring at a higher sampling rate of 1 msec.

Usually, 1-10 local microseismic events with good signal quality occur per week. The number and the rate of occurrence are parameters, which may be indicative for an acceleration of the slope will be forwarded to the early warning system directly. So far we have not been able to localize the microseismic events, because 1) they are so close to the network that we cannot pick P- and S-phase arrivals and 2) the site is very heterogeneous (rough topography, fractured rock, solid rock, boulder fields) with strong variations of the seismic velocities.

To this end we conducted in October 2006 a seismic calibration experiment. We have been using a GPS-triggered shooting equipment which allowed us to move freely in the slope without need of a trigger cable. Our seismic network was running in event-triggered mode and was course also synchronized with a GPS-clock. In total we fired

11 shots (100-150 g dynamite) covering more or less the area of the network, with maximum source-receiver distances of about 300 m. It turned out that the velocities change drastically by a factor of 2-3 within the seismic network, which partly is on solid rock on the stable part of the slope and partly on the instable and moving part of the site. From this active experiment we hope to establish a suitable 3D velocity model which can be used for the localization of the passively recorded microseismic events.