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Using one-dimensional miniature Accelerometers to monitor Rock Slope Deformation in northern and western Norway

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One-dimensional miniature accelerometers were installed on unstable rock slopes in northern and western Norway to study their ability to detect rock-slope deformation. The study site in western Norway, Åknes is located at 62˚10'N, and in northern Norway, the Nordnesfjellet is located at 69˚30'N. Both study sites contain large moving steep rock-slopes situated 600-900 m above the fjords. The unstable sections are delimited by large open cracks. Previous DGPS monitoring of points on the moving blocks has shown annual movement of several cm. To understand the mechanisms controlling the movement, a better timing of the deformation and movement is needed. Other methods recording the actual movement are in place at both sites, providing good possibilities for comparing events recorded by the accelerometers with the movement pattern.

At both sites four 1D miniature accelerometers of the type Tinytag High Sensitivity Shock loggers were installed on horizontal and vertical unstable rock surfaces for potential differentiation between movement directions. At both sites one of the shock loggers were installed on the vertical stable upslope side of the crack. Data were recorded on an hourly basis during a one-year period from autumn 2005 to autumn 2006. Also bedrock temperatures were obtained from 1 cm below the rock surface at the Åknes site, enabling studies of thermal expansion and contraction of the rock. Standard meteorological parameters were recorded by a meteorological station 50-100 m from the shock logger monitoring sites at Åknes.

Deformation events were registered mainly from late spring through the summer and into the autumn/early winter. Limited deformation events were recorded during the winter and early spring period, when the ground temperatures were below 5˚C, but mainly at or below 0˚C. The largest magnitude events were registered during the late autumn and early winter. Snowmelt seems to trigger the start of the late spring period with more frequent events. Several of the registered events, which are probably representing rock-slope deformations, seem to be largely controlled by rock-surface temperature variations, with a tendency for increased deformation during periods with large temperature gradients in the rock surface. If the recorded events reflect movements, this indicates that these can be associated mainly with thermal expansion and contraction of the rock surfaces, particularly associated with the phase change between water and ice. Precipitation and wind speed did not seem to affect the shock loggers in any systematic way. All the largest magnitude events registered by the shock loggers occurred when the wind direction was parallel to the rock-slope.

The shock loggers on the vertical rock surfaces recorded distinct events during a very significant storm in January 2006, with large wind speeds up to 20-27 m/s at the Åknes site. The wind direction was parallel to the mountain slope at both study sites, the snow cover was significant also at both sites, cold air was penetrating the large cracks at both sites, and events were only recorded on the vertical monitoring sites. Thus it is possible that the unstable blocks can be deformed horizontally during severe storms with cold air being blown into the large cracks.

The low-cost miniature accelerometers seem to provide a useful technology for studying deformation of selected points on potential unstable rock-slopes. The data need, however, to be further analysed in combination with the other types of monitoring data, to distinguish between real movement of the large unstable rock-slope and other processes related to minor rock falls and human activity.