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Detecting Slow Deformation Signals Preceding Dynamic Failure: A New Strategy For The Mitigation Of Natural Hazards (SAFER)

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Rock slope monitoring is a major aim in territorial risk assessment and mitigation. The high velocity that usually characterizes the failure phase of rock instabilities makes the traditional instruments based on slope deformation measurements not applicable for early warning systems. The use of "site specific" microseismic monitoring systems, with particular reference to potential destabilizing factors, such as rainfalls and temperature changes, can allow to detect pre-failure signals in unstable sectors within the rock mass and to predict the possible acceleration to the failure. We deployed a microseismic monitoring system in October 2013 developed by the University of Turin/Compagnia San Paolo and consisting of a network of 4 triaxial 4.5 Hz seismometers connected to a 12 channel data logger on an unstable patch of the Madonna del Sasso, Italian Western Alps. The initial characterization based on geomechanical and geophysical tests allowed to understand the instability mechanism and to design a 'large aperture' configuration which encompasses the entire unstable rock and can monitor subtle changes of the mechanical properties of the medium. Stability analysis showed that the stability of the slope is due to rock bridges.

A continuous recording at 250 Hz sampling frequency (switched in March 2014 to 1 kHz for improving the first arrival time picking and obtain wider frequency content information) and a trigger recording based on a STA/LTA (Short Time Average over Long Time Average) detection algorithm have been used. More than 2000 events with different waveforms, duration and frequency content have been recorded between November 2013 and March 2014. By inspecting the acquired events we identified the key parameters for a reliable distinction among the nature of each signal, i.e. the signal shape in terms of amplitude, duration, kurtosis and the frequency content in terms of range of maximum frequency content, frequency distribution in spectrograms.

Four main classes of recorded signals can be recognised: microseismic events, regional earthquakes, electrical noises and calibration signals, and unclassified events (probably grouping rockfalls, quarry blasts, other anthropic and natural sources of seismic noise).

Since the seismic velocity inside the rock mass is highly heterogeneous, as it resulted from the geophysical investigations and the signals are often noisy an accurate location is not possible. To overcome this limitation a three-dimensional P-wave velocity model linking the DSM (Digital Surface Model) of the cliff obtained from a laser-scanner survey to the results of the cross-hole seismic tomography, the geological observations and the geomechanical measures of the most pervasive fracture planes has been built.

As a next step we will proceed to the localization of event sources, to the improvement and automation of data analysis procedures and to search for correlations between event rates and meteorological data, for a better understanding of the processes driving the rock mass instability.