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Seismic monitoring of rockfalls at Spitz quarry (NÖ, Austria)

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In the recent past, significant rockfalls, which pose a danger to persons, railways and roads, occurred in the quarry of Spitz (NÖ-Austria). An existing seismic warning system did not fulfill the expected efficiency and reliability standards since the ratio of well-detected events to undetected events or false alarms was not satisfactory. Our aim was to analyze how a seismic warning system must be designed in order to overcome these deficiencies. A small-scale seismic network was deployed in the Spitz quarry to evaluate the possibility of improving the early-warning rockfall monitoring network by means of seismic observations.

A new methodology based on seismic methods, which enables the detection and location of rockfalls above a critical size, was developed. In order to perform this task, a small-scale (200x200 [U+3016] m [U+3017]2) passive seismic network comprised of 7 monitoring seismic stations acquiring data in continuous mode was established in the quarry of Spitz so that it covered the rockfall hazard area. On the 2nd of October 2015, an induced rockfall experiment was performed. It began at 09:00 a.m (local time, 07:00 UTC) and lasted about 1.5 hours. The entire data set was analyzed using the pSysmon software. In order to locate the impact point of the rock falls, we used a procedure based on the back-projection of the maximum resultant amplitude recorded at each station of the network within a time window to every grid-point covering the whole area of interest.

In order to verify the performance of the employed algorithm for detection and localization, we performed man-induced rock falls. We also used a terrestrial laser scanner and a camera, not only to draw the rockfall block trajectories, but also to determine the volume of rock lost or gained in the different areas of the quarry. This allowed us to relate the lost mass with the strength of the collision (Pseudo-magnitude) of the rockfall, and draw and rebuild their associated trajectory.

The location test performed using induced rockfalls indicates that with the deployed network and the developed location method, it is possible to provide a reliable estimate of the impact point of the falling blocks, as well as the strength of the collision. This allows us to define a robust alarm system, having efficiently defined a threshold value. This threshold value is around 0.1 tons, which is associated with a specific value of the pseudo-magnitude according to the results of our field test.