HYDRO-MECHANICAL FORCING AND PROGRESSIVE FAILURE OF THE 2012 PREONZO ROCKSLIDE

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In this presentation we describe the background investigations taken to design, implement and operate an early warning system, which was used successfully to prevent casualties from a catastrophic 210,000 m^3 rock slope failure, which occurred near the village of Preonzo in the Swiss Alps on May 15th, 2012 (Figure 1). We first describe the investigations carried out to explore the physical processes driving the accelerated creep stage, which was a necessary step to reliably derive intervention criteria and operate the early warning system. In the second part we discuss the uncertainties related to failure time prediction based on current process understanding and limitations of currently available early warning strategies.

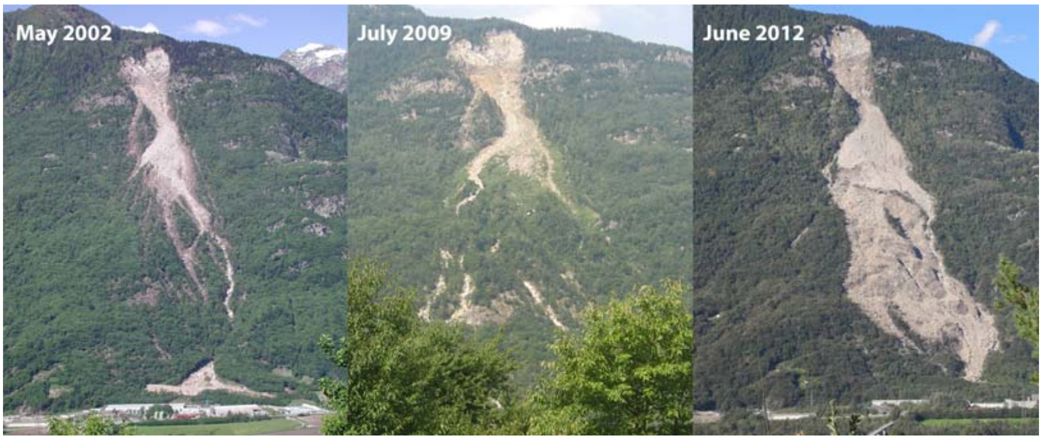

Figure 1. Evolution of the retrogressive rock slope instability of Alpe die Roscioro above the industrial facility of Sgrussa (Preonzo). From Loew et al. 2017

The failure of May 15th, 2012 occurred from a large and retrogressive instability in gneisses and amphibolites with a total volume of about 350,000 m^3, which formed an alpine meadow 1250 m above the valley floor. About 140’000 m^3 of unstable rock mass remained in place and might collapse partially or completely in the future. The instability showed clearly visible signs of movements along a tension crack since 1989 and accelerated creep with significant hydro-mechanical forcing since about 2006 (Figure 2). Because the active rockslide at Preonzo threatened a large industrial facility and important transport routes located directly at the toe of the slope, an early warning system was installed in 2010. The thresholds for pre-alarm, general public alarm and evacuation were derived from crack meter, total station monitoring and meteorological data covering a period of about 10 years, supplemented with information from past failure events with similar predisposition. These thresholds were successfully applied to evacuate the industrial facility and to close important roads a few days before the catastrophic slope failure of May 15th, 2012. A key element of the decisions taken by the authorities has been relationships between external forcing factors (like rain) and observed slope reactions. The final slope acceleration during the last days leading to catastrophic failure occurred without an external trigger, i.e. can be related to unstable crack growth through rock bridges occurring at the basal rupture plane. This behavior was not predicted by existing acceleration and time-to-failure models.

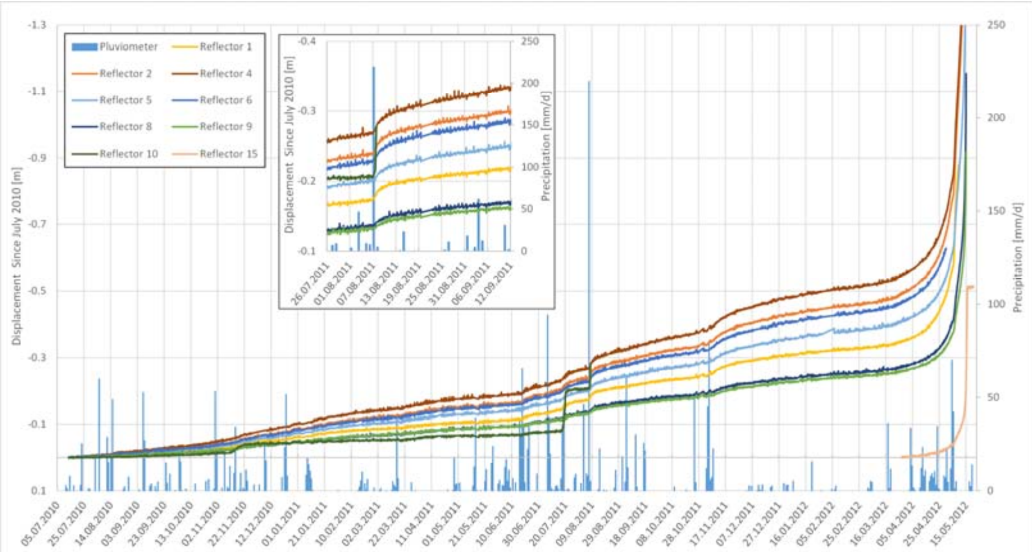

Figure 2. Reflector displacements measured along line-of-site with robotic total station and local daily precipitation. From Loew et al. 2017

The rock slope failure occurred in two events, exposing a compound rupture plane dipping 42° and generating deposits in the mid-slope portion with a travel angle of 39°. Three hours after the second rockslide, the fresh deposits became reactivated in a devastating debris avalanche that reached the foot of the slope but did not destroy any infrastructure. The final run-out distance of this combined rock collapse – debris avalanche corresponded to the predictions made in the year 2004. Fracture sets exposed in the new failure surface significantly differ from the surrounding outcrops in stable ground and can be explained as 1) newly formed Riedel shears crosscutting rock-bridges within the basal shear plane, and 2) curved tensile fractures forming between pre-existing tectonic fracture sets in the head scarp area.

Keywords: early warning, progressive failure, rockslide, Preonzo, monitoring, hydro-mechanical forcing.

References

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