Kinematics of the 1991 Randa rockslides (Valais, Switzerland)

M. Sartori[1,2], F. Baillifard[1,3], M. Jaboyedoff[1,4], and J.-D. Rouiller[1]

(1) CREALP - Research Center on Alpine Environment, Industrie 45, 1951 Sion, Switzerland. (2) Department of Geology and Paleontology, University of Geneva, Maraîchers 13, 1211 Genève 4, Switzerland. (3) Institute of Geology and Paleontology, University of Lausanne, BFSH2, 1015 Lausanne, Switzerland, (4) Quanterra, Chemin Tour-Grise 28, 1007 Lausanne, Switzerland.

Abstract. About 22 mio m^3 of rock fell from a cliff near the village of Randa (10 km north of Zermatt, Switzerland) on April 18, 1991. A second retrogressive rockslide of about 7 mio m^3 followed on May 9, 1991. At present, a rock mass situated above the scarp is still slowly moving toward the valley, involving several mio m^3 of rock.

A kinematic approach to study of this well-documented rockslide was made "a posteriori" in order to identify the parameters relevant to the detection of such failures involving large volumes of rock. A 3D model of the pre-rockslide geometry is presented, and is used to interpret the geostructural, hydrogeological, and chronological data.

The steepness of the cliff, the massive lithology (mainly orthogneiss), the location on a topographic ridge outcropping at the confluence between a glacial cirque and the main valley, and the existence of previous events of instability were the pre-existing field conditions that affected the stability of the area. The structural cause of instability was a 30° dipping, more than 500-m-long, persistent fault, which cut the base of the rock face. Together with a steeply dipping set of persistent joints, this basal discontinuity delimited a 20-mio-m^3 rock block, with a potential sliding direction approximately parallel to the axis of the valley. To the North, the fractures delimiting the unstable mass were less persistent and separated by rock bridges; this rock volume acted as key block.

This topographic and structural configuration was freed from glacier support about 15,000 years BP. The various mechanisms of degradation that led to the final loss of equilibrium required various amounts of time. During the late- and post-glacial periods, seismic activity and weathering of the orthogneiss along the fissure network due to infiltration of meteoric water, joined to reduce the mechanical resistance of the sliding surfaces and the rocks bridges. In addition, crystallisation of clay minerals due to mineralogical alteration of the fault gouge accumulated along the sliding surface, reducing its angle of internal friction, and sealing the surface against water circulation. Once this basal fracture began to act as an aquiclude, the seasonal increase of the hydraulic head in the fissures promoted hydraulic fracturing on the highly stressed edges of the key block. Acceleration of this mechanical degradation occurred during the 20-year period before the 1991 rockslides, giving rise to an increasing rockfall activity, that constituted a forewarning sign. The final triggering event corresponded to a snow-melt period with high water table, leading to fracturation around the key block.

On April 18, 1991, the key block finally failed, allowing subsidiary orthogneiss blocks to slide. They fell in turn over a period of several hours. The May 9, 1991, rockslide was the first of a series of expected future retrogressive re-equilibrium stages of the very fractured and decompressed paragneisses, which lie on the orthogneiss base cut by the April 18th event.