Large landslide combined with mud/soil flows on weathered gypsum substratum.

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The study area is located in the “La Glaive” forest above Ollon, SW Switzerland. Retreat of the alpine glaciers and weather of gypsum substratum are probably the main causes of a large-scale landslide (600 x 400 meters, mean slope 45°). Several mud flows originated within the landslide area. The last event happened in 1998 and stopped just above a road, 340 meters away from the starting zone. About 2500 m^3 were suddenly mobilized. The mud flow causes lie in the soil nature and the several forest fires between 1960 and 1997, which burnt the vegetation.

Detailed maps of geomorphology and landslide activity reveal a typical scar with outcropping gypsum and an accumulation zone probably continuing below the Rhone plain. The sliding surface might be situated at the anhydrite-gypsum transition. Field observations indicate that several sliding surfaces might exist, which needs confirmation by seismic reflexion measurements.

To define rapidly the failure surface of the large landslide, the sloping local base level method (SLBL) was used. It is a quick way to identify and to assess large landslide before detailed field observations (Jaboyedoff and Tacher 2006). The model was fitted on the scar area and on borehole information. Two interpretations were reasonable: a deep landslide (figure 1) and a more superficial landslide. These results will be confronted with seismic measurements.

A classical approach was made to study which type of material is implied in the mud flow: grain size determination, bulk densities, Atterberg limits, mineralogical measurements…

As shown in figure 2, The 1998 mud flow started in a redzine type soil developed on gypsum composed of four horizons: 2 cm organic part h1, 10 to 35 cm organic-mineral part h2 composed of sandy gravel with clay (G-GC, USCS), a transitional horizon h3 of a gravely sand with no clay (SP, USCS) and altered gypsum h4 of sand (SP, USCS). All horizons present a powdery texture.
After Atterberg limits measurement on each horizon (except H1), a diminution of Wl, Wp and Ip is observed with the depth and H2 is dissociated from H3 and H4 by an higher Ip. The observations are certainly due to the slight higher content of clay and organical material. XR measurements reveal that clay content is very minor: H2 has about 5% of clay essentially represented by illite, a non-swelling type. This experience shows that only a slight amount of clay can drastically change the mechanical properties of the soil.

Root densities and shear resistance unconsolidated undrained values (Cuu) are particularly high in H1 and H2 (Cuu = 22 kPa) but relatively low in H3 and H4 (Cuu = 13 kPa). Thus the mud flow’s sliding surface is situated in the upper part of H4.

Shear resistance is generally lower where the vegetation is less dense and/or soil creeping occurs. In these places mud flow hazard is increased.

The conditions that favoured the development of the mud flows were abundant rainfalls, cohesionless soil material and disappearance of the vegetable cover. Because this flow was composed of extremely fine materials, it was very mobile and went downslope quickly (Dikau and Schrott 1996). It tended to follow a shallow depression and eroded the borders. Progressively the material was deposed and the mudflow spread out into a very flat fan.

During rainfall, it was possible that H3 and H4 reach the liquidity state before H2. This phenomena combined with a water level elevation could reduce the effective stress and caused the rupture.

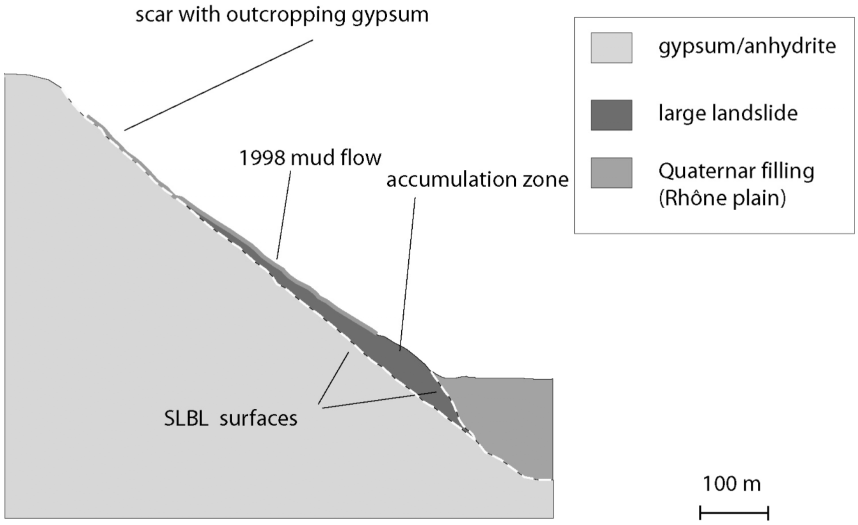

Figure 1: Representation of the failure surface using the SLBL method

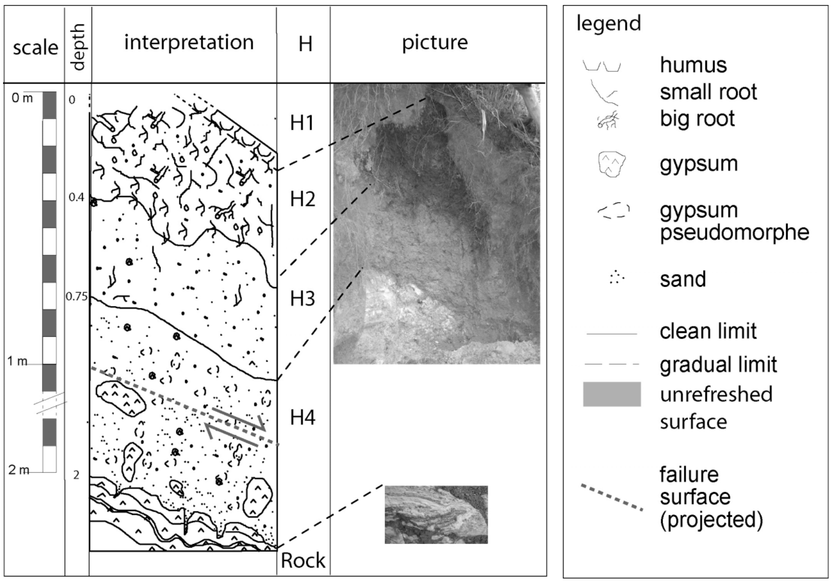

Figure 2: Soil section near the mud flow starting zone

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