The Tessina Landslide

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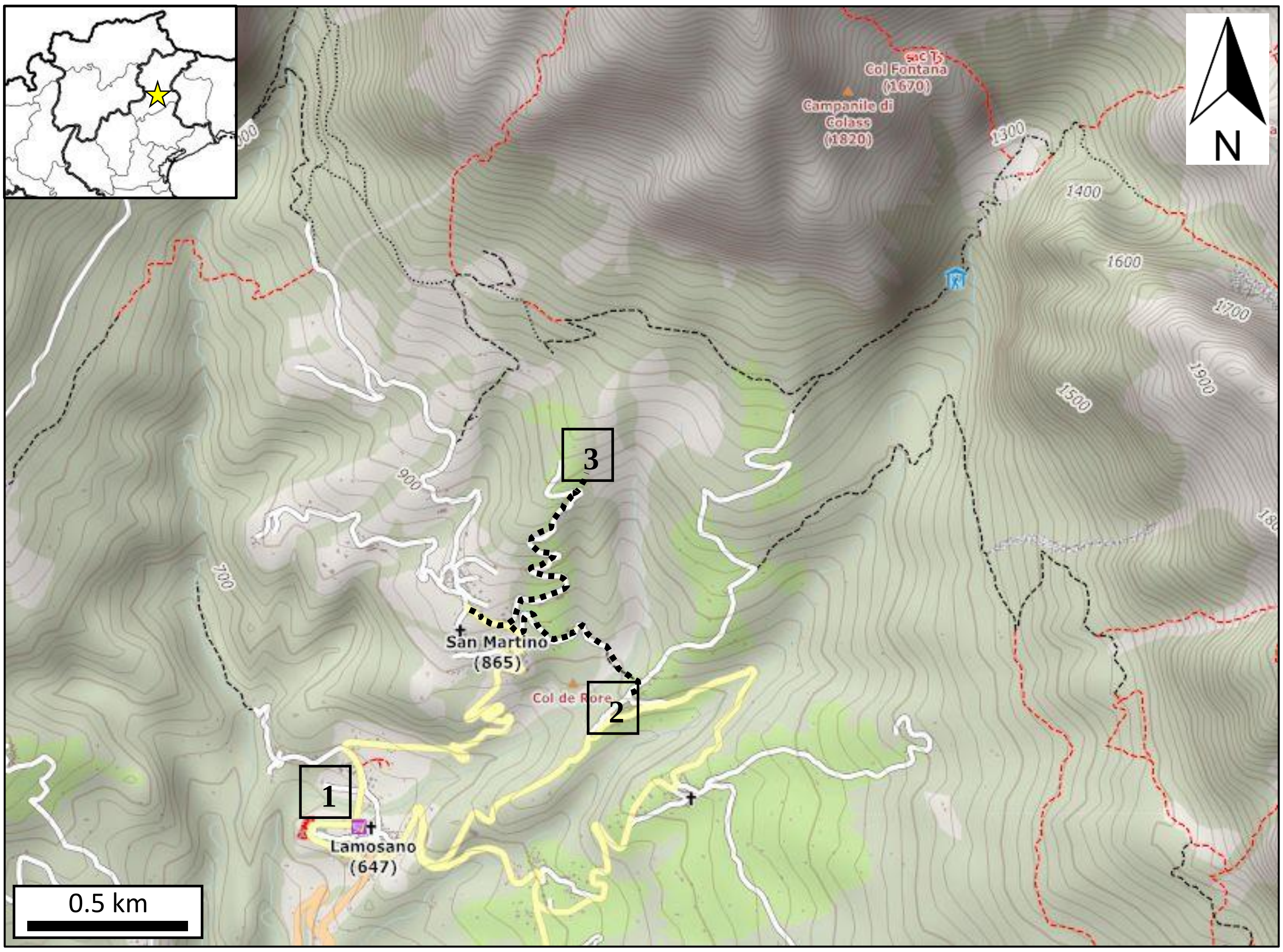

Fig. 1: Topographic map of the excursion area. Numbers correspond to the stops; dashed line indicates a path that will be travelled by foot.

The Tessina landslide is located in the Alpago basin, a large circular area (80 km^2 ca.) characterized by several gravitational movements. The main predisposing factor of these movements is given by the presence of flysch, a stratified sedimentary formation (middle Holocene) that is 1000-1200 m thick and is composed of sandstone, low-permeability marl, and clays.

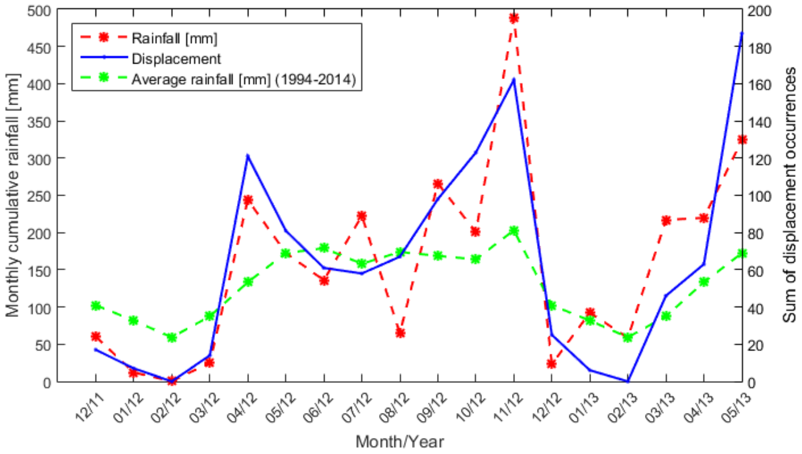

Fig. 2: Monthly cumulative rainfalls and displacement occurrences captured from automatic photographical monitoring.

The second predisposing and triggering factor is related to the pluviometry of the area: according to the recent data based on 20 years of hourly measurements (1994-2014; San Martino weather station) here we have a mean annual precipitation of 1683.3 mm and an average of 121 rainy days a year and a slight bimodal seasonality with peaks in November (203.1 mm) and Spring. This is one of the most wet area of the Veneto region together with Cansiglio (20 km far), Cismon and Recoaro areas.

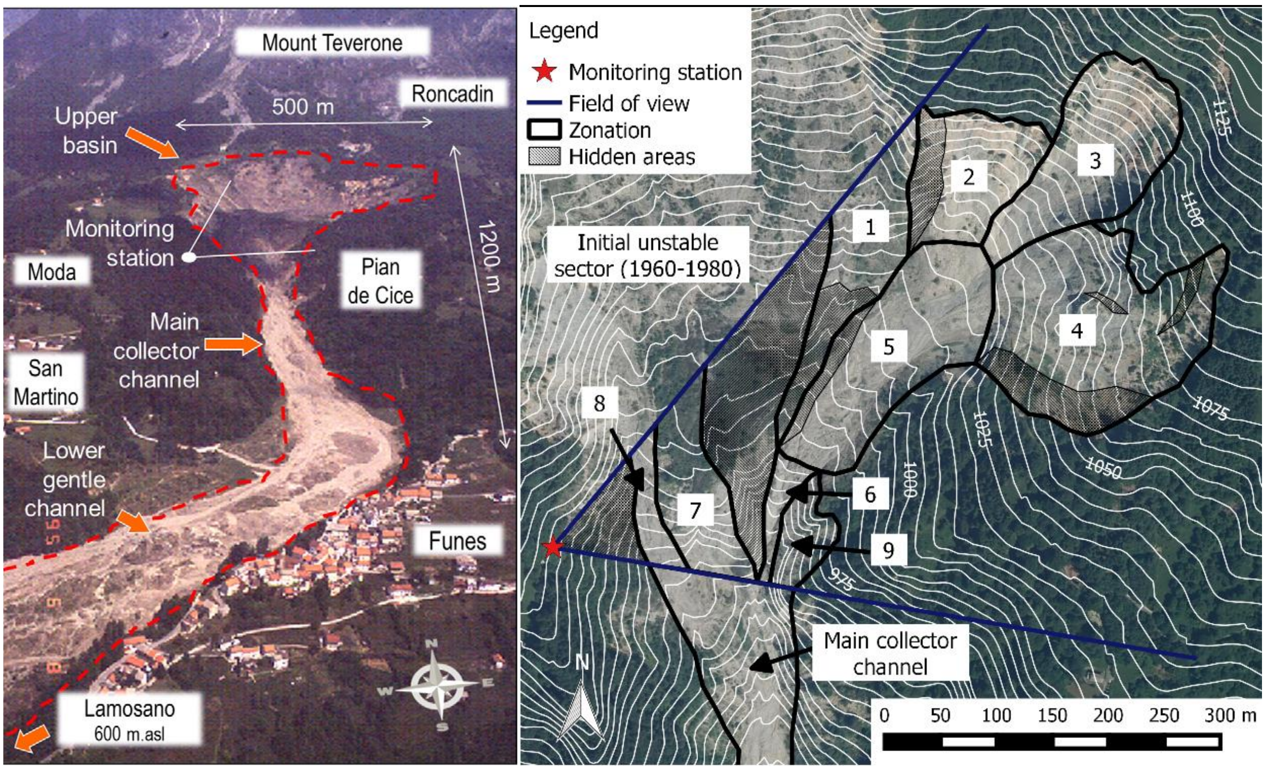

Fig. 3. Bird's-eye view of the landslide in 1995 and details of the crown area, object of photographical monitoring.

Geology

In the Tessina basin, the Flysch formation is faulted and folded, partially eroded, and bounded to the north by a highly fragmented limestone mass (Calcare del Fadalto; Jurassic-Cretaceous) of Mt. Teverone. Thin (1-2 m) outcrops of marly and marly-limestone Scaglia Rossa (Cretaceous-Paleocene) are visible at the bottom slope of the mountain, where they are irregularly interposed between the steep cliffs of Mt. Teverone and the highest scarps of the landslide. Its rose-coloured appearance is distinguishable along the upper border of several scarps and marks the beginning of the unweathered flysch in the upper part of the source area. Moraine deposits cover the flysch to the NW (Moda) and NE (Roncadin and Pian de Cice) of the landslide, while other surficial Quaternary deposits were mobilized by the landslide in the past and mixed with the shallow, loosened flysch.

History

The Tessina landslide has been evolving continuously since it formed prior to 1960, and it is now one of the most active landslides in the Eastern Alps. Like many other mudflows, the body of the landslide can be divided into three different geomorphological zones (Fig. 1): an upper source area that is characterized by intense surficial erosion and rotational slides, a collector channel where the fractured material is progressively remoulded and imbibed with water, and a lower accumulation channel where the mud flows and extends up to the villages of Funes and Lamosano. The landslide formed between the elevations of 1220 and 625 m asl and has a total length of almost 3 km and a maximum width of ~500 m.

Analysing multitemporal aerial photographs and digital elevation models an old landslide was present before the triggering of the current slide in 1960 (Van Westen and Lulie Getahun, 2003). After a period of heavy rainfall, a large rotational slide was activated on 30 October 1960 with a slip surface 20-30 m deep. The slide involved ~1 million m^3 of weathered flysch and Quaternary deposits, which were fluidified and reached the villages of Funes and Lamosano downstream. Over the following 3 years, other mass movement processes occurred after recurrent rainy periods and caused the filling of the Tessina valley with layers of material ranging from 30 to 50 m thick. As a result, the village of Funes, which was on a steep ridge high above the riverbed, was now quite close to the landslide deposit and some infrastructure was damaged (Angeli et al., 1994; Pasuto and Silvano, 1995). Interestingly, after a long rainy period in 1966, the province of Belluno was affected by disastrous flooding, but the landslide was not reactivated. The activity of the landslide progressively decreased until 1987, when several movements were reported in the channelized portion of the mudflow. Other important landslide reactivations occurred in 1992 and 1995, when, after periods of heavy rainfall and snowmelt, a collapse of ~2.5 million m^3 increased the level of the lower accumulation area near

Funes by ~13 m and reached the downstream village of Lamosano. These events followed the expansion of the source area to the northeast, where moraine and scree deposits were also involved (Pasuto et al., 1993).

According to previous studies (Dall'Olio, 1987), the activity of the oldest section of the head of the landslide, which is the northwestern part, decreased from 1960 to 1980 but never stopped. Conversely, the central scarps and northeastern crown discharge new materials with a greater frequency. All of the upper scarps as well as the depletion zone of the landslide are currently active with a complex intermittent behaviour; the movements of the source areas appear to be more prone to being triggered by rainfall, while the downstream parts generally have delayed movements that are linked to increases of the groundwater level (Mantovani et al., 2000). These studies described variations of these results, which were ascribed to the overload caused by the flow from the scarps. This conclusion was also supported by the possible presence of a gentle retaining structure in the submerged Flysch formation below the depletion basin, which separates the upper main accumulation area from the collector channel (Dall'Olio et al., 1987).

<u>Stop 1: Funes village.</u>

Walking from San Martino to Funes it is possible to cross the landslide along a temporary road that is damaged whenever a landslide event occurs. Form here it is possible to touch the landslide material and to observe the upper channel with Mt. Teverone in the background.

<u>Stop 2: Monitoring station.</u>

Hiking on the west side of the valley, along via Moda, we can reach the monitoring station. From here we can observe the north-eastern crown of the landslide body.

Fig. 4. The monitoring station at Moda when it was equipped with a stereo-photogrammetric setup (Antonello et al, 2013).

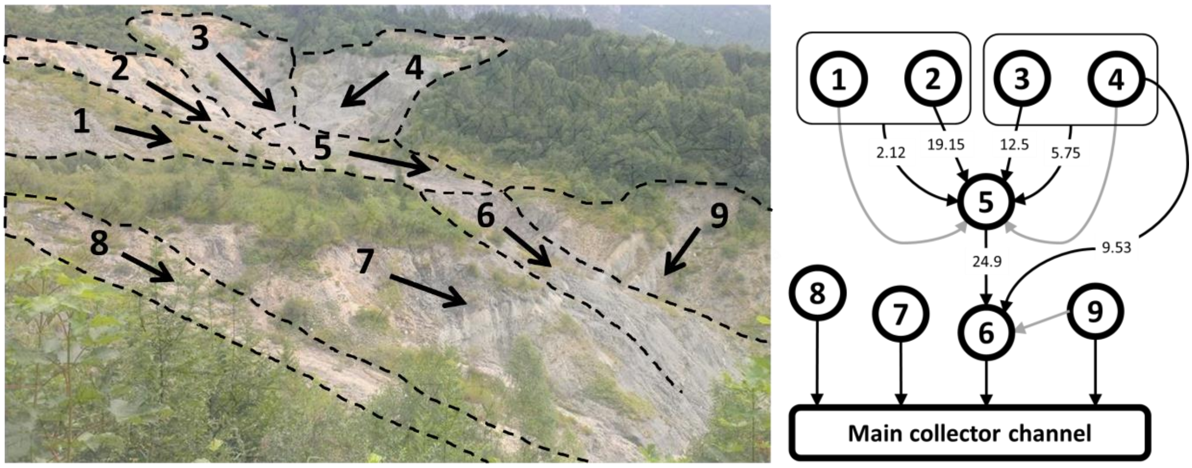

Fig. 5: (a) Photo taken from the monitoring station with zonation of the landslide areas. (b) displacement-induced probabilistic graph.

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