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THE FEBRUARY 1ST, 2014 PANICAGLIA LANDSLIDE AT BORGO SAN LORENZO (MUGELLO)

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ABSTRACT: On February 1st, 2014 a massive landslide occurred in the area of Panicaglia, Borgo San Lorenzo (Mugello, Tuscany), involving roads and related subservices, residential and other private buildings that collapsed or were seriously damaged and evacuated. The phenomenon affected the western edge of the fluvial terrace surface and the underlying slope, cut in lacustrine, fluvio-lacustrine and alluvial deposits, on the hydrographical left side of Le Cale Creek (left tributary of the Sieve River). Geometric, lithostratigraphic, geotechnical and geophysical features of the landslide were analyzed through a survey campaign carried out for the Municipality of Borgo San Lorenzo.

KEYWORDS: Landslides, fluvial terrace, fluvio-lacustrine deposits, Plio-Quaternary Mugello basin, northern Apennines, flat dilatometer test DMT

1. INTRODUCTION

On February 1st, 2014 a landslide affected the entire western side of the village of Panicaglia (Borgo San Lorenzo, Florence). The landslide involved roads and related subservices, residential and other private buildings that collapsed or were serioulsly damaged and evacuated. The landslide occurred after an important meteoric event that led to conditions of substantial soil saturation. Here we report the main results of the geological investigations carried out for the Municipality of Borgo San Lorenzo, that aimed at the reconstruction of the landslide geometry and at establishing geotechnical soil properties for remedial measures planning and designing.

2. GEOLOGICAL SETTING

The investigated area lies in the central part of the Plio-Quaternary, fluvio-lacustrine Mugello Basin (Martini & Sagri, 1994), on the western edge of the surface of a fluvial terrace ("terrazzo rissiano" Sanesi, 1965), cut by Le Cale Creek and two left tributaries of the same stream, between about 285 m a.s.l. and about 235 m a.s.l. On the terrace surface, alluvial deposits mainly gravel with sandy-silty matrix, ca. 12 m thick, crop out. Alluvial deposits are attributable to Sieve River Synthem, Scarperia Subsynthem, latest Early Pleistocene (?)-Middle Pleistocene (after Abbazzi et al., 1995; Bortolotti et al., 2010). The depositional environment of these sediments is of the braided-river type. These deposits overlie, by unconformable erosional contact, fluvio-lacustrine deposits of the Mugello Basin Synthem, Pulicciano Subsynthem, Lower Pleistocene. Fluvio-lacustrine deposits (see Benvenuti, 1997; Benvenuti, 2003) mainly consist of gravels with silty-sandy matrix in the upper layers, here up to 9 m thick, that pass down to silty-clayey textures, with sandy-silty intercalations, overconsolidated and fissured. Fluvio-lacustrine sediments relate to fan, fan-delta, delta front and lake depositions (Benvenuti, 2003). The thickness of fluvio-lacustrine deposits was estimated here to be about 400 m (Gemina, 1962). Halfway up the slope there is another terrace consisting of alluvial deposits, gravels with sandy-silty matrix, silty sands and clayey silts, ca. 8 m thick, referable to Sieve River Synthem, Luco di Mugello Subsynthem, Middle-Upper Pleistocene ("terrazzo wurmiano" Sanesi, 1965). On the valley floor, near Le Cale Creek, there is a further terrace consisting of mainly gravelly alluvial deposits, ca. 5 m thick, referable to the Sieve River Synthem, Sagginale Subsynthem, Upper Pleistocene(?)-Holocene ("terrazzo olocenico" Sanesi, 1965). On the scarp and the underlying slope, eluvial-colluvial deposits and anthropic deposits up to about 10 m thick occur.

3. MATERIALS AND METHODS

The survey campaign consisted in the execution of:
i) a conventional topographic survey, with a detailed field mapping of the landslide geomorphological features,
ii) cores for a total length of 200 m,
iii) 32 standard penetration tests (SPT),
iv) 3 flat dilatometer tests (DMT), v) 4 electrical cone penetrometer tests (ECPT),
vi), geotechnical laboratory tests on 20 collected soil samples,
vii) 6 refraction seismic prospecting for a total length of 728.5 m,
viii) 1 down hole (50 m), ix) 1 ambient noise Horizontal-to-Vertical Spectral Ratio (HVSR) measurement.

A total of 6 inclinometer casings and 8 open piezo-

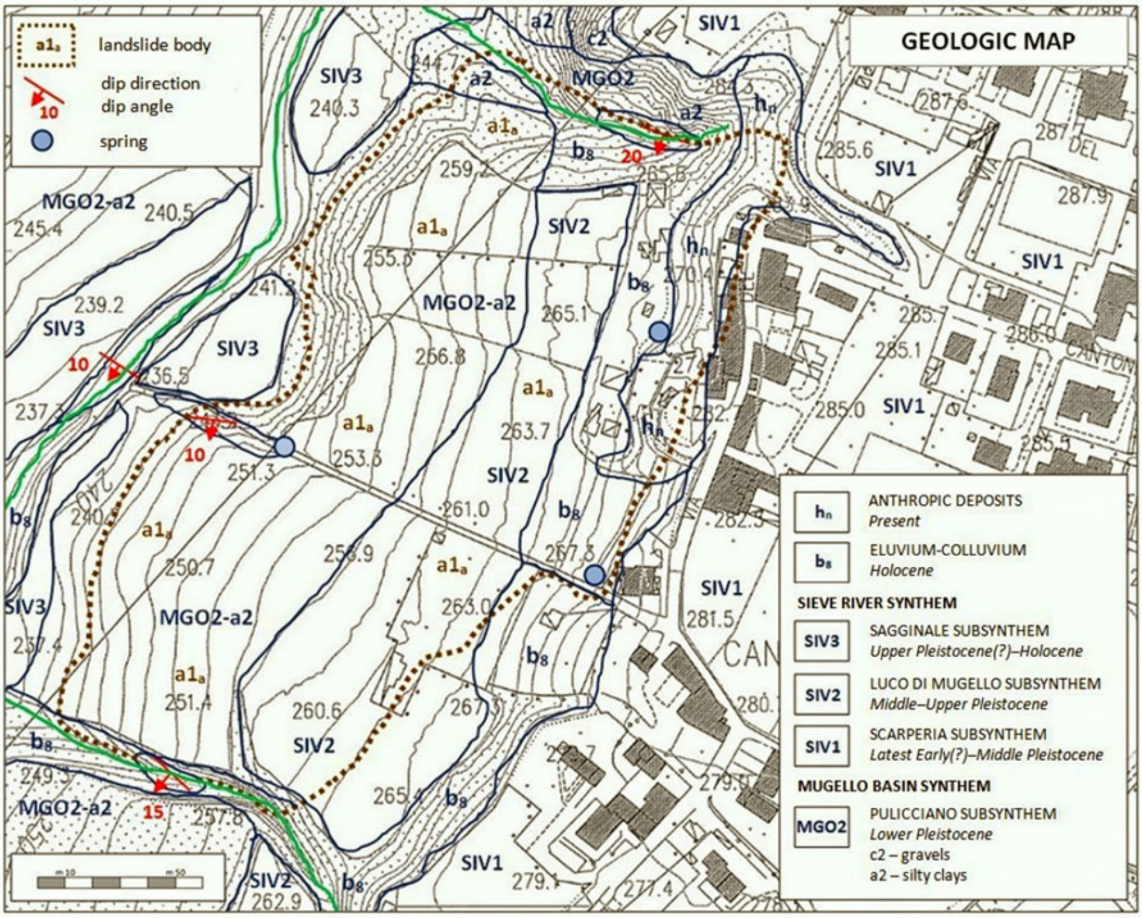

Fig. 1 - Panicaglia Landslide Geologic Map.

meters have been installed and monitoring during the last four years.

4. RESULTS

4.1 Morphology of the Panicaglia Landslide

The landslide crown (according to Varnes, 1978) develops over a total length of about 320 m and involves the morphologic scarp that delimits the upper terrace surface, from the top, towards the north, down to its base, and then affects the underlying slope. The landslide body extends downhill involving the morphologic scarp that constitutes the upper boundary of the alluvial floodplain of the Le Cale Creek. The length of the landslide body, from the crown to the toe, is about 150 m. The zone involved in the landslide covers an area of about 42.000 m², with an approximate volume of 250.000 m^3. The main scarp has a break at a distance of about 180 m from the crown. About 30 m further downhill, there is another scarp that continues up to the ditch that delimits the landslide area to the south. The height of the main scarp, which has progressively increased in the development of the phenomenon, has reached a maximum of about 3.5 m in the north portion of failure, where the primary plastic deformations of the head and of the landslide body occur. Proceeding southwards, the height of the main scarp lowers to about 1 m. Another characteristic element of the landslide is a fracture antithetical to the crown, which develops parallel to it, at a distance of about 15÷20 m. The landslide foot is not clearly identifiable. The landslide toe, consisting of a swelling to a maximum height of about 1 m, only delineated in the initial phases of the phenomenon, affects the slope that delimits upstream the floodplain of the Le Cale Creek. The landslide is of a complex type, ascribable to rotational slide (in the upper part, with subvertical breaking surface) and to translational slide (in the lower part, with a subparallel sliding surface to the slope). Some surficial features, like ondulations, counterslopes and steps, can be referred to previous gravitational activity, index of an active slope dynamics. These quiescent features were reactivated during the 2014 event. The memory of landslides that have affected buildings and pre-existing artefacts in the previous decades points to conditions of generalized instability of the morphological scarp and the underlying areas.

4.2 Depth of the sliding surface

The sliding surfaces stand at about 16÷18 m from the ground surface in the upper part of the slope, close to the morphological scarp, at about 10÷12 m in the

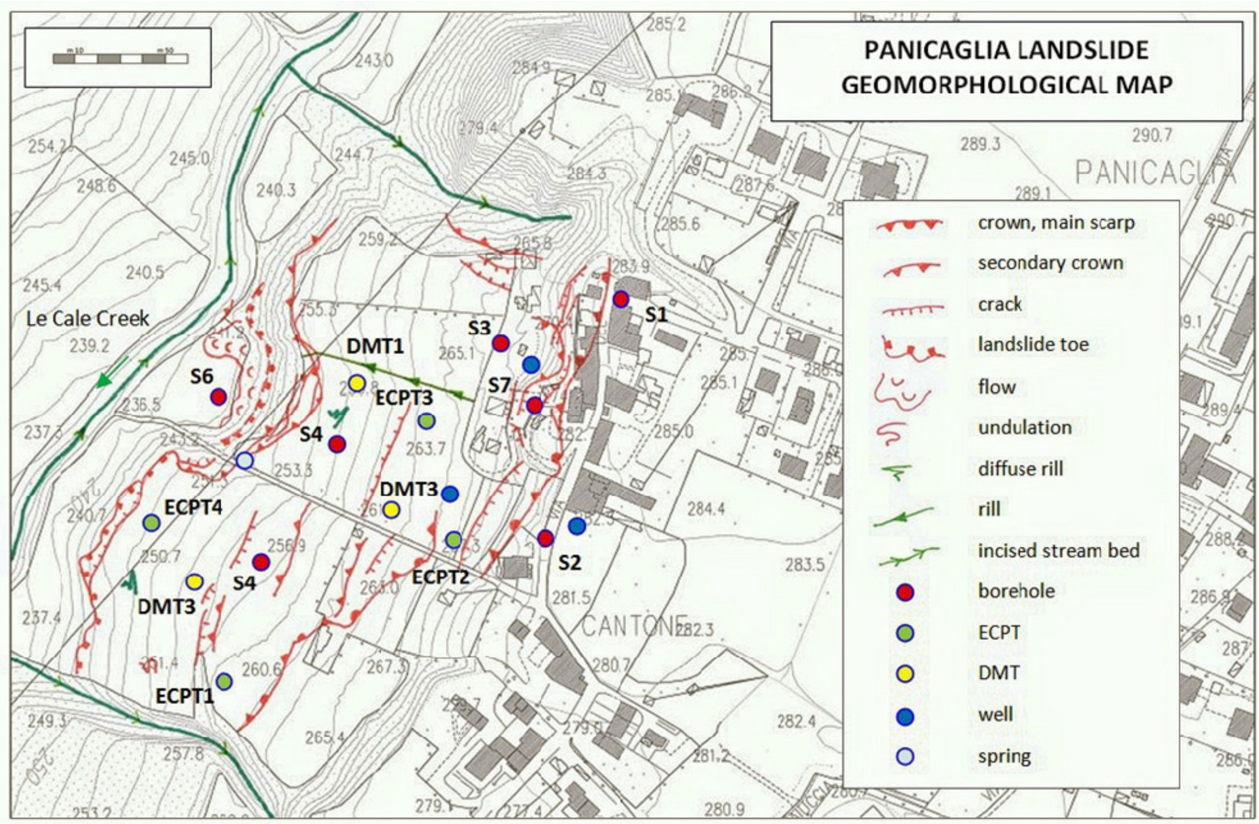

Fig. 2 - Panicaglia Landslide Geomorphological Map (topographic base map is Regione Toscana Technical Map – CTR, enhanced with conventional topographical survey).

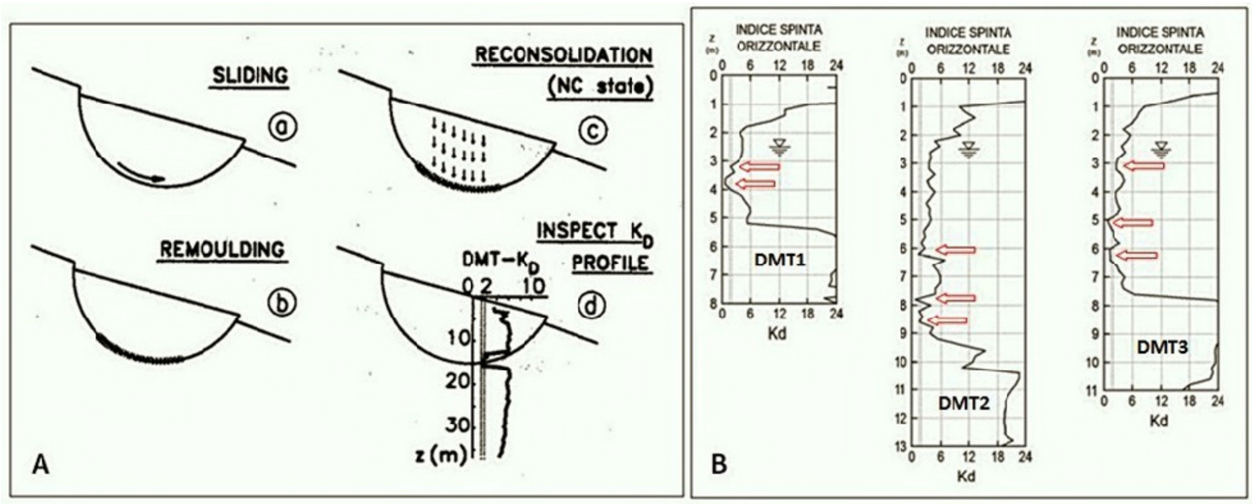

Fig. 3 - A) DMT-KD method for detecting slip surface in OC clay slopes from Totani et al., 1997 B) detecting failure surfaces by DMT in the Panicaglia site.

middle section, and at about 4 m in the lower part. The failure surfaces show a subvertical trend in the upper part of the slope, conditioned by the release of overburden pressure determined by the presence of the morphological scarp and by the joints system that involved the gravelly-sandy deposits of the upper terrace, and then assume a subparallel trend to ground surface in the mid-slope and in the foot slope. The slip surfaces, set near the contact between the coarse textured fluvial and fluvio-lacustrine units and the underlying fine textured lacustrine deposits, were already identified during the execution of field geognostic surveys and subsequently verified by slope inclinometer data. The results of the investigations allowed us to test, in particular, the reliability of the DMT (Marchetti, 1980; ASTM, 1986) to diagnose, quickly and at relatively low cost, the presence of active or previous sliding surfaces in overconsolidated clay slopes (see Totani et al., 1997; Marchetti, 1999).

5. DISCUSSION AND CONCLUSION

The lithologic and stratigraphic discontinuity between coarse textured fluvial and fluvio-lacustrine deposits and the underlying fine-textured lacustrine deposits constitutes the weak element of all the slope system. A clear contrast between geotechnical granular behaviour of the upper unit and the cohesive behaviour of the lower unit is evident here. The complex gravitational phenomenon tends to reactivate periodically with the rising of the ground-water table, when conditions of saturation occur close to the ground surface below the morphologic scarp. A sudden increase in porewater pressure along the slip surfaces causes a decrease of soil residual shear strength thus triggering a new failure. Landslide shows a state of substantial dormancy once the masses have been rebalanced and the piezometric levels lowered. Such an evolution of the phenomenon, with phases of paroxysmal activity triggered by critical meteorological conditions, alternating with periods of dormancy, was also observed for other gravitational movements occurring in similar geomorphological and lithostratigraphic contexts that are very common in Mugello.

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