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A LARGE, SLOW-MOVING EARTH FLOW IN THE NORTHERN APENNINES: THE SIGNATICO LANDSLIDE (ITALY)

ABSTRACT: MANDRONE G., BURATTI L., CHELLI A., LOPARDO L. & TELLINI C., *A large, slow-moving earth flow in the Northern Apennines: the Signatico Landslide (Italy)*. (IT ISSN 0391-9838, 2009).

The Signatico landslide is located in Northern Italy, on the Po plain side of the Apennines, along the river Parma. It is a complex landslide with a total length of about 3 km (the accumulation zone only occupies over 1 km of the river bed). It involves rotational slides and falls from the crown, but the displaced material is very quickly weathered and dismembered, moving downstream as a long, slow flow. This landslide has undergone many reactivations, historically dating back to the Middle Ages. Now, many human facilities are directly at risk: an important road, some villages and some other scattered houses. A comparison of aerial photos taken over the last 30 years was made, in order to identify signals of the landslide evolution while engineering-geological surveys investigated the landslide and the surrounding areas. A monitoring system is also in progress. The aim of this study is to forecast a possible new reactivation. In this case, it is important to give, as soon as technically possible, the information to civil protection so that loss reduction measures can be adequately planned.

KEY WORDS: Landslide, Reactivation, Monitoring System, Parma, Italy Valley.

RIASSUNTO: MANDRONE G., BURATTI L., CHELLI A., LOPARDO L. & TELLINI C., *Una grande colata di terra a cinematica lenta nell'Appennino Settentrionale: la Frana di Signatico*. (IT ISSN 0391-9838, 2009).

La Frana di Signatico è ubicata in Nord Italia, sul lato padano dell'Appennino settentrionale, lungo il T. Parma. Si tratta di una frana complessa lunga circa 3 km (la sola zona di accumulo si allunga per più di 1 km nel fondovalle). La zona di corona è interessata da scivolamenti rotazionali e crolli, ma il materiale movimentato si smembra e si altera molto velocemente, muovendosi verso valle come una lunga, lenta colata di terra. Questa frana ha subito molte riattivazioni fra cui, la più antica, risale al Medio Evo. Attualmente, molte infrastrutture sono direttamente a rischio di frana: la strada importante che conduce all'alta Val Parma, alcune frazioni del comune di Corniglio e diverse case sparse. È stato compiuto un confronto fra le foto aeree relative agli ultimi 30 anni allo scopo di identificare segnali dell'evoluzione della frana. Studi a carattere geologico-tecnico sono stati condotti nell'area in frana ed in un suo intorno significativo. Inoltre, un sistema di monitoraggio è in attività. Lo scopo dello studio è quello di prevedere una possibile riattivazione di questa porzione di versante, al fine di fornire, non appena tecnicamente possibile e nel più breve tempo, le informazioni relative a questa possibilità alla protezione civile, così da predisporre le contromisure per la mitigazione del rischio.

TERMINI CHIAVE: Frana, Riattivazione, Sistema di monitoraggio, Val Parma, Italia.

INTRODUCTION

The Signatico landslide is located about 30 km south of Parma (fig. 1), in Emilia Romagna (Northern Italy), along the Parma Torrent, in the municipality of Corniglio. This territory pertains to the Northern Apennines and involves a large number of landslides of different types and sizes (Perego & Vescovi, 2000). In fact, the last inventory of the Regione Emilia Romagna (1999) reports over 30,000 landslides, involving approximately 20% of the mountainous and hilly areas. The percentage of territory involved in landslides is one of the highest in Italy and many of them are very large (i.e. often millions of m^3) complex landslides evolving in slow earth flows.

The large number of landslides is linked, mainly, to the geological features of the Northern Apennines. The complex tectonic history of the chain determined the superimposition of many stratigraphic units containing heterogeneous and/or chaotic rocks characterized by poor geomechanical properties, which cause the strong tendency to slope movement. Moreover, these rocks underwent deep physical and mechanical degradation during the cold periods of the late Quaternary, further increasing their susceptibility to landslide.

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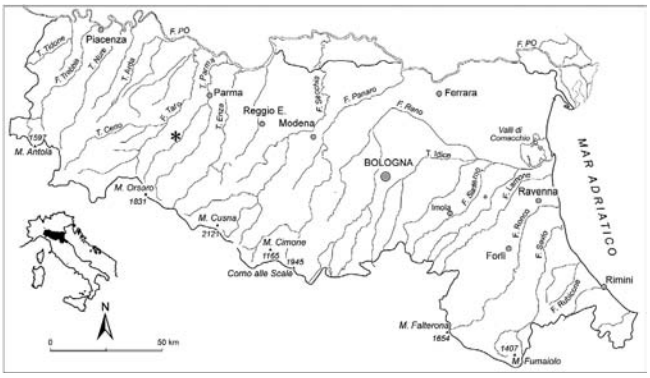

FIG. 1 - Geographic location: the star marks the Signatico Landslide (Parma, northern Apennines, Italy).

Most of the landslides in this area are dormant, and they have often undergone reactivations separated by long time intervals (Tellini & Chelli, 2003). For example, the landslide of Carobbio (just on the opposite side of the Parma Torrent, fig. 2) dates back to over 25,000 years ago (Tellini & Chelli, 2003), and there are several reports documenting its partial reactivation in the last 150 years. Furthermore, the landslide affecting the village of Corniglio (Larini & *alii*, 2001) has been historically known since the 6th and 7th centuries and, starting from the 18th century, there have been reactivations approximately every 100 years.

The Signatico landslide is one of the most important of the Parma Valley. It includes the small villages of Signatico and Curatico, some scattered groups of houses and the principal road of the upper part of the valley, connecting Parma (to the north) with the «Cento Laghi» Italian National Park (to the south). In the past it has undergone many reactivations (the last one in the 70s); in the past century the returning time has been approximately 30-40 years. The aim of this study is to collect the extensive information already existing on this phenomenon and develop the examination of the materials, the triggering factors of the slope movement, and its style and distribution of activity.

Many topics are involved in this study, but this paper deals especially with landslide geomorphologic evolution and geomechanical characterization, with the aim of forecasting a possible reactivation. Further developments will concern the results of the monitoring system and the correlation between failures and rainfalls.

METHODS

The examination of historical maps, books and documents has allowed us to learn about the phases of landslide activity since the 19th century. The multi-temporal comparison of aerial photos of different years (1977, 1987, 2001, 2003), with scales ranging from 1:20,000 to 1:10,000, was made to diagnose landslide evolution. Moreover, a detailed geomorphologic survey investigated it.

Recently, a new monitoring system was installed with the purpose of determining the shape of the sliding masses, check any movement in the villages, and identify the depth of the sliding surfaces in the upper part of the landslide and in the fan. Moreover, groundwater level variations were monitored and compared to data from the rain gauges to find possible correlations between movements and rainfalls.

The materials involved in the landslide were investigated using an engineering-geological approach, in which the technical properties were emphasized. Heterogeneous rock masses were distinguished from clayey and/or chaotic formations using the recent suggestions by Marinos & Hoek (2001), while weak rocks were distinguished from soils and debris using classic geotechnical techniques.

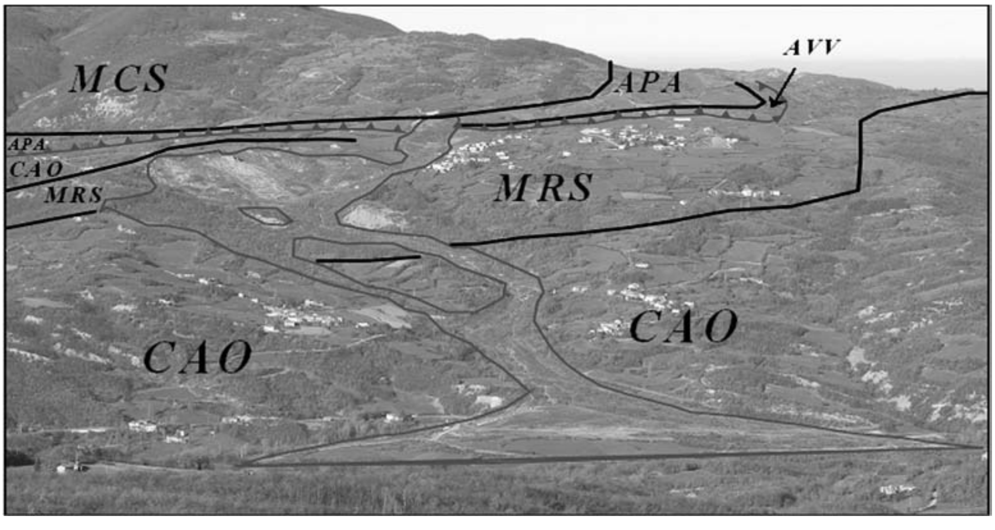

FIG. 2 - Geologic framework of the Signatico landslide and surrounding area (on the right the village of Signatico, on the left the village of Curatico). Keys: MCS) M. Cassio Flysch F., APA) Clay with blocks, AVV) Varicoloured clay, MRS) Pink marls (member of Bersatico), CAO) M. Caio Flysch F., grey line with small triangles = thrust, (MCS over CAO), grey line = limit of the landslide, black line = lithological limit.

GEOLOGICAL AND GEOMORPHOLOGICAL FRAMEWORK

The Northern Apennines are a fold and thrust belt of complex origin and evolution resulting from the collision of the Adria Plate with the European Plate, starting in the Late Cretaceous, with the consequent closure of the «Ligurian-Piedmontese» oceanic basin (Bettelli & De Nardo, 2001).

The Signatico landslide lies in a sector of the Parma valley defined by gentle slopes and large, wide glacial and periglacial covers. The substratum is made of Ligurian units (Vescovi, 1998; Regione Emilia Romagna 1990), composed mainly by shale and limestone and local sandstone. These lithological features and the tectonic deformations control the landform and favor the development of frequent landslides that often involve large bodies of helmintoid flysch. Bedding has a structural control especially on the right side of the valley, due to the N-NW dipping of the strata. The area around the Signatico landslide is characterized by the tectonic contact of two Units (Cassio Unit over the Caio Unit). In detail, the Cassio Unit is placed on an overturned synform made by the Caio Unit, with the axis trending NE-SW. The first one is made of a basal complex (clay and shale with blocks) and a flysch, while the second one is composed of marls and turbidites. It is within this last unit that the crown of the landslide mainly evolves, but a retrogressive evolution involves the clay and shale with blocks of the Caio Unit (fig. 2, fig. 3).

The crown of the Signatico landslide collapsed in the past through different rotational landslides involving mainly clay and marl, and is rapidly evolving into multiple and successive flows, which are flowing down the slope and the main valley for about 3 km. This kind of landslide is very common in the Northern Apennines (Borgatti & *alii*, 2006) and in Southern Italy (Picarelli & *alii*, 2005), but according to literature they are well known all over the world (Messerich & Coe, 2003).

Following the classification by Cruden & Varnes (1996), the Signatico landslide can be referred to as complex and composite. It is a reactivated landslide with evident rotational slides in the crown and earth flows in the middle and lower part. The rate of movement ranges from slow to very slow. In the last century the distribution of the activity of the landslide has been retrogressing, advancing and enlarging. The morphometric characteristics are summarized in tab. 1.

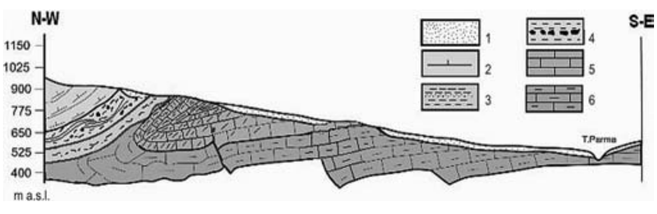

FIG. 3 - Geologic cross section along the Signatico Landslide. Keys: 1) landslide deposits, 2) M Cassio Flysch, 3) Varicoloured clay, 4) Clay with blocks, 5) Pink marls and 6) M. Caio Flysch.

TABLE 1 - Location and morphometric features of the Signatico landslide

Location:	Corniglio, Parma, Emilia-Romagna, Italy
Geographic coordinates:	44° 32' 00" Lat. N 10° 08' 27" Long. E
Steepness of the slope:	depletion zone: 20° sliding zone: 10° accumulation zone: 7°
Landslide morphometry:	elevation of top: 900 m elevation of tip: 450 m difference in elevation: 450 m maximum length: 3120 m maximum width: 1265 m assumed average thickness: ~15 m landslide area: 1.1 • 10^6 m^2 assumed volume 15 • 10^6 m^3

HISTORICAL EVOLUTION

The analysis of the historical documents highlights that the Signatico landslide has undergone many phases of activity. The first historic report dates back to the 9^{th} century but the oldest well-known reactivation was in 1710, when the Church of Signatico was destroyed and the River Parma dammed.

Afterwards, movements of significant parts of the landslide are reported (Almagià, 1907; Dall'Olio, 1975):

- 1836 - woods of Signatico and Curatico were damaged;
- 1879 - some houses and the oratory of Curatico were destroyed;
- 1896 - the fan of the main landslide dammed the Parma Torrent creating a lake, later emptied out by human intervention;
- 1901 - part of the provincial road was destroyed;
- 1906 - the largest recent event dammed the Parma Torrent and created a huge lake, which survived for many years.

Some of the landslide events occurred during the cold period that developed in Europe between the 16^{th} century and the middle of the 19^{th} century, called «Little Ice Age». During this time glaciers in the Alps clearly advanced while on the Apennines rainfall increased seriously, thus affecting slope stability.

The multi-temporal comparison of the aerial photos and the topographic maps of the last years has allowed us to distinguish several failures and portions of the landslide with different states of activity (fig. 4). In 1945 a big portion gave way on the right flank of the main body reaching the toe and damming the river, thus creating a lake once again. Lakes were not created during the 1957 and 1977 events. In particular, in 1977 the landslide was affected by an important retrogression of the crown and increased its frontal fan towards NE, down the valley for over 1 km. It also definitely affected the village of Signatico, which was evacuated and, in the following years, transferred to a safer place, some hundreds meters NE off the old village.

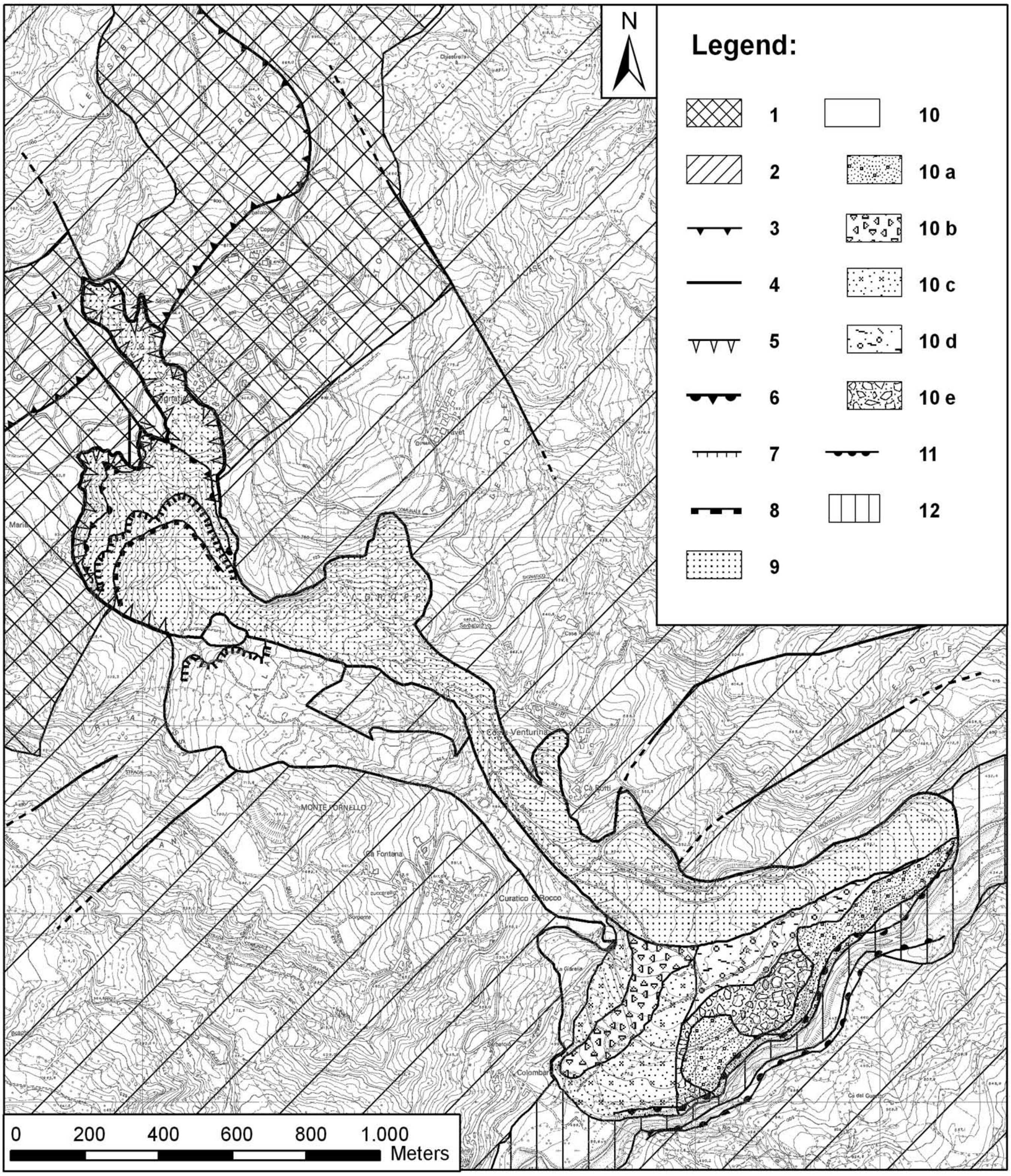

FIG. 4 - Geographical and geomorphological sketch map of the Signatico landslide. The outcropping formations are grouped as lithotechnic units (see engineering geology characterization paragraph). Legend: 1) WH lithotechnic unit; 2) TH lithotecnic unit; 3) overthrust; 4) fault; 5) main scarp of landslide events occurred in both 1957 and 1977; 6) main scarp of landslide events occurred in both 1945 and 1947; 7) main scarp of landslide events occurred in 1896, 1901 and 1906; 8) main scarp of landslide event occurred in 1850; 9) active landslide; 10) dormant landslide: 10a) landslide events 2000-2002, 10b) landslide event occurred in 1947, 10c) landslide events occurred in 1945, 10d) landslide events occurred in 1906, 10e) landslide events occurred in 1896; 11) fluvial scarp; 12) alluvial deposit.

After the 1977 event, apart from some small movements at the foot of the accumulation area, the only significant partial reactivation was in 2001. It mobilized different portions of the crown and, again, caused partial reactivation of the toe, with severe problems to the road, which was completely rebuilt in the 70'.

ENGINEERING GEOLOGICAL CHARACTERIZATION

The study area concerns different kinds of rocks and soils, both as bedrock and covers: heterogeneous rock masses, clay and shale formations, slope deposits, alluvial and lacustrine deposits.

Heterogeneous rock masses (often described as weak and complex) are very difficult to study due to their geological and tectonic complexity. In the study area, most of the heterogeneous rock masses are flysch, marl or shale, showing the following characteristics: heterogeneity in mechanical behavior (i.e. alternation of 'hard' and 'weak' constituents), presence of clay minerals, tectonic fatigue and sheared discontinuities (often resulting in soil-like material). A new technique for studying these rock masses has been recently proposed by Marinos & Hoek (2001), based on the application of the Hoek & Brown (1997) criterion, and successfully used for a geomechanical characterization of the rocks in these areas (Mandrone, 2006).

Detailed fieldwork allowed an accurate geomechanical description of the formations outcropping near the landslide, so at least four groups of geological formations with different geomechanical characteristics were identified (tab. 2).

From an engineering geological point of view, the following two big groups of rock masses are distinguishable (the values of the Hoek and Brown classification are presented in tab. 3):

- truly heterogeneous rock mass with, approximately proportional, alternations between hard and weak level; failures mostly involve the rock matrix; the values of global strength (σ_{cm}) are approximately a few units of MPa and the deformation modulus (E_m) is approximately a few thousands of MPa;
- rock mass in which the behavior of the weak levels (mainly clay and silt) prevails; it is highly conditioned by the degree of saturation in water; it can easily pass from brittle to ductile failure mode even for modest stress ranges; the values of σ_{cm} are lower than 1-2 MPa and the E_m is only a few hundreds of MPa.

An important role is played by the deformations connected to the main thrust. Outcrops nearby this tectonic line are characterized by intensively deformed rocks in which sandstone levels are frequently broken inside sheared clay layers, forming a chaotic structure.

Other materials can be referred to as "soils", but the engineering geological properties are different:

- cohesion-less soils of alluvial origin: gravel and pebble with small silt levels, probably connecting the different lakes created by the landslide;
- landslide deposits: heterogeneous and heterometric deposits with many rock blocks, with sharp edges, in a clayey reddish matrix (mainly due to the pink marls).

Landslide deposits can be divided in two more groups, depending on the grain size of the matrix; at the top of the landslide prevail clayey silts while at the bottom are more common sandy silt (tab. 4).

TABLE 2 - Description of the geological formation involved in the landslide

Geological formations	Lithological description
Varicolored clay, Blocks in clay matrix	Multi-layered deep-water shaly rock units (varicolored shale with calcareous or arenaceous lenses) with typical blocks in matrix fabric derived from a polyphasic folding and shearing of partly unconsolidated sediments.
Mt. Caio Flysch Fm	Marly limestones and marls in thick beds with thin shale or sandstone layers
Cassio Flysch Fm	Regular interbedded layers of carbonatic sandstone and marls (prevailing)
Tizzano pink marls	Very thick layers of scaly marls with rare sandstone and/or shale beds

TABLE 3 - Synthetic description of the geological formations according to the classification proposed by Marinos & Hoek (2001) and Mandrone 2006

Geological formations	Flysch type	GSI	σ_{ci}	m_i	Group
Varicolored clay, blocks in clay matrix	H	10	26	4	WH
Tizzano pink marls (tectonically deformed)	F	5	20	5	WH
Mt. Caio Flysch Fm (tectonically deformed)	F	20	18	3	WH
Tizzano pink marls	D	30	44	6	TH
Mt. Cassio Flysch Fm	D	35	38	5	TH
Mt. Caio Flysch Fm	C-D	37	85	6	TH

TABLE 4 - Grain size and Atterberg limits referred to 3 sample from the bottom (B1-3) of the landslide body and 2 from the top (T1-2)

	(%)	*B1*	*B2*	*B3*	*T1*	*T2*
Grain size	Gravel	10.1	13.2	51.7	7.4	16.9
	Sand	23.8	31.0	11.8	3.4	19.4
	Silt	39.3	37.0	20.1	50.8	40.9
	Clay	26.7	18.9	16.6	38.4	22.8
Atterberg limits	Wl	36.3	38.4	35.5	51.8	36.2
	Wp	12.4	21.5	28.6	31.0	26.4
	Ip	23.9	16.9	6.9	20.1	9.8

MONITORING SYSTEM

A monitoring system has been recently set up and the first results are being processed. The purposes of the monitoring, in this case are to:

- determine the shape of the sliding masses;
- check any movement in the village;
- identify the depth of the sliding masses.

Moreover, groundwater level variations are being monitored and compared to data from the rain gauges to find possible correlations between movements and rainfalls.

Classic inclinometers and an electric piezometer are on the lateral border of the channel and in the crown, while a TDR (Time Domain Reflectometry) inclinometer is in a borehole in the central part of the fan, in order to identify the sliding surfaces and the velocity of the flow (this method is based on a coaxial cable firmly joined to the casing so that physical deformation of the casing corresponds to electromagnetic variation along the cable).

Rain gauges are present very close to this area, so in a few months it will be possible to compare water table variations with rainfalls.

The first results of observations state that the inclinometer near Costa Venturina (on the left side of the channel) shows only superficial movements (2-4 mm), the one in the village of Signatico, near the crown, highlights a 3-4 mm displacement at 28 m of depth, while the ones near Curatico (on the right-hand side of the channel) are almost stable. Moreover, the velocity of deformation is quite regular for deep movements, while superficial displacements show different stage of activity (fig. 5), probably due to the influence of frequent rainfall in wet periods (fig. 6). In fact, the superficial movement in SIGN I1 (2-4 m) increases in velocity abruptly with the measurements of June and August 2005, which can be correlated to heavy rainfall in springtime (about 250 mm). The deep movement in SIGN I2 (28 m) seems to be rather settled, not directly connected to frequent rainfall in short periods.

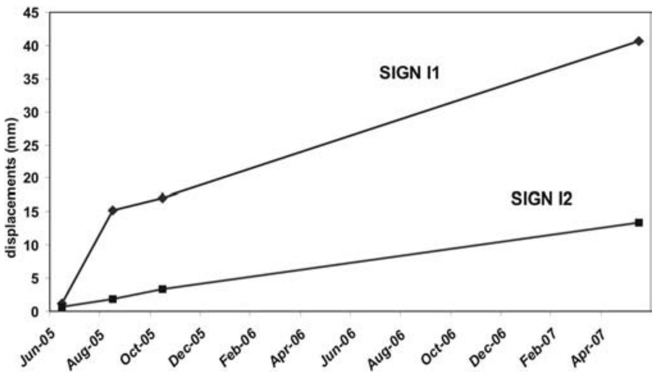

FIG. 5 - Movements in two different inclinometers at the crown of the landslide, respectively, at –4 m (I1) and at –28 m (I2) from the ground surface.

The study also focuses on the permeability of the covers and the infiltration of rainfall. Soils on the surface are not-permeable but under certain circumstances rains might reach some subsurface levels and increase the pore pressure. The first result of the electric piezometers (fig. 6) seems to show that the rainfall in the spring time can affect the water table, which increases rapidly, while in the summer and autumn, levels are almost regular with no significant variation. In any case, the short time of observation does not allow us to state secure correlation between infiltrations and variations in water table.

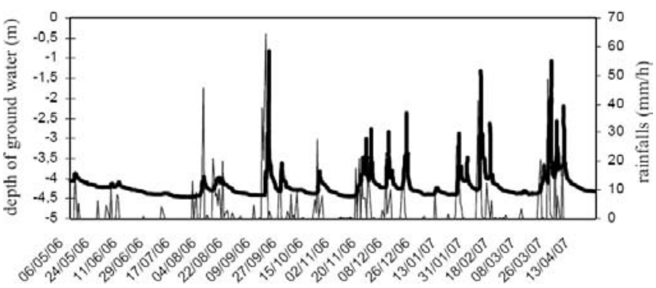

FIG. 6 - Response of the water table (thick line) to rainfalls (thin line) in a piezometer in the village of Signatico.

DISCUSSION AND CONCLUSION

The Signatico landslide has been active for many centuries. In the past century, reactivations occurred every 30-40 years; the last big event occurred in 1977.

Usually, prolonged rainfall is the triggering factor for these kinds of landslides, but the rainfall event in 1977 was not very exceptional, so the activation might not only be due to water, but probably also to a progressive process. Weathering, erosion and degradation easily affect the shale and clay formations that are widespread at the top of the landslide. These phenomena, persisting for long period, create large quantity of unconsolidated deposits on the steep slopes surrounding the head of the landslide.

When a consisting quantity of this clayey and loose material is available, rainfall can act, inducing slides and flows, which can even reach the river bed, sometimes creating a temporary dam and the consequent lake (fig. 7). The first results from the inclinometer at Signatico seem to highlight that a big portion of slope is still moving, while the flanks seem stable.

Besides, due to the risk of the river blockage (Clerici & *alii*, 1996), many human activities are directly at risk including:

- parts of both the new and the old village of Signatico, already involved in the past, that are still in a very dangerous position;
- the most important road of the upper part of the valley;
- the small villages of Costa Venturina and Curatico are not directly involved, but they are very close to the active phenomenon.

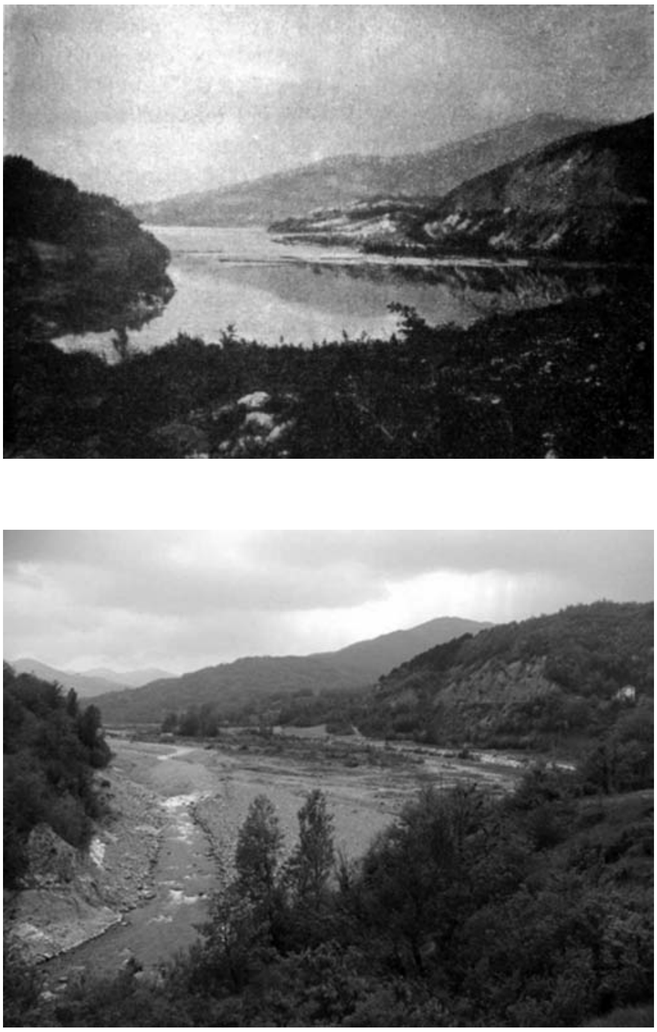

FIG. 7 - An old picture of 1906 (top) and a recent photo (bottom) showing the river bed and the zone of accumulation of the landslide that in the past created the lake.

The monitoring system is working from a couple of year and it is still in progress. Only these kinds of studies, coupled with field observation and detailed analyses of older events, can allow to identify the rate of risk. Indeed, the aim of these studies is to forecast a possible new landslide reactivation, and to alert, as soon as technically possible, the Civil Protection Agency so that loss reduction measures can be adequately planned and implemented.

REFERENCES

ALMAGIÀ R. (1907) - *Studi geografici sopra le frane in Italia (vol. 1)*. Memorie della Società Geografica Italiana, 13, 342 pp.

BETTELLI G. & DE NARDO M.T. (2001) - *Geological outlines of the Emilia Apennines (Italy) and introduction to the rock units cropping out in the areas of the landslides reactivated in the 1994-1999 period*. Italian Journal of Engineering Geology and Environment, 8, 1-26.

BORGATTI L., CORSINI A., BARBIERI M., SARTINI G., TRUFFELLI G., CAPUTO G. & PUGLIESI C. (2006) - *Large reactivated landslides in weak rock masses: a case study from the Northern Apennines (Italy)*. Landslide, 3, 115-126.

CLERICI A., PEREGO S., GIUDICE G. & RICCIARDELLI M. (1996) - *La formazione di un lago di sbarramento da frana: simulazione mediante un sistema informativo geografico*. Geologia Tecnica & Ambientale, 1, 51-57.

CRUDEN D.M. & VARNES D.J. (1996) - *Landslide types and processes*. In: *Landslides: investigation and mitigation*, Special Report 247, Turner A.K. & Schuster R.L., eds. Transportation Research Board, National Research Council, Washington, 36-75.

DALL'OGLIO E. (1975) - *Itinerari turistici nella provincia di Parma (vol. 1)*. Artegrafica Silva, Parma, 315 pp.

HOEK E. & BROWN E.T. (1997) - *Practical estimates of rock mass strength*. International Journal on Rock Mechanics & Mining Sciences & Geomechanics Abs, 34 (8), 1165-1186.

LARINI G., MALAGUTTI C., PELLEGRINI M. & TELLINI C. (2001) - *La lama di Corniglio (Appennino parmense), riattivata negli anni 1994-1999*. Quaderni di Geologia Applicata, 8(2), 59-114

MARINOS P. & HOEK E. (2001) - *Estimating the geotechnical properties of heterogeneous rock masses such as flysch*. Bulletin of Engineering Geology and the Environment, 60, 85-92.

MANDRONE G. (2006) - *Engineering geological mapping of heterogeneous rock masses in the northern Apennines: an example from the Parma Valley (Italy)*. Bulletin Engineering Geology and the Environment, 65, 245-252.

MESSERICH J.A. & COE J.A. (2003) - *Topographic Map of the Active Part of the Slumgullion Landslide on July 31, 2000, Hinsdale County, Colorado*. U.S. Geological Survey Open-File Report 03-144.

PEREGO S. & VESCOVI P. (2000) - *Relationships between mass wasting and rainfall in the Parma valley (Northern Apennines)*. Geografia Fisica e Dinamica Quaternaria, 23, 153-164.

PICARELLI L., URCIUOLI G., RAMONDINIM M. & COMEGNA L. (2005) - *Main features of mudslides in tectonised highly fissured clay shales*. Landslide, 2, 15-30.

REGIONE EMILIA ROMAGNA (1990) - *Carta geologica dell'Appennino emiliano-romagnolo, 1:50.000*. Selca, Firenze.

REGIONE EMILIA ROMAGNA (1999) - *I numeri sulle frane*. Garberi, M.L., Palumbo, A. & Pizziolo M. eds., Grafiche Damiani, Bologna, 94 pp.

TELLINI C. & CHELLI A. (2003) - *Ancient and recent landslide occurrences in the Emilia Apennines (Northern Apennines, Italy)*. In: Castaldini D., Gentili B., Materazzi M. & Pambianchi G., eds, «Proceedings of Workshop on Geomorphological sensitivity and system response», Camerino-Modena Apennines (Italy), July 4th-9th, 2003, 105-114.

VESCOVI P. (1998) - *Le unità subliguri dell'alta Val Parma*. Atti Ticinensi di Scienze della Terra, 40, 215-231.

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