The earth flows in the Emilia Apennines (Italy) with reference to those reactivated in April 2013 –extended abstract-

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The Emilia sector of Northern Apennines is among the most landslide-prone areas in the world, due to the prevalence of weak rocks with high clay content. Ancient and recent earth flows, by the thousands, are clearly visible on these versants forming a typical landscape. Late Jurassic–Early Eocene units, also named *"Helmintoid Flysch"* and "*Argille Scagliose"*, due to the clay content and *bimrock* structure, represent the main source of landslides.

The Emilia-Romagna Regional Geological Survey has identified over 70,000 landslide bodies that cover one fifth of the hilly and mountainous territory. The great majority (~ 90%) of these large landslide bodies originated as earth flows. The majority of them (52%) reaches a depth ranging from 10 to 30 meters and about 12% of them exceeds 40 m. The depth has seldom reached a magnitude of 80-100 metres, as in the Corniglio case.

Ancient dormant earth flows have been areas wrongly judged as suitable for human settlement since ancient times, thanks to the low slope of their frontal and mid-accumulation zones: a real trap for hamlets and villages. As a result, in the Emilia-Romagna Region territory, 281 inhabited centres (defined as four or more buildings, excluding "scattered houses") lie upon or are directly affected by active landslides and 1608 by dormant landslides.

In terms of shear strength properties of landslide material, Φ' shows a range of variability from 20° to 25°, while cohesion peak values, in most cases, are lower than 30 kPa.

In consequence of reactivation, only in few cases the movement led to a significant advancement of the toe (e.g. 10, 28, 56 and 330 and 2000 metres respectively in the Boschi di Valoria, Corniglio, Cerrè Sologno , Cà Lita and Capriglio cases).

As evident, the scale of deformations and displacement velocities decreases moving from the source sector in the direction of the toe, which, as already stated, is generally the last section of the landslide to reactivate. In the majority of cases, if the mudflow coming from the main scarp covers hundreds of meters, the deformation of the ancient basal fan is limited to several or tens of metres. The usual maximal velocity is up to few decimetres per day.

Prolonged precipitation plays a major role in triggering the reactivation. In general, antecedent precipitations may be considered determinant, even if they occurred months before, as recently demonstrated in 2013 by the Capriglio/Pianestolla event.

Reactivation often occurs by surcharge -by the part of minor earth flows- in the crown area, that is the most unstable part of the slope. Once activated, the progressive rupture migrates valleyward.

From the moment it is triggered, the time required for a full reactivation of a landslide can vary between a few days (e.g. Morano, Capriglio-Pianestolla) to to a few years (e.g. Corniglio)

Experience teaches us that the instability is often prepared, months and years in advance, by the overburden on the original landslide body, due to the gradual superimposition of new earth/mud flows. When the limit equilibrium is reached, few precipitations may produce apparently disproportionate effects.

As a consequence of intense precipitations lasting from September 2012, two large earth flows reactivated in April 2013: Capriglio-Pianestolla (Fig. 1) the 6th of April and -after ten days- Sauna , both in the Province of Parma.

In particular, the mechanism of reactivation of Capriglio-Pianestolla occurred as just described but its evolution was deeply unusual. In fact, after only few days from the triggering, this earth flow reached a magnitude that has no precedents in the local memory. We may conclude that

in this event the antecedent precipitation (and the unusual increasing of pore pressures) made a difference, predisposing the slope to such an unusual rapid collapse.

In conclusion all these experiences have proved to be a useful tool to understanding the conditions and behaviours that usually lead to the reactivation of an ancient earth flow.

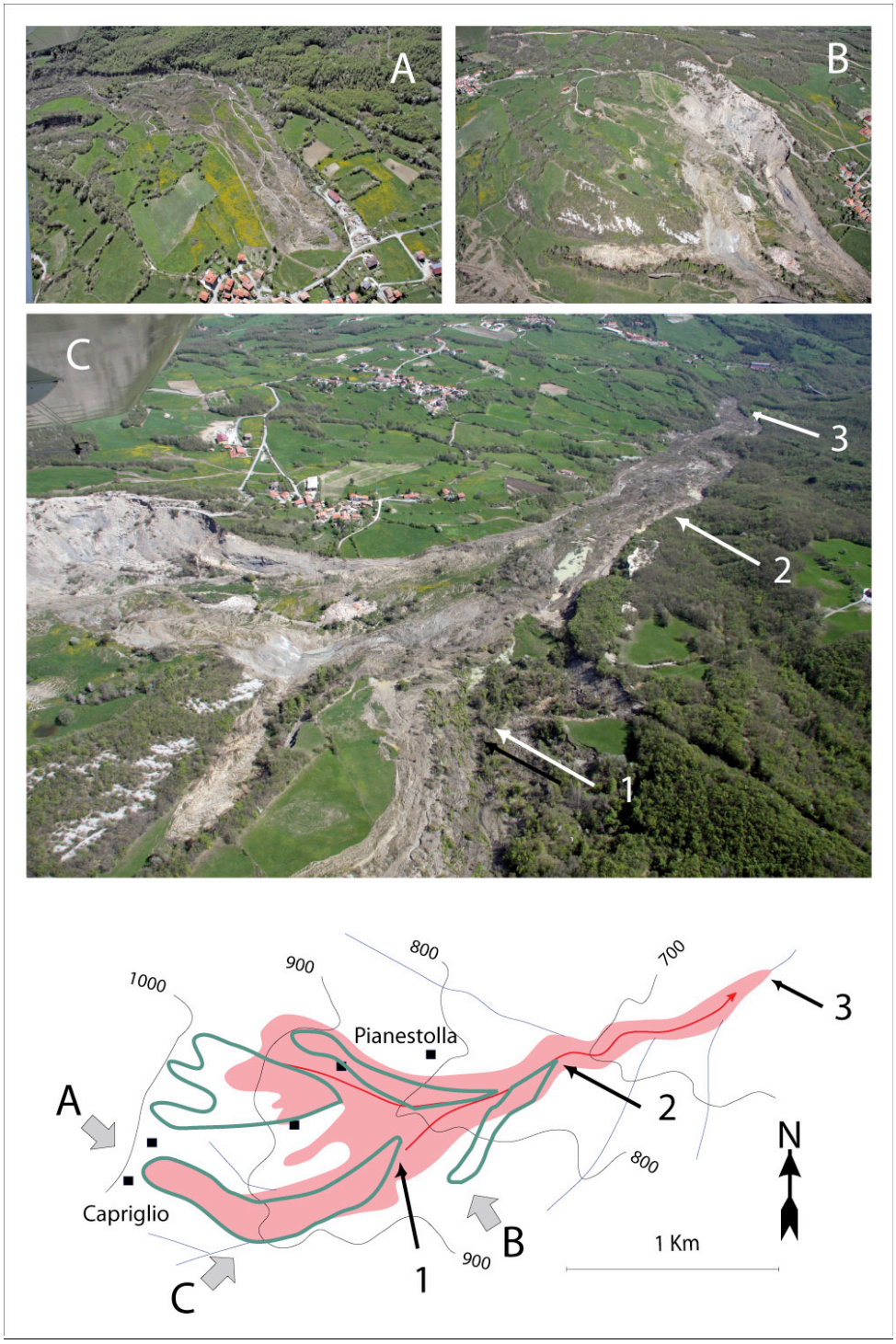

Fig 1: During the night between the 5th and 6th of April 2013, the Capriglio earth flow reactivated. After six days, the landslide of Pianestolla, located nearby on the left slope, reactivated and joined the travelling tongue of Capriglio forming a unique earth flow. At this point the large mass of clay accelerated. Aerial photos demonstrate that the flow, up to 150 metres large, advanced for 1154 metres in 20 days, which means an average velocity of 57,5 metres per day. LEGEND: A, B and C = aerial photos shot points and directions; Red = situation 4 May 2013. Green = perimeter of dormant earth flows, situation before 2013, described from geological maps; 1 = tip position of the earth flow before the 6th of April; 2 = position after 8 days (14th of April); position after 28 days (4th of May).