The Tsakona landslide in Peloponnese – Greece

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EXTENDED ABSTRACT

In February 2003 a large landslide (Figure 1) occurred at a freshly operated national road at the central part of Peloponnese, which involved the fast movement of approximately 6,000,000 m^3 of soil disrupting completely the traffic. Notably, over about 200m the highway slipped for approximately 100m in plan and about 40m vertically. The landslide was destructive, altering the landscape in an area of 400m upslope and 700m downslope, resulting in a series of cracks of large width and depth, an altering of the streams flow, the creation of ponds, the destruction of agricultural roads and hamlets, etc. The road reconstruction, which includes a long bridge, has not yet been completed.

At the landslide area the national road was passing through a mixed section that includes a considerable cut slope and fill. Part of the excavation material had been tipped downslope creating in places a fill of appreciable plan area and volume. The surface drainage of the uphill area was passing through long culverts buried under the road embankment.

The sliding became visible on the pavement shortly after the opening of the national road in year 2000. In 2001 a geotechnical investigation revealed that the instability was not restricted within the road earthworks but involved a greater area of about 800 m length and 6,000,000 m^3, which could, under certain circumstances move disputing the traffic. Moreover, a careful appraisal of the geomorphology revealed that the landslide was pre-existing. The slip surface was found to follow the interface between the deep colluvial material covering the slope and the bedrock. The maximum depth to the slip surface was 20 to 35 m. In January 2003, after a very intense rainfall period, a considerable settlement of the pavement was observed right above the axis of one of the two culverts crossing the road embankment. Soon the settlement was enlarged and became a "crater" with a progressively enlarging diameter, while rapid widening of the pavement cracks was observed. In addition, the water flowing through the drainage culverts and the water outflow from local "springs" had been appreciably increased. Finally, the large activation took place in February 2003. This included a surficial earthflow-mudflow (Figures 1 and 2) and a huge thrust downhill, expanding the limits of the landslide which reached down to the riverbed (Figure 3), blocking locally the flow of a the river.

This event initiated another geotechnical investigation with the primary scope of remediating the national road. The investigation was supplemented by geotechnical analyses. It was concluded that only a deviation from the landsliding area, either by a tunnel that passes beneath the slip surface or by a bridge that passes over the unstable area, would provide sufficient safety at an acceptable cost. A bridge was finally chosen, which is now under construction. The complex geological environment required a careful geotechnical investigation in order to determine safe locations for the bridge piers.

Some lessons from this failure are:

a) Careful observations of the geomorphology assisted by appropriate geological and geotechnical investigation can provide clues of past earth movements, which may recur. Often these observations are meaningful at a scale larger than the area immediately affected by the geotechnical project at hand.

b) Average rates of displacement measured for just a few years cannot be used to predict future displacements, particularly if they are not linked to rainfall records. In this case, a prolonged very wet season most probably provided the final trigger of an already "mature" landslide.

c) Although the displacement rate measured during the 2000-2001 investigation was low, an acceleration could not be dismissed in a modified environment, due to combined geological processes and manmade interventions.

Concluding, the elaborated geological and geotechnical investigation showed that the various lithological, hydrogeological, geotectonical and morphological factors interacted in a geological time scale to create an unstable area, which has been activated in the past more than once. This phenomenon extended over an area a lot larger than that of the national road earthworks.

The corresponding failure is one of the largest higway landslides in Greece (1300 m length, 300 m width, landsliding volume about 9,000,000 m^3), being a complex translation of a deep slide and a flow of surficial material. The materials moved were colluvium, weathered mantle and recent embankment and fill materials. The deep slide developed mainly around the interface of the coluvium with the flysch bedrock

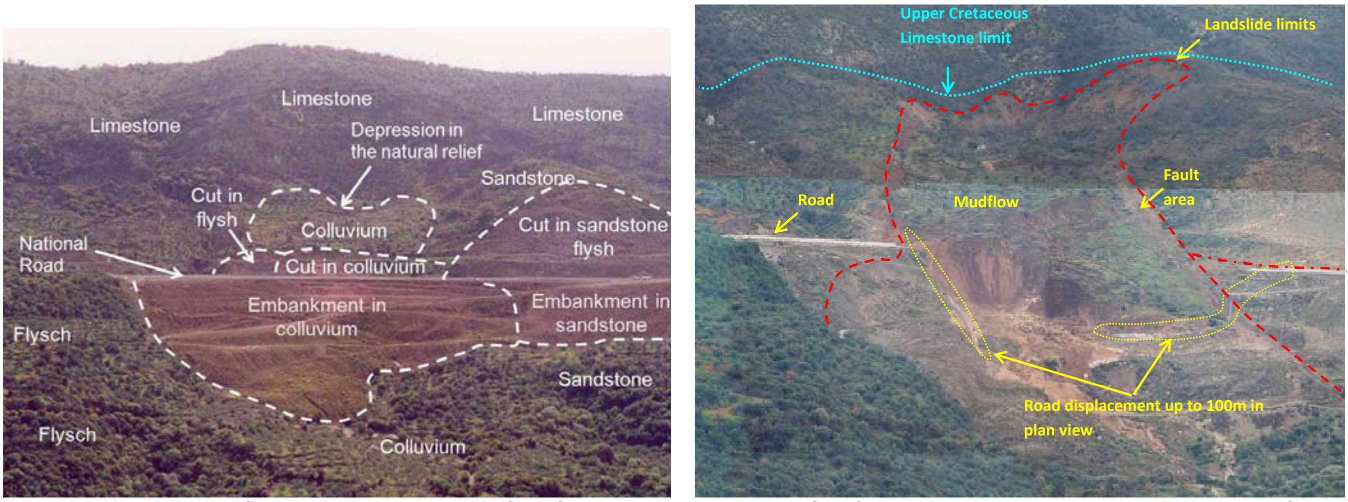

Figure 1. General view of the landslide area a) before final triggering and b) after final triggering (including a disruption of the National Road between Ch. 16+300 and 16+600).

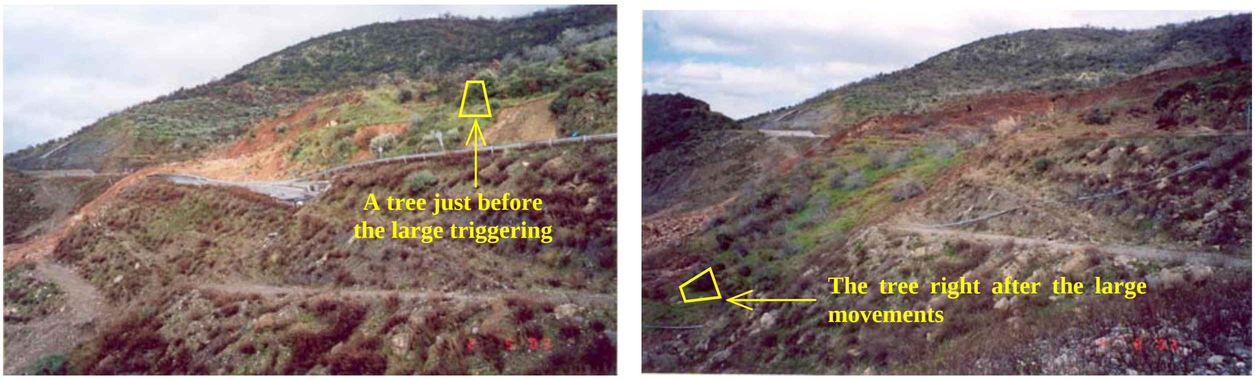

Figure 2. Landslide development (view from south to north, i.e. towards Tripoli) (from Dounias *et al*, 2006).

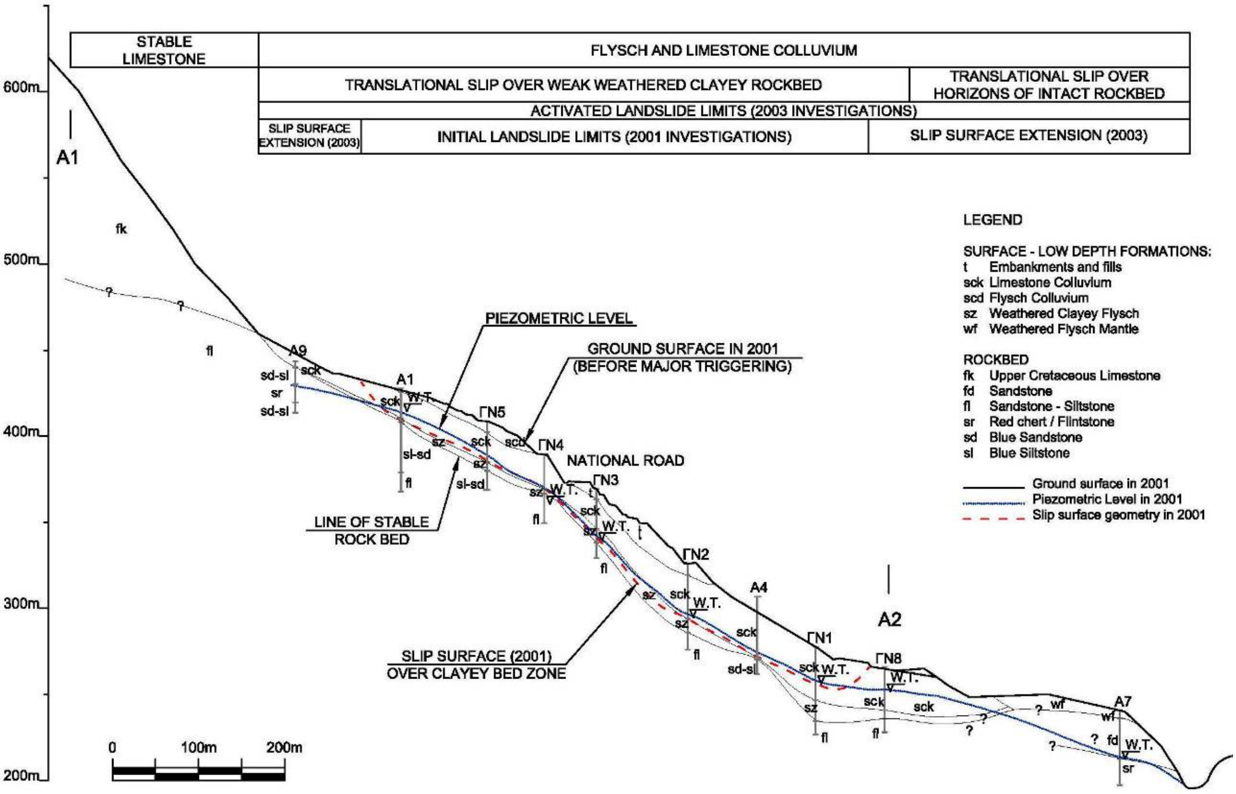

Figure 3. Cross section of the slip surface in 2001 along axis shown in Fig. 8 (from Belokas et al, 2013).