FAULT ZONE LANDSLIDES: THE EFFECTS AND GEOMORPHOLOGICAL CHARACTERISTICS OF KOYULHISAR (SİVAS-TURKEY) LANDSLIDE, MARCH 2005.

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Abstract

One of the landslide areas of Turkey extends along the Northern Anatolian strike-slip fault zone. The dissected topography by the running water and fault lines and well and deep weathered parent materials has led to the mass movements especially landslides. The landslide called Kuzulu occurred on 17 March 2005 caused to destroy of the most part of the Kuzulu village and 15 people and 375 animals died. During the landslide a 15 million cubic meter materials has been slided from the original part and accumulated on the valley bottom.

Keywords: Landslide, Gemorphology, Northern Anatolian Zones, Koyulhisar, Kelkit River

Introduction

The term landslide is used widely in a general sense to mean any down slope movement of a mass of regolitic or bedrock under the influence of gravity. The main reasons of the landslides are climatic properties of the given area especially rainfall intensity, the weathered degree of the parent materials, sloppy topography and fault scarps (Carrara et al., 1982; Bovis,1993; Cruden and Varnes, 1996; Thornes et al., 1998; Alacantara, 2002). Kelkit river valley extending along the strike-slip Northern Anatolian Fault zone (NAFZ) is deeply dissected by the Kelkit River and its tributaries. The Kelkit River has set up along the NAFZ or it follows the NAFZ. The steep slopes and thick weathered volcanic material, road construction on the steep slopes and the earthquakes cause the formation mass movements notably landslides along the Kelkit valley.

The Formation of Kuzulu Landslide

The Kuzulu Landslide area is located in the northern part of the NAFZ, in the Kelkit river watershed area Fig. 1 and photo 1). This area is found between the Northern Anatolian orogenic belt and Anatolian microplate. The main reasons in the formation of landslide are the existence of well weathered volcanic materials, instability of the slope and high erosional process carried out by running water. Irrigation of agricultural land along the Kelkit valley and main roads passing the Kelkit valley produce suitable environment for settlements. But the earthquakes occurring frequently have led to the considerable causalities. In this article the landslide called Kuzulu Landside occurred on 17 March 2005 will be examined.

Landslide area was examined during the summer after it had occurred. The measurements were carried out by GPS, and map is digitalized for the determining the landslide process and geologic cross section and blocdiagram are drawn.

Geologic and Geomorphologic properties of Landslide area

The Northern Anatolian Fault Zone is the main destructive earthquake areas of Turkey. This fault line is formed as the result of the compressional tectonic movements occurred post alpine period. Indeed after the alpine orogenic movements the eastern part of the Anatolia has subjected to compressional tectonic regime due to the northward movement of the Arabian plate. The crust along the northern Anatolian fault zone was dissected by fault lines and pull-apart tectonic basins have formed. Tectonic movements are also responsible

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for the shaping of the NAFZ (Şengör, 1979; Şengör et al., 1985; Honkura et al., 1991; Oshiman et al., 1991; Barka et al., 2000, Atalay 2007). The Kelkit River which is the main tributaries of Yeşilırmak River flowing into Black Sea follows the fault line. The NAFZ has been deeply dissected by the streams connecting the Kelkit River. The Anguz stream that landslide occurred is one of the tributaries of Kelkit river.

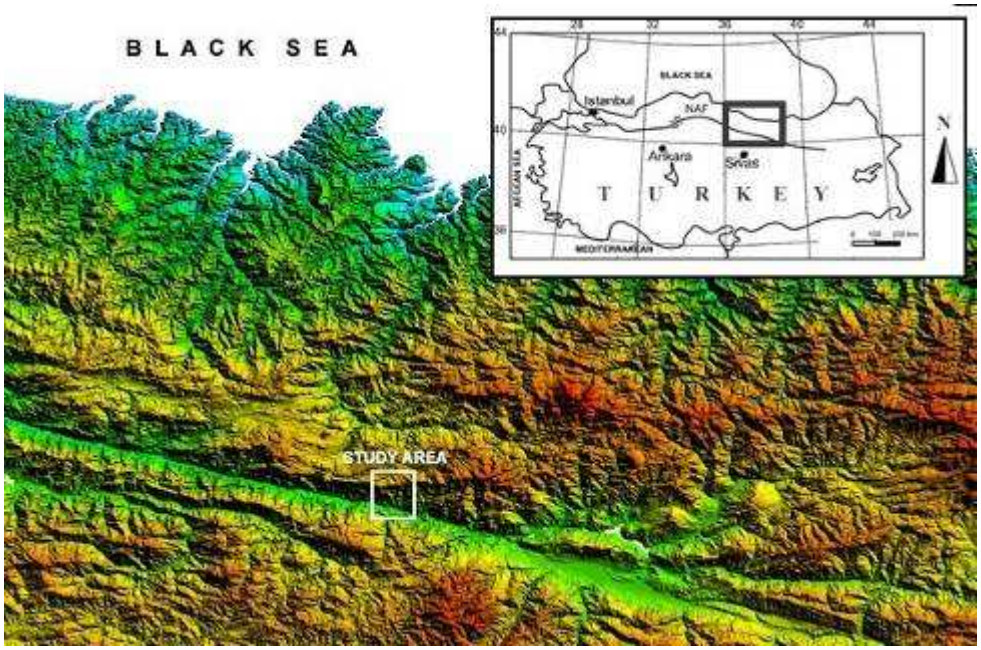


Figure 1: Location map of landslide area in Kuzulu

Photo 1: The North Anatolian fault that goes to Kelkit Valley and northern slopes

Photo 2: The rupture zone forming canopy part in the landslide area

The Northern Anatolian orogenic belt is made up of volcano-sedimentary strata, ophiolites and limestones belonging to Upper Cretaceous geological period. The andesite and andesitic tuffs are also found especially on the upper part of the Cretaceous formation. The fluvial terrace that composed of rounded gravel and sands that is found at altitude of 600-700 m indicates old river course or valley. The soft and less cohesive terrace deposit has been deeply dissected both horizontal and vertical direction by the running water. Upper Craterous limestones discordantly overlying on volcano-sedimentary formation form cliffs and step slopes.

The andesite and andesitic tuffs overlying the mesozoic volcano-sedimentary formation deeply weathered. These weathered materials have slided towards the south direction along the valley. On the other hand it can be clearly seen paleolandslide and its

debris in that area. This debris provided an additional material in the formation of recent landslide.

Photo 3: Upper heel area and unruptured old landslide mass

Photo 4: The delivery canal having been formed with corrrosion of the wreckage of the lanslide in the western slopes of the Kuzulu Valley.

Photo 5: The latter formed river delivery canal. The first landslide material has excavated the ground of the valley by corrosion

Photo 6: The northern look from to the Kuzulu Valley. The formed landslide lake in thee eastern slopes of the valley.

The Kuzulu stream basin has a dentritic drainage pattern due to the uniform surface for the infiltration of water. The Kuzulu stream is in the shape of a narrow and deep valley and there are two fault lines crossing in the Kuzulu basin. The Kuzulu village is situated a somewhat flat and vide valley floor at the altitude of 1200 m in the upper watershed area of Kuzulu stream. Here fluvial deposit that composed of gravel and sands are found at altitude of 900-1200 m. The fluvial deposit or terraces indicates the existence of the old river valley. This deposit has deeply dissected by the Kuzulu stream in accordance with uplifting of the area and the lowering of the NAFZ.

The inclination of Agnus valley slope increases towards south due to the intense backward erosion.

The Formation of Kuzulu Landslide Occurred on March 2005

The Kuzulu landslide (Koyulhisar district) is very important in terms of the volume of slided material, morphologic properties and destructive effects. Landslide material is composed of deeply weathered volcanic materials (andesite and andesitic tuff) and the debris coming from the upper part of the slope and/or slope failure. In addition to this it can be seen a paleolandslide material within the slided material. The debris material and

weathered parent material is saturated with atmospheric water and water coming snowmelt. Saturated debris and/or weathered material and the clayey material beneath the weathered material have increased fluidization, liquefaction and force of gravity. So the materials have transported toward the valley. In addition to these the shocks produced from the earthquake with 2.8 magnitudes occurred 150 km east of the landslide area affected the encouraging of landslide. In other words, the earthquake occurring in the vicinity of NAFZ is one the main reason in the formation of landslide.

Landslide area is in shape of "Z" at altitude of 1550-1650 m in the upper part of the slope. This area can be termed the head of the landslide and the failure area. The middle part of the landslide area is the accumulation area of the slided materials and is in conic shape or resembling dejection cone. This accumulation area extends at the altitude of 850-1500 m and its inclination is more than 20 degree. The old cemented landslide materials form a spurs on the slided debris.

The accumulation zone of the landslide area is found lower part of landslide area and/or the lower part of the Kuzulu valley. The inclination of the debris material accumulated zone is very low due to the fluidization and liquefaction process. The debris flows destroyed the houses that were constructed on the valley. On the other hand, the transported material by the Fındıcak stream is accumulated on the valley bottom, so the small lake was formed behind the accumulated debris material. But the lake dried up due seepage of the water quickly.

As a result the during the Kuzulu landslide the 15 millions cubic meter debris was transported from the upper part of the Kuzulu stream or the amount of the slided material is about 15 million cubic meters, and 21 houses were completely destroyed and 15 people and 375 animals died (Tatar et al., 2005;Gokceoglu et al., 2005).

Second land slide that occurred on 22 March 2005 caused the important causalities, in fact landslide material was moved at least 50 m along the valley and some house were completely destroyed (Photo 6). The velocity of the transported debris material is recorded as 6 m/sec. For that reason the landslide can be classified as a destructive character.

Conclusions

The main reasons of Kuzulu landslides can be cited following articles:

1. The NAFZ is not only the earthquake zone but also landslide area due to the fact that the fault scarps lead to the deterioration of the natural balance along the steep slopes.
2. The earthquake has increased the landslide events.
3. The backward erosion of the streams toward the upper part of the mountainous areas has caused the dissecting of the topography. So the very rugged topography has formed.
4. The parent materials composed of flysch and deeply weathered volcanic tuff and the andesite supplies abundant debris materials.
5. Road construction on the steep slopes leads to the deterioration of slope stabilization.
6. Misuse of land, especially destruction of the natural vegetation cover are considerable prevent the interception of rainfall so gullies were formed on steep slopes that composed of less cohesive deposit.
7. Major causalities have occurred on the valley floor, some of the settlements that established on the valley and slope have been completely destroyed.

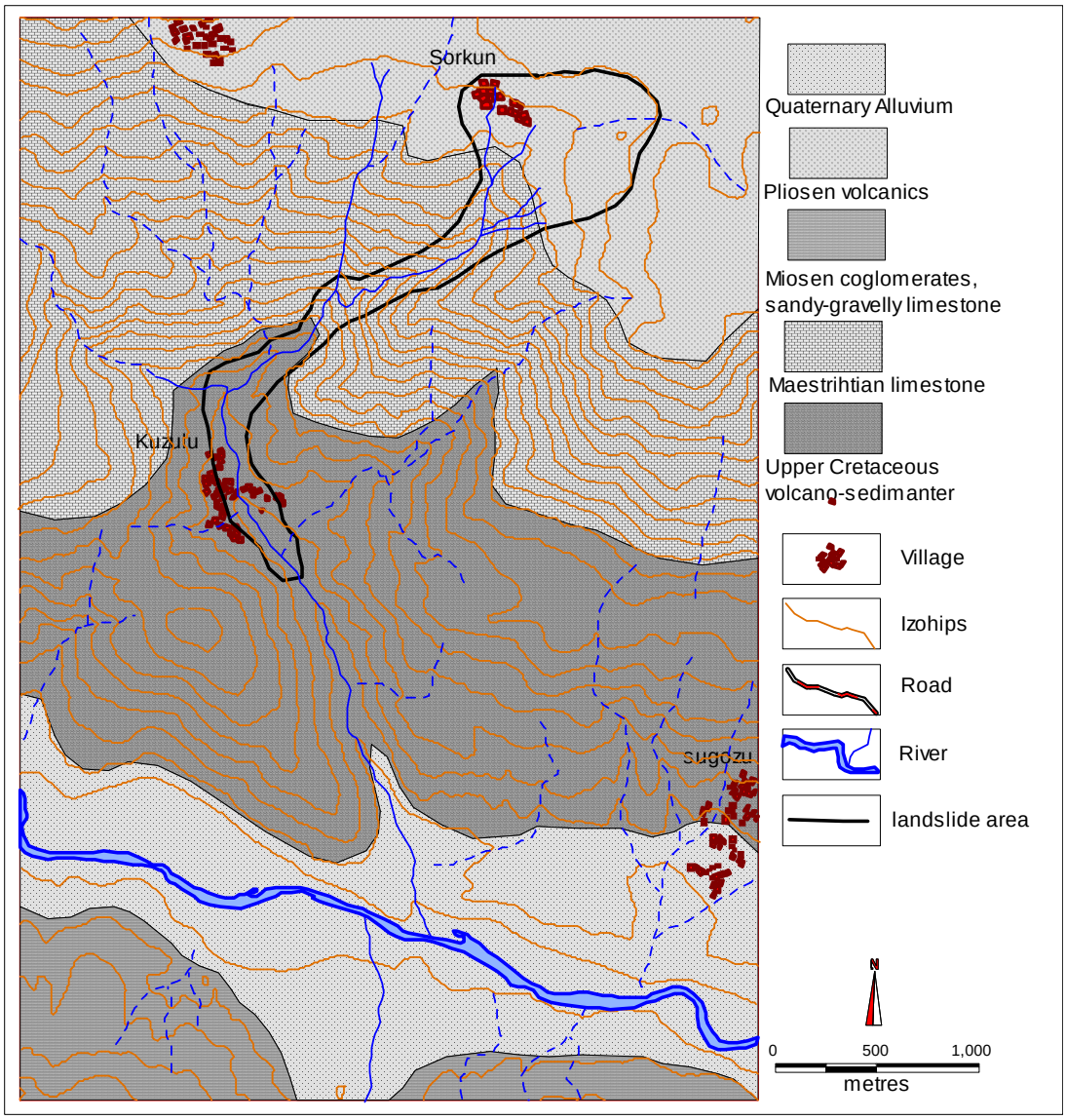


Figure 2: Topographical-geological map of landslide area

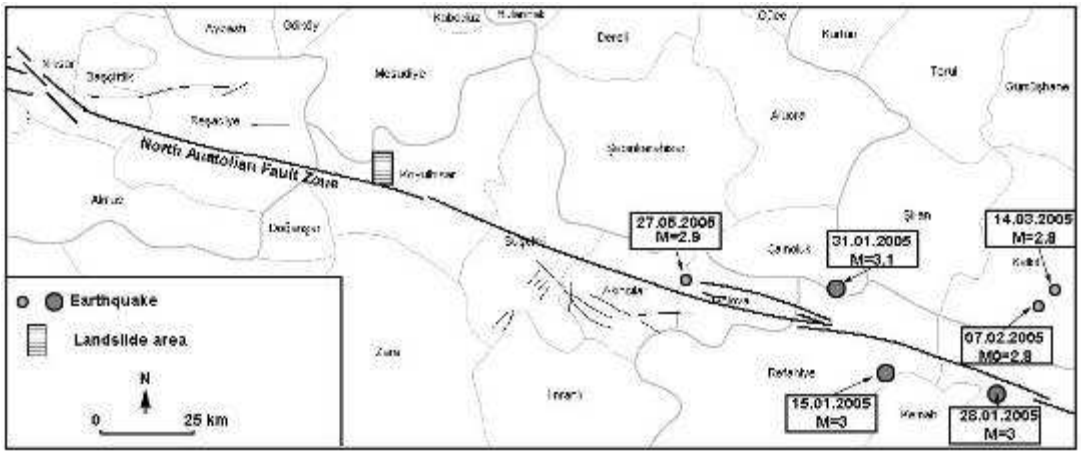


Figure 3: The earthquakes occurred along tectonic zone near to the landslide area

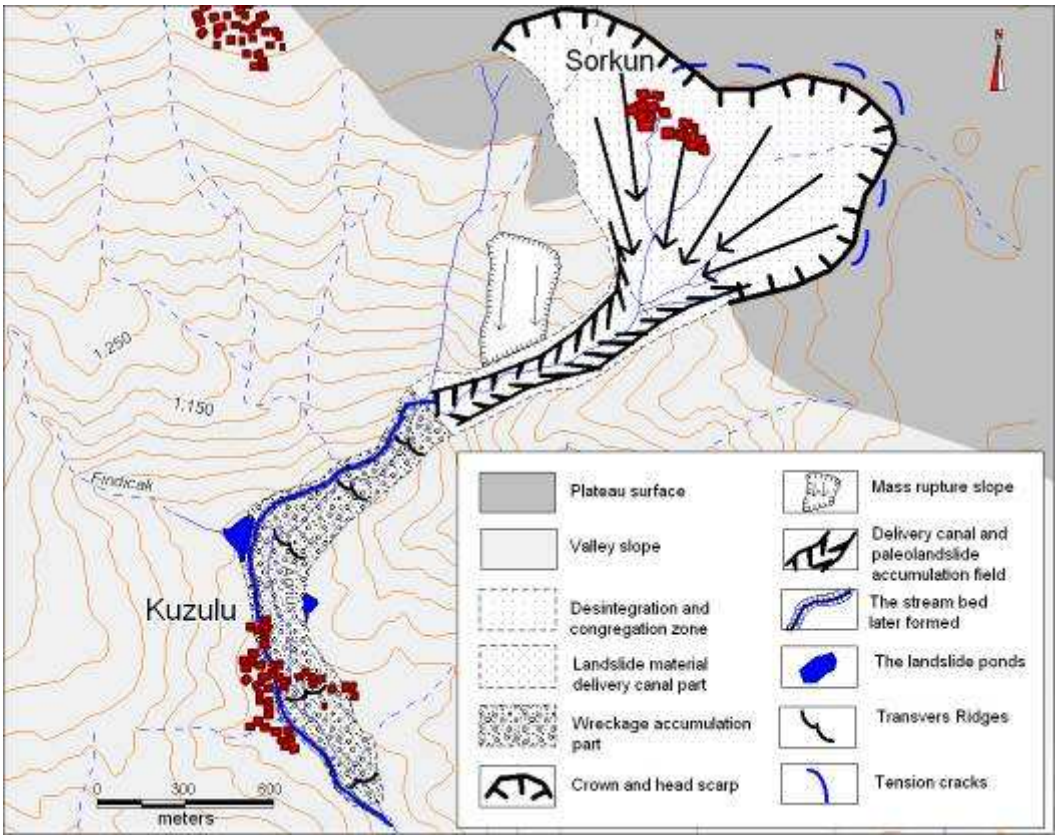


Figure 4: Geomorphological map of the landslide area

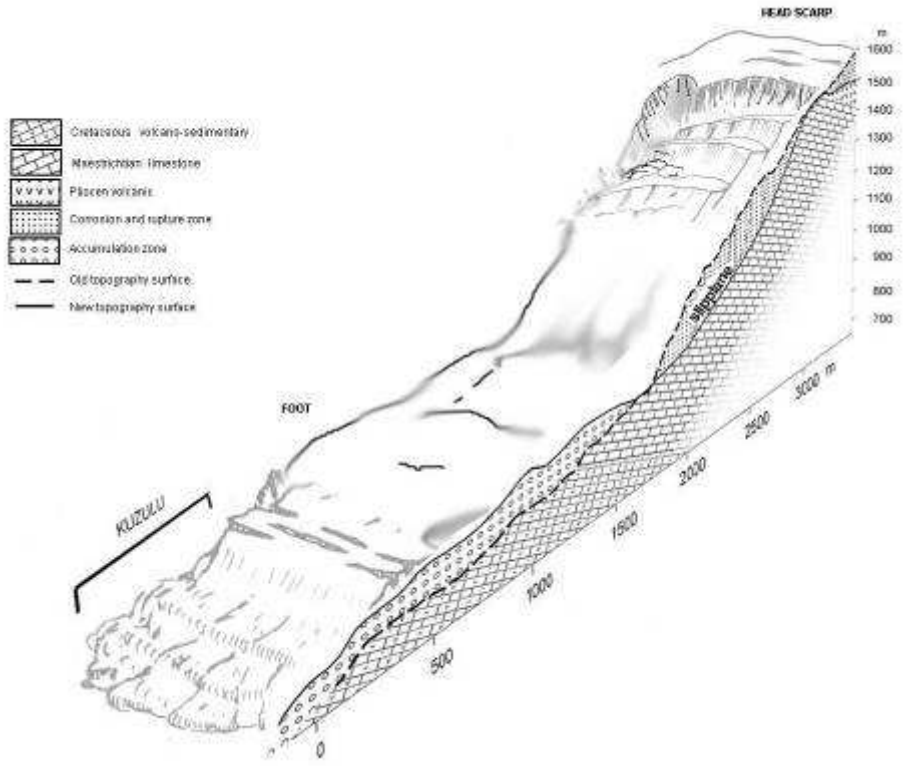
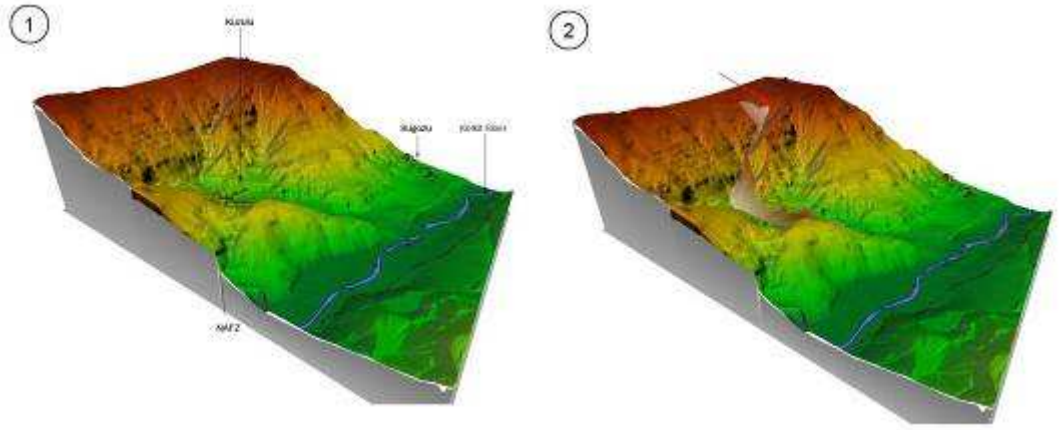


Figure 5: Geological and geomorphological 3 Dimentional drawing of the Kuzulu landslide parts.



Figure–6: 3 Dimentional views stimulated by digital elevation modelling before and after the Kuzulu Landslide.

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