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Geotechnical assessment of the 2005 Kuzulu landslide (Turkey)

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Abstract

In this study, a complex landslide, which occurred on 17 March 2005 near Koyulhisar town of Sivas Province of Turkey, is presented. The landslide resulted in 15 deaths and the destruction of about thirty houses at Kuzulu village. The main aims of this study are to assess the landslide in terms of engineering geology and geotechnics, to back-analyze the landslide in the source area, and to estimate its motion and destructive forces on structures. Furthermore, the effect of a future earthquake on stability condition of the mobilized but not completely failed mass adjacent to the right flank of the landslide is also investigated. Field observations, eyewitnesses, geomechanical laboratory tests, interpretations on pre-event aerial photographs and analyses using different approaches have been fundamentals of this study. Site observations indicate that the initial landslide in the source area occurred in highly weathered volcanics along a failure surface passing through the volcanics and along the interface between the volcanics and underlying limestone. Then the movement transformed into an earth flow and moved down through a V-shaped channel in the underlying limestone about 2 km until it stopped at a small settlement, which is called Kuzulu. Site observations and back-analysis of the initial slide suggest that the most likely cause should be water pressure increase as it is the season of snow melting and thawing of the groundwater. Interpretations on pre-event aerial photographs and the information obtained from eyewitnesses indicated that slope movements in the study area, where old landslide topography is evident, were continuing for many years. The simulation of the landslide with consideration of Bingham type yielding criterion together with water pressure variation suggested that the maximum velocity of the earth flow was 14.4 m/s and 13.6 m/s when it reached Kuzulu. Furthermore, this evaluation showed that the earth flow reached Kuzulu after 300 s, which is consistent with the information obtained from local people. The impact of the earth flow on the structures could be about 170 kPa against which only reinforced concrete structures may resist. Dynamic analyses suggested that a future earthquake, which may occur in the region, may result in a complete failure of the unstable mass remaining at the source area.

Keywords: Back analysis; Earth flow; Earthquake; Impact force; Kuzulu (Sivas, Turkey); Landslide; Snow melting

1. Introduction

Large landslides are often characterized by a complex style of activity (Cruden and Varnes, 1996) due to their capability to suddenly change behavior. Such landslides can pass from a slump to a flow characterized by relatively high mobility in terms of both velocity and run out (i.e. Hungr, 1995; Crosta, 2001) But the modeling of these failures is generally difficult because they prevent direct observation of the phenomenon during its evaluation. The most recent, large and catastrophic

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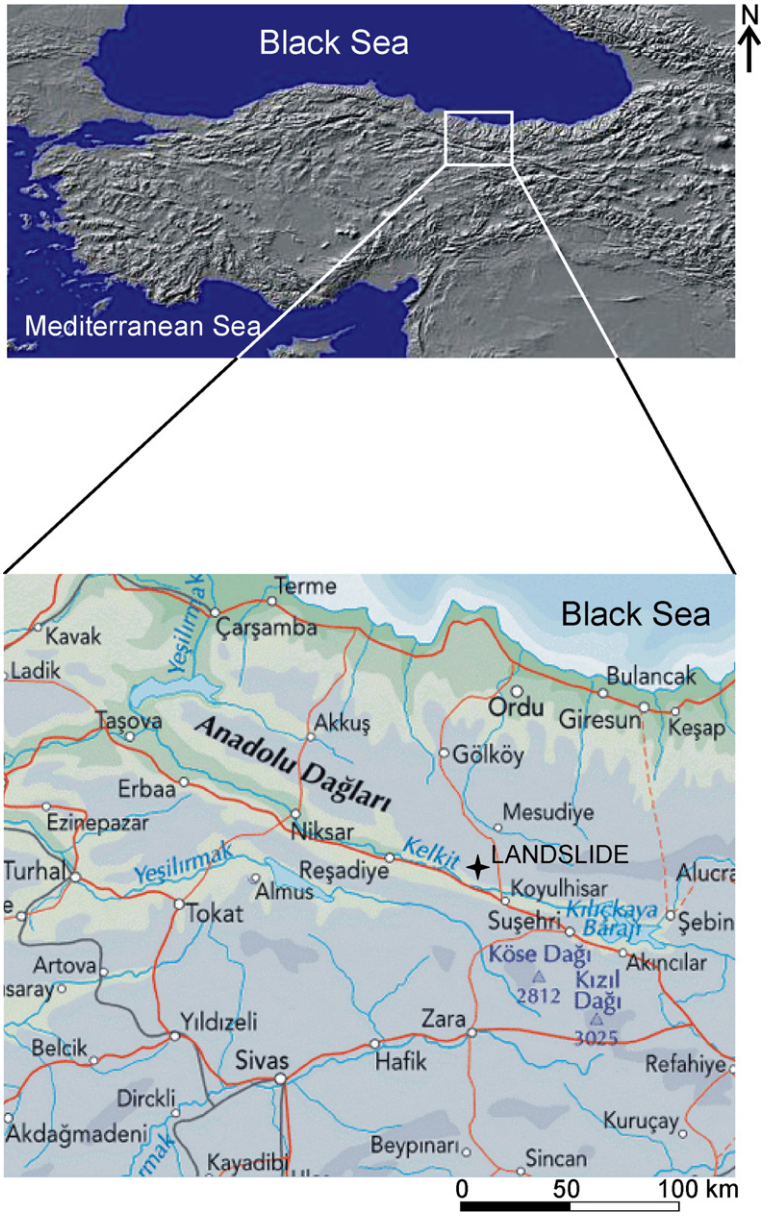

Fig. 1. Location map of the Kuzulu landslide.

complex landslide occurred in Turkey on 17 March 2005 near the Sugözü village of Koyulhisar town (Sivas, Central Anadolu) and destroyed Kuzulu village. The landslide initiated within highly weathered volcanics in the mode of sliding and then transformed to an earth flow. It killed 15 people, and more than 30 houses and a mosque were buried and damaged by the earth flow material. A second but smaller landslide originated from the same source areas after 4 days and caused additional damages. Just after the main event, the governor of the province established an investigation committee consisting of members from two universities and the General Directorates of Mineral Research and Exploration (MTA), State Hydraulic Works (DSI), and Highways (TCK) on the scale and effects of the landslide (http://www.sivas.gov.tr/koyulhisar/bilim.htm). Then Gokceoglu et al. (2005) paid attention to the factors conditioning this landslide and its environmental impacts, and produced a landslide-susceptibility map of the landslide area and its close vicinity using the conditional