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Integrated geochemical, geoelectrical, and UAV-based methods for analyzing the Güzelyalı landslide (Çanakkale, Türkiye)

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Abstract: The number of reactivations increased in the Güzelyalı-Erenköy landslide area after 2013 in Çanakkale, Türkiye, where historical landslide activity has been recorded since 1875. This area is home to numerous summer residences and experiences ongoing slow-moving landslide activity along a 400-m-long slope, extending from the heavily trafficked Çanakkale-İzmir highway to the coastline. In this study, the nature of the reactivations was evaluated by considering the conditioning and triggering factors that contributed to the landslide. The evaluation was based on geochemical analyses, field observations, geoelectric measurements, and unmanned aerial vehicle (UAV) data. The results revealed that the sliding occurred along a moist slip surface, rich in various clay minerals such as illite, montmorillonite, and vermiculite, at a depth of approximately 4.5 m, as determined by ERT (Electrical Resistivity Tomography). Vertical movements within the landslide area, including rises and subsidences, accounted for changes of up to 0.1 m between 2013 and 2023. Chemical Index of Weathering (CIW), Chemical Index of Alteration (CIA), and Plagioclase Index of Alteration (PIA) calculations obtained from the X-ray fluorescence (XRF) spectroscopy analysis indicate that the sliding surface is subjected to strong weathering, and these values are compatible with the X-Ray diffraction (XRD) data.

Key words: Güzelyalı landslide, UAV monitoring, geoelectrical slip detection, landslide reactivation

1. Introduction

Besides the slope and subsurface geometry of the sliding surface, the presence of the clayey layer on the sliding surface has a facilitating effect in the development of landslides (Morgenstern and Tchalenko, 1967; Gillott, 1987; Shuzui, 2001; Wen and Aydin, 2003). The slip surface can be fault planes (Tibaldi et al., 1995; Hart et al., 2012), subhorizontal planes of joint sets (Ekinci et al., 2013), and bedding surface of fold limbs (Wang et al., 2003; Chang et al., 2005; Tsou et al., 2011). This plane of structural weakness allows precipitation and snowmelt waters to penetrate significant depths and the slip surface is covered with a clayey layer due to the weathering over time. Claying is visible evidence of intense weathering at the sliding surface, and the increase in water content, decrease in permeability and increased clay formation constitute the preliminary cause of many landslides developing along weak zones (Skempton and Petley, 1967; Koor et al., 2000). The clay unit that makes up the slip surface can be a combination of multiple types in some cases, so the movement can be triggered due to a interaction of different clay types (Erginal et al., 2009). For example, smectite, kaolinite and illite type clays detected on tuff bearing units interbedded with lignite in an open pit excavation area in Türkiye (Bayhan et al., 1993) gave rise to serious rotational landslides along pre-existing fault planes (Erginal et al., 2008).

Especially in settlements developed on a clay-rich geological sequence prone to landslides and slope failures cause significant deformations. Therefore, it is very important to know the clay types of the critical slip planes where the landslide develops and the subsurface geometry of the clay-covered slip plane before stability analysis and remedial works. Geophysical methods provide very concrete data in this respect in terms of determining the location and geometry of the deep sliding surface based on the electrical resistivity differences from the surface to the deep (Hack, 2000; Jongmans and Garambois, 2007). One of the most used in-situ methods in determining the sliding surface and clayey and water-rich units in landslide surveys is the electrical resistivity tomography (ERT) technique, which is highly preferred in shallow geophysical studies (Ekinci et al., 2013; Perrone et al., 2014). ERT with a wide range of investigation depths is the primary geophysical

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