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Combination of discontinuity characteristics and GIS for regional assessment of natural rock slopes in a mountainous area (NE Turkey)

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ABSTRACT

Geographical Information Systems (GIS) have a very large spectrum of users. As in many engineering applications, GIS are frequently used in geotechnical projects, especially in producing various thematic and zoning maps such as various susceptibility and hazard maps. Instability maps for large areas with similar characteristic can be produced in a practical way by evaluating the results obtained by the data collected from field and laboratory studies.

In order to introduce a methodology for producing rock slope instability maps for a large area, discontinuity controlled slope failures in the Köse Granitoid Complex (NE Turkey) were selected. To determine the types of failure such as planar, wedge, and toppling, and possible instable slope orientations kinematic analyses were carried out in the limited areas. The relationships between orientations of natural slopes and discontinuities obtained from kinematic analyses were evaluated with GIS software. Finally, discontinuity controlled instability maps were produced for the study area.

Resulting maps show that the most common type of failure is wedge type. Additionally, the distributions of unstable areas along road networks were determined. Various land use types such as agriculture, grassland, settlement, and forest were also classified in order to predict the possible effects of slope instabilities. The methodology introduced in this study indicates highly promising results for the assessment of rock slope instability in large areas.

1. Introduction

The most important part of any slope design study is stability analysis. A safe and economical slope design can be produced only if data are realistic and representative, and the most suitable stability method is chosen. There are many types of stability analyses for rock or soil slopes. The most popular methods for soil slope analysis include those by Fellenius (1936), Bishop (1955) and Janbu (1954). Kinematic analyses are used for preliminary design of rock slopes (Hoek and Bray, 1981; Goodman, 1989; Wyllie and Mah, 2004). Limit equilibrium and numerical analyses are used for slope designs in more complex settings. The most important factors in the selection of an analytical method are geotechnical characteristics of the material constituting the slope (rock or soil) and failure mechanics. A reliable slope design can be achieved only through stability analyses conducted in due consideration to these two factors.

In studies on the stability of rock slopes, the kinematic analysis method is commonly used. Some researchers prefer using limit equilibrium and numerical analysis in addition to kinematic analysis, and perform stability analysis for local areas (Gurocak et al., 2008; Gischig et al., 2011; Alemdag et al., 2014, 2015; Kaya et al., 2016; Kaya, 2016; Gurocak et al., 2017). Additionally, some researchers have produced probabilistic and GIS-based risk maps, by using probabilistic analysis, fuzzy inference systems, as well as other commonly used methods (Gökçeoğlu et al., 2000; Yoon et al., 2002; Park et al., 2016).

The present study aims at generating instability maps, and determines the distributions of possible slope instabilities on land use and along the road network in the Köse Granitoid Complex, which includes intensely jointed and moderately weathered rocks cropping out in an area of ~250 km^2 (Fig. 1). Field and laboratory work were conducted, and resulting data were analyzed utilizing the kinematic method. Results were evaluated to produce possible discontinuity controlled slope instability maps for the whole area of the Köse Granitoid Complex. In the final stage, the produced maps have been used to determine the

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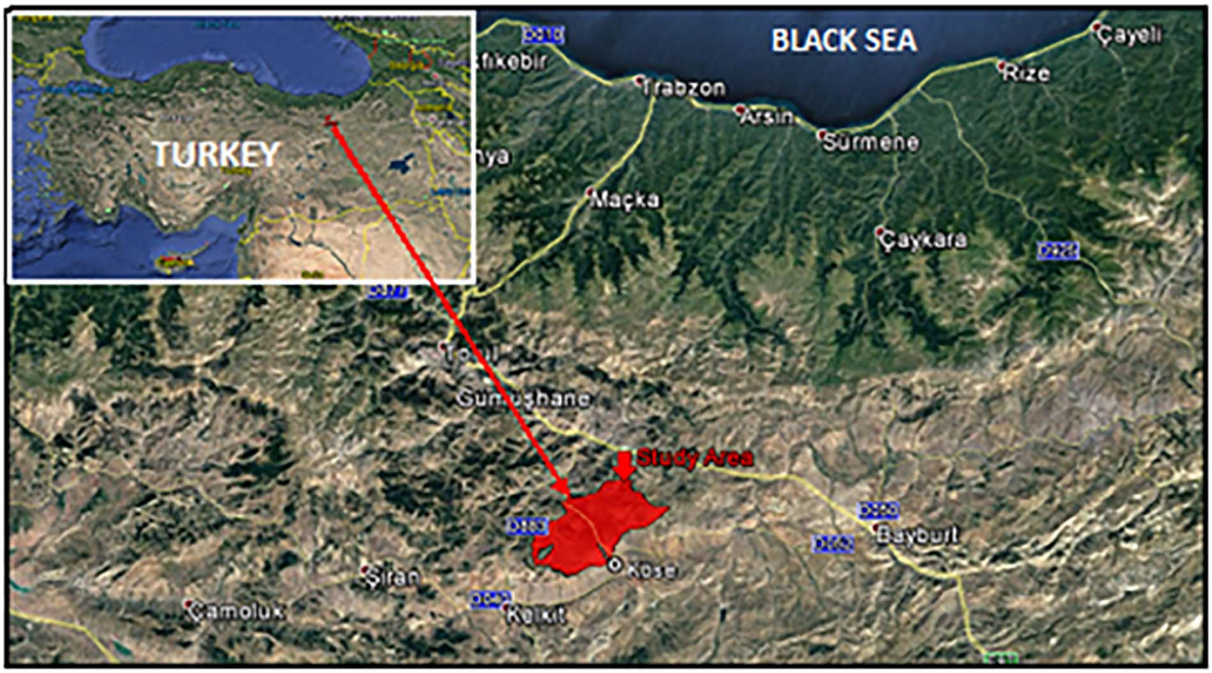

Fig. 1. Location map of the study area.

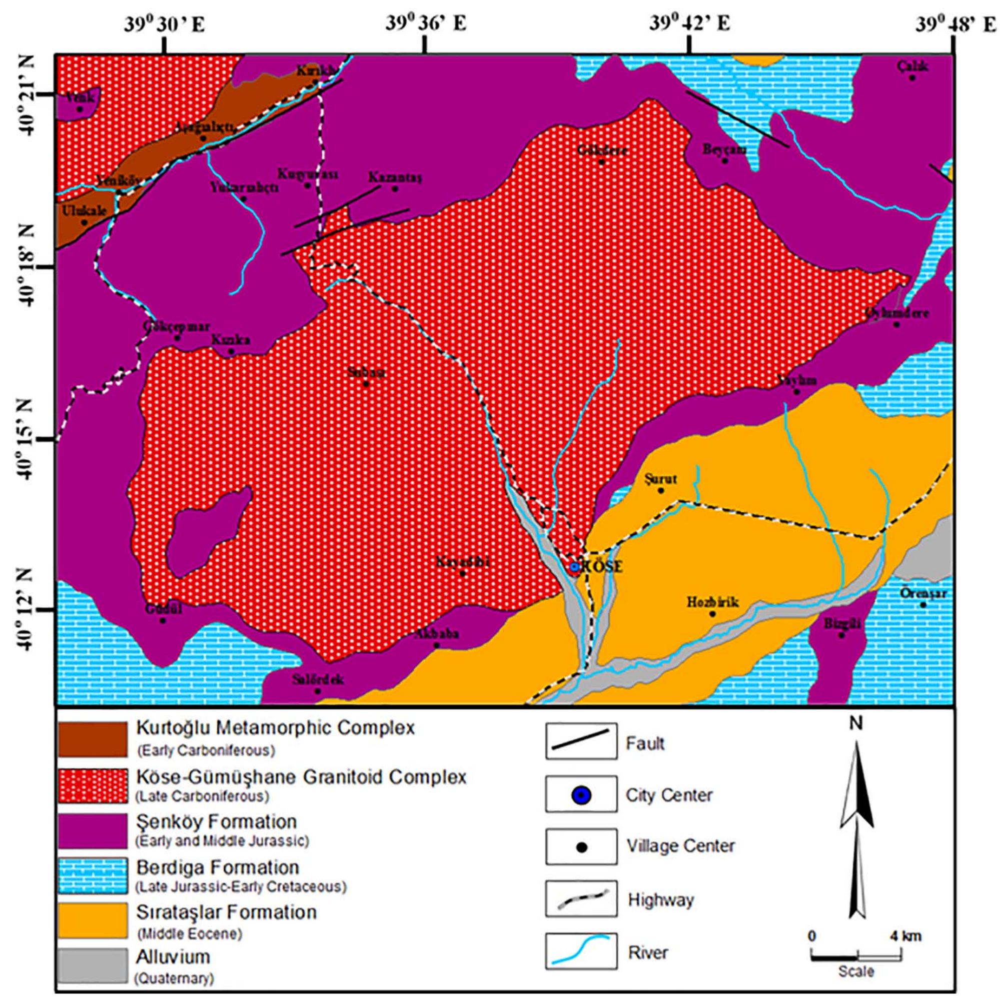

Fig. 2. Geological map of study area, modified after Güven (1993).