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Estimation of engineering properties of selected tuffs by using grain/matrix ratio

Mustafa Korkanç*, Burak Solak

Niğde University, Geological Engineering Department, 51245 Niğde, Turkey

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ABSTRACT

Petrographic properties of rocks substantially affect their physical and mechanical properties. In the present study, for the purpose of examining the relationship between the petrographic and geomechanical properties of pyroclastic rocks, fresh samples were taken from tuffs of different textural properties that have wide distribution in Cappadocia region. Experimental studies were conducted on 20 fresh samples to determine their engineering properties through petrographic examinations. Dry and saturated unit weights, water absorption by weight, effective porosity, capillary water absorption, slake durability index, P-wave velocity, point load index, uniaxial compressive strength and nail penetration index of the samples were determined. Higher geomechanical values were obtained from the samples of Kavak tuffs affected by hydromechanical alteration and by tuffs with high welded rates. On thin sections prepared with the fresh samples, petrographic studies were carried out by using a point counter with a polarizing microscope, and mineral composition, texture, void ratio, volcanic glass presence and state of these fragments within the rock, secondary mineral formation and opaque mineral presence were determined. Grain/matrix ratio (GMR) was calculated by using the ratios of phenocrysts, microlites, volcanic glass, voids and opaque minerals after point counting on thin sections. A potential relationship between the petrographic and geomechanical properties of fresh samples was tried to determine by counting correlation analysis. Such a relationship can be significantly and extensively suggestible for engineering applications. For this purpose, we used the poorly-welded Kavak and densely-welded Kızılkaya tuff samples in our study.

1. Introduction

The study area is within the borders of Cappadocia Volcanic Province (CVP) where extensive Miocene, Pliocene and Quaternary volcanism has occurred (Fig. 1). In CVP, volcanism consists of an extensive tuff field characterized by fairy chimneys formed through weathering processes. Due to its unique historical and cultural heritage, CVP is a region of exceptional natural wonders and also attracts geologists' attention. Within the scope of this study, intensive field surveys were carried out within the provincial borders of Niğde and Nevşehir. Detailed volcanological, geochemical and geochronological studies were conducted on the region by researchers such as Besang et al. (1977), Batum (1978), Innocenti et al. (1975, 1982), Pasquare et al. (1988), Ercan et al. (1990, 1992), Toprak and Göncüoğlu (1993), Le Pennec et al. (1994), Mues-Schumacher and Schumacher (1996), Temel et al. (1998), Türkecan et al. (2003), Le Pennec et al. (2005), Viereck et al. (2006), Aydar et al. (2012).

However, the number of studies focusing on the building material properties of the tuffs in the region and their strength and weathering properties is more limited (Erguvanlı and Yüzer, 1977; Erdoğan, 1986; De Witte et al., 1988; Topal, 1995; Topal and Doyuran, 1997; Gökçeoğlu et al., 2000; Korkanç, 2007). Recent studies, on the other hand, are mostly concerned with the stability and engineering properties of the underground openings of the region's tuffs, opened for various purposes both in the past and the present (Aydan et al., 1999; Ulusay et al. 1999, 2006, 2013; Ulusay et al. 2013; Aydan and Ulusay, 2013; 2003).

Use of tuffs as building stones is common all around the world due to their ease of processability. The number of studies that focus

* Corresponding author.
E-mail address: mkorkanc@nigde.edu.tr (M. Korkanç).

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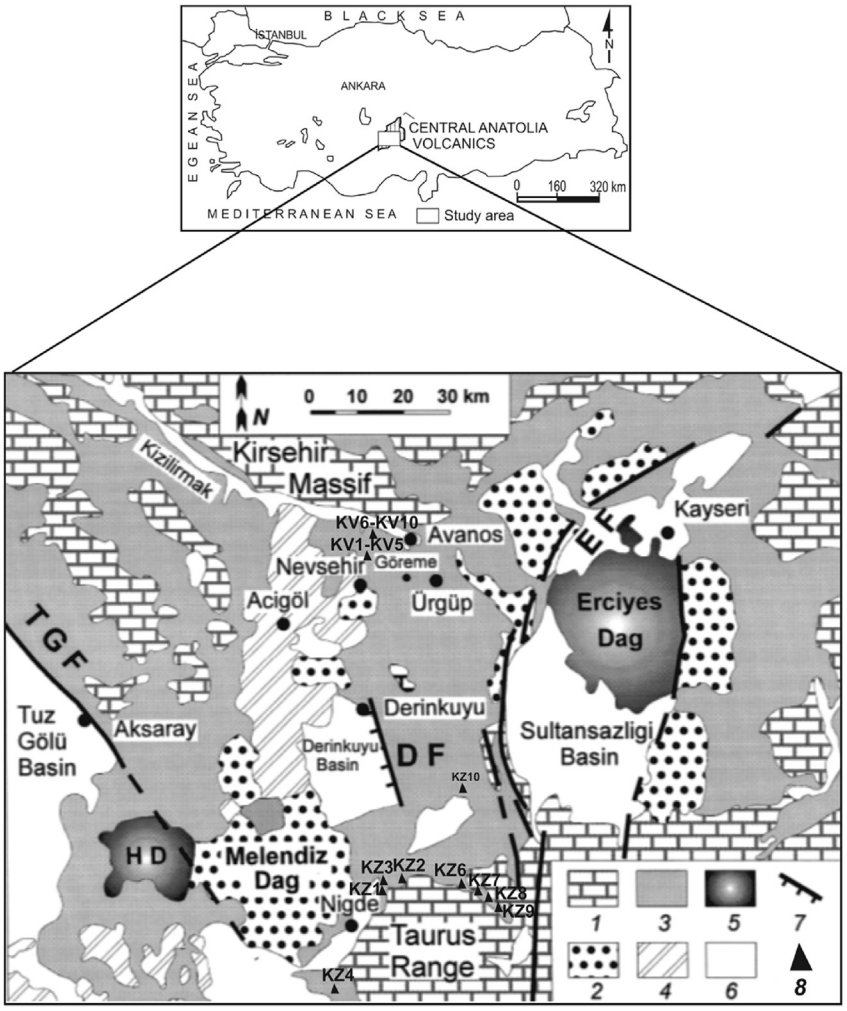

1. Basement rocks, 2. Major Miocene-Pliocene volcanic complexes, 3. Ignimbrites and contemporaneous continental sediments, 4. Mainly monogenetic Quaternary volcanism, 5. Large Quaternary volcanoes, 6. Quaternary alluvium, 7. Major Neogene to Quaternary faults (TGF: Tuz Gölü Fault, EF: Ecemis Fault, DF: Derinkuyu Fault), 8. Sampling location.

Fig. 1. Geological map of the Cappadocia region (after Le Pennec et al., 1994).

on the petrographic and geomechanical properties of these kinds of rocks has increased in recent years (Moon, 1993a, 1993b; Streck and Grunder, 1995; Soriano et al., 2002; Quane and Russell, 2004; Öner et al., 2006; Yaşar et al., 2009; Koralay et al., 2011; Türkdönmez and Bozcu, 2012; Korkanç, 2013). The strength properties of rocks are affected by their mineralogical and textural features (Hartley, 1974; Ramana et al., 1986; Tuğrul and Zarif, 1999; Arel and Tuğrul, 2001; Akesson et al., 2001; Rigopoulos et al., 2010, 2011; Ündül and Tuğrul, 2011; Ceryan, 2014; Fener and İnce, 2015). Tuğrul and Zarif (1999) stated that physical and mechanical properties of rocks are connected with their mineralogical and textural properties. In this context, they aimed to find significant relations between the engineering properties and petrographic properties of granitic rocks. Basing on the findings they obtained, it was reported that in comparison with mineralogical properties, textural properties are more effective on engineering parameters. The authors also reported that, in addition the types of crystal contacts, fragment forms and sizes significantly affect the engineering properties of granitic rocks. Ulusay et al. (1994) revealed that the influence of textural characteristics appear to be more important than mineralogy for predicting engineering properties. It is also noted that type of contacts, grain shape and size, rock fragments with packing density and proximity are the petrographic characteristics which have significant influence upon engineering properties of the sandstones. Petrographic characteristics known to affect mechanical properties of sandstones include grain size, packing density, packing proximity, degree of grain interlocking, void space, and mineral composition (Shakoor and Bonelli, 1991). Heidari et al. (2013) showed that textural characteristics are more important than mineral compositions for predicting engineering characteristics.

In this study the authors aim to determine how the petrographic properties of tuffs that exhibit varying colours and textural properties change, and the effect of these petrographic properties on engineering properties of tuffs. Rocks of varying colours and textures determined during field studies and petrographic analyses were sampled and examined in detail. Basing on the petrographic analyses obtained, a grain/matrix ratio was calculated and the possible relationship between this ratio and geomechanical properties was tried to be determined.