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Petrographic and geochemical characteristics of upper Miocene Tekkedag volcanics (Central Anatolia—Turkey)

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ABSTRACT

The Tekkedağ volcanic complex, which extends as a ridge in the direction of NW–SE, is one of the poorly known volcanic centers and is exposed to the southwest of Kayseri located within the Central Anatolian Volcanic Province (CAVP) of Turkey. The mineralogical composition of Tekkedağ volcanics reveals an assemblage of plagioclase (labradorite, bytownite)+pyroxene (augite, diopside and enstatite)+Fe–Ti oxide (magnetite, rutile) ± olivine (forsterite) mineral composition having hypocrystaline porphryric, hypohyaline porphryric, gleomeroporphryric and seriate textures under the microscope. Confocal Raman Spectroscopy (CRS) has been used to define the mineral types. Tekkedağ volcanics have medium K_2O contents and are calc-alkaline in character. Geochemically, Tekkedağ volcanics show a narrow range of major element compositions and are classified as augite andesite/basaltic andesite. On the variation diagrams based on MgO versus major and trace elements, they show good positive and negative correlations, indicating fractional crystallization of plagioclase, clinopyroxene and Fe–Ti oxide. Tekkedağ volcanics display enrichment in large-ion lithophile elements (LILEs) relative to high field-strength elements (HFSEs) in chondrite, MORB, E-MORB and lower crust normalized multi-element diagrams. In all normalized multi-element diagrams, the trace element patterns of all samples are similar in shape and exhibit depletions in Ba, Nb, P and Ti as characteristics of subduction-related magmas. Rare earth element (REE) patterns for Tekkedağ volcanics show REE enrichment with respect to chondrite values. They exhibit marked enrichment in light rare earth elements (LREEs) $((La/Sm)_N=4.13–4.62)$ relative to heavy rare earth elements (HREEs) $((Sm/Lu)_N=1.34–1.92)$. Furthermore, all samples have negative Eu anomalies $((Eu/Eu^*)_N=0.77–0.90)$, indicating the significant role of plagioclase in the fractional crystallization. Elemental ratios such as K/P (15.46–21.69), La/Nb (2.01–4.26), Rb/Nb (8.74–10.59), Ba/Nb (38.54–75.77), Nb/Ta (1.16–2.14), Ce/P (2.13–4.32) and Th/U (1.77–3.97) propose that the magma was subjected to conceivable crustal contamination during the evolution of these Tekkedağ volcanics. This statement is supported by the AFC modeling based on the trace elements. As a result, despite the lack of isotopic data, the petrographic and geochemical results suggest a significant role of plagioclase, clinopyroxene and Fe–Ti oxide fractionation during the evolution of the Volcanic Arc Basalts (VAB) nature of the Tekkedağ volcanics. Furthermore, these results reveal that the volcanics of Tekkedağ were produced from a parental magma derived from an enriched source of mixed subduction and/or crustal products.

1. Introduction

Turkey comprises a significant part of the Alpine-Himalayan folded belt, which is one of the most remarkable collision zones on the earth. The Neo-Tethyan Ocean, opened in the Triassic and closed in the Upper Cretaceous, played a significant part in the evolution of Turkey (Şengör and Yılmaz, 1981). This period has been called the paleotectonic period of Turkey, and it ended at the beginning of the Miocene time. A new tectonic regime developed from the Miocene to the Quaternary in Turkey, acting in the convergence and continental collision of the region. This period is referred to as the Neotectonic period. The collision of the Arabian plate with the Eurasian plate during the upper Miocene caused the lateral tectonic escape of the Anatolian block and the origination of intra-continental strike-slip faults such as the North Anatolian Fault and the East Anatolian Fault (Bozkurt, 2001). Volcanism acted with a widespread exposure during the Neogene-Quaternary in the Anatolian block and shows a close genetic connection with the tectonic events occurring during the Neotectonic period. During this period, four major different volcanic realms were formed. In terms of geographic positions, these can be classified as the Eastern Anatolian (EAVP), Central Anatolian (CAVP), Western Anatolian (WAVP) and

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Galetean Volcanic Provinces (GVP) (Fig. 1a). The Central Anatolian Volcanic Province (CAVP) is one of the most fascinating and remarkable areas. There are several volcanic products and huge volcanic forms that are well-preserved, such as the Erciyes and Mount Hasan stratovolcanoes. The Neogene-Quaternary volcanism in Central Anatolia has already been investigated by numerous researchers, mainly with a focus on the geologic, petrographic, tectonic and geochemical characteristics (Beekman, 1963; Pasquare, 1968; Ayrancı, 1970; Keller, 1974; Innocenti et al., 1975, 1982; Batum, 1978a, b; Ercan, 1987; Pasquare et al., 1988; Ercan et al., 1990, 1991; Druitt et al., 1995; Notsu et al., 1995; Aydar and Gourgaud, 1998, 2002; Deniel et al., 1998; Kürkçüoğlu et al., 1998; Temel et al., 1998; Toprak, 1998; Dirik, 2001; Yurtmen and Rowbotham, 2002; Şen et al., 2003; Kurt et al., 2004; Koralay, 2006; Koralay et al., 2007; Koralay and Kadıoğlu, 2008; Güçtekin and Köprübaşı, 2009; Kürkçüoğlu, 2010). According to these researchers, the volcanic activity in the region can be divided into three stages according to Rb–Sr, K–Ar and Ar–Ar dating:

- The first stage is mainly characterized by the domes and lava flows of andesitic composition. The age of the volcanic products of the first period varies between 13.5 and 8.5 Ma.
- The second stage is described by the extensive non-welded or welded ignimbrite units with rhyolite to dacite compositions, and it occurred in the time interval from 8.5–9 to 2.7 Ma.
- The third stage is represented by the development of the stratovolcanoes (Erciyes, Mount Hasan) and several monogenetic volcanic centers. The age of the latest lava flows from this stage was determined to the interval of 0.7–0.27 Ma.

All researchers consider that a characteristic calc-alkaline volcanism took place during the Middle Miocene-Quaternary time and those convergence phenomena, which are also responsible for the origin of the calc-alkaline volcanism in the Central Anatolia, occurred between the Arabian and Eurasian plates. Previous studies related to the evolution of the Tekkedağ volcanics are very limited in terms of geochemistry and petrogenesis.

Although there are well-documented individual volcanic centers and huge stratovolcanoes in Central Anatolia, small volcanic centers such as Tekkedağ have not been investigated in detail so far. To the best of our knowledge, no prior geochemical

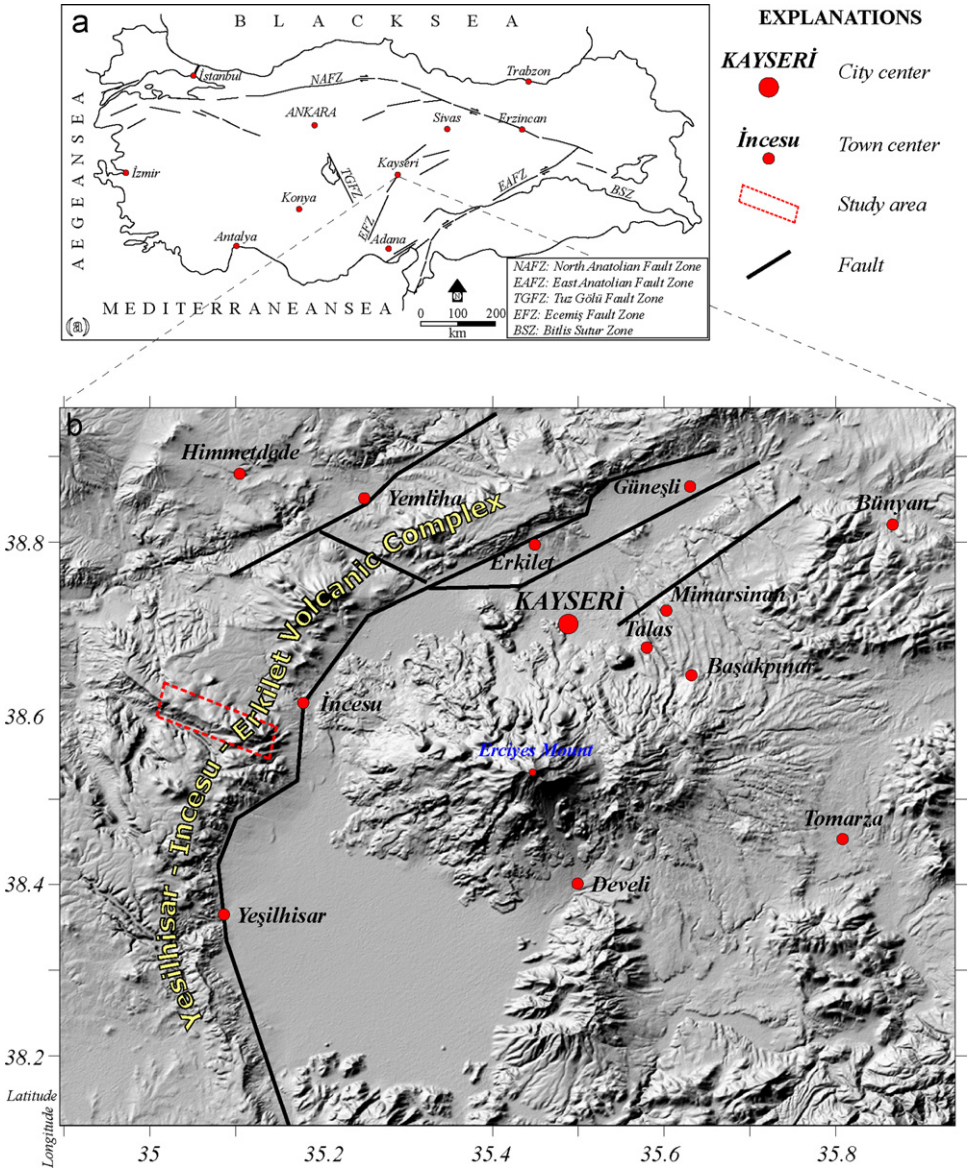

Fig. 1. (a) Simplified tectonic map of Turkey showing the distribution of major neotectonic structures and (b) Digital Elevation Model (DEM) of the investigated area.