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Mineral Chemistry and Petrography of Lava Successions From Kepsut-Dursunbey Volcanic Field, NW Turkey: Implications For Magmatic Processes and Crystallization Conditions

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***Abstract*—**Kepsut-Dursunbey volcanic field (KDVF) is located in NW Turkey and contains various products of the post-collisional Neogene magmatic activity. Two distinct volcanic suites have been recognized; the Kepsut volcanic suite (KVS) and the Dursunbey volcanic suite (DVS). The KVS includes basaltic trachyandesite-basaltic andesite-andesite lavas and associated pyroclastic rocks. The DVS consists of dacite-rhyodacite lavas and extensive pumice-ash fall and flow deposits. Petrographical features (i.e. existence of xenocrysts, glomerocrysts, and mixing-compatible textures) and mineral chemistry of phenocryst assemblages of both suites provide evidence for magma mixing/AFC. Calculated crystallization pressures and temperatures give values of 5.7–7.0 kbar and 927–982 °C for the KVS and 3.7–5.3 kbar and 783-787°C for the DVS, indicating separate magma reservoirs and crystallization in magma chambers at deep and mid crustal levels, respectively. These observations support the establishment and evolution of KDVF magma system promoted by episodic basaltic inputs which may generate and mix with crustal melts.

***Keywords*—**mineral chemistry, mixing, basaltic inputs, NW Turkey

I. Introduction

TURKEY is situated in the Alpine-Himalayan mountain belt between the continents of Eurasia and Africa and has a complex geology as a result of the collision between these major continents. In western Turkey, the terminal continental collision following the closure of the Tethys Ocean was followed by extensive magmatism which initiated around the Eocene and lasted almost continuously to prehistoric times ([1], [2], [3], [4]). Post collisional magmatism produced a wide range of magmatic associations, including plutonic, hypabyssal and volcanic rocks, which are closely related in space and time to tectonic processes ([5], [6], [7], [8], [9] and references there in).

The nature, origin, and evolution of the Neogene volcanism in NW Turkey have been the subject of many studies focusing on the whole-rock geochemistry and petrogenesis of the magmatic rocks (e.g. [2], [10], [7], [5], [11], [12], [9], [13] etc.). However, there are very few published mineralogical and petrographical data on any of the lava successions of W Turkey. (e.g. [14], [15]).

The Kepsut-Dursunbey volcanic field is located in NW Turkey and comprise lavas represented by various compositions ranging from basaltic andesite to rhyolite and associated pyroclastics (Fig. 1). The knowledge on the volcanic rocks of study area is limited. Previous works have provided some introductory geological and geochemical information about the study area (e.g. [16], [17], [18], [19]). Studies establishing the volcanic successions, descriptions of the volcanic episodes, constraining evolution of magma conduit system and storage conditions are lacking in this area. Their petrogenetic characteristics are also poorly known.

This paper seeks to fill that gap by focusing on the mineral chemistry and petrography of lavas from the KDVF. In this study, as an alternative to using whole-rock geochemistry, mineral chemistry and petrographical features are used to determine crystallization conditions and magmatic processes occurring during early stages of magma evolution.

II. Analytical Methods

Mineral compositions were determined with a JEOL JXA-8900R electron probe micro analyzer in the Electron Microanalysis and Imaging Laboratory at the University of Nevada, Las Vegas. Amphibole and plagioclase analyses were conducted with a 15 kV accelerating voltage, 10 nA current, and 10 um beam diameter. Mica analyses were conducted with a 15 kV accelerating voltage, 5 nA current, and 10 um beam diameter. Natural minerals were used as standards and counting times were 30 seconds on peak and background for all elements.

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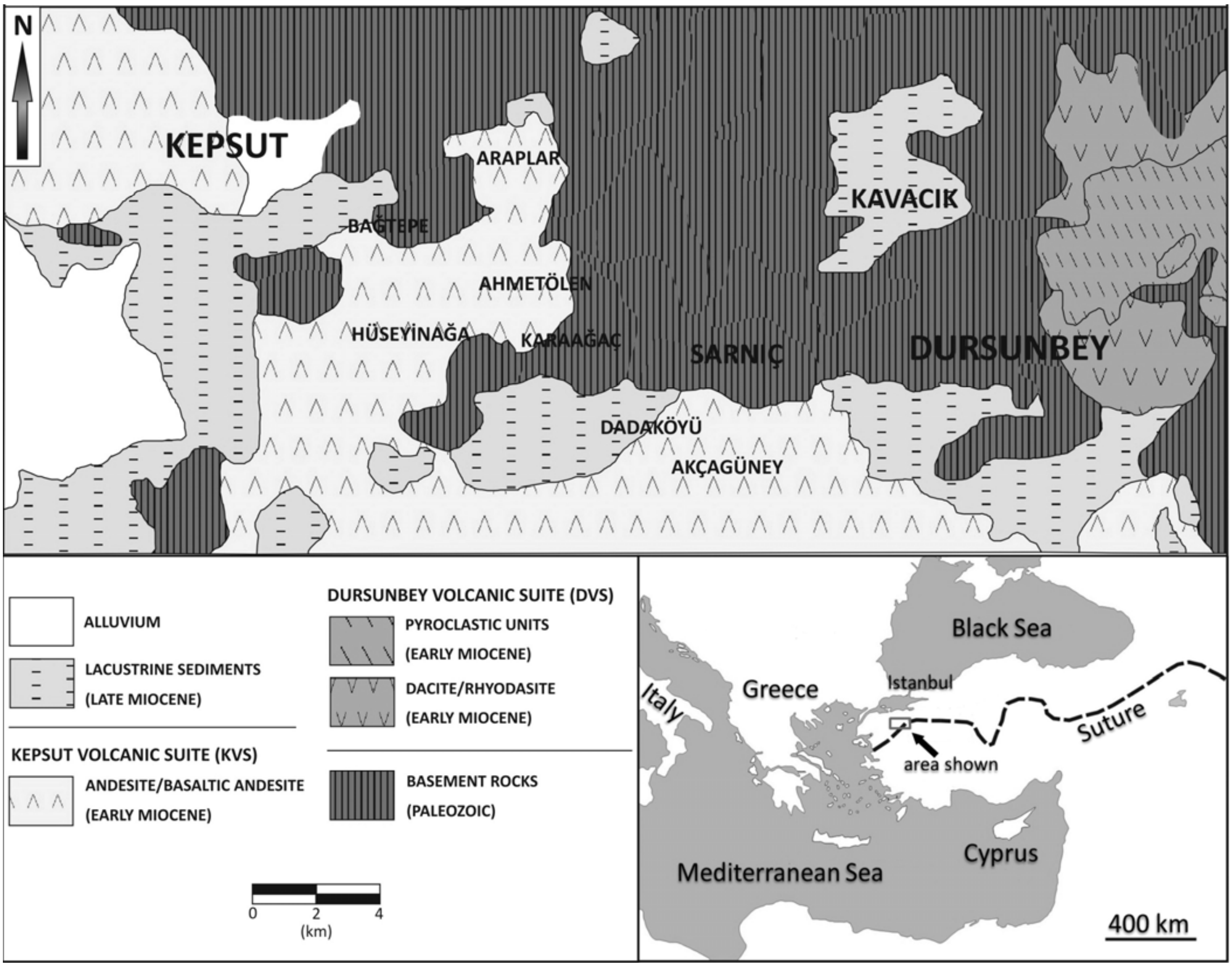

Fig. 1 Geological map of the area studied

III. Petrography and Mineral Chemistry

The andesite, basaltic andesite and basaltic trachyandesite lavas of KVS are porphyritic in texture and composed of 20-35 modal % phenocrysts. The most common phenocryst assemblage observed in this rock group is Plagioclase (60-85%), biotite (3-8%), hornblende (5-8%), sanidine (3-5%), clinopyroxene (8-10 %) and orthopyroxene (1-5%). The matrix of the basaltic trachyandesites and basaltic andesites is commonly microlithic or glassy and shows flow-related parallel alignment of microlites (Trachytic texture) in groundmass. The glomerophyric textures, in which different phenocrysts such as plagioclase, clinopyroxenes and orthopyroxenes are clustered in irregular groups, are also seen in this group.

The rhyodacite lavas of DVS consist of sanidine (20-30%), quartz (20-25%), plagioclase (20-40%), biotite (3-5%) and hornblend (3-5%). Dacite lavas of this group contain quartz hornblend (3-5%). (10-20%), plagioclase (55-80%), biotite (5-10%) and The groundmass is either glassy or microcrystalline. Many of rhyodacite lavas are devitrified and display spherolithic texture. Phenocrysts range in size up to a maximum of 4 mm.

Plagioclase is the main felsic mineral of KVS and DVS. It is euhedral, partly zoned with typical polysynthetic twinning. Compositions of the plagioclase phenocrysts and microlites of KVS and DVS lavas range from An70 to An59 and An 22 to An36, respectively. Many plagioclase phenocrystals display patchy zones and oscilatory zoning. Some KVS samples have both euhedral and rounded plagioclases indicating crystallization in different stages (Fig.2). Rounded plagioclase phenocrystals with pre-resoption zoning display post-resorption reaction rims. Synneusis and sieve textured crystals are also common in both KVS and DVS (Fig. 3, 4). In some KVS samples acidic plagioclases together with quartz

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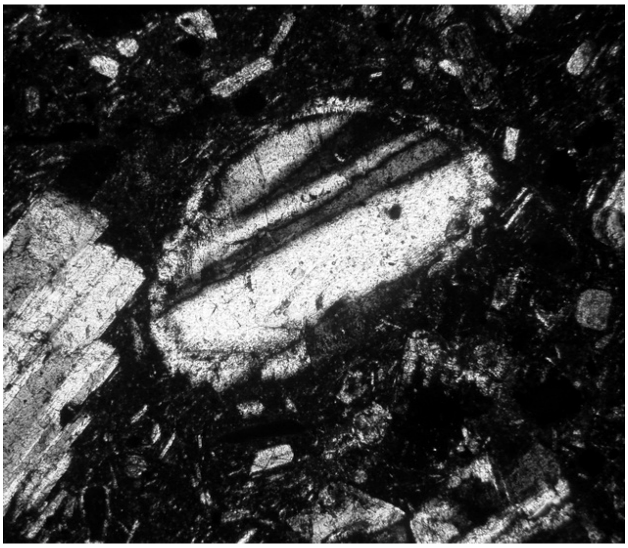
Fig. 2 Coexistence of euhedral and rounded plagioclases in KVS

represent xenocrysts from felsic phase which are surrounded by biotite and amphibole microcrystals from mafic phase.

Clinopyroxene is present in all intermediate to basic rocks of KVS. Some of them are mantled by hornblende. Its composition ranges from Wo44 En47 Fs9 to Wo32 En54 Fs14., generally represented by endiopside, augite and rarely diopside. Orthopyroxenes are characterized by enstatite and their composition range from Wo2 En78 Fs20 to Wo1.5 En71 Fs27.5 in basic rocks of KVS.

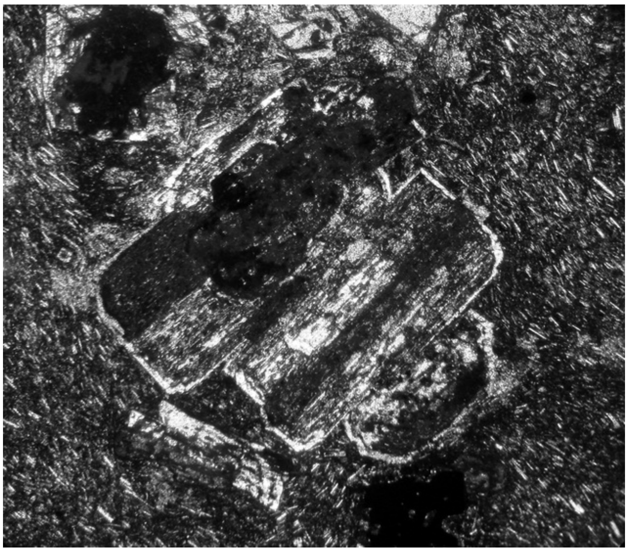
Fig. 3 Synneusis texture in plagioclase phenocrystals of KVS lavas

Biotite is common mafic mineral of DVS lavas and seen as phenocrysts and interstitial microlites in some KVS lavas. Biotite crystals of DVS are rich in Ti (3.7-4.3 wt % TiO_2) and also in Al (13.76-14.32 wt. %Al_2O_3).


Fig. 4 Sieve textured plagioclase phenocrystals in DVS lavas

Amphiboles are common mafic mineral in both DVS and KVS. They are dominanatly idiomorphic and represented by magnesio-hornblend in DVS lavas and tschermakitic hornblend- tschermakite, pargasite-pargasitic hornblend in KVS lavas (Fig 5).

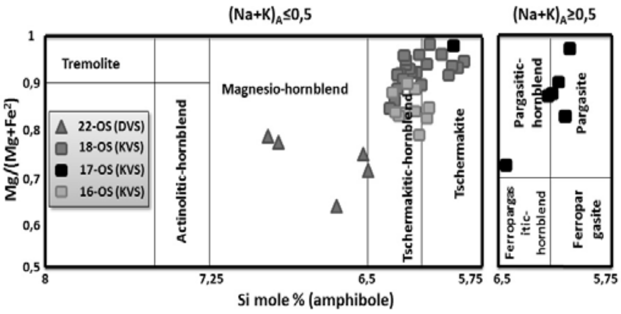

Fig. 5 Amphibole compositions of DVS and KVS lavas (after [20])

IV. AMPHIBOLE-PLAGIOCLASE THERMOMETER

Electronmicroprobe data for the amphibole and plagioclase phenocrysts from the KVS and DVS were used to calculate temperature using the equations suggested by [21]. The temperatures were calculated using rim compositions of plagioclase-amphibole pairs and uncertainty in the geothermometer is considered to be ±40 °C as proposed by Holland and Blundy (1994). Pressures for the mineral assemblages used in the temperature calculations were calculated using Al-in-hornblende method and equations proposed by different authors ([22], [23], [24], Table 1). The results obtained from the amphibole-plagioclase thermometer and Al-in-hornblend geobarometer are given in Table 1. Calculated pressures and temperatures using geothermometers/barometers give values of 5.7–7.0 kbar and 927–982 °C for the KVS and 3.7–5.3 kbar and 783-787°C for the DVS, indicating crystallization in magma chambers at deep and mid crustal levels (21km and 12km, respectively).

TABLE I
TABLE SHOWING CALCULATED CRYSTALLIZATION TEMPERATURES AND PRESSURES

Sample no	18-OS	17-OS	16-OS	20-OS	22-OS
Group	KVS	KVS	KVS	DVS	DVS
Rock name	bas. and.	bas. and.	bas. and.	dacite	rhyodacite
T (°C)	980	982	927	783	787
P (kbar)					
HZ86*	5,7	6,6	6,1	4,8	3,7
H87*	6,0	7,0	6,4	5,0	3,8
S92*	6,1	6,9	6,5	5,3	4,2
P ave.(kbar)	5,90	6,90	6,30	4,90	3,90

HZ86*= Hammarstrom and Zen 1986, H87*= Hollister et al. 1987, S92*=Schmidt 1992.

V. DISCUSSION AND CONCLUSIONS

Two distinct volcanic suites have been recognized in KDVF; the Kepsut volcanic suite (KVS) and the Dursunbey volcanic suite (DVS). Both KVS and DVS are Early Miocene in age and representative for the post-collisional magmatism in western Anatolia (Turkey).

Mainly andesites, latites, basaltic andesites and pyroclastic rocks of KVS were formed during the early stage of volcanism in the study area. Without a major interruption in the volcanism, partly contemporanously, KVS followed by an extensive felsic volcanism. Products of this phase are named as the Dursunbey volcanic suite (DVS) in this study . Rhyolithic domes, lavas and extensive pyroclastic units were formed during this volcanic activity. Pyroclastic rocks of DVS are represented by pyroclastic fall deposits and pyroclastic flow deposits. Pyroclastic fall deposits formed from ash fall, ash-block fall and pumice- ash fall deposits. Flow deposits are represented by ash-block flow deposits and ignimbrites, probably produced by explosive sub-plinian and ignimbrite forming eruptions. This was followed by basaltic trachyandesitic and basaltic dykes and lava flows in sorrounding areas.

The lavas of KDVF display textural and chemical evidence for interaction of mafic and silicic magmas. This is evidenced by disequilibrium textures such as existence of rounded plagioclase phenocrysts with reaction rims (regrowth), hornblend -mantled clinopyroxenes (corona texture), synneusis, sieve textured plagioclase, patchy zones and oscilatory zoning in plagioclase phenocrysts. Basic lavas of KVS also contains xenocrysts represented by biotite mantled quartz and asidic plagioclase ovoids and glomerocrysts entrained from melt zones near base of the crust. The observed disequilibrium textures in both suites are consistent with models involving magma mixing/AFC proposed for the origin and evolution of other continental volcanic fields ([25], [26], [27], [28] etc.). A number of recent studies indicate that such textures are present on a regional scale within the volcanic fields of Western Anatolia (e.g. [5], [15], [16]) and were probably caused by the influx of a hotter basaltic magma into the crustal magma chambers. Therefore, the mineral chemistry and petrographical features discussed in this paper, rules out closed system fractionation and suggests that the processes of mixing and AFC have played an important role in the development of the KDVF; KVS and DVS.

Mainly based on the geothermometry and barometry studies on both KVS and DVS lavas, we present a model for the evolution of KDVF. Calculated pressures and temperatures using a range of geothermometers/barometers give values of 5.7–7.0 kbar and 927–982 °C for the KVS and 3.7–4.2 kbar and 787-790°C for the DVS. Two levels of magma storage may be distinguished: deep reservoirs between 17 and 21 km and shallow reservoirs between 12 and 9 km for KVS and DVS, respectively, indicating separate magma reservoirs and crystallization in magma chambers at deep and mid crustal levels. A main deep magma reservoir served as a source for the intermediate to basic lavas of KVS. However, the existence of similar mixing-compatible (disequilibrium) textures in both KVS and DVS support the establishment and evolution of KDVF magma system promoted by episodic basaltic inputs which may generate and mix/mingle with crustal melts at different depths.

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