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Geology, Petrography and Geochemistry of the Subduction Related Volcanic Rocks, West of Konya, Central Anatolia

Orta Anadolu da Konya'nın Batısındaki dalmabatma ile ilişkili volkanik kayaçların jeolojisi, petrografisi, ve jeokimyası

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Abstract

The northwest of Konya is covered by Neogene volcanic breccias, agglomerates, tuffites, tuffs and lavas of andesite, dacite and basaltic andesite. The basaltic andesites contain about 7-10% of olivine, 3-5 % clinopyroxene, 5-10 % orthopyroxene, 60-70 % plagioclase and 5-10 % opaque minerals while the andesitic lavas include 50-60 % plagioclase, 10-15 % hornblende, 5% biotite, 2 %, clinopyroxene, 1 % sanidine, 1 % quartz and 3 % opaque minerals. Main constituents in the dacitic rocks are plagioclase (35-40%), quartz (10-15 %), hornblende (15-20 %), biotite (10-12 %), opaque minerals (2-3%) and sanidine (3 %). The plagioclase in dacites and andesitic rocks have oscillatory zoning and sieve texture .

The volcanic rocks range in composition from basaltic andesites to dacites with calc-alkaline character. Co-variation of major and trace element contents suggest fractional crystallization of hornblende, plagioclase, pyroxene and titaniferous magnetite. The plagioclase fractionation is confirmed by a slight development of negative Eu anomaly. High LREE/HREE and L1LE/ HFSE ratios show that the samples were possibly formed from a subduction-related magma at active continental margin. The strong fractionated and riched REE patterns of the rocks indicate that the formation of these rocks may have involved continental crust.

Key **Words:** calcalkaline, subduction, Central Anatolia, volcanism, Neogene

Öz

Konya'nın KB'sı Neojen yaşlı volkanik breş, aglomera, tüfit, tüf ve andesit, dasit ve bazaltik andezit lavlarıyla kaplıdır Bazaltik andezitler yaklaşık olarak % 7-10 olivin, %3-5 klinopiroksen, %5-10 ortopiroksen, %6()-7() plajiyoklaz ve % 5-10 opak mineralfenokristalleri içerirken andezitik lavlar % 50-60 plajiyoklaz, % 10-15 hornblende, %5 biyotit, %2 klinopiroksen, %1 sanidin, %1 kuvars ve % 3 opak mineral oluşmaktadır Dasitik kayaçlar %35-40 plajiyoklaz, % 10-15 kuvars, %15-20 hornblend, %10-12 biyotit, % 2-3 opak mineral, % 3 sanidin içerirler Dasit ve andezitik kayaçlar salınım zonlanma ve elek dokusuna sahiptirler

Volkanik kayaçların bileşimi bazallik andezitten dasite kadar değişir ve tipik bir kalkalkalin karakter gösterirler. Ana ve iz element içeriklerinin değişimi hornblend, plajiyoklaz, piroksen, ve titanlı magnetitin fraksiyonel kristalleşmesine ileri sürmektedir Plajiyoklaz farklılaşması zayıf negatif Eu anomalisinin gelişimi ile *doğrulanmaktadır. Yüksek LREE/HREE ve LILE/HFSE oranları çalışılan örneklerin aktif kıta kenarında dalma batma ile ilişkili bir magmadan oluştuğunu göstermektedir Kayaçların oldukça farklılaşmış ve zengin RE E grafiği bu kayaçların oluşumunda kıta kabuğunun içerildiğine işaret etmektedir.*

***Anahtar** Sözcükler: kalkalkalin, dalma-batma, Orta Anadolu, volkanizma, Ne ojen*

INTRODUCTION

The northwest of Konya in Central Anatolia is covered by products of Neogene volcanism. Location of the study area is shown on Figure 2. The volcanism in the area is suggested to be formed as a result of the continental collision (Kellet at al., 1977) . The volcanism in the area is considered to have started in the late Miocene and early Pliocene (Keller et al.,1977), producing dacite, andesite, basaltic andesite and pyroclastic rocks; all of which are calc-alcaline in composition. Temel et al.(1998) suggest that the volcanic rocks are products of assimilation and fractional crystallization (AFC) processes of a magma.

According to Keller et al. (1977), the genesis of the andesitic-dacitic magmas is related to a former subcluction zone, which became active more than 12 m.y. ago. Kurt (1994, 1996,) suggested that dacites were evolved mainly by hornblende fractionation from an andesitic parental magma under hydrous conditions at shallow levels in the continental crust. It is suggested that both crystal fractionation and magma mixing have been involved in the evolution of the dacites.

Özkan (1998) gave a detailed account of the Neogene geology and strathigraphy of the area on the basis of their fossil content.

This paper reports field relations petrographic and petrological characteristics of various Neogene volcanic rocks at northwest Konya.

GENERAL GEOLOGY

The basement of the area is Silurian-Cretaceous aged rocks, which consist of phyllite, schist, quartzite, dolomite, limestone, metavolcanic rocks, diorite, diabase, gabbro, peridodite and serpantin ite (Özcan ve diğ., 1990; Eren, 1993; Kurt, 1994). İt is unconfornıably overlain by Upper Miocene-Lower Pliocene aged Ulumuhsine formation (Eren, 1993), which is made up by limestone, limestone-mudstone alternation, marl, bands of chert and trace fossils-bearing limestone deposited in a shallow and open-lake environment, and conglomerates formed in a braided stream environment (Özkan, 1998).

The pyroclastic rocks, which consist of volcanic breccia, agglomerate, tuffite and tuffs, conformably overlaid the Ulumuhsine formation. The clasts in volcanic breccia and agglomerates, with a size ranging from a few cm to 1 m, vary in composition from basalts through andesites to dacites. They are also partially derived from the basement rocks. The breccia and agglomerates, which varies in thickness from 9 to 60 m, occur mainly around Aktepe and south-west of Sille. They are mainly cemented by white-cream tuffaceous matrix, however some breccias also contain a carbonate-rich matrix on account of lacustrine environment in which they were deposited. Greenish white, yellow and pink coloured tuff and tuffites are exposed generally around Tatköy, Sulutaş and in the east of Takkalı Tepe, with a thickness between 2 to 80 m. The tuffs have medium to thick bedding, and have been greatly transformed to clays by weathering and hydrothermal alteration.

The youngest volcanic rocks are andesite, dacite, and basaltic andesite. The basaltic andesites are limited around at south of Absıray Tepe and west of Ulumuhsine village. The rocks contain phenocyrsts of feldspar, hornblende and biotite. Dacitic rocks are composed of the phenocrysts of feldspars, hornblendes, quartzs, and biotites. The dacitic lavas with the cooling joints were extruded as volcanic domes. Dacites and andesites cover large area

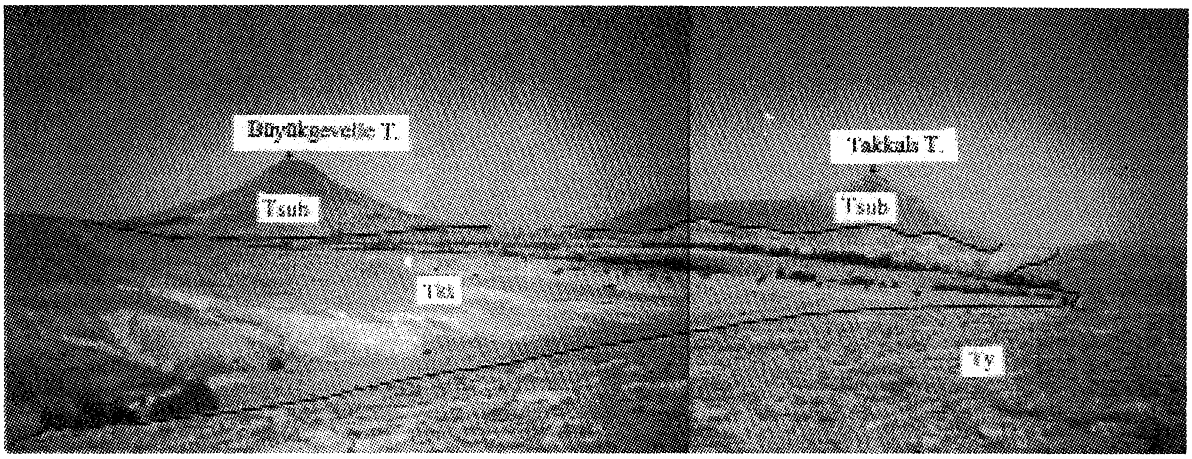


Figure 1. A view of Takkalitepe and Büyükgevelle tepe, Tsub: dacite/andesite Tkt: tuff Tu: limestone of Ulumuhsine formation

Sekili. *Takkalitepe and Büyükgevelle tepe den bir görünüş. Tsub: dasit/andezit Tkt: tüf Tu: Ulumuhsine formasyonu kireçtaşı*

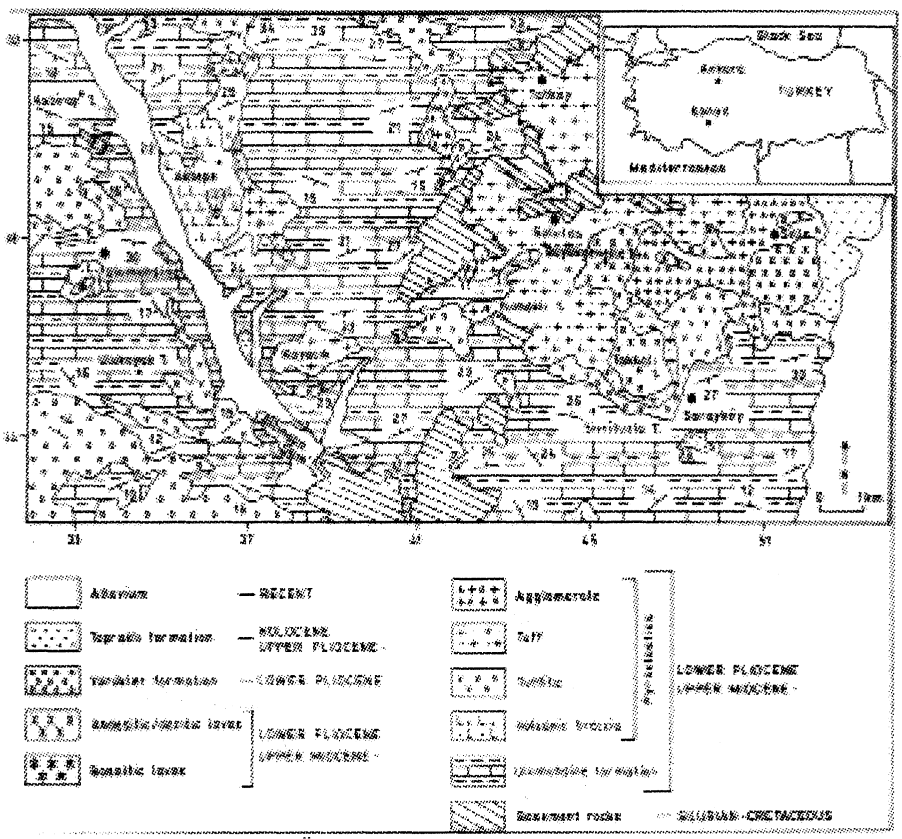


Figure 2. Geological map of **the** study area (Özkan, 1998).

Şekil 2. *Çalışma alanının jeoloji haritası* around Takkalı Tepe, east of Sulutas and South of Sille (Fig. 1,Fig.2).

Lower Pliocene aged Yürükler formation overlies unconformably volcanic rocks, and contains red conglomerate, red and caliche nodulled mudstone deposites. All these lithologies are pverlined unconformably by the Upper Pliocene- Holocene aged

Topraklı formation consist of red, gray conglomerate, cream, red and caliche nodulled mudstone

PETROGRAPHY

Tuffs

The tuff generally varies from crystal through vitric to lithic tuffs. The vitric tuffs have piagioclase, quartz, amphibole, biotite, clinopyroxene, zirkon and rare apatite in a vitrophyric porphyritic texture. The crystal tuffs consist of plagioclase, quartz, biotite and rare sanidine. Some samples may contain lithic (10-20%) and vitroclastic (3-6%) fragments. The matrix contains abundant quartz, some carbonate, and accessory zircon.

The modal mineralogical composition of the rock units are quartz (65-70 %), plagioclase (10-18%), biotite (1-3%), sanidine (2 %), carbonate (2-6%) and opaques (1-2%).

Phenocrysts of plagioclase are subhedral to anhedral crystals with albite twinning and oscillatory zoning, and may be replaced by very fine-grained quartz. Quartz phenocrysts have undoluse extinction. Subhedral biotite with apatite inclusions, are partly altered to chlorite along its cleavages.

The lithic fragments, commonly angular, were derived from the country rocks, which are metasedimentary, metaigneous and volcanic rocks. The metabasic rock fragments are mainly composed of by serpantine and olivine minerals while the volcanic fragments are made up of quartz, plagioclase, opaque oxides and glassy matrix. Some of them display hypocrystalline porphyritic and microlitic textures. The metasedimentary rock fragments comprise quartz, biotite, muscovite, chlorite and clay minerals.

The groundmass of the tuff was made up mostly by glass-shards and minor crystal fragments, which is common in the tuffs and volcanic breccias. They are mostly concentrated in the form of aggregates. The fragments of the tuff are generally distributed irregularly though flow texture was locally observed. Alteration processes induced formation of iron oxides in the matrix.

Bazaltic Andesite

The rock contains about 7-10 % of olivine, 3-5 % clinopyroxene, 5-10 % orthopyroxene, 60-70 % plagioclase and 3-5 % opaque minerals in a hypocrystalline porphyritic texture.

The plagioclase phenocrysts are subhedral laths with albite twinning and rare oscillatory zoning. Subhedral clinopyroxene phenocrysts show simple and complex twinning with concentric zoning, and may contain abundant iddingsite. The olivine phenocrysts are commonly subhedral, often inverted to iddingsite and rimmed by iron oxide. Some of phenocrysts are embayed by groundmass crystals.

Some of the microphenocrysts in the groundmass are yellowish brown colour indicating iddingsitisation. The groundmass is commonly intersertal with minor glass, and composed of plagioclase laths, granules of olivine, clinopyroxene and opaque oxides .

Andesitic Lavas

The rocks are hypocrystalline porphyritic and the modally ontain 50-70 of % plagioclase, 10-18 % of hornblende, 5% of biotite, 2 % of clinopyroxene, 1 % of sanidine, 1 % of quartz and 3 % of opaque oxides. Accessory apatite, zircon, occurs within both within the groundmass and as inclusions within the phenocrysts.

The plagioclase phenocrysts are frequently sieved with a thin overgrowth rim. They display albite twining, oscillatory and patchy zoning, (Gigure 3), and have abundant inlusions of biotite, apatite and opaque oxide grains. The hornblende exhibits strong pleochroism in shades of olive green to pale brown. They are subhedral or anhedral, generally being completely or partially replaced by iron oxides and chlorite. Biotites are subhedral to anhedral with green to dark brown pleochroism. Some phenocryst is completely or partialy altered to chlorite or opaque minerals while fresh ones may have iron rich rim

Groundmass minerals are plagioclase, hornblende, quartz, opaque minerals, glass and alteration products such as chlorite, quartz, and epidote. In the fine grained groundmass, quartz and plagioclase microlites are present with minor glasses.

Dacitic Lavas

The samples contains phenocrysts of plagioclase 35-40 %, quartz 10-18 %, hornblende 15-20 %,

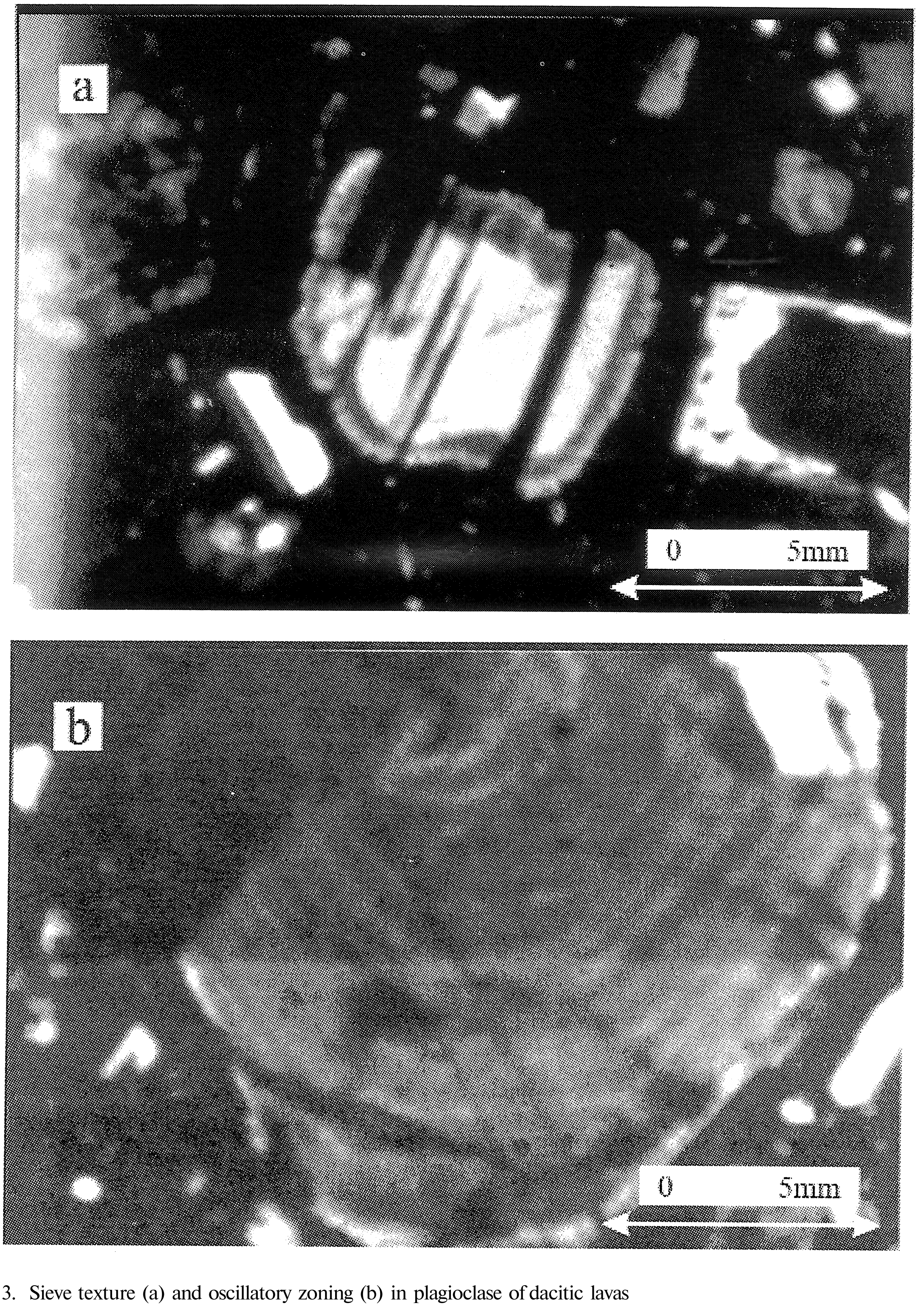


Figure 3. Sieve texture (a) and oscillatory zoning (b) in plagioclase of dacitic lavas

Şekil 3.Andeziiik lavların plјiyoklazlanndaki elek dokusu (ajve salınım zonlanma(b) biotite 10-15%, oxides 2-4 %, 3 % sanidine and accessory apatite in a hypocrystalline porphyritic texture.

The plagioclase crystals commonly display albite twining, oscillatory zoning and sieve texture.

They also show glomeroporphyn+ic texture with biotite.

Phenocrysts of the quartz crystals are rounded, and their embayments were filled by groundmass material.

The biotite forms as subhedral phenocrysts with green, brown to dark brown pleochroism, where they oxidized. Some biotite phenocrysts, containing apatite inclusions, are partialy or completely pseudomorphed by opaque minerals.

The hornblendes occur as subhedral to anhedral crystals that may be replaced by fine-grained opaque oxides. Sanidine in dacite is invariably rounded and embayed.

Groundmass is made up mostly by minerals of plagioclase, hornblende, biotite and quartz, and minor glass.

GEOCHEMISTRY

Ten samples were analysed to determine contents of major oxides, trace and rare earth elements (REE) by ICP-MS at ACME Analytical laboratories in Canada, and their results are presented in Table 1.

According to a Na2O+K2O vs. SİO2 diagram, composition of the subalkaline samples ranges from basaltic andesite through andesite to dacite (Figure 4). As the samples contain high water (generally > 2.w4%), which may indicate mobilization of Na2O and K2O, the samples were plot on a discrimination diagram based on immobile elements (Figure 5) . The two discrimination diagrams show coherency to each other, indicating that alkaline elements were not significantly mobilised. On an AFM diagram, the rocks display marked alkaline enrichment and plot in the calc-alkaline field (Figure 6). In the samples (except tuff samples), SİO2 generally has positive correlation with K2O and Rb, and negative correlation with TİO2, CaO, MgO, Cr, Y, Zr and Sr, which suggest that crystal fractionation of mafic minerals played a significant role in the genesis of the rocks. Depletion of CaO and MgO, and enrichment of K2O with increasing SİO2 content reflect the crystallization of hornblende, plagioclase and pyroxene. The decrease in TİO2 may reflect crystallization of titaniferous magnetite or Ti- bearing mafic minerals such as pyroxene and hornblende.

Ce/Nb (3.75-6.8) and Ba/Nb (53.9-95) ratios for volcanic rocks emphasize their close similarity to the average composition for the lower continental crust (Taylor and McLennan, 1985). Low La/Th (2.6-3.36), high Ba/La (21.9-28.4) and Ba/Nb (53.9-95) ratios in the samples, except tuff samples, are similar to those of convergent margin lavas related to a subduction zone (Sun, 1980).Figure is confirming subduction event in the genesis of the samples. The samples are characterised by high K2O (2.84-3.26 wt.%), Rb(70-104 ppm), Ba (593-1112ppm), K/Rb (191.4-337), K2O/Na2O except basaltic andesite K2O/Na2O (0.71 -1.06) and FeO/MgO (2.07-2.51) ratios, which is similar to Andean type andesites series formed in relation with subduction event.

In MORB-normalized some trace element patterns are shown in figure, which show an enrichment in large ion litophile elements (LILE), particularly Rb and Ba, and depletion in high field strength elements (HFSE). These feature are typical of subduction related magmas, and can be formed by subducting slab, the melt or fluid component derived from basaltic crust and pelagic sediments (organic, carbonate or clay-rich) detrital sediments. The rocks show progressively decreasing negative Sr, P and Ti anomalies suggesting fractional crystallization of plagioclase, magnetite and apatite. A slight increase in Zr with fractionation may also reflect cpx crystallization (Villemant et al., 1981). All samples have a characteristic negative Nb anomaly, which indicates a subduction component in their genesis (Pearce, 1983).

Chondrite-normalized REE patterns (Figure) for the rocks generally show a strongly fractionated REE pattern with high LREE/ LREE for the rocks. The samples are LREE enriched with (Ce/Sm)N=2.67-4.4, which are similar to those of (wt.%), trace and rare earth element analyses (ppm) of the rocks.

iğe /. Kayaçların ana(%), iz(ppm) ve nadir toprak element analizleri

Element	1	2	Avr.	3	4	Avr.	5	6	7	Avr.	8	9	10	Avr.
SiO_2	63.73	63.79	**63.76**	52.52	52.40	**52.46**	63.39	60.26	60.90	**61.51**	66.70	65.72	65.94	**66.1**
Al_2O_3	16.84	16.80	**18.82**	15.34	15.46	**15.40**	15.59	16.35	16.5	**16.14**	14.64	16.13	15.75	**15.5**
Fe_2O_3	3.47	3.50	**3.49**	7.73	7.78	**7.75**	4.50	5.82	5.0	**5.1**	4.14	3.72	3.67	**3.84**
MgO	1.39	1.40	**1.39**	6.48	6.55	**6.51**	2.01	2.87	2.5	**2.46**	1.74	1.44	1.42	**1.53**
CaO	3.71	3.82	**3.76**	8.78	8.90	**8.84**	4.70	6	5.10	**5.26**	4.45	3.86	3.85	**4.05**
Na_2O	2.82	2.86	**2.84**	2.82	2.96	**2.89**	3.14	3.10	3.13	**3.12**	3.10	3.29	3.26	**3.21**
K_2O	2.07	2	**2.04**	1.32	1.36	**1.34**	3.39	3.12	3.49	**3.33**	3.32	3.49	3.68	**3.49**
TiO_2	0.34	0.35	**0.34**	1.03	1.07	**1.05**	0.58	0.60	0.68	**0.62**	0.56	0.44	0.42	**0.47**
P_2O_5	0.11	0.10	**0.11**	0.47	0.49	**0.48**	0.17	0.21	0.20	**0.19**	0.19	0.15	0.14	**0.16**
MnO	0.06	0.06	**0.06**	0.14	0.16	**0.15**	0.07	0.08	0.08	**0.076**	0.07	0.07	0.07	**0.07**
LOI	5.2	5	**5.1**	2.4	2.46	**2.43**	2.2	1.60	2.2	**2**	0.9	1.5	1.6	**1.33**
Total	**99.74**	**99.68**	**99.71**	**99.78**	**99.59**	**99.68**	**99.74**	**99.99**	**99.78**	**99.84**	**99.81**	**99.81**	**99.80**	**99.80**
Cr	20	20	**20**	330	336	**333**	40	53	40	**44.3**	10	30	50	**30**
Ba	591	595	**593**	959	964	**961.5**	1258	1218	860	**1112**	922	996	964	**960.6**
Ni	6	6	**6**	98	99	**98.5**	15	14	10	**13**	9	5	6	**6.66**
Sc	8	7	**7.5**	22	22	**22**	11	10	11	**11**	9	7	7	**8**
Zn	35	36	**35.5**	49	51	**50**	28	50	55	**44.3**	32	23	26	**27**
Cu	9	10	**9.5**	48	49	**48.5**	6	40	35	**27**	8	4	5	**5.66**
Co	7.2	7	**7.1**	30	30	**30**	8	13	6	**9.1**	8	8	8	**8.16**
Cs	4.1	4	**4**	2	2	**2.15**	3	3	3.1	**3.16**	5	4	4.2	**4.13**
Ga	18	18	**18**	18	18	**17.9**	19	17	17	**17.7**	16	20	20	**18.87**
Hf	4	4	**4**	5	5	**4.75**	4	4	4	**3.7**	3	4	4.3	**4**
Nb	11	11	**11**	16	16	**16**	12	11	12	**11.7**	13	14	13	**13.2**
Rb	88	88	**88**	70	70	**70**	103	110	100	**104.4**	84	111	117	**103.6**
Sn	2	2	**2**	2	2	**2**	2	3	2	**2.33**	1	1	2	**2**
Sr	251	252	**251,5**	730	735	**732.7**	613	620	565	**599.3**	625	555	552	**577.8**
Ta	1	1	**1**	1	1	**1**	1.0	1	1	**1.0**	1	1	1	**1.1**
Th	19	19	**19**	11	11	**11**	16	16	16	**15.7**	16	18	19	**17.5**
Tl	0.3	0	**0.15**	0	0	**0**	0.7	1	0.7	**0.66**	0.4	0.7	0.5	**0.5**
U	5	5	**5**	4	4	**4**	6	5	6	**5.6**	6	7	7	**6.4**
V	58	60	**59**	150	155	**152,5**	78	70	75	**74.3**	71	43	49	**54.3**
W	2	2	**2**	1	1	**1**	2	2	2	**2**	2	2	2	**2**
Zr	134	134	**134**	174	174	**174**	135	190	155	**160**	122	165	154	**147.3**
Y	19	19	**19**	24	25	**24,5**	20	23	20	**20.87**	17	20	19	**18.5**
La	49	50	**49.5**	37	37	**37**	36	42	39	**39.1**	37	42	52	**43.8**
Ce	75	75	**75**	60	60	**60**	55	60	80	**65**	57	64	79	**66.56**
Pr	7	7	**7**	7	7	**7**	6	6	6.3	**6.16**	6	7	8	**7**
Nd	28	28	**28**	30	30	**30**	25	25	25	**25**	23	27	30	**26.8**
Sm	4	4	**4**	5	5	**5**	4	4	4	**4**	4	4	5	**4.16**
Eu	1	1	**1**	2	2	**2**	1	1	1	**1**	1	1	1	**1.09**
Gd	4	4	**4**	5	5	**5**	4	4	4	**4**	4	4	4	**4.13**
Tb	1	1	**1**	1	1	**1**	0.6	0.5	0.6	**0.55**	0.5	0.6	0.6	**0.56**
Dy	3	3	**3**	4	4	**4**	3	3	3	**3.47**	3	3	3	**3.13**
Ho	0.6	0.6	**0.6**	1	1	**1**	0.7	0.6	0.7	**0.63**	0.5	0.6	0.6	**0.60**
Er	2	2	**2**	2	2	**2**	1.7	1.7	1.8	**1.75**	1.5	1.8	1.7	**1.67**
Tm	0.3	0.3	**0.3**	0.3	0.3	**0**	0.2	0.2	0.3	**0.25**	0.2	0.3	0.3	**0.26**
Yb	2	2	**2**	2	2	**2**	2	2	2	**1.85**	2	1.9	2	**1.81**
Lu	0.3	0.3	**0.30**	0.3	0.3	**0.3**	0.3	0.3	0.3	**0.27**	0.2	0.3	0.3	**0.26**

Note: Fe2O3 is the total iron as Fe2O3. Tuff (1,2), basaltic andesite (3,4), andesites (5,6,7), dacites (8,9,10).

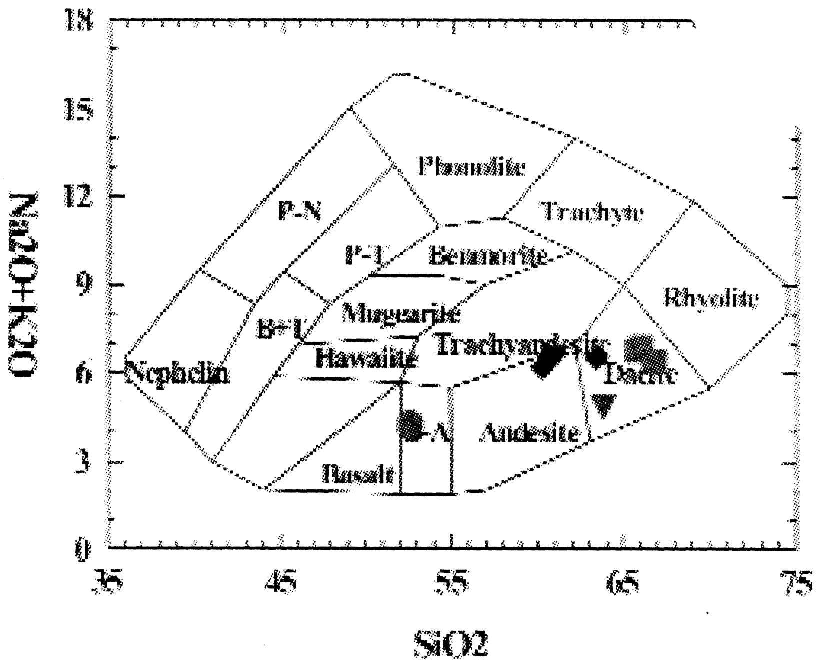
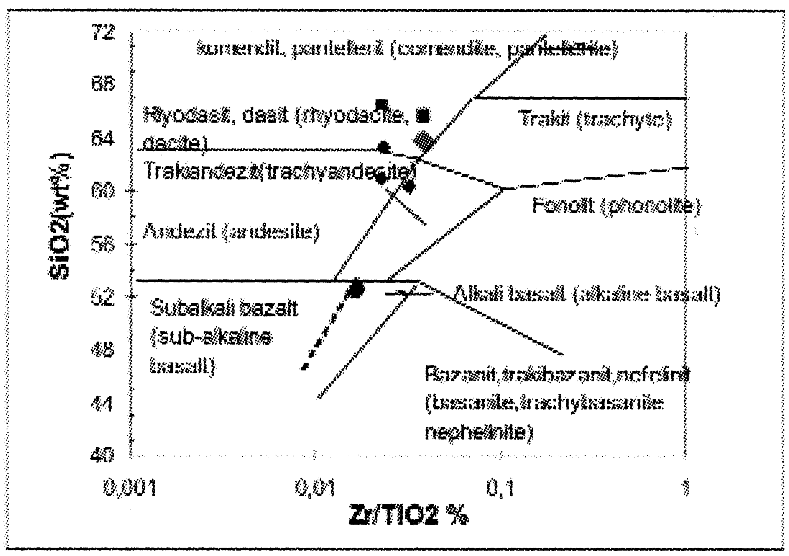


Figure 4. Na2O+K2O vs. SiO2 showing the composition of the volcanic rock. Boundaries from Cox et al. (1979). Filled circle; basaltic andesite, ınverted triangle; tuff, square; dacite, diamond; andesite.

Şekil 4. *Volkanik kayaçların bileşimini gösteren Na2O+K2O - SiO2 diyagramı (Cox ve diği. 1979). İçi dolu daire bazaltik andezit, ters üçgen tüf, kare: dasit, paralelkenar: andezit*



gure 5. Nomenclature of the volcanics(after Winchester&Floyd, 1977). Filled circle; basaltic andesite, ınverted triangle; ff, square; dasite, diamond; andesite.

kil 5. *Volkaniklerin terminolojisi (Winchester&Floyd, 1977). , İçi dolu daire bazaltik andezit, ters üçgen tüf, kare: dasit ıralelkenar: andezit*

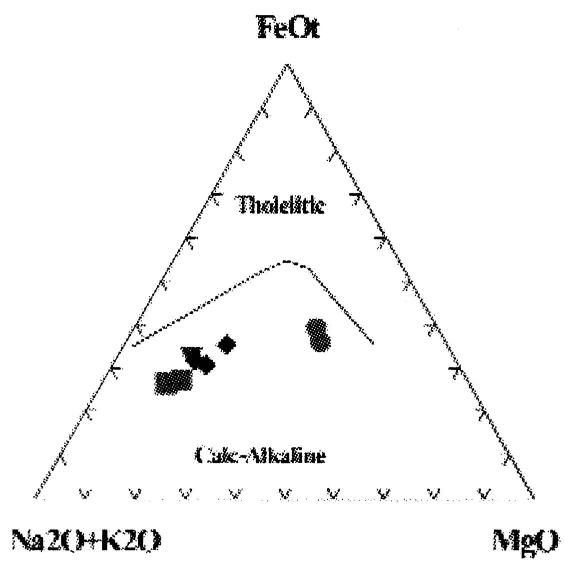


Figure 6. AFM diagram showing calc-alkâlirie compositions (after Ifviiîe &Barâgâr, 1971)'.Filled circle; basaltic andesite, inverted triangle; tüff, square; dasite, diamond; andesite.

Şekil 6. *Kalkalkalin bileşimi gösteren AFM diyagramı (Irvine and Baragar, 1971). İçi dolu daire bazaltik andezit, ters üçgen: tüf, kare: dasit, paralel kenar: andezit*

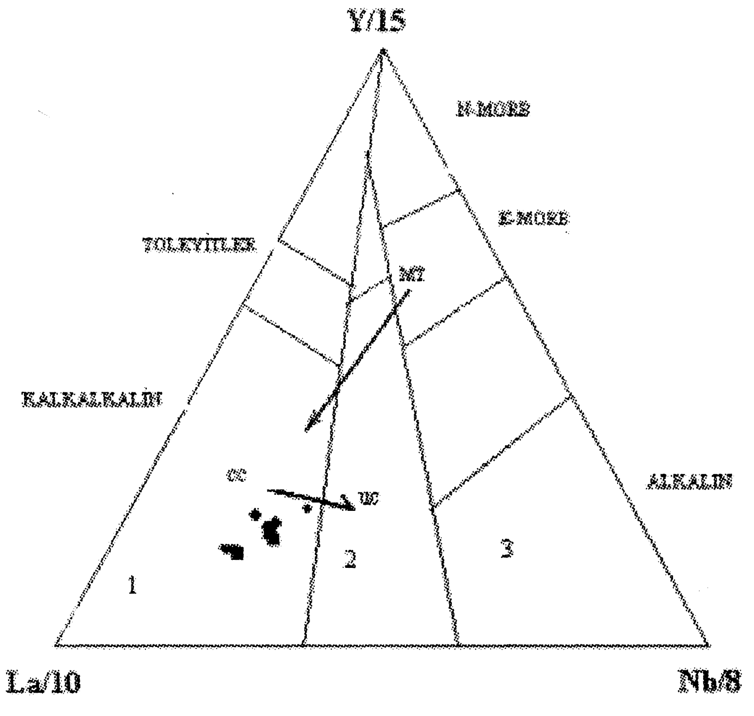


Figure 7. Y-La-Nb triangular diagram (Cabanis and Lecolle, 1989). Filled circle; basaltic andesite, inverted triangle; tuff, square; dasite, diamond; andesite.

Şekil 7. *Y-La-Nb üçgen diyagramı (Cabanis and Lecolle, 1989). İçi dolu daire bazaltik andezit, ters üçgen tüf, kare: dasit, paralelkenar: andezit*

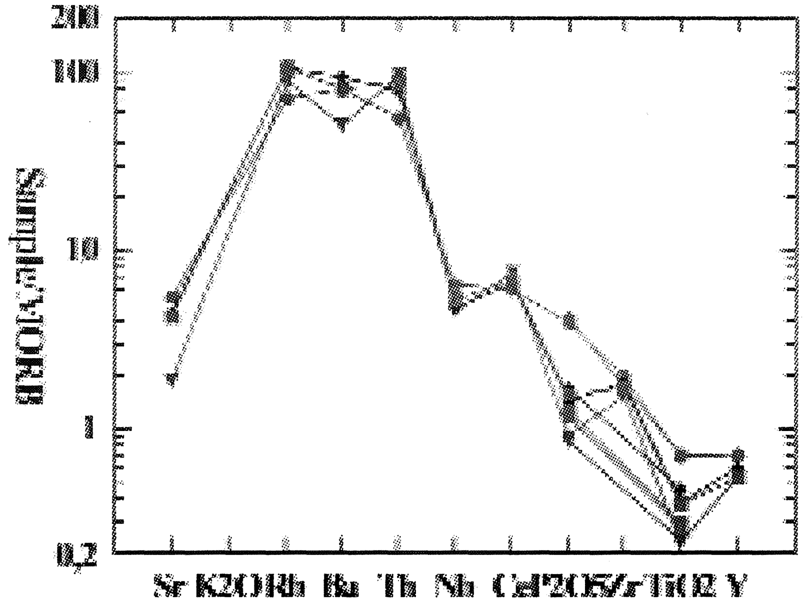


Figure 8. MORB-normalised element patterns of rocks. MORB normalizing values are from Pearce (1983). Filled circle; basaltic andesite, inverted triangle; tuff, square; dasite, diamond; andesite.

Şekil 8. *Kay açların bazı element içeriklerinin MORB'a oranlanmış örümcek diyagramı. Normalize değerler Pearce (1983)'ten alınmıştır. İçi dolu daire bazaltik andezit, ters üçgen tüf, kare: dasit, paralelkenar: andezit*

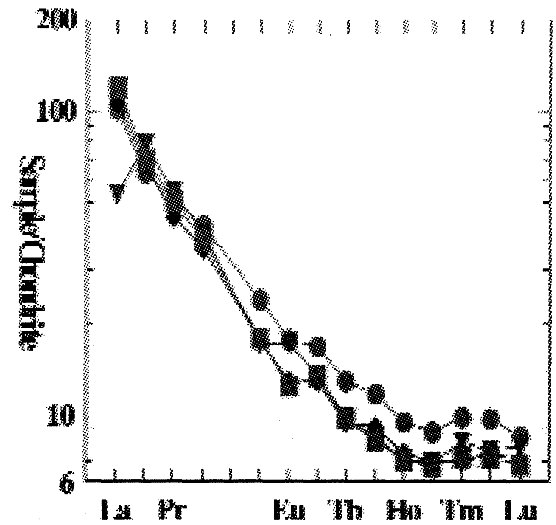


Figure 9. Chondrite-normalized rare earth element patterns for rocks. Normalizing values from Boynton (1984). Filled circle; basaltic andesite, inverted triangle; tüff, square; dasite, diamond; andesite.

Şekil 9. *Kondrite oanlanmış nadir toprak element diyagramı. Normalize değerler Boynton (1984).'den alınmıştır. İçi dolu daire bazaltik andezit, ters üçgen tüf, kare: dasit, paralelkenar: andezit* subduction-related magmas (Wood et al., 1979a-b; Wood, 1980; Pearce 1982, 1983). The more fractionated and LREE-enriched character of the volcanic rocks indicates that the evolution of the rocks involved continental crust (Watters &Pearce,1987). All samples, except the basaltic andesites, show which is more fractionated than the basaltic andesites $(La/Lu)_N$ 11.8-12.3. Plagioclase fractionation is evident from the slight development of a negative Eu anomaly $(Eu/Eu^*)_N$= 0.74-0.89 in andesites and dacites rocks, though other samples don't have any negative Eu anomaly.

DISCUSSION AND CONCLUSIONS

Neogene volcanism produced volcanic breccias, agglomerates, tuffites, tuffs and lavas of andesite, dacite and basaltic andesite in northwest of Konya. The volcanic rocks exhibit disequilibrium textures such as oscillatory zoning and sieve texture in plagioclase. Oscillatory zoning in plagioclase can be related to magma mixing (Hollister and Gancarz, 1971; Nakamura 1973). Sieve textures in plagioclase result from the dissolution of plagioclase (Tsuchiyama, 1985) probably due to influxes of new magma. The geochemical investigation suggests that the crystal fractionation of hornblende, plagioclase, clinopyroxene, magnetite and apatite played a significant role in the genesis of the volcanic rocks. The volcanic rocks display enrichment in K_2O, Rb, Ba, K/Rb, and high K_2O/Na_2O except basaltic andesite and FeO/MgO ratios, which are similar to subduction-related Andean type volcanics. All geochemical evidence suggests that these rocks may have been formed in relation with a subduction zone at active continental margin. The volcanism is considered to be formed in the collisional zone between the Arabian-African and Anatolian plates.

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GENİŞLETİLMİŞ ÖZET

Orta Anadolu'da Konya KB 'sı yaygın piroklastik kayaç ve lavlarla kaplıdır. Piroklastik kayaçlar volkanik breş, aglomera, tüfit ve tüfden oluşurken lavlar andesit, dasit ve bazaltik andezit bileşimini taşımaktadır. Bu çalışmada volkanik kayaçların genel jeolojisi, petrografisi ve jeokimyasal karakteristiklerinin ortaya çıkarılması amaçlanmıştır.

Breş ve aglomeralar başlıca beyaz-krem renkli tüflü matriks ve karbonatça zengin bir matriksle çimentolanmışlardır. Tüfler kristal, vitrik ve litik tüf olarak yer almaktadır. Vitrik tüf plajiyoklaz, kuvars, mfıbol, biyotit, klinopiroksen, ve nadir apatitten oluşurken kristal tüf plajiyoklaz, kuvars, biyotit, ve nadir sanidinden oluşmaktadır. Bazı örnekler bol kuvars, bazı karbonat ve tali zirkon içeren bir matriks içerisinde litik (10-20 %) ve vitroklastik (3-6%) parçalar içerirler.

Bazaltik andrezitler yaklaşık olarak 7-10% olivin, 3-5 % klinopiroksen, 5-10 % ortopiroksen, 60-70 % plajiyoklaz ve 5-10 % opak mineral fenokristalleri içerirken andezitik lavlar 50-60 % plajiyoklaz, 10-15 % hornblende, 5% biyotit, 2 % klinopiroksen, 1 % sanidin, 1 % kuvars ve 3 % opak mineral oluşmaktadır. Dasitik kayaçlar 35-40 % plajiyoklaz, 10-15 %kuvars, 15-20 % hornblend, 10-12 % biyotit, 2-3 % opak mineral, 3 % sanidin içerirler. Dasit ve andezitik kayaçlar salınım zonlanması ve elek dokusuna sahiptirler

Volkanik kayaçların bileşimi bazaltik andezitten dasite kadar değişir ve tipik olarak kalkalkalin özellik gösterirler. Genellikle (tüfler hariç) SiO2'in artmasıyla K2O, Rb ve Nb artarken TİO2, CaO, MgO, Cr, Y, Zr ve Sr azalır. Bu ilişki mafık minerallerin kayaçların petrojenezinde önemli bir rol oynadığını ileri sürmektedir. SİO2 'in artmasıyla CaO ve MgO'ın azalması, ve K2O'in artması hornblend, plajiyoklaz ve piroksenin kristalleşmesini yansıtmaktadır. Örnekler orojenik kalkalkali toplulukların bir özelliği olan düşük-orta konsantrasyonda Nb (11-16 ppm), Zr (122-174 ppm) ve Y (17-25 ppm) ve yüksek oranda Al içermektedirler . Ana ve iz element içerikleri kayaçların aktif kıta kenarında oluştuğunu göstermektedir. Kondrite oranlı REE diyagramında kayaçlar genellikle yüksek LREE/HREE oranlarına sahip oldukça farklılaşmış REE grafiği gösterirler. Plajiyoklaz farklılaşması zayıf negatif Eu anomalisinin gelişimi ile doğrulanmaktadır. Kayaçların oldukça farklılaşmış ve zengin REE grafiği bu kayaçların oluşumunda kıta kabuğunun yer aldığına işaret etmektedir.

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