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Alkali Basalts From the Galatia Volcanic Complex, NW Central Anatolia, Turkey

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Abstract: Alkali basalts occur as small lava flows associated with the andesitic lava flows and pyroclastics of Early to Middle Miocene age which are the main constituents of the Galatia volcanic complex. The northern margin of the complex is bordered by the North Anatolian Fault whereas the southern margin is surrounded by a continental sedimentary sequence which interfingers with the volcanics. New K-Ar age determinations of the basalts reveal that alkali basalts erupted at two different periods of time: Early Miocene and Late Miocene. The Lower Miocene basalts are contemporaneous with the major phase of the andesitic volcanism in the area. Eruption of the Upper Miocene basalts was preceded by 10 Ma period of quiescence of eruptive activity.

All the basalts, regardless of their age, display alkaline geochemical characteristics and have very similar REE and multielement patterns corresponding to rift-type intra-plate basalts. Primitive mantle normalised trace element diagrams demonstrate Rb, Ba, K, Th and U (LILE) enrichment indicating a weak island arc signature.

The geochemical, geochronological and field relations suggest that the Lower Miocene alkali basalts, being in the same age range as the major phase (andesitic) volcanics of the complex, erupted contemparaneously with the development of the sedimentary basins, whereas Upper Miocene alkali basalts might have erupted in local extensional zones which developed subsequent to the closure of the northern branch of Neo-Tethys.

Key Words: NW Central Anatolia, Galatia, volcanic, basalt, alkali.

İç Anadolu Bölgesi Kuzey Batısındaki Galatya Volkanik Kompleksi Alkali Bazaltları

Özet: Galatya volkanik kompleksinin esas ürünlerini oluşturan Erken-Orta Miyosen yaşlı lav akıntıları ve piroklastikler ile birliktelik sunan alkali bazaltlar, kompleks içerisinde lav akıntıları şeklinde küçük yüzlekler vermektedir. Kompleksin kuzey sınırı Kuzey Anadolu Fayı ile belirlenirken, güney sınır volkanikler ile arakatlılı karasal tortul istifler ile çevrelenmektedir. Bazaltlardan elde edilen yeni K-Ar yaş verileri, alkali bazaltların, Erken Miyosen ve Geç Miyosen olmak üzere iki farklı zamanda püskürdüğünü göstermektedir. Alt Miyosen bazaltları, bölgedeki ana fazı oluşturan andezitik volkanizma ile eş yaşlıdır. Volkanik etkinlik sürecinde, 10 milyon senelik bir suskunluk dönemini takiben, Üst Miyosen bazaltları püskürmüştür.

Her iki döneme ait bazaltlar alkalin karakterde olup, rift tipi, levha içi bazaltlara karşılık gelen Nadir Toprak Element (NTE) ve multielement profillerine sahiptir. Örümcek diyagramlar, zayıf ada yayı etkisini işaret eden, Rb, Ba, K, Th, U (Büyük İyonlu Litofil element) zenginleşmesini göstermektedir.

Jeokimyasal ve jeokronolojik veriler ile arazi ilişkileri, kompleksin ana faz (andezitik) volkanikleri ile aynı yaşta olan Alt Miyosen alkali bazaltlarının, tortul havzaların gelişimiyle eş yaşlı olarak püskürdüğünü, Üst Miyosen alkali bazaltlarının ise, Neo-Tetis'in kuzey kolunun kapanmasını takiben gelişen lokal gerilme zonları içerisinde püskürmüş olabileceğini düşündürmektedir.

Anahtar Sözcükler: KB İç Anadolu, Galatya, volkanik, bazalt, alkali.

Introduction

Northwestern Central Anatolia, comprising the Galatia Volcanic Complex and Ankara volcanics (Tankut et al., 1991) is one of the centres of Tertiary eruptions spread over Anatolia. The Galatia Volcanic Complex (Fig.1) is a large and continuous volcanic terrain, and is characterised by a depression, filled with sedimentary and contemporaneous volcanic rocks of Early-Middle Miocene age (Toprak et al.,1996). The northern margin of this depression is bordered by the North Anatolian Fault, whereas the southern margin is surrounded by a continental sedimentary sequence which interfingers with the volcanics. The major eruptive phase comprises andesitic lava flows and pyroclastics which overlie basement rocks of pre-Miocene age. Alkali basalts occur sporadically and constitute a volumetrically small portion of the complex.

Although exposures are not widespread in the area, the basalts provide important clues for the understanding of the tectonic evolution of the province. Previous studies have demonstrated the stratigraphic relations of the basalts (Stefanski and Lahn, 1941; Erol, 1954; Fourquin et al., 1970; Çalgın et al., 1973; Akyürek et al., 1979; Manetti et al., 1983; Helvacı et al.,1989; Türkmenoğlu et al., 1991), but beyond K-Ar age data for some basalts reported by Keller et al. (1992) no detailed information on the ages of the alkali basalts has so far been available. This paper presents the results of recent K-Ar geochronological and geochemical studies on samples from the main basaltic exposures, Güvem and Orta areas to the east, Özmuş and Güdül to the west of the Galatia complex (Fig.1). For details of the exact locations of the samples refer to TUBITAK report by Tankut et al. (1995).

Geochronology and Geochemistry

All the studied basalts are holocrystalline and contain a low proportion of phenocrysts. Olivine, clinopyroxene and rare plagioclase, which is confined to the groundmass, are the dominant mineral phases. Orthoyroxene is absent and the rocks are nepheline normative. Geochronological and geochemical data were obtained for basaltic samples from well known exposures of the complex, in the laboratories of Leeds University, UK.

On the basis of K-Ar radiometric ages of the rocks, reported by Wilson et al. (1997), two age groups, Early Miocene and Late Miocene, are distinguished for the eruption of the studied alkali basalts. Representative basalt samples from Özmuş and Güdül areas give ages of 18.2 Ma and 18.8 Ma respectively, while the sample from the Güvem area gives an age of 9.51 Ma. (Table 1). The age of the Orta sample is reported by Keller et al.(1992) to be Late Miocene (10.6 Ma).

Major, trace element and REE compositions of the basalts are given in Tables 2 and 3. All the basalt samples have SiO_2 <49.28% with mg # ranging from 59 to 64 (except the sample Güd 10). With their high Na_2O and K_2O contents, total alkalis >5 and K_2O/Na_2O > 1/3, they display alkaline characteristics (Fig. 2) and have very similar REE and multielement profiles (Figs. 3 and 4) corresponding to rift-type intra-plate basalts, as is also

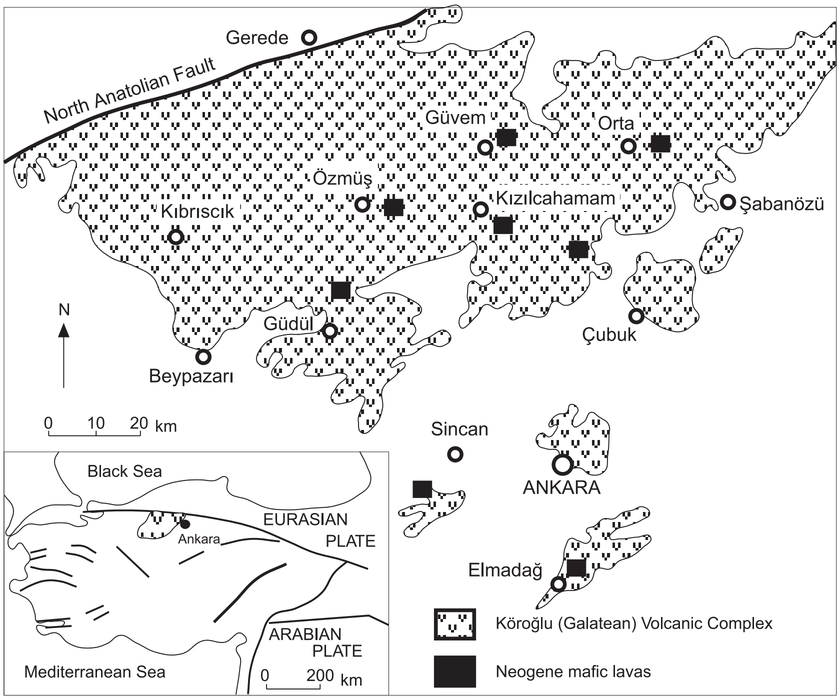

Figure 1. Distribution of volcanic rocks in northwest Central Anatolia (After Tankut et al., 1991).

Sample No.	Sample type	% K	Ar No.		Vol. 40 Ar rad.	% 40 Ar rad.	Age Ma.
Güv 486	Güvem,	2.04	5827	5836	0.0761	31.1	
	basalt				0.0754	33.5	9.51±0.29
Özm 11	Özmüş,	1.36	5828	5839	0.0951	67.8	18.2±0.50
	basalt				0.0987	52.6	
Güd 10	Güdül,	2.067	–		0.1526	70.6	18.8±0.6
	basalt				0.1516	71.1	
	Orta (*)						10.6±0.20
	basalt						

Table 1. Radiometric ages of the basalts from Galatia Complex (* age of the Orta sample is after Keller et al., 1992).

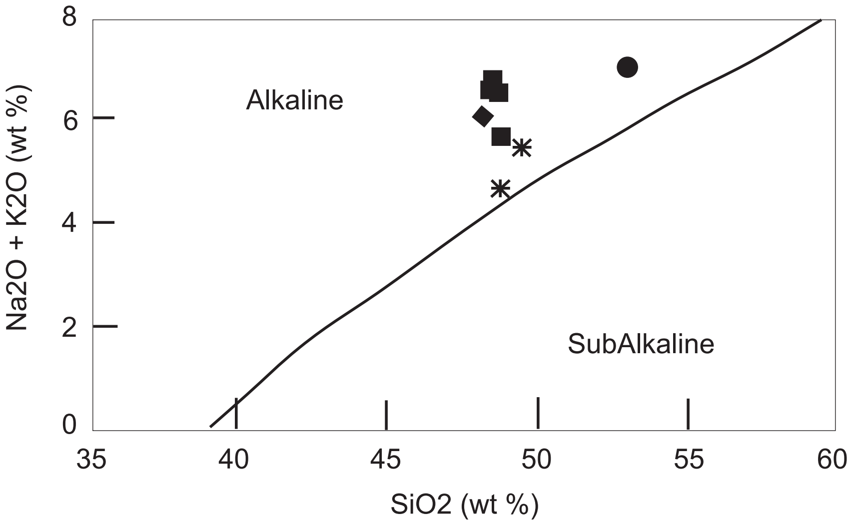

Figure 2. TAS diagram of basalts from Galatia Volcanic Complex (Irvine and Baragar, 1971). Symbols: (●) Güdül, (◆) Orta, (■) Güvem, (✶) Özmüş.

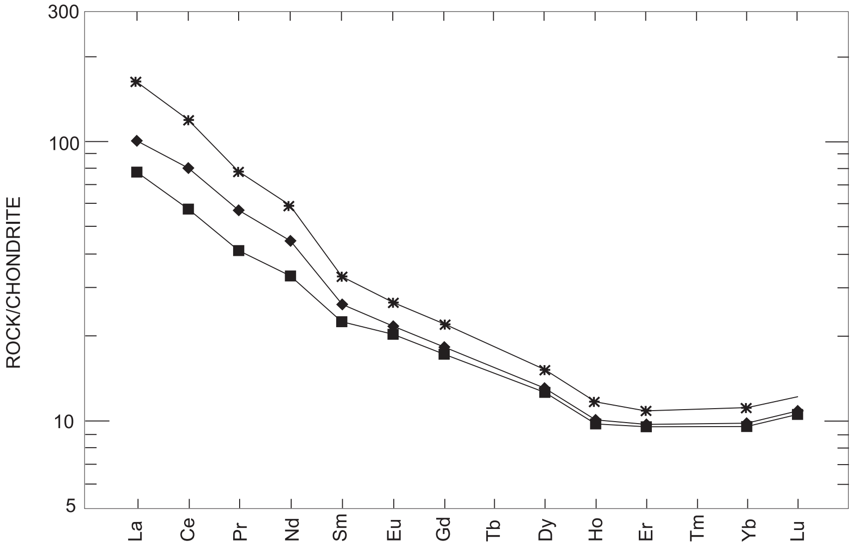

Figure 3. Chondrite normalised REE patterns of basalts from Galatia Volcanic Complex (normalisation constants from Anders and Ebihara, 1982). Symbols are the same as in Figure 2.

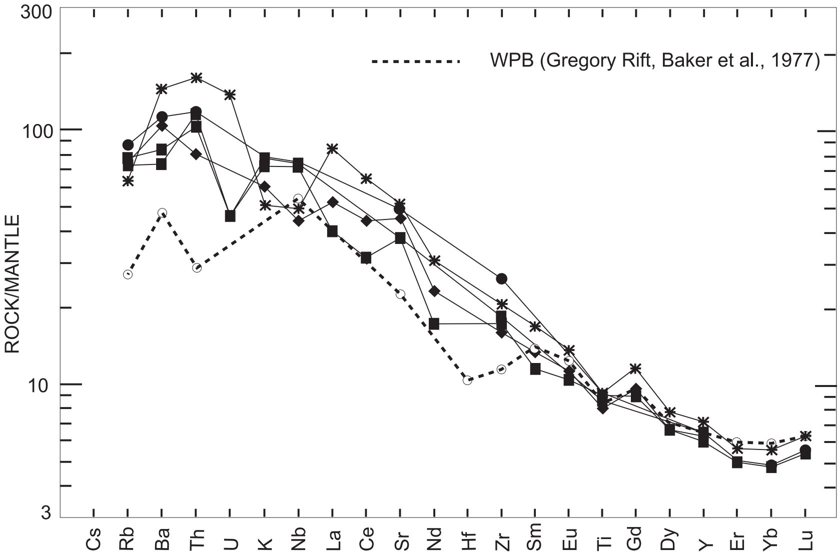

Figure 4. Primordial mantle normalised multi-element plots of representative basalts from Galatia Volcanic Complex (normalisation constants from Sun, 1982). Symbols are the same as in Figure 2.

Table 2. Major and trace element compositions of the basalts from Galatia Complex (Güv:Güvem, Güd:Güdül, Özm:Özmuş).

No.	Güv483 b	Güv486 b	Güv487 b	Güv526 b	Güv527 b	Güd 10	Orta29	Özm10	Özm11
SiO_2	47.20	47.44	47.49	47.91	47.15	51.68	47.35	48.42	49.28
TiO_2	1.73	1.66	1.66	1.72	1.70	1.56	1.51	1.66	1.69
Al_2O_3	16.85	16.87	16.31	17.30	17.07	17.56	16.36	16.26	16.57
FeO^*	8.37	8.84	9.21	8.53	8.74	8.82	8.89	9.75	9.79
MnO	0.14	0.17	0.16	0.16	0.15	0.16	0.13	0.16	0.16
MgO	6.74	6.64	8.34	6.35	6.54	2.41	7.03	8.01	6.22
CaO	9.19	9.27	8.99	9.41	9.34	7.58	10.38	9.67	9.74
Na_2O	3.85	4.01	2.84	4.13	3.10	4.41	4.06	3.65	3.76
K_2O	2.75	2.43	2.30	2.29	2.36	2.45	1.90	0.97	1.62
P_2O_5	0.52	0.54	0.51	0.54	0.51	0.86	0.63	0.73	0.77
L.O.I.	2.50	1.94	2.22	1.78	3.65	2.11	1.02	1.08	0.78
Total	99.85	99.81	100.04	100.12	100.31	99.58	99.28	100.4	100.4
Sc	14	17	17	16	16	7	19	13	16
V	135	136	135	135	132	95	126	142	132
Cr	85	177	107	177	127	57	181	207	190
Co	35	39	42	39	39	28	37	41	38
Ni	83	97	112	97	97	42	128	157	173
Cu	39	38	39	36	38	50	39	41	42
Zn	61	65	71	64	65	94	69	77	77
Rb	42	53	38	41	53	48	40	32	35
Sr	673	727	703	703	727	917	842	967	973
Y	23	25	25	25	25	25	25	27	28
Zr	160	179	180	180	179	248	154	194	201
Nb	44	47	45	46	45	45	28	29	32
Ba	511	515	462	458	503	685	640	872	903
Pb	3	2	6	1	-	10	2	15	12
Th	9	9	8	10	7	10	7	14	14
U	-	2	1	3	2	0	-	1	3

shown by the Ti/100-Zr-Y/3 plots (Fig. 4). The multielement diagrams, demonstrate Rb,Ba,K,Th,U (LIL) enrichment, indicating a weak island arc signature (Fig. 4).

High Cr and Ni values (85-207 ppm and 83-173 ppm respectively, except Güd10 sample), and absence of Eu anomalies in REE profiles (Fig.2) imply negligible amounts of crystal fractionation of the magmas subsequent to separation from their source. Therefore, they can be regarded to represent a magma composition close to that of the primary magma. The sample Güd10 contains 51.68% SiO_2, 2.41% MgO, 8.82% FeO with mg#, 35.11, 57 ppm Cr, and 42 ppm Ni and seems to represent a more differentiated magma.

Discussion

K-Ar ages of the basalts provide evidence that they erupted at two different periods of time: Early Miocene and Late Miocene. The Lower Miocene basalts are contemporaneous with the major volcanic phase of the Galatia Complex; eruption of the Upper Miocene basalts was preceded by 10 Ma period of quiscence of eruptive activity.

The Lower Miocene basalts are not much different, in terms of trace element characteristics, from the Upper Miocene basalts. All the basalts, regardless of age, are alkaline and are of within plate type tectonic setting (Fig.5). The relatively higher LREE and MREE (La to Sm) abundances (Fig.3) in the Lower Miocene basalts compared to a representative sample (Güv. 486) of the Upper Miocene basalts may imply different magma sources. On the other hand, a slight island arc signature, evidenced by LILE enrichment in all of the basalts, suggests that a component of subduction modified mantle, already affected by fluids derived from a pre-existing subduction zone, may also be involved in their petrogenesis. This is well explained by the status of the region during the Tertiary; that is, during the Latest Paleocene-Early Eocene the region in the Tethyan domain

Table 3. REE composition of the basalts from Galatia Complex.

No.	Güv 486	Özm 11	Orta 29
La	25.00	53.60	32.50
Ce	49.10	102.80	68.80
Pr	5.23	10.12	7.25
Nd	20.60	37.00	27.50
Sm	4.52	6.68	5.22
Eu	1.54	2.03	1.65
Gd	4.69	6.12	4.99
Dy	4.28	5.16	4.41
Ho	0.74	0.90	0.77
Er	2.10	2.42	2.14
Yb	2.06	2.44	2.12
Lu	0.35	0.41	0.36

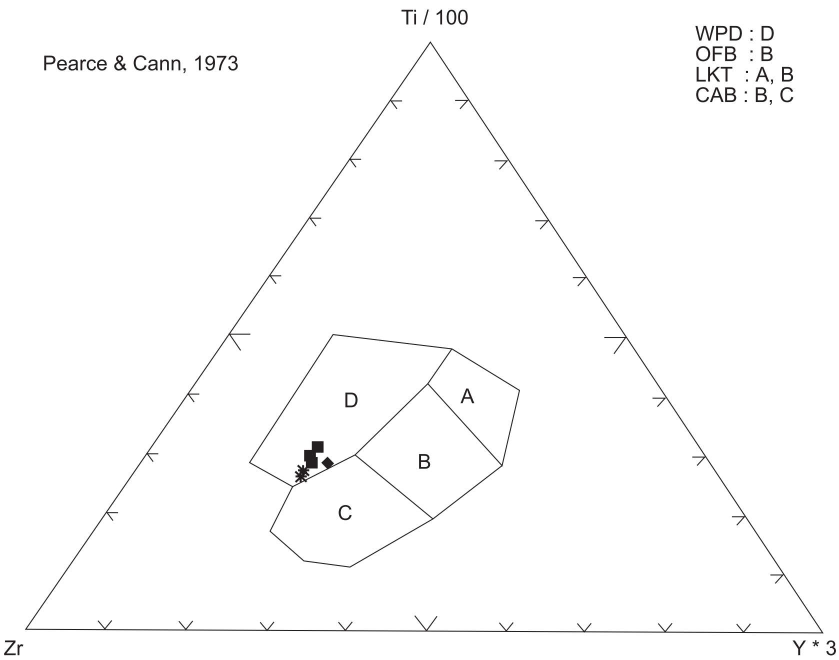

Figure 5. Zr-Ti/100-3Y plots of basalts from Galatia Volcanic Complex (Pearce and Cann, 1973). Symbols are the same as in Figure 2.

is assumed to have been the site of plate convergence and involved in subduction and collision activities (Şengör and Yılmaz, 1981). The convergence continued until Late Pliocene (Koçyiğit, 1991) and caused development of a localized extensional regime.

In the light of above results, it is suggested that the Lower Miocene alkali basalts, being of the same age as the major phase volcanics (andesitic) of the complex, erupted contemporaneously with the development of the sedimentary basins (Toprak et al.,1996), whereas the Upper Miocene alkali basalts might have erupted in local extensional zones which developed subsequent to the closure of the northern branch of Neo-Tethys.

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