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The Coexistence of the Silica Oversaturated (ALKOS) and Undersaturated Alkaline (ALKUS) Rocks in the Kortundağ and Baranadağ Plutons from the Central Anatolian Alkaline Plutonism, E Kaman/NW Kırşehir, Turkey

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Abstract: Baranadağ and Kortundağ plutons, outcropping in the Kaman-Kırşehir region, constitute the important members of the Central Anatolian post-collisional alkaline plutonism. The Baranadağ pluton comprises only one lithodem called Baranadağ quartz monzonite, whereas, the Kortundağ pluton consists of four mapable units such as Hamit quartz syenite, Durmuşlu nepheline-nosean-melanite porphyritic syenite, Bayındır nepheline-cancrinite syenite, and Çamsarı quartz syenite. Among these units, the Baranadağ quartz monzonite and Hamit quartz syenite cut the metamorphics of the Kırşehir Block. On the other hand, Durmuşlu, Bayındır and Çamsarı are emplaced in both the Hamit quartz syenite and the metamorphics.

The Baranadağ quartz monzonite, Hamit quartz syenite and Çamsarı quartz syenite determine an association by means of geological setting, textural features, and mineralogical-chemical composition. These units contain feldspar megacrysts, an association of hornblende + augite + biotite, and have silica saturated alkaline (ALKOS) character. These units also show fractional crystallization from Baranadağ to Çamsarı by means of mineralogical and geochemical data.

It has been proposed that these three units were formed by fractional crystallization from a single magma source.

Durmuşlu and Bayındır units, on the other hand, contain the same felsic and mafic mineral assemblages which consist of nepheline + sodalite, and melanite + arfvedsonite + aegirine/aegirine-augite, respectively. These two units show silica undersaturated alkaline (ALKUS) character. These mineralogical-chemical data also reveal that there has been a fractionation process occurred from the Durmuşlu to Bayındır. In other words, alkaline rocks of Bayındır and Durmuşlu formed by fractional crystallization from a magma source which is different than that of Baranadağ, Hamit and Çamsarı units. This different magma source of the Durmuşlu and Bayındır units is also assumed to be generated subsequently from the enriched upper mantle material. It is proposed that ALKOS and ALKUS rocks were formed by fractional crystallization from two different magma sources which were probably formed by the partial melting of upper mantle material with different degrees of melting in different times.

Key Words: Central Anatolian post–COLG plutonism, Baranadağ and Kortundağ plutons, alkaline oversaturated magma, alkaline undersaturated magma, fractional crystallization, partial melting.

Orta Anadolu Alkali Plütonizmasındaki Kortundağ ve Baranadağ Plütonlarında (D Kaman–KB Kırşehir, Türkiye) Silisçe Aşırı Doygun (ALKOS) ve Silisçe Tüketilmiş (ALKUS) Alkali Kayaç Birlikteliği

Özet: Baranadağ ve Kortundağ plütonları İç Anadolu çarpışma sonrası alkali plütonizmasının, Kaman-Kırşehir yöresinde yüzeyleyen önemli üyelerini oluştururlar. Bunlardan Baranadağ plütonu, Baranadağ kuvars monzoniti olarak haritalanabilir bir litodem biriminden oluşurken; Kortundağ plütonu, Hamit kuvars-siyeniti, Durmuşlu nefelin-nozean-melanit siyenit porfiri, Bayındır nefelin-kankrinit siyeniti ve Çamsarı kuvars siyeniti gibi haritalanabilir dört litodem biriminden oluşmaktadır. Baranadağ kuvars monzoniti ve Hamit kuvars siyeniti, Kırşehir Bloğu metamorfitlerini sıcak dokanakla kesmektedir. Diğer yandan, Durmuşlu, Bayındır ve Çamsarı birimleri ise hem Hamit siyenitini ve hem de metamorfitleri kesmektedir.

Baranadağ kuvars monzoniti, Hamit kuvars siyeniti ve Çamsarı kuvars siyeniti jeolojik konum, dokusal özellik ve mineralojik-kimyasal bileşim açısından bir topluluk oluşturmaktadır. Bu birimler, metamorfitleri kesmekte, alkali feldspat megakristalleri ve hornblend+ojit+biyotit mineral topluluğu içermekte ve silisçe aşırı doygun alkalin (ALKOS) karakter göstermektedir. Ayrıca bu birimler mineralojik ve jeokimyasal açıdan Baranadağ' dan Çamsarı'ya doğru fraksiyonel kristalleşme göstermektedir. Diğer bir deyişle bu üç birimin tek bir magma kaynağından itibaren fraksiyonel kristalleşme ile oluştuğu ileri sürülebilmektedir.

Bunları oluşturan magmanın %10-20 arasındaki kısmi ergime derecesi ile non-modal Rayleigh/fraksiyonel tip ergimeyle zenginleşmiş üst mantodan türediği ileri sürülebilmektedir.

Durmuşlu ve Bayındır birimleri, nefelin+sodalit ve melanit + arfvedsonit + egirin/egirinojitten oluşan mafik mineral topluluğu ve aynı felsik mineral topluluğu içermektedir. Her iki birim de silisçe tüketilmiş alkalin (ALKUS) karakter göstermektedir. Mineralojik-kimyasal veriler Durmuşlu' dan Bayındır' a doğru fraksiyonlanma sürecinin varlığına işaret etmektedir. Diğer bir deyişle, Bayındır ve Durmuşlu alkalin kayaçları Baranadağ, Hamit ve Çamsarı birimlerinden farklı olan bir magma kaynağından fraksiyonel kristalleşmeyle oluşmuştur. Durmuşlu ve Bayındır birimlerinin bu farklı magma kökeni %10' dan daha az ergime derecesiyle yine non-modal Rayleigh/fraksiyonel tipi kısmi ergimeyle zenginleşmiş üst mantodan kaynaklandığı ileri sürülebilir. Bu açıdan düşünüldüğünde Kaman yöresi (NW Kırşehir) alkalin kayaçlarının farklı zamanlarda üst manto malzemesinin farklı kısmi ergime derecesinde kısmi ergimesiyle oluşan iki farklı magma kaynağından fraksiyonel kristalleşme ile oluştuğu ileri sürülebilmektedir.

Anahtar Sözcükler: Orta Anadolu Çarpışma sonrası (post–COLG) plütonizması, Baranadağ ve Kortundağ plütonları, silisçe aşırı doygun alkalin magma, silisçe tüketilmiş alkalin magma, fraksiyonel kristalleşme, kısmi ergime.

Introduction

Kortundağ and Baranadağ plutons, outcropping in the Kaman-Kırşehir region in Central Anatolia, Turkey (Figure 1), constitute some important members of the widespread metasedimentary, igneous and ophiolitic rock association in Central Anatolia so-called Kırşehir block (Görür et al., 1984; Poisson, 1986), Central Anatolian Crystalline Complex (Göncüoğlu et al., 1991), or Central Anatolian post-collisional plutonism (Türeli et al., 1993; Boztuğ et al.,1994; Göncüoğlu and Türeli, 1994; İlbeyli and Pearce, 1997; Boztuğ and Yılmaz, 1997). Some recent studies reveal that the tectono-magmatic evolution of Central Anatolia is closely related to the Cretaceous closure of northern branch of Neo-Tethyan oceanic realm. The Central Anatolian Ophiolites (Göncüoğlu et al., 1991; Yalınız et al., 1996, 1997) and collision-related Central Anatolian plutonism (Boztuğ, 1998), i.e. syn-collisional peraluminous plutons (Alpaslan and Boztuğ, 1997), post-collisional high-K calcalkaline monzonitic subunit constituting the composite Yozgat batholith (Tatar and Boztuğ, 1998), and post-collisional alkaline subdivisions (Yılmaz and Boztuğ, 1998; Boztuğ et al., 1998) have been issued from this geodynamic context.

This paper deals mainly with the coexistency of the silica oversaturated (ALKOS) and undersaturated alkaline (ALKUS) plutons in the Kaman-Kırşehir region. Some 198 rock samples were collected from the plutons during the geological mapping. All these rock samples have been studied to determine the mineralogical compositions and textural features under polarising microscopy. After microscopical study, some fresh and representative samples were choosen for the major and trace element geochemistry that were analyzed by XRF spectrometry (RIGAKU 3270 E-WDS type) using some USGS and CRPG rock standards (Table 1) at the Mineralogical-Petrographical and Geochemical Research Laboratories (MIPJAL) of the Department of Geological Engineering of Cumhuriyet University in Sivas.

Geological Setting

Plutonic rocks, because of being enough resistant rocks against to erosion, constitute two major mountains in Kaman-Kırşehir region which are called Baranadağ and Kortundağ. These plutonic rocks are exposed to intrude the crustal metasediments of Kırşehir Block or Central Anatolian Crystalline Complex, and the gabbroic rocks of the Central Anatolian Ophiolites (Figure 1). A recent study, carried out in these plutonic bodies in Kaman-Kırşehir region, has shown that these plutons can be subdivided into two subgroups, i.e. silica oversaturated alkaline (ALKOS) plutons; Baranadağ quartz monzonite, Hamit quartz syenite and Çamsarı quartz syenite, and silica undersaturated alkaline (ALKUS) plutons, Durmuşlu nepheline-nosean-melanite-syenite porphyry and Bayındır nepheline-cancrinite syenite (Otlu, 1998). The latter subgroup, i.e. silica undersaturated alkaline rocks are obviously seen as dykes cutting the former subgroup in the field (Figures 2, 3). This clear field evidence apparently remarks that the ALKUS rocks are younger than ALKOS rock units. This is the only field data about the age relations of the plutonic rocks in Kaman-Kırşehir region. However, all these plutonic rocks have already been determined as alkaline in chemical composition with an age of Paleocene by earlier workers (Lünel, 1987; Bayhan, 1987, 1988; Erler et al., 1991; Erler and Bayhan, 1995).

General Descriptions

As it is commonly accepted, alkaline magmatic rocks have solidified from magmas derived from upper mantle with different type and degree of partial melting (Fitton and Upton, 1987; Wilson, 1989).

Alkaline rocks contain excess Na and K than required for the formation of feldspars (Fitton and Upton, 1987). The excess of alkalies were used for the formation of feldspathoids (nepheline, leucite), sodalites (sodalite, nosean, hauyn), alkali amphiboles (arfvedsonite, hastingsite), alkali pyroxenes (aegirine, aegirin-augite), and the other alkali-rich minerals (cancrinite, melilite, etc.)

Silica oversaturated (ALKOS) alkaline rocks consist of quartz in normative and modal mineralogical composition. In addition they include trace amounts of alkali amphibole and pyroxene. However, they do not contain the silica depleted feldspathoid and sodalite group minerals.

Table 1. The comparison of the analysis result of the ACE, BEN, GH, (GRPG) and BR,SCO1, AGV1 (USGS) rock standards observed in the Mineralogical and Geochemical Research Laboratories (MIPJAL) of the Dept. of Geological Engineering of Cumhuriyet University (major and trace elements are given in weight percent and in ppm respectively).

		SiO_2	Al_2O_3	TiO_2	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Nb
CRPG	ACE	70.35	14.20	0.11	2.53	0.058	0.03	0.34	6.54	4.49	0.014	110
MİPJAL	ACE	69.92	14.86	0.08	2.61	0.06	0.51	0.44	6.56	4.42	0.02	98
CRPG	GH	75.80	12.50	0.08	1.34	0.05	0.03	0.69	3.85	4.76	0.01	85
MİPJAL	GH	67.08	11.33	0.06	1.32	0.05	0.60	0.82	3.17	4.45	0.02	80
USGS	BR	38.20	10.20	2.60	12.88	0.20	13.28	13.80	3.05	1.40	1.04	98
MİPJAL	BR	38.33	9.90	2.49	10.13	0.17	10.20	14.23	3.19	1.62	1.44	52
USGS	SCO1	62.78	13.67	0.628	5.14	0.053	2.72	2.62	0.90	2.77	0.206	11
MİPJAL	SCO1	63.72	16.43	0.68	5.78	0.06	3.20	3.26	0.63	2.98	0.20	12
USGS	AGV1	58.79	17.14	1.05	6.76	0.092	1.53	4.94	4.26	2.91	0.49	15
MİPJAL	AGV1	58.59	15.85	1.08	6.45	0.10	1.42	4.75	3.79	2.96	0.48	10

		Zr	Y	Ba	Cr	Co	Cu	Pb	Zn	Rb	Sr	Ga	Th
CRPG	ACE	780	184	55	3.34	0.2	4	39	224	152	3	3.9	18.5
MİPJAL	ACE	780	181	80	9	4	13	39	216	148	5	44	18
CRPG	GH	150	75	20	6	1	14	45	85	390	10	23	87
MİPJAL	GH	146	129	19	11	3	13	39	77	294	11	24	70
USGS	BR	250	30	1050	380	52	72	8	160	47	1320	19	11
MİPJAL	BR	205	13	786	176	22	38	5	94	13	827	13	3
USGS	SCO1	160	26	570	68	10.5	28.7	31	103	127	174	15	9.7
MİPJAL	SCO1	160	29	584	54	6	28	41	105	105	169	18	4
USGS	AGV1	227	20	1226	10.1	15.3	60	36	88	67.3	662	20	6.5
MİPJAL	AGV1	212	15	1161	14	7	46	28	82	47	555	18	1

* CRPG and USGS valves of rock standards have been taken after Govindaraju (1989).

Silica undersaturated (ALKUS) alkaline rocks contain silica-depleted minerals as feldspathoid and sodalite in normative and modal mineralogical composition and do not contain any free quartz.

Silica Oversaturated Alkaline (ALKOS) Rocks

Baranadağ quartz-monzonite, Hamit quartz-syenite and Çamsarı quartz-syenite show silica oversaturated alkaline features in mineralogical-petrographical and geochemical characteristics. The geological setting, textural, mineralogical-petrographical and geochemical data show that Çamsarı quartz-syenite is a highly fractionated unit derived from the magma of Baranadağ quartz monzonite and Hamit quartz syenite units. Çamsarı quartz-syenite has the granular texture comprising of the medium-fine grains whereas Baranadağ quartz-monzonite and Hamit quartz-syenite show the typical porphyritic texture and includes K-feldspar megacrysts (Ekici and Boztuğ, 1997). Baranadağ quartz-monzonite and Hamit quartz-syenite have the mafic magmatic enclaves showing the magma mingling (Didier and Barbarin, 1991).

Baranadağ quartz-monzonite and Hamit quartz-syenite are similar in mineralogical-petrographical features. However, Hamit quartz-syenite includes more K-feldspar than Baranadağ quartz-monzonite. The main felsic minerals of these units are K-feldspar (orthoclase+microcline+perthite), plagioclase and quartz whereas their mafic minerals are hastingsite+augite +biotite (Baranadağ), and hastingsite+biotite+augite (Hamit). Çamsarı quartz-syenite, showing granular texture, includes the felsic minerals which are similar to that of Baranadağ and Hamit, includes the hastingsite+biotite+flourite as mafic minerals.

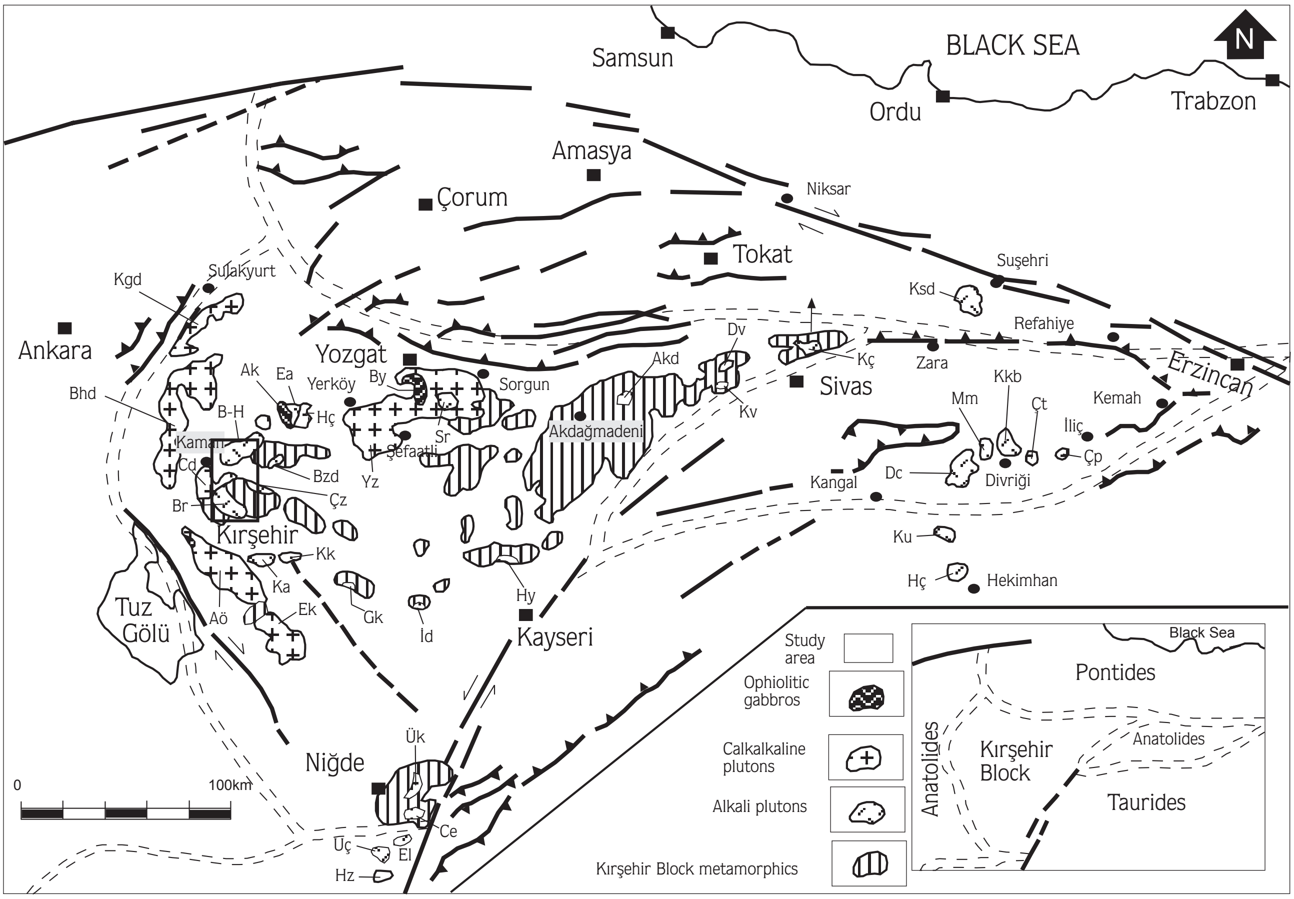


Figure 1. Geographic situation of the metamorpic and plutonic rocks of Central Anatolia. The abbreviations of the plutons, from E to W, are as follow: Çp, Çöpler; Çt, Çaltı; Kkb, Karakeban; Mm, Murmana; Dc, Dumluca; Ku, Kuluncak; Hç, Hasançelebi; Ksd, Kösedağ; Kç, Karaçayır; Dv, Davulalan; Kv, Kavik; Akd, Akdağmadeni; Hy, Hayriye; Ük, Üçkapılı; Ce, Celaller; El, Elmalı; Uç, Uçurumtepe; Hz, Horoz; İd, İdişdağ; Yz, Yozgat; By, Başnayayla; Hç, Halaçlı; Ea, Eğrialan; Ak, Akçakent; Bzd, Buzlukdağ; B-H, Bayındır - Hamit; Cd, Cefalıkdağ; Br, Baranadağ; Çz, Çayağzı; Kk, Kesikköprü; Ka, Kuruağıl; Gk, Gümüşkent; Ek, Ekecikdağ; Aö, Ağaçören; Bhd, Behrekdağ; Kgd, Karagüneydağ. The inset map shows the tectonic units in Central Anatolia (taken after Boztuğ et al., 1997).

Baranadağ quartz-monzonite, and Hamit and Çamsarı quartz-syenites showing the ALKOS character, were plotted in the quartz-monzonite and quartz-syenite fields in the nomenclature diagram of Debon and Le Fort (1983) (Figure 4 a). These units have a CAFEMIC trend (Figure 4 b) on the characteristic mineral diagram (Debon and Le Fort, 1983) whereas an ALKOS character (Figure 4 c) on the QBF diagram (Debon and Le Fort, 1983). On the other hand, it is obvious that Hamit and Çamsarı quartz-syenites are the fractionated equivalents of Baranadağ unit on the Figure 4 b and Figure 4 c. Total alkali-silica diagram of Rickwood (1989) and Brown et al. (1984) diagram also show that Çamsarı quartz-syenite is fractionated equivalents of the other units (Figure 5). When the field relationship of Çamsarı quartz-syenite and its mafic mineral content are considered, it could be suggested that these units were formed by the fractional crystallization process from a magma source having ALKOS character. This conclusion is also supported by the trace element-trace element and trace element/trace element-trace element/trace element variation diagrams (Figure 6). On these diagrams, the fractional crystallization from Baranadağ-Hamit units to Çamsarı unit is deduced. On the other hand, it is also clear that ALKOS and ALKUS associations are associated (Figure 6). This feature is also observed on the MORB-normalized (Clark, 1994) spiderdiagram (Figure 7 a, b). As it will be noticed on this diagram, Sr is incorporated in anorthite-

Table 2. Wholerock major and some trace element chemical analysis results of the Kortundağ and Baranadağ plutons. Major and trace elements are given in weight percent and in ppm respectively. tFe_2O_3. total iron oxide as ferric iron; LOI. Loss on ignition.

Baranadağ quartz monzonite

Sample No	SiO_2	TiO_2	Al_2O_3	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
NO.61	64.15	0.39	17.74	3.68	0.1	1.65	3.69	3.81	5.24	0.18	0.28	100.91
NO.63	63.84	0.39	17.92	3.76	0.11	1.6	3.19	3.82	5.34	0.17	0.73	100.87
NO.64	63.01	0.38	17.57	3.36	0.1	1.62	2.99	3.2	8.21	0.18	0.27	100.89
NO.65	63.52	0.4	17.54	3.98	0.11	1.65	3.31	3.84	4.95	0.19	0.6	100.09
NO.67	62.15	0.46	17.53	4.47	0.11	1.89	4.17	3.66	4.88	0.21	0.53	100.06
NO.68	62.34	0.35	19.16	2.98	0.08	0.88	3.3	3.87	7.26	0.13	0.6	100.95
NO.69	59.05	0.42	18.69	4.49	0.1	1.45	4.38	3.09	7.69	0.24	0.49	100.09
NO.70	65.52	0.4	18.67	3.5	0.09	1.23	3.65	4.21	5.92	0.19	0.33	100.71
NO 71.	64.98	0.36	17.77	3.42	0.08	1.19	2.98	3.91	5.89	0.18	0.18	100.94
NO. 77	61.09	0.5	19.15	4.11	0.1	1.26	4.65	3.71	5.39	0.16	0.33	100.45
NO. 79	62.28	0.53	17.43	4.8	0.1	2.22	4.55	3.48	4.83	0.23	0.67	101.12
NO. 80	63.03	0.56	17.23	4.88	0.11	2.14	4.56	3.57	4.63	0.21	0.45	101.37
NO. 147	62.37	0.46	17.78	4.01	0.1	1.75	3.5	3.98	5.76	0.21	0.55	100.48
NO. 149	64.39	0.36	17.96	3.57	0.11	1.47	3.12	3.98	5.31	0.14	0.55	100.95
NO. 150	61.64	0.47	18.58	4.57	0.11	1.81	3.83	3.93	5.26	0.20	0.68	101.08
NO. 151	63.20	0.44	18.13	4.29	0.11	1.75	3.64	3.8	5.09	0.20	0.55	101.2
NO. 152	63.52	0.41	18.06	4.02	0.12	1.58	3.59	3.9	5.17	0.17	0.65	101.18
NO. 154	60.26	0.46	18.8	5	0.11	1.69	4.97	4.12	4.62	0.25	0.8	101.09
NO. 155	63.77	0.42	17.78	4.19	0.11	1.71	4.1	3.9	4.45	0.25	0.4	101.08
NO. 157	61.32	0.46	18.03	4.31	0.11	1.67	4.43	3.89	5.51	0.24	0.5	100.47
NO. 159	61.22	0.48	18.11	4.46	0.11	1.91	4.73	4.11	5.4	0.26	0.49	101.28
NO. 160	60.85	0.49	18.04	4.86	0.12	1.96	4.84	3.77	5.28	0.26	0.5	100.97
NO. 165	63.20	0.39	18.09	3.73	0.1	1.69	3.69	3.82	5.57	0.19	0.74	101.21
NO. 167	63.63	0.42	18	3.82	0.09	1.79	3.94	3.73	4.8	0.18	0.33	100.73
NO. 168	60.63	0.47	18.11	4.34	0.1	2.08	4.6	3.59	4.9	0.22	0.6	99.64

Sample No	Cr	Co	Cu	Pb	Zn	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th
NO.61	15	12	9	59	92	174	1292	578	18	21	237	36	26
NO.63	12	13	10	42	91	171	1164	580	22	24	256	36	15
NO.64	1	11	29	52	91	238	1424	635	16	22	217	48	18
NO.65	42	14	9	38	97	182	814	451	19	21	226	38	30
NO.67	24	15	13	42	101	159	858	545	19	25	255	37	23
NO.68	5	10	16	40	94	217	527	1220	18	37	224	41	16
NO.69	12	16	9	37	103	196	1189	1002	18	28	307	41	32
NO.70	8	12	12	49	89	208	946	811	20	23	299	42	52
NO 71.	20	12	15	40	89	238	927	708	18	26	293	46	45
NO. 77	8	14	13	36	88	126	1425	746	19	17	228	29	22
NO. 79	33	17	15	37	96	139	1260	628	20	15	235	29	11
NO. 80	21	17	15	43	101	125	945	579	21	23	251	32	10
NO. 147	37	14	12	43	97	198	773	553	19	26	288	43	40
NO. 149	21	12	6	50	93	177	883	455	21	19	229	38	63
NO. 150	10	16	9	38	95	156	1047	542	21	21	245	37	25
NO. 151	15	15	5	50	100	170	914	505	19	20	228	41	28
NO. 152	29	14	8	40	91	165	931	484	19	21	241	37	27
NO. 154	13	17	21	44	101	132	1278	667	21	17	202	33	31
NO. 155	32	14	10	44	93	128	500	494	21	16	196	30	33
NO. 157	26	15	10	42	88	178	969	705	18	28	251	39	26
NO. 159	17	15	6	35	94	155	1056	818	19	21	269	37	18
NO. 160	16	17	14	43	98	168	938	757	18	22	230	36	27
NO. 165	18	13	13	13	90	161	1312	636	19	17	251	35	21
NO. 167	40	13	15	15	95	147	1053	605	20	18	225	32	21
NO. 168	27	15	12	12	95	131	1384	690	19	16	241	30	14

Hamit quartz syenite

Sample No	SiO_2	TiO_2	Al_2O_3	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
NO. 5	60.98	0.47	18.10	4.37	0.09	1.68	4.38	3.28	4.93	0.19	0.34	98.81
NO. 6	62.61	0.48	18.65	4.33	0.08	1.58	4.36	3.46	4.60	0.16	1.16	101.47
NO. 9	64.11	0.36	18.30	3.07	0.06	1.00	2.43	4.23	5.94	0.14	0.9	100.54
NO. 10	65.79	0.32	17.54	3.23	0.07	1.21	2.78	3.91	5.99	0.16	0.4	101.4
NO. 11	61.85	0.44	17.74	4.35	0.11	1.91	4.06	3.85	5.80	0.27	0.49	100.87
NO. 12	67.28	0.19	18.10	1.43	0.04	0.82	1.53	4.93	5.80	0.06	0.58	100.76
NO. 14	63.26	0.39	17.79	3.51	0.09	1.49	3.39	3.77	5.72	0.15	0.6	100.16
NO. 20	61.35	0.46	17.97	4.53	0.09	2.02	4.19	3.36	4.88	0.18	1.13	100.16
NO. 50	64.71	0.33	17.91	3.12	0.07	0.99	3.18	3.68	5.35	0.14	0.99	100.47
NO. 52	62.62	0.36	18.30	3.41	0.07	1.23	3.63	3.77	5.27	0.13	1.71	100.5
NO. 59	60.99	0.48	18.76	4.71	0.08	1.89	4.59	3.56	4.53	0.17	0.9	100.66
NO. 93	64.31	0.30	18.19	2.73	0.08	1.15	2.70	3.78	6.87	0.14	0.37	100.62
NO. 112	64.88	0.34	18.55	2.54	0.07	1.13	2.07	4.44	6.74	0.11	0.58	101.45
NO. 119	62.90	0.43	17.88	4.17	0.10	1.60	3.74	3.90	5.94	0.23	0.38	101.27
NO. 143	60.35	0.45	17.56	4.63	0.11	1.72	4.29	3.39	4.95	0.18	0.95	98.58

Sample No	Cr	Co	Cu	Pb	Zn	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th
NO. 5	nd	15	10	39	77	132	2323	736	21	12	250	28	36
NO. 6	nd	15	6	30	78	129	1983	713	20	14	266	27	46
NO. 9	9	10	6	44	78	257	756	608	21	24	314	48	113
NO. 10	23	11	5	43	83	261	817	630	21	26	305	47	56
NO. 11	16	15	12	42	90	218	756	648	17	25	231	42	44
NO. 12	23	4	8	55	69	368	304	225	22	40	352	61	127
NO. 14	7	11	15	49	81	181	1772	812	20	19	254	34	16
NO. 20	nd	16	14	41	86	128	2615	763	18	15	251	25	19
NO. 50	12	10	10	91	84	207	1520	825	20	15	260	36	25
NO. 52	nd	12	14	115	74	170	2032	814	18	16	250	31	23
NO. 59	nd	16	12	45	70	127	2246	733	20	13	267	26	17
NO. 93	22	9	6	55	80	244	900	644	22	21	279	45	98
NO. 112	19	8	9	58	77	303	424	373	20	35	372	60	89
NO. 119	19	14	13	41	93	206	1060	776	19	15	282	43	18
NO. 143	nd	16	10	55	84	138	2500	691	20	30	254	28	11

Çamsarı quartz syenite

Sample No	SiO_2	TiO_2	Al_2O_3	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
NO. 24	69.93	0.08	16.68	1.02	0.03	0.44	0.75	4.75	5.19	0.03	1.12	100.02
NO. 26	68.22	0.14	18.50	1.10	0.00	0.40	0.29	5.02	6.18	0.04	0.99	100.88
NO. 28	69.09	0.14	17.31	1.06	0.02	0.40	1.05	4.61	5.89	0.06	0.85	100.48
NO. 30	66.30	0.16	18.57	1.73	0.04	0.51	1.41	5.45	6.19	0.05	0.56	100.97
NO. 35	67.71	0.16	18.20	1.40	0.03	0.41	1.05	5.10	6.47	0.04	0.64	101.21
NO. 103	70.05	0.14	16.53	1.17	0.03	0.50	1.16	4.81	4.95	0.05	0.50	99.89
NO. 107	71.53	0.08	16.01	0.88	0.02	0.41	0.88	3.95	5.92	0.05	0.55	100.28
NO. 118	65.05	0.32	18.61	2.41	0.07	0.61	1.81	5.11	6.29	0.09	0.41	100.78
NO. 121	65.58	0.28	18.73	1.86	0.05	0.52	1.36	5.48	6.49	0.04	0.59	100.98

Sample No	Cr	Co	Cu	Pb	Zn	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th
NO. 24	46	3	5	71	57	475	97	99	24	37	223	75	56
NO. 26	33	3	9	62	57	377	210	145	23	39	343	62	99
NO. 28	14	3	7	82	59	421	247	205	25	42	288	68	59
NO. 30	30	5	5	78	71	430	156	201	26	36	563	72	134
NO. 35	19	4	6	119	76	378	265	246	21	51	395	65	116
NO. 103	16	3	8	48	60	275	521	283	19	20	212	44	66
NO. 107	28	2	8	76	54	351	174	167	23	26	195	55	46
NO. 118	11	8	7	79	79	315	573	382	23	75	612	64	64
NO. 121	9	6	5	68	69	353	nd	60	23	68	876	67	169

Durmuşlu nepheline - nosean - melanite syenite porhyry

Sample No	SiO_2	TiO_2	Al_2O_3	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
NO. 5a	56.24	0.32	20.76	3.09	0.10	0.64	3.72	5.46	8.48	0.10	1.52	100.43
NO. 102	57.82	0.20	21.23	2.13	0.07	0.57	2.66	5.96	8.81	0.07	1.43	100.95
NO. 113	57.48	0.34	21.07	2.34	0.10	0.54	1.81	6.80	8.77	0.07	2.13	101.45
NO. 120	57.51	0.28	20.51	2.84	0.09	0.67	3.40	5.48	8.67	0.10	1.43	100.98
NO. 128	56.83	0.34	20.33	3.39	0.11	0.64	4.02	5.79	8.08	0.11	1.70	101.34
NO. 129	57.25	0.28	20.43	2.88	0.09	0.77	3.64	5.26	8.44	0.10	1.74	100.88

Sample No	Cr	Co	Cu	Pb	Zn	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th
NO. 5a	nd	10	9	104	110	254	1869	1304	19	37	455	45	32
NO. 102	nd	7	12	142	121	349	971	887	22	45	537	54	44
NO. 113	7	8	11	152	97	255	446	768	20	64	519	50	74
NO. 120	nd	10	12	99	105	250	1940	1407	19	35	435	43	28
NO. 128	nd	12	11	110	120	251	1469	1168	19	40	469	44	34
NO. 129	nd	10	16	100	103	245	1924	1392	17	34	425	42	30

Bayındır nepheline - cancrinite syenite

Sample No	SiO_2	TiO_2	Al_2O_3	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
NO. 21	62.15	0.3	19.77	2.52	0.07	0.62	1.78	5.46	7.16	0.06	0.73	101.12
NO. 22	63.85	0.24	19.59	1.91	0.08	0.39	0.7	4.85	8.85	0.05	0.45	100.96
NO. 25	63.48	0.19	19.91	1.77	0.01	0.32	1.16	5.74	6.96	0.05	0.75	100.34
NO. 34	62.49	0.12	20.08	1.39	0.07	0.55	1.49	6.82	7.12	0.03	1.24	101.4
NO. 36	61.79	0.1	21.21	1.16	0.06	0.34	1	6.94	7.57	0.03	1.18	101.38
NO. 46	65.11	0.04	19.24	1.22	0.04	0.36	1.11	7.55	5.48	0.02	0.88	101.05
NO. 106	59.67	0.29	20.96	2.97	0.09	0.54	2.2	4.9	8.64	0.1	0.77	101.13
NO. 114	60.02	0.36	19.85	3.57	0.1	0.88	2.6	5.4	7.34	0.16	0.97	101.25
NO. 115	64.45	0.23	19.61	1.62	0.04	0.41	1.44	6.09	6.3	0.05	0.67	100.91
NO. 117	63.6	0.23	19.92	1.57	0.03	0.31	0.7	5.91	7.46	0.04	0.3	100.07

Sample No	Cr	Co	Cu	Pb	Zn	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th
NO. 21	nd	8	6	77	90	259	442	303	24	46	803	53	282
NO. 22	14	6	3	72	76	318	105	149	21	46	247	52	66
NO. 25	1	5	6	58	76	298	289	217	23	44	921	55	108
NO. 34	8	4	5	90	106	246	104	206	24	40	154	32	38
NO. 36	10	3	4	145	90	354	63	113	22	46	259	52	101
NO. 46	4	3	7	113	87	385	nd	48	31	46	697	60	73
NO. 106	nd	10	21	60	94	235	1621	962	18	51	374	43	65
NO. 114	nd	12	32	113	99	205	1628	857	20	51	427	41	72
NO. 115	4	5	8	71	82	301	375	314	25	48	401	55	160
NO. 117	10	5	6	84	79	375	51	96	21	69	301	59	42

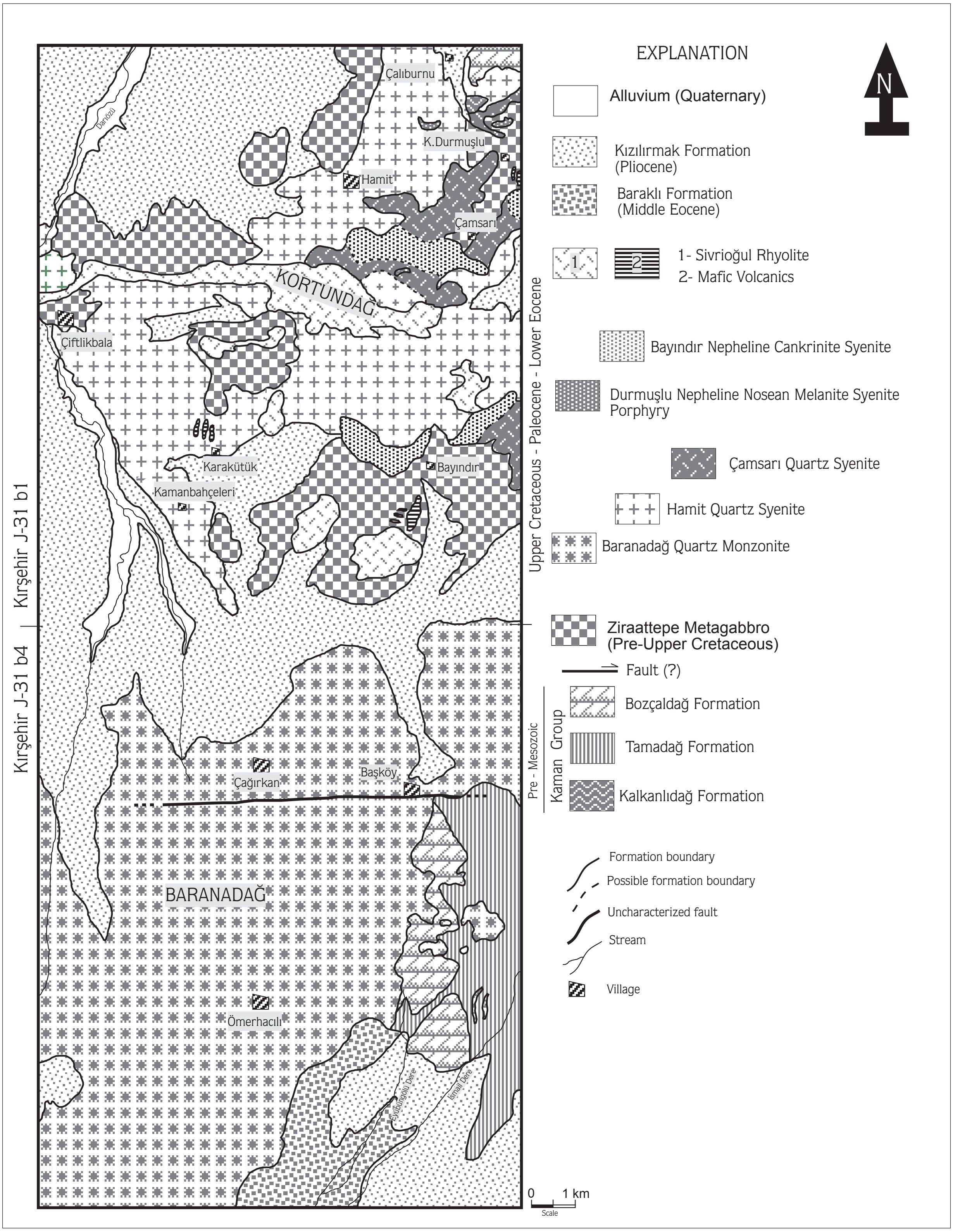


Figure 2. The geological map of the Kortundağ and Baranadağ area.

Table 3. The correlation of the ALKOS and ALKUS alkaline rocks in Kortundağ and Baranadağ plutons.

Features	ALKOS SUITES	ALKUS SUITES
Geological setting	Cut through Paleozoic basement	Cut through Paleozoic basement and ALKOS units
Felsic minerals	Plj + K-feld. + qu	K-spar+plg+nepheline+nosean+cancrinite
Mafic minerals	Hastingsite+ bi + öjit	riebeckite+eagirine+melanite±biotite
Total alkaline-silica(TAS)	ALKALINE	ALKALINE
QBF	ALKOS	ALKUS
LIL	Low K/Rb,K/Rb-Rb‡regularly,FC	High K/Rb
	K/Rb, Rb/Sr, Ba/Rb, Rb → FC	K/Rb-Rb → regularly
	(Figures 6a,b,c,d,e,f,g)	(Figures 6a,b,c,d,e,f,g)
HFS	Low Nb/Y	High Nb/Y
	High Ti/Zr	Low Ti/Zr
	Nb-Y → regularly, FC	Nb-Y → regularly
	(Figures6a,b,c,d,e,f,g)	(Figures 6a,b,c,d,e,f,g)
Geodynamic Setting	Post-Collisional	Within-plate, post-collisional

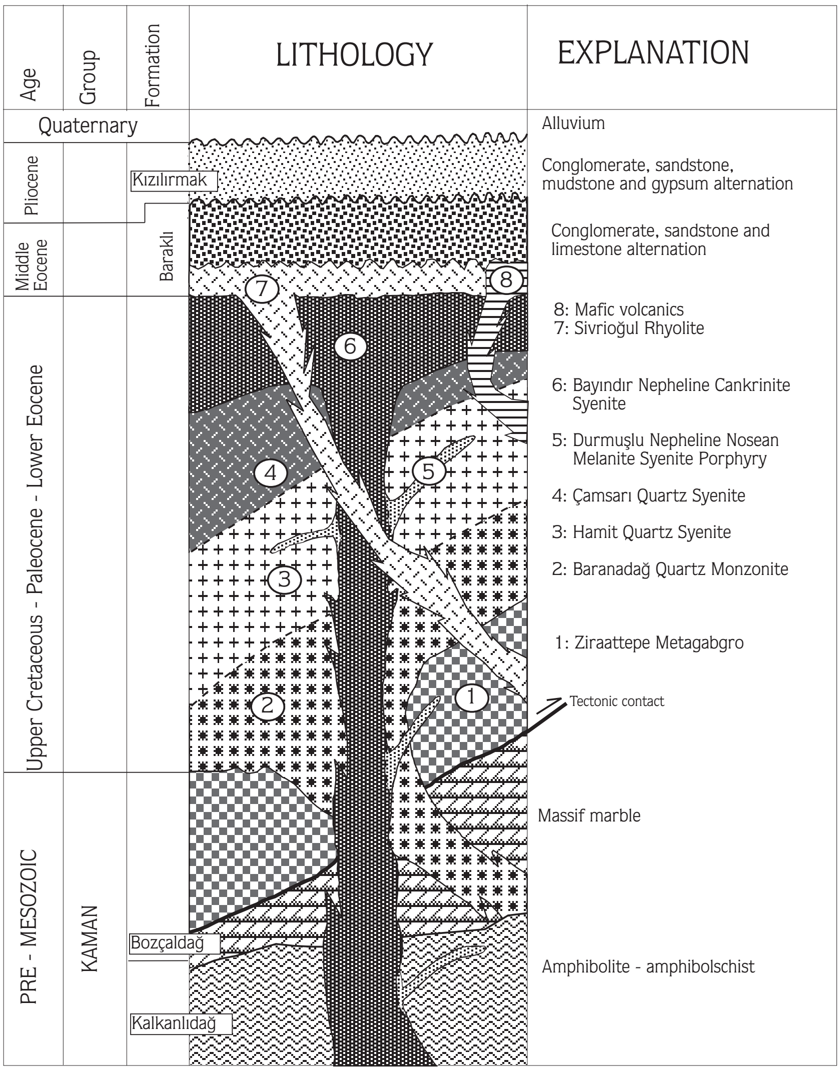


Figure 3. Generalized columnar section of the study area.

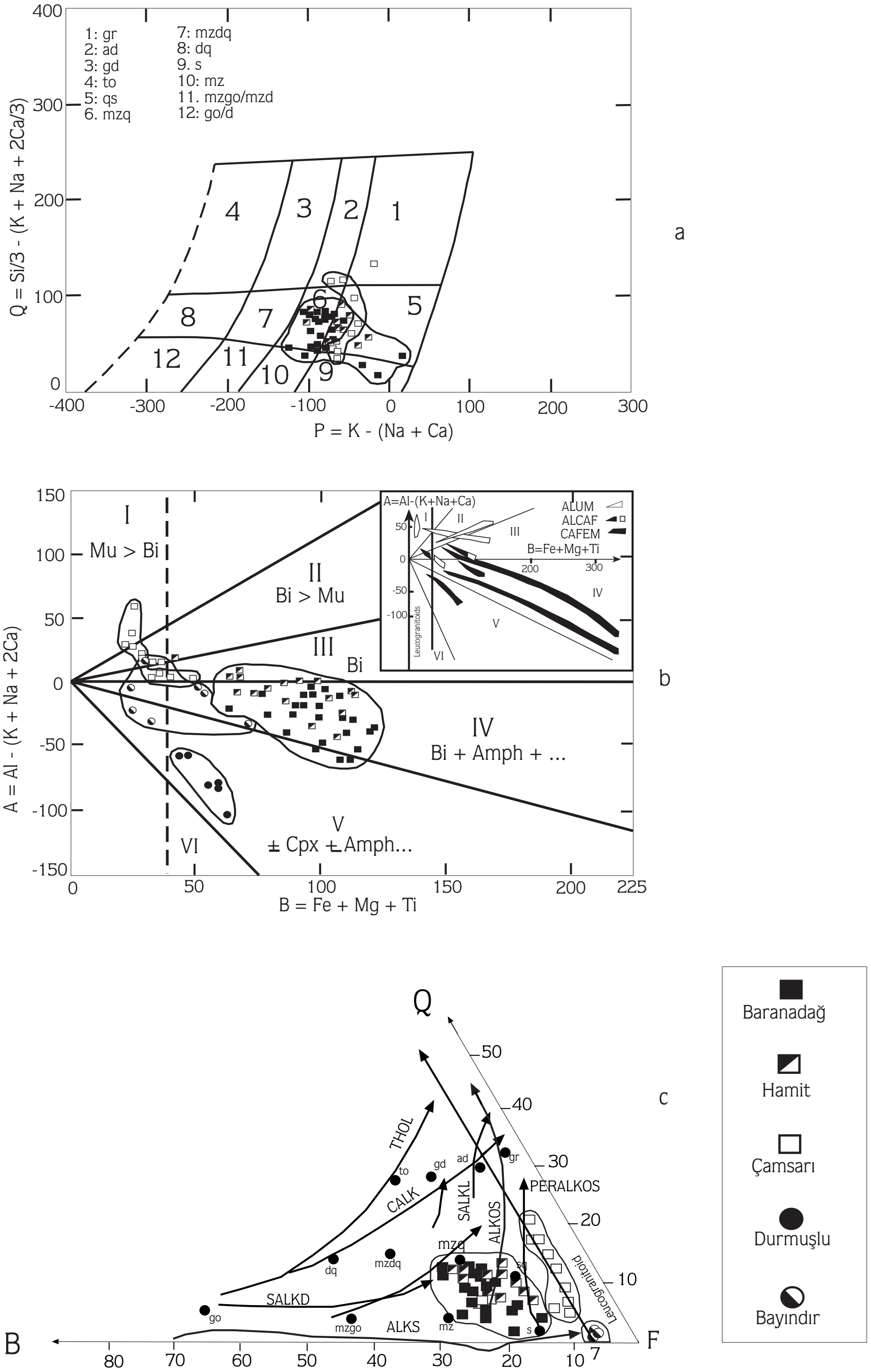


Figure 4a. Q-P chemical nomenclature diagram of the ALKOS and ALKUS alkaline rocks units (Debon and Le Fort, 1983).

Figure 4b. A vs. B diagram of the ALKOS and ALKUS alkaline rocks units (Debon and Le Fort, 1983). I., II. and III. areas represent peralumino whereas; IV., V. and VI. areas represent metalumino. ALCAF; alumino-cafemik, CAFEM; cafemic, ALUM; aluminous.

Figure 4c. Plotting of the ALKOS and ALKUS alkaline rock units on the QBF diagram (Debon ve Le Fort, 1983). THOL, tholeiitic; CALK, calc-alkaline; SALKL, light colored subalkaline; SALKD, dark colored subalkaline; ALKS, silica saturated alkaline; ALKOS, silica over saturated alkaline; PERALKOS, silisa over saturated peralkaline subunites.

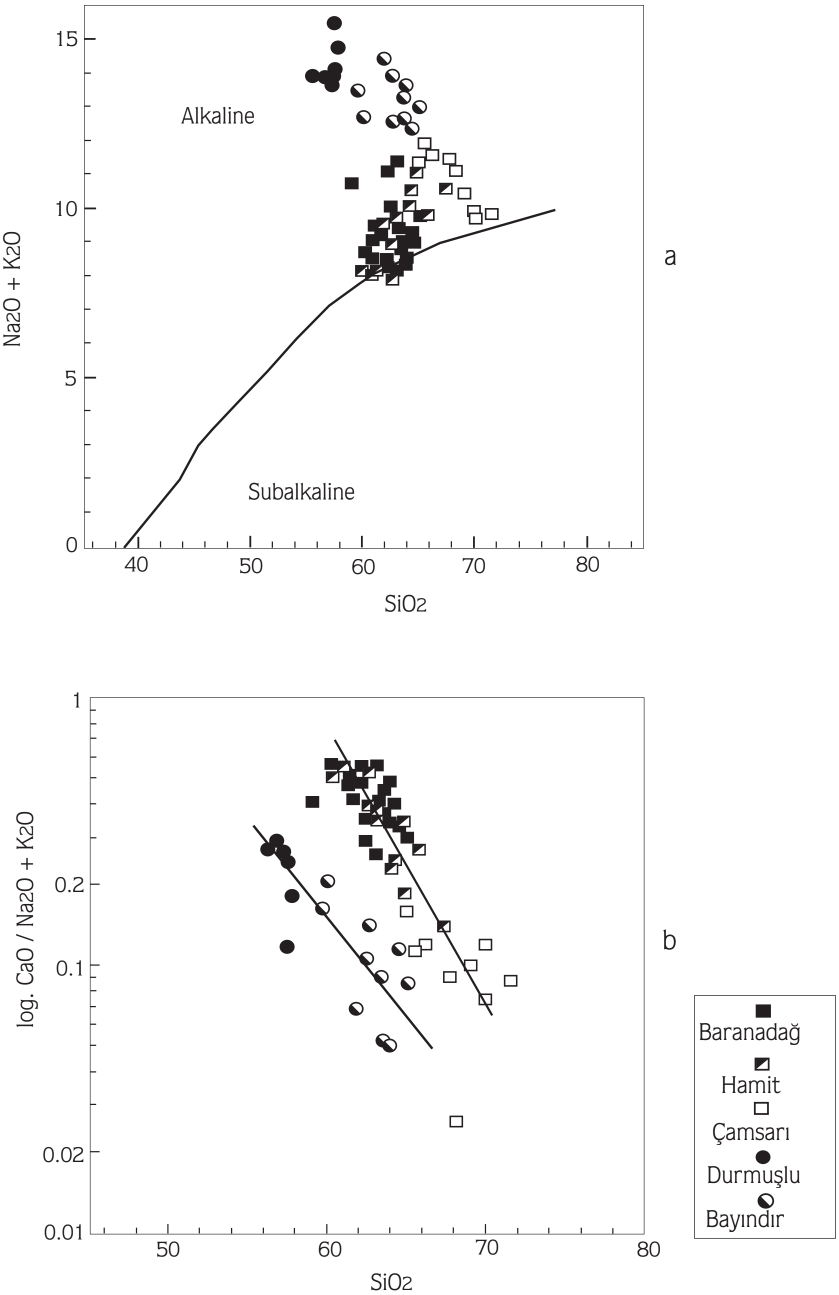


Figure 5. Plotting of ALKOS and ALKUS alkaline rocks units on the total alkaline - silica diagrams (a: Rickwood, 1989; b: Brown et al, 1984)

rich plagioclase during first period of the cooling of the magma. Sr is abundant in Baranadag quartz-monzonite, Hamit quartz-syenite and Çamsarı quartz-syenite, respectively. On the other hand, Rb, Th, Nb, Zr and Y which are known as incompatible elements, represent an increasing from Baranadağ unit to Hamit unit to Çamsarı unit (Figure 7 a). This behaviour of the above elements clarify the fractional crystallization process. On the R1-R2 geotectonic discrimination of Batchelor and Bowden (1985), the rock units having the ALKOS character mainly fall into post-collision uplift and late orogenic fields (Figure 8 a). These units also plot in the VAG and WPG fields of Pearce et al. (1984) (Figure 8b,c). As described by Pearce et al. (1984), the rock association, taking place around the triple joint of syn-COLG-WPG-VAG fields in Figure 8 b-c, is considered to have a post-collisional character. So that, the ALKOS Baranadağ, Hamit and Çamsarı units can be proposed to be post-collisional alkaline rock units. Such an ALKOS post-collisional alkaline magma can be formed by the fractional melting of the upper mantle material with a melting degree of %10-20, and with the non-modal Rayleigh/fractional type of melting (Wilson, 1989; Rollinson, 1993; Albarade, 1996; Tatar and Boztuğ, 1997) under the tensional regime after the Pontide-Anatolide collision. It is suggested that these alkaline magmatic rocks also resemble the group IV type magmatism of Harris et al. (1986), and represent the initial magmatism of the continental rift zone magmatism.

Silica Undersaturated Alkaline (ALKUS) Rocks

Both mineralogically and geochemically well defined silica undersaturated alkaline rocks are observed as vein rocks in the field and called as Durmuşlu nepheline-nosean-melanite syenite porphyry and Bayındır nepheline-cancrinite syenite. The Durmuşlu unit which is a part of the Kortundağ pluton, is observed as vein rocks and cut through metasedimentaries, metagabbros and Hamit quartz syenites (Figures 2 and 3). Whereas, field observations suggest that the Bayındır nepheline-cancrinite syenite has intruded metagabbro, Hamit quartz syenite, and Çamsarı quartz syenite (Figures, 2 and 3). The Durmuşlu unit is characterized by having megacrysts of K-feldspar in porphyritic texture, however, Bayındır unit has a typical granular texture. Durmuşlu unit is composed of phenocrysts of orthoclase, nosean, plagioclase, nepheline, riebeckite, aegirine, melanite and biotite in groundmass which is characterized by having of feldspar, amphibole, pyroxene and garnet. Very little amount of sphene, apatite, cancrinite and fluorite have been observed in the rocks. The Bayındır unit is located nearby the fluorite deposit in the Bayındır village, and is composed of orthoclase, nepheline, cancrinite, riebeckite, aegirine, melanite and biotite and displays granular texture. Accessory minerals are fluorite, apatite, sphene, and zircon. All of the Durmuşlu rock samples and most of the Bayındır samples are not plotted in Figure 4a due to their high content of feldspathoid group minerals. However, three of Bayındır samples which do not contain feldspathoid minerals what so ever, plotted in syenite field of Figure 4a. Durmuşlu and Bayındır units show a cafemic trend (Figure 4b). In Figure 4c, three samples of the Bayındır unit are plotted near the BF boundary, which is characterized by almost 0 % quartz. However, silica undersaturated alkaline rocks (ALKUS) supposed to be plotted under the line of BF of Figure 4c. The Durmuşlu and Bayındır units are different from ALKOS Baranadağ, Hamit and Çamsarı units (Figure 5). The differences between ALKUS and ALKOS units are also observed in Figure 6; concentrations of HFS and LIL content are lower in ALKOS Baranadağ, Hamit and Çamsarı units than in ALKUS units. However, only the Ti/Zr ratio is higher in ALKOS units (Figure 6). MORB normalized trace element spider diagram (Figure 7b) also shows the differences between ALKOS and ALKUS units. Durmuşlu and Bayındır units are showing enrichments in Rb, Th and Nb compared with those of ALKOS units. Figure 7b shows that there is a fractional crystallization trend from Durmuşlu to Bayındır.

Comparative Petrogenetic Discussion

The alkaline rocks outcropping in the Kortundağ and Baranadağ plutons are defined in two different units. Those units are silica over saturated, and silica under saturated. Comparative features of those units are given in Table 3.

The silica over saturated, and silica under saturated rock association of the alkaline suites (Boztuğ and Yılmaz, 1997) in the central Anatolian post-collision magmatism (Boztuğ et al., 1994; Göncüoğlu and Türeli, 1994; İlbeyli and Pearce, 1997) has been firstly described in this study. These rock associations were probably derived from different alkaline magma sources. As far as known from existing literature (Lameyre and Bonin, 1991), the silica under saturated alkaline magma is not formed from the fractional crystallization of any magmatic series (Figure 9). On the other hand, there is a common assumption that the alkaline magmas, particularly silica undersaturated alkaline magmas, are generated by partial melting of the upper mantle peridotites (Fitton and Upton, 1987; Wilson, 1989; Rollinson, 1993; Pitcher, 1993) with a low degree (less than %20) of melting and a non-modal Rayleigh/fractional type of melting.

In the light of these theoretical background, the alkaline rocks (Boztuğ and Yılmaz, 1997) of the Central Anatolian post-collisional plutonism (Boztuğ et al., 1994; Göncüoğlu and Türeli, 1994; İlbeyli and Pearce, 1997) can be suggested to be derived from two different alkaline magmas, i.e. silica oversaturated alkaline and undersaturated alkaline magmas. These different alkaline magmas could have been derived from the partial melting of the upper mantle source rocks due to adiabatic decompression under the tensional regime after the crustal thickening following the Anatolide-Pontide collision.

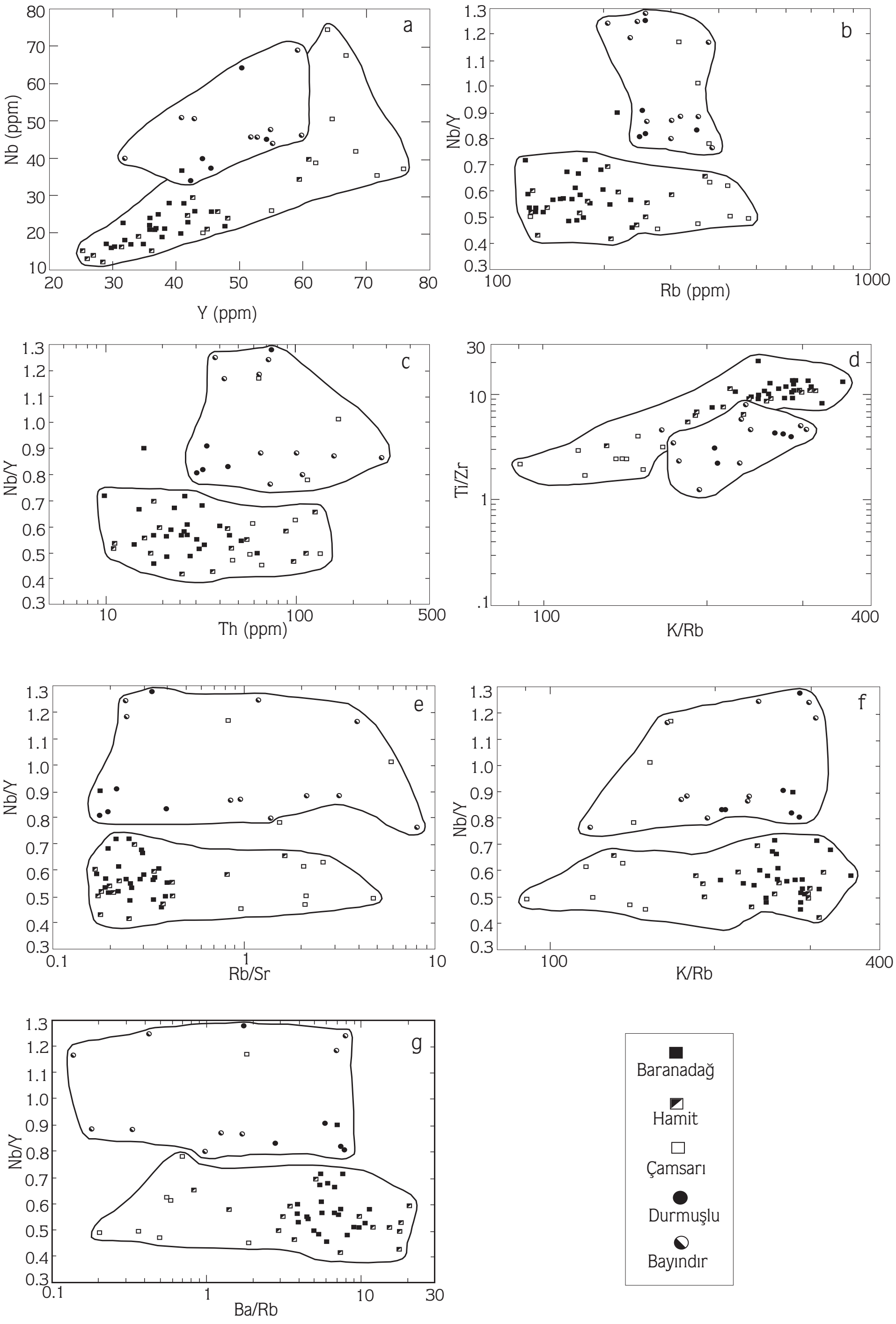
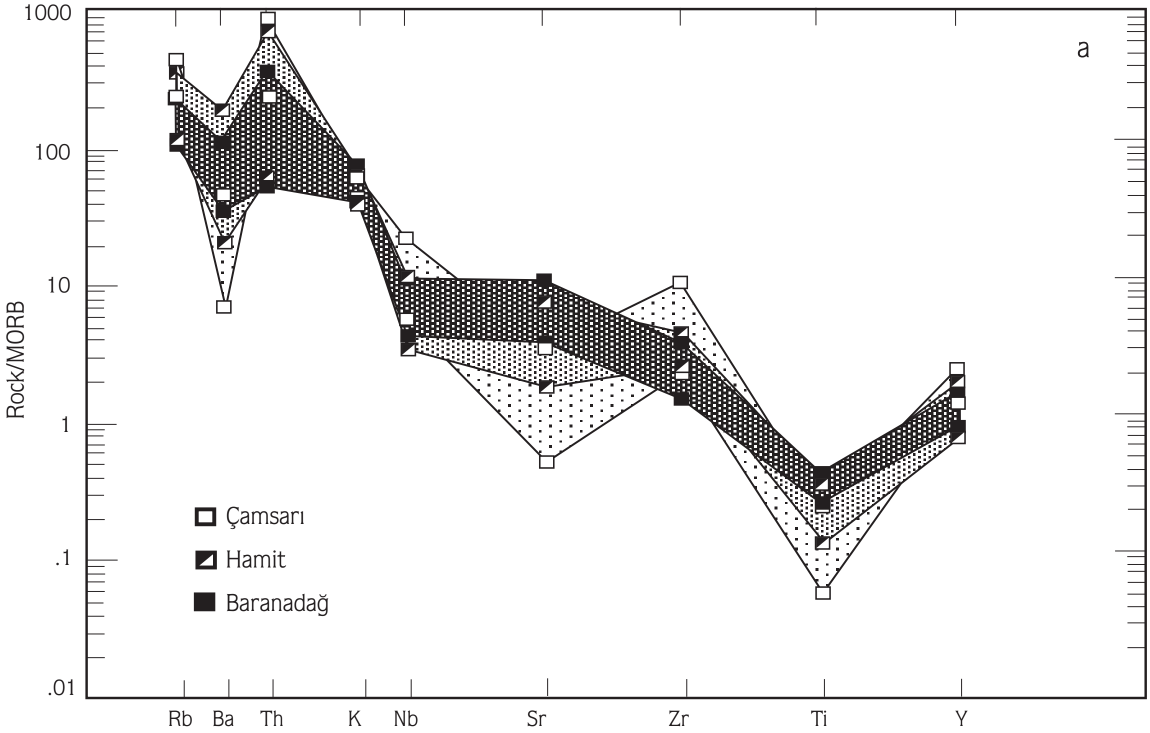


Figure 6. Trace element distribution diagrams of the ALKOS and ALKUS alkaline rock units, outcroping in the Kortundağ and Baranadağ.
a: HFS vs. HFS diagram
b: HFS/HFS vs. LIL diagram
c: HFS/HFS vs. HFS diagram
d: HFS/HFS vs. LIL/LIL diagram
e: HFS/HFS vs. LIL/LIL diagram
f: HFS/HFS vs. LIL/LIL diagram
g: HFS/HFS vs. LIL/LIL diagram



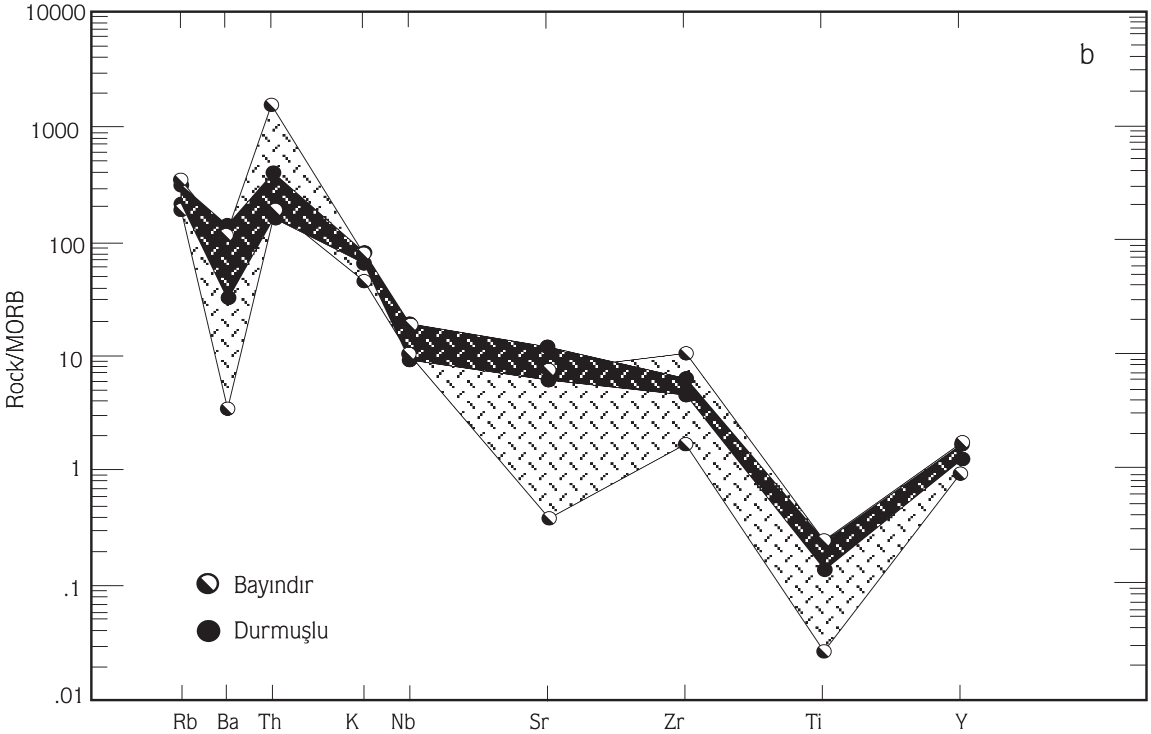


Figure 7a. MORB normalized trace element diagram of the ALKOS alkaline rock units (Baranadağ, Hamit and Çamsarı units). b. MORB normalized trace elements diagram of the ALKUS alkaline rock unit (Durmuşlu and Bayındır units).

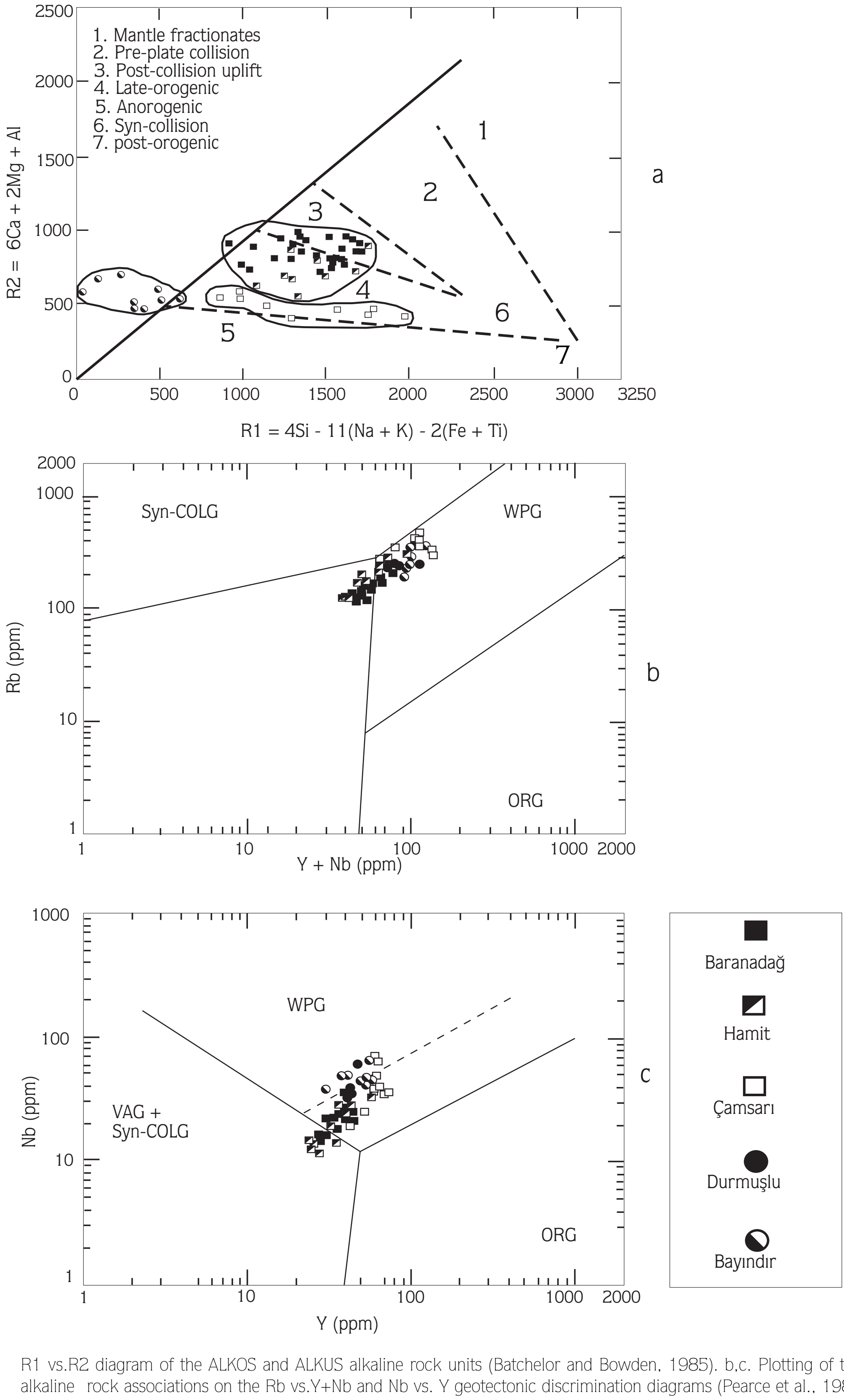


Figure 8a. R1 vs.R2 diagram of the ALKOS and ALKUS alkaline rock units (Batchelor and Bowden, 1985). b,c. Plotting of the ALKOS and ALKUS alkaline rock associations on the Rb vs.Y+Nb and Nb vs. Y geotectonic discrimination diagrams (Pearce et al., 1984).

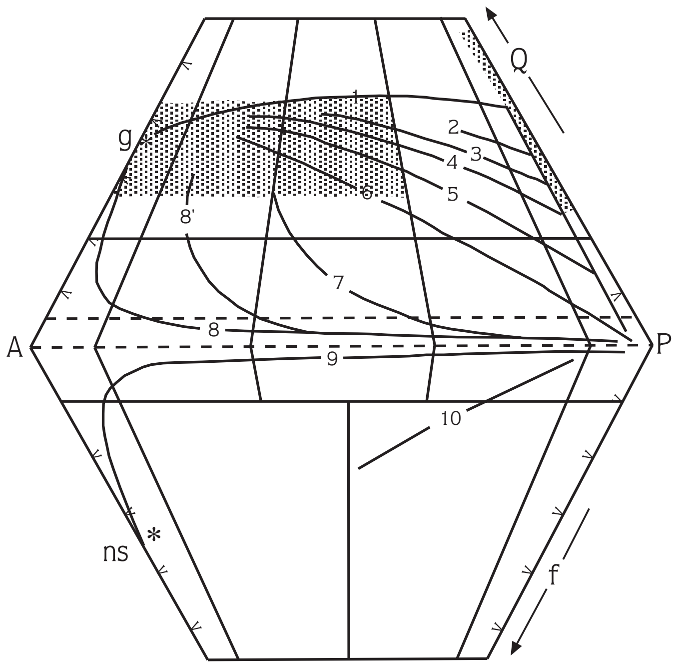


Figure 9. Average trends in some plutonic suites (after Lameyre and Bowden, 1982). Star with g. granitic minimum melts; star with ns: nepheline syenite minumum melts. Shaded areas: granitic rocks of crustal origin. Tholeiitic: (1) Troodos and Skaergaard; calc-alkaline tonalitic-trondhjemitic: (2) SW Finland; calc-alkaline granodioritic: (3) Corsica-Sardinia, (4) Chile, (5) Peru, (6) Sierra Nevada; monzonitic: (7) Vosges and Corsica; alkaline silica-oversaturated. (8) Niger-Nigeria, Corsica, Oslo, Kerguelen Archipelago; alkaline silica-undersaturated: (9) Oslo, Laacher See, Kerguelen Archipelago; alkaline strongly silica-undersaturated. (10) Tahiti-Nui.

Conclusion

Two different alkaline rock units which are thought to be derived from different magmas, have been determined in the Kortundağ and Baranadağ plutons. They intrude the crustal metasediments of Central Anatolian Crystalline Complex, and the gabbros of Central Anatolian Ophiolite. These are silica oversaturated (ALKOS) Baranadağ quartz monzonite, Hamit quartz syenite and Çamsarı syenite and silica undersaturated (ALKUS) Durmuşlu nepheline-nosean-melanite syenite porphyry and Bayındır nepheline-cancrinite syenite. Field observation shows that the silica understaurated (ALKUS) rocks are younger than silica oversaturated (ALKOS) rocks. These two different alkaline magmas are assumed to be derived from upper mantle source rocks under the tensional regime with different degree and type of partial melting in space and time related to Anatolide-Pontide collision.

References

Albaréde, F., 1996, Introduction to Geochemical Modelling, Cambridge University Press,

Alpaslan, M., Boztuğ, D., 1997, Yıldızeli yöresinde (B–Sivas) çarpışmayla eş zamanlı ve çarpışma sonrası plütonların birlikteliği. Turkish J. of earth sci., 6, 1–12.

Batchelor, B. and Bowden, P., 1985, Petrogenetic interpretation of granitoid rock series using multicationic parameters. Chem. Geol., 48, 43-55.

Bayhan, H., 1987, Cefalıkdağ ve Baranadağ plütonlarının (Kaman) petrografik ve kimyasal-mineralojik özellikleri. Jeoloji Müh. Derg., 30-31, 11-16

Bayhan, H., 1988, Bayındır - Akpınar (Kaman) yöresindeki alkali kayaçların jeokimyası ve kökensel yorumu. Türkiye Jeoloji Kurumu Bülteni, 31, 59-71.

Boztuğ, D., 1998, Orta Anadolu'da metamorfizma-magmatizma sinkronizasyonu ve S-I-A tipi magmatik kayaç birliklerinin jeodinamik önemi. 51. Türkiye Jeoloji Kurultayı Bildiri Özleri, 31.

Boztuğ, D., Yılmaz, S. and Kesgin, Y., 1994; İç-Doğu Anadolu alkalin provensindeki Kösedağ plütonu (Suşehri -KD Sivas) doğu kesiminin petrografisi ve petrojenezi. Türkiye Jeoloji Kurumu Bülteni, C. 37/2, 1-14.

Boztuğ, D. and Yılmaz, S., 1997, Some variabilities in the partial melting of the source and solidification processes of the melts in the genesis of the Central Anatolian (CA) post-collisional alkaline plutonism, Turkey. European Union of Geosciences (EUG) 9, Strasbourg - France, 502.

Boztuğ, D., Debon, F., İnan, S., Tutkun, S.Z., Avcı, N. and Kesgin, Ö., 1997, Comparative geochemistry of four plutons from the Cretaceous-Palaeogene Central-Eastern Anatolian alkaline province (Divriği region, Sivas, Turkey). Turkish Journal of Earth Sciences, 6, 95-115.

Boztuğ, D., Tatar, S., Otlu, N. and Yılmaz, S., 1998, Orta Anadolu çarpışma sonrası plütonizmasında kalkalkali ve alkali monzonitik birlikler. 51. Türkiye Jeoloji Kurultayı Bildiri Özleri, 37.

Brown, G.C., Thorpe, R.S. and Webb, P.C., 1984, The geochemical characteristics of granitoids in contrasting arcs and comments on magma sources. J. Geol. Soc. Lond., 141, 411-426.

Clark, D., 1994, NEWPET: Memorial University of Newfoundland Departemnt of Earth Sci. Centre for Earth Resources Research St. John's, NF, Canada.

Debon F., and Le Fort, P., 1983, A chemical-mineralogical classification of common plutonic rocks and associations. Transactions of the Royal society of Edinburg: Earth sciences, 73, 135-149.

Didier, J. and Barbarin, B., 1991, Enclaves and Granite Petrology. Devolopments in Petrology No. 13, 625p Elsevier, Amsterdam.

Ekici, T. and Boztuğ, D., 1997, Granitoyidlerdeki K-feldispat megakristallerinin anlamı ve önemi. Çukurova Üniversitesi' nde Jeoloji Mühendisliği Eğitiminin 20. Yılı Sempozyumu, Geosound, 30, 507–518.

Erler, A. and Bayhan, H., 1995, Orta Anadolu Granitoidleri' nin genel değerlendirilmesi ve sorunları. Yerbilimleri 17, 49-67.

Erler, A.,Akıman, O., Unan, C., Dalkılıç, F., Dalkılıç, B., Geven, A., and Önen, P., 1991, Kaman (Kırşehir) ve Yozgat yörelerinde Kırşehir Masifi magmatik kayaçlarının petrolojisi ve jeokimyası. Doğa - Tr. J. of Engineering and Environmental Sci., 15, 76-100.

Fitton, J.G. and Upton, B.G.J. 1987, Alkaline Igneous Rocks. Geol. Soc. Special Pub. No.30.

Govindaraju, K., 1989, Compilation of working values and sample description for 272 geostandarts. Geostandarts Newsletter, 13, 1–113.

Göncüoğlu, M.C. and Türeli, T.K., 1994, Alpine collisional - type granitoids from Western Central Anatolian Crystalline Complex, Turkey. Jour. of Kocaeli Univ., Earth Sci., No. 1, 39-46.

Göncüoğlu, M.C., Toprak, V., Kuşçu, I., Erler, A. and Olgun, E., 1991, Orta Anadolu Masifinin batı bölümünün jeolojisi. TPAO Rapor No: 2909 (unpublished), Ankara.

Görür, N., Oktay, F.Y., Seymen, I. and şengör, A.M.C., 1984, Paleotectonic Evolution of the Tuzgölü Basin Complex, Central Turkey: Sedimantary Record of a Neo-Tethyan Closure. In: Dixon, J.E. and Robertson, A.H.F. (eds). The Geological Evolution of the Eastern Mediterranean. Blackwell Scientific Publications, Oxford, 467-482.

Harris, N.B.W.,Pearce, J.A. and Tindle, A.G., 1986, Geochemical characteristics of collision-zone magmatism. In coward, M.P. ve Riesi A.C., (eds), Collision Tectonics, Geological Soc. of London Spec. Publ. No. 19, 67-68.

İlbeyli, N. and Pearce, J., 1997; Petrogenesis of the collision - related Central Anatolian Granitoids, Turkey. European Union of Geosciences (EUG-9), Strasbourg - France, Abstracts, 502.

Jaques, A.L. and Green, D.H., 1980, Anhydrous melting of peridotite at 0 - 15 Kb pressure and the genesis of tholeiitic basalts. Contrib. Mineral. Petrol. 73, 287-310.

Lameyre, J. and Bonin, B., 1991, Granites in the main plutonic series. In Didier, J. and Barbarin, B. (eds), Enclaves and granite petrology, Developments in Petrology, 3-17.

Lameyre, J. and Bowden, P., 1982, Plutonic rock type series: discrimination of various granitoids seriesand related rocks. J. Volcanol. Geotherm. Res., 14: 169-186.

Lünel, A.T., 1987, An Approach to the naming, origin and age of Baranedağ monzonite of Kırşehir intrusive suite. METU Jour. of Pure and Applied Sci., 18,3, 385-404.

Otlu, N., 1998, Kortundağ-Baranadağ arası (D Kaman, KB Kırşehir) plütonik kayaçlarının petrolojik incelenmesi. C.Ü. Fen Bilimleri Enst., PhD Thesis, 187p. (unpublished).

Pearce, J.A., Harris, B.W. and Tindle, A.G., 1984, Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. J. Petrol., 25, 956-983.

Pitcher, W.S., 1993, The Nature and Origin of Granite. Chapman and Hall, 321 p.

Poisson, A., 1986, Anatolian micro-continents in the Eastern Mediterranean context: The neo-Tethysian oceanic troughs. Science de la Terre, Memoire 47, 311-328.

Rickwood, P.C., 1989, Boundary lines within petrologic diagrams which use oxides of major and minor elements. Lithos, 22, 247-263.

Rollinson, H.R.,1993, Using Geochemical data: Evaluation, presentation, interpretation. Longman Sci. and Technical, John Wiley and Sons, 352p.

Tatar, S. and Boztuğ, D., 1997, Yozgat Batoliti GB kesiminde (Şefaatli-Yerköy arası) FC ve magma mingling/mixing süreçlerinin kanıtları. Çukurova Üniversitesi' nde Jeoloji Mühendisliği Eğitiminin 20. Yılı Sempozyumu, Bildiri özleri, 215, Adana.

Tatar, S. and Boztuğ, D., 1998, Kompozit Yozgat Batoliti' ndeki I/HLO tipi monzonitik birlikte fraksiyonel kristalleşme ve asimilasyon-fraksiyonel kristalleşmeyle oluşmuş ters zonlanma. . 51. Türkiye Jeoloji Kurultayı Bildiri Özleri, 35.

Türeli, T.K., Göncüoğlu, M.C. and Akıman, O., 1993, Origin and petrology of Ekecikdağ granitoid in Western Anatolian Crystalline Massif. Symposium for the 25th Anniversary of Earth Sciences at Hacettepe University, November 15-17, 1993, Beytepe-Ankara, Abstracts, 45-46.

Wilson, M., 1989; Igneous Petrogenesis, London Unwin Hyman. 456 p.

Yalınız, M.K., Floyd, P.A. and Göncüoğlu, M.C., 1996, Supra-subduction zone ophiolites of Central Anatolia: Geochemical evidence from the Sarıkaraman Ophiolite, Aksaray, Turkey, Mineralogical Magazine, 60, 402, 697-710.

Yalınız, M.K., Floyd, P.A., and Göncüoğlu, M.C., 1997, Geochemistry and petrogenesis of intrusive and extrusive ophiolitic plagiogranites, Central Anatolian Crystalline Complex, Turkey. Lithos, 42, 225-241.

Yılmaz, S. and Boztuğ, D., 1994, Granitoyid petrojenezinde magma mingling/mixing kavramı, Jeoloji Mühendisliği, 44-45, 1-20.

Yılmaz, S., and Boztuğ, D., 1998, Çiçekdağ Magmatik Kompleksi' nin (KB Kırşehir) petrojenezi. . 51. Türkiye Jeoloji Kurultayı Bildiri Özleri, 33.