Tr. J. of Earth Sciences
7 (1998) 185–199

Petrogenesis of the Çiçekdağ Igneous Complex, N of Kırşehir, Central Anatolia, Turkey

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Received: 21.05.1998

Abstract: Central Anatolia typically represents well-preserved geological features of a collision zone. This collision zone is characterized by some geological events occurred in the Anatolide passive margin of the Anatolide-Pontide collision along the Ankara Erzincan suture zone. This suture zone is commonly known to be formed by the pre-Maastrichtian northward subduction of the northern branch of Neo-Tethys beneath the Pontides which was constituting the southernmost tip of Eurasiain plate at that time. These geological occurrences are inverted metamorphism; ophiolitic slabs derived from main suture zone; syn-collisional and S/C_{ST} type magmatism; post-collisional, high-K calcalkaline, hybrid and I/H_{LO} type magmatism; post-collisional, within-plate, A-type alkaline magmatism; and post-collisional Central Anatolian basins.

Among these geological occurrences, the ophiolitic slabs derived from Ankara-Erzincan suture zone; post-collisional, high-K calcalkaline, hybrid I/H_{LO} type magmatism; and post-collisional, within-plate, A-type alkaline magmatism are observed as a good association in space and time in the Çiçekdağ region in Central Anatolia.

The ophiolitic slab, named as Central Anatolian ophiolite, is composed of two mapable units which are called Çökelik volcanics and Akçakent gabbro. There are some gabbroic intrusions within the Çökelik volcanics in some localities, however, the major boundary between these two units is a thrust fault along which the Akçakent gabbro thrusted onto the Çökelik volcanics from east to west. The rocks of Akçakent gabbro possess a preserved ophitic texture and mineralogical composition which can lead one to call them uralite-gabbro. Some major and trace element geochemical data determine a depleted mantle and low-K tholeiitic characteristics in composition.

The Halaçlı monzogranite, characterizing the post-collisional, high-K calcalkaline, hybrid I/H_{LO} type magmatism, intrudes the Central Anatolian Ophiolite by forming some contact metamorphic hornfelses derived particularly from the Çökelik volcanics. The phaneritic-porphyritic texture is a recognizing feature in the rocks of Halaçlı monzogranite due particularly to existence of common K-feldspar megacrysts. The major rock forming minerals are composed of quartz+K-feldspar + plagioclase (An_{32-44})+hornblende + augite +biotite association.

The Eğrialan syenite, part of post-collisional, within-plate, A-type alkaline magmatism, is seen to intrude both of the Central Anatolian Ophiolite and Halaçlı monzogranite. The rocks of this syenitic body can be subdivided into medium to coarse-grained and medium-grained rocks on the basis of texture. The major rock forming minerals consist of orthoclase+plagioclase(An_{32-40}) ± nepheline + riebekite / arfvedsonite+aegirine+biotite±melanite garnet; as for the accessory constituents they are composed of sphene+apatite+xenotime+monazite+allanite+zircon+fluorite minerals. The Eğrialan syenite includes some fluorite mineralizations within the syenitic body itself, and also at the contact with gabbros.

Key Words: Çiçekdağ igneous complex, high-K calcalkaline, alkaline magmatism, Central Anatolian ophiolite, igneous petrogenesis, collision zone magmatism.

Çiçekdağ Magmatik Kompleksinin Petrojenezi, K Kırşehir, Orta Anadolu, Türkiye

Özet: Orta Anadolu, çarpışma zonunu karakterize eden jeolojik özelliklerin bazılarının korunarak birlikte gözlenebildiği bir bölgedir. Orta Anadolu'daki bu çarpışma zonu, Maestrihtiyen'de Neo-tetis'in kuzey kolunun Avrasya plakası (Pontik basement) altına, kuzeye dalması ile oluşan Ankara-Erzincan sütur zonu boyunca Anatolid-Pontid çarpışmasının Anatolid pasif kenarında oluşmuş bazı jeolojik olaylar ile karakterize edilmektedir. Bu jeolojik olaylar şunlardır: Terslenmiş metamorfizma, ana sütur zonundan türemiş ofiyolit dilimleri, çarpışmayla eşzamanlı ve S/C_{ST} tipi magmatizma, çarpışma sonrası, yüksek K'lu kalkalkalin, hibrid ve I/H_{LO} tipi magmatizma, çarpışma sonrası, levha içi, A-tipi alkalin magmatizma ve çarpışma sonrası Orta Anadolu basenleridir.

Bu jeolojik oluşumlardan, Ankara-Erzincan sütur zonundan türemiş ofiyolitik dilimler ile çarpışma sonrası yüksek K'lu kalkalkalin, hibrid I/H_{LO} tipi magmatizma ve çarpışma sonrası levha içi A-tipi alkalin magmatizma Orta Anadolu'da Çiçekdağ bölgesinde zaman-konum bakımından iyi bir beraberlik sunarlar.

Orta Anadolu ofiyoliti olarak isimlendirilen ofiyolitik dilim, çalışma alanında Çökelik volkaniti ve Akçakent gabrosu olarak, haritalanabilir iki birimden oluşmaktadır. Akçakent gabrosu, bazı lokasyonlarda Çökelik volkaniti içerisinde gabroyik intrüzyonlar şeklinde gözlenmektedir. Bununla beraber, bu iki birim arasında, Akçakent gabrosunun Çökelik volkaniti üzerine doğudan-batıya doğru bindirdiği faylı bir sınır tanımlanmaktadır. Akçakent gabrosu kayaçları ofitik dokulu olup, uralit gabro olarak isimlendirilebilecek bir mineralojik bileşime sahiptir. Bazı major ve iz element jeokimyası verilerine göre, bileşim olarak tüketilmiş mantodan türeyen düşük K'lu toleyitik bir karekter sergilemektedir.

Halaçlı monzograniti, çarpışma sonrası, yüksek K'lu kalkalkalin, hibrid I/H_{LO}- tipi magmatizmadan oluşan bir özelliğe sahip olup, kısmen Çökelik volkanitinden türemiş bazı kontakt metamorfik hornfelslerin varlığıyla da belirlenen, Orta Anadolu Ofiyolitleri içerisine sokulum yapmıştır. Halaçlı monzograniti kayaçlarında K-feldispat megakristallerinin varlığıyla faneritik-porfiritik bir doku tanımlanmıştır. Ana kayaç yapıcı mineralleri, kuvars + K-feldipat + plajiyoklaz ($An_{32–44}$) + hornblend + öjit + biyotitten oluşur.

Çarpışma sonrası levha içi A-tipi magmatizmanın bir üyesi olan Eğrialan siyeniti, Orta Anadolu ofiyolitleri ve Halaçlı monzograniti içerisine sokulum yapmış olarak görülmektedir. Bu siyenitik kütlenin kayaçları, dokusal özellikleri göz önüne alınarak orta-iri taneli ve orta taneli kayaçlar olarak alt sınıflara ayrılmıştır. Ana kayaç yapıcı mineralleri ortoklaz + plajiyoklaz($An_{32–40}$) ± nefelin + ribekit/arfvedsonit + egirin + biyotit ± melanit granattan oluşmaktadır. Aksesuvar mineral olarak titanit + apatit + xenotim + monazit + allanit + zirkon + florit mineralleri bulunur. Eğrialan siyeniti, siyenitik kütleler içerisinde ve gabrolar ile kontakt oluşturan kesimlerde florit mineralizasyonları içerirler.

Anahtar Sözcükler: Çiçekdağ magmatik kompleksi, yüksek K'lu kalkalkalin magmatizma, alkali magmatizma, Orta Anadolu ofiyoliti, magmatik petrojenez, çarpışma zonu magmatizması.

Introduction

Some decades ago, it was only said the existence of some intrusive rocks, without pointing out anything on the main types and subtypes of magma genesis, in Central Anatolia which were also associated with the metamorphic rocks. However, Ketin (1955, 1959) has descriptively pointed out the co-existence of granitic, syenitic and gabbroic rocks in Central Anatolia without remarking the magma genesis. On the other hand, the metamorphic rocks have firstly been identified as independent lithodem units by Göncüoğlu (1977) in Niğde massif, Central Anatolia. The assemblage of intrusive-metamorphic rocks led the geologists to describe "Kızılırmak massif", "Central Anatolian massif" or "Kırşehir massif" consisting of metamorphic-magmatic rock complex (after Erkan, 1981). The metamorphic and magmatic rocks in Central Anatolia have also been named by Seymen (1981) as "Kaman metamorphic supersuite" and "Kırşehir intrusive suite", respectively. On the other hand, Lünel (1985) has used the term of "Kırşehir complex" to determine the magmatic-metamorphic rock association in Central Anatolia. Görür et al. (1984) and Poisson (1986) have touched on the geodynamic significance of the magmatic and metamorphic rock assemblage in space and time that they described this assemblage as "Kırşehir block". In all these descriptions, the igneous rocks in Central Anatolia were proposed to be asidic in composition, i.e. granitic-granodioritic-monzonitic mineralogy. On the other hand, apart from the asidic intrusive rocks, the existence of gabbroic and even alkaline rocks was remarked in the studies carried out in Central Anatolia in last decade, and the crystalline rocks have been collectively called "Central Anatolian Crystalline Complex (CACC)" by Göncüoğlu et al. (1991, 1992). These authors further named the felsic magmatics as central Anatolian Granitoids and the mafic/ultramafic rocks as the Central Anatolian optiolites. After the appearence of different igneous rock associations in Central Anatolia, the igneous geology of Central Anatolia have attracted geologists to do some research work in this region. These studies have shown that different igneous rocks were derived from different magmas in different geodynamic settings (Erler et al., 1991; Türeli, 1991; Akıman et al., 1993; Göncüoğlu and Türeli, 1993, 1994; Boztuğ, 1994-1995; Erler and Bayhan, 1995; Geven, 1995; Kadıoğlu, 1996; Erler and Göncüoğlu, 1996; Kadıoğlu and Güleç, 1996). Some most recent studies (Ekici, 1997; Ekici and Boztuğ, 1997; Tatar, 1997; Tatar and Boztuğ, 1997; Boztuğ and Yılmaz, 1997; Otlu and Boztuğ, 1997) have concluded that the igneous rocks in Central Anatolia can be subdivided into several genetic associations such as S/C_{ST} -type, two-mica granitic association; I/H_{LO} -type, high-K calc-alkaline monzonitic association; and A-type, alkaline syenitic association. However, some detailed studies performed purely on the alkaline association have revealed that this association should also be subdivided into some alkaline subtypes on the basis of wall-rock, associated mineralization/ore deposit, silica saturation index, solidification conditions of magmas, and the partial melting conditions of source material during magma genesis (Boztuğ and Yılmaz, 1997; Boztuğ, 1998, this volume). Thus, all these studies on the igneous geology of Central Anatolia have concluded that the concept of a single granitic-granodioritic-monzonitic rock unit in Central Anatolia must be replaced by an agreement that there should be different rock associations among which, even, each association can be subdivided into several subtypes.

This paper deals essentially with the petrogenesis of the "Çiçekdağ igneous complex" which is defined by Göncüoğlu and Türeli (1994) in the Çiçekdağ (N of Kırşehir) region (Figure 1). Geology of the Çiçekdağ area and the igneous rocks of it were studied by Ketin (1955, 1959) and the preliminary geochemical work was performed by Erdoğan et al. (1996). In this study , an area of approximately 300 km^2 has been geologically mapped to the scale of 1/25 000. Some 107 rock

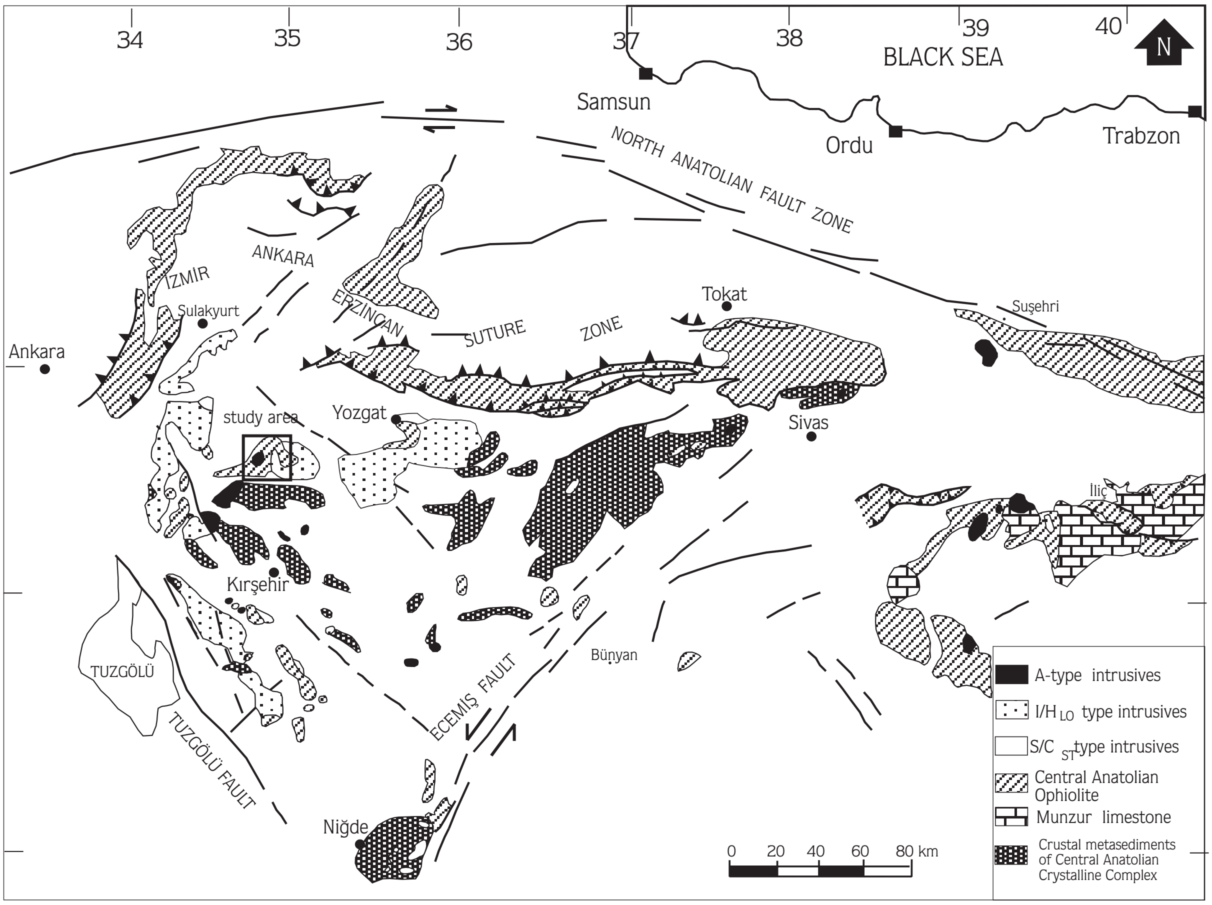

Figure 1. Geological and geographical settings of the plutonic rock in the Central Anatolia, Turkey (based on Bingöl, 1989).

samples have been collected from the mapped area from which 11, 14 and 13 rock samples belonging to the Akçakent gabbro of Central Anatolian Ophiolite, Halaçlı monzogranite, and Eğrialan syenite, respectively, have been analysed for the major and trace element compositions. All the chemical analyses have been performed with the Rigaku 3270 E-WDS model XRF spectrometry using some USGS and CRPG rock standards (Govindaraju, 1989) for calibration at the Mineralogical-Petrographical and Geochemical Research Laboratories of the Dept. of Geological Engineering of Cumhuriyet University in Sivas.

Geology of the Çiçekdağ Area

There are five different units in the mapped area (Figure 2). The oldest units are composed of Çökelik volcanics and Akçakent gabbro which constitute part of the Central Anatolian Ophiolite (Göncüoğlu at al. 1991). The Çökelik volcanics defined by Erdoğan et al. (1996) are exposed in the western and eastern parts of studied area (Figure 2). Just around Çökelik village, there are some well-preserved basaltic pillow lavas which are intercalated with siliceous-clayey-calcareous sediments. Erdoğan et al. (1996) found in these sediments some fossils yielding Turonian-Santonian age. The most important knowledge, obtained from these sediments in the field during mapping, is that they are primarily associated with mafic pillow lavas indicating the submarine mafic magmatism. There are some porphyritic syenite, monzonite and monzogranite dykes within the Çökelik volcanics around Alan village (Figure 2). Both of the Çökelik volcanics and Akçakent gabbros are considered to be part of Upper Cretaceous ophiolitic melange by Erler and Bayhan (1995), and to be part of an ensimatic arc issued from İzmir-Ankara ocean by Göncüoğlu and Türeli (1994).

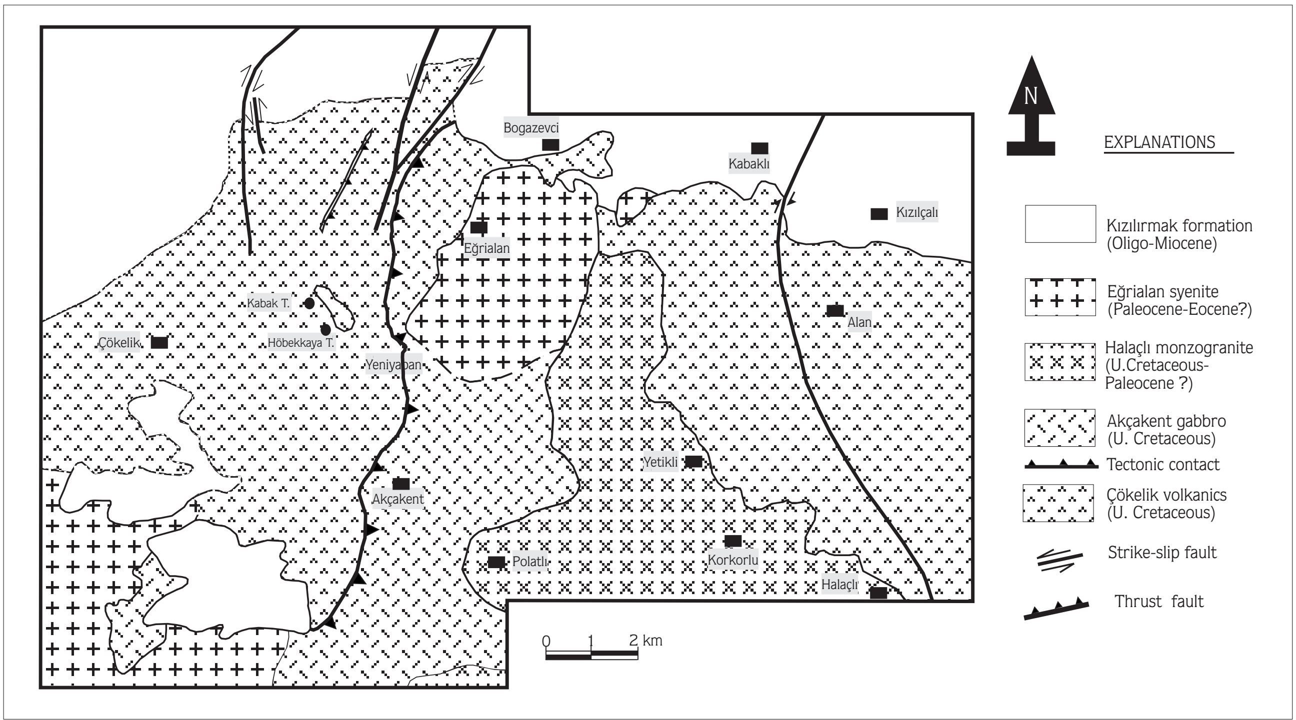

Figure 2. Geological map of the magmatic rocks and surrounding units in the west of the Çiçekdağ region, North Kırşehir, Central Anatolia.

Akçakent gabbro consists mainly of isotropic gabbro and scarcely of cumulate gabbros particularly exposed around Akçakent town. The contact relation between Çökelik volcanics and Akçakent gabbro is a thrust fault along which the Akçakent gabbro has been thrusted onto the Çökelik volcanics from east to west. However, there are also some small gabbroic intrusive bodies within the Çökelik volcanics that the most apparent outcrops of these types of gabbros are exposed around Kabak tepe and Höbekkaya tepe district (Figure 2). The Halaçlı monzogranite which was described as “Yozgat Magmatics” by Erdoğan et al. (1996) in the study area intrudes both of the Çökelik volcanics and Akçakent gabbro by forming some contact metamorphic rocks along the boundaries. The well-defined contact metamorphic rocks have been particularly developed at the contacts with the Çökelik volvanics where the mafic volcanics have been transformed into tremolite/actinolite-epidote hornfelses. The presence of K-feldspar megacrysts is the most distinguishing feature in the Halaçlı monzogranite in the field. This monzogranite body is evaluated to be one of the members of the post-collisional Central Anatolian granitoids (Göncüoğlu and Türeli, 1994; İlbeyli and Pearce, 1997; Boztuğ, this volume). It is also equivalent of the Lökköy K-feldspar megacrystalline monzogranite of Ekici and Boztuğ (1997) and of the Yassıağıl K-feldspar megacrystalline monzogranite (Tatar and Boztuğ, 1997). By taking into account these correlations, the Halaçlı monzogranite is suggested to possess an age of sometime around U. Cretaceous - Paleocene. The Eğrialan syenite crops out in the northern and southwestern parts of the mapped area (Figure 2). It is clearly seen to intrude the Akçakent gabbro in a fluorite mine open pit just to the northwestern part of the Yeniyapan village. The Eğrialan syenite consists mainly of phaneritic-coarse grained, syenitic rocks and rarely of fine to medium grained syenitic rocks. The latter one is observed to outcrop within the phaneritic coarse grained syenites in the field. Both the phaneritic coarse grained and fine to medium grained vein rocks are associated with flourite mineralizations. In addition to these syenitic rocks, there are also some widespread vein rocks which are composed of fine to medium grained syenitic rocks. These are seen to cut the Akçakent gabbro and both of the phaneritic coarse grained and fine - to medium grained syenitic rocks in the field. There is a remarkable point in the field that the phaneritic coarse grained syenites contain only large biotite flakes as the mafic component in hand specimen. Birgili et al. (1975) have shown that the earliest sedimentary cover in Çiçekdağı area is Late Paleocene-Eocene in age. In the mapped area, however, the Oligo-Miocene Kızılırmak formation, composed of red colored conglomerate-sandstone-siltstone alternated with gypsum, unconformably overlies all the units. The most important structural elements of the mapped area consist of N-S trending thrust fault between the Akçakent gabbro and Çökelik volcanics, and other N-S trending faults with strike-slip component (Figure 2).

Petrography and Bulk Geochemistry

The petrographical determination of the intrusive rock units, i.e. Akçakent gabbro from the Central Anatolian ophiolite, Halaçlı monzogranite and Eğrialan syenite have been based on the chemical nomenclature diagram (Figure 3) proposed by Debon and Le Fort (1983). This nomenclature has always been tested and verified by the microscopical observations using a Labophot-pol type of binocular polarising microscopy. The main mineralogical-petrographical and wholerock geochemical characteristics of the Akçakent gabbro from the Central Anatolian ophiolite, Halaçlı monzogranite and Eğrialan syenite can be summarized as follows.

Central Anatolian Ophiolite

The isolated outcrops of Late Cretaceous ophiolitic rocks have been determined as the Central Anatolian Ophiolite (Göncüoğlu et al., 1991) which is represented by two subunits in the studied area. These subunits are Çökelik volcanics (Erdoğan et al., 1996) and Akçakent gabbro (Figure 2). Çökelik volcanics represent altered diabase and altered basalt which are composed of chlorite, albite, calcite, epidote, relict pyroxene, plagioclase, tremolite/actinolite and opaque minerals. The rock samples of Çökelik volcanics have been affected by both of weathering and hydrothermal alterations in addition to contact metamorphic transformation. Thus, only the Akçakent gabbro has been studied by means of mineralogy-petrography and bulk chemistry from the Central Anatolian Ophiolite in the mapped area.

Akçakent Gabbro

It is composed mainly of gabbro, uralite-gabbro, and scarcely microdiorite, diorite on the basis of actual mineralogical composition. This mineralogical composition range is also convenient with the chemical nomenclature diagram, based on wholerock chemical analyses (Table 1), that plott basically in the gabbro/diorite field in Figure 3. The gabbroic rocks usually display medium-grained and subophitic texture. The major rock forming minerals consist of augite and plagioclase (An_{48-56}) on the basis of optical data. Most of the rock samples of the Akçakent gabbro are observed to have been affected by low-temperature mineral transformation that augites replaced by tremolite/actinolite, called uralitization, talc and epidote group minerals. The uralitization process is sometimes so strong that the gabbro itself can be determined as uralite gabbro. The same process is also observed in the dioritic rocks that most of the primary brown-olive green hornblende minerals are transformed to acicular actinolite/tremolite minerals. These mineralogical transformations are regarded to be induced by the contact metamorphic affects of the intrusive emplacement of Halaçlı monzogranite and Eğrialan syenite. The Akçakent gabbro represents subalkaline-tholeiitic chemistry (Figure 4b), and even with a low-K tholeiitic character that the SiO_2 and K_2O contents are usually less than 50 % and 0.40 %, respectively (Table 1). MORB normalized trace element spiderdiagram of the Akçakent gabbro shows a typical depleted-mantle material trend, except somewhat enrichment of Rb in all samples, and Th of some samples. K content also indicates a wide variation range (Figure 5).

Halaçlı Monzogranite

This unit comprises monzogranites showing medium to coarse-grained, phaneritic-porphyritic texture which is particularly remarked by the presence of K-feldspar megacrysts. Both the chemical and microscopical nomenclatures are consistent with each other, however, the chemical nomenclature of Debon and Le Fort (1983) indicates the adamellitic composition (Figure 3). But, as pointed out by Debon and Le Fort (1983, p.136), the adamellite classification in their chemical nomenclature may correspond to monzogranite determination of IUGS classification system of Streckeisen (1976). Quartz content of the Halaçlı monzogranite ranges from 20 to 30 % in the total of felsic constituents, whereas the plagioclase (An_{32-44} on the basis of optical data) proportion varies between 40 % and 45 % in total feldspar content. The most common mafic mineral is brownish-green hornblende, found almost in all the samples. A few rock samples also contain some augite type of clinopyroxene which are mainly found within the hornblende minerals. On the other hand, some monzogranites include some brownish biotite flakes in addition to hornblende. The accessory minerals consist essentially of apatite, zircon, allanite, titanite and opaque minerals. Some samples of the Halaçlı monzogranite show some special microscopical textures indicating the

Table 1. Results of the wholerock major and trace element geochemical analyses of the rock samples from the Akçakent gabbro, Halaçlı monzogranite and Eğrialan syenite.

EĞRİALAN SYENITE

SAMPLE	SiO_2	TiO_2	Al_2O_3	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	TOTAL	Cr
ÇYB-41	62.10	0.58	19.75	2.27	0.06	0.88	0.97	4.82	7.61	0.80	1.92	101.76	6
ÇYB-42	62.68	0.37	20.03	2.27	0.12	0.93	1.69	5.08	7.05	0.09	0.92	101.23	nd.
ÇYB-43	61.47	0.39	18.98	3.19	0.12	0.95	3.19	5.14	6.35	0.12	0.66	100.56	nd.
ÇYB-44	60.39	0.41	19.58	3.30	0.12	0.96	3.13	4.61	7.08	0.14	0.92	100.64	640
ÇYB-45	59.42	0.44	18.50	2.64	0.15	0.81	2.74	4.95	6.74	0.09	2.28	98.76	nd.
ÇYB-60	66.47	0.03	18.53	1.63	0.03	0.31	0.58	6.51	6.69	0.03	0.29	101.10	12
ÇYB-62	61.38	0.33	18.96	3.03	0.11	0.82	2.26	5.31	6.85	0.08	1.74	100.87	nd.
ÇYB-96	61.20	0.42	19.26	3.93	0.12	1.24	4.08	4.96	5.86	0.18	0.32	101.57	nd.
ÇYB-97	60.05	0.61	18.58	4.90	0.14	1.41	4.26	4.42	6.01	0.30	0.40	101.08	nd.
ÇYB-98	59.23	0.49	18.52	3.49	0.12	1.14	3.80	4.23	6.74	0.21	0.80	98.77	nd.
ÇYB-99	61.90	0.43	18.89	3.85	0.11	0.99	3.56	4.91	6.13	0.16	0.25	101.18	3
ÇYB-100	60.53	0.42	19.13	3.00	0.09	0.88	3.48	4.28	7.04	0.17	0.71	98.73	nd.
ÇYB-101	63.42	0.29	18.41	1.93	0.02	0.42	1.05	5.08	6.98	0.05	0.58	98.23	3

Co	Cu	Pb	Zn	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th
7	6	86	104	300	593	307	23	67	646	52	57
7	6	99	124	268	1070	832	24	46	604	56	62
11	8	118	106	236	868	749	24	46	833	53	82
14	23	24	57	19	8	85	12	2	13	2	nd.
9	8	103	108	273	821	584	22	57	866	61	94
5	4	87	68	309	4	70	27	15	517	50	68
10	7	80	80	244	843	661	21	31	524	52	49
13	7	80	80	244	843	661	21	31	524	52	49
17	8	72	110	161	1473	1191	19	25	363	38	18
12	18	153	115	182	1656	1334	21	24	303	37	12
13	6	70	111	190	837	850	22	24	336	40	19
10	6	80	88	187	1574	1268	20	23	321	38	14
6	9	87	93	274	890	386	25	42	786	55	50

HALAÇLI MONZOGRANITE

SAMPLE	SiO_2	TiO_2	Al_2O_3	tFe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	TOTAL	Cr
ÇYB-7	66.51	0.37	16.14	3.89	0.08	1.53	3.62	3.00	4.85	0.14	0.58	100.71	15
ÇYB-23	64.55	0.44	17.28	3.91	0.08	1.65	3.81	3.36	4.36	0.16	0.55	100.15	16
ÇYB-24	65.57	0.43	16.54	4.18	0.08	1.74	3.84	3.20	4.37	0.17	0.65	100.77	22
ÇYB-28	64.58	0.41	15.83	4.10	0.08	1.53	3.75	2.81	4.83	0.16	0.31	98.39	16
ÇYB-29	64.67	0.41	17.12	4.40	0.10	1.98	3.96	3.50	4.29	0.15	0.68	101.26	16
ÇYB-30	66.86	0.36	16.78	3.64	0.08	1.58	3.42	3.04	5.13	0.14	0.45	101.48	10
ÇYB-35	66.66	0.39	16.39	3.73	0.08	1.60	3.54	3.05	4.64	0.15	0.19	100.42	15
ÇYB-47	67.16	0.38	15.73	3.66	0.08	1.57	3.29	2.95	4.98	0.15	0.53	100.48	8
ÇYB-48	65.53	0.42	15.83	4.48	0.09	1.76	3.75	2.82	4.94	0.16	0.48	100.26	19
ÇYB-50	63.69	0.50	16.28	5.19	0.10	2.29	4.13	3.03	4.29	0.14	0.97	100.61	37
ÇYB-51	66.06	0.46	16.00	4.67	0.09	1.88	4.26	3.00	4.47	0.17	0.39	101.45	28
ÇYB-76	66.08	0.45	16.67	4.17	0.09	1.71	3.74	3.38	4.53	0.15	0.79	101.76	10
ÇYB-77	66.90	0.32	16.34	3.56	0.08	1.57	3.39	3.15	4.97	0.13	0.49	100.90	9
ÇYB-93	64.63	0.48	16.20	4.88	9.10	1.88	4.39	3.02	4.47	0.18	0.32	100.55	28

13	8	42	75	189	906	489	16	21	194	39	21
13	7	44	76	162	907	586	18	18	235	33	19
14	6	36	75	157	897	561	18	20	223	35	19
14	6	39	78	178	1150	532	17	24	212	38	28
15	3	29	75	158	998	510	17	17	200	32	19
12	10	44	77	185	1199	550	19	19	205	37	21
13	6	35	72	170	1021	535	18	21	215	36	25
12	10	48	72	176	1411	506	19	22	202	37	35
15	9	51	86	178	887	489	16	20	205	38	20
18	12	42	85	153	868	481	16	16	193	33	18
16	13	49	83	169	728	490	18	19	211	36	25
14	9	59	82	172	941	554	19	19	226	34	17
12	8	45	72	193	1125	475	18	15	172	33	15
17	12	86	101	173	839	501	20	20	215	34	15

AKÇAKENT GABBRO													
ÇYB-53	48.44	0.11	18.30	4.16	0.10	8.44	17.06	0.83	0.09	0.02	0.74	98.29	640
ÇYB-54	48.14	0.12	13.56	7.53	0.15	13.61	12.83	0.65	0.11	0.02	2.24	98.96	849
ÇYB-56	48.45	0.08	20.33	3.80	0.08	8.63	15.72	0.83	0.02	0.02	1.24	99.20	342
ÇYB-58	48.75	0.17	18.97	4.09	0.09	7.84	16.63	1.31	nd.	0.03	1.09	98.97	343
ÇYB-72	48.40	0.23	15.60	6.29	0.12	10.48	15.65	1.00	0.14	0.02	0.97	98.90	362
ÇYB-73	48.90	0.23	16.70	4.53	0.10	8.71	17.24	0.93	0.02	0.02	0.86	98.24	693
ÇYB-74	48.37	0.12	16.42	3.46	0.07	10.71	16.68	1.09	0.07	0.02	1.64	98.65	440
ÇYB-79	48.18	0.24	16.87	7.01	0.11	9.32	14.03	1.32	0.03	0.04	1.40	98.55	107
ÇYB-94	46.82	0.13	21.98	3.70	0.07	7.28	16.05	1.34	0.01	0.02	0.87	98.27	418
ÇYB-95	47.69	0.09	21.05	3.56	0.07	8.03	15.17	1.18	0.22	0.02	1.09	98.17	392
ÇYB-103	48.80	0.14	18.87	3.79	0.08	8.55	16.78	0.97	0.06	0.03	0.85	98.92	331

14	23	24	57	19	8	85	12	2	13	2	nd.
26	64	125	76	20	9	66	11	2	10	2	nd.
13	57	44	57	18	7	117	12	2	14	nd.	nd.
14	134	17	50	17	nd.	124	12	2	16	3	nd.
22	8	61	62	17	11	85	12	2	14	2	nd.
16	168	13	54	18	88	104	12	2	14	3	nd.
12	106	16	47	19	nd.	102	13	2	15	2	nd.
24	16	3	51	17	nd.	112	15	2	20	4	nd.
13	66	11	50	18	nd.	111	14	2	17	2	nd.
12	10	10	54	21	nd.	123	17	2	17	2	nd.
13	68	8	53	19	27	89	13	2	13	3	nd.

tFe_2O_3 = total iron oxido as ferric iron. LOI = loss on ignition. Major and trace elements are given in weight % and ppm, respectively.

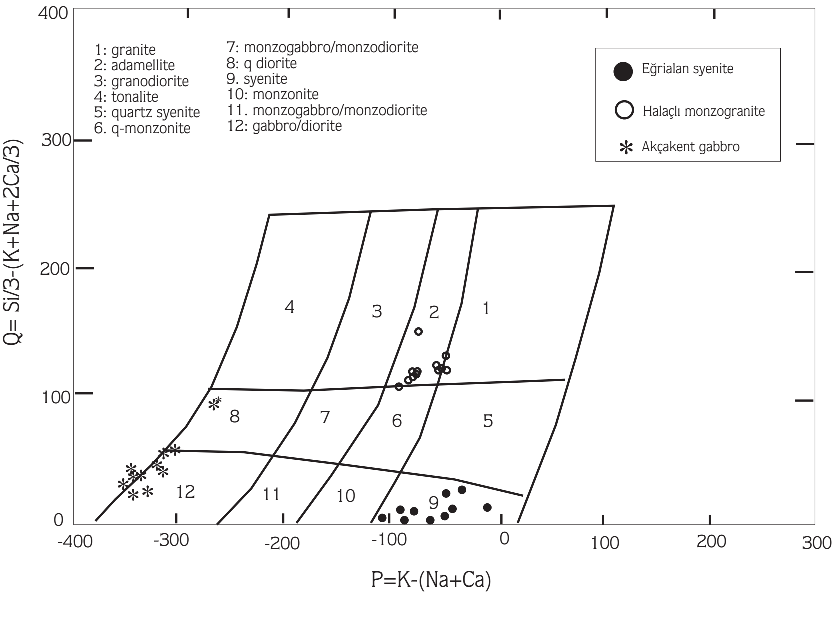

Figure 3. Chemical nomenclature diagram (Debon and Le Fort, 1983) of the Akçakent gabbro, Halaçlı monzogranite and Eğrialan syenite.

magma mixing type of interaction between the co-eval felsic and mafic magmas (Didier and Barbarin, 1991; Barbarin and Didier, 1992; Hibbard, 1991, 1995; Pitcher, 1993). These textures are of antirapakivi mantling, poikilitic plagioclase/orthoclase, small lath-shaped plagioclase within large plagioclase, spongy cellular plagioclase and appinitic texture. The Halaçlı monzogranite shows an apparent calc-alkaline and potassic trend of the subalkaline association in Figure 4a,b,c. The frequency distribution of Aluminium Saturation Index (ASI, White and Chappel, 1988, p.172) represents a clear I-type character for the Halaçlı monzogranite in Figure 4d. This chemical composition is convenient with those of Lökköy K-feldspar megacrystalline monzogranite of Ekici and Boztuğ (1997), and of Yassıağıl K-feldspar megacrystalline monzogranite of Tatar and Boztuğ (1997) in the Yozgat batholith in Central Anatolia. MORB normalized trace element spiderdiagram of the Halaçlı monzogranite is strictly homogenous in Figure 5. Slightly negative and positive anomalies in the contents of Ba and Th, respectively, with a good fractionation from LIL (Rb, Ba, K, Sr) to HFS (Th, Nb, Zr, Ti, Y) elements are most diagnostic characteristics, except Y, of the Halaçlı monzogranite.

Eğrialan Syenite

It consists of medium-grained and coarse-grained syenitic rocks. These two types of rocks in the Eğrialan syenitic body are plotted in the syenite field of the chemical nomenclature diagram (Figure 3), however, a few rock samples, containing nepheline + altered feldspathoidal minerals in the actual mineralogical composition, take place in the feldspathoidal part of Figure 3. The major felsic constituents of the medium- and coarse-grained syenites are composed mainly of orthoclase + plagioclase (An_{32-40} on the basis of optical data), and sometimes, some negligible amounts of nepheline and altered feldspathoidal minerals in some rock samples. Orthoclase minerals may constitute 75-80 % of the total feldspars. In addition to fresh nepheline minerals, less than 6-7 % of mineralogical composition, the altered feldspathoidal minerals are also seen to be transformed into some aggregates consisting of brownish colored platy zeolite + clay minerals + sericite assemblage. The pseudomorphy of these altered minerals resemble to the morphology of nepheline and/or nosean minerals, i.e. euhedral to subhedral and hexagonal and stubby prismatic in shapes. The mafic components are made up of riebekite/arfvedsonite + aegirine + biotite, and some melanite type of garnet minerals in some samples. Garnet minerals are particularly observed to constitute the rim of the aegirine minerals under the microscopy. As for the accessory minerals of these syenites, they consist of titanite + apatite + xenotime + monazite+allanite+zircon (especially in the form of inclusions within reddish-brown biotite flakes)+fluorite mineral assemblage. The alkaline nature of the Eğrialan syenitic body is clearly shown in Figure 4a (dividing line between subalkaline and alkaline associations has been taken after Rickwood, 1989). Alkaline character (indeed alkali-calcic) of this pluton is also remarked in Figure 4e which is proposed by Brown et al. (1984) on the basis of Peacock (1931) classification. As shown in Figure 4e, the intersection of the trend of all the rock samples of Eğrialan syenite corresponds to a silica content less than 56 wt %. Most of the rock samples from the Eğrialan syenite represent enrichments in the Th, Nb, Zr and Y elements, however, some samples show also depletion by means of Th content in the MORB (Pearce et al., 1984) normalized trace element spider diagram (Figure 5). On the other hand, the rock sample of ÇYB-44 apparently exhibits unusual depletion in the contents of Ba, Sr and Ti; the rock sample of ÇYB-60 represents considerable depletions in the contents of Rb, Ba, Nb, Sr, Zr and Y elements (Figure 5). Considering Mason and Moore (1982, p. 125-135) and Wilson (1989, p.17), these trace element characteristics are assumed to be sourced from the actual mineralogical composition. So, the coarse-grained rock samples containing more biotite than the other mafic minerals show an enrichment in the Th content. The Ba and Sr depletion of the rock sample of ÇYB-44 is thought to be related to the feldspar content in which the proportion of plagioclase is very less in amount. As for the rock sample of ÇYB-60, it is a leucocratic quartz-albite microsyenite type of rock that its depletion of Rb, Ba and Sr elements is due to the absence of high temperature feldspar minerals; whereas its depletion of Nb, Zr and Y elements is caused from the lack of mafic and accessory minerals.

Petrogenetic Considerations

As pointed out in the introduction part of this paper, there is no any concensus on the petrogenesis of the felsic calc-alkaline, alkaline and mafic gabbroic plutonism in Central Anatolia. Various geodynamic settings, i.e. arcs whether active continental margin or ensimatic, and collision whether syn- or post-collision, are suggested for different types of magmatism (see Erler and Bayhan, 1995; Erler and Göncüoğlu, 1996; Boztuğ, this volume). Although most of the authors agree that the felsic calc-alkaline magmatism and alkaline magmatism can be related to the Upper Cretaceous collision of Anatolides and Pontides along Ankara-Erzincan suture zone (Boztuğ et al., 1994; Erler and Bayhan, 1995; Ekici et al., 1997; Ekici and Boztuğ, 1997; Tatar et al., 1997; Tatar and Boztuğ, 1997; Boztuğ and Yılmaz, 1997; Boztuğ, this volume), there are various arguments on the petrogenesis

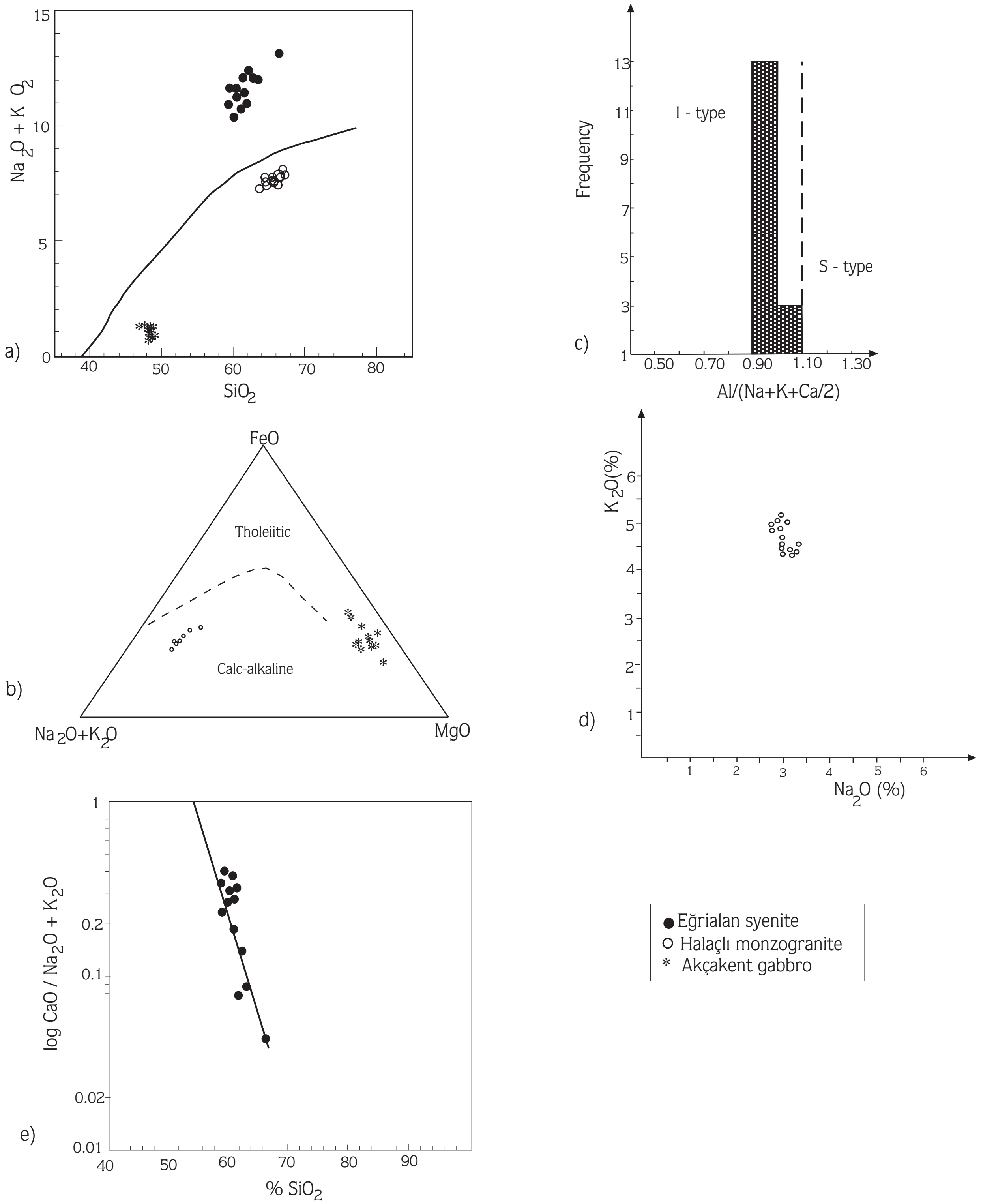

Figure 4. a) Total alkali (Na_2O+K_2O) versus silica (SiO_2) diagram (Rickwood, 1989) of the Akçakent gabbro, Halaçlı monzogranite and Eğrialan syenite; b) AFM triangular diagram (Irvine and Baragar, 1971) of the Akçakent gabbro and Halaçlı monzogranite; c) Frequency versus aluminium saturation index diagram (White and Chappel, 1988) of the Halaçlı monzogranite; d) K_2O versus Na_2O diagram of the Halaçlı monzogranite; e) log CaO/(Na_2O+K_2O) versus SiO_2 diagram (Brown et al., 1984) of the Eğrialan syenite.

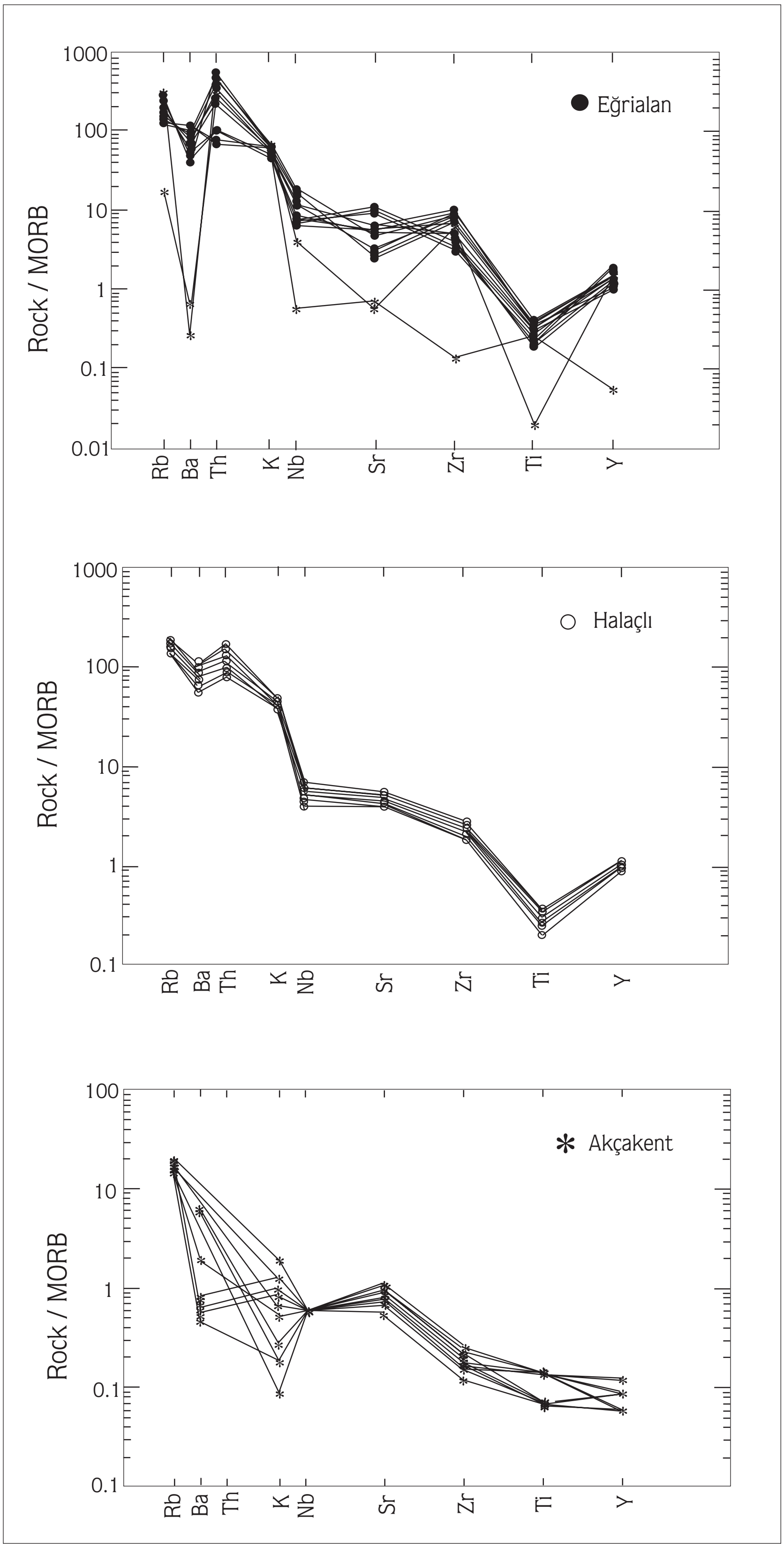

Figure 5. MORB normalized trace element spider diagram of the Akçakent gabbro, Halaçlı monzogranite and Eğrialan syenite.

of the gabbroic rocks in Central Anatolia. These arguments can be briefly given as follow:

Göncüoğlu et al. (1991) points out that the gabbroic rocks associated with volcanic rocks which are exposed in different parts of the CACC (see Figure 1) are part of "Central Anatolian Ophiolites". These gabbroic rocks in Ekecikdağ and Sarıkaraman areas also include some plagiogranites belonging to the ophiolites (Göncüoğlu and Türeli, 1993; Yalınız et al. 1996, Floyd et al. 1998). Some other gabbroic rocks outcropping in the northern part of the Yozgat batholith (Figure 1) are also interpreted as part of the Central Anatolian Ophiolites (Erler and Göncüoğlu, 1996). Koçak and Leake (1994) confirm that the gabbroic rocks in Ortaköy are part of an allochthonous major ophiolite sheet. On the other hand, some gabbroic rocks exposed in the Ağaçören pluton, located just to the north of the Ekecikdağ pluton, have been proposed by Kadıoğlu et al. (1995) and Kadıoğlu and Güleç (1996) as being derived from a mafic magma source rather than an ophiolitic genesis. This mafic magma source is suggested to be coeval with the felsic magma source of the Ağaçören pluton on the basis of some magma mingling and magma mixing events (Kadıoğlu and Güleç, 1996). On the basis of these arguments,

-The gabbroic rocks in Central Anatolia can be suggested to be part of (1) an allochtonous equivalent of the supra-subduction zone ophiolites of Central Anatolia derived from the northern branch of Neo-Tethys (Göncüoğlu and Türeli, 1993, 1994; Erler and Göncüoğlu, 1995; Yalınız et al., 1996, Floyd et al. 1998), (2) the non-ophiolitic mafic magma source which is co-eval with the felsic magma source, particularly in the Ekecikdağ pluton, (Kadıoğlu and Güleç, 1996; Kadıoğlu et al., 1995), (3) the non-ophiolitic mafic magma source derived from the post-collisional mafic magmatism which may also be determined underplating mafic magma source (Bergantz, 1989; Bergantz and Dawes, 1994; Wiebe, 1996) i.e. as observed in the mafic parts of Dumluca, Murmana and Karakeban plutons, (Boztuğ et al.,1997), (4) both of the supra-subduction zone ophiolites related to the northern branch of the Neotethyan oceanic crust, and the post-collisional mafic magma source depending particularly upon the geological-stratigraphical setting in the field and the mineralogical-geochemical characteristics.

The Akçakent gabbro is considered to be part of Central Anatolian Ophiolite here, since, it is spatially and temporally well-associated with the Çökelik volcanics unit which is a typical submarine mafic magmatic occurrence. Both of the two subunits belong to Central Anatolian Ophiolite which derived from the northern branch of Neo-Tethyan oceanic crust (Göncüoğlu and Türeli, 1993). Mineralogical and geochemical data on the Akçakent gabbro also reveal a depleted mantle source origin.

As for the petrogenetic discussion of the Halaçlı monzogranite and Eğrialan syenite, both of these rock units display post-collisional character in Figure 6. For example, the Halaçlı monzogranite is clearly plotted next to triple junction point of VAG - WPG - syn-COLG subfields of trace element discriminant diagram of Pearce et al. (1984). As pointed out by Pearce et al. (1984) (Figure 6a), such a geodynamic setting is especially related to the post-collisional character which is already remarked in the R1 - R2 diagram of Batchelor and Bowden (1985) given in Figure 6b. On the other hand, the Eğrialan syenite is not plotted in the trace element geotectonic discrimination diagrams of Pearce et al. (1984) because of not having free quartz in actual mineralogical composition. But, plotted in the R1- R2 diagram, the rock samples takes dominantly place in the silica undersaturated and subordinately late orogenic subfields (Figure 6b). Similarly, both the Halaçlı monzogranite and Eğrialan syenite are located in the post-collisional subfield of a triangular diagram based on trace elements of Thiéblemont and Cabanis (1990) (Figure 6c). As a concluding remark, the Halaçlı monzogranite can also be classified as a hybrid$_{\text{late orogenic}}$ (H_{LO}) granitoid in relation to origin and tectonic setting classification of granitoids (Barbarin, 1990; p. 230) by taking care the widespread presence of K-feldspar megacrysts, calc-alkaline potassic chemistry, and post-collisional setting. This interpretation contrasts with the suggestion of Erdoğan et al. (1996) who indicated that the granitoids are of arc type and were related to the northward subduction of the Inner Tauride Ocean. Similarly, the Eğrialan syenite is considered to be part of the post-collisional, A-type, alkaline syenitic association (Boztuğ, 1998, this volume) in Central Anatolia.

Conclusions

Mineralogical-petrographical and wholerock geochemical studies, based on the geological mapping to the scale of 1/25.000 in Çiçekdağ area have concluded that the igneous rocks are classified into three main groups as suggested by Ketin (1959). These are, from bottom to top, the Central Anatolian Ophiolite, Halaçlı monzogranite and Eğrialan syenite. The Central Anatolian Ophiolite has also been subdivided into two mapable subunits such as Çökelik volcanics and Akçakent gabbro

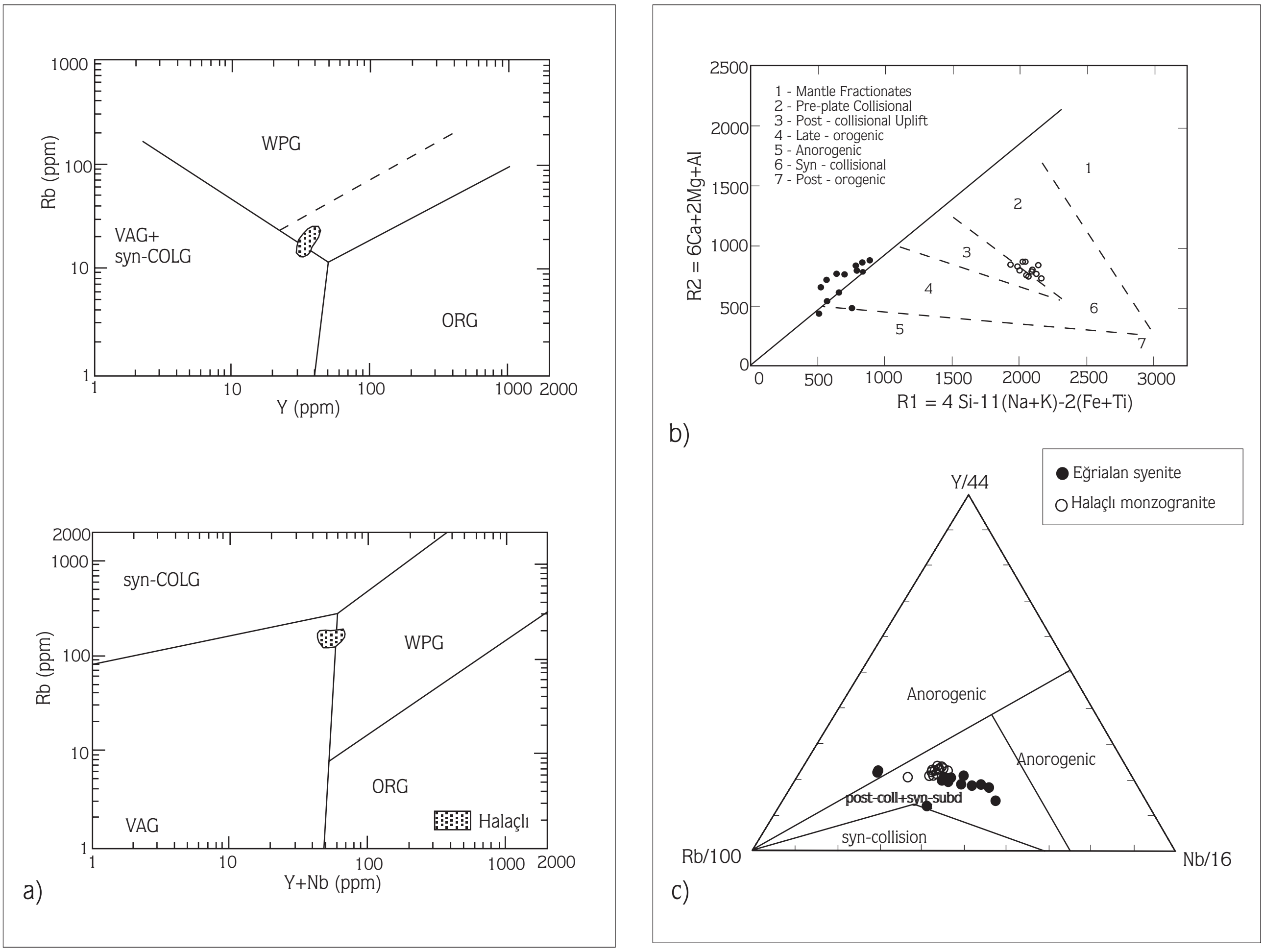

Figure 6. a. Rb versus Y, and Rb versus Y+Nb diagrams of the Halaçlı monzogranite; Pearce et al. (1984); b. R1 - R2 diagram of the Halaçlı monzogranite and Eğrialan syenite, Batchelor and Bowden, (1985); c. Y/44 - Rb/100 - Nb/16 triangular diagram of the Halaçlı monzogranite and Eğrialan syenite, Thiéblemont and Cabanis, (1990).

during the fieldwork. The Çökelik volcanics unit represents a well-preserved pillow-lava structure primarily intercalated with calcareous-clayey-silicieous sediments apparently characterizing the submarine mafic volcanism. The contact between the Çökelik volcanics and Akçakent gabbro is a major N-S trending thrust fault along which the Akçakent gabbro is thrusted onto the Çökelik volcanics from east to west. However, there are also some small gabbroic intrusives within the Çökelik volcanics (Erdoğan et al., 1996). The Halaçlı monzogranite cuts both of the Çökelik volcanics and Akçakent gabbro unit of the Central Anatolian Ophiolite by forming some contact metamorphic transformations around the contacts. The youngest intrusive unit in the mapped area is the Eğrialan syenite which apparently intrudes both of Akçakent gabbro and Halaçlı monzogranite.

The Çökelik volcanics unit of the Central Anatolian Ophiolite consists mainly of altered diabase and altered basalt due to both of weathering and hydrothermal alterations in addition to contact metamorphic transformation. Preliminary data suggests an island arc origin (Göncüoğlu and Türeli, 1993; Erdoğan et al., 1996). The other unit of the Central Anatolian Ophiolite, i.e. the Akçakent gabbro, comprising essentially of uralite-gabbros, represents a low-K tholeiitic chemistry and depleted mantle source origin in composition. Halaçlı monzogranite, composed essentially of monzogranites with K-feldspar megacrysts, typically shows a post-collisional, hybrid, I-type or H_{LO} type and calcalkaline composition. As for the youngest intrusive unit which is the Eğrialan syenite, it is made up of phaneritic - coarse grained syenites and fine to medium grained syenites. The most diagnostic feature of the coarse grained syenites is the porphyritic texture distinguished by the presence of K-feldspar megacrysts associated with large biotite flakes. The Eğrialan syenite clearly exhibits an A-type and alkaline mineralogy and chemistry in composition. Both of the major and trace element geotectonic discrimination diagrams reveal a post-collisional setting for both of the Halaçlı monzogranite and Eğrialan syenite.

Acknowledgements

This research has been partly supported by the C.U. Research Foundation in Sivas.

References

Akıman, O., Erler, A., Göncüoğlu, M.C., Güleç, N., Geven, A. and Türeli, T.K., 1993. Geochemical characteristics of granitoids along the western margin of the Central Anatolian crystalline complex and their tectonic implications. Geological Journal, 28, 371-382.

Barbarin, B., 1990. Granitoids: main petrogenetic classifications in relation to origin and tectonic setting. Geological Journal, 25, 227-238.

Barbarin, B. and Didier, J., 1992. Genesis and evolution of mafic microgranular enclaves through various types of interaction between coexisting felsic and mafic magmas. Transactions of the Royal Society of Edinburgh: Earth Sciences, 83, 145-153.

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

Bergantz, G.W., 1989. Underplating and partial melting: implications for melt generation and extraction. Science 245, 1093-95.

Bergantz, G.W. and Dawes, R., 1994. Aspects of magma generation and ascent in continental lithosphere. In Ryan, M.P. (ed.) Magmatic Systems, 291-317. San Diego: Academic Press.

Bingöl, E., 1989. 1 / 2.000.000 ölçekli Türkiye Jeoloji Haritasy. MTA Yayını, Ankara.

Birgili, S.,Yoldaş, R. and Ünalan, G., 1975. Çankırı-Çorum Havzası'nın jeolojisi ve petrol olanakları: Ankara, General Directorate of Mineral Research and Exploration (MTA), Report No. 5621, 78p.

Boztuğ, D., 1994-1995. Kırşehir bloğundaki Yozgat batoliti doğu kesiminin (Sorgun güneyi) petrografisi, ana element jeokimyası ve petrojenezi. İstanbul Üniversitesi, Yerbilimleri, 9,1-2, 1-20.

Boztuğ, D., 1998 Post-collisional Central Anatolain alkaline plutonism, Turkey. Tr. J. of Earth Sciences, (this issue).

Boztuğ, D., Yılmaz, S. and Öztürk, A., 1994. Post-collisional alkaline plutonism in the Central-Eastern Anatolia, Turkey. International Volcanological Congress, IAVCEI'94, 12-16 September 1994, METU-Ankara, Turkey, Abstract Volume, Theme 1, Collision Related Magmatism.

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. Turkish Journal of Earth Sciences, 6, 95-115.

Boztuğ, D and Yılmaz, S., 1997. Some variabilities in the partial melting of the sources and solidification processes of the melts in the genesis of the Central Anatolian post-collisional alkaline plutonism. EUG-9, Strasbourg-France, 23-27 March 1997, Symposium 55: Post-Collisional Magmatism, Abstracts, 502.

Brown G.C., Thorpe, R.S. and Webb, P.C., 1984. The geochemical characteristics of granitoids in contrasting arcs and comments on magma sources, Jour. Geol. Soc. London, 141, 413-426.

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

Didier, J. ve Barbarin, B., (eds) 1991. Enclaves and granite petrology. Devolopments in petrology 13, Elsevier, Amsterdam, 625p.

Ekici, T., 1997. Yozgat Batoliti Yozgat Güneyi Kesiminin Petrolojisi. C.Ü. Fen Bilimleri Ensititüsü Yüksek Lisans Tezi, 75p, (unpublished).

Ekici, T. ve Boztuğ, D., 1997. Anatolid-Pontid çarpışma sisteminin pasif kenarında yer alan Yozgat batolitinde syn-COLG ve post-COLG granitoyid birlikteliği. Çukurova Üniv. Jeoloji Müh. Eğitiminin 20. Yılı Semp., Geosound, 30, 519–538.

Ekici, T., Boztuğ, D., Tatar, S. and Otlu, N., 1997. The co-existency of the syn-COLG and post-COLG granitoids in the Yozgat batholith from passive margin of the Anatolide-Pontide collision. EUG-9, Strasbourg-France, 23-27 March 1997, Symposium 55: Post-Collisional Magmatism, Terra Nova Abstracts, V. 9, 503.

Erdoğan, B., Akay, E. and şirin, M., 1996. Geology of the Yozgat region and the evolution of the collisional Çankırı Basin, Geology Review, 38, 788-806.

Erkan, Y., 1981. Orta Anadolu masifinin metamorfizması üzerinde yapılmış çalışmalarda varılan sonuçlar. İç Anadolu'nun Jeolojisi Simpozyumu, Türkiye Jeoloji Kurumu 35. Bil. ve Tek. Kurultayı, 9-11, Ankara.

Erler, A., Akıman, O., Unan, C., Dalkılıç, F., Dalkılıç, B., Geven, A. ve Önen, P., 1991. Kaman (Kırşehir) ve Yozgat yörelerinde Kırşehir masifi magmatik kayaçlarının petrolojisi ve jeokimyası: TÜBİTAK, Doğa-Tr. J. of Eng. and Env. Sc., 15, 76-100.

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

Erler, A. and Göncüoğlu, M.C., 1995. Geologic and tectonic setting of Yozgat Batholith,Second International Turkish Geology Workshop, Sivas, 6-8 September, Abstracts, 34.

Erler, A. and Göncüoğlu, M.C., 1996. Geologic and tectonic setting of the Yozgat batholith, Northern Central Anatolian Crystalline Complex, Turkey, International Geology Review, 38, 8, 714-726.

Floyd, P.A., Yalınız, M.K., and Göncüoğlu, M.C., 1998. Geochemistry of intrusive and extrusive ophiolite plagiogranites, Central Anatolian Crystalline Complex, Turkey. Lithos, 42, 225-241.

Geven, A., 1995. Cefalıkdağ granitoyidinin petrografi ve jeokimyası (Orta Anadolu Kristalen Kütlesi batısı) , Yerbilimleri, 17, 1-16.

Govindaraju, K., 1989. Compilation of working values and sample description for 272 geostandards. Geostandards Newsletter, 13, 1-113.

Göncüoğlu, M.C., 1977. Geologie des westlichen Niğde massives. Ph.D. Thesis, Bonn University, 167p., (unpublished).

Göncüoğlu, M.C., Toprak, V., Erler, A. and Kuşçu, İ., 1991. Orta Anadolu batı kesiminin jeolojisi, Bölüm I, Güney Kesim. TPAO Rap. No 2909, 176 pp, (unpublished).

Göncüoğlu M.C., Erler, A., Toprak, V., K., Olgun, E. and Rojay, B., 1992. Orta Anadolu masifinin batı bölümünün jeolojisi, Bölüm: 2, Orta Kesim: TPAO Rap. No: 3155, 76pp (unpublished).

Göncüoğlu, M.C. and Türeli, K.T., 1993. Orta Anadolu ofiyoliti plajiyogranitlerinin petrolojisi ve jeodinamik yorumu (Aksaray-Türkiye). Doğa Türk Yerbilimleri Dergisi, 2, 195-203.

Göncüoğlu, M.C and Türeli, K.T., 1994. Alpine collisional-type granitoids from Western Central Anatolian Crystalline Complex, Turkey. Journal of Kocaeli Univ., Earth Science Section, 1, 39-46.

Görür, N., Oktay, F.Y., Seymen, İ. and Şengör, A.M.C., 1984. Paleo-tectonic evolution of the Tuzgölü basin complex, Central Turkey: Sedimentary record of a Neo-tethyan closure. In: Dixon, J.E. and Robertson, A.H.F., (eds.), The Geological Evolution of the Eastern Mediterranean, Blackwell Sci. Publ., Edinburgh, 467-482.

Hibbard, M. J., 1991. Textural anatomy of twelve magma mixed granitoid systems: In Didier, J. and Barbarin, B (eds.), Enclaves and Granite Petrology, Development in Petrology, 13, Elsevier, 431-444.

Hibbard, M. J., 1995. Petrography to Petrogenesis. Prentice Hall. 587pp.

Irvine, T.N. and Baragar, W.R.A., 1971. A guide to the chemical classification of common volcanic rocks. Can. Jour. Earth Sci., 8, 523-548.

İlbeyli N. and Pearce, J.A., 1997. Petrogenesis of the collition-related Central Anatolian granitoids, Turkey, EUG 9, Strasbourg-France, 23-27 March 1997, Symposium 55: Post-Collisional Magmatism, Vol. 9, Terra Nova Abstracts, 502.

Kadıoğlu, Y.K., 1996. Genesis of Ağaçören intrusive suite and its enclaves (Central Anatolia): Constraints from geological, petrographic, geophysical and geochemical data, Ph.D. Thesis, M.E.T.U., 242pp (unpublished).

Kadıoğlu, Y.K., Güleç, N. and Ateş, A., 1995. Structural position of gabbroic rocks in Ağaçören granitoid: Field observation and aeromagnetic data. Second International Turkish Workshop: "Work in Progress on the Geology of Turkey", September 6-8, 1995, Sivas, Turkey, Abstracts, 55.

Kadıoğlu, Y.K. and Güleç, N., 1996. Mafic microgranular enclaves and interaction between felsic and mafic magmas in the Ağaçören intrusive suite: Evidence from petrographic features and mineral chemistry, International Geology Review, 38, 854-867.

Ketin, İ., 1955. On the geology of Yozgat region and the tectonic features of the Central Anatolian Masif (Kırşehir Crystallines), Türkiye Jeol. Kur. Bült., v. 6, No. 1, 29-40.

Ketin, İ., 1959. Uber Alter und Art der kristallinen Gesteine und Erzlagerstaetten in Zentral-Anatolien, Berg- und Hüttenmaennische Monatshefte, 104/8, 163-169.

Koçak and Leake, 1994. The petrology of the Ortaköy district and its ophiolite at the western edge of the Middle Anatolian Massif, Turkey, Journal of African Earth Sciences, 18, No. 2, 163-174.

Lünel, A.T., 1985. An approach to the naming, origin and age of Baranadağ monzonite of Kırşehir intrusive Suite. METU J. Pure and Appl., Sci., 18,3, 385-404.

Mason, B. ve Moore, C. B., 1982. Principles of Geochemistry, John Wiley and Sons, New York , 344p.

Otlu, N. ve Boztuğ, D., 1997. İç Anadolu alkali plütonizmasındaki Kortundağ ve Baranadağ plütonlarında (D Kaman- KB Kırşehir) silisçe aşırı doygun (ALKOS) ve silisçe tüketilmiş (ALKUS) alkali kayaç birlikteliği. Çukurova Üniv. Jeoloji Müh. Eğitiminin 20. Yılı Semp., Geosound, 30, 779–805.

Peacock, M.A., 1931. Classification of igneous rock series. Jour. Geol., 39, 54-67.

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

Pitcher, W.S., 1993. The Nature and Origin of Granite: Chapmann and Hall, 321 pp.

Poisson, A., 1986. Anatolian micro-continents in the Eastern Mediterranean context: The neo-Tethysian oceanic trouhgs. Sci. de la Térre, Mém., 47, 311-328.

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

Seymen, İ., 1981. Kaman (Kırşehir) dolayında Kırşehir masifinin metamorfizması: Türkiye Jeoloji Kurumu 35. Bilimsel ve Teknik Kurultayı, İç Anadolu'nun Jeolojisi Sempozyumu, Türkiye Jeol. Kur. Yayını, 12-15.

Streckeisen, A., 1976. To each plutonic rock its proper name, Earth Sci. Rev., 12, 1-33.

Şengör, A.M.C. and Yılmaz, Y., 1981. Tethyan evolution of Turkey: A plate tectonic approach. Tectonophysics, 75, 181-241.

Tatar, S., 1997. Yozgat Batoliti Şefaatli Kuzey Kesiminin (Güney Yozgat) Petrolojik İncelenmesi, C.Ü., Fen Bilimleri Enst., Yüksek Lisans Tezi, 94s, (unpublished).

Tatar, S. ve Boztuğ, D., 1997. Yozgat batoliti GB kesiminde (Şefaatli-Yerköy arası) FC ve magma mingling/mixing süreçlerinin kanıtları. Çukurova Üniv. Jeoloji Müh. Eğitiminin 20. Yılı Semp., Geosound, 30, 539–562.

Tatar, S., Boztuğ, D., Ekici, T. and Otlu, N., 1997. Outward fractional crystallization and mingling/mixing processes in the SW part of the Yozgat batholith. EUG-9, Strasbourg-France, 23-27 March 1997, Symposium 51: Generation of Granitic Rocks and Deep Crustal Processes, Abstracts, 460.

Thiéblemont, D. and Cabanis, B., 1990. Utilisation d'un diagramme (Rb/100)-Tb-Ta pour la discrimination géochimique et l'étude pétrogénétique des roches magmatiques acides, Bull. Soc. Geol., France, 8, 1, 23-35.

Türeli, K., 1991. Geology, petrology and geochemistry of Ekecikdağ plutonic rocks (Aksaray region-Central Anatolia), M.E.T.U., Ph.D. Thesis, 194pp.,(unpublished).

White, A.J.R. and Chappel, B.W., 1988. Some supracrustal (S-type) granites of the Lachlan Fold Belt. Trans. Royal Soc. Edinburgh: Earth Sciences, 79, 169-181.

Wiebe, R.A.,1996. Mafic-silisic layered intrusions: the role of basaltic injections on magmatic processes and the evolution of silisic magma chamber, Transactions of the Royal Soc. of Edinburgh Earth Sci., 87, 233-242.

Wilson, M., 1989. Igneous Petrogenesis, London, Unwin-Hyman, pp.456.

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