Turk J Earth Sci
8 (1999) 113–123
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Field, Petrographic and Geochemical Features of the Baranadağ Quartz Monzonite of the Central Anatolian Granitoids, Turkey

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Received: 06.11.1998

Abstract: The Baranadağ quartz monzonite is one of the granitioid intrusions of the Central Anatolian Crystalline Complex (CACC) which represents the passive continental margin of the Anatolide-Tauride platform. Medium to coarse-grained Baranadağ quartz monzonites typically include mafic microgranular enclaves and K-feldspar megacrysts and are cut by aplitic dykes representing the youngest magmatic activity of the study area. The intrusion is mainly composed of orthoclase, plagioclase, quartz, hornblende, biotite and clinopyroxene. It displays a slightly alkaline character and relatively well-developed calc-alkaline trend. The metaluminous Baranadağ quartz monzonites show comparable field, petrographic and/or geochemical features with those of the H-type (Hybrid) granitoids of the CACC. This requires significant input from mafic magma. By considering the other H-type granitoids of the complex, the Baranadağ quartz monzonites have been classified as post-collisional granite (Post COLG).

Key Words: Baranadağ quartz monzonite, Central Anatolian Crystalline Complex, Hybrid-type granitoids, Post-collisional granites.

Orta Anadolu Granitoyitlerinden Baranadağ Kuvars Monzonitinin Arazi, Petrografi ve Jeokimyasal Özellikleri, Türkiye

Özet: Baranadağ kuvars monzoniti, Anatolid-Torid platformunun pasif kıta kenarını temsil eden Orta Anadolu Kristalen Kompleksindeki granitoyit intrüzyonlarından biridir. Orta-iri taneli Baranadağ kuvars monzoniti, mafik anklav ve K-feldspar megakristallerini içerir, ve en genç magmatik aktiviteyi temsil eden aplitik dayklarla kesilmiştir. Intrüzyon asıl olarak, ortoklas, plajyoklas, kuvars, hornblend, biyotit ve klinopiroksenden oluşur. Hafif alkalin karakter ve oldukça iyi gelişmiş kalk-alkalin eğilimi sergiler. Metaluminus Baranadağ kuvars monzoniti, Orta Anadolu Kristalen Kompleksinin H-tipi (Hibrid) granitoyitleriyle karşılaştırılabilen arazi, petrografik ve jeokimyasal özellikleri gösterir. Bu, mafik magmadan önemli miktarda beslenme gerektirir. Baranadağ kuvars monzoniti, kompleksteki diğer H-tipi granitoyitler göze alındığında, çarpışma sonrası granitleri olarak sınıflandırılmışlardır.

Anahtar Sözcükler: Baranadağ kuvars monzoniti, Orta Anadolu Kristalen Kompleksi, Hibrid-tipi granitoyitler, Çarpışma sonrası granitler.

Introduction

Metamorphic, ophiolitic and magmatic rocks assemblages in Central Anatolia are defined as the Kırşehir Massif by Seymen (1982), the Kırşehir Complex by Lünel (1985) and recently the Central Anatolian Crystalline Complex (CACC) by Göncüoğlu et al. (1991). The complex lies in a triangular area bounded by the Tuzgölü Fault to the west, the Ecemiş Fault to the east and the İzmir-Ankara-Erzincan suture to the north (Fig. 1) and represents the passive continental margin of the Anatolide-Tauride platform (Göncüoğlu et al., 1991). The metamorphic rocks are the oldest rock units of the CACC which include gneisses, schists, calc-schists, phyllites, marbles and very low grade metamorphic rocks. Radiometric age data are interpreted by Göncüoğlu (1986) to indicate a pre-Cenomanian age for the main stage of metamorphism in the CACC. The metamorphic units of the CACC are tectonically overlain by Mesozoic ophiolitic rocks (Özgül, 1976) which consist of mafic and ultramafic rocks, radiolarites, and pelagic limestones. The complex is overlain by Maastrichtian to Quaternary aged cover units including clastics, carbonates, volcanics, and evaporites.

Granitoids of the complex (Central Anatolian Granitoids: CAGS) intrude the isolated outcrops of the ophiolitic and metamorphic rocks of the complex. The emplacement of granitoid intrusions was followed by the emplacement of the syenitoid intrusions (Erler and Göncüoğlu, 1996; Aydın et al., 1997). The CAGs have been the subject of several field, petrographic and

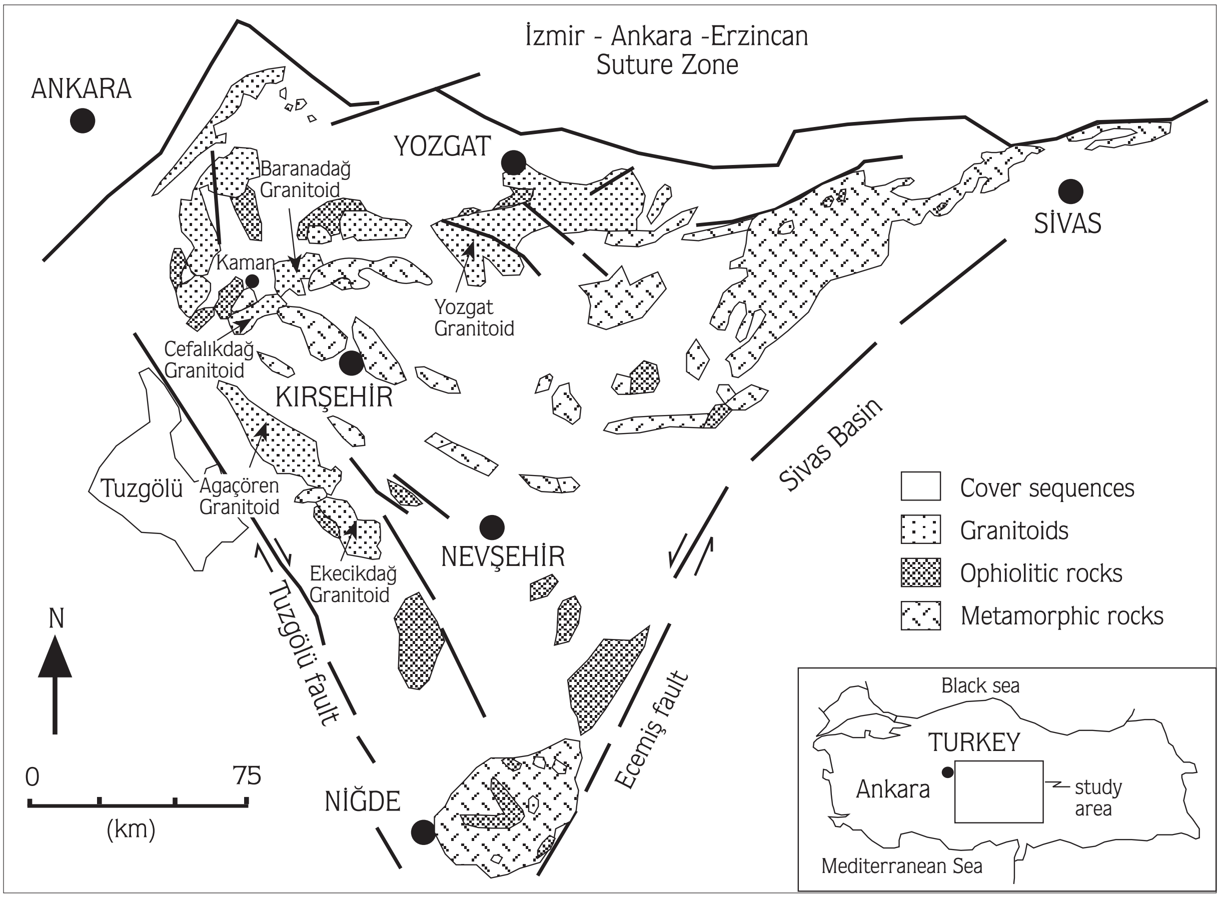

Figure 1. Simplified geological map of the Central Anatolian Crystalline Complex (modified from Aydın et al., 1998b).

geochemical studies, but there is no general consensus on their tectonic settings (Erler et al., 1991; Türeli, 1991; Geven, 1992; Erler and Bayhan, 1995; Akıman et al., 1993; Erler and Göncüoğlu, 1996; Kadıoğlu, 1996; Kadıoğlu and Güleç, 1996; Tatar and Boztuğ, 1997; Boztuğ, 1997; Otlu and Boztuğ, 1997; Aydın et al., 1997; 1998a, b). There are few radiometric age data on the granitoids. An age of 54 Ma was found by the total Pb method for the Baranadağ granitoid (Ayan, 1963). For the Cefalıkdağ Granitoid, 71±1 Ma age was obtained from the Rb-Sr method (Ataman, 1972). Erkan and Ataman (1981) suggested the range of K-Ar ages from 69.0±1.7 to 74.2±2.7 Ma as the emplacement or cooling age of igneous rocks intruding regional metamorphic rocks.

The Baranadağ Granitoid is part of the CAGs exposed at the western side of the CACC and displays a close spatial relationship with the Cefalıkdağ granitoid. Baranadağ and Cefalıkdağ granitoids, overlain by Eocene sediments, were collectively named 'Baranadağ pluton' by Seymen (1982). There is a shear zone at the contact between the Baranadağ and Cefalıkdağ granitoids at the southwest of the study area (Geven, 1992). Pinkish K-feldspar megacrysts, and mafic enclaves are characteristic for the granitoid, and it is usually cut by aplitic dykes.

The aim of this study was to examine the evolution of the CAGs with combined field, petrographic and geochemical features of the Baranadağ intrusion. During this study, special attention was given to petrographic details of the observed rock types including mafic microgranular enclaves and K-feldspar megacrysts. Additionally, mineral identification was substantiated by utilizing electron microprobe data.

Petrographic Features

Sample locations are shown in Figure 2 and the results of the modal analyses are presented in Table 1 and Figure 3. A few, but representative mineral analyses are given in Table 2. The medium- to coarse-grained Baranadağ intrusion is light gray and typically includes K-feldspar megacryts, mafic microgranular enclaves and xenoliths derived from metamorphic rocks of the complex. The intrusion is dominated by quartz monzonite (Fig. 3) and cut by aplitic dykes which represent the youngest magmatic activity of the study area. The Baranadağ quartz monzonite is composed of orthoclase, plagioclase, quartz, hornblende, biotite and clinopyroxene (Fig. 4). Titanite, apatite, iron-oxide minerals and zircon are the accessory minerals of the intrusion. The intrusion displays variable degrees of low temperature alteration minerals including kaolinite, sericite, calcite and chlorite.

Orthoclase is the most common felsic mineral (33-56 modal %) and displays perthitic texture, Carlsbad twinning, kaolinization and sericitization. It may include apatite, quartz ± zircon ± biotite poikilitically (Fig. 4). It has also been observed as K-feldspar megacryts (up to 3 cm in length). The second common mineral (24-47 modal %) is plagioclase showing polysynthetic twinning and zoning. The plagioclase composition is andesine (An_{28-36}). It usually displays kaolinization and calcitization. The least common felsic mineral is quartz (3-15 modal %) which occurs as anhedral grain and shows a myrmekitic and graphic texture.

Hornblende, clinopyroxene and biotite are the mafic minerals of the intrusion. Hornblende is the most abundant mafic mineral (up to 15 modal %). According to Leake's (1974) amphibole classification system, the composition of amphiboles are calcic amphiboles $(Ca+Na)_B>1.34$, $Na_B<0.67$) which are of magnesian hornblende / tschermakitic hornblende compositions. Rarely observed relict clinopyroxenes are the most mafic minerals (up to 6 modal %) of the intrusion and their compositions are diopsite (En_{34} Fs_{16} Wo_{50}; Morimoto, 1988). Primary biotite displays light yellow to dark brown pleochroism (up to 7 modal %). Biotite can also be observed as a secondary alteration mineral.

Dark colored, fine- to medium-grained mafic microgranular enclaves (up to 10 cm in diameter) are quartz dioritic to monzonitic in composition. They consist of plagioclase, quartz, hornblende, biotite, clinopyroxene, titanite, apatite and iron oxide opaque minerals. Among those, plagioclase and hornblende dominate the mineralogy of the enclaves. Note the presence of acicular apatite grains (Fig. 5).

Table 1. Representative modal analyses of the Baranadağ intrusion. Abbreviations: Q- quartz; A- alkali feldspar; P- plagioclase; G- granite; QS- quartz syenite; QM- quartz monzonite; M- monzonite; E- mafic microgranular enclave.

	BD 11	BD 15	BD 16	BD 17	BD 18	BD 19	BD 20	BD 25	BD 26	BD 59	BD 63	BD 79	BD 87	BD 92	BD 92A	BD 97	BD 101	BD 104	BD 109	BD 111	BD 115	BD 116	BD 12	BD 69H	BD 114
Orthoclase	54	56	45	33	34	36	41	56	41	46	39	56	44	54	25	56	35	45	49	52	45	38	45	49	47
Plagioclase	24	24	35	40	36	42	35	34	27	37	33	26	31	33	40	34	47	37	41	31	38	37	19	18	27
Quartz	10	12	12	13	8	9	15	3	6	6	9	6	13	5	6	3	8	11	8	5	7	8	29	30	21
Hornblende	6	4	3	3	13	3	6	1	15	3	7	4	6	4	18	2	1	5	3	6	7	9	3	-	1
Clinopyroxene	-	-	-	-	-	-	-	1	6	1	4	2	-	-	2	1	-	-	-	--	-	-	-	-	-
Biotite	-	1	2	7	1	5	-	-	-	-	-	+	+	-	2	-	1	-	+	+	-	-	+	1	+
Chlorite	-	+	+	+	1	-	-	-	2	2	+	4	+	+	2	+	3	1	+	+	+	-	+	-	+
Titanite	3	+	+	1	2	+	1	1	1	2	3	2	1	1	3	1	1	+	+	2	1	3	+	+	+
Apatite	1	+	+	+	+	+	+	-	+	1	+	+	+	+	+	+	-	+	+	-	+	+	+	-	+
Zircon	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	-
Opaque	2	2	2	1	4	3	2	2	2	2	3	1	2	2	2	2	2	1	1	2	1	3	2	1	11
A	62	60	50	39	44	42	45	60	56	51	49	64	50	59	36	60	39	49	50	59	50	46	49	51	50
P	27	26	37	46	46	48	38	37	37	42	40	29	35	35	56	37	52	40	42	35	42	45	20	18	28
Q	11	14	13	15	10	10	17	3	7	7	11	7	15	6	8	3	9	11	8	6	8	9	31	31	22
Rock name	QS	QS	QM	QM	QM	QM	M	QM	QM	QM	QS	QM	QM	QM	E	QM	QM	QM	QM	QM	QM	QM	G	G	G

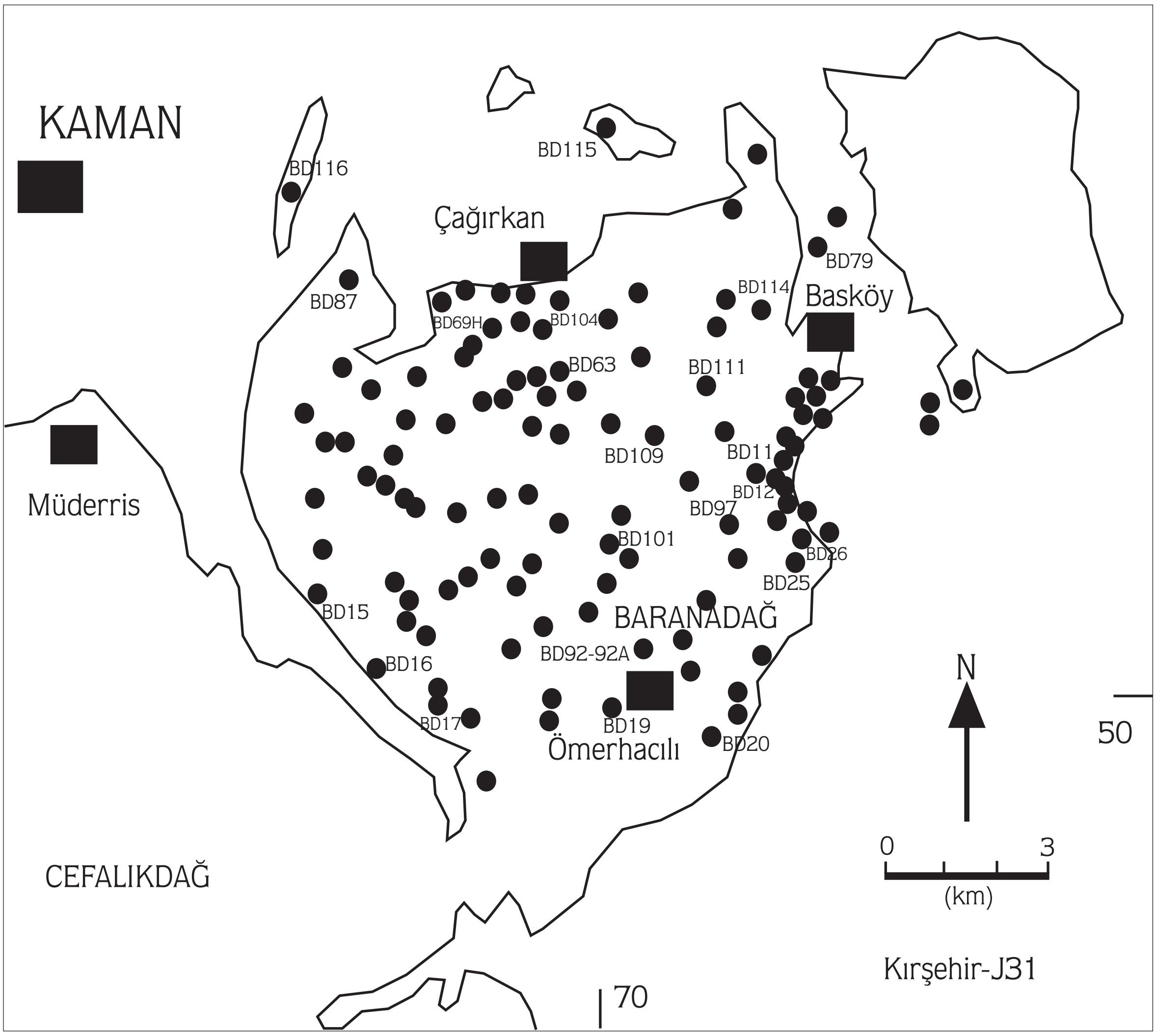

Figure 2. Location map showing petrographically examined samples. Sample numbers (e.g. BD11) denote chemically analysed ones.

Geochemistry

Whole rock major and trace element analyses of the Baranadağ quartz monzonite, aplitic dykes (BD12; BD69H; BD114) and one mafic microgranular enclave (BD92A) are presented in Table 3. The silica, aluminum, calcium, sodium and potassium oxide contents of the intrusion vary from 60.81 to 64.91; 15.12 to 18.71; 3.03 to 5.65; 2.20 to 3.91; 5.17 to 6.53 wt %, respectively. The silica, aluminum, calcium, sodium and potassium oxide contents of the analyzed aplitic dykes vary from 70.81 to 72.79; 14.40 to 15.45; 0.84 to 1.36; 2.97 to 3.60; 5.06 to 6.16 wt %, respectively (Table 3). Selected major element Harker diagrams are shown in Figure 6. Overall CaO and Al_2O_3 wt % decrease with increasing SiO_2 wt %. However, a few samples do not follow this general trend which is particularly evident in Al_2O_3 and can be attributed to the alteration of plagioclase grains. TiO_2 wt % slightly increases with increasing SiO_2 wt %.

The Baranadağ quartz monzonite shows a slightly alkaline character (Fig. 7a). However, it displays relatively well-developed calc-alkaline trend in Figure 7b. The intrusion is metaluminous (Figure 7c). The aplitic dykes display a subalkaline character and are concentrated on

Table 2. Representative mineral analyses of the Baranadağ intrusion. Structural formulae of the pyroxenes are on the basis of 6 oxygen, of amphiboles are on 23 oxygen, and of feldspars are on 32 oxygens. Mineral analyses by electron microprobe were performed in the Department of Geological Sciences at University College London.

Pyroxenes			
	BD63	BD63	BD63
Wt % oxide			
SiO_2	52.27	51.47	51.59
Al_2O_3	0.52	1.49	0.8
TiO_2	0	0.24	0
Fe_2O_3	1.61	2.46	2.59
FeO	9.06	8.81	8.78
MnO	0.78	0.8	0.75
MgO	11.41	10.94	10.93
CaO	23.1	22.64	23.02
Na_2O	0.6	0.78	0.61
K_2O	0	0	0.11
Total	99.29	99.62	99.21
Si	1.99	1.95	1.97
Aliv	0.01	0.05	0.03
Alvi	0.01	0.02	0.01
Ti	0	0.01	0
Fe^{+3}	0.05	0.07	0.08
Fe^{+2}	0.29	0.28	0.28
Mn	0.02	0.03	0.02
Mg	0.65	0.62	0.62
Ca	0.94	0.92	0.94
Na	0.04	0.06	0.05
K	0	0	0.01
Sum Z	2	2	2
Sum X + Y	2	2	2
Mg	0.34	0.34	0.33
Fe + Mn	0.16	0.17	0.16
Ca	0.5	0.5	0.5
X_{ac}	0.04	0.06	0.05
X_{others}	0.96	0.94	0.95

Amphiboles				
	BD63	BD63	BD101	BD101
Wt % oxide				
SiO_2	42.51	42.17	44.09	44.26
Al_2O_3	10.1	9.68	8.5	8.6
TiO_2	1.4	1.16	1.2	1.38
Fe_2O_3	3.13	2.12	2.87	3.27
FeO	15.34	16.45	16.93	16.27
MnO	0.63	0.6	0.83	0.82
MgO	10.23	9.43	9.34	9.55
CaO	11.83	11.66	11.38	11.36
Na_2O	2.11	1.8	2.08	1.97
K_2O	1.67	1.75	1.29	1.27
Total	98.93	96.84	98.49	98.75
Si	6.395	6.497	6.67	6.657
Al^{iv}	1.605	1.503	1.33	1.343
Al^{vi}	0.186	0.256	0.186	0.182
Ti	0.158	0.134	0.136	0.156
Fe^{+3}	0.354	0.246	0.326	0.37
Fe^{+2}	1.93	2.12	2.141	2.047
Mn	0.08	0.079	0.106	0.105
Mg	2.293	2.165	2.104	2.14
Ca	1.907	1.924	1.844	1.83
Na	0.615	0.538	0.609	0.574
K	0.321	0.345	0.249	0.244
Sum Tel	8	8	8	8
M1-M3	5	5	5	5
M4	2	2	2	2
A	0.843	0.808	0.702	0.649

Feldspars					
	BD63	BD63	BD63	BD101	BD101
Wt % oxide					
SiO_2	59.67	65.53	65.07	60.87	61.71
Al_2O_3	25.46	18.33	18.41	24.48	24.35
Fe_2O_3	0.29	0	0	0.19	0
CaO	7.66	0	0	6.04	6
Na_2O	7.16	1.06	1.77	8.47	8.19
K_2O	0.35	15.01	14.28	0.27	0.24
Total	100.6	99.93	99.53	100.3	100.5
Si	10.6	12.05	12	10.82	10.91
Al	5.334	3.972	4.003	5.129	5.076
Fe_3	0.038	0	0	0.025	0
Ca	1.459	0	0	1.151	1.136
Na	2.466	0.379	0.632	2.918	2.808
K	0.08	3.521	3.36	0.061	0.054
An	36	0	0	28	28
Ab	62	10	16	71	70
Or	2	90	84	1	1

the alkaline corner of the AFM diagram (Figure 7a, b). The dykes are metaluminous to slightly peraluminous (Figure 7c).

Discussion and Conclusions

Petrographic features of the Baranadağ quartz monzonites, particularly K-feldspar megacrysts, mafic microgranular enclaves and the presence of abundance mafic minerals, suggest that Baranadağ quartz monzonites can be classified as H-type (Hybrid) of Barbarin (1990). Similar to the other H-type granitoid intrusions of the CACC (e.g., Yozgat, Ekecikdağ, Cefalıkdağ granitoids), the Baranadağ quartz monzonites are metaluminous (cf. Aydın et al., 1998b), but are slightly more alkaline than the others.

The Baranadağ quartz monzonites mostly plot within the Syncollisional Granite (Syn-COLG) field and two of them fall within the Volcanic Arc Granite (VAG) area (Pearce et al., 1984; Figure 8). Although other H-type granitoids of the CACC fall generally within the VAG and/or around the triple junction of the Syn-COLG, VAG and WPG (Within Plate Granite) fields, none of the field,

Table 3. Representative whole rock major and trace element analyses of the Baranadağ intrusion. Major elements by Atomic Absorption Spectroscopy (Rank Hilger Atomspek H1551) and trace elements by XRF (Jeol JSX-60S) were performed in Department of Geological Engineering at Middle East Technical University.

	Quartz Monzonite															
(wt%)	BD11	BD15	BD16	BD17	BD18	BD19	BD20	BD25	BD26	BD59	BD63	BD79	BD87	BD92	BD97	BD101
SiO_2	63.47	63.39	63.53	63.76	61.67	60.84	63.61	63.28	61.11	60.88	60.81	64.91	63.49	62.82	62.71	64.85
TiO_2	0.94	0.97	0.96	0.95	0.87	0.87	0.96	0.97	0.89	0.89	0.87	0.96	0.96	0.96	0.93	0.99
Al_2O_3	17.26	16.87	16.73	16.85	17.24	16.90	16.80	17.26	15.12	17.30	17.21	16.15	17.14	17.58	17.86	16.37
Fe_2O_3	1.04	1.42	0.35	1.38	1.47	1.81	1.74	1.16	1.94	1.69	1.95	1.19	1.37	1.27	0.46	0.64
FeO	2.17	2.15	3.50	2.55	3.02	2.82	1.70	2.38	3.55	2.63	2.36	2.04	2.20	1.96	2.82	2.56
MnO	0.08	0.09	0.10	0.09	0.11	0.11	0.08	0.09	0.15	0.11	0.11	0.08	0.08	0.08	0.08	0.08
MgO	1.02	2.00	1.77	1.56	2.09	2.19	1.42	1.26	2.14	1.79	2.00	1.11	1.57	1.49	0.99	1.23
CaO	3.05	3.45	3.46	3.72	4.25	4.83	3.80	3.83	5.65	4.61	4.73	3.03	3.68	3.38	3.41	3.17
Na_2O	3.59	3.91	3.43	3.44	3.62	3.51	3.77	2.98	2.20	3.38	3.55	3.57	3.65	3.91	3.36	3.45
K_2O	6.46	5.24	5.55	5.38	5.29	5.17	5.36	5.97	6.16	6.09	5.88	6.19	5.57	5.61	6.53	5.52
P_2O_5	0.10	0.08	0.09	0.08	0.09	0.10	0.11	0.02	0.17	0.32	0.22	0.28	0.45	0.15	0.13	0.16
LOI	0.52	0.44	0.43	0.41	0.45	0.49	0.20	0.33	0.47	0.45	0.47	0.30	0.41	0.45	0.38	0.52
Total	99.70	100.01	99.90	100.17	100.17	99.64	99.55	99.53	99.55	100.14	100.16	99.81	100.57	99.66	99.66	99.54
(ppm)																
Rb	302	252	259	231	234	215	248	176	257	286	257	317	259	249	302	298
Sr	541	487	418	489	508	514	535	690	559	761	751	619	531	542	658	425
Nb	15	15	14	14	14	13	14	14	12	13	13	15	15	15	14	15
Hf	7	7	6	6	7	7	23	10	7	10	11	10	7	7	8	4
Zr	291	265	238	260	271	263	260	320	294	331	349	320	272	269	319	231
Y	18	16	16	16	15	15	16	13	14	17	17	19	16	17	18	18
Th	52	33	29	31	29	21	25	24	14	17	26	47	33	33	18	36

	Quartz Monzonite					Apilitic Dykes			Enclave
(wt%)	BD104	BD109	BD111	BD115	BD116	BD12	BD69H	BD114	BD92A
SiO_2	61.93	63.07	61.06	62.35	63.06	72.79	72.28	70.81	60.92
TiO_2	0.92	0.93	0.89	0.91	0.97	1.24	1.25	1.16	0.87
Al_2O_3	18.17	16.80	18.71	17.20	16.82	14.40	14.77	15.45	15.71
Fe_2O_3	1.46	0.73	0.93	2.05	1.13	0.87	0.78	1.07	1.41
FeO	1.73	2.93	2.30	1.52	2.07	0.47	0.12	0.69	2.95
MnO	0.07	0.09	0.08	0.59	0.08	0.02	0.02	0.04	0.10
MgO	1.30	1.57	1.14	1.62	0.98	0.03	0.57	0.25	3.02
CaO	3.55	3.69	3.75	3.58	3.68	0.92	0.84	1.36	5.56
Na_2O	3.71	3.57	3.80	3.49	3.89	3.60	2.97	3.55	3.34
K_2O	6.23	5.58	6.42	6.51	5.82	5.06	6.16	5.61	5.34
P_2O_5	0.17	0.20	0.14	0.11	0.18	0.04	0.16	0.10	0.16
LOI	0.52	0.46	0.48	0.44	0.74	0.26	0.08	0.36	0.31
Total	99.76	99.62	99.70	100.37	99.42	99.70	100.00	100.45	99.69
(ppm)									
Rb	311	248	278	320	332	552	863	579	198
Sr	610	525	691	716	641	208	142	266	553
Nb	14	14	14	14	14	18	17	17	14
Hf	10	7	8	11	10	3	3	3	8
Zr	311	284	343	324	328	140	116	170	274
Y	18	16	18	19	20	24	29	28	13
Th	49	24	18	39	50	52	41	57	20

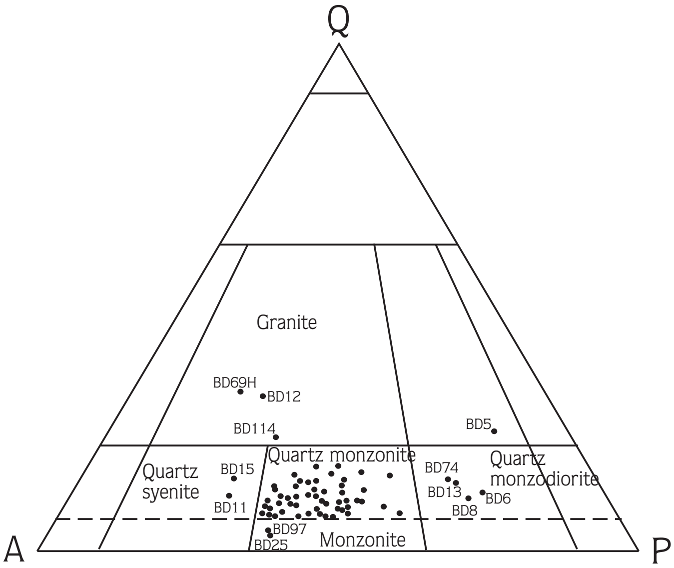

Figure 3. Q-A-P modal classification diagram of the Baranadağ intrusion (after Streckesien, 1979). Abbreviations: Q- quartz; A- alkali feldspar; P- plagioclase.

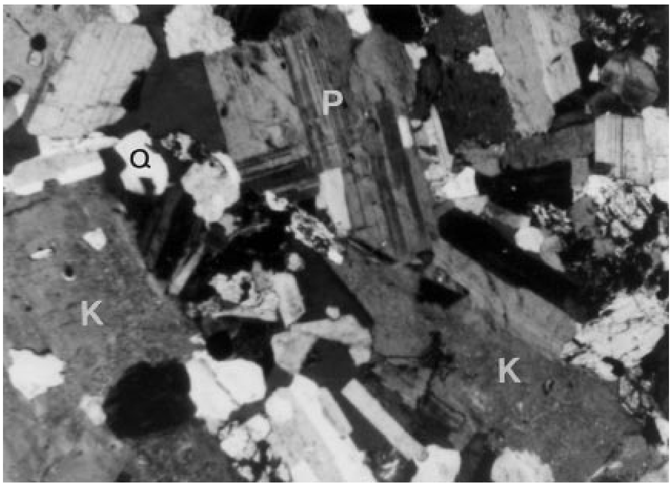

Figure 4. Photomicrograph of quartz monzonite showing orthoclase (K), plagioclase (P), quartz (Q) (Sample no: BD63; XPL; X2.5).

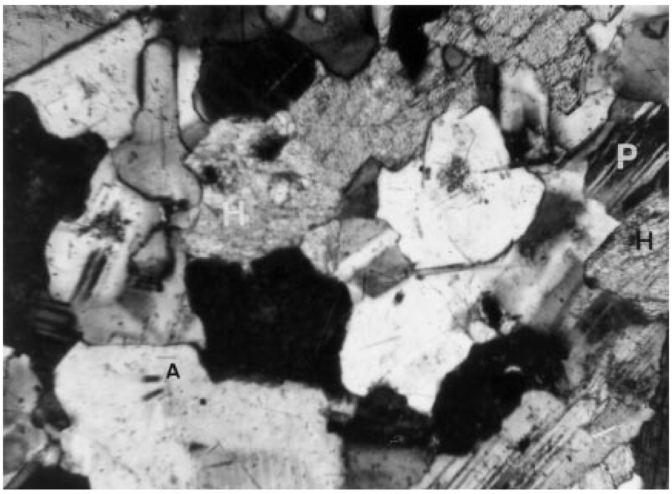

Figure 5. Photomicrograph of mafic microgranular enclave. (Sample no: BD92A; XPL; X10). Abbreviations: P- plagioclase; H- hornblende; A- apatite.

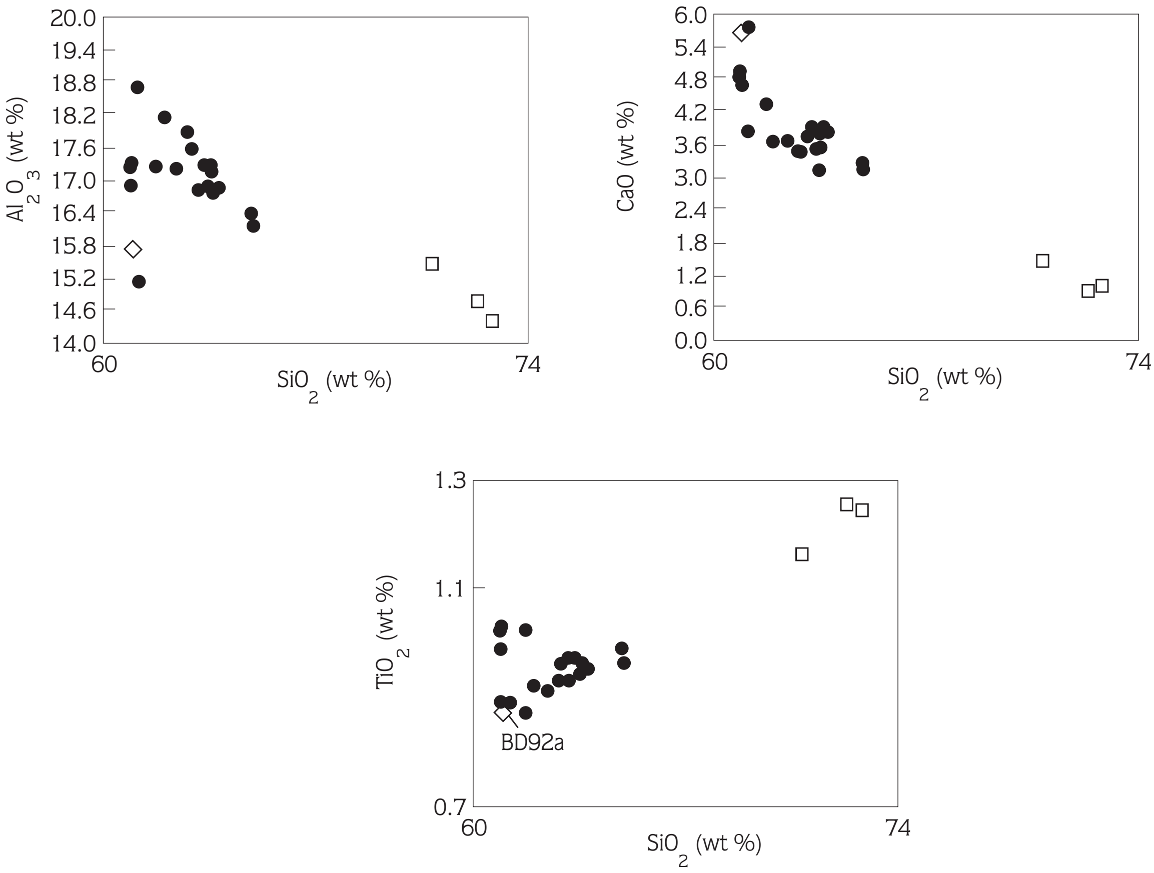

Figure 6. Harker diagram of the Baranadağ intrusion. Quartz monzonite: filled circle; aplitic dykes: open square; mafic microgranular enclaves: open diamond.

petrographic or geochemical features of the Baranadağ quartz monzonites are comparable with those of the C-type granitoids of the complex which generally plot within the Syn-COLG area (Aydın, 1997; Aydın et al., 1998c). This rather unusual appearance of the Baranadağ quartz monzonites in the Pearce diagram is consistent with the slightly alkaline nature of the intrusion (see Figs. 7a and 8) which can be attributed to high total alkali and Rb content of the intrusion.

To sum up, the metaluminous Baranadağ quartz monzonites display comparable field, petrographic and/or geochemical features with those of the H-type granitoids of the CAGs. On the basis of field and petrographic features of the intrusion, particularly the presence of the mafic microgranular enclave and K-feldspar megacryst, the genesis of the intrusion requires significant input from mafic magma. By considering other H-type granitoids of the complex, the intrusion is classified as Post-COLG (Aydın et al., 1998b) and probably represents a mature stage of the post-collisional magmatism in the CACC.

Acknowledgment

This research was a part of the TÜBİTAK project (Project No: TBAG-677) carried out by METU. A. P. Önen would like to thank to Prof. Dr. Ayhan Erler for his continuous support during the chemical gathering part of the research and to Mr. Naci Sayın for his kind help during the field work. She would like to extend her thanks to the Department of Geological Sciences of the University College London for using the electron microprobe facilities.

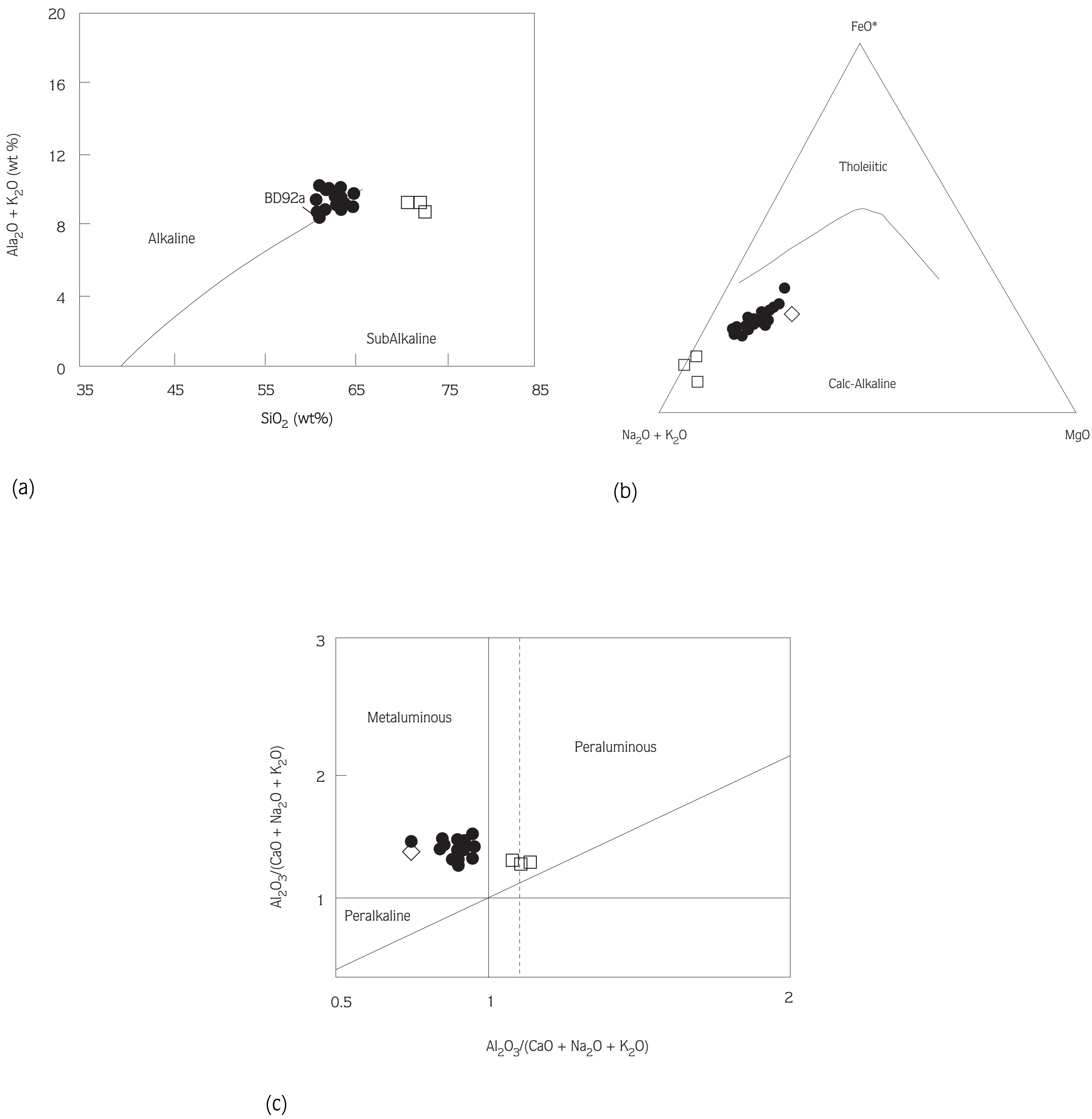

Figure 7. Total alkali versus silica diagram (after Irvine and Baragar, 1971) (a), AFM diagram (after Irvine and Baragar, 1971); (b) Shand Index diagram (after Maniar and Piccoli, 1989); (c) of the Baranadağ intrusion. Symbols are the same as those in Figure 6.

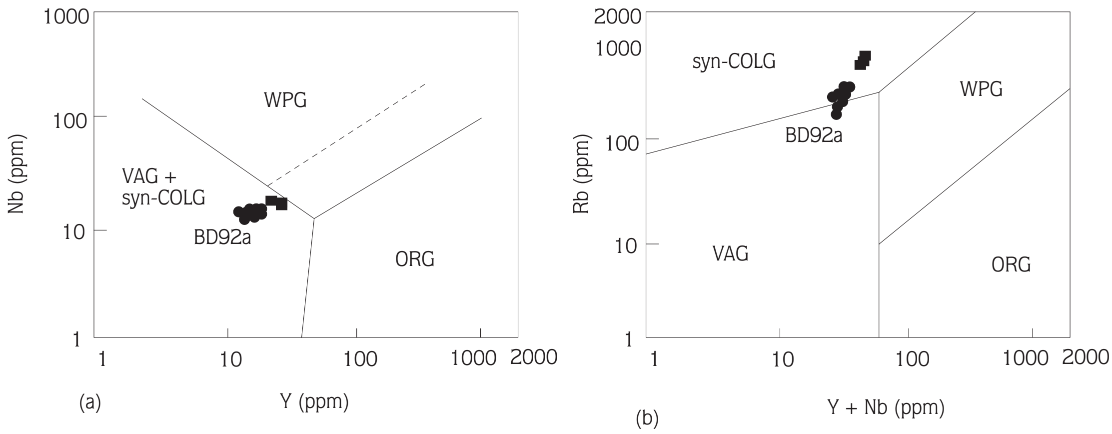

Figure 8. Nb versus Y (a) and Rb versus Y+Nb (b) diagrams (after Pearce et al., 1984) of the Baranadağ intrusion. Symbols are the same as those in Figure 6.

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