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Extrusive Members of Postcollisional A-Type Magmatism in Central Anatolia: Karahidir Volcanics, Idis Dagi–Avanos Area, Turkey

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Abstract

The Idis Dagi Igneous Complex is one of a number of late-stage plutonic bodies within the Central Anatolian Crystalline Complex. It intrudes Paleozoic–Mesozoic metamorphic basement rocks and Late Cretaceous granitoids. The complex comprises mainly quartz syenites and alkali-feldspar quartz syenites known as the Idis Dagi Syenitoids.

Trachydacitic, trachyandesitic, and dacitic rocks (Karahidir Volcanics) have been recently found as dikes cutting the Idis Dagi Syenitoids or as huge blocks within an olistostromal unit of latest Cretaceous(?)–Early Paleocene age that immediately overlies the Idis Dagi Igneous Complex. Petrographic and geochemical data indicate that the Idis Dagi Syenitoids and the Karahidir Volcanics display similar humped patterns on chondrite- and MORB-normalized spider diagrams, with peaks at Rb, Th, and Ce, and also negative Nb anomalies. These features are similar to patterns considered typical of postcollisional, A-type igneous rocks. A postcollisional setting is also suggested by the distribution of data on tectonic discrimination diagrams involving Nb, Y, and Rb. As a whole, the geochemical data suggest that the Idis Dagi Syenitoids and Karahidir Volcanics are cogenetic. Thus, the Karahidir Volcanics represent the shallow intrusive and volcanic equivalents of the deeper-level Idis Dagi Syenitoids.

The syenitoid rocks are considered the final phase of the magmatism in the Central Anatolian Crystalline Complex and are classified as post-orogenic alkaline rocks. Their chemical features suggest a largely mantle-derived magma contribution, together with a noticeable crustal component in their genesis. They were formed during postcollisional uplift that followed crustal thickening related to the southward emplacement of ophiolitic nappes during closure of the Izmir-Ankara-Erzincan Oceanic strand of Neotethys. The Karahidir Volcanics were exposed during regional extension that resulted in the formation of latest Cretaceous(?)–Early Paleocene extensional basins, and were emplaced as huge blocks into the continental clastic rocks by gravity sliding. This extension phase is characteristic of the development of all the other latest Cretaceous–Early Tertiary intracratonic basins in central Anatolia.

Introduction

THE CENTRAL ANATOLIAN CRYSTALLINE COMPLEX (CACC), together with the Menderes Massif in the west (Fig. 1, inset map), represents the metamorphosed and telescoped northern passive margin of the Tauride-Anatolide platform facing the Izmir-Ankara-Erzincan (IAE) branch of the Alpide northern Neotethys ocean. The CACC displays features typical of a collisional belt formed during the closure of the IAE ocean (Göncüoglu et al., 1991) and is essentially composed of three main units: (1) Central Anatolian Metamorphics (comprising the Gümüsler, Kaleboynu, and Asigedigi metamorphics); over which are thrust (2) the Central Anatolian Ophiolites; both of these are intruded by (3) the Central Anatolian Granitoids.

Although various geological studies have been conducted on the plutonic rocks of central Anatolia (e.g., Erler et al., 1991; Akiman et al., 1993;

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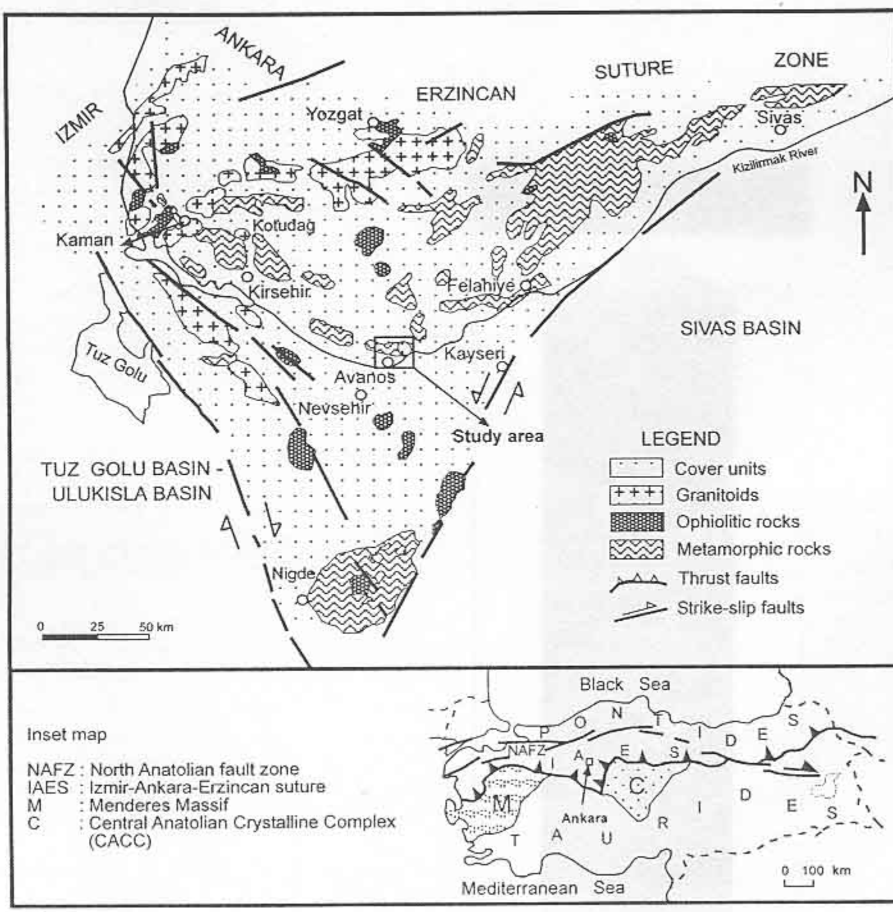

FIG. 1. The location of the study area in the CACC (simplified from Ketin, 1963; Bingöl, 1989). The inset map shows the location of the Central Anatolian Crystalline Complex with respect to the main Alpine units in Turkey.

Göncüoglu and Türeli, 1994; Erler and Bayhan, 1995; Erler and Göncüoglu, 1996; Kadioglu and Güleç, 1996; Yilmaz-Sahin and Boztug, 1998; Tatar and Boztug, 1998; Aydin et al., 1998), gaps remain in our understanding of their evolution. To sum up the previous data, the diverse plutonic rocks in the CACC are considered to be the products of the latest Cretaceous post-collisonal period. According to Aydin et al. (1998), this period started just after the climax of a collisional event and gave rise to C-type granitoid rocks. Through time, crustal thickening was followed by lithospheric delamination that predated underplating by mantle-derived mafic magma. This stage is considered as mature and gave rise to H-type granitoid rocks of the complex, whereas the advanced and final stages are characterized by silica-saturated and silica-undersaturated syenitoid rocks, respectively.

The Idis Dagi Igneous Complex (IIC) constitutes an important part of the Central Anatolian Granitoids suite and comprises mainly quartz syenites and alkali-feldspar quartz syenites—namely the Idis Dagi Syenitoids (Köksal, 1996; Göncüoglu et al., 1997). These syenitoids are cut by feldspathoidal dikes. Further feldspathoidal volcanic rocks known as the Karahidir Volcanics (Kara and Dönmez, 1990) occur as blocks in the Göynük Volcanoclastic Olistostrome that unconformably overlies the IIC (Göncüoglu et al., 1993). The silica-oversaturated and -undersaturated alkaline dikes were reported in previous studies (e.g., Otlu and Boztug, 1998) in the western part of the CACC.

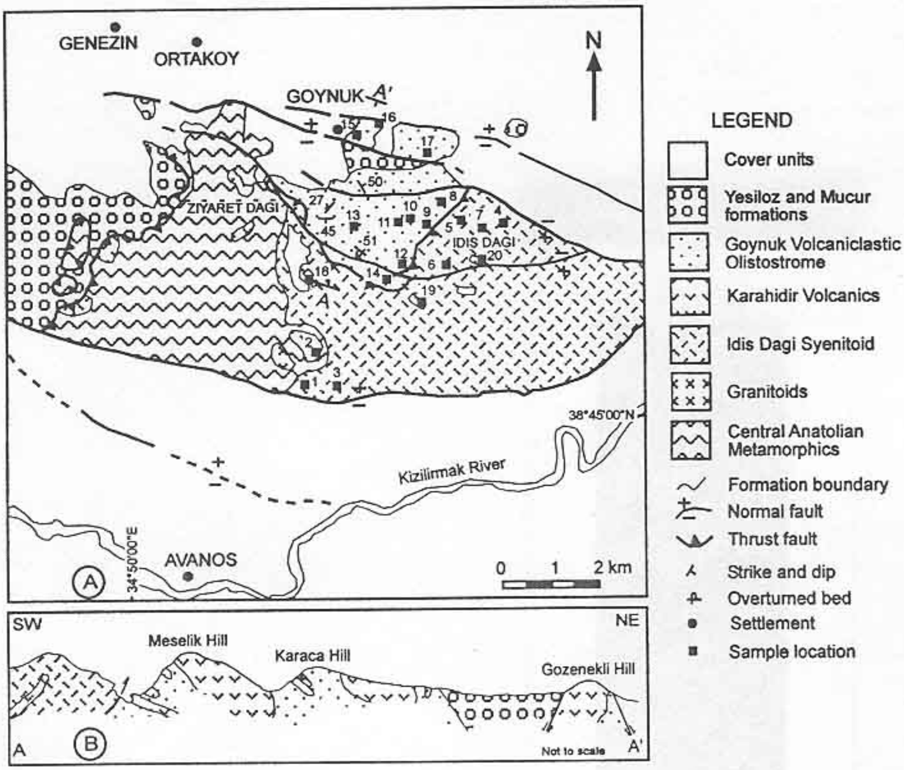

FIG. 2. Geological map (A) and detailed cross section (B) showing the areal distribution and contact relationships of the Göynük Volcaniclastic Olistostrome of the Idis Dagi–Avanos area (after Köksal, 1996).

However, their volcanic equivalents were previously unrecognized in the CACC.

The present research attempts to promote an understanding of the genetic relationship of the volcanic rocks to the postcollisional A-type syenitoids in the Idis Dagi–Avanos area. In this study, the geology and petrology of the Karahidir Volcanics will be presented and their genetic relationship to the syenitic rocks of the study area will be discussed.

Geology of the Idis Dagi–Avanos Area

The Idis Dagi-Avanos area is located northeast of Nevsehir, within the CACC. The basement rocks of the study area consist of the Mesozoic(?) Asigedigi Metamorphics that represent the uppermost unit of the Central Anatolian Metamorphics and comprise platform-type metacarbonates. The Idis Dagi Syenitoids intruded the granitoids and the Asigedigi Metamorphics with the development of contact metamorphic aureoles (Köksal and Göncüoglu, 1997; Göncüoglu et al., 1997). The Karahidir Volcanics occur as dikes cutting the Idis Dagi Syenitoids and as blocks in the Göynük Volcanoclastic Olistostrome (Figs. 2A and 2B). Petrological work on the alkaline rocks was performed by Köksal (1996) in the Idis Dagi–Avanos area and by Aydin (1985) farther west in the Gümüskent area.

The Göynük Volcaniclastic Olistostrome is a volcano-sedimentary sequence with blocks of Karahidir Volcanics and Idis Dagi Syenitoids. Clastic members of the Göynük Volcaniclastic Olistostrome suggest a fluvial environment.

The olistostrome unconformably overlies the basement rocks, and was formed within a fault-controlled extensional basin (Göncüoglu et al., 1994) in latest Cretaceous–Early Paleocene time. The middle Paleocene–late Paleocene Yesilöz Formation comprises the Saytepe Conglomerate Member and the Asaftepe Member, which are terrestrial and lacustrine deposits. The middle Eocene Mucur Formation, characterizing shallow marine (reefal) deposition, transgressively overlies the basement rocks.

It is suggested that in the early Miocene, a compressional system affected the Idis Dagi area, and that the basement rocks were thrust over the Tertiary cover units (Fig. 2B).

The neotectonic period began in the Late Miocene in the study area. In this period, a new tensional system was established, and the Ürgüp and Asarcik formations (cover units in Fig. 2A) were deposited within basins that are controlled by the Central Kizilirmak Fault Zone (Toprak, 1994). Quaternary travertine occurrences, talus deposits, the Karatas Volcanics, and Kizilirmak River terraces of Quaternary age also are mainly controlled by the Central Kizilirmak Fault Zone (Köksal, 1996).

Idis Dagi Syenitoids

In the Idis Dagi area, plutonic rocks of the IIC that contain a little quartz are mineralogically defined as syenitoids. Dikes of the Idis Dagi Syenitoids intrude the adjacent Asigedigi Metamorphics that also occur as roof pendants in the syenite body. Petrographically, the Idis Dagi Syenitoids are composed of a quartz syenite and an alkali feldspar–rich syenite. The quartz syenite is the dominant rock type in the study area, whereas the alkali feldspar–rich type is more abundant in the eastern and northern parts of the body. The syenites are generally medium- to fine-grained with a dominant phaneritic texture, although a porphyritic texture is also widespread. Disregarding the minor differences in modal mineralogy of the two subtypes, the Idis Dagi Syenitoids are generally composed of alkali feldspar, quartz, plagioclase, and amphibole, with minor amounts of biotite, muscovite, and clinopyroxene. Accessory minerals include titanite, zircon, apatite, and opaque phases, and one or more of a number of secondary minerals such as epidote, chlorite, and calcite.

Geochemical data indicate that the Idis Dagi Syenitoids exhibit well-defined alkaline and peralkaline oversaturated trends (Göncüoglu et al., 1997). The analyzed samples show humped patterns on chondrite-and MORB-normalized spidergrams with Rb, Th, and Ce peaks, and also negative Nb anomalies (Table 1). The Idis Dagi Syenitoids belong to the within-plate A-type granitoid group on the basis of their geochemical composition (comparisons with Whalen et al., 1987). Furthermore, it has geochemical characteristics of the A2 subgroup of Eby (1992), including postcollisional granitoids emplaced after a long period of high heat flow and granitic magmatism (Köksal, 1996). A postcollisional setting is also suggested by the distribution of data over different fields in chemically based tectonic discrimination diagrams employing Nb, Y, and Rb (Pearce et al., 1984). These characteristics are consistent with geochemical data from other CACC granitoids and with the regional geology (Göncüoglu et al., 1997).

Karahidir Volcanics

Olistoliths of the Karahidir Volcanics within the Göynük Volcanoclastic Olistostrome range from boulder-sized to tens of meters in diameter. The largest volcanic olistolith is covered, at the northern slope of Meselik Hill, by alternating conglomerate, sandstone, and siltstone (Fig. 2B). North of Meselik Hill, another cycle of olistostromes with smaller syenitic and andesitic blocks occurs between the green flyschoidal clastics and volcaniclastics. The ellipsoidal volcanic block that forms Köydikmeni Hill is about 2.5 km in length and is surrounded by a clastic series. North of that block volcanogenic sandstone layers and smaller volcanic blocks crop out. Another volcanic block similar to that of Köydikmeni Hill is observed on Gözenekli Hill, and smaller blocks with similar lithologies are found on Gedikkasi Hill. On the northern slope of Gözenekli Hill, violet-grey and green sandstone, siltstone, and shale layers with trachytic and latitic volcanic blocks are present (Fig. 2B).

Depending on the megascopic features, the Karahidir Volcanics in the study area can mainly be differentiated into trachytic, latitic, and andesitic types, in addition to scarce feldspathoidal rocks also observed as olistoliths. The trachytes are pink-violet or violet, and their trachytic texture is recognizable from a lineation of ~1 cm long, whitish pink feldspar crystals. Biotite, and minor amounts of quartz and clinopyroxene, also are present. The latites are grey-violet and fine-grained, and contain scarce altered feldspar and biotite phenocrysts. The latites are mainly jointed (joint spacing from 5 to 10 cm) and porphyritic. The andesites are fine-grained and dark violet. Porphyritic texture is observable with feldspar grains up to 0.5 cm in some samples. Dikes are mainly trachytic and andesitic in composition (Köksal, 1996; Köksal and Göncüoglu, 1997).

A pre-Maastrichtian–Paleocene age is assumed for the Karahidir Volcanics (Göncüoglu et al., 1993).

TABLE 1. Whole-Rock Major- and Trace-Element Geochemical Analyses of Samples from the Idis Dagi Syenitoids

Sample		SiO_2	TiO_2	Al_2O_3	$Fe_2O_3^{(T)}$	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
SK-1	+[1]	64.00	0.56	15.47	3.88	0.04	1.36	4.30	3.02	4.28	0.12	3.33	100.37
SK-2	+	65.35	0.39	17.61	2.63	0.05	0.95	2.87	4.78	4.40	0.09	0.74	99.85
SK-3	+	65.25	0.49	16.40	3.72	0.07	0.75	4.29	4.13	4.68	0.09	0.32	100.20
SK-4	+	67.38	0.25	17.31	1.70	0.02	0.04	1.14	5.32	6.00	0.09	0.66	99.90
SK-5	+	66.34	0.43	16.53	2.93	0.03	0.75	3.48	3.77	4.82	0.14	0.64	99.85
SK-6	+	62.25	0.44	17.12	3.53	0.05	0.08	1.72	3.04	8.87	0.13	2.41	99.65
SK-7	+	64.91	0.44	15.79	3.48	0.07	0.80	2.37	3.82	5.31	0.09	2.70	99.79

Sample	Cr	Ni	V	Cu	Pb	Zn	S	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th	La	Ce	Nd	Cl
SK-1	16	3	67	5	48	40	82	153	903	679	17	16	209	22	28	39	66	30	462
SK-2	21	1	40	4	44	44	69	146	1370	1249	19	11	240	17	14	30	56	18	448
SK-3	15	2	45	6	43	46	237	179	1180	997	20	20	284	31	30	43	94	42	178
SK-4	12	0	27	2	58	37	60	262	991	592	23	20	343	13	62	101	157	37	121
SK-5	11	2	38	5	32	28	60	159	1424	826	19	14	235	17	30	43	85	23	508
SK-6	8	2	55	42	30	49	93	259	2933	847	21	36	331	25	61	83	183	55	470
SK-7	15	3	35	3	63	57	66	198	1130	650	18	19	281	27	40	64	129	41	221

[1] + = Idis-Dagi Syenitoids.

Occurrences of Karahidir Volcanics in Sarikaya-Karahidir, Karaova, and Karaburna were reported by Göncüoglu et al. (1993). The Kotudag Volcanics in the Kirsehir region (Fig. 1) reflect petrographic features similar to those of the Karahidir Volcanics, but they are assumed to be of Late Cretaceous–Paleocene age and related to active continental-edge volcanism (Seymen, 1981; Tolluoglu, 1993).

Petrology of the Karahidir Volcanics

Petrography

Dikes of the Karahidir Volcanics and the volcanic blocks in Göynük Volcanoclastic Olistostrome have very similar petrographic characteristics. They are both hypocrystalline, glomeroporphyritic rocks. Microscopically, the Karahidir Volcanics are mainly composed of K-feldspar and plagioclase; quartz, amphibole, clinopyroxene, biotite, and muscovite are common constituents. Zircon, apatite, titanite, and opaque minerals occur as accessory minerals, whereas chlorite and calcite are secondary phases. The Karahidir Volcanics are generally altered by pervasive sericitization, carbonatization, and argillization. Trachytic texture is prominent in some samples. Based upon modal mineralogy, the Karahidir Volcanics are trachytes and/or latites. K-feldspar is sanidine, as phenocrysts and microphenocrysts, and is the main mineral in the dikes, as well as in the volcanic blocks, generally exceeding 20 modal percent. Plagioclase occurs both as microphenocrysts in the groundmass and as phenocrysts (5–15%). It is euhedral to subhedral and has an oligoclase and/or andesine composition based upon the method devised by Michel Lévy. Small amounts of quartz (4–7% as phenocrysts) are found in some of the samples from dikes; it occurs mainly as rounded and corroded forms with anhedral grain boundaries. Biotite occurs as flaky subhedral phenocrysts and also as microphenocrysts in the groundmass. Biotite phenocrysts are present but scarce, generally less than 10%. Amphibole occurs in small amounts (<5%), displays subhedral crystal forms, and may be riddled with inclusions of opaque minerals. Green, subhedral clinopyroxene is observed in a few samples in small amounts (<5%) and, based on extinction angles, is inferred to have an aegirine-augite composition. Accessory minerals include zircon, apatite, titanite, and opaque phases. Hematite, chlorite, and calcite are also present as result of alteration. Pseudoleucite is the only feldspathoid mineral in the Karahidir Volcanics and occurs in small amounts (about 1%) in some of the samples from the olistostrome; it is a hexagonal, colorless mineral showing weak birefringence. The typical complicated polysynthetic twinning of leucite is not observable in pseudoleucite. Inclusions of zircon and opaque minerals are locally present in pseudoleucite (Köksal, 1996).

Petrochemistry

Geochemical analyses were carried out on 13 fresh, representative samples from the Karahidir Volcanics; the data are presented in Table 2. The samples were analyzed by X-ray fluorescence spectrometry (ARL 8420 spectrometer) in the Department of Earth Sciences, Keele University, and calibrated against both international and internal Keele standards of appropriate composition. Details on methods, accuracy, and precision were reported by Floyd and Castillo (1992).

Harker diagrams for the Karahidir Volcanics and Idis Dagi Syenitoids are presented in Figure 3. In the graphs of TiO_2, Al_2O_3, total Fe_2O_3, MnO, MgO, CaO, and P_2O_5, negative trends are observed. These trends are compatible with fractional crystallization, although the lack of trends for K_2O and Na_2O (Fig. 3) may be a result of secondary alteration.

In terms of classification, the chemical data generally support their characterization as trachytes based on modal proportions (Table 2), even allowing for some mobility of the major oxides as a result of weak alteration. Based on the total alkalies–silica classification diagram of Le Bas et al. (1986), the samples are equivalent to trachyandesites and trachydacites in composition (Köksal, 1996). In similar fashion, trace-element classifications based on "immobile" elements (Nb/Y versus Zr/TiO_2 diagram of Winchester and Floyd, 1977), shows that the Karahidir Volcanics fall in the trachyandesite field (Fig. 4). In the $FeO^* - Na_2O + K_2O - MgO$ diagram (Irvine and Baragar, 1971), they apparently exhibit a calc-alkaline trend (Fig. 5), which may again be a consequence of alkali-element mobility.

MORB-normalized spider diagrams of the Karahidir Volcanics are plotted in Figure 6, and are compared with average data for the upper and lower crust and oceanic-island basalts from the literature (Sun, 1980; Taylor and McLennan, 1981; Weaver and Tarney, 1984). The Karahidir Volcanics display a pattern more similar to that of the upper continental crust, rather than lower continental crust or

TABLE 2. Whole-Rock Major- and Trace-Element Geochemical Analyses of Samples from the Karahidir Volcanics[1]

Sample		SiO_2	TiO_2	Al_2O_3	$Fe_2O_3^{(T)}$	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
SK-8	∇[1]	69.55	0.43	15.10	2.90	0.04	0.66	1.48	3.65	4.48	0.11	1.58	99.97
SK-9	O	67.67	0.38	15.45	2.60	0.05	0.54	2.86	3.35	4.76	0.08	2.41	100.14
SK-10	O	69.03	0.39	15.28	2.53	0.03	0.43	2.41	3.18	5.23	0.08	1.91	100.49
SK-11	∇	63.88	0.42	16.83	2.80	0.04	0.56	3.00	5.89	3.30	0.10	3.29	100.10
SK-12	∇	60.05	0.42	15.95	3.40	0.08	0.71	5.20	2.84	5.47	0.12	5.32	99.57
SK-13	∇	64.63	0.34	15.27	2.60	0.06	0.68	4.49	3.30	3.89	0.08	4.81	100.16
SK-14	∇	67.21	0.36	16.38	2.31	0.03	0.30	2.83	4.16	5.17	0.07	1.49	100.31
SK-15	∇	67.77	0.35	14.62	1.95	0.03	0.44	3.12	2.20	3.97	0.07	5.15	99.66
SK-16	∇	66.61	0.38	15.04	2.50	0.02	0.58	3.06	2.15	3.93	0.09	5.45	99.82
SK-17	∇	61.13	0.56	15.84	4.42	0.06	1.10	5.67	3.31	4.29	0.14	3.36	99.87
SK-18	X	66.12	0.27	16.14	2.50	0.07	0.41	2.18	4.49	5.46	0.04	2.09	99.77
SK-19	X	67.20	0.39	15.24	2.67	0.04	0.32	2.75	3.60	4.33	0.09	3.30	99.94
SK-20	X	63.51	0.48	16.16	4.05	0.12	1.18	3.97	2.79	4.55	0.10	3.11	100.03

Sample	Cr	Ni	V	Cu	Pb	Zn	S	Rb	Ba	Sr	Ga	Nb	Zr	Y	Th	La	Ce	Nd	Cl
SK-8	9	1	30	6	48	49	75	173	1165	471	18	13	227	15	26	58	86	32	102
SK-9	28	3	23	4	41	52	99	196	1068	495	20	13	219	16	26	55	85	30	160
SK-10	11	0	36	4	56	52	199	214	1130	441	18	14	227	17	31	49	97	39	101
SK-11	8	3	52	3	31	62	75	140	879	573	18	15	229	20	34	64	124	36	113
SK-12	13	3	55	13	75	80	96	237	1606	744	18	16	259	21	39	49	94	31	141
SK-13	16	3	34	8	40	44	183	161	2871	515	18	13	215	18	32	55	101	39	145
SK-14	9	1	34	3	46	40	67	233	1123	784	20	14	233	14	47	64	85	25	703
SK-15	9	1	27	4	32	47	71	130	1987	885	19	11	209	12	24	46	66	16	75
SK-16	11	1	30	9	35	49	114	119	2192	791	18	13	227	12	26	52	68	25	88
SK-17	33	7	89	15	58	73	60	170	694	490	17	17	192	25	36	49	109	35	457
SK-18	9	1	19	3	78	69	75	216	974	542	23	22	319	20	65	101	147	36	537
SK-19	9	1	38	2	27	50	142	167	1086	389	18	12	209	18	27	55	86	42	180
SK-20	10	1	49	4	28	50	67	172	1302	777	19	16	260	22	33	49	108	36	191

[1]X = volcanic dikes intruding the Idis-Dagi Syenitoids; O = feldspathoid-bearing volcanic blocks; inverted triangles = volcanic blocks in the Göynük Volcaniclastic Olistostrome.

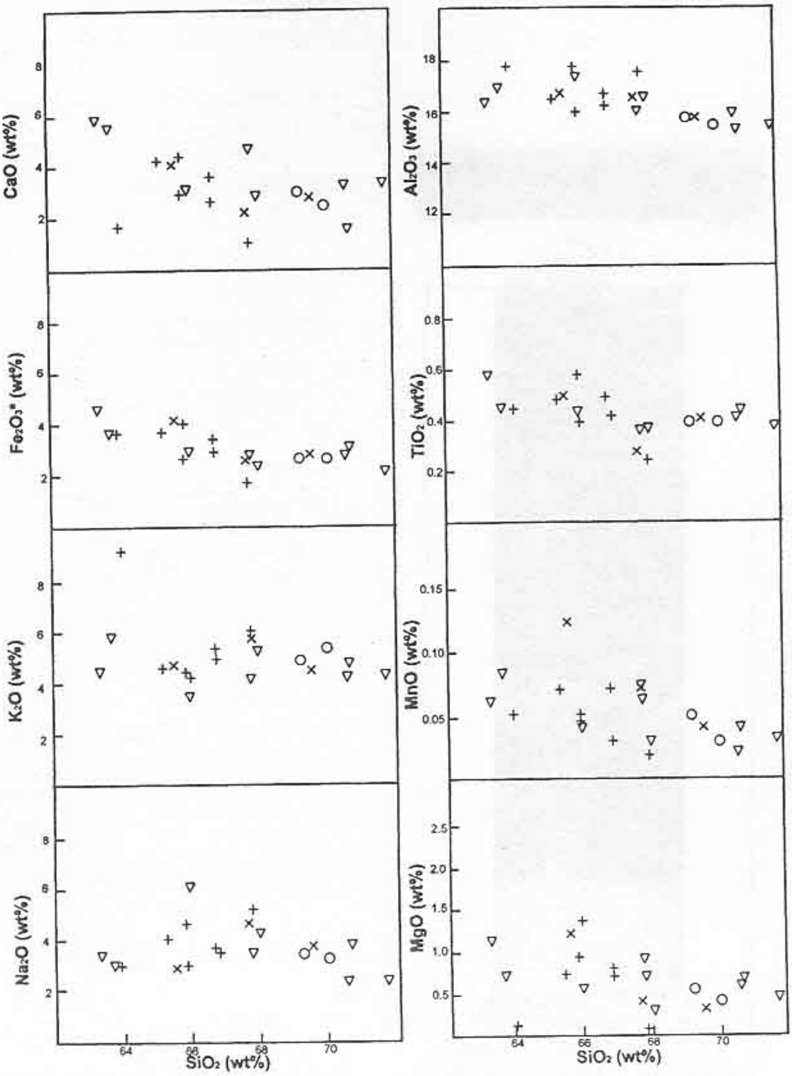

FIG. 3. Major oxide–SiO_2 variation diagrams of the Karahidir volcanics. Symbols: inverted triangles = volcanic blocks in the Göynük Volcaniclastic Olistostrome; open circles = feldspathoid-bearing volcanic blocks; x = volcanic dikes intruding the Idis Dagi Syenitoid; + = Idis Dagi Syenitoids.

oceanic-island basalts. However, the Karahidir Volcanics are enriched in Rb, Ba, Th, La, Ce, Sr, and Nd, and depleted in Ti with respect to upper-crustal values. Zr and Y values are very close to the upper-continental-crust data given by Taylor and McLennan (1981). In diagrams for the Karahidir Volcanics, samples from dikes, non-feldspathoidal blocks, and feldspathoidal blocks plot almost in the same fields and do not show different patterns.

Geochemical Comparison of the Extrusive and Intrusive Rocks

The genetic relationship between the Idis Dagi Syenitoids and the Karahidir Volcanics may be examined using different geochemical diagrams. For comparison of the Karahidir Volcanics and the Idis Dagi Syenitoids, it would be useful to plot samples from both on a single diagram, using their

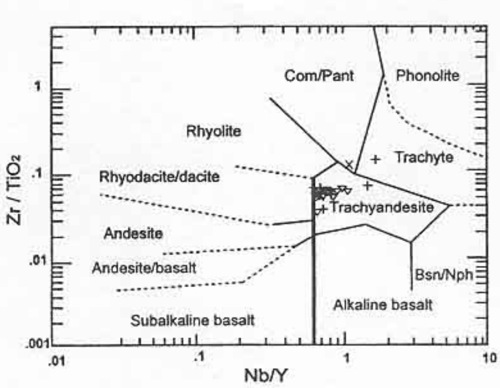

FIG. 4. Distribution of the samples from the Karahidir Volcanics and the Idis Dagi Syenitoids in the Nb/Y versus Zr/TiO_2 diagram (Winchester and Floyd, 1977). Abbreviations: Com/Pant = comendite/ pantellerite; Bsn/Nph = basanite/ nephelinite; Alk-Bas = alkali basalt. Symbols are the same as those used in Figure 3.

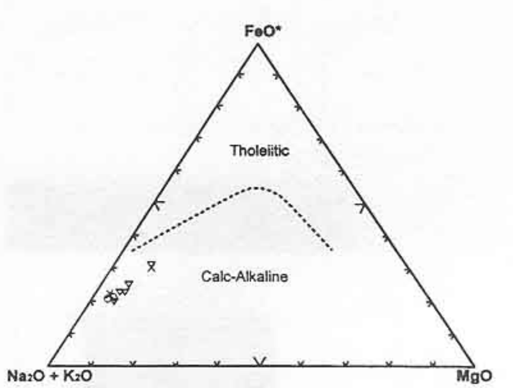

FIG. 5. Distribution of Karahidir Volcanics samples in the FeO^* – Na_2O + K_2O – MgO ternary diagram (Irvine and Baragar, 1971). Symbols are the same as those used in Figure 3.

trace-element ratios. In the Nb/Y versus Zr/TiO_2 diagram of Winchester and Floyd (1977), analyses of the Karahidir Volcanics and the Idis Dagi Syenitoids fall into almost the same fields (Fig. 4). Similarly, on a diagram using the three immobile elements Zr, Nb, and Y, the Karahidir Volcanics and the Idis Dagi Syenitoids plot in almost the same area (Köksal, 1996).

MORB-normalized spider diagrams for the Karahidir Volcanics and the Idis Dagi Syenitoids are given in Figures 7A and 7B, respectively. In both diagrams, negative Ba, Nb, Nd, and Ti anomalies, and positive Th and La anomalies, are present. The patterns in these diagrams for both rock groups are quite similar. The strong similarities among the geochemical characteristics of the Idis Dagi Syenitoids and the Karahidir Volcanics suggest a genetic relationship. Therefore, it is suggested that the Karahidir Volcanics are the volcanic and subvolcanic equivalents of the Idis Dagi Syenitoids (Köksal, 1996).

Discussion and Conclusions

One of the critical problems pertaining to postcollisional magmatism in CACC is that the penecontemporaneous extrusive rocks have not yet been described in detail. In an earlier study, Tolluoglu (1993) examined the geochemical characteristics of the Buzlukdag Syenitoid that intrudes the Kotudag Volcanite in the northern part of the area, north of the city of Kirsehir, and within the CACC.

According to Tolluoglu (1993), the Kotudag Volcanite consists of rhyolite, dacite, trachyte, and trachyandesite/andesite. It is calc-alkaline to alkaline in character, and is assumed to represent volcanism at an active continental margin. The Buzlukdag Syenitoid, on the other hand, consists of quartz syenite, syenite, and monzonite, and is alkaline in character. Tolluoglu (1993) suggested that the Buzlukdag Syenitoid and Kotudag Volcanite developed from different magmatic sources. Göncüoglu et al. (1993) suggested that the syenitoids of the CACC are of lower crust–upper mantle origin, and are postcollisional intrusions of Early Maastrichtian age. According to Göncüoglu et al. (1993), the Idis Dagi Syenitoids were derived by the partial melting of the upper mantle due to release of pressure, resulting from thermal relaxation and postcollisional uplift of the thickened crust of CACC. Köksal (1996) and Göncüoglu et al. (1997) have shown that the Idis Dagi Syenitoids belong to the A-type granitoid group, as determined from the Ga/Al ratio versus immobile-element (especially Zr) discrimination diagrams of Whalen et al. (1987). On the discrimination diagrams of Eby (1992), the Idis Dagi Syenitoids belong to the A2 group, which includes postcollisional granites and those that were emplaced at the end of a long period of high heat flow and granitic magmatism.

In the Rb/Y + Nb and Nb/Y diagrams of Pearce et al. (1984), the Idis Dagi Syenitoids plot at the intersection of the VAG + syn-COLG and WPG fields, the area in which most postcollisional granitoids fall (Pearce et al., 1984). In spider diagrams nics correlate well with those of the Idis Dagi Syenitoid. Therefore, a common magmatic source for both units is probable. Thus, it can be suggested that the Karahidir Volcanics represent the subvolcanic and volcanic equivalents of the Idis Dagi Syenitoid. Outcrops of the Karahidir Volcanics are very limited and are mainly concentrated in the uppermost Maastrichtian–lower Paleocene olistostromes accumulated in fault-controlled extensional basins (e.g., the Kizilirmak Basin, Göncüoglu et al., 1993).

The Göynük Volcaniclastic Olistostrome contains not only large blocks of the Karahidir Volcanics, but also blocks of the Idis Dagi Syenitoids and metamorphic rocks. These blocks may have been derived from footwall scarps along basin-margin faults. At the edges of these blocks, the effects of cataclastic deformation are widespread (Göncüoglu et al., 1993).

In conclusion, we suggest that the Karahidir Volcanics were the final products of postcollisional magmatism in central Anatolia. The association of huge blocks of the volcanic rocks with continental sediments in extensional basins of late Maastrichtian–early Paleocene age indicates that postcollisional extension in central Anatolia continued until early Tertiary time.

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