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GEOCHEMICAL CHARACTERISTICS OF THE ERENLERDAGI VOLCANICS, KONYA, CENTRAL TURKEY

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Abstract

Late Miocene to Pliocene volcanism produced lava domes with mafic microgranular enclaves (MMEs), nuée ardentes and pyroclastic fall and flow (ignimbrites) deposits in the WSW and NW of Konya city. All samples are predominantly high K-calc alkaline in composition but calc-alkaline and shoshonitic composition also exist. The felsic volcanics are mainly dacite, andesite, basaltic trachyandesite and rare trachyandesite in compositon. But, the MMEs have basaltic andesite and andesite compositon. SiO_2 increases with decreasing TiO_2, FeOt, MgO and CaO, suggesting fractional crystallization of mafic minerals. All samples have fractionated chondrite-normalised REE pattern (La/Yb_N: 6.7-18.1), and negative Eu anomaly (Eu/Eu: 0.67-0.89), indicating plagioclase fractionation. In primitive mantle-normalized spider diagram, the samples show an enrichment in large ion litophile elements (LILE) such as Cs and Ba, and depletion in high field strength elements (HFSE), e.g. Dy and Y. They show negative Nb, Ta and Ti anomalies, indicating a subduction signature for their genesis.*

Based on geochemical data, the volcanics are suggested to have been formed by Assimilation-Fractional Crystallization (AFC) and/or magma mixing process. Various geotectonic diagrams imply volcanic arc to post collisional setting for the samples.

Keywords: *Erenlerdağı, volcanism, enclave.*

1. Introduction

The collision of Eurasian and Arabian plates along the Miocene thrust front caused deformation of the Anatolian plate, determines the beginning of the Neotectonic period, which shortened the Eastern Anatolia and is followed by the formation of the East and North Anatolian faults. The Anatolian block begins to move to the west along these two major faults (McKenzie, 1972; McKenzie and Yilmaz, 1991). Intensive volcanic activity developed in Turkey during the Neotectonic period, producing volcanic rocks covered an area of about 85,000 km^2 in East, Central and West Anatolia (Ketin, 1983).

In Central Anatolia, calc-alkaline volcanic units cover large areas located in the WSW and NW of Konya city (Figure 1), in where transtensive and transpressive tectonic regimes have been effective since the Late Miocene (Kempler and Garfunkel, 1991). Keller *et al.* (1977), suggests that volcanism had been active from Late Miocene 11.9 Ma. to Pliocene 3.35 Ma. A limited number of studies related to the Konya volcanics have been done (Ota and Dincel, 1975; Keller *et al.*, 1977; Ulu *et al.*, 1994; Temel *et al.*, 1996; Kurt *et al.*, 2003).

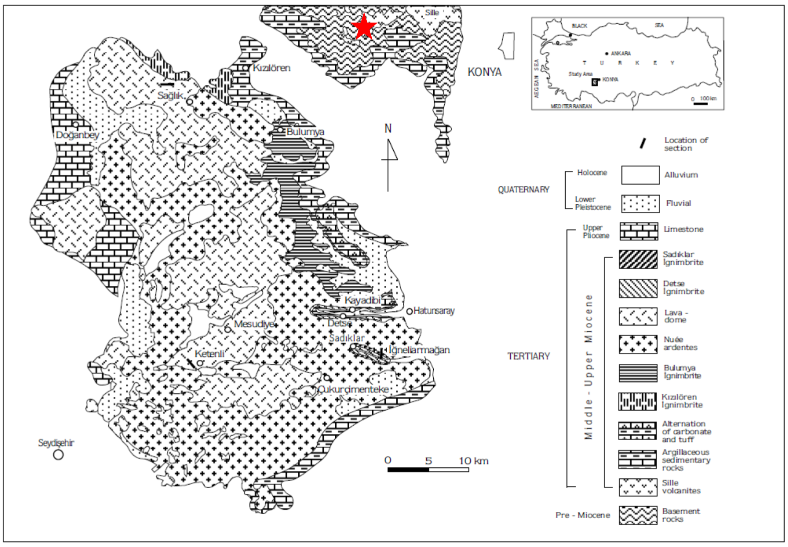

Figure 1 - Location and geological map of the study area (modified from Keller *et al*., 1977)

★ : sill.

The volcanics form as lava domes, sill, nue´e ardentes and ignimbrite deposits. It is aimed to explain the origin of magmas in the Konya region, with new data obtained from the sill.

Pre- Miocene basement is represented by phyllite, schist, quartzite and dolomitic limestone, metavolcanic rocks, diorite, diabase, gabbro, peridotite and serpentinite (Özcan *et al*., 1990; Eren, 1993; Kurt, 1994). It is unconformably overlain by Upper Miocene-Lower Pliocene aged Ulumuhsine formation (Eren, 1993), which is made up by limestone, limestone-mudstone alternation, marl, bands of chert and trace fossils- bearing limestone. The pyroclastic rocks, which consist of volcanic breccia, agglomerate, tuffite and tuffs, conformably overlaid the Ulumuhsine formation. The youngest volcanic rocks are andesite, dacite, and basaltic andesite. Lower Pliocene aged Yürükler formation overlies unconformably volcanic rocks, and contains red conglomerate, red and caliche nodulled mudstone deposites. All these lithologies are overlined unconformably by the Upper Pliocene- Holocene Topraklı formation with conglomerate, and caliche nodulled mudstone formation.

2. Materials and Methods

Twenty one samples were analyzed to determine contents of major oxides, trace and rare earth elements (REE) by ICP-MS at ACME Analytical laboratories in Canada, and fourteen of which are presented in Table 1, with analyses of various volcanic samples in previous studies (Tables 2-5).

2.1. Geochemistry

In an AFM ternary diagram (Figure 2a), the samples clearly define a calc-alkaline trend. The samples are concentrated on high K calc-alkaline series (Figure 2b), but some samples were also found on shoshonite, particularly sill samples, and calc-alkaline areas in a SiO2 vs K2O diagram. The felsic samples are predominantly dacite and andesite, and rare trachyandesite in composition though the sill samples have basaltic trachyandesite composition (Figure 3a). MMEs are however mostly basaltic andesite and andesite in composition. The SiO2 increases with decreasing TiO2, FeOt, MgO, CaO, Ni and Co, suggesting fractional crystallization of pyroxene (±olivine), ilmenite and magnetite (not shown). Primitive mantle normalized spider trace element diagram of the samples from Sağlık lava domes, Takkeli tepe volcanics and sill (Figure 3b) are characterized by an enrichment in large ion litophile elements (LILEs), particularly Cs and Ba, and depletion in high field strength elements

(HFSEs). The rocks show progressively decreasing negative Nb, P and Ti anomalies, which are typical of subduction related magmas (Pearce, 1983). Chondrite-normalized REE patterns (Figure 4a) for the three rock groups usually exhibit a strongly fractionated REE pattern with high LREE/ HREE for the rocks. The samples are LREE enriched with (Ce / Sm) N=2.77-3.04, which are similar to those of subduction-related magmas (Pearce 1982, 1983). The more fractionated and LREE-enriched character of the volcanic rocks indicates that the evolution of the rocks involved continental crust (Watters and Pearce, 1987). Plagioclase fractionation is evident from the slight development of a negative Eu anomaly (Eu/Eu*) N:= 0.84-0.90. Figure 4 b-c shows that the samples have mostly volcanic arc geotectonic setting, but some samples have also post collisional setting.

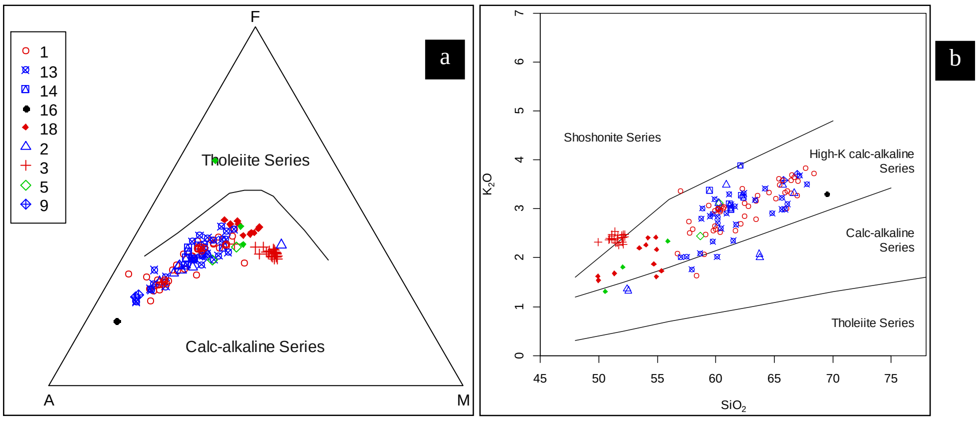

Figure 2 - a) AFM classification of the samples (Irvine and Baragar, 1971) b) SiO_2 vs K_2O diagram of the samples (after Peccerillo and Taylor, 1976).

Symbols; 1: Sağlık lava domes, 2: Takkeli tepe volcanics (Kurt *et al.*, 2003), 3: sill, 5: two-pyroxene andesite, 9: Kızıloren ignimbrite (Temel *et al.*, 1996), 13: Nueerdant (Temel *et al.*, 1996), 14: Erenkaya ignimbrite (Temel *et al.*, 1996), 16: Sille lava dome (Temel *et al.*, 1996), 18: MMEs.

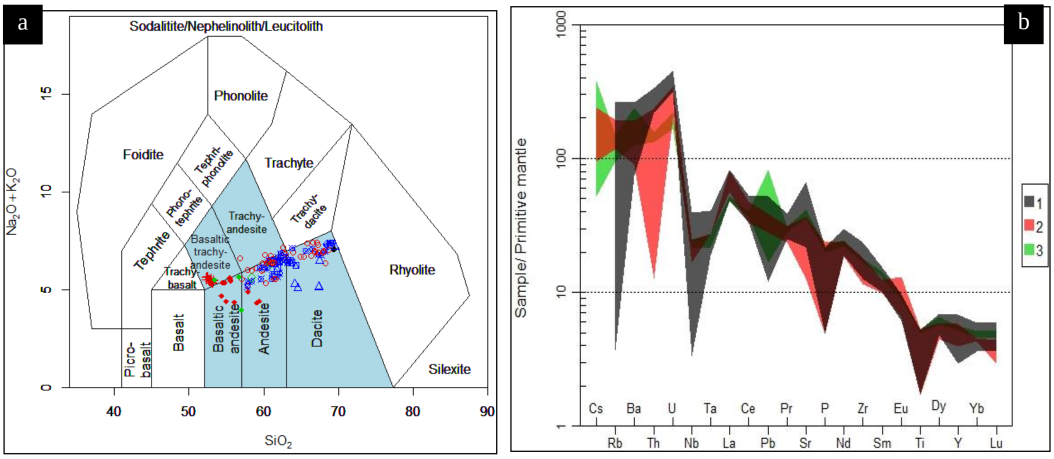

Figure 3 - a) Total alkaline vs SiO2 diagram (Middlemost, 1994) of the samples. b) Primitive mantle normalized spider trace element diagram (McDonough and Sun, 1995) of the Sağlık lava domes (1), Takkeli tepe volcanics (2) and sill (3).

The symbols are as in Fig.2.

Table 1 - Geochemical analyses of the sill samples.

Sample	S2A	S4	T1.1	T1.4	S2B	S5	F2	T1.5	S6	T2.7	F3	T2.2	T2.8	T2.5
SiO2	49.95	50.83	50.95	51.1	51.34	51.44	51.56	51.63	51.71	51.96	52.04	52.09	52.21	52.23
TiO2	1.06	1.04	1.07	1.06	1.06	1.05	1.04	1.04	1.03	1	1.04	1.01	1	1.04
Al2O3	15.92	15.52	15.51	15.37	15.64	15.63	15.48	15.08	15.56	14.93	15.45	15.01	14.7	14.96
Fe2O3	6.67	8.17	7.3	7.67	7.8	7.82	7.9	7.76	7.57	8.09	7.58	8.22	8.37	8.21
MgO	3.86	7.35	5.8	5.52	7.19	7.3	7.27	6.35	7.22	7.1	7.13	7.27	6.98	7.11
CaO	11.9	8.36	10.63	10.49	8.46	8.57	8.28	9.95	8.68	9.16	8.6	8.94	9.17	9.23
Na2O	3.08	2.96	3.11	3.04	3.02	3	2.95	2.93	2.97	2.82	3.07	2.88	2.82	2.93
K2O	2.32	2.37	2.39	2.47	2.37	2.3	2.31	2.46	2.26	2.42	2.32	2.47	2.43	2.47
P2O5	0.42	0.42	0.43	0.44	0.42	0.41	0.42	0.44	0.42	0.42	0.42	0.42	0.43	0.43
MnO	0.11	0.13	0.12	0.14	0.13	0.13	0.13	0.13	0.12	0.14	0.13	0.14	0.14	0.14
LOI	4.3	2.4	2.3	2.3	2.1	1.9	2.2	1.8	2	1.5	1.8	1.1	1.3	0.8
Sum	**99.6**	**99.62**	**99.63**	**99.64**	**99.61**	**99.61**	**99.61**	**99.62**	**99.58**	**99.59**	**99.61**	**99.61**	**99.62**	**99.6**
Ni	79	106	114	99	113	99	108	82	107	80	104	76	83	78
Co	27	29	37	30	29	30	30	30	29	30	30	31	30	31
Pb	9	3	5	8	12	5	6	8	6	4	6	3	4	3
Rb	61	75	73	79	74	60	72	82	59	90	61	88	88	90
Sr	775	748	821	748	745	742	701	765	789	736	756	747	726	770
Ba	1583	846	898	941	849	862	864	919	1079	904	830	921	899	952
Hf	4.8	4.3	5.3	5.3	4.3	4.6	5	5.3	5.1	5	4.8	5.2	4.8	5
Nb	15.6	15.5	15.9	14.4	15.5	15.7	16	14.6	15.3	14.1	15.7	14.3	14.4	15.3
Ta	0.9	0.9	0.9	0.9	1	0.8	1	0.8	0.9	0.8	0.9	0.9	0.8	0.8
Th	11.4	10.6	10.9	11	11.2	11.7	11	12	11.4	10.9	11	11.6	12.1	12.5
U	4	3.5	3.8	3.9	3.7	3.9	3.6	4	3.4	4	3.7	4	4.2	4
Zr	184.6	179.1	184.5	179.6	179.5	180.6	177.3	183.3	176.9	181.3	177	183.7	175.1	186.3
Y	23.9	23.2	23.1	23	22.7	23.4	22.7	23.3	23.1	23.8	23.2	23.6	23.3	24.1
Cs	7.1	7.1	1.1	2.2	6.4	7.1	5.8	3.2	6.6	4.8	8	4.7	5.1	4.8
La	32.5	31.4	31.2	31.1	31.8	33.1	32.5	31.9	32.5	31.6	32.1	32.4	31.6	33
Ce	64.9	63	64.3	63.5	63.4	65.9	64.7	63.9	63.5	63.7	63.2	66.5	64.3	66.4
Pr	7.41	7.18	7.36	7.37	7.31	7.51	7.37	7.44	7.37	7.43	7.34	7.6	7.35	7.79
Nd	29.8	28.6	29	30	29	29.3	29.3	28.8	28.5	27.8	29.9	30.2	28.4	29.8
Sm	5.37	5.49	5.48	5.42	5.19	5.43	5.35	5.46	5.24	5.32	5.26	5.66	5.31	5.74
Eu	1.42	1.45	1.44	1.41	1.39	1.44	1.4	1.44	1.4	1.4	1.36	1.44	1.41	1.48
Gd	4.74	4.54	4.5	4.7	4.5	4.72	4.47	4.77	4.65	4.69	4.55	4.74	4.59	4.63
Tb	0.73	0.73	0.75	0.75	0.73	0.75	0.74	0.74	0.74	0.75	0.72	0.76	0.74	0.77
Dy	4.16	4.08	4.09	4.11	3.88	4.44	4.14	3.9	4.09	4.16	4.11	4.33	4.02	4.1
Ho	0.81	0.8	0.82	0.8	0.82	0.8	0.82	0.82	0.8	0.85	0.81	0.83	0.77	0.79
Er	2.36	2.27	2.4	2.25	2.2	2.34	2.37	2.35	2.41	2.32	2.38	2.32	2.29	2.35
Tm	0.34	0.33	0.34	0.34	0.34	0.37	0.36	0.33	0.35	0.34	0.36	0.35	0.32	0.35
Yb	2.17	2.11	2.14	2.17	2.14	2.17	2.16	2.05	2.28	2.2	2.28	2.16	2.13	2.17
Lu	0.31	0.32	0.32	0.33	0.32	0.35	0.34	0.32	0.34	0.32	0.34	0.33	0.31	0.34

Table 2 - Results of the geochemical analyses of the samples from the Sağlık lava domes (Kocak and Zedef, 2016)

Samp.	**1B**	**2C**	**3B**	**4B**	**5B**	**7B**	**8B**	**9C**	**11B**	**40B**	**41B**	**42B**	**43B**	**44B**	**46B**	**47B**
SiO2	66.11	59.9	67	64.57	65.75	65.44	65.39	59.76	66.46	60.18	60.35	60.69	60.38	60.67	60.15	59.89
TiO2	0.45	0.8	0.45	0.47	0.47	0.47	0.48	0.83	0.43	0.8	0.79	0.79	0.78	0.79	0.8	0.83
Al2O3	15.52	15.91	15.23	15.43	15.39	15.15	15.24	16.07	15.54	16.94	17.07	16.64	16.53	16.8	16.94	16.97
Fe2O3	3.76	6.3	3.68	3.74	3.78	3.84	3.95	6.27	3.57	6.11	5.99	5.95	6.12	6.04	6.01	6.19
MgO	1.61	3.37	1.58	1.54	1.7	1.56	1.73	3.33	1.42	2.54	2.45	2.39	2.51	2.38	2.61	2.69
CaO	3.73	5.26	3.44	4.73	4.1	4.48	4.01	5.38	3.51	5.93	5.77	5.68	5.88	5.77	5.78	6.04
Na2O	3.39	2.73	3.26	3.22	3.27	3.26	3.23	2.84	3.19	3.39	3.39	3.3	3.33	3.33	3.4	3.34
K2O	3.37	2.64	3.57	3.34	3.58	3.49	3.62	2.56	3.58	2.99	2.97	3.04	2.94	3	3.01	2.96
P2O5	0.17	0.13	0.16	0.17	0.18	0.18	0.18	0.16	0.16	0.25	0.24	0.24	0.25	0.26	0.25	0.25
MnO	0.08	0.13	0.07	0.1	0.08	0.1	0.1	0.12	0.07	0.11	0.11	0.1	0.11	0.11	0.11	0.11
LOI	1.6	2.6	1.3	2.4	1.4	1.8	1.8	2.4	1.8	0.4	0.5	0.9	0.8	0.5	0.6	0.4
Sum	**99.75**	**99.79**	**99.75**	**99.75**	**99.75**	**99.75**	**99.75**	**99.74**	**99.75**	**99.64**	**99.65**	**99.67**	**99.66**	**99.66**	**99.65**	**99.65**
Ni	3.4	2.1	3.2	3	3.4	3.2	3.5	2.6	3.2	2	1.9	2.4	2.6	2.3	1.8	1.9
Co	6.7	12.2	7.7	8.7	8.4	7.3	7.7	14.3	8	14.6	13.7	12.8	14	14.7	13.8	14.1
Hf	4	4	4.1	3.5	4.7	4.1	4.8	4.3	4.2	3.9	5	4.5	4.4	5.2	5.2	4.1
Nb	13.9	12.8	14.6	14.1	15	14.1	13.4	12.2	13.3	12.5	13.5	13.1	12.1	12.6	13.8	11.4
Rb	125.9	93.4	130.5	115.2	131.6	122.7	130.4	99.6	135.3	92.3	91.9	95.5	94.4	96.9	93	90.3
Ba	1024	490	1027	984	1015	980	988	621	981	1151	1103	1055	1120	1176	1134	1087
Sr	529.2	524.9	501.8	514.5	503.7	541	479.4	577.4	518.8	949.5	906.7	858.2	906.4	878.4	900.7	925.6
Pb	3.2	5.4	3.5	2.4	2.8	3.5	2.5	5	7.8	2.3	1.9	1.8	1.8	1.9	2	2.1
Zn	27	35	23	30	31	25	26	39	35	19	15	17	20	18	16	14
Ta	1.3	1	1.5	1.1	1.4	1.2	1.3	1	1.2	1	0.7	1.2	1	1	0.9	0.9
Th	23.3	20.4	26.8	23.7	26.7	24.4	24.6	17.7	25.7	21.2	21.3	20.7	22	22.3	21.3	20.7
U	7.7	6.3	8.8	7.7	9	8.9	9	7.3	8.1	6.6	6.3	6.3	6.2	6.5	6.5	6.4
Zr	151.2	133.7	166.7	143.6	168.6	155.5	170.3	146.1	157.6	173.2	168.1	164.1	174.5	175.2	170.2	164.5
Y	17.5	21.2	18.5	18.6	19.1	18.2	18.6	23.2	17.8	23.9	24.9	21.6	22.1	25.1	21.9	22.8
La	42.5	31.6	46.9	42.8	46.6	44.1	41.4	32	42.1	49.1	51.4	46	49	53	51.4	49.8
Ce	71.5	56.7	80.9	75.2	82	76.9	72	58.8	73	86.4	84.6	83.1	84.4	86.7	88.4	85
Pr	7.3	6.32	8.32	7.83	8.47	7.96	7.56	6.49	7.38	9.6	9.35	9	9.26	9.75	9.51	9.41
Nd	28.6	23.7	26.8	26.9	29.8	26.8	25.8	23.9	27.3	37.1	33.8	34.6	34.1	35.5	35.5	36.3
Sm	4.41	4.25	4.48	4.41	4.79	4.09	4.7	4.48	4.2	5.94	5.54	5.71	5.78	6.16	5.82	5.69
Eu	1.04	1.1	0.97	0.97	1.03	0.96	0.97	1.02	0.95	1.42	1.37	1.38	1.42	1.49	1.45	1.4
Gd	3.88	4.07	4.22	4.14	4.49	3.86	4.09	4.32	3.64	5	5.07	4.95	5.3	5.22	5.08	5.08
Tb	0.54	0.64	0.59	0.56	0.6	0.57	0.58	0.68	0.53	0.7	0.7	0.67	0.72	0.77	0.7	0.73
Dy	3.3	3.71	3.76	3.46	3.21	3.43	3.47	4.18	3.3	3.84	3.93	4.15	3.58	4.68	3.62	3.79
Ho	0.6	0.88	0.58	0.56	0.65	0.64	0.68	0.84	0.56	0.8	0.86	0.69	0.79	0.98	0.81	0.77
Er	1.96	2.32	2.03	1.92	1.91	1.74	1.92	2.63	1.91	2.23	2.74	1.98	2.29	2.36	2.49	2.42
Tm	0.27	0.4	0.27	0.29	0.29	0.34	0.3	0.33	0.26	0.31	0.37	0.31	0.36	0.38	0.32	0.36
Yb	1.6	2.2	1.99	1.69	1.87	1.88	1.77	2.12	2	2.31	1.91	2.23	2.21	2.59	2.23	2.3
Lu	0.29	0.41	0.33	0.31	0.33	0.29	0.28	0.39	0.25	0.32	0.33	0.32	0.3	0.35	0.33	0.39

Table 3 - Results of the geochemical analyses of the samples from MMEs (Kocak, 2016; Temel *et al.*, 1998).

Samples	Kocak, 2016											Temel *et al.*, 1998		
	5A	**8A**	**4A**	**42A**	**43A**	**41A**	**1A**	**40A**	**2A**	**47A**	**9A**	**KO-39**	**KO-50**	**KO-53**
SiO2	49.92	49.95	51.33	53.46	54.02	54.19	54.71	54.88	54.93	54.94	55.35	55.89	52.06	50.54
TiO2	0.81	0.8	0.9	1.17	1.14	1.11	0.93	1.11	0.89	1.13	0.87	0.83	0.86	0.76
Al2O3	14.66	14.79	15.4	17.59	17.53	17.94	16.19	17.69	16.17	17.73	16.1	16.24	16.4	14.31
Fe2O3	6.23	6.2	7.22	8.54	8.37	8.16	7.4	8.18	7.1	8.08	6.69	7.33	8.41	8.61
MgO	3.5	3.65	4.24	3.79	3.9	3.08	4.31	3.49	4.2	3.44	4.01	4.57	4.13	1.09
CaO	11.93	10.91	8.06	7.91	7.98	7.21	6	7.61	5.3	7.74	5.72	7.79	9.82	9.39
Na2O	2.68	2.45	2.29	3.05	3.02	3.05	2.76	3.12	2.41	3.23	2.38	3.23	3.54	2.2
K2O	1.62	1.54	1.68	2.2	2.26	2.41	1.87	2.42	1.61	2.17	1.73	2.34	1.81	1.31
P2O5	0.17	0.16	0.2	0.28	0.27	0.3	0.16	0.27	0.17	0.29	0.17	0.27	0.27	0.24
MnO	0.37	0.4	0.23	0.13	0.13	0.13	0.18	0.12	0.18	0.13	0.15	0.123	0.193	0.17
LOI	7.8	8.9	8.2	1.5	0.9	2	5.2	0.7	6.8	0.7	6.5	0.98	1.87	0.83
Sum	99.74	99.75	99.72	99.58	99.55	99.58	99.71	99.58	99.73	99.58	99.73	99.59	99.36	99.25
Ni	2.2	1.4	2.3	2.6	2.9	2.2	2.9	2.4	2.8	2.1	2.4	10.8	19.1	184.5
Co	14.4	13.6	15.8	21.9	21.2	20.6	16	21.3	15.5	20.1	15.2	34.4	27.6	46.9
Pb	4.4	2.7	5.5	2.9	2.6	2.9	5.4	2.5	6.1	2.9	6.9			
Rb	57.3	47.9	57.2	62.2	65	70.5	66.6	71	50.4	63.5	52.2	62.2	51.5	25.9
Sr	615.3	548.6	577.1	1213	1221	1222	635.5	1207	495.9	1249	541.5	1195	637.7	1162
Hf	3.6	2.4	3.2	4.1	3.6	4.8	3.2	3.9	3.3	4.3	3.6			
Nb	8.7	7.6	9.1	11.6	11.8	11.9	10.2	10.3	8.4	13.6	8.1	9.2	14.7	5.3
Ta	0.7	0.4	0.5	0.5	0.6	0.7	0.5	0.9	0.5	0.8	0.6			
Th	8.5	7.5	7.3	14.4	16.2	16.4	8	15.7	8.9	16.2	9			
U	8.3	3	3.5	3.8	5	4.5	4.3	4.5	2.8	5.4	2.8	175.5	153.9	164.4
Zr	128.7	113.3	125.2	148.7	152.7	156.5	116.8	149.2	115	151.7	124	150	113.5	127.6
Y	23.3	20.3	24.2	24.9	25.1	28.4	23.2	22.8	18.9	23.8	20.2	21.1	30.5	16.4
La	25.8	24.6	28.4	47.3	49.1	53.7	25.7	46.2	22.8	49.2	25.4			
Ce	46.6	43.6	53.2	81.8	86.8	91.4	50	85.3	45.9	87.4	48.1			
Pr	5.39	5.25	6.29	9.8	10.11	10.73	5.87	9.82	5.25	10.28	5.66			
Nd	22.7	23.3	26.6	40.6	39.7	38.7	21.6	32	19.3	37.9	23.2			
Sm	4.12	4.01	4.84	6.68	6.87	6.76	4.62	6.66	4.27	6.73	4.57			
Eu	1.11	1.04	1.27	1.67	1.59	1.83	1.26	1.71	1.11	1.65	1.01			
Gd	3.99	3.58	4.68	5.36	6.09	6.19	4.4	5.63	3.89	5.65	4.48			
Tb	0.63	0.6	0.72	0.82	0.82	0.83	0.69	0.81	0.59	0.81	0.65			
Dy	4.09	3.52	4.28	4.23	4.47	5.09	4.04	4.23	3.37	4.16	3.76			
Ho	0.79	0.79	0.91	0.89	0.8	1	0.89	0.92	0.71	0.82	0.72			
Er	2.28	2.14	2.62	2.68	2.82	2.96	2.61	2.49	2.13	2.52	2.33			
Tm	0.3	0.29	0.34	0.39	0.36	0.39	0.42	0.4	0.32	0.35	0.31			
Yb	2.13	1.87	2.34	2.38	2.64	2.26	2.6	2.36	2.09	2.68	2.17			
Lu	0.38	0.3	0.35	0.34	0.35	0.33	0.4	0.32	0.32	0.35	0.34			

Table 4 - Results of the average geochemical analyses of the samples ignmbrite, Nue´e ardentes, two pyroxene andesites, Sille lava dome (Temel *et al.*, 1998).

	Lava domes		**Kızıloren Ignimbrite**		**Nue´e ardentes**		**Erenkaya Igni.**		**Two pyrx. Andes.**		**Sille**
Sample	ave.	std(26)	ave.	std (n:2)	ave	std (n:34)	Aver.	Std(7)	Ave.	Std(n:2)	
SiO2	62.0	3.60	66.4	0.58	61.4	2.9	61.4	0.92	59.5	0.81	69.5
TiO2	0.6	0.19	0.4	0.00	0.7	0.2	0.7	0.06	0.8	0.09	0.5
Al2O3	16.5	0.76	15.6	0.25	16.5	0.6	16.5	0.59	16.3	0.03	16.9
Fe2O3	5.4	1.41	3.0	0.00	5.5	1.3	5.5	0.52	6.3	0.60	1.9
MgO	4.0	7.74	1.0	0.02	2.5	0.8	2.2	0.46	3.7	0.47	0.7
CaO	5.5	1.50	3.3	0.01	5.4	1.2	5.2	0.40	7.0	0.76	3.4
Na2O	3.5	0.29	3.4	0.03	3.4	0.3	2.9	0.47	3.2	0.02	3.8
K2O	4.5	7.87	3.6	0.06	2.8	0.5	3.3	0.29	2.8	0.34	3.3
P2O5	0.2	0.07	0.2	0.01	0.2	0.1	0.2	0.02	0.2	0.00	0.2
MnO	0.5	1.92	0.1	0.00	0.1	0.0	0.2	0.25	0.1	0.01	0.0
Cr2O3	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0
LOI	2.8	9.86	2.4	0.12	1.0	0.6	1.9	0.81	0.7	0.29	1.0
Sum	**99.9**	**0.64**	**99.3**	**0.78**	**97.1**	**15.2**	**99.8**	**0.51**	**100.1**	**0.79**	**101.1**
Nl	12	7	6	0	11	4	9	2	49	30	5
Ba	1057	268	990	95	987	247	950	97	759	15	957
Co	19	8	26	1	20	6	17	5	23	3	11
Ga	18	1	18	0	22	27	17	0	17	1	22
Nb	14.6	5.7	24.9	0.1	14.2	3.9	13.1	1.6	12.2	0.7	13.3
Rb	91.0	29.5	131.6	8.1	90.6	20.3	123.7	19.7	96.1	17.8	122.2
Sr	791.1	238.5	771.7	13.6	845.5	768.5	591.9	36.5	515.5	19.5	468.8
V	104.8	43.9	35.0	1.1	103.5	39.6	77.3	9.8	126.8	21.7	73.7
Zr	178.7	25.4	158.9	0.3	164.2	17.1	178.3	7.2	160.7	18.3	174.9
Y	21.7	3.3	15.2	0.8	22.2	3.4	22.4	1.6	21.8	1.7	23.9

Table 5 - Results of the geochemical analyses of the samples from Takkeli tepe volcanics (Kurt *et al.*, 2003).

sample	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
SiO2	63.73	63.79	52.52	52.40	63.39	60.26	60.90	66.70	65.72	65.94
TiO2	0.34	0.35	1.03	1.07	0.58	0.60	0.68	0.56	0.44	0.42
Al2O3	16.84	16.80	15.34	15.46	15.59	16.35	*16.5*	14.64	16.13	15.75
Fe2O3	3.47	3.50	7.73	7.78	4.50	5.82	5.0	4.14	3.72	3.67
MgO	1.39	1.40	6.4S	6.55	2.01	2.87	2.5	1.74	1.44	1.42
CaO	3.71	3.82	8.7S	8.9	4.7	*6*	5.10	4.45	.3.86	3.85
Na2O	2.82	2.86	2.82	2.96	3.14	3.10	3.13	3.10	3.29	3.26
K2O	2.07	2	1.32	1.36	3.39	3.12	3.49	3.32	3.49	3.6S
P2O5	0.11	0.10	0.47	0.49	0.17	0.21	0.20	0.19	0.15	0.14
MnO	0.06	0.06	0.14	0.16	0.07	0.08	0.08	0.07	0.07	0.07
LOI	5.2	5	2.4	2.46	2.2	1.60	2.2	0.9	1.5	1.6
Sum	**99.74**	**99.68**	**99.78**	**99.59**	**99.74**	**99.99**	**99.78**	**99.81**	**99.81**	**99.80**
Ni	6	6	98	99	15	14	*10*	9	5	6
Ba	35	36	49	51	28	50	55	32	23	26
Rb	18	18	18	18	19	17	17	16	20	20
Sr	11	11	16	16	12	11	12	13	14	13
Hf	7.2	7	30	30	8	13	6	8	8	8
Nb	4.1	4	2	2	3	3	3.1	*5*	4	4.2
Ta	88	88	70	70	103	110	100	84	111	117
Th	2	2	2	2	2	3	2	1	1	2
U	251	252	730	735	613	620	565	625	555	552
Zr	5	5	4	4	6	*5*	6	6	7	7
Y	58	60	150	155	78	70	*75*	71	43	49
La	2	2	1	1	*2*	2	2	2	2	2
Ce	134	134	174	174	135	190	155	122	165	154
Pr	19	19	24	25	20	23	20	17	20	19
Nd	49.0	50.0	37.0	37.0	*36.0*	42.0	39.0	37.0	42.0	52.0
Sm	75.0	75.0	60.0	60.0	*55.0*	60.0	80.0	57.0	64.0	79.0
Eu	7.0	7.0	7.0	7.0	6.0	6.0	6.3	6.0	7.0	8.0
Gd	28.0	28.0	30.0	30.0	*25.0*	25.0	25.0	23.0	27.0	30.0
Tb	4.0	4.0	5.0	5.0	4.0	4.0	4.0	4.0	4.0	5.0
Dy	1.0	I	*2.0*	2.0	I	1.0	1.0	1.0	1.0	1.0
Ho	4.0	4.0	5.0	5.0	4.0	4.0	4.0	4.0	4.0	4.0
Er	1.0	I	1.0	1.0	0.6	0.5	0.6	0.5	0.6	0.6
Tm	3.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	3.0
Yb	0.6	0.6	1.0	1.0	0.7	0.6	0.7	0.5	0.6	0.6
Lu	2.0	2.0	2.0	2.0	1.7	1.7	1.8	1.5	1.8	1.7

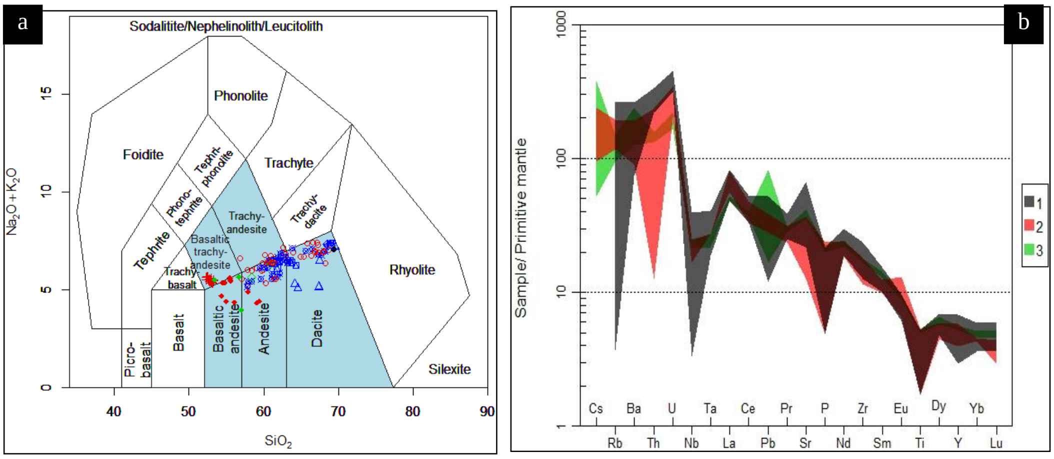

Figure 4 - a) Total alkaline vs SiO2 diagram (Middlemost, 1994) of the samples. b) Primitive mantle normalized spider trace element diagram (McDonough and Sun, 1995) of the Sağlık lava domes (1), Takkeli tepe volcanics (2) and sill (3).

The symbols are as in Fig.2

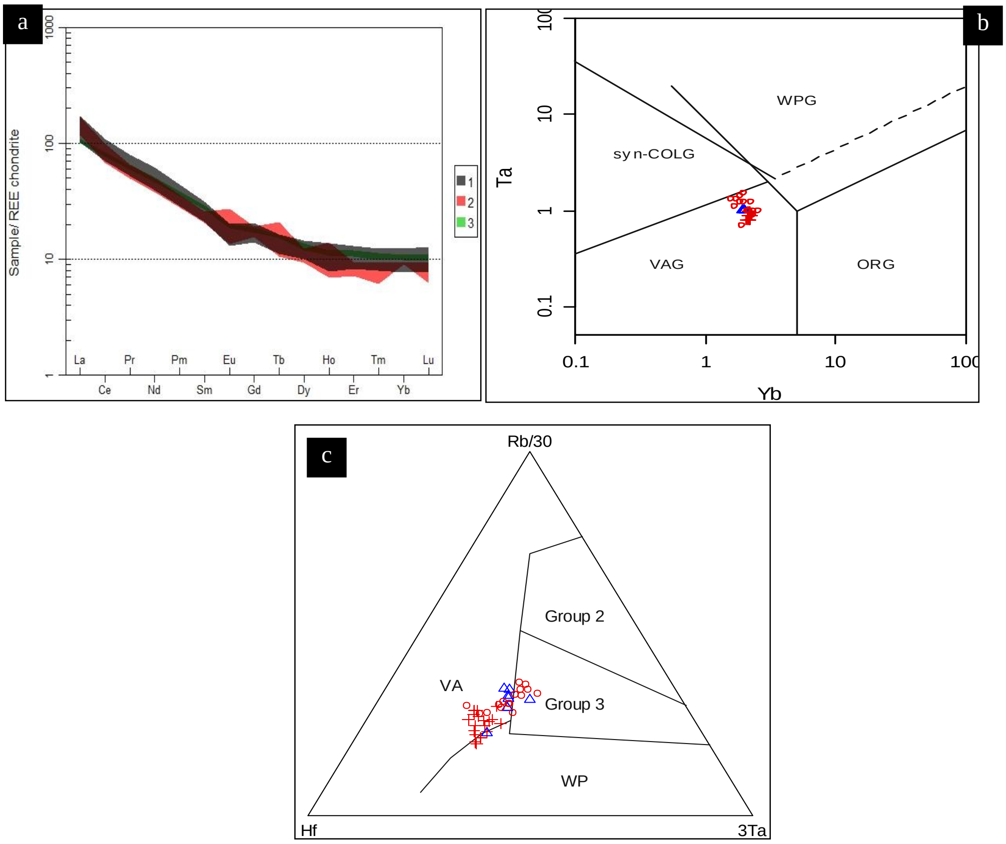

Figure 5 - a) Chondrite normalized REE pattern of the Sağlık lava domes (1), Takkeli tepe volcanics (2) and sill (3). Normalized values are from Boynton, 1984. b) Ta vs Yb diagram (after Pearce *et al.*, 1984) c) Hf-Rb/30-Ta*3 (Harris *et al.*, 1986).

Group 2: syncollisional, Group 3: Post collisional, WP: Within plate, The symbols are as in Fig.2.

3. Discussions and Conclusions

Fractional crystallization is evident in the the Harker variation diagrams and chondrite normalized REE diagrams (negative Eu anomaly). However, presence of MMEs in volcanics proposes mafic-felsic interaction and mingling (Barbarin and Didier, 1992; Kocak, 2006) by injection hot mafic magma injected into felsic magma. Dusty zone on the plagioclase phenocryst rims and reverse zoning in plagioclases (Temel *et al.*, 1998) strong enrichments in incompatible elements e.g., Rb, Sr, Ba and K_2O also support this suggestion. Combined AFC and/or magma mixing between mantle-derived magmas and crustal components are proposed for the Erenlerdagi volcanics by Temel *et al.* (1998).

The samples are characterized by high K_2O (1.32-3.83 wt.%), Rb (2-157 ppm), Ba (490-1715 ppm), K_2O/Na_2O (0.5 -1.2) and FeO_t/MgO (0.94-8.00) ratios, which is comparable to Andean type andesites series developed in relation with a subduction event. The samples have mostly High-K calc-alkaline in composition, which is typical of continental orogenic regions. Accordingly, Large ion lithophyle elements e.g., K, Rb, Ba, Sr, and Zr, are high in orogenic series (Gill, 1981). In various geotectonic diagrams, volcanic arc is dominated, but there is a tendency from Volcanic arc to Post collisional area. Existence of shoshonitic sill samples may indicate a change of the compressional regime into an extensional one. Similarly, the trachytic rocks formed in Anatolia such as Galata Galatia Volcanic Province, and Oglakci (Sivrihisar, Eskisehir) area are postulated to be formed in the extensional tectonic regime (Temel, 2001). The volcanics have relatively high Rb/Y (0.1-9.7), and low Nb/Y (0.17-1.7) ratios, indicating a subduction zone enrichments or by crustal contamination, as Rb is enriched giving elevated Rb/Nb ratios. Within-plate type enrichments induce development of Nb/Y(~1) ratio (Edwards *et al.*,1991).

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