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Geochemistry of Neogene Lacustrine Sediments from Western of Elazığ (Turkey): Implications for Provenance and Tectonic Setting

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Abstract

Sediment geochemistry of the Neogene lacustrine environment from Karabakır Formation in the western of Elazığ, were used to constrain provenance and tectonic setting. The basement of the studied sediments is Permo-Triassic Keban Metamorphics, upper Cretaceous Elazığ Magmatics, middle Eocene-upper Oligocene marine Kırkgeçit Formation. The Neogene basaltic volcanics are at the top of the lacustrine sediments in the area. The lacustrine deposit of Karabakır Formation consists of clayey limestone and limestones. Clayey-limestone samples were collected from Kurttepe section of the formation, and were analyzed for major, trace and rare earth elements (REEs). Samples were compared with Aksaray Neogene lacustrine occurrences which are very close to the investigated lacustrine sediments. Geochemistry of Kurttepe and Aksaray samples shows similarity. In two group samples, Th, Zr, Nb, Y and Ba are lower, Cu, Zn, Sc, Ni, V, and Y are higher contents of with respect to PAAS which can be explained as the result of lacustrine sediments derivation from more basic source than the PAAS. La/Sc, La/Co, Th/Co, Th/Sc, La/Cr ratios of Kurttepe samples are concordant with andesites and Th/Cr are concordant with basalts. Chondrite normalized of two datagroups show that REE patterns have low LREE/HREE ratios and no Eu anomalies, and different from Post Archean Australian Shale (PAAS), showing the source of two sample groups have basic - neutral in character. The samples fall within the volcanic arc basalt (VIB) and normal MORB (N-MORB) field in the discriminant plot of 2Nb-Zr/4 - Y. Samples fall in the oceanic island arc field in the plot of La/Sc vs. Ti/Zr. All geochemical data show that Elazığ Magmatics are the main magmatic unit which could give material to the lacustrine sediments.

Elazığ (Türkiye) Batısındaki Neojen Göl Sedimanların Jeokimyası: Kaynak Kayaç ve Tektonik Ortam Tayini

Anahtar kelimeler

Jeokimya; Neojen; Lakustrin Sedimanlar; Elazığ

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Özet

Elazığ batısında Karabakır Formasyonu'na ait Neojen göl ortamın jeokimyası kaynak kayaç ve tektonik ortam tayini için bu sedimanların jeokimyası kullanılmıştır. Çalışılan sedimanların temel kayaçlarını Permo-Triyas Keban Metamorfitleri, üst Kretase Elazığ Magmatitleri, orta Eosen-üst Oligosen denizel Kırkgeçit Formasyonu oluşturmaktadır. Neojen bazaltik volkanitler göl sedimanların üzerinde yer alır. KarabakırFormasyonu'nun göl yataklarını killi kireçtaşıve kireçtaşları oluşturmaktadır. Killi kireçtaşı örnekleri Kurttepe kesitinden alınmıştır veve majör, iz ve nadir toprak elementleri (NTE) analiz edilmiştir. Örnekler incelenen göl sedimanlara çok yakın olan Aksaray Neojen göl oluşumları ile karşılaştırılmıştır. Kurttepe ve Aksaray örneklerinin jeokimyası benzerlik göstermektedir. Arkean sonrası Avustralya Şeylleri (PAAS) verilerine göre iki örnek grubunda Th, Zr, Nb, Y, Ba düşük, Cu, Zn, Sc, Ni, V yüksek olması bu sedimanların kaynak kaya bileşiminin PAAS'a göre daha bazik olduğunu göstermektedir. Kurttepe örneklerinin La/Sc, La/Co, Th/Sc, Th/Co, Th/Sc, La/Cr oranları andezit bileşimi, Th/Cr basalt bileşimi ile uyumludur. İki örnek grubu verilerinin kondrite normalize diyagramları düşük LREE/HREE oranları ve Eu anomalisi göstermemektedir ve PAAS'dan farklıdır. Bu da bu örneklerin bazik-nötral bileşimde olduğunu göstermektedir. Örnekler 2Nb-Zr/4 - Y üçgen diyagramında volkanik yay bazaltı (VIB) ve normal MORB (N-MORB) alanına düşmektedir. La/Sc değerlerine karşı Ti/Zr değerlerine göre çizilen diyagramlarda örnekler okyanus adayayı alanına düşmektedir. Tüm jeokimyasal veriler Elazığ Magmatitleri'nin göl sedimanlaına malzeme veren ana magmatik birim olduğunu göstermektedir.

1. Introduction

Geochemical compositions of siliciclastic rocks provide useful information on the provenance as well as tectonic setting (Bahatia and Crooki 1986; Roser and Korsch, 1988; Dabard, 1990; McLennan et al., 1993; Armstrong-Altrin, 2015). The composition of detrital sediments is mainly controlled by the composition of the source rocks, and to a minor extent, by weathering and diagenetic processes.

During the Neogene, variable lacustrine deposits were sedimented in the eastern Turkey. The studie area is a one of these basins. Previous researches related to the studied area are based on type of sedimentary basins and tectonics (Aksoy, 1993; Üstündağ, 1996). However, the detailed geochemistry of this lacustrine deposit has not been studied. The main purpose of this paper is to evaluate the composition and the geochemistry (major, trace, and rare earth elements) of Neogene lacustrine sediments from the Karabakır Formation, in order to provide information on the provenance and to constrain the tectonic setting at the west of Elazığ. On the other hand the Neogene lacustrine basin at the Aksaray region is very close to the investigated area (Figure 1). Akkoca (2016) determined and discussed the distribution of Mg-bearing neoformed minerals and evaluated how mineralogy and element geochemistry vary according to the evolution of depositional settings in the Aksaray Basin. It will be also described the correlations of geochemical features between Aksaray and investigated Neogene Kurttepe lacustrine sediments. Thus, a larger scaled provenance analysis will be performed.

2. Geology

The lacustrine sediments are located in the western of Elazığ (Figure 1). The basement of the studied sediments is Permo-Triassic Keban Metamorphics, upper Cretaceous Elazığ Magmatics and middle Eocene
-upper Oligocene marine Kırkgeçit Formation (Figure 1; Figure 2a). The Neogene basaltic volcanics are at the top of the lacustrine sediments in the area (Üstündağ, 1996). The Quaternary alluviumsare the youngest units in this area.

Metamorphic rocks, exposed in the west and eastern part of area, are the oldest rock units, and are comprise marbles, calcophyllites, calcschists, metaconglomerates and undergone amphibolite–greenschist facies metamorphism in the eastern Taurides (Yazgan, 1987). Massive marble outcrops represent these metamorphites in the studied area.

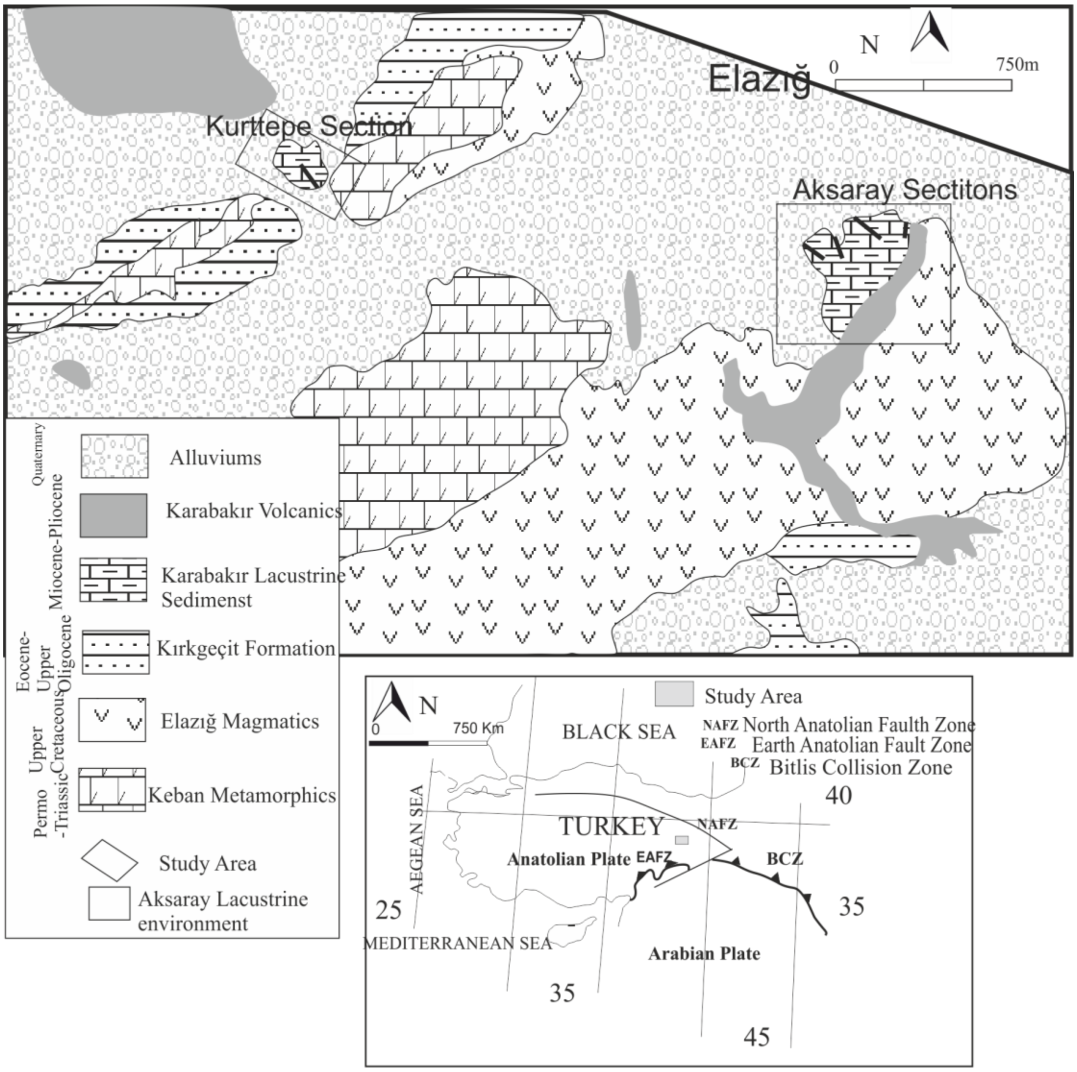

Figure 1. Detailed geological map of the study area (modified from Aksoy, 1993).

The upper Cretaceous Elazığ Magmatics, at the north-east of the basin, are represented by pyroclastic deposits and lavas with a wide compositional spectrum from basalt to andesite (Figure 1, Figure 2).

The Eocene-upper Oligocene Kırkgeçit Formation, at the north-east of the basin, consists of flysch formed mainly by sandstone, mudstone and conglomerate lenses (Figure1, Figure 2). This formation feed from Elazığ Magmatics and Keban Metamorphics.

These rocks are unconformably overlain by upper Miocene-Pliocene lacustrine sedimentary units around Kurttepe (Figure 1, Figure 2c). Pliocene lava flows and tuffites are situated at the north-west of the lacustrine unit and have basaltic to andesitic in composition (Figure 1). These units were studied around area by Kürüm et al. (2006), and named as Elazığ Volcanics.

The studied Kurttepe lacustrine deposit is composed of coarse to fine-grained clayey-limestones and limestones. The limestones are usually beige or gray (Figure 2c) .The lowest of lacustrine column contain clayey-limestones, which is about 1.5 m thick, is made of beige clayey limestones. Limestones grade continuously from those almost entirely made up ooliths and cement which contain few ooliths (Figure 2d).

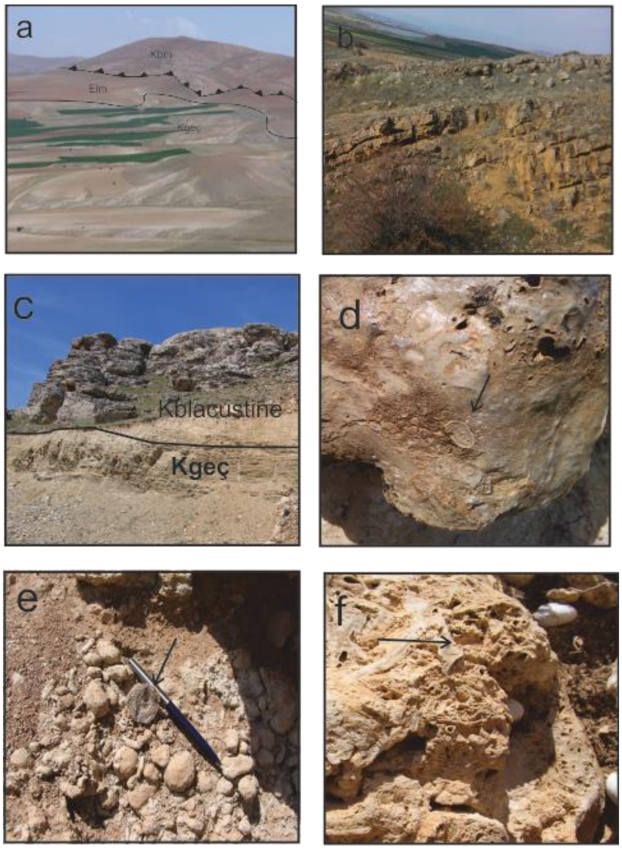

Figure 2. General view of (a) Keban Metamorphics, Elazığ Magmatics and Kırkgeçit Formation, (b) thick-bedded, sandstone, limestone alternations of Kırkgeçit Formation. (c-d-e) Pizolitic or pizolitic-oolitic limestones, pizolites that are up to 3 cm in diameter. (f) The uppermost part of the column is made of calcreteand,has karstikdissolution features.

Investigated lacustrine deposit is assigned as Late Miocene–Early Pliocene age, based on its stratigraphic position.

3. Material and Methods

Clayey-limestone samples were collected along Kurttepe section (Figure 3). Whole rock chemical analyses of 10 representative samples were made at Acme Analytical Laboratories Ltd. (Canada), using ICP AES for determination of major and trace elements and ICP-MS for REEs. Correlation coefficients were calculated from the data set for geochemical analyses Accordingly, the significance level is $\alpha = 0.05$.

In this study, 12 samples were also used from Aksaray lacustrine region for comparison (data from Akkoca, 2016).

4. Results

4.1. Geochemistry

4.1.1. Major and trace element geochemistry

In Kurttepe samples, average concentrations of SiO_2, Al_2O_3, Fe_2O_3 and MgO are ranged as 33.40 %, 8.54 %, 4.02 %, and 2.72 %, respectively (Table 1). Aksaray values are also shown in this table. According to SiO_2/Al_2O_3 vs. Fe_2O_3/K_2O ratios in Herron (1988) diagram Kurttepe and Aksaray samples are defined as Fe shale, except two shale samples (Figure 4).

The variation in the abundance of Fe, Na, Ti in samples with the Al_2O_3 content is shown in Figure 5. These elements show positive correlation with Al_2O_3. This shows that they are mainly concentrated in phyllosilicates (Figure 5 a,b,c,d). In Figure 5e, Rb displays strong positive correlation with K_2O showing a similar geochemical behavior, K_2O and Rb are probably supplied by detrital components in samples (Plank and Langmuir, 1998).

The trace elements were compared in Kurttepe, Aksaray and Post Archean Australian Shale (PAAS; data from Taylor and McLennan, 1985). Element concentrations were normalized with respect to $(E)_{Al}$ Hassan et al. (1999); Leo et al. (2002), since the concentrations of most elements in clayey rocks are well correlated with Al_2O_3 and as a result, their concentrations are diluted (Taylor and Mc Lennan, 1985).

Kurttepe and Aksaray samples have similar trace element contents. Th, Zr, U, Nb are choose initially partitioned to melts through crystallization and for

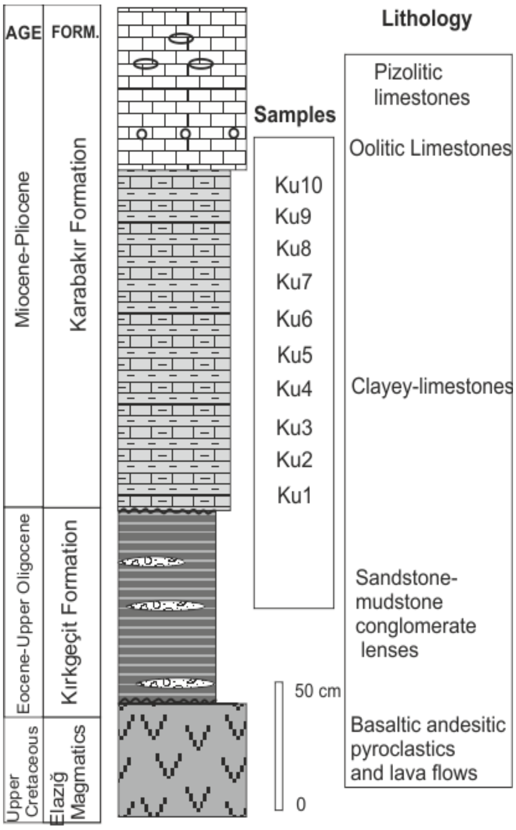

Figure 3. Kurttepe lithostratigraphic section, showing the location of samples.

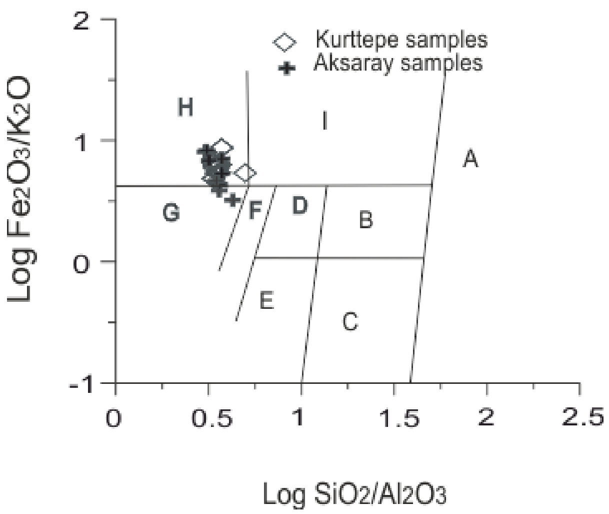

Figure 4. Chemical classification scheme for studied samples after [11]. A: quartz arenite, B: sublitharenite, C: subarkose, D: litharenite, E: arkose, F: greywacke, G: shale, H: Fe-shale, I: Fe-sand

this reason, these elements are enriched in felsic rather than mafic rocks (Feng and Kerrich, 1990). Sc is higher at the arc-related mafic rocks (Mohamed and Hassanen, 1996). Higher content of Cu, Sc, Ni, Cr, and V transition metals with respect to PAAS can be explained as the result of sediment derivation from a more basic source than the PAAS (Cullers, 1995). The Ba content of igneous rocks generally increases with increasing Si content (Ure and Berrow, 1982; Smith, 1999a). Lower Th, Zr, U, Nb, Y values compared to PAAS indicate the presence of mafic phases in the source area (Ullah et al., 2015). Lower Th, Zr, Nb, Y, Ba and, higher Cu, Zn, Sc, Ni, V contents of with respect to PAAS can be explained as the result of sediment derivation from a more basic source than the PAAS (Figure 6).

4.1.2. REE geochemistry

Concentrations of rare earth elements (REE) are listed in Table 2. Kurttepe and Aksaray samples have similar concentrations of the REEs. Total REEs show a positive correlation with SiO_2, Al_2O_3, TiO_2, K_2O, Cs, Ga, Hf, Nb, Rb, Ta, Th, Sr, negative correlation with CaO in two sample groups, which mean that REEs are associated with clay and feldspars (Table 3). Different studies (McLennan, 1989; Condie, 1991) suggest that clay and heavy minerals are the most significant host of rare earth elements in sedimentary rocks.

The negative correlations between total (REEs) and CaO are coherent with the decrease in REE content with increasing carbonate content. Positive correlations between TiO_2 - ∑REE suggest that some Ti- bearing minerals may at least partially control the distribution of certain trace elements (Gonzalez -Lopez et al., 2005).

Chondrite-normalized patterns are plotted in Figure 7. Kurttepe and Aksaray samples show very similar patterns, with LREE (La/Lu) = 4.11– 4.53, and Eu/Eu* values mean=0.82-0.78, respectively (Table 2). On the other hand, Kurttepe and Aksaray samples show different patterns relative to PAAS (Figure 7).

Table 1. Major and trace element abundances of Kurttepe samples (Ku), Aksaray lacustrine samples (AK) and Average Post-Archean Australian shale (PAAS; data from Taylor and McLennan, 1985) for comparison. A:Aksaray samples average values.

	Elements													
	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K2O	TiO_2	P_2O_5	MnO	Cr_2O_3	LOI	Total	Al_2O_3/ TiO_2
KU1	28.7	7.24	3.39	1.72	29.3	0.57	0.79	0.32	0.07	0.08	0.00	27.5	99.9	22.63
KU2	42.8	10.8	5.30	3.31	16.0	1.15	1.37	0.46	0.08	0.07	0.01	18.3	99.8	23.48
KU3	40.0	11.9	5.68	3.83	15.1	0.32	0.70	0.61	0.07	0.08	0.02	21.3	99.8	19.66
KU4	41.8	10.1	5.18	2.64	18.4	1.68	0.73	0.55	0.07	0.11	0.01	18.4	99.8	18.53
KU5	39.8	10.0	4.97	3.16	18.4	1.06	1.14	0.43	0.07	0.09	0.00	20.6	99.8	23.42
KU7	21.9	6.44	3.06	2.01	33.8	0.06	0.37	0.34	0.04	0.04	0.01	31.8	99.9	18.94
KU9	26.1	7.47	3.51	2.09	30.1	0.15	0.51	0.40	0.09	0.05	0.01	29.3	99.9	18.68
KU10	32.9	6.16	2.09	0.99	29.5	1.07	0.78	0.42	0.04	0.04	0.01	25.7	99.8	14.67
KU11	29.9	7.29	3.50	5.31	23.6	0.33	0.65	0.35	0.05	0.04	0.01	28.7	99.8	20.83
KU12	29.6	7.73	3.56	2.10	27.6	0.45	0.77	0.36	0.10	0.06	0.01	27.5	99.9	21.47
Ave.	33.4	8.54	4.02	2.72	24.2	0.68	0.78	0.42	0.07	0.07	0.01	24.9	99.8	20.14
AK.	27.7	7.23	3.38	1.69	28.0	0.07	0.57	0.37	0.05	0.04	0.01	20.8	99.9	19.29
PAAS	62.8	18.9	6.5	2.2	1.3	1.2	3.7	1.0	0.16	0.11	0.007	…	…	18.9

Table 1.Continued										
	Ba	Ni	Sc	Co	Cs	Ga	Hf	Nb	Rb	Sr
KU1	157	22	10	7.8	0.6	6.6	1.5	3.2	23.9	248.3
KU2	219	34	14	9.4	1.9	11.2	2.1	6.0	47.0	324.3
KU3	123	72	19	20.5	1.9	11.8	2.0	4.7	21.0	131.7
KU4	173	32	16	14.1	0.6	9.4	1.9	1.9	18.4	240.0
KU5	236	34	13	12.6	1.4	9.8	1.9	4.7	37.6	312.1
KU7	86	37	10	10.4	0.7	5.3	1.3	2.8	11.6	144.5
KU9	128	57	10	12.7	1.2	6.6	1.4	4.4	17.4	201.5
KU10	181	20	7	5.4	0.8	5.4	1.6	9.5	22.2	700.8
KU11	120	42	9	8.8	1.1	7.0	1.5	4.1	25.0	343.9
KU12	150	38	10	9.3	0.8	6.9	1.7	3.9	24.1	218.9
Average	157.30	38.80	11.80	11.10	1.10	8.00	1.69	4.52	24.82	286.60
AK.	67.99	51	11	11.74	1.36	7.61	1.8	5.05	22.29	231.91
PAAS	650	55	16	23	15	20	5	19	160	200

Table 1.Continued

	Ta	Th	U	V	Zr	Y	Cu	Pb	Zn	Ni	As
KU1	0.2	2.2	0.8	84	59.2	14.8	14.6	9.3	33	17.6	5.9
KU2	0.4	4.0	1.4	119	78.0	16.2	30.9	12.9	68	32.8	4.6
KU3	0.2	2.7	0.8	147	77.5	17.1	65.6	9.1	56	65.7	11.4
KU4	0.2	1.2	0.6	156	71.1	20.0	19.4	9.6	47	24.4	5.2
KU5	0.4	3.8	1.3	116	72.1	16.4	27.7	11.2	54	29.1	5.9
KU7	0.1	1.6	0.5	82	45.6	12.2	19.8	5.6	30	34.8	5.0
KU9	0.3	2.5	0.8	88	58.1	13.5	32.6	7.2	35	49.0	7.9
KU10	0.5	3.1	1.8	77	69.2	10.6	7.6	5.7	30	16.3	5.2
KU11	0.3	2.5	0.7	93	56.3	11.4	19.6	5.8	33	34.2	3.4
KU12	0.3	2.8	0.8	87	62.7	12.7	26.5	8.1	38	34.2	7.7
Average	0.29	2.64	0.95	104.90	64.98	14.49	26.43	8.45	42.40	33.81	6.22
AK.	0.4625	2.675	0.825	79.63	65.59	10.91	22.05	4.3	37.75	43.1	4.9
PAAS	---	14	3.10	150	210	30	50	20	85	55	---

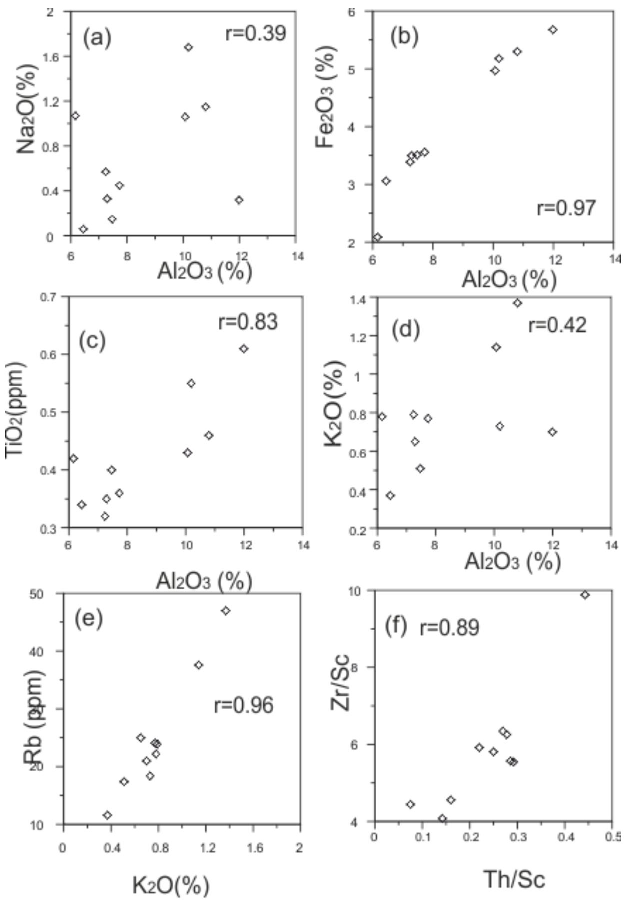

Figure 5. a.b.c.d. Correlation graphics between some major elements and Al_2O_3. e. K_2O-Rb correlation, f. Correlation graphic between Th/Sc and Zr/Sc ratios.

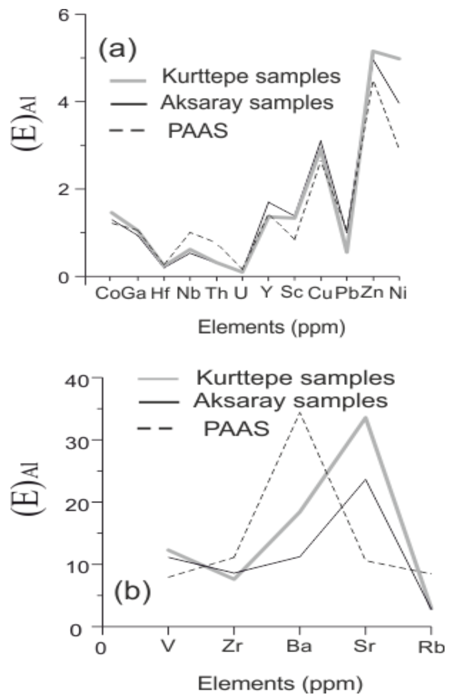

Figure 6 a.b. Trace element comparison of Kurttepe, Aksaray samples (data from Akkoca, 2016) and Post Archean Australian Shales (PAAS).$(E)_{Al}$: Al normalized element.

Table 2. Rare earth element concentrations of Kurttepe and Aksaray lacustrine samples (data from Akkoca, 2016 and Post-Archean Australian Shale (PAAS) for comparison. Eu/Eu* = $(Eu)_N / [(Sm)_N)(Gd)_N)]$. N: Chondrite normalization values are from McDonough and Sun (1995).

	KU1	KU2	KU3	KU4	KU5	KU7	KU9	KU10	KU11	KU12	Average	Aksaray (Aver.)
La	9.1	12.1	11.3	7.3	11.3	7.9	10.1	14.3	8.7	9.1	10.12	8.29
Ce	14.2	18.5	20.9	12.3	18.5	11.9	18.0	23.2	15.0	16.1	16.86	16.31
Pr	1.87	2.53	2.65	1.82	2.31	1.66	2.32	2.89	1.87	1.93	2.19	2.01
Nd	7.5	10.0	11.2	7.6	9.7	7.2	9.6	11.1	7.3	7.7	8.89	8.21
Sm	1.79	2.15	2.48	2.07	1.98	1.44	2.00	2.22	1.72	1.68	1.95	1.78
Eu	0.52	0.65	0.75	0.70	0.60	0.44	0.57	0.61	0.49	0.50	0.58	0.48
Gd	2.11	2.61	2.89	2.87	2.48	1.80	2.25	2.14	1.85	1.93	2.29	1.86
Tb	0.33	0.42	0.45	0.47	0.39	0.28	0.33	0.31	0.28	0.30	0.36	0.31
Dy	2.12	2.68	3.13	3.06	2.64	1.95	2.21	1.88	1.93	2.09	2.37	2.00
Ho	0.46	0.58	0.61	0.64	0.54	0.42	0.44	0.40	0.40	0.43	0.49	0.42
Er	1.36	1.71	1.90	1.98	1.72	1.22	1.39	1.07	1.30	1.27	1.49	1.24
Tm	0.20	0.25	0.26	0.30	0.23	0.18	0.19	0.14	0.17	0.18	0.21	0.21
Yb	1.47	1.83	1.85	2.17	1.73	1.21	1.29	1.00	1.18	1.37	1.51	1.28
Lu	0.23	0.28	0.28	0.33	0.26	0.18	0.20	0.15	0.18	0.20	0.23	0.20
(La/Lu)N	3.44	3.76	3.51	1.92	3.78	3.82	4.39	8.29	4.20	3.96	4.11	4.53
(La/Yb)N	4.58	4.89	4.51	2.49	4.83	4.83	5.79	10.57	5.45	4.91	5.28	5.88
(La/Sm)N	3.32	3.67	2.97	2.30	3.72	3.58	3.29	4.20	3.30	3.53	3.39	2.82
Eu/Eu*	0.80	0.82	0.84	0.86	0.81	0.82	0.80	0.84	0.82	0.83	0.82	0.78

Table 3. Correlation coefficients between total REE-major and trace element concentration.

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	Cr_2O_3	Ba	Ni	Sc	Co
∑REE	0.57	0.44	0.25	0.04	-0.46	0.27	0.49	0.57	0.45	0.49	0.23	0.28	0.23
	Cs	Ga	Hf	Nb	Rb	Sr	Ta	Th	U	V	W	Zr	∑REE
	0.66	0.48	0.57	0.78	0.43	0.46	0.67	0.68	0.77	0.25	0.64	0.78	1.00

4. Discussion

4.1. Provenance and tectonic setting

The composition of sediments is primarily controlled by the composition of the source rocks (Amstrong et al., 2013). Provenance studies of clastic sedimentary rocks often aim to reveal the composition and geological evolution of the sediment source areas and to constrain the tectonic setting of the depositional basin (Zaid and Gahtani, 2015).

Al_2O_3/TiO_2 ratios of most clastic sediments display the average composition of the source area. Al_2O_3/TiO_2 ratios generally increase with increasing SiO_2 content. Al_2O_3/TiO_2 ratios range from 3 to 11 for mafic rocks, 11-21 for intermediate rocks and 21-70 for felsic rocks (Hayashi et al., 1997). According to the average Al_2O_3/TiO_2 ratios Kurttepe and Aksaray samples show intermediate source rock for these samples (Table 1).

La/Sc, La/Cr, La/Co, Th/Sc, Th/Cr and Th/Co ratios are particularly sensitive to the composition of sediment sources (Taylor and McLenan, 1985). In samples, La/Sc, La/Co, Th/Sc, Th/Co, Th/Sc, La/Cr ratios are compatible with andesites, Th/Cr are concordant with basalts (Table 4).

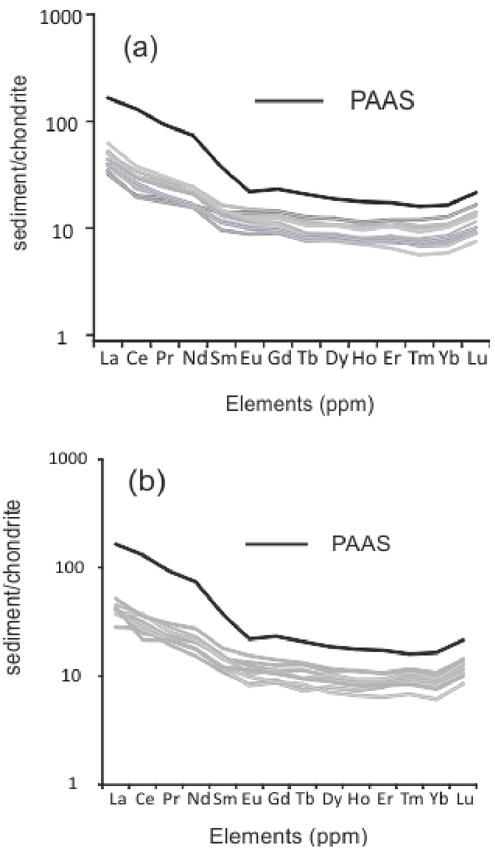

Figure 7. Multielement plots for Kurttepe (a), Aksaray (b) samples (data from Akkoca (2016)), normalized with chondrite values from Condie (1993), PAAS values also used in plots for comparison.

REE patterns have been used widely in geochemical studies of sedimentary rocks. REE are most suitable for the determination of provenance and tectonic setting. The degree of differentiation of LREE from HREE is a measure of the proportion of felsic to mafic components in the source region (Taylor and McLennan, 1985). Enrichment or depletion of LREEs and HREEs was quantified by the ratio of $(La/Yb)_N$ (N: chondrite normalized; (data from Sun and McDonough, 1989). Average $(La/Yb)_N$ is 5.28 and $(Gd/Yb)_N$ is 1.28. These values are not compatible with PAAS (Table 2), showing the source of two sample groups has basic-neutral in character. Average Eu/Eu* value is 0.82, which is also support to a mafic-neutral source rocks (McLennan et al., 1993; Cullers, 1995). These findings show the source of Kurttepe and Aksaray sample groups have similar geochemistry and basic-neutral in character.

Elazığ Magmatics, and Kırkgeçit Formation must give material investigated Kurttepe and compared Aksaray lacustrine sediments. Elazığ Magmatics consist of vertical sequence from gabbroic–dioritic plutonic rocks at the base, through basaltic–andesitic volcanics, volcaniclastics around area (Aksoy, 1993).

La/Sc, Ti/Zr ratios have been used to discriminate sediments from different tectonic settings (Bahatia and Bahrook, 1986; Floyd and Leveridge, 1987). Kurttepe and Aksaray samples fall in the volcanic arc basalt, and N-MORB volcanic arc basalt. In the plot of La/Sc vs. Ti/Zr, samples fall in the oceanic island arc field (Figure 8). Handling trace element attitude in La–Th–Sc plot (Figure 8, after Bahatia and Crook, 1986) samples are established in the field of volcanic arc basalts. The samples fall within the volcanic arc basalt (VIB) and normal MORB (N-MORB) field in the discriminant plot of 2Nb-Zr/4–Y (Figure 8). Ternary plot of Lanthanum-Thorium-Scandium (La-Th-Sc), after Bahatia and Crook (1986), also show these phenomena.

Table 4. A comparison of elemental ratios Condie (1993) of the Kurttepe and Aksaray samples

FVR: Felsic volcanic rocks, AND: Andesites, BSL: Basalts

	Kurttepe	Aksaray	FVR	AND	BSL
La/Sc	0.9	0.82	1.88	1.05	0.32
La/Cr	0.1	0.09	3.00	0.31	0.08
La/Co	1.1	0.81	5.00	0.74	0.29
Th/Sc	0.2	0.26	0.50	0.17	0.07
Th/Cr	0.0	0.03	0.80	0.05	0.02
Th/Co	0.3	0.26	1.33	0.12	0.06

Geochemical properties are concordant with stratigraphy of area. As mentioned earlier Keban Metamorphics, Elazığ Magmatics and Kırkgeçit Formation are prevalent at the basements of lacustrine sediments. Keban Metamorphics has marble and could give carbonate solutions to the lacustrine environments. The thick limestones at the upper most of unit could be evidence of these phenomena. Elazığ Magmatics are the main magmatic unit which could give material to the lacustrine sediments. Many workers studied the Elazığ Magmatics around study area (Bingöl, 1984; Michard et al., 1985; Yılmaz et al., 1993). They defined that these magmatics are typical in island arc tholeiites, and are formed in Late Cretaceous aged island-arc related to the supra-subduction zone of the southern branch of Neotethys. As will be seen from the above mentioned all investigated samples plot in fields for volcanic arc**.** In study area, Neogene basalts interrupt or at the top level of these lacustrine sediments at the Aksaray region which is the very close and conjugate of Kurttepe sediments, show that these Neogene basalts occurred after lacustrine formation. These can be supported with geochemistry. The geochemistry of Kurttepe and Aksaray sediments are not compatible with Neogene basaltic volcanics, which investigated Kürüm et al., 2006 (Figure 10b). They investigated these Neogene basalts in the study area, and defined that this basaltic unit were occurred in the within – plate basalts. For this reason, Karabakır volcanics could not be given material to the Kurttepe and Aksaray lacustrine environments.

Conclusion

Geochemical analyses of samples from Neogene lacustrine environments ensure understanding for determination of the source rock composition and tectonic setting.

1. According to SiO_2/Al_2O_3 vs. Fe_2O_3/K_2O ratios, Kurttepe and Aksaray samples are mainly defined as Fe shale.

2. Th, Zr, Nb, Y, Ba are lower, Cu, Zn, Sc, Ni, V are higher contents of with respect to PAAS, which show that investigated sediments arederivedfrom a more basic source than the PAAS.

3. According to the average Al_2O_3/TiO_2 ratios Kurttepe and Aksaray samples show intermediate source rock.

4. La/Sc, La/Co, Th/Sc, Th/Co, Th/Sc, La/Cr ratios are compatible with andesites, Th/Cr are concordant with basalts in Kurttepe samples.

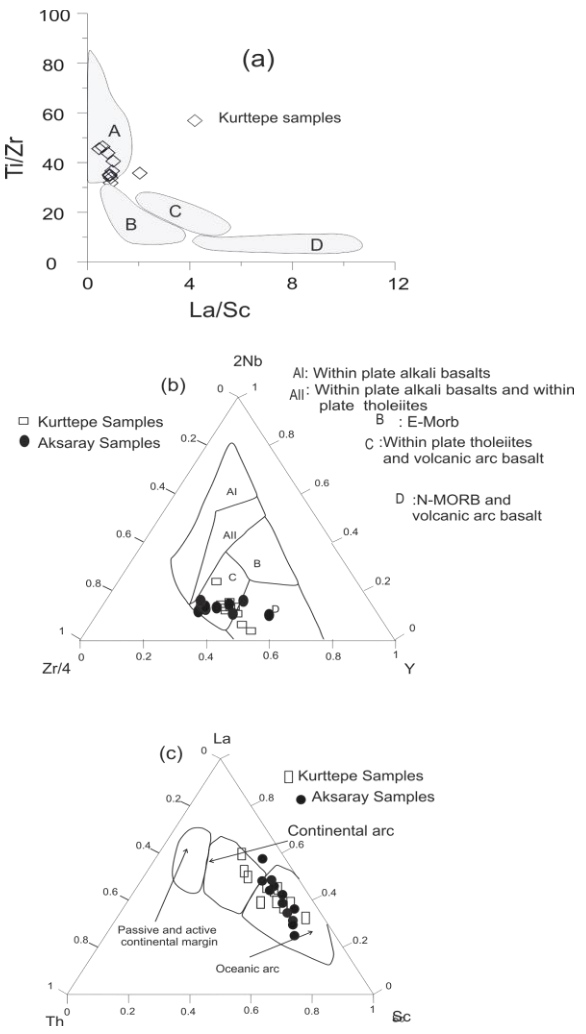

Figure 8.a. Tectono-magmatic discrimination diagrams for two sample groups (Aksaray samples, from Akkoca, 2015). b. La/Sc vs. Ti/Zr tectonic discrimination diagram of the samples. Lines represent the fields from various tectonic settings after Bahatia and Crook (1986). A: oceanic island arc; B: continental island arc; C: active continental margin; D: passive margin. b. 2Nb – Zr/4 – Y diagram after Mescede (1986). c. Ternary plot of Lanthanum-Thorium-Scandium (La-Th-Sc), after Bahatia and Crook (1986).

5. Kurttepe and Aksaray sample groups have similar REE geochemistry and basic-neutral in character.
6. La/Sc, Ti/Zr, La,Th,Sc, 6.Nb,Zr,Y compositions imply that deposition took place in within the volcanic arc basalt.

7. All geochemical data show that Elazığ Magmatics are the main magmatic unit which could give material to the Kurttepe and Aksaray lacustrine sediments. The geochemistry of these sediments is not coherent with geochemistry of Neogene basaltic volcanics. Therefore, Karabakır Volcanics could not be given material to the Kurttepe and Aksaray lake environments. Stratigraphy of the area also shows these phenomena.

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References

Akkoca, B.D. (2016). Variations in mineral and geochemical compositions of authigenic Mg-clay-bearing deposits from a Neogene Lake environment in South of Elaziğ, Karabakır Formation, Eastern Turkey. *International Journal of Scientific Engineering and Applied Science (IJSEAS).,* **2**: 3.

Aksoy, E. (1993). General geological properties of west and south of Elazığ. *Turkish Journal of Earth Sciences, TUBITAK,* **5**: 113-123 (in Turkish with English abstract).

Armstrong-Altrin J. S., Nagarajan R., Madhavaraju, J., Rosalez-Hoz L., Yong, L., Balaram, V., Cruz-Martınez, A., Avila-Ramırez, G, (2013). Geochemistry of the Jurassic and Upper source-area weathering, provenance, and tectonic setting. *C. R. Geoscience* **345**: 185–202.

Armstrong-Altrin, J.S. (2015). Evaluation of two multidimensional discrimination diagrams from beach and deep-sea sediments from the Gulf of Mexico and their application to Precambrian clastic sedimentary rocks. *International Geology Review.*, **57**: 11-12, 1446-1461.

Bahatia, M.R., Crook, K.A.W. (1986). Trace element characteristics of graywackes and tectonic setting discrimination of sedimentary basins. *Contributions to Mineralogy and Petrology.,* **92**: 181-193.

Bingöl, A.F., (1984). Geology of the Elazığ Area in the Eastern Taurus Region. In Tekeli, O., Göncüoğlu, M.C., (eds), Geology of the Taurus Belt, p. 209-217.

Condie, K.C. (1993). Chemical composition and evolution of the upper continental crust: contrasting results from surface samples and shales. *Chemical Geology* **104**: 1-37.

Condie, K.C., (1991). Another look at rare earth elements in shales: *Geochimica et Cosmochimica Acta*, **55**: 2527-2531.

Cullers, R. L. (1995). The controls on the major- and trace-element evolution of shales, siltstones and sandstones of Ordovician to Tertiary age in wet mountains region, Colorado, USA. *Chem. Geol*. **123**: 107–131.

Dabard, M.P. (1990). Lower Brioverian formations (Upper Proterozoic) of the Armorican Massif (France): Geodynamic evolution of source areas revealed by sandstone petrography and geochemistry. *Sedimentary Geology*, **69**: 45-58.

Feng, R., Kerrich, R. (1990). Geochemistry of fine grained clastic sediments in the Archaean Abitibi Greenstone Belt, Canada: Implications for provenance and tectonic setting. *Geochimica et Cosmochimica Acta.,* **54**: 1061-1081.

Floyd, P.A., Leveridge, B.E., (1987). Tectonic environment of the Devonian Gramscatho basin, south Cornwall framework mode and geochemical evidence from turbiditic sandstones. *Journal of the Geological.Society*, London, **144**: 531-542.

Gonzalez, J. M., Jurado, V., Laiz, L., Zimmermann, J., Hermosin, B., Saiz-Jimenez, C. (2005). Pectinatus portalensis sp. nov. In Validation of Publication of New Names and New Combinations Previously Effectively Published Outside the IJSEM, List no. 102. Int J Syst *Evol Microbiol.,* **55**: 547–549.

Hassan, S., Ishiga, H., Roser, B.P., Dozen, K., Naka, T., (1999). Geochemistry of Permian–Triassic shales in the Salt Range, Pakistan: implications for provenance and tectonism at the Gondwana margin. *Chemical Geology*, **158**: 293–314.

Hayashi, K.I., Fujisawa, H., Holland, H.D., Ohmoto, H., (1997). Geochemistry of 1.9 Ga sedimentary rocks from northeastern Labrador, Canada. *Geochim Cosmochim Acta.,* **61**: 4115-4137.

Herron, M. (1988). Geochemical classification of terrigenous sands and shales from core or log data*. Journal of Sedimentary Research,* **58**: 5.

Kürüm, S., Akgül, B., Erdem, E. (2006). Examples of Neogene Volcanism in Eastern Turkey: comparative petrographic, geochemical and petrologic features of Malatya-Elazığ-Tunceli Volcanics. *Journal Geological Society of India.*, **68**: 129-136

Leo, D.P., Dinelli, E., Mongelli, G., & Schiattarella, M., (2002). Geology and geochemistry of Jurassic pelagic sediments, Scisti Silicei Formation, southern Apennines, Italy. *Sedimentary Geology*, **150**: 229-246.

McLennan, S.M., (1989). "Rare earth elements in sedimentary rocks: Influence of provenance and sedimentary processes", In: Lipin B.R.., McKay G.A. (eds.), Geochemistry and Mineralogy of Rare Earth Elements. Mineralogical Society of America Reviews in Mineralogy, 169-200.

McLennan, S.M., Hemming, S., McDanniel, D.K., Hanson, G.N., (1993). "Geochemical approaches to sedimentation, provenance, and tectonics". In: Johnsson, M.J., Basu, A. (eds.). Processes Controlling the Composition of Clastic Sediments. Geological Society of America, Special Paper, 285, 21-40.

McDonough, W.F. and Sun, S.-S. (1995) The Composition of the Earth. Chemical Geology, 120, 223-253.

Meschede, M., (1986). A method of discriminating between different types of mid-ocean ridge basalts and continental tholeiites with the Nb-Zr-Y diagram: *Chemical Geology*, v. **56**: p. 207-218.

Michard, A., Whitechurch, H., Ricou, L.E., Montigny, R., Yazgan, E., (1985). Tauric Subduction (Malatya–Elazıg Province) and Its Bearing on the Tectonics of the Tethyan Realm in Turkey. In: Dixon JE, Robertson AHF (eds), The Geological Evolution of the Eastern Mediterranean. Geol Soc Spec Publ Lond, 361-373.

Mohamed, F.H., Hassanen, M.A. (1996). Geochemical evolution of arc-related mafic plutonism in the Umm Naggat district, Eastern Desert of Egypt. *Journal of African Earth Science*, **22(3)**: 269-283.

Plank, T., Langmuir, C.H. (1998). The chemical composition of subducting sediment and its consequences for the crust and mantle. Chemical Geology., **145: (3-4),** 325-394

Roser, B.P., Korsch, R.J. (1988). Provenance signatures of sandstone-mudstone suites determined using discriminant function analysis of major-element data. *Chemical Geology.*, **67**: 119-139.

Smith, K.S., (1999a). Geoavailability, in Marshall, C.P., and Fairbridge, R.W., eds., Encyclopedia of geochemistry: Kluwer Academic Publishers, Dordrecht, The Netherlands, p. 262–263.

Sun, S., McDonough, W.F., (1989). Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. In: Saunders, A.D., Norry, M.j.Eds., Magmatism in Ocean Basins, Geol. Soc. Spec. Publ., London, pp.313-345.

Taylor, S. R., McLennan, S. H., (1985). The Continental Crust: Its Composition and Evolution, Blackwell, Oxford, pp. 1-312.

Ullah, S., Khan, T. M, Khan, U., Rahman, K., Ullah, N., Ahmad T. (2015). The perception of local community about climate change and ITS impacts on their lives at tehsil timergara, districtdir (lower), khyber pakhtunkhwa Pakistan*. Asian J Agri Biol*., **3(1):** 15-22.

Ure, A.M., Berrow, M.L. (1982). The chemical constituents of soils. In: H.J.M. Bowen (Editor), Environmental Chemistry. R. Soc. Chem., Burlington House, London, pp. 94-202.

Üstündag, S., (1996). Petrographic Properties of Limestones of Karabakır Formation around Elazığ, Master thesis, Firat University Graduate School of Natural and Applied Sciences, pp. 1-39.

Yazgan, E. (1987). Geodynamics Evolution of the Southern Taurides in the Region In: O. Tekeli and M. C. Göncüoğlu (Eds.), Geology of the Taurus Belt, Int. Symp., Proceedings, 199-208.

Yılmaz, Y., Yiğitbag, E., Genç, C., (1993). Ophiolitic and Metamorphic Assemblages of Southeast Anatolia and Their Significance in the Geological Evolution of the Orogenic Belt. Tectonics, **12(5):,** 1280-1297.

Zaid, S.M., Gahtani, F.A. (2015). Provenance, diagenesis, tectonic setting and geochemistry of Hawkesbury sandstone (Middle Triassic), southern Sydney Basin, Australia. Turk J Earth Sci **24**: 72–98.