The Geochemical Variation of Trace Elements in Basrah City, South of Iraq

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Abstract: ***31 surface samples were collected from 15 sites distributed in various industrial, agricultural and residential areas in Basrah governorate to study the mineralogical and geochemical properties as well as study the grain size distribution of the recent sediments that cover the study area. The results of grain size analysis shows high percentage of sand in the western and southern part of Basrah while the northern and eastern parts composed of clays. The mineralogical study showed the predominant minerals in the area were quartz, calcite, gypsum, feldspar, dolomite, and halite while kaolinite, palygorskite, Illite, Chlorite, montmorillonite, and Montmorillonite- Chlorite were the major clay minerals that diagnosed in the study area. The geochemical study of the trace elements shows that the increasing of trace elements concentrations were in the northern and western part of the governorate due to the presence of different industries, while the geochemical study of the rare earth elements shows that the source rocks of the study area sediments was andesite rocks that derived from the igneous rocks in the north and north east of Iraq.***

1. Introduction

Basrah governorate is located in the South-Eastern part of Iraq, and its covered with the recent sediments where the current study is concerned by studying the texture and mineralogical properties as well as the geochemical variation of trace elements Ba, Co, Cr, Ni, Pb, Sr, and Zn to and Rare earth elements La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, and Y of these sediments.

The study area is located in the South-Eastern part of Iraq between longitudes (47˚ 15' - 47˚ 30') E and latitudes (30˚ 03' - 30˚ 55') N with the area 19070 Km^2 figure (1), and its representing the southern part of the shallow basin of the Mesopotamian zone, which is part of the Arabian plate [1].

The sediments of study area is a part of the Quaternary period extending from Pleistocene-Holocene Epoch which are deposited recent with clay-silt texture, and transported by Tigris, Euphrates and Shatt Al-Arab rivers beside aeolian deposits transported by wind and dust storm [2].

2. Methods

31 surface samples were collected from 15 sites distributed in various industrial, agricultural and residential areas. The samples were transferred to the laboratory, at the beginning the samples were dried overnight by using oven at about 105˚C, then the samples was mixed well and then divided into three parts the first part was crushed by agate mortar then sieved by 63 µm sieve and saved in plastic containers for mineralogical analysis, the second part of the sample was saved for the grain size analysis while the third part of the sample was saved for the chemical analysis.

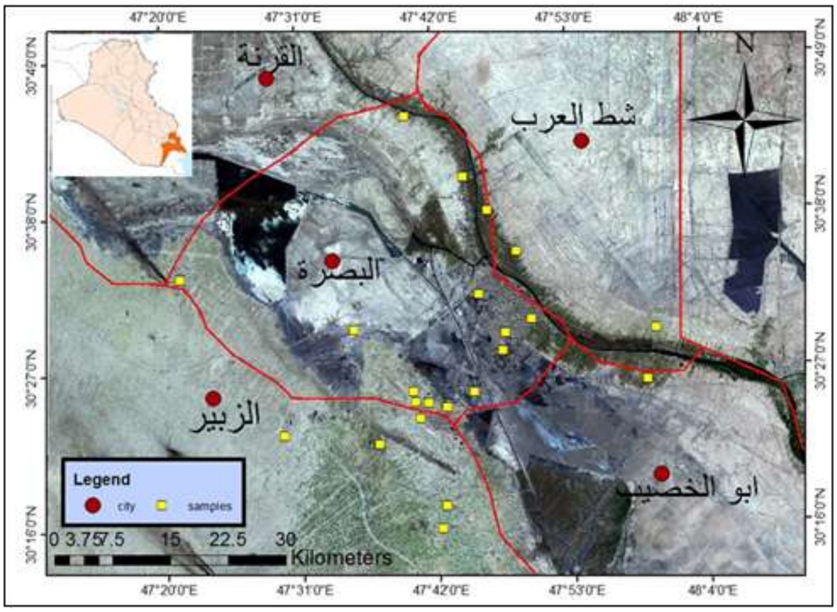

Figure 1: The study area

2.1 Grain size analysis

The grain size analysis was carried out to separate the mud from the sand by using sieve 63µm, and the hydrometer for the mud proportion where the test was carried out according to the standard [3], [4], and [5] by using (Hydrometer, 152H, France).

2.2 Mineralogy

The mineralogical study focused on the identification and diagnosis the major minerals and clay minerals by using X-Ray diffraction unit (D2 PHASER 2010 by BRUKER company). Both the bulk powder and the oriented slides were prepared according to [5], [6], [7], [8] where they were scanned in the angle range 2θ˚ between (2˚- 60˚) for non-clay minerals and between (5˚- 30˚) for clay minerals. The oriented samples was analyzed in different phases (non-treated samples, samples treated by ethylene glycol for 24 hours, and samples treated with heated 550˚C for two hours). The semi-quantitative method was used to estimate the approximate percentages of clay minerals by calculating the area under the reflection curve for each clay mineral.

2.3 Geochemistry

The geochemical study focused on finding the concentrations of trace elements (Ba, Co, Cr, Ni, Pb, Sr, and Zn) and rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, and Y) by using Inductivity Coupled Plasma Mass Spectrometry (ICP-MS).

3. Results and Discussion

3.1 Grain size analysis

Table (1), figure (2) shows the result of the grain size analysis in the current study and their respective designation according to [5], where the results show high percentage of sand in the western and south-western areas of Basrah governorate and its texture range between fine sand, loamy fine sand and sandy loam. While the northern, north-eastern and for north-western areas of Basrah governorate that affected by Shatt al-Arab were clay soils, and figure (3) shows the texture of the deposits of study area according to [5].

Table 1: Grain size analysis and texture for deposits in study area

Sample number	*sand weight*	*silt weight*	*clay weight*	*texture*
Ns1	85	7	8	Loamy Fine Sand
Ns2	78	13	10	Sandy loam
Ns3	76	13	10	Sandy Loam
Ns4	83	13	5	Loamy Fine Sand
Ns5	95	4	2	Fine Sand
Ns6	99	0.7	0.6	Fine Sand
Ns7	89	6	5	Fine Sand
Ns8	94	3	2	Fine Sand
Ns9	81	89	10	Loamy Fine Sand
Ns10	3	16	82	Clay
Ns11	3	2	95	Clay
Ns12	99.9	0.03	0.02	Fine Sand
Ns13	4	21	75	Clay
Ns14	10	38	52	Clay
Ns15	6.4	16.84	76.75	Clay
Ns16	16	32	52	Clay
Ns17	24	24	52	Clay
Ns18	81	10	9	Loamy Fine Sand
Ns19	90	6	4	Fine Sand
Ns20	91	3	6	Fine Sand
Ns21	94	3	3	Fine Sand
Ns22	75	14	11	Sandy Loam

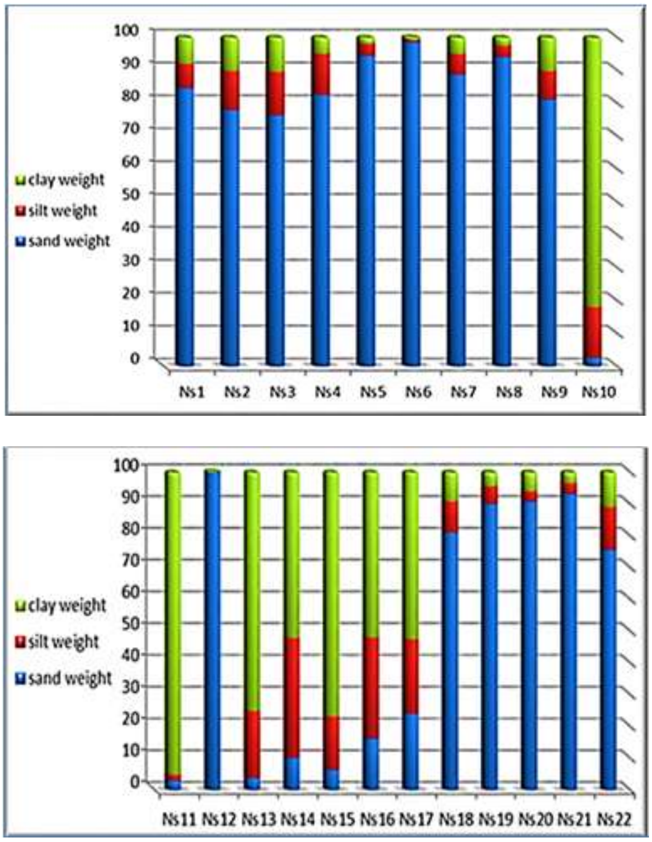

Figure 2: The distribution of sand, silt, clay of deposits of study area

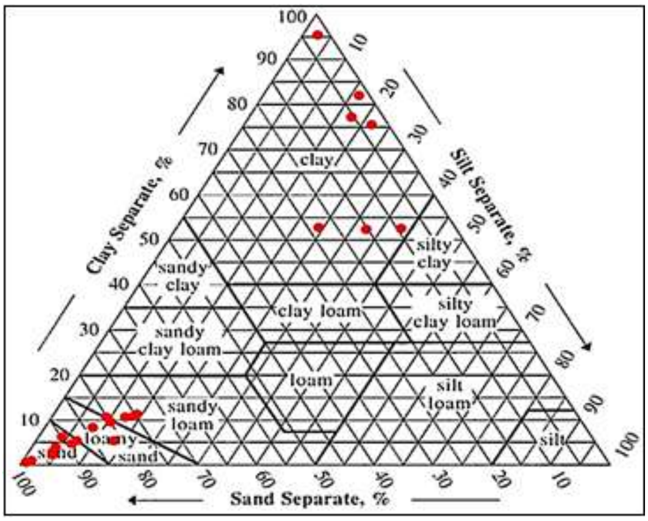

Figure 3: Texture of deposits of study area [5]

3.2 Mineralogy

The figure (4) refers to the X-Ray charts of the bulk samples of the study area where the charts shows that the major

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minerals are represented by calcite, quartz, gypsum, feldspar, dolomite , and halite.While figure (5) refers to the X-Ray charts of the clay patterns which represented by kaolinite, montmorillonite, chlorite, illite, palygorskite, montmorillonite-chlorite irregular mixed layers.

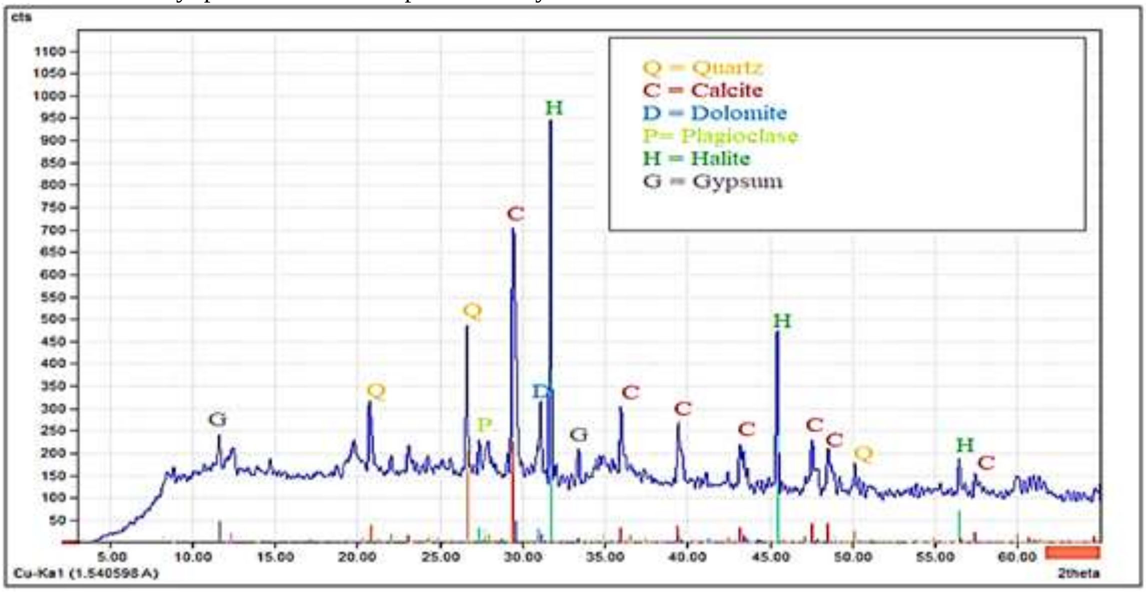

Figure 4: XRD charts for bulk sample in the study area

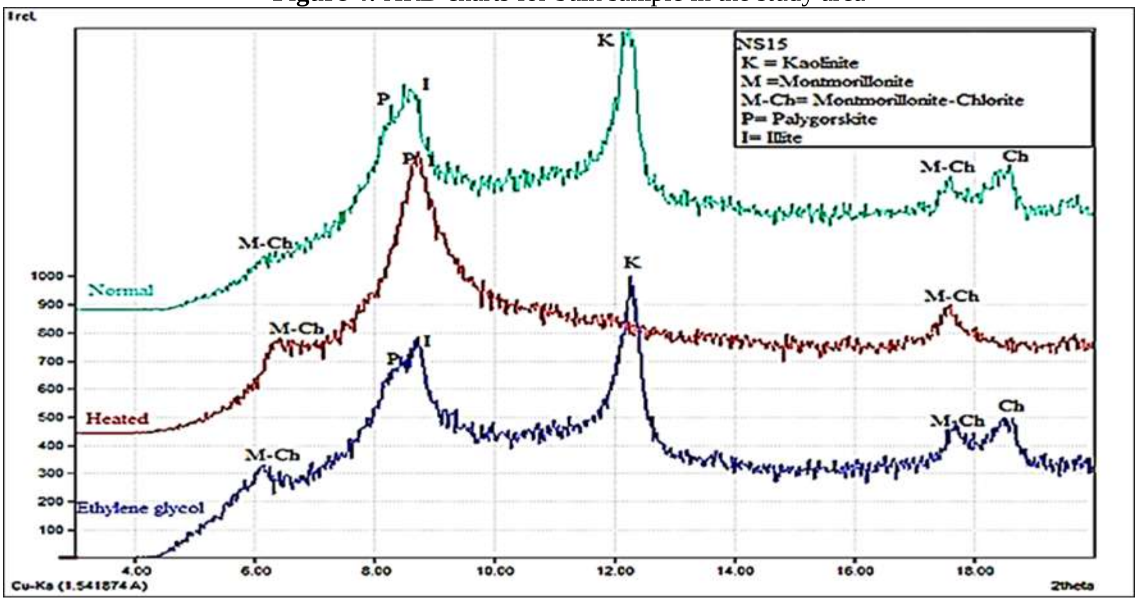

Figure 5: XRD charts of clay minerals for sample of the study area

3.3 Geochemistry

3.3.1 Geochemistry of trace elements

Trace elements define as the elements which have specific gravity greater than 5 gm/cm^3 and atomic weight greater than 40 [9], and their concentrations are scare and insufficient to form their own independent minerals, but its inter within the composition of minerals by adsorption on the surfaces of these minerals or by replacement due to the convergence of its radius and charge with the major elements [10]. Trace elements are toxic when an increase in their natural concentrations occurs, where the anthropogenic factors such as mining, smelting, fertilizers, pesticides, and municipal domestic wastes as well as the natural factors such as erosion and weathering of rocks causes increasing in the concentrations of trace elements [11].

Table (2), and figure (6) represented the distribution of trace elements (Ba, Co, Cr, Ni, Pb, Sr, and Zn) in different locations of Basrah governorate where the concentrations of these elements ranged between Ba (159.5 – 4528) ppm, Co (3 – 44) ppm, Cr (50 – 717) ppm, Ni (14 – 206) ppm, Pb (7 – 759) ppm, Sr (182.5 – 1260) ppm, and Zn (21 – 207) ppm respectively. The increasing of these elements concentrations seem to be obvious in the northern and western parts of the governorate due to the presence of the different industries such as Hartha power plant in the north, and oil well drilling and oil extractions in Rumela oil field in the west.

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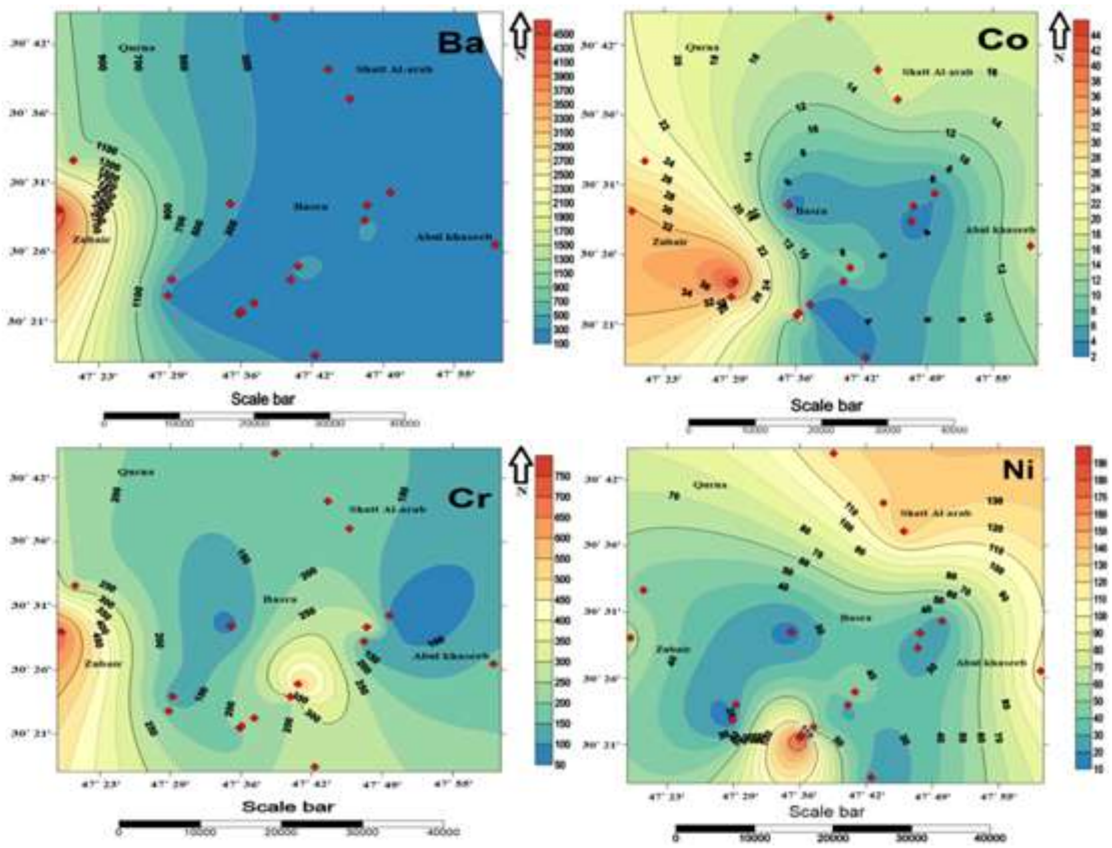
Table 2: The concentrations of trace elements (ppm) in the study area

Samples	*The concentrations of trace elements (ppm)*						
	Ba	*Co*	*Cr*	*Ni*	*Pb*	*Sr*	*Zn*
Ns3	316	10	550	53	40	508	64
Ns4	278	5	250	25	62	1195	42
Ns6	264	4	290	22	21	190.5	26
Ns9	309	3	100	23	28	228	48
Ns10	159.5	17	170	120	17	453	71
Ns12	274	4	50	23	163	338	121
Ns14	181	17	180	137	9	626	67
Ns15	202	16	160	125	28	423	79
Ns16	227	16	200	126	36	574	120
Ns17A	322	3	80	14	14	191.5	21
Ns17B	245	9	160	64	8	689	38
NS17C	300	5	140	50	10	497	34
NS17D	257	13	170	98	13	754	66
NS19	211	4	320	27	11	253	28
NS20A	203	3	230	56	35	182.5	23
NS20B	230	8	178	181	68	802	96
NS20C	200	3	122	81	32	658	50
NS20D	275	23	275	206	286	460.1	104
NS20E	164	14	217	149	44	543.5	71
NS21A	296	28	190	14	7	390	27
NS21B	319	44	123	23	9	250.5	21
NS22A	1265	25	260	46	590	975	73
NS22B	4528	33	717	67	759	1260	207
Range	159.5-4528	3-44	50-717	14-206	7-759	182.5-1260	21-207
Average	479.37	13.35	223.13	75.22	99.57	540.94	65.09



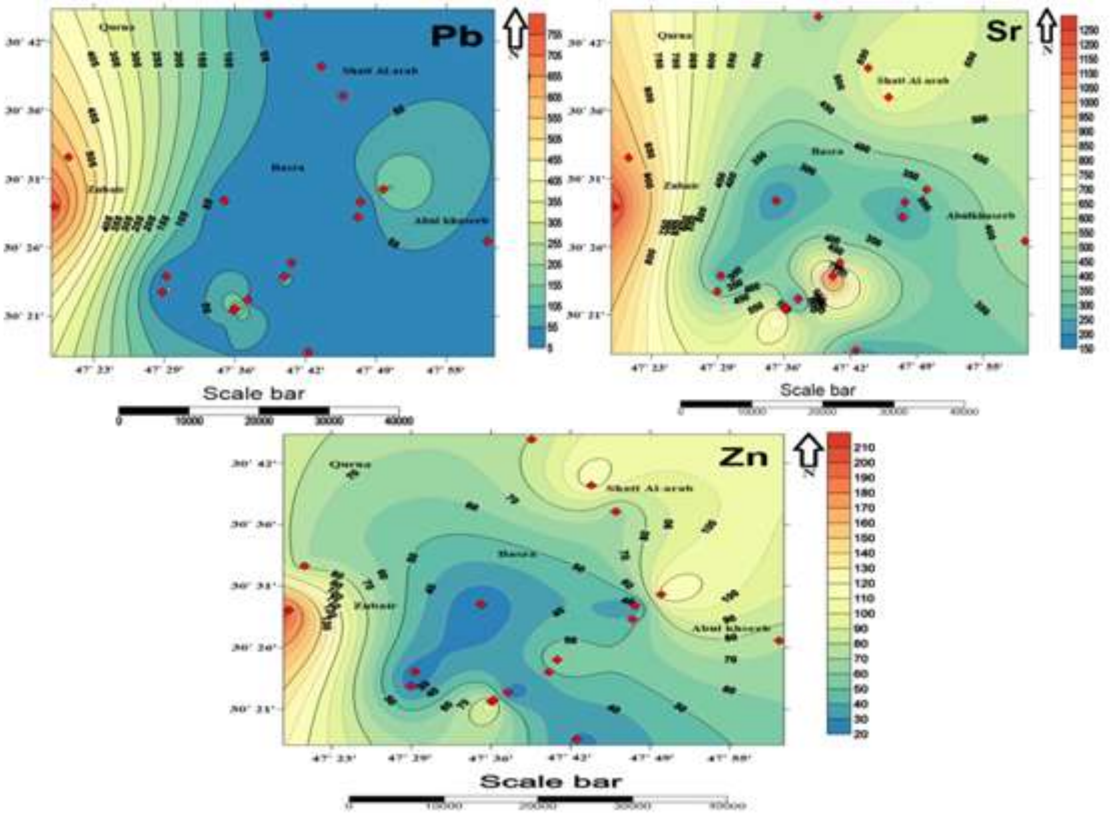


Figure 6: The distribution of trace elements in the study area

3.3.2 Geochemistry of rare earth elements

The current study is concerned with the rare earth elements in the surface recent sediments in Basrah governorate, which gives a clear image of the origin of the source rocks of the studied sediments, as they were not affected by the modification processes of the mother rocks [12], and this was done by representing the elements and putting them in spatial patterns, where they were normalized to the chondrite-Cl table (3), then the normalized values were draw on the semi-logarithmic diagram where the X-Axis represent the rare earth element ranged due to these atomic numbers and the logarithmic Y-Axis representing the normalized values, figure (7).

Figure (8) represent the distribution curve of rare earth elements in the current study comparative with the distribution curves of the rare earth elements in the different igneous rocks and its noted the similarity with the intermediate igneous rocks (andesite) in the first class and the mafic igneous rocks (basalt) in the second class, that refers to the intermediate and mafic source of the sediments that derived from the igneous rocks in the north and north east of Iraq.

Table 3: The concentrations of rare earth elements normalized to the chondrites rocks in the current study

samples	*The concentrations of REE in the study area (ppm)*													
	La	*Ce*	*Pr*	*Nd*	*Sm*	*Eu*	*Gd*	*Tb*	*Dy*	*Ho*	*Er*	*Tm*	*Yb*	*Lu*
Ns3	29.155	21.108	18.759	14.346	8.701	6.552	5.556	5	5.092	3.878	4.498	3.933	5.363	4.724
Ns4	21.526	14.734	13.504	10.127	6.667	4.368	4.150	4.138	3.123	3.173	2.530	2.247	2.863	2.887
Ns6	22.071	15.674	13.650	9.705	6.667	4.368	4.216	3.276	2.835	2.233	2.651	2.528	3.185	3.150
Ns9	19.619	13.375	11.533	8.158	5.974	3.908	3.660	3.103	2.730	2.585	2.209	1.685	2.621	2.887
Ns10	41.417	29.781	24.307	19.269	13.636	8.046	8.529	7.759	6.982	5.875	5.301	6.180	5.645	5.249
Ns12	14.714	9.195	9.197	6.751	4.156	3.218	3.170	2.241	2.073	2.703	2.209	1.966	2.661	2.362
Ns14	40.872	30.721	24.745	19.269	11.861	8.161	9.020	7.069	6.640	6.110	5.703	5.899	6.008	5.774
Ns15	39.237	28.527	23.358	17.581	11.948	8.276	8.725	7.241	6.588	5.993	5.823	5.618	4.919	4.724
Ns16	40.599	29.363	24.818	18.284	12.814	7.701	8.039	7.586	7.192	5.405	5.823	5.899	5.323	3.937
Ns17A	17.166	11.285	10.584	7.736	5.195	4.023	3.856	3.103	2.913	2.468	2.410	2.247	2.823	2.362
Ns17B	22.071	16.196	13.066	10.830	7.965	5.172	4.510	4.828	3.596	3.173	3.092	3.371	3.105	3.675
NS17C	19.074	13.898	12.190	9.705	7.100	3.218	3.889	3.276	3.675	3.055	2.530	2.528	3.266	2.625
NS17D	32.425	23.615	18.394	15.190	9.264	5.862	6.340	5.172	5.223	4.818	4.297	3.933	4.032	4.724
NS19	21.526	15.152	12.774	9.845	6.277	3.908	3.497	3.448	3.228	3.173	2.972	1.966	3.065	2.625
NS20A	22.071	15.256	12.774	9.142	4.848	4.483	3.693	2.931	3.123	2.585	3.012	2.247	2.742	3.150
NS20B	21.798	14.629	12.628	9.423	4.935	4.138	3.922	3.276	3.097	3.055	3.012	2.247	2.661	2.887
NS20C	22.343	15.361	12.774	9.423	4.892	4.483	3.725	3.103	3.097	2.703	3.052	2.247	2.581	2.887
NS20D	22.071	15.361	12.555	9.142	4.892	4.023	3.954	2.931	3.123	2.350	2.972	2.247	2.621	2.887
NS20E	22.071	15.256	12.774	9.142	4.848	4.138	3.693	3.276	3.071	2.468	3.012	2.247	2.419	3.150

NS21A	20.708	14.107	12.701	9.705	5.671	4.943	5.654	3.103	3.202	3.525	2.811	2.809	3.629	2.625
NS21B	19.891	14.316	12.774	9.423	5.758	5.172	5.654	2.759	3.150	1.175	3.614	8.427	3.629	2.625
NS22A	27.248	20.063	17.445	11.533	7.792	4.368	5.098	4.138	3.360	2.820	3.373	2.809	2.863	2.887
NS22B	28.065	20.481	17.518	11.955	7.879	4.598	5.196	3.793	3.307	3.173	3.213	3.371	2.984	3.150
Range	14.71 - 41.42	9.20 - 30.72	9.20 - 24.82	6.75 - 19.27	4.15 - 13.64	3.22 - 8.28	3.17 - 9.02	2.24 - 7.76	2.07 - 7.19	1.18 - 6.11	2.21 - 5.82	1.69 - 11.24	2.42 - 6.01	2.36 - 5.77
Average	25.554	18.150	15.427	11.551	7.380	5.092	5.119	4.198	3.931	3.413	3.483	3.420	3.522	3.389

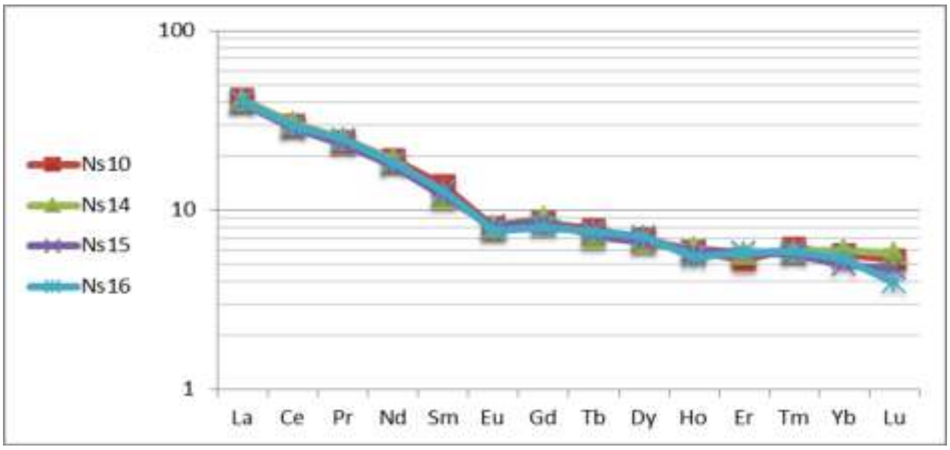


Figure 7: The rare earth elements normalized curves of selected samples of the study area

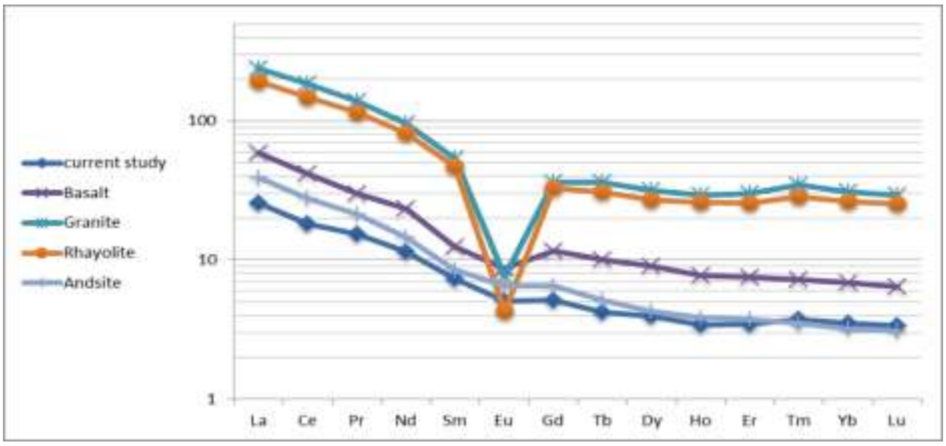


Figure 8: Comparison of the rates of REE in the current study with the rates of REE in selected igneous rocks

4. Conclusion

1) The deposits of the study area are considered as recent sediments composed from high percentage of sand and silt and low proportion of clay in the western and southern part of Basrah while the northern and eastern part are mainly component from clays.
2) calcite, quartz, gypsum, feldspar, dolomite, and halite are the major minerals that diagnosed by the mineralogical study, while kaolinite, palygorskite, illite, chlorite, montmorillonite, montmorillonite-chlorite irregular mixed layers are the major clay minerals that diagnosed in the study area.
3) The concentrations of trace elements increasing in the samples at the northern and western part of the governorate was due to the presence of different industries.
4) The distribution patterns of rare earth elements of the sediments shows match with standard samples of the upper continental crust (UCC) which its mainly consist of andesite rock.

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