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Geochemical And Mineralogical Studies Of Sedimentary Alluviums - A Case Study In The City Of Omidiyeh In The Southwest Of Iran.

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Abstract

Alluvial fans are cone-shaped deposits that are known to be important deposits of minerals and water resources. An accurate knowledge of alluvial deposits not only provides access to many natural resources, but also prevents various environmental risks, including the transfer of various toxic elements. To date, many methods have been introduced for the investigation of alluvial deposits, but this study presents for the first time geochemical methods that can significantly reduce costs and investigation time in areas associated with alluvial deposits.
This study was carried out in the southwest of Iran and near the city of Omidiye on 120 sediment samples from various alluvial conifers. In this study, the samples collected through petrographic and geochemical studies were carefully analyzed, and in addition to determining the major and minor elements in these samples, the primary origin of the sediments, the primary tectonic position of these sediments, and the nature of the constituents were also determined for the first time using geochemical data. In addition to the geochemical investigations, detailed hydrochemical studies were carried out to determine the relationship between the properties of the groundwater and the type of sediments on the surface. These studies can be seen as a model for similar studies around the world.

Keywords: *Alluvial fans, Geochemical methods, Sediment samples, Petrographic studies, Hydrochemical studies*

Introduction

Alluvial cones are conical or funnel-shaped sediments that are formed on the outskirts of mountains, and as we go from the mountains to the plain, their thickness decreases and their width increases (Mazzorana et al., 2020; Tavanaei et al., 2020).
From an economic point of view, the identification of alluvial cone sediments can be of particular importance (Bowman, 2019). For example, alluvial cone sediments can be the center of groundwater accumulation, and most of the underground water reservoirs in the sedimentary basin are fed by the water entering the alluvial

cone sediments (Zhang et al., 2019). Also, most of the gold in the world is extracted from ancient alluvial cone sediments in South Africa, which are left in placer form (Ahmad et al., 2020).

At the same time, a large amount of placer uranium is extracted from ancient igneous sediments in the sedimentary basins of South Africa. It is a geological, geochemical, and morphotectonic study of alluvial cones in southwestern Iran and near Omidiye City. The results of this research will undoubtedly contribute significantly to understanding the sedimentary environment and will provide a clear perspective for environmental, mineral, agricultural, and urban risk studies in other parts of the world.

Geological location

The studied area is in the southwest of Iran, in Khuzestan Province, and 5 kilometers southeast of Omidiyeh, with geographical coordinates of 49 degrees, 43 minutes, and 57 seconds to 49 degrees, 45 minutes, and 3 seconds east longitude, and 30 degrees, 45 minutes, and 7 seconds to 30 degrees And it is located 43 minutes and 25 seconds north latitude from the equator. The studied cinder cone (Omidiye cinder cone) is a very large and typical cinder cone with a length of more than 25 km and a width of 10 km (Figure 1).

Research Methodology

In order to carry out this research, after the office studies (including the study of numerous articles and books), preliminary geological studies of the studied area were carried out, including tectonic and petrological studies. After knowing all the geological features of the area, random sampling was done in compliance with all sampling standards. In this research phase, 120 soil samples from different parts of alluvial cones in the area (from the bottom of the waterway) were considered.

In collecting these soil samples, it was tried to collect samples from the upstream (proximal), middle (medial), and distal (distal) parts of the alluvium to be a complete representation of the geological and environmental characteristics of the region. The samples collected for mineralogical and geochemical studies were sent to the geochemical laboratories of the Geological Organization of Iran after grading and recording the primary sedimentary characteristics. In these laboratories, oxides, minerals, and rare earth elements were determined with the help of XRD, XRF, and ICP Mass devices. In addition, four samples of underground water in the area were collected to check the quality of underground water in this area and were analyzed and investigated by the Geological Organization of Iran.

Discussion and review

In this section, first, the petrography results are examined, then the geochemical results, and finally, the interpretation of the relevant results is discussed.

Petrographic studies

Petrographic studies provide special information about the sedimentary properties, origin, components, and other sedimentary properties of the studied samples (Pourmorad and Mohanty, 2022). The petrographic study of the studied samples according to (Figure 2) shows that the main constituents of these sediments include rock fragments (chert, lime, sand, and igneous rock fragments), with an average of 83% in siliceous sediments of litho-arenite petrofacies. The mentioned sediments in the studied area show that the grains are well-to-moderately well-rounded and have a calcareous matrix (Figure 2-A).

These sediments in the top part of the alluvial fan have relatively good and semi-angular grains (Figure 2-B). These sediments contain semi-angular to semi-rounded constituent particles and point, linear, and convex-concave contacts (Figures 2-C, D). In addition, potassium feldspar is more abundant than plagioclase in the mentioned samples. Based on microscopic evidence, feldspars are semi-weathered or weathered in the studied areas (Figure 2-E).

Based on the percentage of the main constituents in all the studied samples (quartz, feldspar, and crushed stone), these samples are included in the range of lith-arnite in the classification table of Folk (1980) (Figure 3).

Geochemical studies

To carry out these studies, 120 samples (in 2 study sections) were collected from the Omidiye region and subjected to mineralogical (XRD), elemental (XRF), and mass spectrometry (ICP-MS) analyses in the Geological Laboratory of Iran. These 4 samples of water from agricultural wells in the region have been subjected to chemical and physical analysis in order to determine its elements and quality and its effect on agricultural lands and crops, as well as hydrochemical studies in these areas.

Oxides

One of the most important elements studied in the samples is oxide. The results of the analysis of the samples in the Omidiye region show that according to the studies conducted, the most abundant oxides in this region are calcium oxide (CaO) and silica oxide (Sio2), as well as the lowest oxides in These regions are Na2O, P2O5, SrO, TiO2, and K2O oxides. The results of the study of the analysis results of these samples in the study area are according to the table (Table 1 and Figure 4).

Secondary elements

The results of the study of secondary elements in the studied areas show that the most abundant secondary element in the studied area is titanium (Ti). The average concentration of this element in the study area is 1451 ppm. After the titanium element, other elements in terms of ppm include Zr (72.8 ppm), V (45.6 ppm), Ce (21.2 ppm), and La (12.8 ppm), respectively (Figure 5).

Rare earth elements

The most abundant rare earth elements in the studied area include Ce with an average of 21.12 ppm, followed by La with an average of 12.4 ppm, Y with an average of 9.11 ppm, Nd with an average of 9.3 ppm, Sc with an average of 4.7 ppm, Pr with 2.76 ppm, Sm with an average of 2.06 ppm, Gd with an average of 1.8 ppm, Dg with an average of 1.56 ppm (Figure 6). One of the most important methods of geochemical studies is the elemental comparison between different parts of a region in terms of the abundance of available oxides (Abu et al, 2020). In fact, the abundance of different elements in each environment indicates the conditions of formation and the type of environment that forms it (Oreshkina et al, 2020).

In the studied area, the most abundant oxides and elements are Cao and SiO2. This can indicate that the sedimentary maturity in the region is uniform (Sahraeyan and Bahrami, 2016). The changes in calcium oxide in the region have almost similar trends compared to silicon oxide, by comparing the table in It should be noted that in addition to the abundance of calcium oxide in the region, the trend of changes in silicon oxide is opposite to the trend of changes in calcium oxide in some areas, and the reason for these changes can be due to the presence of small stones in these sediments. They cause an increase in the percentage of CaO and a relative decrease in SiO2 (Abu et al, 2018).

Studying the main elements based on the aluminum scale

Aluminum is usually a stable element in nature and often increases in wet weather and decreases in dry weather (Pourmorad et al, 2021). In fact, aluminum oxide is considered a constant factor during diagenesis, weathering, and metamorphism. is taken (Smirnov et al, 2019). Therefore, this factor is used as a scale in studies of the main elements in detrital sediments (Sahraeyan and Bahrami, 2016). In the studied area, aluminum oxide shows a positive trend with Fe2O3, K2O, MgO, and TiO2 oxides and to some extent with SiO2 and a negative correlation with CaO oxide (Figure 7).

Examining the changes of Tio2 with AL2O3 shows that these two oxides have a positive trend toward each other (Figure 8-A). The concentration of the titanium element is higher in phyllosilicates due to the lack of mobility and movement during sedimentation processes compared to other elements. It is a good indicator for source rock interpretation (Sharma et al, 2020). The mutual increase of AL2O3 with Tio2 can indicate the association of Tio2 with phyllosilicates in these areas (Pourmorad et al, 2022). In addition, the examination of the changes of titanium oxide with V and Cr elements also shows a positive relationship between this oxide and the mentioned elements (Figure 8-B, C). In addition, the correlation of Cr and V with Tio2 oxide indicates the presence of heavy minerals in these areas because Cr and V are associated with iron and titanium in heavy minerals (Al-Hashim and Corcoran, 2020).

Geochemical classification of sandstones based on the Herron index (1988)

The graph of log (Fe2O3/K2O) versus log (SiO2/K2O) is used to classify sandstones (Herron, 1988)). The location of the data related to the sections studied (from the sandstone samples taken from the Aghajari formations and the Lehbari section of the mentioned areas) This graph shows that in the studied area, most of the samples are within the range of litho-arneitic to Iron-bearing sands are placed in iron-bearing shales (Figure 9).

Geochemical classification of sandstones based on the index of Petty John et al. (1987):

The graph of log (Na_2O/K_2O) versus log (SiO_2/Al_2o_3), which is based on chemical maturity indices, are used to classify clastic sandstones (Pettijohn et al, 1987). Drawing the results of the analysis of the main factor on (Figure 10). It shows that most of the sandstone samples have litho-arnite composition, and these results also agree with the petrographic data.

Determining the geological position of sediments

Determining the tectonic position of the sediments in the study area according to Bhatia's diagram (Bhatia, 1986) shows that the samples in this area are more inclined toward the continental arc islands and the active continental margin (Figure 11). The reason for the displacement of the samples compared to the ranges determined by Bhatia (Bhatia, 1986) can be the presence of Fe_2O_3 and MgO oxides in the network of carbonate pebbles in the sand samples studied (Heidari and Raheb, 2020; Pourmorad et al., 2022). The data obtained from mineralogical studies show that violet chlorite is the most abundant clay mineral in the studied deposits, especially in this region. Calcite, quartz, feldspar, and dolomite are among the non-clay minerals found in these deposits, and in the studied area, besides these minerals, gypsum is observed as another non-clay mineral (Table 2). According to the hydrochemical studies of the underground waters of the region, some elements such as CL, NI, Ca, and Mgo are above the permissible limits, the CL and NI elements are probably caused by oil pollution, and the calcium and magnesium elements are probably caused by the geological formations in the area (Table 3). The tests and analyses of the deep well water show that there is no problem in terms of microbial contamination, but only in terms of the presence of dissolved salts and ions; specifically, the amount of sulfates, calcium, and magnesium in the wells exceeds the standard limit. It is such that the amount of sulfate and magnesium is more than 250 and 30 mg/liter, respectively, and the presence of calcium and magnesium elements in addition to the hardness of the water is due to the density of the surface texture of the soil and as a result of its lack of permeability. Also, the presence of some heavy elements such as chromium, which shows a concentration higher than the standard, and the high concentration of some compounds compared to the amount recommended in the standards, show that the water of the wells in the studied area is contaminated due to improper discharge of industrial wastewater and agricultural toxins, and the use of Pesticides and poisons containing heavy metals in agricultural lands, the presence of large and small industries as well as oil and gas sources, the presence of main and secondary roads with heavy traffic due to incomplete fuel causing the release of heavy metals are among the most important factors that pollute deep waters.

Conclusion

The conducted studies provide several results that can be used as a study model for similar studies around the world. The most important results obtained from this research include the following.

- The petrographic studies show that the Aghajari formation, with its dominant sandstone lithology in the upper reaches of the studied alluvial fan, can be one of the main sources of these sediments. According to these studies, the main constituents of the studied sediments include quartz, feldspar, and Rubble stone.
- Based on geochemical studies, the most abundant oxides in the studied samples include CaO, SiO_2, and MgO.
- The most abundant rare earth elements in the studied samples include Nd, Y, La, and Ce, respectively. In addition, the most abundant heavy metals include Cd, Cu, Pb, and Zn, respectively.
- Geochemical studies with the help of the aluminum oxide index show that this oxide shows a positive trend with Fe_2O_3, K_2O, MgO, and TiO_2 oxides and, to some extent, with SiO_2, and a negative correlation with CaO oxide. The mutual increase of AL_2O_3 with Tio_2 can indicate the association of Tio_2 with phyllosilicates in these areas. In addition, the correlation of Cr and V with TiO_2 oxide indicates the presence of heavy minerals in these areas because Cr and V are associated with iron and titanium in heavy minerals.
- The geochemical classification of sandstones based on the indices of Herron (1988) and Petty John et al. (1987) shows that in the studied area, most of the samples are in the range of lite arenites to iron-bearing sands and iron-bearing shales. they take These results also agree with the petrographic data.
- Determining the tectonic position of the sediments in the study area according to Bhatia's diagram (Bhatia, 1986) shows that the samples from this area are more inclined toward the continental arc islands and the active continental margin. The reason for the displacement of the samples compared to the ranges determined by Bhatia (Bhatia, 1986) can be the presence of Fe_2O_3 and MgO oxides in the network of carbonated pebbles in the sand samples.

Mineralogical studies show that violet chlorite is the most abundant clay mineral found in the studied deposits, especially in this region.

- Based on the hydrochemical studies of the underground waters of the region, some elements such as Cl, NI, Ca, and Mgo are above the permissible limits; the CL, and NI elements are probably caused by oil pollution, and the calcium and magnesium elements are probably caused by the geological formations in the area.

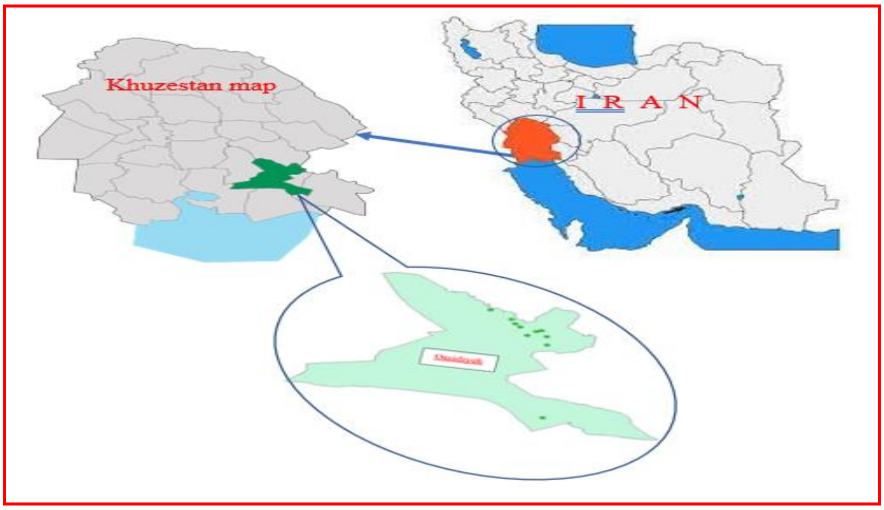

Figure 1) - Geographical location of the studied area

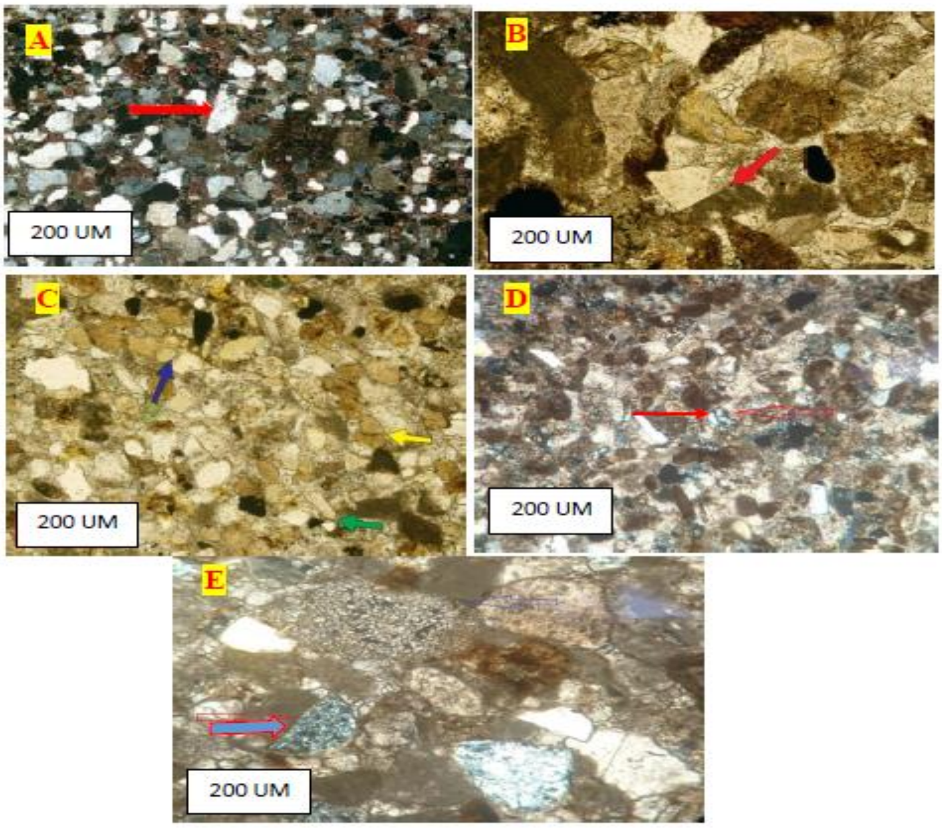

Figure 2)- Microscopic images of the composition of particles and sedimentary rocks in the upstream formations of the study area., A) Coarse particles in coarse sandstones with semi-angular to rounded grains and semi-rounded grains with good to medium sphericity., (B) Convex and concave point contact of gravels and small stones in Bakhtiari Formation., (C) point contacts (green arrow), linear (blue arrow) and convex and concave (yellow arrow) contacts in litharnite type sandstone in Aghajari Formation., (D) semi-angular to semi-rounded sand grains with moderate melting and containing polycrystalline quartz (red arrow) in Gachsaran Formation., E) chert (red arrow) and calcite cement (blue arrow) along with quartzes with direct wave extinction in Aghajari Formation.

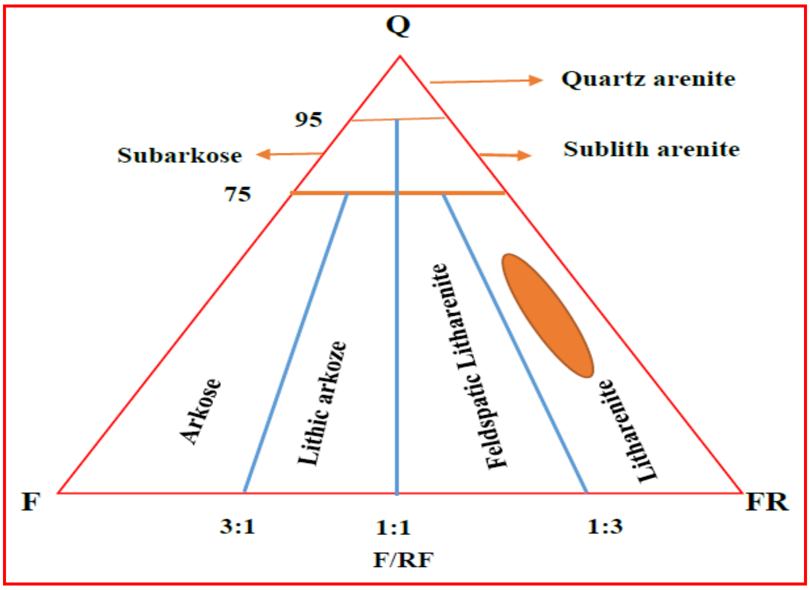

Figure 3- The position of the data obtained from the point counting of the studied samples in the classification model of Folk (1980), which shows the lite-arenite composition of these samples.

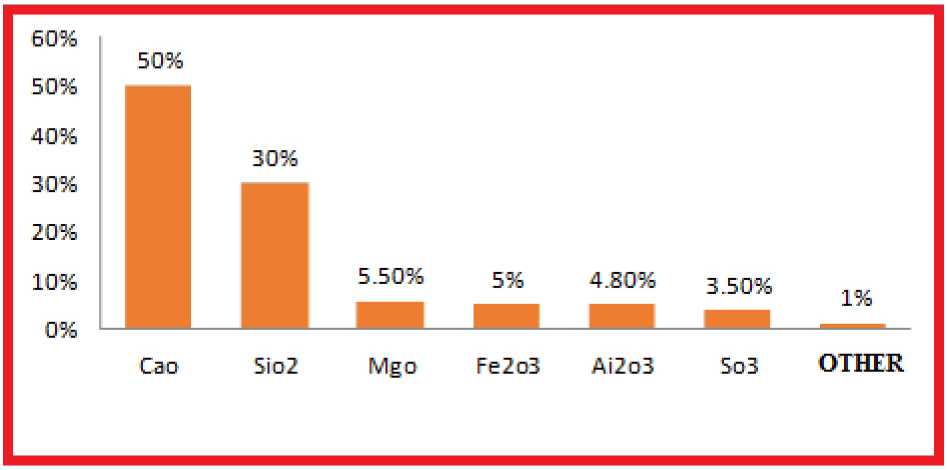

Figure 4 - Column chart of the average percentage of oxides and main elements in the samples taken from the study area

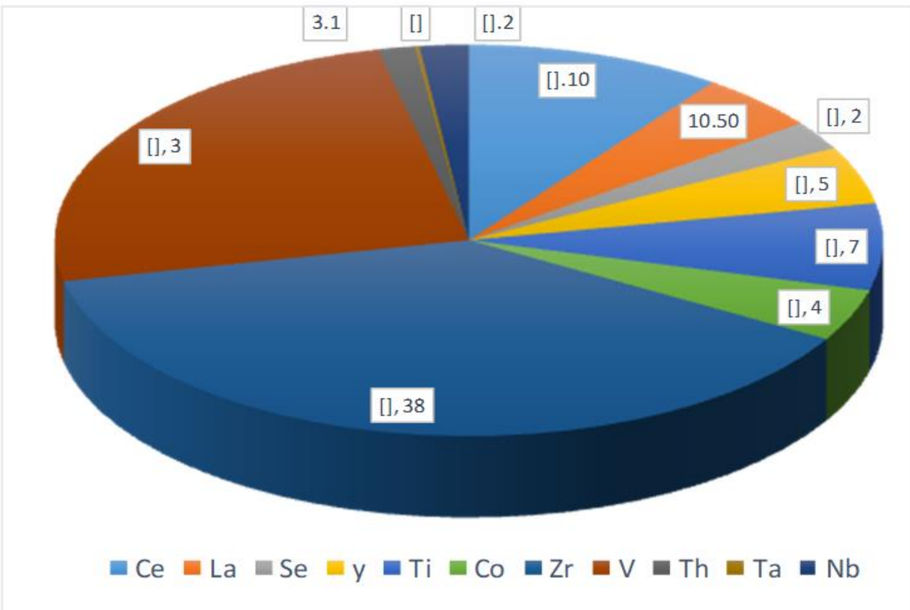

Figure 5- Percentage abundance of secondary elements in the samples of the studied area

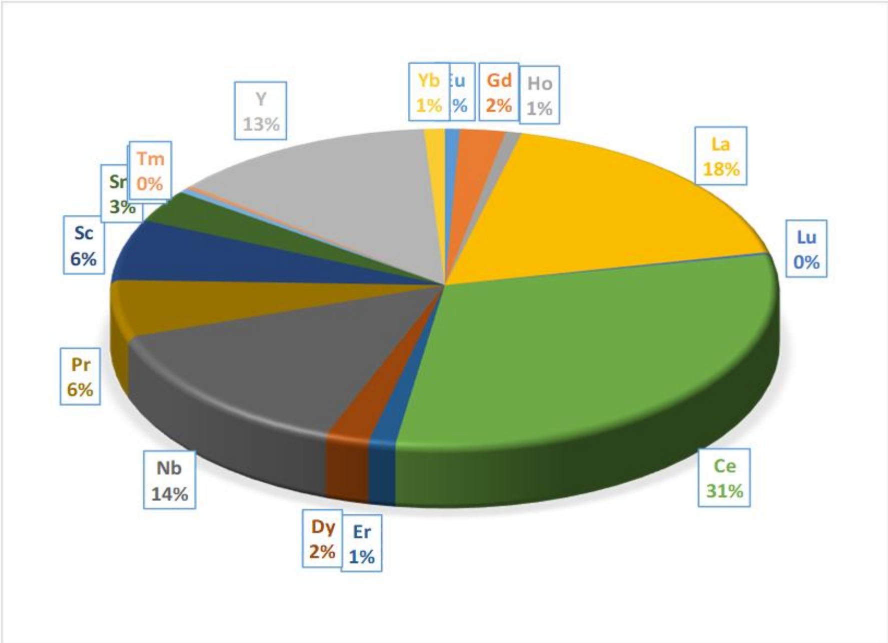

Figure 6)- The average abundance of rare earth elements in the studied areas (ppm)

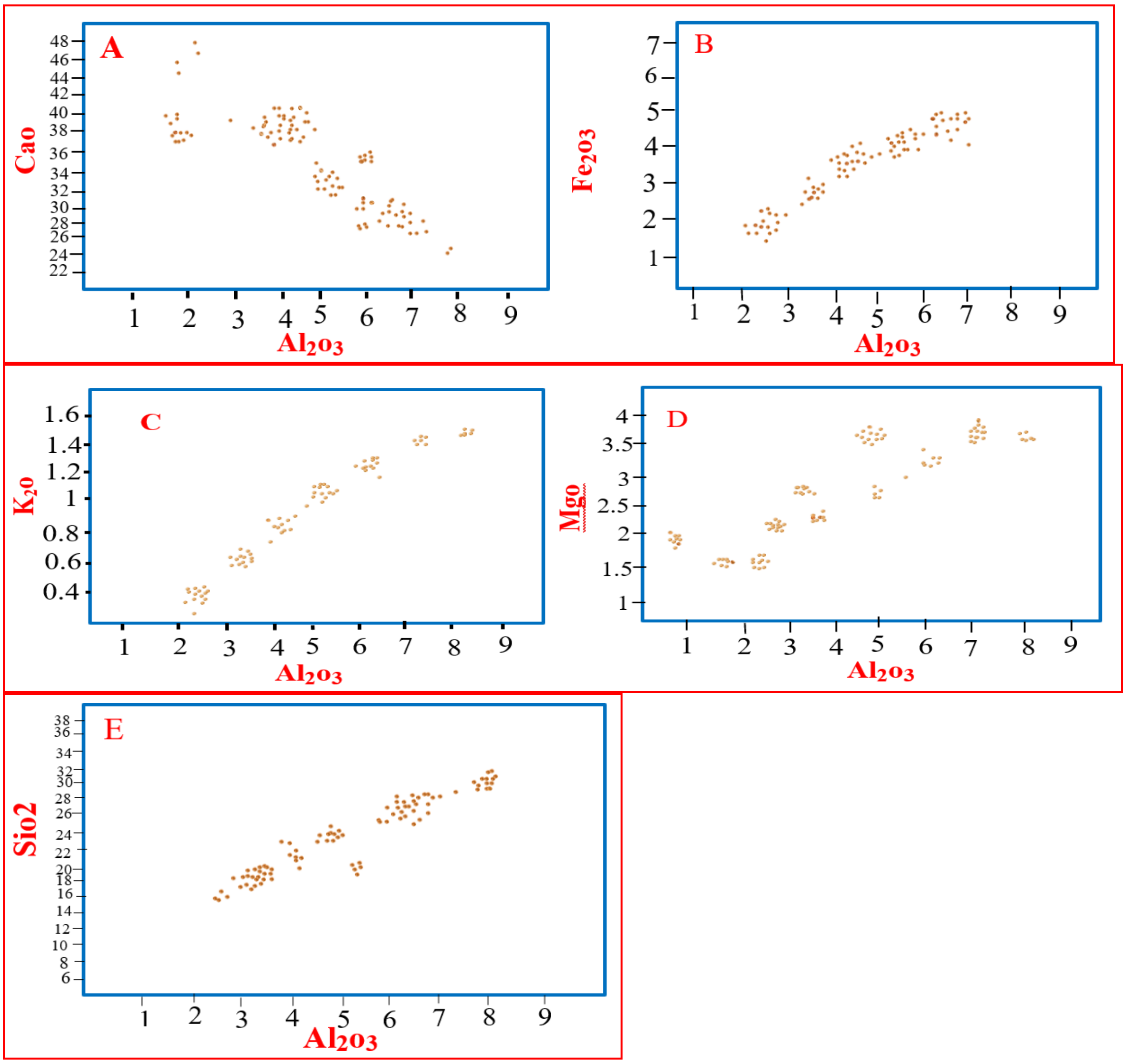

Figure7)- Examining the changes of main oxides with aluminum oxide. (A) negative correlation between AL2O3 and Cao, (B) positive correlation between AL2O3 and Fe2O3, (C) positive correlation between AL2O3 and K2O, (D) positive correlation between AL2O3 and MgO, (E) positive correlation between AL2O3 and SiO2.

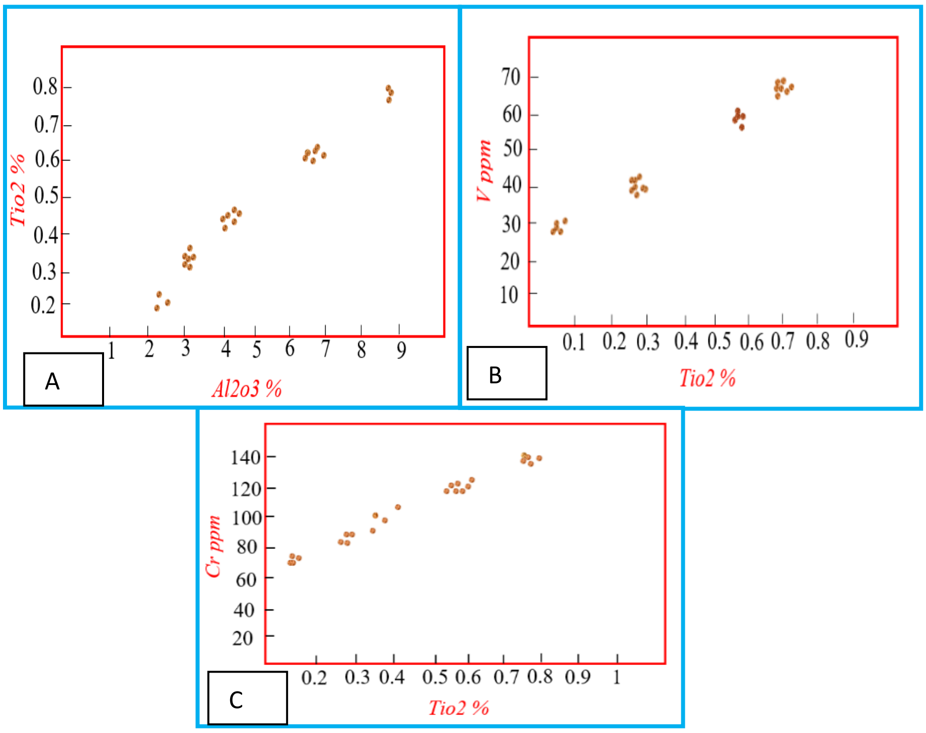

Figure8)-The position of the two-dimensional diagram and the positive relationship between titanium oxide and aluminum oxides and secondary elements (V and Cr)

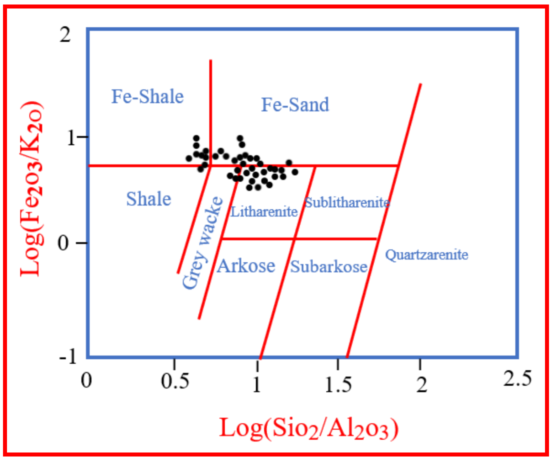

Figure 9)- Geochemical classification of the studied samples on the chart presented by Herron, 1988

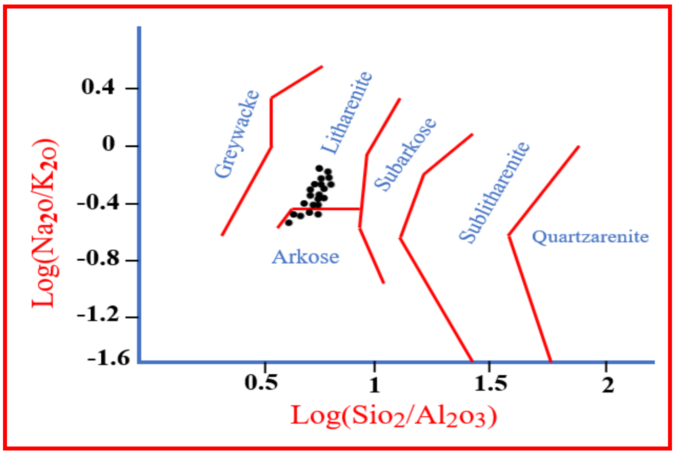

Figure 10)- Geochemical classification of the studied samples on the graph (Pettijohn, 1987)

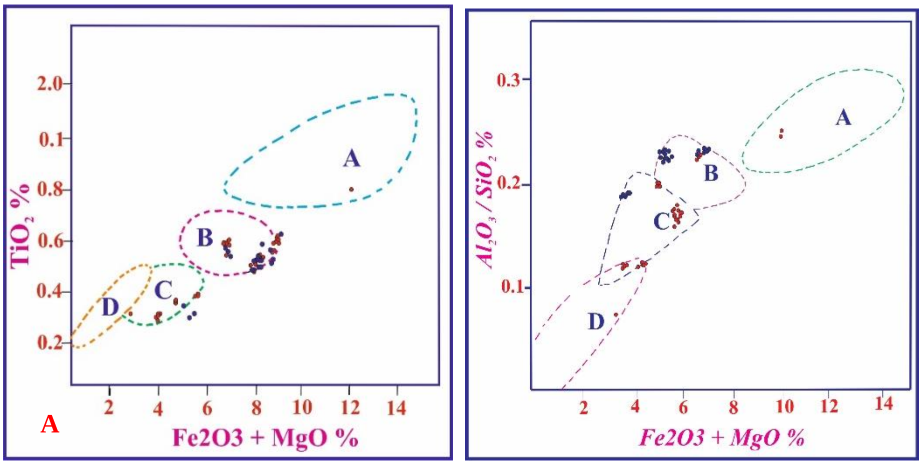

Figure 11)- Determining the tectonic position of sediments in the study area according to Bhatia's diagram (Bhatia, 1986)

Table 1- The average percentage of oxides and elements in the samples

Oxides	Cao	Sio2	Mgo	Al2o3	Fe203	So_3	Na2O, P2O5, SrO, TiO2, K2O
Percnt	50	30.2	5.50	4.8	5	3.5	1

Table 2- Mineralogical results of some studied samples in the studied area

XRD Analysis results	Sample number
Calcite, quartz, dolomite, feldspar, gypsum clay minerals	Om-1
Calcite, quartz feldspar, some dolomite and clay minerals	Om-20
Calcite, quartzfeldspar, illite, dolomite, and clay minerals	Om-30
Calcite, quartz orthosis, dolomite, feldspar, clay minerals	Om-40
Calcite, quartz, dolomite, feldspar, clay minerals and gypsum	Om-50
Calcite, quartz, dolomite, feldspar, clay minerals + gypsum	Om-60
Calcite, quartz dolomite, feldspar gypsum + clay minerals	Om-70
Calcite, quartz feldspar + dolomite	Om-80
Calcite, quartz dolomite, gypsum feldspar + clay minerals	Om-90
Calcite, quartz, dolomite, feldspar + clay minerals and gypsum	Om-100

Table 3- Chemical test results of 4 deep wells

Normalrate	average	Well-4	Well-3	Well-2	Well-1	unit	
6.50-8.50	7.3	7-8.1	6.7-7.9	6.8-7.8	6.6-7.6	___	PH
1500	1536	1528	1499	1539	1580	mg/l	TDS
<200	193	195	191	187	198	mg/l	COD
<30	31	29	34	33	28	mg/l	Mg
<250	252	256	249	255	247	mg/l	So4
<300	314	332	298	318	310	mg/l	Ca
3000	3052	2989	3211	3010	2998	µs/cm	Ec
0.05	0.0794	0.0695	0.0742	0.0931	0.0811	Ppb	Pb
<50	48	48	47	48	49	Ppb	Cd
0.1	0.3026	0.2439	0.0654	0.3479	0.5534	Ppb	Cr
0.02	0.1846	0.1759	0.1851	0.1943	0.1831	Ppb	Ni
<5000	4725	4736	4892	4290	4982	Ppb	Fe
<5000	4670	4921	4371	4560	4830	Ppb	Al

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